CBD

UNEP

CONVENTION ON BIOLOGICAL DIVERSITY

Distr.
GENERAL
UNEP/CBD/EM-RAIW/1/2
6 November 2002
ORIGINAL: ENGLISH

EXPERT MEETING ON METHODS AND GUIDELINES FOR THE RAPID ASSESSEMENT OF BIOLOGICAL DIVERSITY OF INLAND WATER ECOSYSTEMS
Montreal, 2-4 December 2002

GUIDELINES FOR THE RAPID ASSESSMENT OF BIODIVERSITY IN INLAND WATER ECOSYSTEMS

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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 was requested to develop a work plan on inland water ecosystem conservation by *inter alia* developing and disseminating regional guidelines for rapid assessment of inland water biological diversity for different types of inland water ecosystems.

2. In addition, in paragraph 9 (e) 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 should undertake assessments of alien species within their inland water ecosystems.

3. In section C of Annex I to decision IV/4, Parties were urged to adopt an integrated approach in their assessment, management and where possible remedial action of inland water ecoystems, including associated terrestrial and inshore marine ecosystems. The paragraph further states that assessments should involve all stakeholders, should be cross-sectoral and should make full use of indigenous knowledge (para 14). Parties are reminded that the transboundary nature of many inland water ecosystems should be fully taken into account in assessments, and that it may be appropriate for relevant regional and international bodies to contribute to such assessments (para 18). In accordance with recommendation II/1 of the Subsidiary Body on Scientific, Technical and Technological Advice, endorsed by the Conference of the Parties in decision III/10, assessments should be simple, inexpensive, rapid and easy to use. It is recognized that such rapid assessment programmes will never replace thorough inventories. Therefore, the

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Conference of the Parties takes note of the need to evaluate specific rapid assessment programmes for inland water ecosystems currently under development (para 19).

4. In paragraphs 11 (a) and (c) of the Third Joint Work Plan (2002-2006) of the Convention on Biological Diversity and the Convention on Wetlands (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 for adoption by both conventions (see activity 2.4 under inland water ecosystems) 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.

5. To facilitate the development of regional guidelines on the assessment of different types of inland water ecosystems by SBSTTA, the Executive Secretary commissioned Conservation International to compile information on the rapid assessment of inland water biological diversity and convened, in collaboration with the Ramsar Bureau, an Expert Meeting to further develop these. 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 balance.

6. The present paper is intended to help the Expert Group to:

(a) review existing methods for the rapid assessment of the biodiversity of inland water ecosystems; and

(b) develop regional guidelines for the application of rapid assessment methods.

In addition the group may wish to make recommendations on:

(i) how to balance the need for cost-effective methods and quick answers on the one hand and the requirement to develop long-term monitoring systems capable of identifying the cumulative effects of various pressures on aquatic ecosystems on the other; and

(ii) appropriate ways of creating an enabling environment for the successful application of these methods including capacity-building.

GUIDELINES FOR THE RAPID ASSESSMENT OF BIODIVERSITY IN INLAND WATER ECOSYSTEMS

Introduction to Inland Water Ecosystems

7. Inland waters comprise a large and diverse group of aquatic ecosystems. They are defined as any aquatic ecosystem lying within the boundaries of continental or island landmasses. Ecologically, the phrase ‘inland water ecosystem’ is broad in scope, encompassing several types of water, their associated habitats, and an incredible diversity of living forms. There are many types of waters found across the face of the earth, above and below ground, moving and still, large and small, fresh, brackish or saline. These include rivers, lakes, streams, ponds, marshes, swamps, bogs, floodplains, estuaries, aquifers, and underground rivers and lakes, just to name a few common forms. Different ecological zones and habitats are associated with all of these systems, making the term inland water ecosystem a rather broad and far-reaching ecological concept.

Threats to Inland Water Ecosystems

8. One of the critical conservation challenges facing us today is preservation of inland water ecosystems. This challenge persists mainly because of the tremendous human impact on these ecosystems. Humans use inland waters for water and food consumption, food production (both aqua- and agriculture), sanitation, transportation, energy, industry, recreation, and culture. The flow-through nature of river systems often is assumed to provide sufficient cleansing for sewage, garbage disposal, industrial and urban pollution or agricultural runoff, with little consideration to either local or downstream effects. However, even a cursory inspection of the Danube, Mississippi and São Francisco rivers, for example, convinces us that continual self-cleansing and maintenance of sustainable fisheries are not only *not* guaranteed, but are highly unlikely. Similarly, rivers are channeled, flooded areas are dyked, and dams are constructed without consideration to the sizable loss of economic value in renewable aquatic resources. Another serious threat comes from the introduction of non-native animals and plants into an inland water system. Invasive fishes, plants, and invertebrates can have devastating effects on native species.

