CONVENTION ON WETLANDS (Ramsar, Iran, 1971)

11th Meeting of the Scientific and Technical Review Panel
Gland, Switzerland, 8-11 April 2003

DOC. STRP11-10

Agenda item 6.1 i)

Draft Guidelines for methods, including indicators, for monitoring and the rapid assessment of wetland biodiversity

1. Attached to this note is an Information Paper being considered by the Convention on Biological Diversity's (CBD) Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) at its 8th meeting in March 2003.

2. This provides background material for the high priority task requested of the Panel for 2003-2005 concerning development of practical methods, including indicators, for monitoring wetlands and for the rapid assessment of wetland biodiversity, including both inland waters and coastal and marine systems.

3. Annex III of the attached CBD paper provides Guidelines on the Rapid Assessment of Inland Water Biodiversity, which have been prepared with input from the Ramsar Bureau under the 3rd CBD/Ramsar Joint Work Plan.

4. A similar paper concerning methods and guidance for rapid assessment of marine and coastal biological diversity is currently being prepared by the CBD secretariat with input from the Ramsar Bureau, and will be transmitted to the STRP as soon as it becomes available.

5. Concerning indicators, in February 2003 the CBD held a liaison group meeting, attended by the Ramsar Bureau, to further develop guidance on national-level indicators for biological diversity, which included a focus on inland waters assessment indicators. A paper on this topic is in preparation for considered by SBSTTA9 in late 2003, and will be transmitted to the STRP as soon as it becomes available.

6. The Panel should also be aware that a number of other initiatives concerning the development of indicators relevant to wetlands are underway, including through *inter alia* the Food and Agriculture Organisation (FAO), the Millennium Ecosystem Assessment (MA), and the Global Terrestrial Observing System (GTOS), and members may wish to seek further information and input from these organizations in support of its work on this matter.

CBD

UNEP

CONVENTION ON BIOLOGICAL DIVERSITY

Distr.
GENERAL

UNEP/CBD/SBSTTA/8/INF/5
31 January 2003

ORIGINAL: ENGLISH

SUBSIDIARY BODY ON SCIENTIFIC,
TECHNICAL AND TECHNOLOGICAL ADVICE
Eighth meeting
Montreal, 10-14 March 2003
Item 5.1 of the provisional agenda*

* UNEP/CBD/SBSTTA/8/1.

Report of the Expert Meeting on Methods and Guidelines for the Rapid Assessment of Biological Diversity of Inland Water Ecosystems

Note by the Executive Secretary

INTRODUCTION

1. In paragraph 8 (b) of the programme of work on the biological diversity of inland water ecosystems (decision IV/4, annex I), the Conference of the Parties to the Convention on Biological Diversity requested the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to develop a work plan on inland water ecosystems which should include, *inter alia*, the development and dissemination of regional guidelines for rapid assessment of inland water biological diversity for different types of inland water ecosystems. In paragraphs 6 and 7 of the programme of work, the Conference of the Parties requested that in the development of rapid-assessment methodologies special attention be paid to early cooperation with the small island States and the territories of certain States in which inland water ecosystems suffer from ecological disaster.

2. To facilitate the development of the guidelines the Executive Secretary commissioned Conservation International to compile information on methods for the rapid assessment of inland water biological diversity and guidelines for their application and convened, in collaboration with the Ramsar Bureau, an expert meeting to further develop these guidelines. The experts were selected by the Executive Secretary in consultation with Secretariat of the Ramsar Convention Bureau from nominations provided by national focal points of the Convention on Biological Diversity and the Ramsar Convention in accordance with the *modus operandi* of SBSTTA (decision IV/16, annex I). They were selected on the basis of their expertise in the relevant field, and with due regard to geographical representation, to the special conditions of least developed countries and small island developing States, and to gender.

3. Accordingly, the meeting was attended by government-nominated experts from Antigua and Barbuda, Belgium, Canada, Comoros, Cuba, Ghana, Lithuania, Peru, Poland, Saint Lucia, Slovakia, and South Africa, a representative of the Ramsar Convention Bureau and representatives of the following United Nations, intergovernmental and non-governmental organizations: the Global Environment Monitoring System (GEMS) of the United Nations Environment Programme (UNEP), the Food and Agriculture Organization of the United Nations (FAO), IUCN - The World Conservation), Conservation International, The Nature Conservancy and the University of Quebec at Montreal (UQAM). A resource person from Conservation International supported the Secretariat. A list of participants is contained in annex I below.

ITEM 1. OPENING OF THE MEETING

4. The meeting was opened by a representative of the Executive Secretary of the Convention on Biological Diversity at 9:30 a.m., on Monday 2 December 2002. In his statement, he welcomed the participants and thanked them for making available their time and expertise to contribute to the implementation of the programme of work on inland waters.

5. A representative of the Executive Secretary of the Ramsar Convention also made an opening statement emphasizing the synergies that have developed between the two conventions and the relevance of the meeting to both convention processes.

ITEM 2. ORGANIZATIONAL MATTERS

2.1. Election of officers

6. At the opening session, Ms Teresita Borges Hernández (Cuba) and Ms. Joseph M. Culp from Canada were selected as Co-chairs of the meeting.

2.2. Adoption of the agenda

7. The Expert Meeting adopted the following agenda on the basis of the provisional agenda proposed in document UNEP/CBD/EM-RAIW/1/1:

1. Opening of the meeting.
2. Organizational matters:
    - 2.1. Election of Chairperson;
    - 2.2. Adoption of the agenda;
    - 2.3. Organization of work.
3. Regional guidelines for the rapid assessment of biodiversity of inland water ecosystems.
    - 3.1 Brief review of methods for assessing biodiversity of inland water ecosystems;
    - 3.2 Identification of rapid assessment methods;
    - 3.3 Development of regional guidelines for the application of rapid assessment methods.
4. Other matters.
5. Adoption of the report.
6. Closure of the meeting.

2.3. Organization of work

8. A member of the Secretariat gave a brief presentation outlining the function and structure of the Convention bodies and the objectives of the meeting. The meeting agreed on the proposed organization of work, keeping it flexible to allow for working groups as needs arise.

ITEM 3. ISSUES for in-depth consideration

3.1 Brief review of methods for assessing biodiversity of inland water ecosystems

9. The following presentations were made and discussed:

(a) Nick Davidson, Ramsar Bureau: The Ramsar Convention and wetland assessment;

(b) Andrew Fraser, UNEP-GEMS: The UNEP-GEMS Programme Office for Freshwater Quality Monitoring and Assessment;

(c) Jean-Christophe Vié, IUCN: The IUCN Freshwater Biodiversity Assessment Programme;

(d) Matthias Halwart, FAO: Assessment of availability and use of aquatic biodiversity in a rice-based ecosystem in Kampong Thom Province, Cambodia;

(e) Rudy Vannevel, Belgium: The Water Framework Directive of the European Commission (WFD);

(f) Riszard Kornijów, Poland: Assessing biodiversity.

10. These presentations summarized existing methods for assessing inland water biological diversity and highlighted central elements for consideration in the development of guidelines for rapid assessment of the biological diversity of inland water ecosystems. They can be found on the website of the Convention.

3.2 Identification of rapid assessment methods

11. Leeanne Alonso of Conservation International introduced the background document UNEP/CBD/EM-RAIW/1/2. The approach of a decision tree, which provides a choice of options considering available resources and the purpose of the assessment was found particularly useful.

12. The structure and scope of the document were discussed and gaps identified.

3.3. Development of regional guidelines for the application of rapid assessment methods

13. To make progress on the development of regional guidelines, two Working Groups were formed. Working Group 1, chaired by Jean-Christophe Vié of IUCN, addressed the introductory section of document UNEP/CBD/EM-RAIW/1/2 including the purpose and scope, definitions and terms, issues to be considered when planning a rapid assessment, and the conceptual framework for rapid assessment. Working Group 2, chaired by Wafa Hosn from UQAM, considered the decision tree and associated methodologies.

14. Representatives of small island States welcomed the guidelines and requested the Secretariat to support their rapid application through the facilitation of appropriate training events. Small island States also raised the need to strengthen taxonomic capacities, address issues of invasive alien species and promote sustainable tourism. Annex II contains a summary of the points that were raised with regard to the early cooperation with the small island States in the development of rapid-assessment methodologies.

ITEM 4. OTHER MATTERS

15. No other matters were raised.

ITEM 5. ADOPTION OF THE REPORT

16. The Expert Meeting concluded that the revised document on "Guidelines for the rapid assessment of the biological diversity of inland water ecosystems" gives advice that is useful to wide range of Parties with different circumstances, including with respect to geographic size, inland water types and institutional capacities. Pending some further editorial changes the document should be presented to the eighth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice. It was recognized, however, that the guidelines needed to be tested and that it would be important to gather experience made with their application. The Group also recognized that additional reflections may be required with respect to ecosystem assessments. A shortage of case-studies from small island developing States was also noted. The present report was adopted at the plenary meeting, on Wednesday, 4 December 2002.

ITEM 6. CLOSURE OF THE MEETING

17. Following the customary exchange of courtesies, the meeting was closed at 5 p.m. on Wednesday 4 December 2002 by the Co-Chair, Ms Teresita Borges Hernández.

Annex I

LIST OF PARTICIPANTS

Ms Fatouma Ali Abdallah, Comoros
Mr Leroy Mc.Gregor Ambroise, Saint Lucia
Mr Geoffrey Cowan, South Africa
Mr Joseph M. Culp, Canada
Mr Hederick R. Dankwa, Ghana
Ms Maria Hilda Cuadros Dulanto, Peru
Ms Teresita Borges Hernández, Cuba
Mr Ilja Krno, Slovak Republic
Professor Ryszard Kornijów, Poland
Mr Antanas Kontautas, Lithuania
Mr Lionel Michael, Antigua and Barbuda
Mr Rudy Vannevel, Belgium

Observers
Mr Andrew Fraser, UNEP GEMS/Water Programme Office
Mr Matthias Halwart, FAO
Ms Wafa A. Hosn, UQAM
Ms Mary Lammert Khoury, The Nature Conservancy
Mr Jean-Christophe Vié, IUCN - The World Conservation Union

Resource person
Ms Leeanne E. Alonso, Conservation International

Ramsar Convention Bureau
Mr Nick Davidson, Ramsar Convention on Wetlands

Annex II

Issues relating to early cooperation with the small island States in the development of rapid assessment methodologies

Addressing the vulnerability of small island developing States

1. The Secretariat of the Convention on Biological Diversity was requested to collaborate with small island developing States due to their vulnerability and the resultant threats to their biodiversity. The following issues were raised in particular:

1. *Capacity building and training on rapid assessment;*

2. Small island developing states requested support to enable them to build capacity on the rapid assessment of the biological diversity of inland water ecosystems. A workshop could be facilitated by the Secretariat to train relevant stakeholders on the use of the approaches developed during the Expert meeting. Particular interest was expressed in using rapid assessment methods with respect to:

(a) Qualitative ad quantitative aspects of water quality;

(b) Causes of biodiversity loss and water pollution (e.g. deforestation, pesticide flows, and other industries); and

(c) Unsustainable land-uses (e.g. tourism, agriculture, industry).

2. *Sustainable tourism in vulnerable ecosystems*

3. Capacity should be built among government officials and other stakeholders on the implementation of the guidelines on sustainable tourism in vulnerable ecosystems developed by the Convention. A workshop should be organized to share relevant experiences and discuss the guidelines applicability in islands ecosystems. With a view to contributing to the 10-year review of the Barbados Programme of Action, to take place in 2004, the Secretariat was requested to consider developing specific guidance to small island developing States on issues related to sustainable tourism in islands ecosystems.

3. *Invasive alien species*

4. The Secretariat should support the efforts of small island developing States in assessing threats to biodiversity from invasive alien species and provide guidance on the implementation of mitigation measures.

Annex III

GUIDELINES ON THE RAPID ASSESSMENT OF INLAND WATER BIODIVERSITY FOR ALL TYPES OF INLAND WATER ECOSYSTEMS

executive summary

ES:1 In paragraph 8 (b) of the programme of work on the biodiversity of inland water ecosystems (Decision IV/4, annex I), the Conference of the Parties to the Convention on Biological Diversity requested the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to develop a work plan on inland water ecosystems which should include, *inter alia,* the development and dissemination of regional guidelines for rapid assessment of inland water biological diversity for different types of inland water ecosystems. In paragraphs 6 and 7 of the programme of work, the Conference of the Parties requested that in the development of rapid-assessment methodologies special attention be paid to early cooperation with the small island States and the territories of certain States in which inland water ecosystems suffer from ecological disaster (Annex 1, para 7).

ES:2 To facilitate the development of the guidelines the Executive Secretary commissioned Conservation International to compile information on methods for the rapid assessment of inland water biological diversity and guidelines for their application and convened, in collaboration with the Ramsar Bureau, an expert meeting to further develop these guidelines. The participants were selected among experts nominated by the national focal points of both the Ramsar Convention and the Convention on Biological Diversity, taking into account geographical/regional and gender balance. Relevant United Nations and other international organizations were also represented.

ES:3 The guidelines developed by the experts are designed to serve the needs of Contracting Parties of both the Convention on Biological Diversity and the Ramsar Convention. Rapid assessment methods are placed in the context of more comprehensive inventory, assessment and monitoring programmes, and a conceptual framework for their design and implementation is provided.

ES:4 The experts who drafted the guidelines considered their regional applicability and concluded that they provide advice and technical guidance that is useful to wide range of Parties with different circumstances, including geographic size, inland water types and institutional capacities.

ES:5 The guidelines stress the importance of clearly establishing the purpose as the basis for design and implementation of the assessment. They also emphasize that before deciding on whether a new field survey using rapid assessment methods is necessary, a thorough review of existing knowledge and information, including information held by local communities, should be undertaken.

ES:6 Subsequent steps are then presented in the form of a decision tree to facilitate the selecting appropriate methods to meet the purpose of the assessment. An indication of the categories of information, which can be acquired through each of the rapid assessment methods, is provided. Summary information on a range of appropriate and available methods suitable for each rapid assessment purpose is included, supported by case study examples of each type of assessment.

ES:7 The tools presented in the guidelines focus on the assessment of biological diversity at the species level. However, reference is made to tools, which will assist in the assessment of ecosystems, and a case study provides an example of assessing habitat as a surrogate for biological diversity. In addition, the guidelines do not address the full range of socio-economic or cultural values of the biological diversity of inland water ecosystems. Further elaboration of the guidelines to address ecosystem-scale assessments and assessments of socio-economic and cultural components of biological diversity is recommended.

Contents

I. introduction

1. In paragraph 8 (b) of the programme of work on the biological diversity of inland water ecosystems contained in annex I to decision IV/4, the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) was requested to develop a work plan on inland water ecosystem conservation including *inter alia* the development and dissemination of regional guidelines for rapid assessment of inland water biological diversity for different types of inland water ecosystems.

2. In addition, in paragraph 9 (e) of the programme of work, the Parties to the Convention on Biological Diversity were requested to *inter alia* identify the most cost-effective approaches and methods to describe the status, trends and threats of inland waters and indicate their condition in functional as well as species terms; and to undertake assessments in such inland water ecosystems which may be regarded as important in accordance with the terms of Annex I of the Convention. Furthermore Parties were requested to undertake assessments of threatened species and invasive alien species within their inland water ecosystems.

3. In paragraph 9 (g), Parties were requested to encourage environmental impact assessments (EIAs) of water development projects, aquaculture, and watershed activities including agriculture, forestry, and mining and their cumulative effects on the watersheds, catchments or river basins. EIAs need to gather adequate biological data to document effects on biological diversity. In the same paragraph, Parties were further requested to encourage EIAs, which assess the impacts, not only of individual proposed projects, but also the cumulative effects of existing and proposed developments on the watershed, catchment or river basin.

4. In paragraph 14 of the programme of work, Parties were urged to adopt an integrated approach in their assessments, to involve all stakeholders, be cross-sectoral and make full use of indigenous knowledge. While paragraph 15 sets out criteria for the identification of suitable organisms for the assessment of inland water ecosystems.

5. By paragraphs 10 (a) and (c) of the third joint work plan (2002-2006) of the Convention on Biological Diversity and the Convention on Wetlands (UNEP/CBD/COP/6/INF/14 and Ramsar COP8 DOC. 19), the secretariats of the two conventions agreed to jointly develop technical guidelines on rapid assessment of biological diversity of inland water ecosystems for consideration and adoption by both conventions and to seek to ensure that the technical guidance and tools available from the other convention are used, where appropriate, to implement their programmes of work and to meet the needs of their Parties, particularly through the provision of harmonized guidance.

