ASSESSMENT OF WETLAND ECOLOGICAL CONDITION AND SOCIO-ECONOMIC IMPORTANCE:

AN ANNOTATED BIBLIOGRAPHY

Report to the
Water Research Commission
by

HL Malan, JA Day and SM Marr

Freshwater Research Unit,
University of Cape Town

WRC Report no. KV 172/05
ISBN: 1-77005-396-4
Set: 1-77005-394-8

DECEMBER 2005

This Report is obtainable from:

Water Research Commission
Private Bag X03
Gezina Pretoria 0031
SOUTH AFRICA

This report emanates from the WRC research consultancy K8/590 titled:
STRATEGIC OVERVIEW OF THE RESEARCH NEEDS
REGARDING WETLAND HEALTH AND INTEGRITY

PREFACE

This annotated bibliography arose as a product of a Water Research Commission project titled "Strategic overview of the research needs on wetland health and integrity". An interagency collaborative programme to address the shortfalls in the current understanding of wetland ecological functioning and management methods was launched in 2003. The agencies involved are the Water Research Commission, the Department of Environment Affairs and Tourism, Department of Water Affairs and Forestry, the Department of Agriculture, the Department of Minerals and Energy and the Mondi Wetlands Project. The overarching objective of the Wetlands Research Programme is (WRC 2003; "Wetland research: a description of an interagency collaborative programme." Draft document. Water Research Commission, Pretoria").

"*To develop a sound scientific and technical foundation to promote conservation and sustainable use of wetlands through a systematic and effective rehabilitation programme*"

The Wetlands Research Programme consists of three major sub-programmes:

- Rehabilitation
- Wetland health and integrity
- Wise use

The WRC project that gave rise to this bibliography falls under the second point above, and was part of a scoping exercise to optimize this section of the research programme. Wetland biological and ecological integrity, and in particular the ability to assess and measure those attributes, are essential components of wetland management. It is only by being able to monitor wetland ecological integrity that it can be established if rehabilitation efforts are achieving the desired goal, or that a wetland is being utilized wisely. Wetlands are complex both in terms of ecological functioning as well as the stresses and demands humans make on them. Consequently, many aspects of need to be assessed to establish their health and integrity and there is a considerable body of literature around this topic.

At the same time that this annotated bibliography was being initiated, a literature review, commissioned by DWAF, focusing to a large extent on biotic indices that can be used to assess wetland condition was produced. The literature review is titled "DWAF (2004) *Development of a framework for the assessment of wetland ecological integrity in South Africa. Phase 1: Situation Analysis"* and was compiled by Dr Mandy Uys (Laughing Waters, East London, *pers. comm*. Sept 2004). The above document forms a very useful introduction to the subject of the assessment of wetland ecological health. It presents the current situation in this field, both in South Africa, as well as internationally. The present annotated bibliography is designed to complement the report of Uys and colleagues. It provides a list of relevant sources on wetland assessment, including those included in DWAF (2004). In line, however, with the Terms of Reference of the project, a wider range of topics is covered in the bibliography. Papers that present methods for assessing the socio-economic importance of wetlands, for instance, are also included. Furthermore, with regard to assessment of ecological condition, a wide range of methods have been incorporated into the bibliography. These range from the "hydrogeomorphic approaches" which look at wetland functioning, simple assessments of habitat degradation and anthropogenic activities in the catchment which impact on wetlands, to bioassessment using a variety of faunal and floral groups to evaluate wetland condition. A few papers are also included which look at predicting the effect of landuse changes on wetland condition (which in a sense is the opposite of assessing the present condition or status of a wetland). Other papers evaluate wetland mitigation success (i.e., the creation of wetlands to replace those lost due to development).

Although the focus in South Africa (at least in the immediate future) is unlikely to be on the assessment of created wetlands, understanding these systems does help to give insight into the functioning of natural wetlands, and so such papers have been included. A few of the documents tackle the assessment of ecosystem health at the level of the individual organism or biochemical/sub-cellular level. These papers are indicated by the use of the keyword "bioassay". There is a wealth of research on this topic, although in general they are not specific to wetlands and for this reason only a few have been included in this bibliography.

Source of references

The papers included in this bibliography were obtained during a literature search conducted during July – Nov 2004 at the University of Cape Town. The literature search was fairly comprehensive, but because this is a rapidly expanding field of research, it was by no means exhaustive, and although many of the papers on wetland assessment techniques should have been captured, some are likely to have been omitted. A list of the keywords that were used in the search is given below in addition to the electronic databases that were found to be the most useful. This information is included to aid in subsequent updates of the bibliography. The literature search was confined to papers including the word "wetland/s" in the title or abstract. Assessment techniques or studies carried out on rivers or marine systems were excluded unless they showed particular applicability to freshwater wetland systems.