9. The urgency for conservation of aquatic biodiversity and fisheries is escalating. Demands through channelization, development and damming are threatening watersheds without regard for the dynamics of aquatic ecosystems or the complexities of the life histories of aquatic organisms. Food demands also are increasing. According to information from UNESCO, world fisheries need to produce more than 100 million metric tons by the year 2000. Yet, the marine fisheries have been stuck at approximately 80 million metric tons for almost the last decade. Freshwater systems have great potential if managed properly. For example, the reported fish landings at Manaus, Brazil, at the confluence of the Amazon River and the Rio Negro, exceed 200,000 metric tons annually. At Caicara, on the Rio Orinoco, the landings exceed 75,000 metric tons annually. At a low estimate of $2/lb per whole fish, the resource is worth $1.1 billion annually.

10. Another factor that complicates the conservation of inland water ecosystems is that they tend to be multinational resources. The great Amazon River basin, for example, borders on, or flows through, eight countries. Even smaller rivers systems in South America can be shared by several countries (e.g., the Rio Branco). Where not multinational, aquatic resources are usually multi-political within a country. This multinational character challenges conservation efforts for many reasons, including cooperation, funding, investment potential of all partners, external sources of pollution, and over-fishing. To succeed, conservation efforts for aquatic ecosystems must have a strong multinational and collaborative component. Conservation of aquatic ecosystems is essential not only to preserve biodiversity, but also to manage naturally renewable resources that will be critical for the maintenance of human populations.

Special Considerations for Inland Water Ecosystems

11. The inland water ecosystems of small island states are particularly vulnerable, since they are often isolated from larger inland water systems and may be the sole source of freshwater for the island. Pressures on the water and biodiversity resources of these inland water systems are therefore strong. Similar to terrestrial systems, inland water ecosystems of islands may have high levels of endemic species - species not found anywhere else. These species are high priorities for conservation, as they cannot be found or conserved in other areas. Invasive species of fishes, plants, and invertebrates may have particularly harmful impacts on the endemic and native species of islands.

12. In addition to water resources and quality, a key element of conservation in any inland water system is the protection of the threatened or endangered species within them. These species are in danger of becoming extinct if efforts are not made to protect them and their habitats. Threatened species have been identified as a conservation priority by the Convention of the Parties (CBD Appendix 1). The 2000 IUCN Red List of Threatened Species (IUCN 2000) lists 734 species of threatened fishes, 920 species of threatened mollusks (freshwater and marine), and 407 species of threatened crustaceans (freshwater and

marine). Moreover, freshwater-dependent animals such as mussels, crayfishes, stoneflies, fishes, and amphibian were identified as the most threatened groups in the U.S. (Master et al. 2000). This clearly reflects the vulnerability and degradation of inland water ecosystems worldwide.

13. Frequent and rigorous assessment and monitoring of the health and biodiversity of inland water ecosystems, particularly in small island states and focused on threatened species, are critical to ensuring the long-term sustainability of these valuable resources.

Biodiversity of Inland Water Ecosystems

14. An extensive assortment of taxonomic groups comprise the floral and faunal diversity of inland waters. To consider biodiversity assessment within these wide parameters requires a general understanding of the representative constituents of that diversity. What organisms can be used as the measuring stick for diversity in inland water ecosystems? Fish, invertebrates, plants, birds, mammals, reptiles, amphibians, and periphyton all play important roles in inland water ecology. The relative importance of these groups is briefly explained here (Groombridge and Jenkins 1998).

- **Plants:** Provide substrate, shelter, and food for many other organisms. Trees are ecologically important in providing shade and organic debris (leaves, fruit), structural elements (fallen trunks and branches) that enhance vertebrate diversity, and in promoting the stability of river banks, thus preventing erosion. Aquatic plants similarly provide structure and food to aquatic organisms and help regulate water quality.

- **Invertebrates: molluscs:** Snails are mobile grazers or predators; bivalves are attached bottom-living filter-feeders. Both groups have speciated profusely in certain freshwater systems. The larvae of many bivalves are parasitic on fishes. Because of the feeding mode, bivalves can help maintain water quality but tend to be susceptible to pollution.

- **Invertebrates: crustaceans :** Include larger bottom-living species such as shrimps, crayfish and crabs of lake margins, streams, alluvial forests and estuaries. Also larger plankton: filter-feeding Cladocera and filter-feeding or predatory Copepoda. Many isopods and copepods are important fish parasites.

- **Invertebrates: insects:** In rivers and streams, grazing and predatory aquatic insects (especially larval stages of flying adults) dominate intermediate levels in food webs (between the microscopic producers, mainly algae, and fishes). Also important in lake communities. Fly larvae are numerically dominant in some situations (eg. in Arctic streams or low-oxygen lake beds), and are vectors of human diseases (eg. malaria, river blindness).

- **Vertebrates: fishes:** Fishes are the dominant organisms in terms of biomass, feeding ecology and significance to humans, in virtually all aquatic habitats including freshwaters. Certain water systems, particularly in the tropics, are extremely rich in species. Many species are restricted to single lakes or river basins. They are the basis of important fisheries in inland waters in tropical and temperate zones.