6. To facilitate the development of regional guidelines for rapid assessment of biological diversity in different types of inland water ecosystems by SBSTTA, the Executive Secretary commissioned Conservation International to compile information on methods for the rapid assessment of inland water biological diversity and guidelines for their application. He also convened, in collaboration with the Ramsar Bureau, an expert meeting to further develop these guidelines. The participants were selected among experts nominated by the national focal points of both the Ramsar Convention and the Convention on Biological Diversity, taking into account a geographical/regional and gender balance.

7. The meeting was attended by government-nominated experts from Antigua and Barbuda, Belgium, Canada, Comoros, Cuba, Ghana, Lithuania, Peru, Poland, Saint Lucia, Slovakia, South Africa, a representative of the Ramsar Convention Bureau and representatives of the following United Nations, intergovernmental and non-governmental organizations: the Global Environment Monitoring System (GEMS) of the United Nations Environment Programme (UNEP), the Food and Agriculture Organizations of the United Nations (FAO), IUCN - The World Conservation), Conservation International The Nature Conservancy and the University of Quebec at Montreal.

II. rapid assessment of inland water biodiversity

8. **Rapid assessment,** for the purpose of this guidance, is defined as: "a synoptic assessment, which is often undertaken as a matter of urgency, in the shortest timeframe possible to produce reliable and applicable results".

9. It is important to note that rapid assessment methods for inland waters are not generally designed to take into account temporal variance, such as seasonality, in ecosystems. However, some rapid assessment methods can be (and are being) used in repeat surveys as elements of an integrated monitoring programme to address such temporal variance.

10. Rapid assessment techniques are particularly relevant to the species level of the components of biological diversity, and the present guidance focuses on assessments at that level. Certain other rapid assessment methods, including remote sensing techniques, can be applicable to the ecosystem/wetland habitat level, particularly for rapid inventory assessments, and it may be appropriate to develop further guidance on ecosystem-level rapid assessment methods. However, assessments of the genetic level of biological diversity do not generally lend themselves to "rapid" approaches.

11. The complex nature and variability of inland water ecosystems means that there is no single rapid assessment method that can be applied to the wide range of inland water ecosystems and for the variety of different purposes for which the assessment is undertaken. Furthermore, the resources available to carry out an assessment project will depend on the capacities of the implementing institution. In the detailed guidance that follows, five specific purposes for undertaking rapid assessment are distinguished, and for each purpose a range of appropriate survey methods is summarized and documented with case study examples.

A. *Issues to consider in designing a rapid assessment*

12. **Types of rapid assessments.** Rapid assessments can range from desk-studies, expert group meetings and workshops to field surveys. They can include compiling existing expert knowledge and information, including traditional knowledge and information, and field survey methods.

13. Assessments can be divided into three stages: design/preparation, implementation and reporting. **"Rapid" should be applied to each of these stages**. Rapid assessments provide the necessary results in the shortest practicable time although preparatory and planning work prior to the survey may be time-consuming. Under some circumstances (for example when taking into account seasonality) there may be a delay between the decision to undertake the assessment and the carrying out of the assessment. In other cases (for example in cases of disturbances and disasters) the assessment will be undertaken as a matter of urgency, and preparatory time should be kept to a minimum.

14. **Inventory, assessment and monitoring.** It is important to distinguish between inventory, assessment and monitoring 1/ when designing data-gathering exercises, as they require different types of

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1/ The Conference of the Contracting Parties to the Ramsar Convention has adopted, in resolution VIII.6, the following definitions of wetland inventory, assessment and monitoring:

- *Inventory*: The collection and/or collation of core information for inland water management, including the provision of an information base for specific assessment and monitoring activities.
- *Assessment:* The identification of the status of, and threats to, inland waters as a basis for the collection of more specific information through monitoring activities.
- *Monitoring:* Collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management. (Note that the collection of time-series information that is not hypothesis-driven from inland waters assessment should be termed *surveillance* rather than monitoring, as outlined in Ramsar resolution VI.1.)

Note that "inventory" under this definition covers baseline inventory, but in many cases, depending on specific purpose, priorities and needs, can include not only core biophysical data but also data on management features which provide "assessment" information, although this may also require more extensive data collection and analyses.

information. Wetland inventory provides the basis for guiding the development of appropriate assessment and monitoring, but wetland inventories repeated at given time intervals do not automatically constitute "monitoring".

15. **Rapid assessment means speed but it can be expensive.** Costs will increase particularly when assessing remote areas, large spatial scales, high resolution of localities, and/or a large number of types of features. Undertaking an assessment rapidly can mean a higher cost owing to the need, for example, to simultaneously mobilize large field teams and support them.

16. **Spatial scale.** Rapid assessments can be undertaken at a wide range of spatial scales. In general, a large-scale rapid assessment will consist of the application of a standard method to a larger number of localities or sampling stations.

17. **Compilation of existing data/access to data.** Before determining whether further field-based assessment is required, it is an important first step to compile and assess as much relevant existing data and information as possible. This part of the assessment should establish what data and information exists, and whether it is accessible. Data sources can include geographic information systems and remote sensing information sources, published and unpublished data, and traditional knowledge and information accessed through the contribution, as appropriate, of local and indigenous people. Such compilation should be used as a "gap analysis" to determine whether the purpose of the assessment can be answered from existing information, or whether new field survey is required.

18. For any new data and information collected during a subsequent rapid-assessment field survey, it is essential to create an **audit trail to the data**, including any specimens of biota collected, through the establishment of a full metadata record for the assessment.

19. **Reliability of rapid assessment data.** In all instances of rapid assessment of biological diversity it is particularly important that all outputs and results must include information on the confidence associated with the findings. Where practical, error propagation through the analysis of data and information should be extended to provide an overall estimate of confidence in the final results of the assessment.

20. **Dissemination of results.** A vital component of any rapid assessment is the fast, clear and open dissemination of its results to a range of stakeholders, decision-makers and local communities. It is essential to provide this information to each group in an appropriate form of presentation and level of detail.

B. *When is rapid assessment appropriate?*

21. Rapid assessment is one of a suite of tools and responses that Parties can use for assessing inland waters. Not all types of data and information needed for full inland waters inventory and assessment can be collected through rapid assessment methods. However, it is generally possible to collect some initial information on all generally used core inventory and assessment core data fields, although for some, rapid assessment can only yield preliminary results with a low level of confidence attached to the data set. Such types of data and information can, however, be used to identify where follow-up more detailed assessments may be needed if resources permit. A summary of core data fields for inventory and assessment of biophysical and management features of inland waters, and the general quality of information for each which can be gathered through rapid assessment, is provided in table 1.

Table 1. *Adequacy of data and information quality which can be (partly) collected through "rapid assessment" field survey methods for core wetland inventory and assessment data fields for biophysical and management features of wetlands.* 2/

2/ derived from Ramsar Resolution VIII.6.

Biophysical features	*Adequacy of data quality collected through "rapid assessment"*
• Site name (official name of site and catchment)	✓
• Area and boundary (size and variation, range and average values) *	✓
• Location (projection system, map coordinates, map centroid, elevation) *	✓
• Geomorphic setting (where it occurs within the landscape, linkage with other aquatic habitat, biogeographical region) *	✓
• General description (shape, cross-section and plan view)	✓
• Climate – zone and major features	(✓)
• Soil (structure and colour)	✓
• Water regime (e.g. periodicity, extent of flooding and depth, source of surface water and links with groundwater)	(✓)
• Water chemistry (e.g. salinity, pH, colour, transparency, nutrients)	✓
• Biota (vegetation zones and structure, animal populations and distribution, special features including rare/endangered species)	✓
Management features	
• Land use – local, and in the river basin and/or coastal zone	(✓)
• Pressures on the wetland – within the wetland and in the river basin and/or coastal zone	(✓)
• Land tenure and administrative authority – for the wetland, and for critical parts of the river basin and/or coastal zone	(✓)
• Conservation and management status of the wetland – including legal instruments and social or cultural traditions that influence the management of the wetland	(✓)
• Ecosystem values and benefits (goods and services) derived from the wetland – including products, functions and attributes and, where possible, their services to human well-being	(✓)
• Management plans and monitoring programmes – in place and planned within the inland water and in the river basin and/or coastal zone	(✓)

* *These features can usually be derived from topographical maps or remotely sensed images, especially aerial photographs.*

22. **Addressing socio-economic and cultural features of biodiversity.** This guidance covers chiefly assessment of the biotic components of biological diversity. For many assessment purposes, it is also important to collect information on socio-economic and cultural features of biological diversity, although full economic valuation assessment is generally well outside the scope of rapid assessment. Nevertheless, as part of a rapid inventory assessment or risk assessment it may be useful to compile an initial indication of which socio-economic and cultural features are of relevance in the survey site. This can provide an indication of the likely changes to the natural resource base, and may be used to indicate which features should be the subject of more detailed follow-up assessment.

23. For an indicative list of the socio-economic functions and values of inland waters, which are derived from biological diversity, see annex II of UNEP/CBD/SBSTTA/8/8/Add. 3.

24. Cultural functions and values of inland waters 3/ that should be taken into account include:

(a) Palaeontological and archaeological records;

(b) Historic buildings and artefacts;

(c) Cultural landscapes;

(d) Traditional production and agro-ecosystems, e.g. ricefields, salinas, exploited estuaries;

(e) Collective water and land management practices;

(f) Self-management practices, including customary rights and tenure;

(g) Traditional techniques for exploiting wetland resources;

(h) Oral traditions;

(i) Traditional knowledge;

(j) Religious aspects, beliefs and mythology;

(k) "The arts" – music, song, dance, painting, literature and cinema.

25. **Assessing threats to inland water biodiversity.** In many rapid assessments it will not be possible to fully assess the threats to, or pressures, on biological diversity. Nevertheless, as for socio-economic and cultural features, it may be useful for identifying where the focus of any further assessment may be needed, to make a provisional assessment of threat categories. For this purpose, a checklist of threat categories such as that being developed by the IUCN Species Survival Commission (SSC) as part of their Species Information Service (SIS) may be helpful. 4/

C. *Rapid assessment in relation to monitoring*

26. Hypothesis-based research for monitoring purposes needed for management of systems may require more comprehensive tools and methodologies than rapid-assessment can provide. However, some rapid assessment methods were originally developed for monitoring, but can be applied for the purposes of rapid assessment. Similarly, certain rapid-assessment tools/methodologies can be applied for longer term hypothesis-driven monitoring by repeated surveys. This can be a particularly valuable technique for addressing seasonality issues.

27. **Rapid assessment and trends in biological diversity.** Rapid assessment designed to assess trends in biological diversity implies that more than one repeat survey will be required. For gathering such information, regular time-series data may be necessary and in such circumstances this can be considered as rapid assessment if each survey is undertaken using a rapid-assessment method.

28. **Seasonality.** Most rapid assessments involve a single "snapshot" survey of a locality. However, the seasonality of many inland water systems and the biota dependent upon them (for example, migratory species) mean that surveys for different taxa may need to be made at different times of year. The timing of a rapid assessment in relation to seasonality is a critically important issue to take into account if the assessment is to yield reliable results, so it is important to understand the seasonality of an inland water system and to take this into account in the design and timing of a rapid assessment.

29. Other types of temporal variations in inland waters may also need to be taken into account, notably variations in flow regimes of different types of inland water ecosystems, which may be:

3/ Derived from Ramsar COP8 DOC. 15 Cultural aspects of wetlands.

4/ See http://www.iucn.org/themes/ssc/sis/authority.htm.

(a) Perennial systems which experience surface flow throughout the year and do not cease to flow during droughts;

(b) Seasonal systems which experience flow predictably during the annual wet season but may be dry for several months each year;

(c) Episodic (periodic or intermittent) systems, which experience flow for an extended period but are not predictable or seasonal. These systems usually have flow contribution from rainfall as well as groundwater. At times, surface flow may occur in some segments only, with subsurface flow in other segments. The fauna can differ considerably depending on the duration of flow, colonization succession of different species, proximity of other water sources, and extent of time during which previous flow occurred; or

(d) Ephemeral (short-lived) systems, which experience flow briefly and rarely and return to dry conditions in between. Their flow is usually sourced entirely from precipitation. Only aquatic biota able to complete their life cycles very rapidly (within a few days) are able to exploit such flow conditions.

D. *Special considerations relating to small island States*

30. **Priority types of rapid assessment in small island States.** Given the importance of often limited inland water systems in small island States, and a general lack of information about their biodiversity, and limited institutional capacity, rapid assessment methods are particularly valuable in small island States. Priority purposes of assessment include:

(a) Qualitative and quantitative aspects of water quality and quantity;

(b) Causes of biodiversity loss and water pollution, including deforestation, pesticide flows, and other non-sustainable exploitation; and

(c) Pressures of unsustainable land uses (e.g. tourism, agriculture, industry).

31. FAO provides detailed information on the more important fisheries and aquaculture issues in small island developing States 5/ 6/. The Plan of Action on Agriculture in Small Island Developing States 7/ also recognizes the particular fisheries needs of small island developing States and provides guidance on the sustainable management of inland water and other natural resources.

III. A conceptual framework for rapid assessment

32. This conceptual framework is derived from, and consistent with, the Ramsar Framework for Wetland Inventory (resolution VIII.6). Certain modifications concerning the sequence and titling of steps have been made to take account of the specific approaches of minimizing time scales inherent in rapid assessment.

33. The process of applying the conceptual framework is summarized in figure 1. Steps in the conceptual framework, and guidance for their application are listed in table 2.

34. The framework is designed to provide guidance for planning and undertaking the initial assessment. Follow-up assessments, and those for new areas using a proven procedure and method, need not go through the entire process, although review of methodology should be undertaken in relation to possible differences in local conditions such as different inland water ecosystem types.

35. In assessments undertaken in response to an emergency, e.g. a natural or human-induced disaster, the steps of the conceptual framework should be followed as far as possible. However, it is recognized

5/ http://www.fao.org/docrep/meeting/X0463E.htm.

6/ See also: Fisheries Global Information System. http://www.fao.org/fi/default.asp.

7/ See IUCN Red List Categories http://www.iucn.org/themes/ssc/redlists/categor.htm.

that under such circumstances the need for very rapid response can mean that shortcuts in applying the full framework may be essential.

Figure 1. *Summary of key steps in applying the conceptual framework for rapid assessment (see table 2 for further details)*

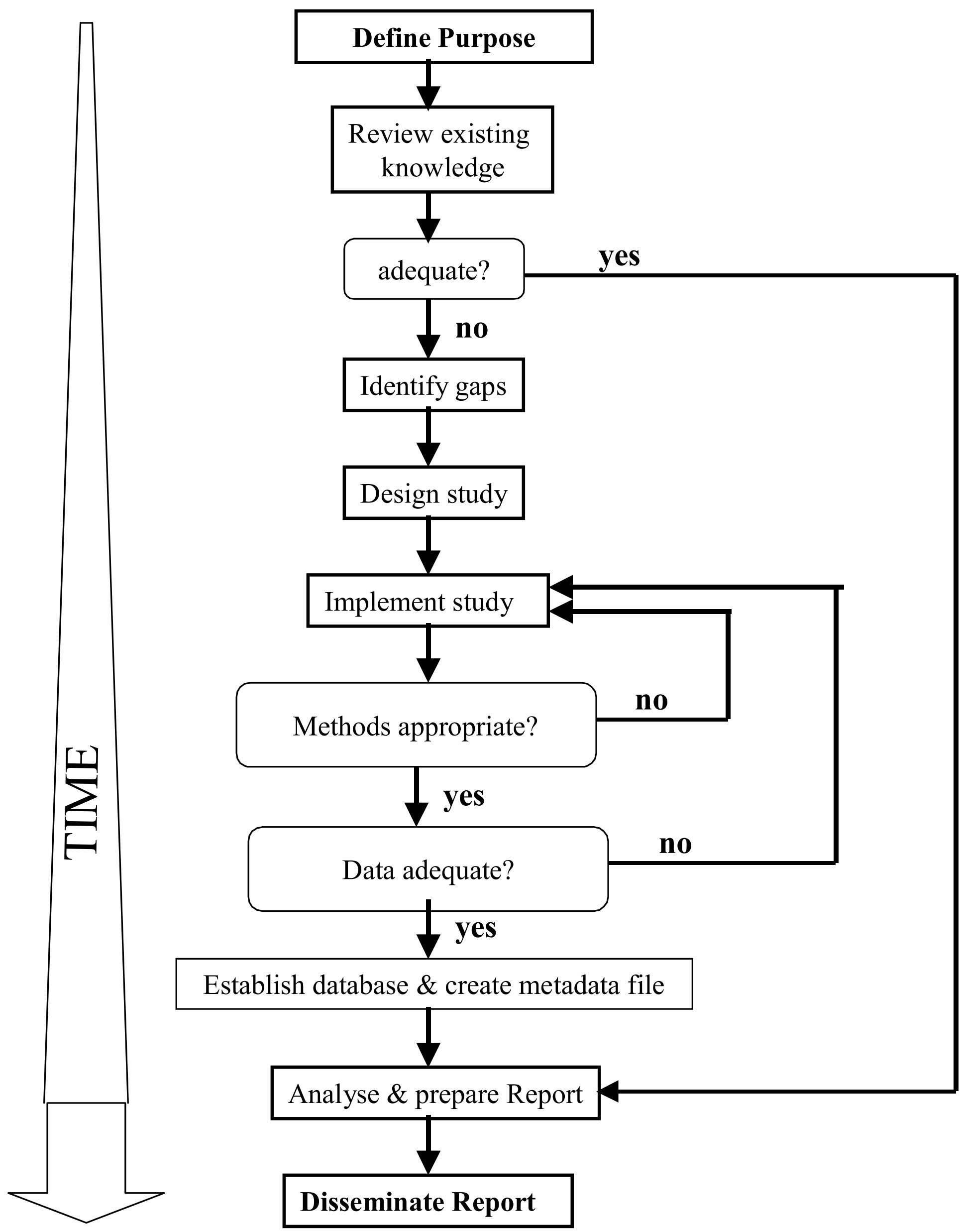

Table 2. *Conceptual framework for designing and implementing a rapid assessment of inland water biodiversity*

Step	Guidance
1. State the purpose and objective	State the reason(s) for undertaking the rapid assessment: why the information is required, and by whom it is required.
a. Determine scale and resolution	Determine the scale and resolution required to achieve the purpose and objective.
b. Define a core or minimum data set	Identify the core, or minimum, data set sufficient to describe the location and size of the inland water(s) and any special features. This can be complemented by additional information on factors affecting the ecological character of the inland water(s) and other management issues, if required.
2. **Review existing knowledge and information – identify gaps** (if done, write report, if not, design study)	Review available information sources and peoples' knowledge (including scientists, stakeholders, and local and indigenous communities), using desk-studies, workshops etc, so as to determine the extent of knowledge and information available for inland water biodiversity in the region being considered. Include all available data sources 8/. Prioritize sites. 9/
3. **Study design**	
a. Review existing assessment methods, and choose appropriate method	Review available methods and seek expert technical advice as needed, to choose the methods that can supply the required information. **Apply the rapid assessment decision tree and choose appropriate field survey methods.**
b. Establish a habitat classification system where needed	Choose a habitat classification that suits the purpose of the assessment, since there is no single classification that has been globally accepted.
c. Establish a time schedule	Establish a time schedule for: a) planning the assessment; b) collecting, processing and interpreting the data collected; and c) reporting the results.

8/ It is important to include identification of not just local data and information but also other relevant national and international sources, which can provide supplementary data and information to underpin the rapid assessment (for example, the UNEP-GEMS/Water programme for water quality and quantity).

9/ IUCN has developed a methodology for prioritizing important sites for conservation of biodiversity of inland waters. See http://www.iucn.org/themes/ssc/programs/freshwater.htm for further information.

Step	Guidance
d. Establish the level of resources required, assess the feasibility & cost-effectiveness that are required	Establish the extent and reliability of the resources available for the assessment. If necessary make contingency plans to ensure that data are not lost due to insufficiency of resources. Assess whether or not the programme, including reporting of the results, can be undertaken within under the current institutional, financial and staff situation. Determine if the costs of data acquisition and analysis are within budget and that a budget is available for the programme to be completed. [Where appropriate, plan a regular review of the programme.]
e. Establish a data management system and a specimen curation system	Establish clear protocols for collecting, recording and storing data, including archiving in electronic or hardcopy formats. Ensure adequate specimen curation. This should enable future users to determine the source of the data, and its accuracy and reliability, and to access reference collections. At this stage it is also necessary to identify suitable data analysis methods. All data analysis should be done by rigorous and tested methods and all information documented. The data management system should support, rather than constrain, the data analysis. A meta-database should be used to: a) record information about the inventory datasets; and b) outline details of data custodianship and access by other users. Use existing international standards (refer to the Ramsar Wetland Inventory Framework)
f. Establish a reporting procedure	Establish a procedure for interpreting and reporting all results in a timely and cost effective manner. The reporting should be succinct and concise, indicate whether or not the objective has been achieved, and contain recommendations for biodiversity management action, including whether further data or information is required.
g. Establish a review and evaluation process	Establish a formal and open review process to ensure the effectiveness of all procedures, including reporting and, when required, supply information to adjust the assessment process.
4. Perform study and include continuous assessment of methodology (go back and revise design if needed)	Undertake study method. Test and adjust the method and specialist equipment being used, assess the training needs for staff involved, and confirm the means of collating, collecting, entering, analysing and interpreting the data. In particular, ensure that any remote sensing can be supported by appropriate “ground-truth” survey.

Step	Guidance
5. **Data assessment and reporting (was purpose of the study achieved? If not, go back to step 3)**	Establish a formal and open review process to ensure the effectiveness of all procedures, including reporting and, when required, supply information to adjust or even terminate the program. Results should be provided in appropriate styles and level of detail to, *inter alia,* local authorities, local communities and other stakeholders, local and national decision-makers, donors and the scientific community.

A. *The rapid assessment decision tree*

36. The primary purpose of this document is to be a practical reference for rapid biodiversity assessment of inland water ecosystems. What we have coined the "decision tree" is a schematic guide to a number of available methods used for rapid assessment of biodiversity in inland water ecosystems. The concept behind the decision tree is simple. It is meant to enable the selection of appropriate biodiversity assessment methods, based on a structured framework of selection criteria. These are organized in a progression of the most important factors of biodiversity assessment of inland waters. The tree begins with the most basic and broad elements of an assessment, and advances through progressively more selective criteria. Eventually a general framework of the necessary assessment should emerge, taking the amalgamated form defined by its purpose, output information, available resources, and scope. The idea is to meld informational parameters, like output and purpose, with logistical parameters such as time frame, available funding, and geographical scope, in order to present a realistic assessment model and determine what methods are available for its implementation.

37. Defining the **purpose** is the first step of a biodiversity assessment. The decision tree (figure 2) provides three general purposes corresponding to five specific purposes, which will determine the assessment type. The five specific **assessment types** used in the decision tree are: ***inventory assessment, specific-species assessment, impact assessment, indictor assessment, economic resource assessment.*** These are organized numerically and coordinated with their output information presented in tables 3-7 in appendix 2. The assessment types are explained in detail below.

38. Once the purpose and assessment type have been determined, the tree leads through a matrix of more specific components of a biological diversity assessment. They include the **resource limitations** and **scope** of the various elements of the assessment. This section begins with an appraisal of the resources available for the assessment. ***Time, money and expertise*** are the critical resource components considered in the tree; availability or limitations on these resources will determine the scope and capacity of any biodiversity assessment. The tree continues through a matrix of six more specific parameters *(taxa, geography, site selection, methods, data collection, analysis)* to determine the scope of each relative to the resource limitations of the assessment. Variable combinations of resource limitations and scope criteria give shape to the assessment project, and eventually offer an example of current programmes and methods available that address the needs and fit within the parameters of the assessment project (see also table 8, appendix 3).

Purpose

39. The decision tree has been created with the supposition that any rapid biodiversity assessment ought to be performed with the overriding goals of conservation and sustainable management/development in mind. The methods used should augment knowledge and understanding in order to establish a baseline of biological diversity, assess changes or the health of inland water ecosystems, and support the sustainable use of the resource. We have identified five specific reasons

within this context to undertake a rapid biodiversity assessment of inland waters that represent a breadth of possible reasons for rapid biodiversity assessment:

(a) Collect general biodiversity data in order to inventory and prioritize species, communities and ecosystems. Obtain baseline biodiversity information for a given area;

(b) Gather information on the status of a focus or target species (such as threatened species). Collect data pertaining to the conservation of a specific species;

(c) Gain information on the effects of human or natural disturbance (changes) on a given area or species;

(d) Gather information that is indicative of the general ecosystem health or condition of a specific inland water ecosystem;

(e) Determine the potential for sustainable use of biological resources in a particular inland water ecosystem.

40. The five purposes are numbered according to the assessment type to which they correspond. The columns in figure 2 are related to the three objectives of the Convention on Biological Diversity. Columns I and II (Inventory assessment and species assessment) are related to the conservation of biodiversity. Columns III, IV and V (Change, indicator, and resource assessments) address the sustainable use while column V (Resource assessment) also refers to the equitable sharing of the benefits arising out of the utilization of genetic resources.

Figure 2. Decision Tree

Decision Tree					
General purpose	Biodiversity baseline		Disturbance and ecosystem health		Resource sustainability and economics
COLUMN	I	II	III	IV	V
Specific purposes	Baseline inventory, prioritization, conservation, identification	Conservation of specific species, status of alien species	Change detection	Overall ecosystem health or condition	Sustainable use of biological resources
Assessment type	Inventory assessment	Species-specific assessment	Change assessment	Indicator assessment	Resource assessment
CBD article	7(a)	7(a), 8(h)	7(b), 7(c)	7(b), 7(c)	7(b), 7(c), 8(i)
Output options	1.Species lists/inventories. 2. Habitat type lists/inventories. 3. Limited data on population size/ structure, community structure and function, and species interactions 4. Abundances, distribution patterns, and ranges. 5. Genetic information. 6. Important species: threatened, endangered 7/, endemics, migratory, invasive alien species, other significance: cultural, scientific, economic, nutritional, social. 7. Diversity indices. 8. Water quality data. 9. Hydrological information.	1. Status of a focal species: distribution, abundance, population size/ structure, genetic, health, size, species interactions, nesting, breeding and feeding information. 2. Ecological data on focal species; habitat, symbionts, predators, prey etc. 3. Threats to focal species and habitats. 4. Life history table. 5. Water quality data. 6. Hydrological information.	1. Monitoring data. 2. Effects of an activity or disturbance on habitat/species/ communities: diversity loss, genetic issues, habitat changes or loss. 3. Monitor impacts. 4. Determine changes in ecological character. 5. Impact reduction options. 6. Biotic indices. 7. Habitat indices. 8. Water quality data. 9. Hydrological information. 10. Early warning indicators.	1. Data on health or condition of inland water systems. 2. Water quality data. 3. Hydrological information. 4. Biological parameters. 5. Biotic indices.	1. Presence, status and condition of economically, culturally, nutritionally, and socially important species. 2. Information on sustainability of use of a species. 3. Limited monitoring data: stock assessment data, habitat status. 4. Limited information relevant to resource management. 5. Water quality data. 6. Hydrological information.
May depend on *		Inventory assessment	Inventory assessment*		Species-specific assessment
To define scope go to Appendix 2	**Table 3**	**Table 4**	**Table 5**	**Table 6**	**Table 7**

*recommended

B. *Assessment types*

41. In order to choose an adequate method for the assessment of inland water biodiversity, we have categorized five types of rapid biodiversity assessment that apply to inland freshwater systems. These assessment types vary according to the purpose and desired output of a particular biodiversity assessment project. Each assessment type has specific outputs and applies to specific purposes. It is therefore important to determine the goals and overall purpose of any biological assessment relating to diversity, conservation, and management. Any particular project, defined by its purpose and output goals, should fall within the range of one or more of these five assessment categories. The assessment types are briefly described and numbered below, with numbers corresponding to purpose numbers above. They are accompanied by case-studies (see appendix 1) and tables to help define the scope of the assessment (appendix 2).

1. Inventory Assessment (appendix I, case studies Ia, Ib and Ic; appendix 2: table 3)

42. Inventory assessments focus on overall biological diversity rather than extensive or detailed information about specific taxa or habitats. The goal is to gather as much information as possible about the ecosystem through extensive and, as much as possible, comprehensive sampling of its biological constituents. Species and habitat type lists are likely to be the most important form of data, but other relevant baseline data could include: species richness, abundances, relative population sizes, distribution and ranges, other cultural significance in addition to biodiversity significance, and other relevant biological information pertaining to water quality, 10/ 11/ hydrology and ecosystem health. Data on geography, geology, climate, and habitat are also important. Local communities can be a valuable source of information concerning species richness of a habitat. For example, through community and consumption surveys information can be gathered in a short time span.

43. A full species inventory assessment (see appendix 1, case study Ia) involves an intense sampling effort to take inventory of the species present in an area. This inventory can then be used to determine the conservation value of an area in terms of its biodiversity. The goal is to sample as many sites and list as many species as possible in the short amount of time allotted for the assessment. Ideally, the species lists would correspond to specific sampling sites within the survey area. Separate lists of species for each taxonomic group observed/collected at each sampling site are useful in order to distinguish among different habitats and localities in the survey area. Taxonomic data would likely include sampling of fish, plankton, epiphytic and benthic invertebrates, aquatic and terrestrial plants, and algae.

44. Habitat types can be inventoried through field survey or analysis of GIS and remote-sensing data. To inventory habitat types in the field, several sites need be sampled in order to get a range of habitat types of the area and the ecological gradations within it. If GIS is available, classification of habitat types is possible using spatial data such as elevation, physiography, and vegetative cover (see appendix 1, case-study Ib). Ideally, information gathered during the assessment on species and ecosystems should be georeferenced.

45. An inventory assessment provides initial information about a defined area of interest. The output information could be useful in prioritizing species or areas of particular concern for conservation (see for example appendix 1, case-study Ic), identifying new species, and developing a broad view of the overall biodiversity of an area. For conservation and management, this information is especially pertinent in the prioritization of species and areas. Prioritized species should then be assessed according to species-specific assessment methods (table 4). If localities or habitats are prioritized for particular human stresses

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10/ See e.g.: U.S. Geological Survey. National water quality assessment program. http://water.usgs.gov.

11/ DePauw, N. and Vanhooren, G. 1983. Methods for biological quality assessment of water courses in Belgium. Hydrolobiologia, 100, 153-168.

on them, then they should be considered for assessment according to the change assessment methods (table 5).

46. Possible outputs from an inventory assessment include:

Data

- Baseline biodiversity data: species lists/inventories, habitat type lists/inventories, limited data on population size/structure, abundances, distributional patterns and ranges
- Ecological data pertaining to the area: important habitats, communities and relationships
- Background information on geology, geography, water quality, hydrology, climate, and habitat zones for greater ecological context

Applications

- Species prioritization: identify and prioritize any species of special concern or interest
- Area/habitat prioritization: identify and describe important habitats or areas
- Conservation recommendations
- Basic data and diversity indices (see Appendix 4)

2. Species-specific assessment (appendix 1: case-study II; appendix 2: table 4)

47. A species-specific assessment provides a rapid appraisal of the status of a particular species or taxonomic group in a given area. The assessment provides more detailed biological information about the focus species within the context of its protection, use, or eradication (in the case of invasive species). Thus, this assessment type generally pertains to ecologically or economically important species and can provide rapid information about an important species in an area where its status is unknown or of particular interest. Likewise, the assessment can be used to confirm the status of species as threatened, endangered, or stable in a certain area. Data and output information focus on the target species within ecological, behavioural, cultural, and economic contexts.

48. Possible outputs from a species-specific assessment include:

Data:

- Data pertaining to the status of focal species: distribution, abundance, population size/structure, genetics, health, size, nesting, breeding and feeding information
- Ecology and behaviour, information pertaining to focal species: habitat, range, symbionts, predators, prey, reproductive and breeding information

Applications:

- Conservation recommendations
- Identify economic possibilities/interests
- Identify threats and stresses to focal species and habitat
- Assess status of alien species
- Habitat classifications and similarity/comparative indices (see appendix 4)

3. Change assessment (appendix 1; case- study III; appendix 2: table 5)

49. Often an assessment is needed in order to determine the effects of human activities (pollution, physical alterations, etc.) or natural disturbances (storms, exceptional drought, etc.) on the ecological integrity and associated biodiversity of an area. The information collected in this type of assessment can be either retroactive or proactive in nature.

50. A retroactive approach aims to assess *actual* disturbances or alterations of various projects or management practices as they apply to biodiversity and biological integrity. In terms of biodiversity, this

approach can be difficult without pre-disturbance (baseline) data for comparison, and therefore may require trend analyses or the use of reference sites or environmental quality standards (EQS). Reference sites are areas of the same region that parallel the pre-disturbance condition of the impacted area in order to provide data for comparative analysis. Four approaches to assessment may be distinguished:

(a) Comparing two or more different sites at the same time;

(b) Comparing the same site at different times (trends);

(c) Comparing the impacted site to a reference site;

(d) Comparing the observed status to EQS. Most existing rapid assessment methods are designed for this purpose; some of these (either biological, physical-chemical or eco-toxicological) may be used as “early warning indicators”.