- **Vertebrates: amphibians:** Larvae of most species need water for development. Some frogs, salamanders and caecilians are entirely aquatic; generally in streams, small rivers and pools. Larvae are typically herbivorous grazers, adults are predatory.

- **Vertebrates: reptiles:** Because of their large size, crocodiles can play an important role in aquatic systems, by nutrient enrichment and shaping habitat structure. They, as well as freshwater turtles and snakes are all predators or scavengers.

- **Vertebrates: birds:** Top predators. Wetlands are often key feeding and staging areas for migratory species. Likely to assist passive dispersal of small aquatic organisms.

- **Vertebrates: mammals:** Top predators, and grazers. Large species widely impacted by habitat modification and hunting. Through damming activities, beavers play an important role in shaping and creating aquatic habitats.

Rapid Assessment

15. The complex nature and implicit variability of inland water ecosystems makes the creation of a standard assessment protocol challenging. The methods used to assess riparian (rivers) ecosystems will not necessarily overlap with those of lacustrine (lake) ecosystems. The methods used to survey aquatic plant communities in the Everglades in Florida will certainly not be the same as those used to determine the effect of introduced trout species on the Rio Futaleufu in Chile. Furthermore, the resources available to carry out an assessment project by university biology students will differ from those available to the United States Environmental Protection Agency. Not only is there no single protocol that can be applied to the wide range of natural habitats and taxonomic groups that need assessment, there is none that could fit the various needs and resources of so many interested parties. Beyond these variables, there are many other incalculable and intangible variables associated with geography, geopolitics, water, season and other elements that complicate the idea of a “standardized” rapid assessment method.

16. Nonetheless, there are several methods available for biodiversity assessment; the challenge lies in finding and choosing those methods that are rapid and can meet, or be adapted to meet, the purpose, limitations, and specific conditions of every project. One reason that a standard set of rapid assessment methods is challenging to create is because of a subtle paradox in trying to use rapid methods to obtain scientifically useful results. Many types of data require long term monitoring. To be sure, there are many more methods available when time is not an issue, but increasingly, the need for instant information does not allow for lengthy research. There is a need for a compromise between methods that are both rapid and can produce scientifically useful and reliable data. Rapid assessment methods are not conducive to some investigations, but where “instant information” necessary, it gives tangible facts to base decisions.

The Decision Tree

17. 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.

18. **Purpose** is the most basic element of a biodiversity assessment. What is the reason for the assessment? The decision tree (Figure 1) provides five general purposes that meet a range of needs. The purpose of the assessment will determine the assessment type to meet the goals and produce the information required of a particular assessment project.

Figure 1. Decision Tree

Decision Tree

	1	**2**	**3**	**4**	**5**
Purpose	Prioritize species, ID species, baseline biodiversity/ taxonomy information/conservation	Conservation or exploitation of specific species	Effects of human impacts and stresses	Overall health or condition	Sustainable use of biological resources
Assessment Type	Inventory Assessment	Species-specific Assessment	Impact Assessment	Indicator Assessment	Resource Assessment
Outputs	1.Species lists/inventories. 2. Limited data on population size/structure. 3. Genetic information. 4. Abundances, distributions patterns and ranges. 5. Important species: threatened, endangered, endemics, invasives.	1. Status of a focal species: distribution, abundance, population size/structure, genetic, health, size, nesting, breeding and feeding information. 2. Ecological data on focal species; habitat, symbionts, predators, prey etc. 3. Identify threats to focal species and habitats.	1. Monitoring data. 2. Effects of an impact 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.	1. Health or condition of inland water systems. 2. Physical/Chemical parameters (pH/conductivity/ turbidity/-O2/salinity). 3. Biological parameters (health of species, DNA/genetic problems, define/target important species. 4. Indices: Index of Biotic Integrity (IBI) and EPT.	1. Presence, status and condition of economically important species. 2. Sustainable exploitation of a species. 3. Monitoring data: stock assessment data, habitat status. 4. Management options.
	Table 1	**Table 2**	**Table 3**	**Table 4**	**Table 5**

19. Five Assessment Types are used in the decision tree, these are: *Inventory Assessment*, *Specific-species Assessment*, *Impact Assessment*, *Indicator Assessment*, *Economic Resource Assessment*. These are organized numerically and coordinated with their output information (Tables 1-5). The assessment types are explained in detail below.

20. 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 programs and methods available that address the needs and fit within the parameters of the assessment project (see also Table 6).

Below is an outline and brief descriptions of the steps of the "Decision Tree" in the order that they appear in the tree.