51. A proactive approach would assess the *potential* consequences of a particular project such as a dam or development, and also establish a baseline of biodiversity data for long term monitoring of the changes. This approach allows for “before and after” assessment data, as well as identification of species and habitat areas likely to be affected by the impending changes. Comparative analysis of areas where changes have already occurred can be used to predict potential impacts. This is the field of environmental impact assessment (EIA), trend- and scenario-analysis and modelling (in terms of predictions). It relies to a large extend on the results of a retroactive approach, specifically early warning indictors. There is a direct link between the proactive approach and policy responses. Most of these methods are not generally “rapid”.

52. Special attention must be paid to changes on community level, whereas the habitat conditions remain the same. This is the case with fast-spreading pioneer species adapted to the post-disturbance ecological conditions, which replace naturally occurring species. This presents a difficult question concerning the condition of the system, which may become more species-rich, compared to its ecological heritage. The situation is especially complex when new invasive species are considered more desirable than those that made up the original ecological make-up of the system. Change assessment outputs are grouped below depending on whether they pertain to existing or potential changes.

53. Possible outputs from an change assessment include:

Data

- Baseline biodiversity data for long term monitoring of changes. Species lists, abundances, distribution, densities
- Geology, geography, water quality, hydrology, climate, and habitat information pertinent to the particular impact the greater ecological context of the area
- Basic information for wetland risk assessment 12/ and EIA
- Data on specific taxa, changes in water quality, hydrological alterations and habitat structure (requires baseline or reference site data)

Applications

- Identify and prioritize species and communities within the impact range
- Identify and prioritize important habitats within the impact range
- Predict potential impacts through comparison of existing impacts in similar sites
- Conservation recommendations
- Determine effects of human pressures and natural stresses on biodiversity and habitat structure

12/ See Ramsar Resolution VII.10.

- Identify specific pressures, and stresses related to impact
- Identify possible management practices to mitigate pressures and stresses
- Conservation recommendations
- Biotic indices, scores and multimetrics (see Appendix 4) 13 /, 14/, 15/

4. *Indicator Assessment (appendix 1; cases-study IV; Appendix 2; table 6)*

54. An indicator assessment assumes that biological diversity, in terms of species and community diversity, can tell us a great deal about the water quality, hydrology and overall health of particular ecosystems. Biomonitoring is often associated with this type of assessment. Biomonitoring traditionally refers to the use of biological indicators to monitor levels of toxicity and chemical content, but recently this type of approach has been more broadly applied to monitor the overall health of a system rather than its physical and chemical parameters alone 16/. The presence or absence of certain chemical or biological indicators can reflect environmental conditions. Taxonomic groups, individual species, groups of species, or entire communities can be used as indicators. Typically, benthic macro-invertebrates, fish, and algae are used as organismic indicators 17/ 18. . It is therefore possible to use species presence/absence and in some instances abundances and habitat characteristics to assess the condition of inland water ecosystems.

55. Possible outputs from an indicator assessment include:

Data:

- Presence/absence/abundance of species or taxa
- Taxonomic diversity
- Physical/chemical data (e.g. pH/conductivity/turbidity/O_2/salinity)

Applications:

- Assess the overall health or condition of a given inland water ecosystem
- Assess water quality and hydrological status
- Conservation recommendations
- Indices on diversity and ecosystem health, habitat classification, physical-chemical assessment methods and basic data on biological assessment (see Appendix 4 for further details on biomonitoring indices)

5. *Resource assessment (Appendix 1; case-study V; appendix 2; table7)*

56. A resource assessment aims to determine the potential for sustainable use of biological resources in a given area or water system. Data pertains to the presence, status and condition of economically important species, species on which livelihoods depend, or those with a potential for marketing. Ideally a resource assessment can facilitate the development of ecologically sustainable development as an

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13/ Fausch, K.D., J.R. Karr, and P.R. Yant. 1984. Regional application of an index of biotic integrity based on stream fish communities. Transactions of the American Fisheries Society. 113: 39-55.

14/ Goldstein, R.M., T.P. Simon, P.A. Bailey, M. Ell, E. Pearson, K. Schmidt, and J.W. Enblom. 2002. Concepts for an index of biotic integrity for streams of the Red River for the North Basin. http://mn.water.usgs.gov/redn/rpts/ibi/ibi.htm

15/ Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries (Bethesda). 6(6): 21-27.

16/ Nixon, S.C., Mainstone, C.P., Moth Iverson T., Kristensen P., Jeppesen, E., Friberg, N. Papathanassiou, E., Jensen, A. and Pedersen F. 1996. The harmonised monitoring and classification of ecological quality of surface waters in the European Union. Final Report. European Comission, Directorate General XI & WRc, Medmenham. 293 p.

17/ Rosenberg, D.M. and V. H. Resh. eds. 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York, USA

18/ Troychak, M. (ed.). 1997. Streamkeepers- Aquatic Insects as Biomonitors. The Xerces Society, Portland, USA.

alternative to other destructive or unsustainable enterprises. Thus, a major objective of the resource assessment is to develop or determine sustainable use practices as viable economic options in areas with rich biological resources. For this reason, an important factor of resource assessment is the involvement of local communities and governments, for example through community biodiversity surveys 19/. This is especially important in relation to the needs, capacity and expectations of all involved parties. This integrative approach is important to the successful implementation of any sustainable harvesting system. Another extension of a resource assessment may be to provide baseline information used to monitor the health of fisheries and other resources.

57. Possible outputs from a resource assessment include:

Data:

- Determine the presence, status and condition of socio-economically important species
- Identify important parties
- Identify interests, capacity, and expectations of all involved parties
- Baseline monitoring data such as stock assessments

Applications:

- Fishery and other aquatic resources sustainability, habitat status, stock assessments, information for fishermen/resource users
- Options for sustainable development and recommendations for management

IV Design considerations

A. *Resources*

58. The methods available for Rapid Biodiversity Assessment are contingent on the purpose and output of specific projects. Equally important is a consideration of available resources and limitations, especially as they apply to the scope of the assessment. ***Time, money*** and ***expertise*** are resource limitations that determine the methodologies available to a particular assessment project**.** Furthermore, they define the project in terms of its scope in the following areas: ***taxa, geography, site selection, analysis, data, sampling methods.*** These are important components of a biodiversity assessment and the scope, or capacity of each vary depending on the project needs and its resource limitations.

59. Time, money and expertise are the key factors to consider in a rapid biodiversity assessment. In abundance, these resources allow for a great deal of flexibility, while insufficiency limits nearly all aspects of a potential assessment project. However, in some cases abundance in one area can compensate for limitations in another. The availability of these resources will, to a large extent, determine the scope and capabilities of the assessment.

1. Time

60. The idea underlying rapid assessment is to provide information needed for conservation and sustainable use of biological resources. For this to happen, researchers try to amass as much relevant information as possible in a short period of time. Thus, time is a fundamental consideration for any *rapid* assessment of biodiversity.

61. Scientifically, long-term monitoring and research offer statistical advantages over rapid assessment. More detailed and thorough sampling is possible, which can measure change over time and produce more statistically rigorous results. However, the short time frame tacit in a rapid assessment is what makes this type of survey appealing; it allows for a snapshot or overview of biodiversity allowing fast judgment about the condition of an area. Thus, rapid assessment can provide biological information

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19/ NSW National Parks and Wildlife Service. 2002. NSW biodiversity surveys. http://www.npws.nsw.gov.au/wildlife/cbsm.html when informed decisions need to be taken urgently. Rapid assessment can also be a good way to establish baseline data that can then be used for further study and longer-term study if it is warranted. The amount of time available for the assessment is an important resource, and adequate planning should determine how it will be spent. It cannot be stressed enough that a rapid assessment can never replace long-term monitoring and research.

62. There is flexibility in the definition of rapid but the term imparts that time is of the essence. The time frames used here are broadly based on typical lengths of *rapid* biodiversity assessments and are separated as follows: *short* (1-7 days), *medium* (8-30 days), and *long* (30+ days). This refers to the amount of time to complete the entire project from start to finish, including transport, data collection, and preliminary analysis. Final analysis and results may take more time, but preliminary conclusions are important and need to be available quickly, else the purpose of a *rapid* assessment is lost.

2. Money

63. The amount of funding available for an assessment will, along with time, determine the capabilities and scope of a rapid biodiversity assessment. Because monetary amounts are relative, and broad categories cannot account for the fluid nature of currency values, a simple categorization is used. This is not based on values or actual monetary amounts, but rather on the relative amount of funding available to carry out the assessment. Therefore, available capital for a given assessment is either *limited*, meaning that it can be considered limiting, or less than desired to carry out the objectives of the project, or ***ample,*** meaning that there is enough money to carry out all elements of the assessment in a scientifically sound and usable way.

3. Expertise

64. In the same line, an expert is someone who can identify specimens of a taxonomic group to the species level, is familiar with current sampling and collection methods, can analyse data, and is familiar with the taxonomic group within a larger biological and ecological context. It does not refer to people with a general understanding or basic knowledge in the field. It is important to determine the availability of experts on a local, regional and international level. Local expertise is a great resource when it is available. Often local experts will have a good understanding of local geography, ecology, and community issues. However, if there is no local expert, an expert from outside the regional may need to be brought in. In highly specialized cases there may only be a small number, or even just one person who can be considered an expert in the area of study.

65. Institutional support refers to the use of technical facilities for analysis, storage of data, and other forms of support. Expertise should be considered with the availability of institutional support, as a limitation to the capacity and scope of any project. The decision tree delineates this category as “yes” or “no”, meaning that individuals who are experts in the field of study (including local experts) are or are not available for the assessment project.

B. *Scope*

66. The scope requires a consideration of the scale of various elements of an assessment. How much area does the assessment cover? How many species will be sampled? How much data will be collected? How many sites will be sampled? The purpose of this branch of the decision tree is to determine the scope of variable elements of an assessment.

67. In general the scope of a rapid biodiversity assessment is contingent upon purpose and resources of the assessment. Ample resources allow for proportional increases in the scope of various parts of an assessment. It is difficult to have an extensive geographic scope for a two-day assessment on a tight budget. In this respect some aspects of the scope are related to one another as well. For example, it *could* be possible to survey a broad geographic area in two days if the scope of the site selection and data

collection were both highly reduced. In general, if the resources for an assessment are ample, the scope becomes entirely dependent on the purpose and objectives of the project.

68. The scope of an assessment can vary internally in the following areas: ***taxa, geography, site selection, sampling and data analysis.*** Each of these should be considered separately. For example, a given assessment project may have a broad geographical scope, covering an expansive area, while the taxonomic scope could be quite focused, concentrating on a limited number of taxonomic groups.

1. Taxonomic scope

69. The taxonomic scope depends on how many and which taxonomic groups will be involved in the study. Some surveys may focus solely on aquatic invertebrates, while others may include several taxonomic groups. Typically the purpose of the assessment will determine which groups are pertinent to the study, as certain taxonomic groups will be more or less useful in certain assessment types. For example, benthic macro-invertebrates are often used in impact assessments of rivers and streams because they are sensitive to water conditions and are relatively easy to sample. Some types of aquatic mammals or bird species are also affected by changes in water conditions but they are more difficult to sample, and are not good indicators of these changes as the response is more subtle and takes place over a longer time frame. Therefore, they would probably not be as useful to a rapid assessment.

70. It is important to consider that in any given assessment, certain species or taxonomic groups will be more easily sampled than others. The cost (in terms of time and money) of including a taxonomic group that is particularly difficult to survey must be weighed against the benefits of including that group. In some cases it may be better to forego certain groups if time and money would be better spent somewhere else. Related to this is the relative size of the taxonomic group involved. In a given area, the taxonomic scope for a survey of Caddisflies (Trichoptera) may be greater than a survey focusing on aquatic mammals, birds and fish species.

2. Geographic scope

71. The geographic scope of an assessment depends on the taxonomic groups involved and/or the size of the area relevant to the project. The geographic scope can vary depending upon the range of a particular species, the extent of a particular ecosystem or habitat, or the area affected by an impact. This could range from small microhabitats such as a specific sediment type or it may extend across relatively large geographical areas, such as entire watersheds, lake systems, or basins. There are many types of inland water ecosystems and several types of habitats within each system, and the geographic scope can vary accordingly.

72. The geographic scope will also vary depending on how large an area must be studied in order to obtain statistically sound data. Therefore, it is important to determine the geographic scope in terms of the range or size of the surveyed area, and also the number of habitats to be studied. The ability to assess these different levels of geographic scope is dependent on the resources available to the project.

3. Site selection

73. Site selection refers to the number and type of sites needed for the assessment. The number of sites is dealt with in the section data and analysis. Like the geographic scope, the site selection is highly dependent on other aspects of the assessment. An inventory requires a relatively broad assessment of the biodiversity at several sites with variable habitats. A species-specific assessment would concentrate on habitats used by the target species, and may forego several sampling sites in order to provide greater depth of study in fewer sites. Site selection for an impact assessment would concentrate on sites associated with the impact in question. Resource-assessment sites focus on areas that could be used for exploitation. An indicator assessment would include as many sites as are needed to produce the necessary data.

74. In considering the type of sites to be selected, one possible question is whether sites should be chosen by virtue of being characteristic or distinct. Characteristic sites are representative of the typical habitat of a given area. However, in most areas, habitat is not continuous, and localized gradations in habitat create a mosaic of related but distinct communities that grade into one another. Selecting distinct sites allows for survey of these unique and specialized habitats. Choosing between distinct versus representative habitat often depends on the resources and purpose of the assessment. If time is short, it may be best to quickly survey representative areas in order to get a good general picture of the area before trying to assess more unique sites. If more time is available, and the purpose is to survey as many species as possible, or describe habitat types, then distinctive habitats may deserve more attention.

C. *Sampling and data analysis*

75. The type of sampling methods used is determined according to the objective of the assessment and should be more or less the same for all nations, including small island states. The sampling methods used will vary according to the need to be standardized, whether they can/cannot be technical, time limitations, and the type of equipment available**.** Most importantly, the methods should strive to provide insightful, statistically sound data that can be applied to the purpose of the assessment.

76. For most studies, a variety of water quality variables should be measured, including temperature, electrical conductivity (EC, a measure of the total dissolved salts), pH (an indicator of the water's acidity or alkalinity), chlorophyll A, total phosphorous, total nitrogen, dissolved oxygen, and water transparency (Secchi depth). These parameters can be measured with individual instruments or with one combination instrument that includes several types of probes. Macrophytes can be searched visually from above or under the water surface (scuba) or by means of special samplers. Fishes can be sampled using a variety of methods (see table 8), keeping in mind the applicable legislation. Asking local fishermen and examining their catches can be a helpful method, too. Aquatic invertebrates may be sampled from the water column (plankton), from emergent, floating leaved, and submerged vegetation (epiphytic fauna), from the bottom sediments (benthic invertebrates) by appropriate sampling technique. Reptiles and amphibians are generally sampled using nets, traps or by visual search during day and night.