(i) I. Purpose (Figure 1)

21. 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 protect biodiversity and ecosystem sustainability. There are several reasons within this context to undertake a rapid biodiversity assessment of inland waters. Five purposes representing a breadth of possible reasons for rapid biodiversity assessment are as follows:

> **1**) Collect general biodiversity data in order to **inventory** and prioritize species. Obtain baseline biodiversity information for a given area.
>
> **2**) Gather information on the **status of a focus or target species** (such as threatened species). Collect data pertaining to the conservation or exploitation of a specific species.
>
> **3) Gain information on the effects** of human impacts and stresses on a given area or species.
>
> **4**) Gather information that is **indicative of the general health or condition** of a specific inland water ecosystem.
>
> **5**) Determine the potential for **sustainable use of biological resources** in a particular inland water ecosystem.

The five purposes are numbered according to the assessment type to which they correspond.

II. Assessment Types (Tables 1-5)

22. In order to choose an adequate method for inland water biodiversity assessment, 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.

1) Inventory Assessment (Table 1, Case study 1)

23. An Inventory Assessment 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. Several sites need be sampled in order to get a range of habitat types of the area and the ecological gradations within it.

24. The assessment focuses on overall biological diversity, with output information ideally leading to a comprehensive inventory of biodiversity within the given area. Species 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, and other superficial biological information pertaining to water quality and ecosystem health.

25. 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 between different habitats and localities in the survey area. For example, a typical species list could be: *Aquatic Invertebrates Collected at Area 2, Site 5.* Taxonomic data would likely include sampling of fish, macro and benthic invertebrates, aquatic and terrestrial plants, and algae.

26. The inventory assessment provides information that is relatively broad in scope, rather than extensive or detailed information about specific taxa. The goal is to garner as much information as possible about the system as a whole through extensive sampling of its organismic constituents. This calls for methods that cover numbers of species and area. An intense sampling effort is usually required in order to list as many species and sample as many sites as possible so that the survey can give the best "view" of the area being surveyed. Relevant data pertaining to geography, geology, climate, and habitat are also important to the greater ecological context of an inventory assessment.

27. An inventory assessment provides initial information about a defined area of interest. The output information could be useful in prioritizing species or areas of concern, 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 2). If localities or habitats are prioritized for particular human stresses on them, then they should be considered for assessment according to the impact assessment methods (Table 3).

Inventory output:

Data

- Baseline biodiversity data: species 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

2) Species-specific Assessment (Table 2, Case study 2)

28. 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, exploitation, 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, behavioral, cultural, and economic contexts.

Species-specific output:

Data:

- Data pertaining to the status of focal species: distribution, abundance, population size/structure, genetics, health, size, nesting, breeding and feeding information
- Ecology and behavior, 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

3) Impact Assessment (Table 3, Case study 3)

29. Often an assessment is needed in order to determine the effects of particular human impacts on the biodiversity and ecological integrity of an area. The information collected in this type of assessment can be either proactive or retroactive in nature.

30. A proactive approach would assess the *potential* impacts of a particular project such as a dam or development, and also establish a baseline of biodiversity data for long term monitoring of the impact. This approach allows for "before and after" assessment data, as well as identification of species and habitat areas likely to be effected by the impending impact. Comparative analysis of areas where the impact already exists can be used to predict potential impacts.

31. A retroactive approach aims to assess *existing* impacts of various projects or management practices as they apply to biodiversity and biological integrity. In terms of biodiversity, this approach can be difficult without baseline, pre-impact data for comparison, and therefore may require the use of reference sites. Reference sites are areas of the same region that parallel the pre-disturbance condition of the impact area in order provide data for comparative analysis.

32. Another important consideration of retroactive impact assessment is that of change vs. condition. Often the effects of an impact are not obvious because new "invasive" species adapted to the post-disturbance ecological conditions replace naturally occurring pre-impact 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. Impact assessment outputs are grouped below depending on whether they pertain to potential or existing impacts.

***Potential impact output*:**

Data

- Baseline biodiversity data for long term monitoring of impact. 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.

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.

Existing impact output:

Data

- Data on specific taxa, water quality, and habitat (requires baseline or reference site data).

Applications:

- Determine effects of impact and related stresses on biodiversity
- Identify specific pressures, and stresses related to impact.
- Identify possible management practices to mitigate pressures and stresses.
- Conservation recommendations.

4) Indicator Assessment (Table 4, Case study 4)

33. An Indicator Assessment assumes that biological diversity, in terms of species and community diversity, can tell us a great deal about the water quality 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. 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. It is therefore possible to use species presence/absence/abundance and habitat characteristics to assess the condition of inland water ecosystems.

Indicator output:

Data:

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

Applications:

- Assess the overall health or condition of a given inland water ecosystem
- Assess water quality
- Conservation recommendations
- Biomonitoring indices such as the Biotic Integrity Index (IBI) and the Hilsenhoff Biotic Index (HBI) (Appendices A and B)

5) Resource Assessment (Table 5, Case study 5)

34. 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 in the area and the identification of potential markets. Ideally a resource assessment can facilitate the development of ecologically sustainable development as an alternative to other destructive or unsustainable enterprises. Thus, a major objective of the resource assessment is to provide sustainable use concepts 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. 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.