77. Table 8 provides an overview of a number of relevant sampling methods for each taxonomic group. 20/

78. In the context of rapid assessment, data used should be of the appropriate type and quality for their intended use. If more resources are available in time, money and expertise, the possibilities of obtaining reliable data and sound statistical results are higher. In addition, it is important to gather preexisting information on the site, the species, the habitats to gain better insight on the types of data, sampling designs and analyses needed in the assessment. The following questions should be addressed in collecting data:

(a) What are the types of data? The variables of concern are determined by the purpose of the assessment. They can be qualitative such as lists, classes or categories used for example in inventories and ecological description or they can be quantitative, numerically based, such as counts and measurements

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20/ Some good references include: Merritt, R.W., K.W. Cummins, and V.H. Resh. 1996. Design of aquatic insect studies: collecting, sampling and rearing procedures, p. 12-28. *In*: R.W. Merritt and K.W. Cummins (eds.) An introduction to the aquatic insects of North America. 3rd ed. Kendall-Hunt, Dubuque, Iowa.; James, A. and L. Edison (eds). 1979. Biological Indicators of Water Quality. John Wiley Sons Ltd., New York; Platts, S.D., W.F. Megahan, and G.W. Marshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Dept. of Agriculture, Forest Service, General Technical Report INT-138, Intermountain Forest and Range Experiment Station, Ogden, Utah (USA); Nielsen, L.A. and D.L. Johnson (eds.). 1996. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland; and Sutherland, W.J. 2000. The conservation handbook. Research, ,anagement and policy. Blackwell Science Ltd., Oxford, 278 pp. Good websites to use as a reference include the United States Environmental Protection Agency (www.epa.gov/owow/monitoring), the World Conservation Monitoring Centre (www.unep-wcmc.org), the World Biodiversity Database provided by the Expert Center for Taxonomic Identification (ETI) (www.eti.uva.nl), and the Ecological Monitoring and Assessment Network (Canada; http://www.eman-rese.ca/eman/intro.html).

used for example in population densities, abundances, etc. The variables needed to be collected to calculate specific metrics are well documented; 21/

(b) How to collect data? There are two types of sampling designs: probability sampling based on randomness and targeted design that focuses on site-specific problems. Probability sampling design allows making inference about an entire region based on estimates on the sample sites. Simple random sampling defines the population and then randomly selects from the entire population. When there is variability associated with groups or habitats, stratified random sampling can lower the error associated with population estimates. Cluster sampling is designed for very large populations, first grouping sampling units into clusters which are often based on geographic proximity, then clusters are randomly selected and data are only collected from sampling units within these clusters. The use of Geographical Information System (GIS) reduces the effort and time in randomly selecting the assessment sites. Finally, sampling should follow protocols such as those for sampling fish, macroinvertebrates and periphyton. **Ecological Monitoring and Assessment Network hosted by** Environment Canada provides detailed information on monitoring protocols for various taxa; 22/

(c) How much data to collect? The sample size depends on factors such as the resources available, the geographic and temporal scope of the assessment, and the confidence levels. The number and type of sites should provide an adequate sampling for quantitative or qualitative analysis. In general, the greater the number of sites sampled, the greater coverage of the area. Fewer sites allows for more indepth survey at each site. For some assessments, an increased number of sampling sites may be beneficial, where as others may warrant more time spent at each site for more intense sampling. The choice is not either or, and consideration should be given to reach the best compromise between coverage and intensity. Replicates are needed to account for variance associated with measurement error in an assessment;

(d) How to enter data? Using bioinformatics (software, database applications, etc.) to manage data is very reliable and useful. The application can be developed to serve the specific needs of the assessment. Field data sheets or forms can be printed out and filled on site. Biodiversity informatics allows for more efficient analysis, dissemination and integration of the results with other databases. Examples of field data sheets are provided by the EPA program on Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers; 23/

(e) How to analyse data? Depending on the data collected and the purpose of the assessment, methods used for analyses could be simple descriptive, univariate, EDA (exploratory data analysis), or multivariate (clustering, similarity analysis, ordination, MANOVA). Two approaches have been used: multimetrics used by most water resource agencies in the United States or multivariate used by several water resource agencies in Europe and Australia; 24/

(f)How to integrate and report? It is important to integrate data from one assemblage to those of other assemblages to complement the assessment at a larger spatial and temporal scale and to provide more complete assessment of biological diversity. Assessment reports should contain the scientific information, results and recommendations for further action to guide authorities, scientists, but also to reach a broader, non-scientific audience by adding graphical displays, and presentation on multimedia tools. Finally, depending on the ownership of the information, the database collection and the results can

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21/ Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C. <http://www.epa.gov/OWOW/monitoring/techmon.html>

22/ http://eqb-dqe.cciw.ca/eman/ecotools/protocols/freshwater

23/ http://www.epa.gov/OWOW/monitoring/techmon.html

24/ Fruther details on measurements of ecological diversity can be found in Magurran, A.E. 1988. Ecological diversity and its measurement. Princeton University Press, New Jersey, USA.

be disseminated through the internet and relevant networks of biological information to serve the needs of diverse user groups.

Appendix 1

Case-studies

Case study Ia: Full inventory

AquaRAP's full inventory assessment of the Pantanal, Brazil (conducted by the Aquatic Rapid Assessment Program, Conservation International)

Background: The Pantanal is the world's largest wetland. Its survival is threatened by large-scale agriculture, ranching, logging, and especially the Hidrovia Paraguai-Parana project which plans to dredge, straighten bends, dig new channels, and destroy rock outcroppings. In order to develop a conservation strategy for the Pantanal, data on the biology, ecology, and physical and chemical characteristics of the region are urgently needed. See Chernoff et al. (2001).

Purpose: to assess the full biodiversity of the Pantanal, the world's largest wetland

Assessment Type: Full Inventory

Resources:
Time: Medium length (three weeks)
Money: Ample: $100,000 USD
Expertise: Yes, experts for each taxa are available, with a total of 30 scientists. (World experts were flown in and regional experts were on hand.)

Scope:
Taxa:
Flora
data: species lists, health, unique areas
methods: 26 sites sampled by visual searches
analysis: growth patterns, relative abundance
Benthic invertebrates
data: species lists according to sampling stations and area, sediment samples
methods: 15 sites sampled with a Peterson grab
analysis: relative abundance, richness, density, comparisons of sampling sites, occurrence of special species, sediment analysis
Macroinvertebrates (crustaceans)
data: species list, new occurences, endemics, relationships with other species, distribution
methods: seine nets, hand nets, and traps
analysis: distribution according to habitat/microhabitat/region, areas of endemism
Fish
data: species list, new species, endemicity, distribution, habitat characteristics, unique areas
methods: mainly seine nets
analysis: richness, relative abundance, new species, endemicity, regional distribution, distribution patterns, correlations between habitat, characteristics and abundance, ecological and
geographical structure in assemblages
Herpetofauna
data: species list, habitat descriptions

methods: visual searches and vocalizations
analysis: species according to habitat
Geographical: headwaters and floodplain of the southern Pantanal
Site selection: Fish populations were determined per mile. Site selection was determined by these criteria so that a count was done every mile of water.

Case study Ib: Abiotic ecosystem classification

Aquatic ecosystem classification of the Pantanal, Brazil conducted by the Freshwater Initiative, The Nature Conservancy and Universidade Federal de Mato Grasso

Background: The Upper Paraguay River basin covers portions of Brazil, Bolivia, and Paraguay, and represents one of the most aquatically diverse yet threatened watersheds in the world. 25/ To address the need for integrated freshwater conservation in the basin, The Nature Conservancy and the Universidade Federal de Mato Grasso, Brasil, sponsored workshops in August and November 1999 to identify critical places to conserve the representative freshwater biodiversity.

Purpose: to map and prioritize places within the Upper Paraguay River basin critical to represent the freshwater biodiversity.

Assessment Type: Inventory

Resources:
Time: Long (4-6 months)
Money: ample, $50,000 USD
Expertise: yes, twenty-five researchers from Brasil, Bolivia and Paraguay participated.
Data: GIS data: streams, lakes, geology, physiography, vegetation, climate.

Scope:
Habitat units: two levels of abiotic units identified – 21 Ecological Drainage Units, 102 Aquatic Ecological Systems described in terms of timing and duration of flood pulse, position in the drainage network, biological conditions, channel type, background chemistry.
Geographical: Upper Paraguay River Basin
Data: GIS data for streams, lakes, geology, physiography, vegetation, climate; expert opinion
Methods: experts delineated abiotic units on paper maps, descriptions recorded on computers

25/ Chernoff, B., P.W. Willink, and J. R. Montambault (eds.). 2001. A Biological Assessment of Aquatic Ecosystems of the Rio Paraguay Basin, Alto Paraguay, Paraguay. RAP Bulletin of Biological Assessment 19, Conservation International, Washington, DC.

Case study Ic: Ecosystem-scale landscape and habitat assessment

Use of landscape level river signatures in conservation planning: the Greater Addo Elephant National Park, South Africa 26/

Background: A strategy for assigning priorities in biodiversity conservation was developed for the rivers of the proposed Greater Addo Elephant National Park in South Africa. Due to the limited availability of biological information on the freshwater ecosystems in this area, a desktop approach, supplemented by aerial and land surveys, was used to devise a new river classification typology. This typology incorporated landscape attributes as surrogates for biodiversity patterns, resulting in defined physical "signatures" for each river type. Riverine biological diversity is considered to be conserved by including rivers of each type as defined by the respective signatures. Where options existed, and two or more rivers shared the same signature, a simple procedure was used to assign priorities to similar rivers for conservation. This procedure considered the extent of transformation, degree of inclusion within the park, irreplaceability or uniqueness, and geomorphological diversity of each river. The outcome of the study was that 18 of the 31 rivers within the proposed Greater Addo Elephant National Park must be conserved to achieve representation of all the biodiversity patterns identified. It concluded that, given further development and testing, the river signature concept holds promise for elevating the river focus in general conservation planning exercises.

Purpose: To evaluate and consolidate current biodiversity information on the freshwater ecosystems, to contribute to the drafting of an overall conservation plan for the proposed Greater Addo Elephant National Park.

Assessment type: Use of landscape and ecosystem parameters as surrogates for overall biodiversity patterns.

Resources:
Time: one-day aerial survey, three-day land survey, and desktop study.
Money: ample
Expertise: GIS, landscape ecologist

Scope:
Taxa: none
Geographical: approximately 1000 000ha, primarily in the thicket biome, traversing an area from the fold mountains to the coast and including a number of catchment areas.
Site selection: within the Greater Addo Elephant National Park planning domain.
Data: primarily GIS, including land use, land cover, areas invaded by alien plants, elevation, geological formations, rainfall classes, and rivers and streams.
Methods: a multilevel hierarchical approach was followed for the delineation of habitat pattern, providing an increasing resolution to locate types of similar riverine ecosystems.

26/ Roux, D, F. de Moor, J. Cambray and Helen Barber-James. 2002. Use of landscape level river signatures in conservation planning: a South African case study. Conservation Ecology 6(2): 6. http://www.consecol.org/vol6/iss2/art6

Case study II: Species-specific inventory

A study of Morelet's Crocodile (Crocodylus moreletii)

Background: Morelet's crocodile (*Crocodylus moreletii*) is an important component of the herpetofauna of the Laguna del Tigre National Park of Peten, Guatamala. *C. moreleteii* is an endemic species of the Yucatan Peneinsula and is listed as Lower Risk/Conservation dependent in the 2002 IUCN Red List of Threatened Species and in Appendix I of CITES. 27/ Previous population studies of *C. moreletii* in Guatemala have shown that the persistence of the species in the area is threatened by illegal hunting and by increased destruction of habitat due to human encroachment. 28/
Purpose: To acquire detailed information about the Morelet's crocodile (*Crocodylus moreletii)*

Assessment Type: Species-specific
Resources:
Time: Medium length (3 weeks)
Money: Ample: $10,000
Expertise: Yes, 3 herpetologists.

Scope:
Taxa: *Crocodylus moreletii*
Geographic: all wetlands and rivers within the Laguna del Tigre National Park (289,000 hectares)
Site selection: a variety of habitats including running water, tributaries, canos (narrow lotic environments with turbid, almost stagnant water), oxbow lagoons formed by river bends, lagoons not associated with rivers, riparian forest, guamil (secondary growth), sibal (stands of sawgrass), emergent vegetation
Data: count of individuals, area sampled, age, habitat
Methods: spotlighting along shorelines from boat
Analysis: average density, habitat densities, site densities, age ratios according to site, percent occurances according to habitat

27/ IUCN. 2002. 2002 IUCN Red List of Threatened Species. IUCN, Gland, Switzerland. http://www.redlist.org

28/ Bestelmeyer, B. and L. E. Alonso (eds.). 2000. A Biological Assessment of Laguna del Tigre National Park, Peten, Guatemala. RAP Bulletin of Biological Assessment 16, Conservation International, Washington, DC.

Case-study III: Change assessment

Effects of mine tailings on trout and macroinvertebrate populations on the Eagle River near Mintur, Colorado

Background: The Gilman Mine near Minturn, Colorado was in operation from 1870, until it was closed in 1984. An estimated 8 million tons of mine tailings were located at the mine site, and heavy metals from the tailing had been draining into the Eagle River near its headwaters. In 1988 the EPA made the mine an official superfund site. Several environmental impact statements were done to determine the effects of the mine tailings on macroinvertebrate and trout populations below the mine.

Purpose: Determine the impact of mine tailings and seepage of heavy metals on macro-invertebrate and trout populations in the Eagle River below the Gilman Mine.

Assessment Type: Impact assessment (retroactive)

Resources:
Time: Medium length (of the several assessments done, most took one to two weeks)
Money: Ample: EPA *Superfund Site*
Expertise: Yes, experts on freshwater ecology and fisheries.

Scope:
Taxa: Relatively small in scope. Focus was on trout populations and aquatic macroinvertebrate fauna. Particular concern was given to caddis flies, stoneflies, and mayflies.
Geographical: Studies were focused on the Eagle River from the mine site to below the confluence of Gore Creek, a distance of about 20 miles.
Site selection: Fish populations were determined per mile. Site selection was determined by these criteria so that a count was done every mile of water.
Data: Numbers of brown and rainbow trout per mile. Insect counts at sites. General data concerning stream health using physical and chemical parameters. Baseline monitoring data.
Analysis: Comparison of trout populations down stream of mine site with areas further downstream after the confluence with Gore Creek. Long term analysis of recovery using initial baseline data.
Methods: Trout were counted per mile using electro-shocking techniques. Macro-invertebrates were collected using kick-nets.

Case study IV: Indicators assessment

Case-study- using benthic invertebrates as indicators

Purpose: to assess the health of the Salmonberry River

Assessment type: indicator assessment

Resources:
Time: 2 days
Money: $2,000
Expertise: 2 non-scientists experienced in sampling methods

Scope:
Taxa: benthic macroinvertebrates
Geographic: entire Salmonberry watershed
Site selection: 18 sites that represent different stream sizes and habitats
Data: numbers of individual species and species list (Collections of each species were taken and sent to the Bureau of Land Management's Aquatic Ecosystem Lab for identification.)
Methods: riffles were sampled using a D-frame kicknet.
Analysis: The B-IBI, a technique that uses metrics- characteristics of the invertebrate community that are noticeably affected by disturbance, was used to analyse the data. Metric scores are then added to compute a multimetric index, the B-IBI. The scores for the 18 sites on the Salmonberry ranged from 26 to 46, using a ten-metric index with possible scores ranging from 10 to 50. The Oregon Department of Environmental Quality ranks B-IBI scores from 36 to 50 as good sites with minimal disturbance, 25 to 35 as moderately disturbed sites in fair condition, and 10 to 24 as highly disturbed sites in poor condition.
Below are the metrics used for the study and their scorings:

Metrics	Scoring System		
	1 (poor)	3 (fair)	5 (good)
1. Total number of taxa in sample	0-24	25-35	36+
2. Number of mayfly taxa in sample	0-5	6-9	10+
3. Number of stonefly taxa in sample	0-3	4-8	9+
4. Number of caddisfly taxa in sample	0-3	4-8	9+
5. Number of taxa in sample which are intolerant of high organic loads and oxygen depletion	1	2-5	6+
6. Number of taxa in sample which are intolerant of sediment	0	1	2+
7. Percentage of taxa in sample which are tolerant of high organic loads and oxygen depletion	30-100	20-30	Less than 20
8. Percentage of taxa in sample which are tolerant of sediment	15-100	5-15	Less than 5
9. Percentage of individuals in sample which	60-100	40-60	Less than

are members of the three most abundant taxa		40
10. *Pteronarcys* stonefly	absent	present

Case study Va: Resource assessment

Stock Assessment of Fisheries in the Okavango Delta, Botswana

Background: Until the 1980s, the fishery of the Okavango Panhandle, Botswana, was exploited only by anglers based at several fishing camps in the area and by traditional subsistence fishermen. The development since the 1980s of a commercial gillnet fishery in the Panhandle has led to numerous complaints from angling tourism operators. They claim that the commercial fishermen are wiping out the stocks of large cichlid species (locally known as bream), which, together with tigerfish, are the main target of tourist anglers.

Purpose: To document the fish biodiversity and abundance in the system, and to addressing the perceived conflicts between users of the fish resources.
Assessment Type: Economic resources assessment

Resources:
Time: Medium, 3 weeks of field work, plus one month to analyse data
Money: Ample: $20,000
Expertise: Yes, four scientists from South African institutions specializing in fishes, four members of the Botswana Fisheries Unit staff, and a stock assessment adviser from Norway

Scope:
Taxa: Narrow in scope. Focus was on economically valuable fish species, particularly a few species of cichlids and one species of tigerfish
Geographic: The scope was locally concerned with the Panhandle region of the Okavango River in the Okavango Delta, Botswana.
Site selection: Two main areas were studied, the Upper Panhandle and the Guma Lagoon area, where conflicts between commercial fishermen and sportfishing anglers is greatest, 10+ sampling sites per area
Data: Taxonomic identification and counts of all collected specimens to the species level. Size and relative age of fishes collected, reproductive state, genetic samples taken for analysis, habitats where fishes found, spawning grounds, data on the number and sizes of fishes caught by local fishermen and sportfishermen
Analysis: Age and size distribution data on each fish species was analyzed to determine if populations were healthy and sustainable, Data were analyzed in relation to the economic conflicts of the area, held meetings with commercial fishermen and sportfishing anglers to discuss the results.
Methods: Sampling methods used were: gillnets (two graded fleets of the following mesh sizes in mm: [net 1; 21, 27, 36, 56, 73, 96, 118, 130]; [net 2; 50, 75, 100, 115, 125]); 30 m and 3 m long seine nets (with anchovy mesh bunts); a cast net (3 m diameter); a D-frame dipnet; angling; electric fishing; and examining local fishermen's catches and buying relevant specimens from them.