Resource output:

Data:

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

Applications:

- Fishery sustainability, habitat status, stock assessments, information from fishermen/harvesters
- Options for sustainable development and recommendations for management

III. Resources and Scope

35. 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, Methods, Analysis, Data***. 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.

A) Resources (Tables 1-5)

36. 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.

Time

37. The idea underlying rapid assessment is to rapidly provide biological information needed to catalyze conservation action and improve biodiversity protection. For this to happen, researchers try to amass as much information as possible in a short period of time. Thus, time is a fundamental consideration for any *rapid* assessment of biodiversity.

38. Scientifically, long term monitoring and research offers 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 when it is needed, not after, because political and economic leaders will not wait. And often, nothing less than a rapid assessment will do. 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.

39. 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.

Money

40. 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 capitol 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.

Expertise

41. For the purpose of this model, 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 analyze 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 handful, or even just one person who can be considered an expert in the area of study.

42. 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 either are -yes- or are not -no- available for the assessment project.

B) Scope (Tables 1-5)

43. 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.

44. 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.

45. The scope of an assessment can vary internally in the following areas: ***Taxa, Geography, Site Selection, Data, and 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.

Taxonomic Scope

46. 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 impact assessment.

47. 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 Caddis flies, *Tricoptera*, may be greater than a survey focusing on aquatic mammals, birds and fish species.

Geographic Scope

48. 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 effected 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.

49. 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.

Site Selection

50. Site selection refers to the number and type of sites needed for the assessment. Like the geographic scope, the site selection is highly dependent on other aspects of the assessment. Of particular consideration is the number of sampling sites for a given assessment. In general, the greater the number of sites sampled, the greater coverage of the area. Fewer sites allows for more depthful 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.

51. The assessment type will often help dictate the site selection as well. 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. The number and type of sites should provide an adequate sampling for quantitative or qualitative analysis.

52. Another consideration in the site selection is what sites will 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.

Data

53. Data can be either quantitative or qualitative, and is often a bit of both. Quantitative data is numerically based, can be analyzed mathematically, and produces tangible results that can be used as a basis of comparison. Information such as population densities and abundances are based on quantitative data. Qualitative data generally consists of lists and descriptions and is useful for inventory and developing ecological description of an area. Another important distinction between the two is how they are compiled. Quantitative data usually requires standardized methods with regular spatial or temporal parameters to allow for comparison between different surveys, and for statistical relevance. Qualitative data usually requires identification of different taxa for lists and descriptions. Typically both types will be used in some form or another.

54. The scope of data collection depends on how much data will be compiled, and of what type. Methods for some types of data can be quite long, while others are relatively fast. Furthermore, some data requires technical methods, while other types are fairly simple. Data that can be collected quickly and easily is usually the most effective for rapid assessment. Faster methods means reduced sampling time, which allows for and increase in the amount of sampling that can be done.

Analysis

55. Analysis tells the story behind the data. Like data, analysis should pertain directly to the purpose of the assessment. The technique in which the data is analyzed is critical to conveying the relevant results, but is entirely dependent upon the type of data collected. On a more specific level, there are some important questions regarding analysis. What type of analysis will be used, qualitative or quantitative? Will it require expertise in statistics or specialized computer programs? How much time will be needed to carry out the analysis?

Sampling Methods

56. The type of sampling methods used are 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.

57. For most studies, a variety of water quality variables should be measured, including temperature, electrical conductivity (EC, a measure of the salinity or total dissolved salts), pH (an indicator of the water's acidity or alkalinity), dissolved oxygen, and water clarity. These parameters can be measured with individual instruments or with one combination instrument that includes several types of probes. Fishes can be sampled using gillnets of various mesh sizes, seine nets, cast nets, trawl nets, D-frame dipnets, angling, electric fishing, and examining local fishermen’s catches. Aquatic invertebrates may be sampled from marginal, floating and submerged vegetation using long-handled scoop nets or D-frame dipnets, and from

bottom sediments using a scoop net or grab samplers. Kick nets can be used to sample invertebrates from rocky streams and other shallow areas. Reptiles and amphibians are generally sampled by visually searching for animals during the day and night.

58. Table 6 provides an overview of a number of relevant sampling methods for each taxonomic group. Some good references include Merrit at al. (1978), James and Edison (1979), Platts et al. (1983), Nielsen and Johnson (1996), and Barbour et al. (1999). Three good websites to use as a reference include the U.S. Environmental Protection Agency (www.epa.gov/owow/monitoring), the World Conservation Monitoring Centre (www.unep-wcmc.org), and the Ecological Monitoring and Assessment Network (Canada; http://www.eman-rese.ca/eman/intro.html).

Existing Assessment Methods for Inland Waters

59. We include here a table (Appendix C) describing six international programs that conduct some form of rapid assessment of inland waters, each with a unique approach and utilizing different methods. The table shows how the different programs compare in several areas including purpose, geographic scale, data, data analysis, sampling methods, human resources, funding and other important considerations. This list is a valuable tool for the comparison of how current assessment protocols are implemented by different programs and for different purposes. This is not meant to be a comprehensive list but provides an idea of the types of assessments that are currently being conducted worldwide.