Case study Vb. Participatory resource assessment

Assessment of availability and use of aquatic biodiversity in a rice-based ecosystem in Kampong Thom Province, Cambodia 29/, 30/

Background: The importance of aquatic organisms from rice-based farming for the food security of rural households is generally poorly documented because of the complexity of seasonally and spatially variable resources, environments and stakeholder activities. Yet it is crucial that such documentation reaches policy makers to enable them to make informed resource allocation decisions and formulate more pro-poor policies. In Kampong Thom Province, Cambodia, an attempt has been made at documenting the living aquatic resources availability and use patterns by rice farmers. Aquatic species were collected from farmers in the fields using own their tools and techniques. Participatory approaches facilitated learning about the traditional knowledge of the local people including many ethnic minorities. Remarkable insights were gained: These rice ecosystems support a rich aquatic biodiversity, which not only is important as a source of daily food and income for rural households, but also as a habitat for rare species. The most important group in terms of species diversity and importance for the local people are the fishes. A total of 70 different fish species occur in the rice fields, most of which are consumed fresh or fermented into fish paste. Fewer species are fermented either as fillet or in smaller pieces, dried, salted, smoked, or used for preparing fish sauce. Fish, fresh or processed, is the primary source of protein for local people and usually part of every meal. In Kampong Thom an average family of five persons would probably consume about one kilogram of fresh fish every day during the fishing season. The same family would need about 20 kg of fermented fish paste for the dry season. Everything caught above this would be sold in the market. Depending on the fishing tool employed, a farmer can catch 15 to 20 kg of fish on a good day, although the average fish catch during the fishing season is below 10 kg per day. Adding to the value for human consumption is the use of aquatic organisms as animal feeds, bait, or for their medicinal value. Unfortunately, the availability of these aquatic resources is declining. Human population increase is part of the problem, but on the management side it is particularly the destruction of fish breeding grounds and illegal fishing tools.

Purpose: To document and raise awareness about the value of aquatic organisms in rice-based farming in order to ensure that the threats affecting this aquatic biodiversity get highest priority on the agenda of policy makers.

Assessment type: Participatory resource assessment

Resources:
Time: 12 weeks data collection
Money: $10,000, staff time DED and FAO, free verification of species by experts
Expertise: indigenous communities provide local names, identification of species by local research team, verification of species identification by recognized world experts.

29/ T. Balzer, P. Balzer and S. Pon 2002. Traditional use and availability of aquatic biodiversity in rice-based ecosystems - I. Kampong Thom Province, Kingdom of Cambodia. Series editors: M. Halwart and D. Bartley, FAO Inland Water Resources and Aquaculture Service. Guest editor: H. Guttman, Mekong River Commission. CD ROM, ISBN 92-5-104820-7. FAO, Rome.

30/ FAO 2002. Biodiversity and the Ecosystem Approach in Agriculture, Forestry and Fisheries. FAO, Rome. Case study on traditional use and availability of aquatic biodiversity in rice-based ecosystems I. Kampong thom Province, Kingdom of Cambodia. FAO Interdepartmental Working Group on Biodiversity, FAO, Rome.

Scope:
Taxa:
- fishes
- reptiles
- amphibians
- crustaceans
- molluscs
- insects
- aquatic plants

Methods: To collect information from the local people, several different methods were used sequentially. The study was initiated by conducting Participatory Rural Appraisals (PRAs) in three villages. The second step was collection of information on the organisms caught by the local people. At the end of the study, single and group interviews were used to verify the information previously collected.

- *PRAs* were conducted in 3 villages. People were asked, during a village meeting, to enumerate the aquatic animals they collect from their rice fields, their uses etc. At the same time the PRA served as an introduction to the people to ensure that they understood the purpose of the following regular visits in their village.
- *Species collection*

  From the end of September 2001 to the beginning of December 20019, the researchers went to the field almost every day. The collection points were the sites where people went to fish in or near the ricefield ecosystems. A typical situation in Kampong Thom is that the road is built on a dam. Soil for it has been excavated on both sides, forming canals left and right of the road. During the rainy season these canals are filled with water and directly connected to the surrounding rice fields. People gather to catch fish near bridges and culverts, which are like a bottleneck for water and fish. At points like this, as well as within the rice fields, specimens were collected and pictures taken of the various species caught. Samples of every organism smaller than 15 cm were collected and preserved for later identification. The pictures were developed locally, then scanned and computer processed. Taxa were identified as far as possible, using available field guides.

  While collecting the specimens, the fisher-folks were asked to give information on:
  - the availability of the species
  - their uses in rural community,
  - the preferences of the people for them; and
  - the various fishing tools used to harvest them.
- *Interviews*

  At the end of the fishing season, the information collected previously was consolidated and verified in single and group interviews conducted in the villages where the collections were made. Information on preferences was obtained during samplings, PRAs, and group interviews and ranked on a scale from 1 = not liked, 2 = liked, to 3 = highly esteemed. Availability was ranked on a scale from 0 = absent, 1 = rare, 2 = little, 3 = medium, to 4 = abundant, all information obtained in group interviews. Since the people were by then already familiar with the researchers, no initial shyness had to be overcome. People were talking freely about the aquatic animals they used to collect and also about the difficulties and problems they encounter.

Geography: rice fields in the floodplain of the Tonle Sap
Site selection: the collection points were the sites where people went to fish in or near the ricefield ecosystems.

Appendix 2

Defining the scope

Table 3. *Inventory assessment (field studies)*

Time	**Short (1-7 days)**				**Medium (8-30 days)**				**Long (30+ days)**			
Money	**Limited**		**Ample**		**Limited**		**Ample**		**Limited**		**Ample**	
Expertise	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Taxa	Easily identified and sampled species (birds, mammals, selected fish, macroinvertebrates, selected herpetofauna)	Selected groups that can be easily identified with field guides	Expand taxa because more people can sample; easily identified	Several groups that can be easily identified with field guides	Selected taxa with more information, or several taxa with less information	Several groups that can be easily identified with field guides	All taxon (designate a scientist per taxon)	Several groups that can be easily identified with field guides	Several groups that can be easily identified with field guides	Groups that can be easily identified with field guides	All taxon	Groups that can be easily identified with field guides
Geographical	Few accessible target sites	Lists, counts	Few accessible or less accessible sites (fly/ helicopter in)	Few accessible or less accessible sites (fly in)	Several accessible and a few less accessible sites	Several accessible and a few less accessible sites	Most different habitat types	Several accessible and less accessible sites	Several accessible and less accessible sites	Several accessible and less accessible sites	All important sites	All important sites
Data	Incomplete species list, estimate of relative, general habitat characteristics, special species, invasives, water parameters (physical, chemical)	Non-technical, and require no experience, short, inexpensive	Species list, est. of abundance, general habitat characteristics, special species, invasives, water parameters – physical, chemical and crude species abundance, distribution and health	Partial species list, general habitat characteristics, water parameters (physical, chemical), some distribution data	Species list, est. of abundance, general habitat characteristics, special species, invasives, water parameters (physical, chemical), health, limited behavior and small range distribution	Partial species list, general habitat characteristics, invasives, water parameters (physical, chemical), some small range distribution of limited taxa, limited behavior	Species list, abundance habitat characteristics, invasives, special species, water parameters, health, distribution, some behavior	Partial species list, general habitat characteristics, invasives, water parameters, some small range distribution of limited taxa, some behavior	Species list, abundance habitat characteristics, invasives, special species, water parameters, health, distribution, behavior and interactions	Partial species list, general habitat characteristics, invasives, water parameters, some small range distribution of limited taxa, behavior	Species list, abundance habitat characteristics, invasives, special species, water parameters, health, distribution, behavior and interactions	Partial species list, general habitat characteristics, invasives, water parameters, some small range distribution of limited taxa, behavior
Site Selection	A few areas with varied microhabitats	A few areas with varied microhabitats	Several different habitats types	Several different habitats types	Several different habitats types	Several different habitats types	Most important sites, accessible or inaccessible	Most different habitat types	Most different habitat types	Most different habitat types	Most different habitat types	Most different habitat types

Time	Short (1-7 days)				Medium (8-30 days)				Long (30+ days)			
Money	**Limited**		**Ample**		**Limited**		**Ample**		**Limited**		**Ample**	
Expertise	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Methods*	Require short time, but produce biggest and most varied yield of organisms, cheap, ID in field- minimal collecting	Incomplete species list, general habitat characteristics, water parameters – physical, chemical	Short, more equipment, possibly technical, hire people to identify and collect	Require no experience, short	Several methods, some general, some species specific, inexpensive	Several methods, some general, some species specific, non-technical	Lists, abundance, distribution patterns, behaviors	Several methods, some general, some species specific, non-technical	Various methods, inexpensive, can be time intensive and technical	Various methods, inexpensive, can be time intensive	All necessary and suitable methods	Various methods, inexpensive, can be time intensive
Analysis	Lists, counts, simple biotic indices, indicator species	Lists, counts	Include more taxa on lists, counts, simple biotic indices	Lists, counts, water analysis	More thorough anlaysis of abundance; limited distribution	Lists, counts, water analysis, scant distribution analysis	All necessary and suitable methods	Lists, counts, water analysis, partial distribution patterns	Lists, counts, water analysis, partial distribution patterns	Lists, abundance, distribution patterns	Lists, abundance, distribution patterns, behaviors	Lists, abundance, distribution patterns
Programs	Nottawasaga Valley Conservation Authority 31/	USDA Visual Stream Protocol					Conservation International-RAP					

Evaluate and choose specific methods from Table 8 (Appendix 3) depending on time and money, and habitat types sampled.

31/ Jones, C. 2000. Great Lakes 2000 Clean Up. Nottawasaga Valley Conservation Authority. www.nvca.on.ca

Table 4. *Species-specific assessment*

Time	**Short (1-7 days)**				**Medium (8-30 days)**				**Long (30+ days)**			
Money	**Limited**		**Ample**		**Limited**		**Ample**		**Limited**		**Ample**	
Expertise	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Target species	Target species	Target species	Target species	Target species	Target species	Target species	Target species	Target species	Target species	Target species	Target species	Target species
Geographical	Limited, expected sites for species	Limited	Limited in number, but not in accessibility (fly to inaccessible sites)	Limited in number, but not in accessibility (fly to inaccessible sites)	Several accessible, a few less accessible sites (fly to inaccessible sites)	Several accessible, a few less accessible sites (fly to inaccessible sites)	Many accessible and inaccessible sites (fly to inaccessible sites)	Many accessible and inaccessible sites (fly to inaccessible sites)	Many accessible sites and several less accessible sites (fly to inaccessible sites)	Many accessible sites and several less accessible sites (fly to inaccessible sites)	Many accessible sites and several inaccessible sites (fly to inaccessible sites)	Many accessible sites and several inaccessible sites (fly to inaccessible sites)
Data	Presence/ absence, limited dist., health, habitat status snapshoot	Presence/ absence, physical char., habitat description, very limited distribution	Presence/ absence, distribution, health, habitat status, relative abundance, population information		All previous plus+ some behavior	Presence/ absence, limited distribution, physical char., habitat features, relationships among species	All previous including some behavior, status of food source and competition (esp. invasives), relationships among species, DNA extractions	Presence/ absence, limited distribution, physical char., habitat features	All previous plus some seasonal behavior	Presence/ absence, limited distribution, physical char., habitat features, some basic behavior	All previous	Presence/ absence, limited distribution, physical char., habitat features, some basic behavior
Site Selection	Where species is expected, accessible	Where species is expected, accessible	Where species is expected (or not expected), accessible and inaccessible	Where species is expected, accessible and inaccessible	Where species is expected or not expected, accessible and a few less accessible	Where species is expected, accessible and some less accessible	Where species is expected or not expected, accessible and inaccessible	Where species is expected, accessible and inaccessible	Where species is expected or not expected, accessible and less accessible	Where species is expected, accessible and less accessible	Where species is expected or not expected, accessible and inaccessible	Where species is expected, accessible and inaccessible

Time	Short (1-7 days)				Medium (8-30 days)				Long (30+ days)			
Money	Limited		Ample		Limited		Ample		Limited		Ample	
Expertise	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Methods*	Species specific, fast, inexpensive	Species specific, non-technical, fast, inexpensive,	species specific plus other useful, but more general methods, can include technical and more expensive methods	A variety of methods, non-technical	A variety of methods, inexpensive	A variety of methods, non-technical, can include more time intensive methods	Can include technical, more expensive, and some more time intensive methods	A variety of methods, non-technical, can include more time and labor intensive methods	Can include technical, time intensive methods, some in depth surveys and short-term behavior monitoring	A variety of methods, non-technical, can include more time and labor intensive methods	Can include technical, expensive, and time intensive methods, some in depth surveys and short-term behavior monitoring	A variety of methods, non-technical, but possibly costly can include more time and labor intensive methods
Analysis	Status report, limited distribution, population info	Status, very limited distribution, limited population info	Status, distribution, relative abundance, population info and structure	Status, distribution, limited population info	Status, distribution, relative abundance, population info and structure, some behavior	Status, distribution, limited population info	Status, distribution, relative abundance, population info and structure, some behavior, status of food sources and competition esp invasives, genetic info	Status, distribution, limited population info	Status, distribution, relative abundance, population info and structure, some behavior, status of food sources and competition esp invasives	Status, distribution, limited population info, limited behavioral analysis	Status, distribution, relative abundance, population info and structure, some behavior, status of food sources and competition esp invasives, genetic info	Status, distribution, limited population info, limited behavioral analysis

* Evaluate and choose specific methods from table 8 (appendix 3) depending on time and money, and habitat types sampled.

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Table 5. *Change assessment*

Time	All
Money	All
Expertise	All
Taxa	Full inventory, species specific, or biodiversity indicators
Geographical	Sites in impact zone
Data	For full inventory data, see Table 1
	For species specific data, see Table 2
	For data using biodiversity as an indicator of condition, see Table 4
Site Selection	Selected sites of highest concern
Methods*	For full inventory methods, see Table 1
	For species specific methods, see Table 2
	For methods using biodiversity as an indicator of health, see Table 4
Analysis	For full inventory analysis, refer to the Full Inventory table.
	For species specific analysis, refer to the Species Specific table.
	For analysis using biodiversity as an indicator of health, refer to the Biodiversity as an Indicator table.
Programmes	Canadian Environmental Effects Monitoring Program (EEM) http://www.ec.gc.ca/eem

* Evaluate and choose specific methods from table 8 (appendix 3) depending on time and money, and habitat types sampled.

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Table 6.