60. We also include five case studies, one corresponding to each of the purposes and assessment types (Case Studies 1-5). These case studies illustrate how the decision tree can be used to determine the appropriate methods to be used to rapidly assess the biodiversity of inland waters based on the purpose of the assessment.

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Appendix A Index of Biotic Integrity (IBI)

The Index of Biotic Integrity (IBI) was created in 1981 by Dr. James Karr to evaluate biological conditions of rivers and streams. It is intended to reflect the biotic integrity of an area, which is defined as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region" (Karr and Dudley, 1981). In short, biotic integrity is had by an ecosystem when its composition, structure and function are unimpaired by human disturbance.

The original IBI was created for rivers and streams of the central midwestern United States so the measures (metrics) will need to be modified to suite the relevant species in areas outside the central midwest. The IBI categorizes 12 community metrics into 3 universal groupings, though, which should be retained through modifications:

1. Species richness and composition
2. Trophic composition
3. Fish abundance and condition

Each metric for a sample site is scored based on the expected condition of that site without disturbance. Reference sites can used as a base of comparison if no historical data is available. Reference rivers/streams should be of similar size in the same region.

The original IBI modified from Karr 1981 and Fausch et al. 1984)

		Scoring Criteria [a]		
Category	Metric	5	3	1
Species richness and composition	1. Total number of fish species	<5%	5-20%	>20%
	2. Number and identity of darter species	<5%	5-20%	>20%
	3. Number and identity of sunfish species	<5%	5-20%	>20%
	4. Number and identity of sunfish species	<5%	5-20%	>20%
	5. Number and identity of intolerant species	<5%	5-20%	>20%
	6. Proportion of individuals as green sunfish	<5%	5-20%	>20%
Trophic Composition	7. Proportion of individuals as Omnivores	<20%	20-45%	>45%
	8. Proportion of individuals as omnivores[b]	>45%	45-20%	<20%
	9. Proportion of individuals as piscivores (top carnivores)	>5%	5-1%	<1%
Fish abundance and condition	10. Number of individuals in sample	Expectations for metric 10 vary with stream size and other factors		
	11. Proportion of individuals as hybrids	0%	>0-1%	>1%
	12. Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies	0-2%	>2-5%	>5%

[a] Ratings of 5, 3, and 1 are assigned to each metric according to whether its value approximates, deviates, strongly from the value expected at a comparable site that is relatively undisturbed.

[b] Omnivores are defined here as species with diets composed of $\geq$25% plant material and $\geq$25% animal material.

Appendix B. Analyses for using benthic macroinvertebrates as indicators

Hilsenhoff Biotic Index (HBI)

The HBI is an analysis based on the tolerance or intolerance of certain species to various levels of domestic waste.

HBI = [S(Xi*t)]/n

Where:

S = the summation of Xi*t

Xi = the number of individuals in each taxon
t = tolerance value for each taxon in the sample
n = number of individuals in the sample

Description/ Designation	Explanation
Family level biotic index	
0.00-3.75	Excellent
3.76-4.25	Very Good
5.25-5.00	Good
5.01-5.75	Fair
5.76-6.50	Fairly Poor
6.51-7.25	Poor
7.26-10.00	Very Poor

NUMBER OF TAXA

A count of the number of taxa (families) found in the sample (higher is better)

NUMBER OF INDIVIDUALS

The total count of individuals found in the sample

% Dominant Taxa
The percent composition of the most abundant taxa (lower is better)

EPT COUNT

A count of individuals of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), which are pollution-sensitive orders (higher is better)

EPT INDEX

A count of the number of families of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (higher variety is better)

EPT / TOTAL COUNT

EPT divided by the total number of individuals in the sample (higher is better)

CHIRONOMID COUNT

The total number of individual chironomids (midge larvae) in the sample (lower is better)

EPT COUNT / CHIRONOMID COUNT

EPT count divided by the Chironomid count (a higher ratio is better)

Case Study 1: 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, occurence 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 2: Species Specific

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 in the IUCN Red Book 1996) as data deficient and in Appendix I of CITES. 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 (Lara, 1990; Castaneda 1997). See also Bestelmeyer and Alonso (2000).

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 USD
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

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Case Study 3: Impact Assessment

Effects of mine tailings on Trout and Macroinvertebrate populations on the Eagle River near Minturn 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 shocking techniques. Micro-invertebrates were collected using kick-nets.

Case Study 4- Indicators

Cases Study- Using Benthic Invertebrates as Indicators

1. **Purpose**: to assess the health of the Salmonberry River
2. **Assessment type**: indicator assessment
3. **Time**: 2 days
4. **Money**: $2,000

4. **People**: 2 non-scientists experienced in sampling methods

6. **Field Work**

- **a. geographical:** entire Salmonberry watershed
- **b. site selection:** 18 sites that represent different stream sizes and habitats
- **c. taxa:** benthic macroinvertebrates
- **d. 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.)
- **e. 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 analyze 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 is the metrics used for the study and their scorings:

Metric	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 are members of the three most abundant taxa	60-100	40-60	Less than 40
10. *Pteronarcys* stonefly	absent		present

Case Study 5: Economic Resources 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, 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: Indicator Assessment

RESOURCES:

time: Short-Medium; two days field work + analysis of data in off site lab
money: Ample: $2000 USD

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: Relatively small in scope. Focus was on benthic macro-invertebrate fauna, particularly to caddis flies, stoneflies, and mayflies.

geographical: The scope was locally concerned with the Salmonberry watershed.

site selection: Eighteen sites were sampled, with an emphasis on faster moving currents (riffles). These localized habitats were used because they tend to have a higher diversity of macro-invertebrates, and because the current made sampling with a kicknet easier.

data: Taxonomic identification and counts of all collected specimen to the genus level.

analysis: Collected data was analyzed using the *Benthic Index of Biotic Integrity* (see Appendix A). The technique is non-technical, and uses metrics that correlates characteristics of the invertebrate community with the condition of the stream.

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.

Table 1. Inventory 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	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)	Nontechnical, 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
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, nontechnical	Lists, abundance, distribution patterns, behaviors	Several methods, some general, some species specific, nontechnical	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, EPT index, identification of indicator species	Few accessible target sites	Include more taxa on lists, counts, EPT/ IBI, more expertice	Lists, counts, water analysis	More thorough anlaysis of abundance, (patterns?); 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	USDA Visual Stream Protocol					Conservation International- RAP					

* The optimal route under these circumstances would be to hire outside scientists for greatest results.

Table 2. 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)	Limited in number, but not in accessibility (fly to inaccessible)	Several accessible, a few less accessible sites	Several accessible, a few less accessible sites	Many accessible and inaccessible sites	Many accessible and inaccessible sites	Many accessible sites and several less accessible sites	Many accessible sites and several less accessible sites	Many accessible sites and several inaccessible sites	Many accessible sites and several 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,	Presence/ absence, limited distribution, physical char., habitat features	All previous plus+ some behavior	Presence/ absence, limited distribution, physical char., habitat features	All previous including some behavior, status of food source and competition (esp. invasives), 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
Methods	Species specific, fast, inexpensive	Species specific, nontechnical, fast, inexpensive,	species specific plus other useful, but more general methods, can include technical and more expensive methods	A variety of methods, nontechnical	A variety of methods, inexpensive	A variety of methods, nontechnical, can include more time intensive methods	Can include technical, more expensive, and some more time intensive methods	A variety of methods, nontechnical, can include more time and labor intensive methods	Can include technical, time intensive methods, some in depth surveys and short-term behavior monitering	A variety of methods, nontechnical, 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, nontechnical, but possibly costly can include more time and labor intensive methods
Analysis	Status report, limited distribution, population info	Startus, 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

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Table 3. Impact 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.
Programs	Ramsar?

Table 4. Indicator 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	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,	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,	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,	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
Analysis	BiomMAP, IBI, Visual Assessment	Visual Assessment analyses	BiomMAP, IBI, Visual Assessment	BiomMAP, IBI, Visual Assessment	BiomMAP, IBI, Visual Assessment	BiomMAP, IBI, Visual Assessment	BiomMAP, IBI, Visual Assessment	BiomMAP, IBI, Visual Assessment	BiomMAP, IBI, Visual Assessment	BiomMAP, IBI, Visual Assessment	BiomMAP, IBI, Visual Assessment	BiomMAP, IBI, Visual Assessment
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.									

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? 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 5 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; nontechnical	Species specific; fast; possibly more costly (electrofishing)	Species specific; inexpensive; fast; nontechnical	Species specific; inexpensive; more intensive or extensive	Species specific; inexpensive; nontechnical; more intensive or extensive; nontechnical	Species specific; more intensive or extensive; possibly costly	Species specific; more intensive or extensive; possibly costly; nontechnical	Species specific; even more intensive or extensive; longer term (false substrates)	Species specific; inexpensive; nontechnical; even more intensive or extensive; nontechnical	Species specific; even more intensive or extensive; longer term (false substrates)	Species specific; inexpensive; nontechnical; even more intensive or extensive; nontechnical
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	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	Abundance, sizes, habitat characteristics; distribution
Programs												