Time	Short (1-7 days)				Medium (8-30 days)				Long (30+ days)			
Money	**Limited**		**Ample**		**Limited**		**Ample**		**Limited**		**Ample**	
Expertise	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No***
Taxa	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis	Selected groups needed for selected Index or analysis
Geographical	Few key sites where impacts would be expected, as well as at least one control site	Few key sites where impacts would be expected, as well as at least one control site	Sites where impacts would be expected, as well as control sites	Sites where impacts would be expected, as well as control sites	Few key sites where impacts would be expected, as well as at least one control site	Few key sites where impacts would be expected, as well as at least one control sites	Sites where impacts would be expected, as well as control sites	Sites where impacts would be expected, as well as control site	Few key sites where impacts would be expected, as well as at least one control site	Few key sites where impacts would be expected, as well as at least one control site	Sites where impacts would be expected, as well as control sites	Sites where impacts would be expected, as well as control sites
Data	Data required for the Index or Analysis, water quality data, species richness, trophic data, abundance data	Basic data needed for water quality analysis, limited species richness data	Data required for the Index or Analysis, water quality data, species richness, trophic data, abundance data	Data required for the Index or Analysis, water quality data, species richness, trophic data, abundance data	Data required for the Index or Analysis, water quality data, species richness, trophic data, abundance data	Basic data needed for water quality analysis, limited species richness data	Data required for the Index or Analysis, water quality data, species richness, trophic data, abundance data	Data required for the Index or Analysis, water quality data, species richness, trophic data, abundance data	Data required for the Index or Analysis, water quality data, species richness, trophic data, abundance data	Basic data needed for water quality analysis, limited species richness data	Data required for the Index or Analysis, water quality data, species richness, trophic data, abundance data	Data required for the Index or Analysis, water quality data, species richness, trophic data, abundance data
Site Selection	Few key sites where impacts would be expected, as well as at least one control site	Few key sites where impacts would be expected, as well as at least one control site	Sites where impacts would be expected, as well as control sites	Sites where impacts would be expected, as well as control sites	Few key sites where impacts would be expected, as well as at least one control site	Few key sites where impacts would be expected, as well as at least one control sites	Sites where impacts would be expected, as well as control sites	Sites where impacts would be expected, as well as control site	Few key sites where impacts would be expected, as well as at least one control site	Few key sites where impacts would be expected, as well as at least one control site	Sites where impacts would be expected, as well as control sites	Sites where impacts would be expected, as well as control sites
Methods*	Water quality samples, basic fish collecting, limited invertebrate collecting, identifications to species, inexpensive and fast	Basic water quality samples, basic fish collecting, limited invertebrate collecting, ID to order and family level, inexpensive and fast, non-	More complete water quality sampling and analysis, fish and invertebrate sampling, fast	Basic water quality samples, basic fish collecting, limited invertebrate collecting, ID to order and family level, fast	Water quality samples, basic fish collecting, limited invertebrate collecting, identifications to species, inexpensive and fast	Basic water quality samples, basic fish collecting, limited invertebrate collecting, ID to order and family level, inexpensive and fast, non-	More complete water quality sampling and analysis, fish and invertebrate sampling, fast	Basic water quality samples, basic fish collecting, limited invertebrate collecting, ID to order and family level, fast	Water quality samples, basic fish collecting, limited invertebrate collecting, identifications to species, inexpensive and fast	Basic water quality samples, basic fish collecting, limited invertebrate collecting, ID to order and family level, inexpensive and fast, non-	More complete water quality sampling and analysis, fish and invertebrate sampling, fast	Basic water quality samples, basic fish collecting, limited invertebrate collecting, ID to order and family level, fast

Time	Short (1-7 days)				Medium (8-30 days)				Long (30+ days)			
Money	**Limited**		**Ample**		**Limited**		**Ample**		**Limited**		**Ample**	
Expertise	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No***
		technical				technical				technical		
Analysis	BiomMAP, IBI, Visual Assessment analyses	Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses	BiomMAP, IBI, Visual Assessment analyses
Programs	USDA's Stream Visual Assessment Protocol	USDA's Stream Visual Assessment Protocol (identification of invertebrates may not be possible)	Index of Biotic Integrity (IBI)- Nottawasaga Valley Conservation Authority;				EPA, Ramsar?				EPA	
	BioMAP - Nottawasaga Valley Conservation Authority; Benthic Index of Biotic Integrity (B-IBI) - Xerces Society; Ecological Monitoring Assessment Network (EMAN). Cost depends on level of identification.		BioMAP- Nottawasaga Valley Conservation Authority; Benthic Index of Biotic Integrity (B-IBI) - Xerces Society; Ecological Monitoring Assessment Network (EMAN). Cost depends on level of identification.									

* Evaluate and choose specific methods from table 8 (appendix 3) depending on time and money, and habitat types sampled.

♠ Because of the numerous ways to use biodiversity as indicators to assess the condition of ecosystems, programs have been listed to use as examples of the varying taxa, geographical range, data, site selection, methods, and analysis.

Table 7. *Resource assessment*

Time	Short (1-7 days)				Medium (8-30 days)				Long (30+ days)			
Money	**Limited**		**Ample**		**Limited**		**Ample**		**Limited**		**Ample**	
Expertise	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Taxa	Economic species	Economic species	Economic species	Economic species	Economic species	Economic species	Economic species	Economic species	Economic species	Economic species	Economic species	Economic species
Geographical	Few accessible sites	Few accessible sites	Several accessible or less accessible sites	Several accessible or less accessible sites	Several accessible or less accessible sites	Several accessible or less accessible sites	Several accessible and less accessible sites	Several accessible and less accessible sites	Many accessible/ less accessible sites	Many accessible/ less accessible sites	All necessary sites	All necessary sites
Data	Number sampled of species; health; age; sex; other species; water quality; habitat char.; food source; predators	Number sampled; habitat characteristics	Number sampled of species; health; age; sex; other species; water quality; habitat char.; food source; predators	Number sampled; habitat characteristics	Number sampled of species; health; age; sex; other species; water quality; habitat char.; details of food source; details of predators; some behavior; DNA extractions	Number sampled; habitat characteristics (more samples)	Number sampled of species; health; age; sex; other species; water quality; habitat char.; details of food source; details of predators; some behavior; DNA extractions; distribution	Number sampled; habitat characteristics; distribution; (more samples)	Number sampled of species; health; age; sex; other species; water quality; habitat char.; details of food source; details of predators; some behavior; DNA extractions; distribution; some seasonal behavior	Number sampled; habitat characteristics; distribution; (more samples)	Number sampled of species; health; age; sex; other species; water quality; habitat char.; details of food source; details of predators; some behavior; DNA extractions; distribution; some seasonal behavior	Number sampled; habitat characteristics; distribution; (more samples)
Site Selection	Locations known to have species	Locations known to have species	Locations known to have species	Locations known to have species	Locations known to have species	Locations known to have species	Locations known to have species or new occurances	Locations known to have species	Locations known to have species	Locations known to have species	Locations known to have species	Locations known to have species
Methods*	Species specific; inexpensive; fast	Species specific; inexpensive; fast; non-technical	Species specific; fast; possibly more costly (electrofishing)	Species specific; inexpensive; fast; non-technical	Species specific; inexpensive; more intensive or extensive	Species specific; inexpensive; non-technical; more intensive or extensive; non-technical	Species specific; more intensive or extensive; possibly costly	Species specific; more intensive or extensive; possibly costly; non-technical	Species specific; even more intensive or extensive; longer term (false substrates)	Species specific; inexpensive; non-technical; even more intensive or extensive; non-technical	Species specific; even more intensive or extensive; longer term (false substrates)	Species specific; inexpensive; non-technical; even more intensive or extensive; non-technical

Time	**Short (1-7 days)**				**Medium (8-30 days)**				**Long (30+ days)**			
Money	**Limited**		**Ample**		**Limited**		**Ample**		**Limited**		**Ample**	
Expertise	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Analysis	Estimate abundance and richness; sizes; age; sex ratios; major competition; health; availability of food; habitat char., interactions; water quality; stock assessments	Abundance, sizes, habitat characteristics	Estimate abundance and richness; sizes; age; sex ratios; major competition; health; availability of food; habitat char., interactions; water quality; stock assessments	Abundance, sizes, habitat characteristics	Estimate abundance and richness; sizes; age; sex ratios; major competition; health; availability and condition of food source; habitat char., interactions; water quality; stock assessments; condition of predators; genetic info	Abundance, sizes, habitat characteristics	Estimate abundance and richness; sizes; age; sex ratios; major competition; health; availability and condition of food source; habitat char., interactions; water quality; stock assessments; condition of predators; distribution	Abundance, sizes, habitat characteristics; distribution	Estimate abundance and richness; sizes; age; sex ratios; major competition; health; availability and condition of food source; habitat char., interactions; water quality; stock assessments; condition of predators; distribution; seasonal behavioral patterns; Total or partial economic valuation	Abundance, sizes, habitat characteristics; distribution	Estimate abundance and richness; sizes; age; sex ratios; major competition; health; availability and condition of food source; habitat char., interactions; water quality; stock assessments; condition of predators; distribution; seasonal behavioral patterns; Total or partial economic valuation	Abundance, sizes, habitat characteristics; distribution
Programs									INRENA, Peru		INRENA, Peru	

* Evaluate and choose specific methods from table 8 (appendix 3) depending on time and money, and habitat types sampled.

Appendix 3

Sampling methods

Table 8. *Sampling methods*

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Sources of Equipment	References for details of methods
Water Quality	physical probes	pH, O2, electric conductivity temperature, BOD, and flow rate	short- 10 -30 minutes	$100-3000 depending on number of probes and quality	lakes, rivers, wetlands, all water bodies	none	no	pH probe, temperature probe, DO (dissolved oxygen) probe, conductivity meter, flow meter, BOD collection equipment, titration equipment	http://www.geocities.com/RainForest/Vines/4301/tests.html	
	Secchi Disc	water transparency	short, 5-10 minutes	$10	mostly standing water or slow flowing rivers	none	no	secchi disc		Wetzel & Likens (1991) 32/
	Water sample collection and Lab analysis	total phosphorus, total nitrogen, chlorophyll-a	10 minutes in field, 3 hours in laboratory per sample	high - larboratory equipment	all water bodies	training in using laboratory equipkment	water samples	spectrophotometer, filters, bottles, water samples		Wetzel & Likens 1991 Downing & Rigler 1984 33/
	visual assessment of water colour	water colour and type (black, white, clear, etc.), turbidity	fast- 1-5 minutes	0	all water bodies	none	no	water samplers for deeper water (can be used in conjunction with zooplankton sampling)		
	visual assessment of sediment	sediment colour and type (organic, sandy clayish, etc)	fast- 1-5 minutes	0	all water bodies	none	sediment sample	grab sampler (can be done in conjunction with benthic invertebrate sampling)		

32/ Wetzel R.G., Likens G.E. 1991. Limnological analyses. 2nd Ed. Springer-Verlag. New York. 391 pp.

33/ Downing J. A., Rigler F. H. (red.) 1984. A manual of methods for the assesment of secondary productivity in fresh waters. Blackwell Scientific Publications, Oxford.

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Sources of Equipment	References for details of methods
Fishes	seine net	mostly smaller fishes	1-4 hours	$10-$50/ net	shallow water without strong current, small rivers, possible in lakes with a boat	skill in seining	yes, net does not kill fishes	seine net	http://www.nationalfishingsupply.com/seinenets1.html	Bagenal 1978 34/
	gill net	all fish sizes and types	24 hours- leave out overnight	$150-200/net	shallow to medium depth waters, standing waters or slow flowing rivers	none	yes, net kills fishes	gill nets	http://www.nationalfishingsupply.com/seinenets1.html, 35/	Bagenal 1978
	fish traps (fykes)	all fish sizes and types, mostly bottom living fishes	24 hours- leave out overnight	$50-100/trap	mostly shallow waters	none	yes, trap does not kill fishes	fish traps		Bagenal 1978
	trawl	use only for deep water pelagic, schooling and bottom-dwelling fish, can be very destructive to the environment	1-2 hours	$1000 for nets, boat rental and field assistance	only for deeper, large waters without obstacles on the bottom or surface debris	skill in trauling	yes, nets kill fishes	trawl net, boat, at least 2-3 people to help	http://www.fao.org/fiservlet/org.fao.fi.common.FiRefServlet?ds=geartype&fid=103	Bagenal 1978
	dip nets	suitable for small fish near surface	1-5 hours	$5-$20/ net	limited area within rivers, lakes, wetlands	skill in using dip nets	yes	dip net	http://www.sterlingnets.com/dip_nets.html	Bagenal 1978
	hook and line	suitable for any fish type and any water	variable depending on repetition	variable depending on repetition	rivers, lakes, wetlands	skill in line fishing	yes	hook, line, bait		
	sonars	suitable for schooling, pelagic fish, not very precise data	depending on the size of the water body	$100 - 1000	deep lakes and large rivers	skill in operating the sonars	yes	sonar		

34/ Bagenal T. 1978. Methods for Assessment of Fish Production in Fresh Waters. 3rd Ed. Blackwell Scientific Publications. Oxford. 365.

35/ The so-called "biological survey gill nets" can be ordered from: Fårup SpecialnetKaustrupvej 3Velling6950 Ringkøbing Denmark or from: Lundgren Fiskefabrik A/BStorkyrkobrinken 12S-11128 Stockholm, Sweden Tel +45 97 32 32 31

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Sources of Equipment	References for details of methods
	electrofishing	optimal for sampling medium to big fish, better in colder water with some salinity	1-5 hours, variable depending on repetition and habitat type	$500-2000	mostly shallow waters	need training in electrofishing and license	yes, stuns fishes and does not kill them	electro-shocker set	http://www.fisheriesmanagement.co.uk/electrofishing.htm	Bagenal 1978
	dive/ snorkeling	suitable for surveying particular ecosystems that are difficult to locate or reach	usually about 1 hr., but variable depending on repetition	low (snorkeling) to high (scuba), cost of equipment	lakes, rivers	snorkeling no, diving needs certification	yes	snorkel/scuba gear, dip net		
	questionnaire	ask local fishermen about the fishes they have observed and use	2-4 hours	low	all water bodies	none	no	paper, pens, maybe refreshments for locals		
Reptiles and Amphibians	dip nets (amphibians)	suitable for catching tadpoles	variable depending on repetition	$5-$20/ net	rivers, lakes, wetlands	skill in using dip nets	yes	dip net	http://www.sterlingnets.com/dip_nets.html	
	visual search (ambphibians / reptiles)	good for locating relatively visible organisms	variable	$0	land and surface water	knowledge of microhabitats	no	none		
	vocalizations	listen for and sometimes record frog calls and identify species from call	variable, several hours depending on search and record time	low- tape recorder	any water bodies, riparian habitats, land	knowledge of frog calls and identify species from calls, habitats	no	tape recorder, cassettes, playback, flashlights		
	pitfall traps with drift fence (ambphibians / reptiles)	good for collecting animals that are difficult to sight; estimate relative abundance and richness	should be left out 24-48 hours	$0 if old buckets are used	land	skill in setting up pitfall traps with drift fensces	yes	buckets, hand shovel, metal for fence	http://www.agric.nsw.gov.au/reader/2730	

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Sources of Equipment	References for details of methods
	litter search (ambphibians / reptiles)	usually used for finding frogs in conjunction with quaudrants	variable depending on repetition	$0	land	minimal	yes	nothing		
	transects (amphibians/ reptiles)	used to control sample area to quantify and standardize data	dependant on length and number of transects	$0	land	knowledg of establishing transects	yes	marking tape	http://www.npws.nsw.gov.au/wildlife/cbsm.html	
	dive (reptiles)	used especially for looking for turtles	variable depending on repetition	cost of equipment	rivers, lakes	diving certification	yes	snorkel/scuba gear, dip net		
	nooses (reptiles)	suitable for lizards	depends on number of lizards sought	$0 - can be made of grass	land	skill in making noose and spotting lizards	yes	long, flexible, but strong weed/ rope	http://www.macnstuff.com/mcfl/1/lizard.html	
	turtle traps (reptiles)	used to trap turtles on land and water	at least 1 day	$65-$150/ trap	lakes, rivers, land, wetlands	knowledge of turtle traps	yes	turtle trap, bait		Limpus et al. (2002) 36/
	questionnaire	ask local fishermen about the fishes they have observed and use	2-4 hours	low	all water bodies	none	no	paper, pens, maybe refreshments for locals		
Epiphytic macroinvertebrates	various samplers, depending on type of vegetation	littoral (near shore) zone	1-4 hours	$100-$200/ sampler	rivers, lakes, ponds, reservoirs	skill in sampling	yes	tube or box samplers, sieves		Downing & Rigler (1984), Kornijów & Kairesalo (1994) 37/, Kornijów (1997) 38//

36/ Limpus CJ, Limpus DJ, Hamann M. 2002. Freshwater turtle population in the area to be flooded by the Walla Weir, Burnett River, Queensland: Baseline study. Memoirs of the Queensland Museum 48(1):155-168.

37/ Kornijów R., Kairesalo T. 1994. A Simple Apparatus for Sampling EpiphyticCommunities Associated with Emergent Macrophytes. Hydrobiologia 294: 141-143.

38/ Kornijów R. 1998. Quantitative sampler for collecting invertebrates associated with submersed and floating-leaved macrophytes. Aquatic Ecology, 32: 241-244.