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Table 6. Sampling Methods

Taxon	Method	Application	Field Time	Cost	Water type	Required expertise*	Possibility of collecting ?	Equipment	Other
Fishes	seine	shallow water without strong current	1-4 hours	$10-$50/ net	small rivers, possible in lakes with a boat	skill in seining	yes	seine net	http://www.nationalfishingsupply.com/seinenets1.html
	trawl	deeper, large waters without obstacles on the bottom or surface debris, especially useful for deep bottom-dwelling fish	1-2 hours		lakes and large rivers	skill in trauling	yes	trawl net, boat	http://www.fao.org/fiservlet/org.fao.fi.common.FiRefServlet?ds=geartype&fid=103
	dip nets	suitable for small fish near surface	1-5 hours	$5-$20/ net	rivers, lakes, wetlands	skill in using dip nets	yes	dip net	http://www.sterlingnets.com/dip_nets.html
	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	
	rotenone	suitable for small creeks or sections of larger streams with minimal current flow	each application lasts only ~10 min	$18/ pint	small creeks, larger streams with minimal current	knowledge of correct ratios of mixture	yes	rotenone,	representative yet minimal sample of fish obtained
	electrofishing	optimal for sampling medium to big fish, better in colder water with some salinity	variable depending on repetition	$5,500	lakes, rivers	need training in electrofishing	yes	electro-shocker, net	http://www.fisheriesmanagement.co.uk/electrofishing.htm
	dive/ snorkeling	suitable for surveying particular ecosystems that are difficult to locate or reach	usually about 1 hr., but variable depending on repetition	cost of equipment	lakes, rivers	snorkeling no, diving needs certification	yes	snorkel/scuba gear, dip net	
Herps	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	
	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
	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	
Macroinvertebrates (Crustaceans)	dip net	suitable for shallow waters	1-5 hours	$5-$20/ net	lakes, rivers, wetlands	skill in using dip nets	yes	dip net	http://www.sterlingnets.com/dip_nets.html
	seine	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
	visual search/ snorkel/ dive	good for locating organisms in areas where nets are not appropriate (ie. deep water or obstacles)	1 hour	cost of equipment	rivers, lakes	diving certification	yes	snorkel/scuba gear, dip net	
	grab	ideal for sampling deeper water less than 2 meters (Peterson grab for harder bottom substrates and Eckman grab for soft bottom substrates)	variable	$350- $1100	rivers, lakes	skill in using grabs	yes	seive, dip net	http://www.elcee-inst.com.my/limnology.htm
	biological dredge net	ideal for sampling deeper waters	1-4 hours	$560	rivers, lakes	skill in using a dredge net	yes	seive, dip net	http://www.elcee-inst.com.my/limnology.htm

Benthic Invertebrates	kick net	good for wadable streams	1-5 hours	$55	rivers, lakes, wetlands	skill with kick nets	yes	kick net	http://www.acornnaturalists.com/p14008.htm
	artificial substrates	used when natural substrates cannot be sampled because of inacessability, cost, or saftey issues	usually 6 weeks with two trips to site- installation and removal	$20	rivers, lakes	knowledge of creating artificial substrates and placing them in appropriate locals	yes	artificial substrate, baskets if necessary	http://www.des.state.nh.us/wmb/biomonitoring/inverts.htm
	dip net	suitable for shallow waters	1-5 hours	$5-$20/ net	lakes, rivers, wetlands	skill in using dip nets	yes	dip net	http://www.sterlingnets.com/dip_nets.html
	surber sampler	good for wadable streams	1-3 hours	$200	rivers	knowledge of using Surber and requirements to quantify data	yes	Surber sampler, bucket	http://www.kc-denmark.dk/public_html/surber.htm
	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
Plants	visual search	note visible plants within certain area ie. full river mark, high water mark; for qualitative ananlysis	variable depending on area searched	$0	land, lakes, rivers, wetlands	minimal	yes		
	transects	used to control sample area to quantify and standardize data	1-5 hours	$0	land, river, lake, wetlands	knowledg of establishing transects	yes	measuring tape, flagging	http://www.npws.nsw.gov.au/wildlife/cbsm.html
	quadrants	used to control sample area even more so than transects to quantify and standardize data; can do more in depth data analysis	1-5 hours	$0	land, river, lake, wetlands	knowledg of establishing quadrants	yes	measuring tape, flagging	
	random sampling	qualitative, more unbiassed than a visual search	1-5 hours	$0	land, river, lake, wetlands	knowledge of making random samples	yes	nothing	
	scuba diving	allows plants in deep water to be accessed	30-40 minutes	cost of equipment	river, lakes	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 nesting sites	appropriate for aquatic mammals that nest on land	1-5 hours	$0	land	knowledge of nesting habitats	yes	nothing	
	transects	quantifies data if there are many sightings	1-5 hours	$0	river, lakes, wetlands	knowledg 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	cost of hiring an airplane	Anyr5es4wa`	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	$0	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
Water Quality	pH, O2, fecal coliform, temperature and flow rate, total solids, turbidity, nitrates, BOD, phosphate, turbidity, etc.	measures physical and chemical factors that affect biodiversity and biotic integrity	depending on test, can take minutes to days	variable	lakes, rivers, wetlands	experience in sampling techniques and laboratory testing	yes	viles, necessary lab equipment	http://www.geocities.com/RainForest/Vines/4301/tests.html

All methods presuppose an ability to identify organisms to the species level with or without a guidebook