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Sources of Equipment	References for details of methods
Benthic macroinvertebrates	visual search/ snorkel/ dive	good for locating big animals (e.g. crustaceans)	1 hour	cost of equipment	rivers, lakes	diving certification	yes	snorkel/scuba gear, dip net	http://www.nationalfishingsupply.com/seinenets1.html	
	grabs, tube samplers	all invertbrates inhabiting soft or sandy sediments	variable	$350-$1100	good for sampling soft and sandy sediments	skill in using aparatus	yes	samplers, sieve	http://www.elcee-inst.com.my/limnology.htm	Downing & Rigler (1984)
	kick net	all invertebrates inhabiting hard substrates	1-5 hours	$55	good for wadable streams with gravel or stoney bottom	skill with kick nets	yes	kick net	http://www.acornnaturalists.com/p14008.htm	Downing & Rigler (1984)
	dip net	suitable for sampling nectic (swimming) animals (e.g. beetles, water mites) in shallow waters	1-2 hours	$5-$20/ net	lakes, rivers, wetlands	skill in using dip nets	yes	dip net	http://www.sterlingnets.com/dip_nets.html	Downing & Rigler (1984)
	seine	suitable for sampling big invertabrates (crustaceans) in shallow water without strong current	1-4 hours	$10-$20/ net	small rivers, possible in lakes with a boat	skill in seining	yes	seine net	http://www.nationalfishingsupply.com/seinenets1.html	Downing & Rigler (1984)
	surber sampler	all invertebrates inhabiting stony or gravel subtrates	1-3 hours	$200	gravel or stony bottom rivers and streams, standing waters	knowledge of using Surber and requirements to quantify data	yes	Surber sampler, bucket	http://www.kc-denmark.dk/public_html/surber.htm	Downing & Rigler (1984)
	aerial nets	for catching adult invertebrates	1-5 hours	$35-$50	land	skill in using aerial nets	yes	insect net	http://www.rth.org/entomol/insect_collecting_supplies.html	Downing & Rigler (1984)

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Sources of Equipment	References for details of methods
Zooplankton (small invertebrates suspended in water)	box samplers	for plankton crustaceans and rotifers	1-3 hours	$100	rivers, lakes, ponds	skill in using samplers	yes	plankton (box) samplers		Downing & Rigler (1984)
Macrophyes	visual search	note visible plants within certain area ie. full river mark, high water mark; for qualitative ananlysis	variable depending on area searched	$0	rivers, lakes, ponds, wetlands	minimal	yes			
	random sampling	qualitative, more unbiassed than a visual search	1-5 hours	$0	rivers, lakes, ponds, wetlands	knowledge of making random samples	yes	nothing		Downing & Rigler (1984), Moss et al. in press 39/
	grab	good, quantitative method	1-5 hours	$100	rivers, lakes, ponds, wetlands	knowledge on random of transect sampling	yes	sampler		Downing & Rigler (1984)
	scuba diving	allows investigating plants in deep water	30-40 minutes	cost of equipment	rivers, lakes, ponds, wetlands	diving certification	yes	diving equipment, scissors to collect specimens		
Mammals	sighting	look for mammals to surface	variable	$0	rivers, lakes, wetlands	minimal	no	binoculars if necessary		
	locate breeding sites	appropriate for aquatic mammals living also on land	1-5 hours	$0	land	knowledge of breeding habitats	yes	nothing		

39/ Moss B., Stephen D., Alvarez C., Becares E., van de Bund W., van Donk E., de Eyto E., Feldmann T., Fernández-Aláez F., Fernández-Aláez M, Franken R.J.M., García-Criado F, Gross E, Gyllstrom M, Hansson L-A., Irvine K., Järvalt A., Jenssen J-P, Jeppesen E, Kairesalo T., Kornijów R, Krause T, Künnap H., Laas A, Lill E., Lorens B., Luup H, Miracle M.R., Nõges P., Nõges T., Nykannen M., Ott I., Peeters E.T.H.M., Pęczuła W., Phillips G., Romo S., Salujõe J., Scheffer M., Siewertsen K., Smal H., Tesch C, Timm H, Tuvikene L., Tonno I., Vakilainnen K., Virro T. 2002. The determination of ecological quality in shallow lakes - a tested expert system (ECOFRAME) for implementation of the European Water Framework Directive. Aquatic Conservation.

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Sources of Equipment	References for details of methods
	Traps	small and medium sized mammals (e.g. otters, minks)	12 hours- leave out overnight	$20-50/trap	land, riparian, shallow water	none	yes, trap does not kill animals	Tomahawk trap, Sherman traps		
	Tracks	detecting mammal presence on land, riparian	1-4 hours- depends on search time	$0	land and riparian areas	able to detect tracks and identify species from tracks	no	minimal- take photo or make plaster cast		
	transects	quantifies data if there are many sightings	1-5 hours	$0	river, lakes, wetlands	knowledge of establishing transects	no	binoculars if necessary		http://www.npws.nsw.gov.au/wildlife/cbsm.html
Birds	airplane surveys	can get crude estimates of population numbers and relative population abundance; biassed against certain species	1-2 hours	high- cost of hiring an airplane	any open areas	experience in quickly recognizing species	no	binoculars		
	point counts	used in conjunction with transects to control sample area to quantify and standardize data - can be done on foot in dry season and canoe in wet season	1-5 hours	$100 cost of equipment	land, rivers, wetlands	knowledge of parameters for carrying out and recording point counts	no	binoculars, measuring tape, flagging		http://www.npws.nsw.gov.au/wildlife/cbsm.html
	vocalizations	listen for and sometimes record bird calls and identify species from call	variable, several hours depending on search and record time	low- tape recorder (if needed)	any water bodies, riparian habitats, land	knowledge of how to identify bird species from calls, habitats	no	tape recorder, cassettes, playback (if needed)g		

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Sources of Equipment	References for details of methods
	locate nesting sites	bird species nesting near water	1-5 hours	$0	any water bodies	knowledge of nesting habitats	no	binoculars, maps		
Habitat type	field habitat assessment	channel morphology, bank characteristics, discharge, velocity, sedimentation, evidence of distubance, microhabitat structure (riffles etc), riparian attributes, water depth	1-3 hours	low	all water bodies and riparian, land	training in field methods	no	flow meter, tape measure, camera, substrate sampler		www.usgs.gov/nawqa
	spatial data analysis	land use, vegetation type and distribution, riparian corridor characteristics, valley morphology, size and shape of water bodies, channel gradient, water colour, hydrologic regime, slope	variable, depending on data resolution and availability	variable-depending on data resolution and availability	all water bodies and riparian, land	knowledge of reading data and GIS	no	satellite imagery, aerial photos, digital elevation models, land cover, hydrography, geology,		www.freshwaters.org; www.usgs.gov

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Sources of Equipment	References for details of methods
	Manta board survey	Mapping of lakeshore littoral habitats to complement simultaneous mapping of coastal topography, land form and land use	15 km of shoreline per day by team of 4-5 people	Boat, fuel	Lake shoreline with depth of 3-10 m depending on water visibility	Can be acquired in 1-2 days		Manta board; snorkelling equipment; inflatable boat plus outboard; map of shoreline; GPS	The manta board can easily be constructed from marine ply	www.ltbp.org/PDD1.HTM Allison et al. (2000) 40/ Darwall & Tierney 1998 41/

40/ Allison, E., R. G. T. Paley, and V. Cowan (eds.) 2000. Standard operatingprocedures for BIOSS field sampling, data handling and analysis. 80p.

41/ Darwall, W. and P. Tierney. 1998. Survey of aquatic habitats and associated biodiversity adjacent to the Gombe Stream National Park, Tanzania. 51p.

Appendix 4

Assessment methods and indices

Classification of assessment methods. A non-exhaustive and indicative list with references to reviews or key papers

Assessment method	Application	References
Habitat assessment methods		
Habitat classifications		
River Habitat Survey (RHS)		Raven et al. (1998) 42/
CORINE Biotopes classification	terrestrial, aquatic	Nixon et al. (1996) 43/
Ecological Systems Classification	aquatic, terrestrial	Groves et al. (2002) 44/
Huet's Fish zones		Nixon et al. (1996)
Davidson's aquatic communities	estuaries	Nixon et al. (1996)
Predictive systems		
RIVPACS	rivers, benthic macroinvertebrates	Nixon et al. (1996)
HABSCORE	rivers, salmonids	Nixon et al. (1996)
Physical-chemical assessment methods		
Bolton Index		Bolton et al. (1978)
Prati Index		Prati et al. (1971) 45/
Biological assessment methods		
Basic data		
Abundance of individuals of given taxa		Hellawell (1986) 46/
Total numbers of individuals (without identification)		Hellawell (1986)
Species richness		Hellawell (1986)
Diversity Indices		
Simpson's index		Washington (1984) 47/ Hellawell (1986)
Kothé's Species Deficit		Washington (1984)
Odum's 'species per thousend'		Washington (1984)
Gleason's Index		Washington (1984)
Margalef's Index		Washington (1984) Hellawell (1986)
Menhinick's Index		Washington (1984) Hellawell (1986)

42/ Raven P.J., Holmes N.T.H., Dawson F.H., Fox P.J.A., Everard M., Fozzard I.R. & Rouen K.J.. 1998. River Habitat Quality – the physical character of rivers and streams in the UK and Isle of Man. River Habitat Survey, Report No. 2. Environment Agency, Scottish Environment Protection & Environment and Heritage Service. 86 p.

43/ Nixon S.C., Mainstone C.P., Moth Iversen T., Kristensen P., Jeppesen E., Friberg N., Papathanassiou E., Jensen A. & Pedersen F.. 1996. The harmonised monitoring and classification of ecological quality of surface waters in the European Union. Final Report. European Commission, Directorate General XI & WRc, Medmenham. 293 p.

44/ Groves, C. R., Jensen, D.B., Valutis, L.L., Redford, K.H., Shaffer, M.L., Scott, J.M., Baumgartner, J.V., Higgins, J.V., Beck, M.W., and M.G. Anderson. 2002. Planning for biodiversity conservation: putting conservationscience into practice. BioScience 52(6):499-512.

45/ Prati L., Pavanello R. & Pesarin F.. 1971. Assessment of surface water quality by a single index of pollution. Water Research 5: 741-751.

46/ Hellawell J.M.. 1986. Biological indicators of freshwater pollution and environmental management. Pollution Monitoring Series. Elsevier Applied Science. 546 p.

47/ Washington, H.G..1984. Diversity, biotic and similarity indices. A review with special relevance to aquatic ecosystems. Water Research 18: 653-694.

Assessment method	**Application**	**References**
Motomura's geometric series		Washington (1984)
Fisher's 'alpha' (= William's alpha)		Washington (1984) Hellawell (1986)
Yules 'characteristic'		Washington (1984)
Preston's log-normal		Washington (1984)
Brillouins H		Washington (1984)
Shannon-Wiener H'		Washington (1984) Hellawell (1986)
Pielou Eveness		Washington (1984)
Redundancy R		Washington (1984)
Hurlbert's PIE encounter index		Washington (1984)
McIntosh's M		Washington (1984) Hellawell (1986)
Cairns Sequential Comparison Index (SCI)		Washington (1984) Persoone & De Pauw (1979) 48/ Hellawell (1986)
Keefe's TU		Washington (1984)
Biotic indices, scores and multimetrics		
Saprobic systems		
Kolkwitz & Marsson's Saprobic System	bacteria, protozoa	Washington (1984)
Liebmann		Persoone & De Pauw (1979)
Fjerdingstad		Persoone & De Pauw (1979)
Sladecek		Persoone & De Pauw (1979)
Caspers & Karbe		Persoone & De Pauw (1979)
Pantle & Buck		Persoone & De Pauw (1979)
Zelinka & Marvan		Persoone & De Pauw (1979)
Knöpp		Persoone & De Pauw (1979)
Algae		
Palmer's Index	algae	Washington (1984)
Plants		
Haslam & Wolsley's Stream Damage Rating and Pollution Index		Nixon et al. (1996)
Plant Score		Nixon et al. (1996)
Newbold & Holmes' Trophic Index		Nixon et al. (1996)
Fabienne et al.'s Macrophyte Trophic Index		Nixon et al. (1996)
Macroinvertebrate systems		
Wright and Tidd's 'oligochaete indicator'	Oligochaeta	Washington (1984)
Beck's index	macroinvertebrates	Washington (1984)
Beak et al.'s 'lake' index	(lakes)	Washington (1984)
Beak's 'river' index	macroinvertebrates	Washington (1984)
Woodiwiss' Trent Biotic Index (TBI)	macroinvertebrates	Washington (1984)
Chandler's Biotic Score	macroinvertebrates	Washington (1984)

48/ Persoone G. & De Pauw N.. 1979. Systems of Biological Indicators for Water Quality Assessment. In: Ravera O. Biological Aspects of Freshwater Pollution. Commission of the European Communities. Pergamon Press.

Biological Monitoring Working Party Score (BMWP)	macroinvertebrates	Metcalfe (1989) 49/
Average Score Per Taxon (ASPT)	macroinvertebrates	Metcalfe (1989)
Tuffery & Verneaux's Indice Biotique de Qualité Générale	macroinvertebrates	Persoone & De Pauw (1979) Metcalfe (1989)
Indice Biologique Global (IBG)	macroinvertebrates	Metcalfe (1989) AFNOR T90-350.
Belgian Biotic Index (BBI)	macroinvertebrates	De Pauw & Vanhooren (1984) 50/
Goodnights and Whitleys 'oligochaetes'	Oligochaeta	Washington (1984)
Kings and Balls' Index	tubificids, aquatic insects	Washington (1984)
Graham's Index	macroinvertebrates	Washington (1984)
Brinkhurst's index	Tubificids, Limnodrilus	Washington (1984)
Raffaeli and Mason's index	Nematodes, copepods	Washington (1984)
Sander Rarefaction method	polychaetes & bivalves (marine)	Washington (1984)
Heister's modification to Beck's index	macroinvertebrates	Washington (1984)
Hilsenhoff's index	macroinvertebrates	Washington (1984)
EPT-index	Ephemeroptera, Plecoptera, Trichoptera	
Rafaelli and Mason's index		Washington (1984)
K135 Quality Index (Netherlands)	macroinvertebrates	Nixon et al. (1996)
Danish Fauna Index	macroinvertebrates	Nixon et al. (1996)
Wiederholm's Benthic Quality index (BQI)	chironomids, oligochaetes (lakes)	Nixon et al. (1996)
Detrended Correspondence Analyses (DCA)	(lakes)	Nixon et al. (1996)
Jeffrey's Biological Quality Index (BQI)	macrobenthos (estuaries, coastal waters)	Nixon et al. (1996)
Biotic Sediment Index (BSI)	macroinvertebrates (sediments)	De Pauw & Heylen (2001) 51/
Fish		
Karr's Index of Biotic Integrity (IBI) (Fish index)	fish	Karr (1981)
Birds		
International Waterfowl Census on wintering birds	birds	Nixon et al. (1996)
"all in"-systems		
Patrick's histograms	algae to fish; exc. Bacteria	Washington (1984)
Chutter's index	all; exc. Cladocera & Copepoda	Washington (1984)
Similarity indices / Comparative indices		
Jaccard's index		Washington (1984) Hellawell (1986)
Percentage similarity (PSC)		Washington (1984)
Bray-Curtis dissimilarity		Washington (1984)
Pinkham and Pearson's Index		Washington (1984)
Euclidean or 'ecological' distance		Washington (1984)
Sorensen Quotient of similarity		Hellawell (1986)
Mountfort Index of similarity		Hellawell (1986)
Assessment method	**Application**	**References**
Raabe's Comparative measure		Hellawell (1986)

49/ Metcalfe J.L.. 1989. Biological Water Quality Assessment of running Waters Based on Macroinvertebrate Communities: History and Present Status in Europe. Environmental Pollution 60 (1989): 101-139.

50/ De Pauw N. & Hawkes H.A.. 1993. Biological monitoring of river water quality. Proc. Freshwater Europe Symp. on River Water Quality Monitoring and Control. Aston University, Birmingham. p. 87-111.

51/ De Pauw N. & Heylen S.. 2001. Biotic index for sediment quality assessment of watercourses in Flanders, Belgium. Aquatic Ecology 35: 121-133.

Kulezynski's Coefficient of similarity		Hellawell (1986)
Czekanowski's Comparative measure		Hellawell (1986)
Sokal's Distance measure		Hellawell (1986)
Ecosystem health		
AMOEBA		Nixon et al. (1996), Ten Brink et al. (1991) 52/
Integrated or combined assessment systems		
TRIAD - Quality Assessment	BSI, ecotox., phys.-chem. (sediments)	Chapman et al. (1987)
EPA 's Rapid Assessment Protocols (RBP)		Barbour et al. (1992)
SERCON	Physical diversity, naturalness, representativeness, rarity, spp. richness	Boon (UK)

52/ Ten Brink B.J.E., Hosper S.H. & Colijn F. 1991. A Quantitative Method for Description & Assessment of Ecosystems: the AMOEBA-approach. Marine Pollution Bulletin. Vol. 23: 265-270.