The keywords used in the literature search were:
Wetland* and

- Biotic integrity
- Ecological condition
- (Bio)- assessment methods
- (Bio)-monitoring
- indices of ecological health/integrity
- habitat assessment
- biotic assessment
- evaluation
- ecological integrity index
- bioindicators

In addition to ecological assessment, methods to assess the sociological and economic importance of wetlands were also accessed using the following keywords:
Wetland* and

- social/economic/socio-economic
- importance
- assessment
- evaluation

All databases within the UCT library science journal database were searched. The ones that were found to be the most successful were:

- ISI web of Science
- Biblioline: Aquatic biology, Aquaculture and fisheries resources. Water resources worldwide and Africa. NISC international
- Lexis Nexis Environmental database
- Science Direct
- Bookfind online
- EBSCOhost

Searches were also carried out on the Internet.

There are also several recent South African initiatives towards the assessment of wetland condition (for example the "Wetland Health Assessment Technique"of MacFarlane *et al*.), which have not as yet been published. These have been summarised from information supplied by the authors/developers and are included in the bibliography as "personal communications".

Layout and format of this document

Each paper/literature source has been entered into this bibliography in the format as shown below (although not all fields are relevant to each record and therefore will not always be shown):

Reference Type: (e.g. book, journal, conference proceedings, personal communication).
Record Number:
Author:
Year: (Year of publication of document, or year of conference).
Title:
Series Title:
Conference Name:
Conference Location:
City:
Address: (Contact details of authors, if available).
Publisher:
Number of Pages:
Source: (The electronic database from which the abstract was extracted).
Keywords:
Abstract: (If available).
Notes: (If relevant).

The references are entered alphabetically (under the primary author). Keywords for each reference have been chosen and refer to those listed in the index of this bibliography. An abstract of the work is included wherever possible. This abstract was supplied either by the publishing journal (and supplemented by the present authors if deemed necessary) alternatively, if no abstract was available, the present authors summarized the paper. In some cases, it was not possible to get hold of a copy of the original paper, or the abstract was not available over the Internet. Several abstracts came from papers presented at conferences for which a full-length paper is unavailable. Where possible the address of the (primary) author has been included in such cases so that they can be contacted for further information.

Where relevant, notes are also given at the end of the paper.

It should be noted that these comments are subjective and are related to the applicability of the work to the South African research programme on wetland health and integrity. They are in no way a comment on the overall validity of the research findings related in the paper.

ABSTRACTS
(IN ALPHABETICAL ORDER OF PRIMARY AUTHOR)

Reference Type: Conference Proceedings
Record Number: 1
Author: Abila, R.O.; Othina, A.
Year of Conference: 2004
Title: A socio-economic assessment of Yala wetland fisheries (Kenya).
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Kenya Marine and Fisheries Research Institute, P.O. Box 1881, Kisumu, Kenya.
Keywords: Africa, fish, resource economics, social importance.
Abstract: The Yala Swamp, measuring 17,500 ha, is located in Kenya, with its western end bordering Lake Victoria. It is Kenya's largest fresh water wetland, and has three small lakes within the wetland boundary, namely; Kanyaboli (10.5 square km), Sare (5 square km) and Namboyo (0.01 square km). This paper presents the results of an assessment of the socio-economic aspects of the Yala Wetland fisheries. It gives a profile of the fishermen and uses socio-economic approaches to assesses the status of the fisheries, giving estimates of the yield, catch effort level, effort costs and, using market prices, the value of the fisheries. The fish marketing channels are also discussed. Data and information have been obtained from both primary and secondary sources. They include a socio-economic survey in lakes Kanyaboli and Sare, both in Yala Wetland, in which 40 randomly sampled fishermen, fish traders and other stakeholders were interviewed using questionnaires, key informant interviews and participatory methods. This is complemented with analysis of data from relevant published and unpublished papers, technical reports on Yala Wetland and some historical data from existing databases. Besides presenting a socio-economic perspective on Yala Wetland fisheries, this paper provide a useful basis of comparing and assessing the validity of results obtained from purely ecological surveys.

Reference Type: Journal Article
Record Number: 2
Author: Acharya, G.
Year: 2000
Title: Approaches to valuing the hidden hydrological services of wetland ecosystems.
Journal: Ecological Economics.
Volume: 35
Issue: 1
Pages: 63-74
Keywords: Africa, functional assessment, resource economics.
Abstract: This paper investigates the role of the production function approach in capturing the value of hydrological services of wetland ecosystems. Hydrological research in the Hadejia-Nguru wetlands in northern Nigeria suggests that the major role of the wet season inundation of the wetlands is in recharging the underlying aquifers. This paper shows that the hydrological services extend beyond direct use values, and have a significant economic value associated with them. Whereas the direct benefits provided by the wetlands, such as floodplain agriculture, fishing and forestry, have previously been assessed, this paper synthesizes the results of two approaches to capture the value of indirect benefits derived from the role of the wetlands in replenishing and maintaining groundwater resources within the wetland area. It concludes that the economic value of ecological functions in sustaining the livelihood and cultures of human societies cannot be disregarded in development and conservation policy.
Notes: This appears to be a key paper for assessing the economic value of wetlands in Africa.

Reference Type: Report
Record Number: 3
Author: Acreman, M.C.; Miller, F.M.
Year: 2004
Title: Impact assessment on Wetlands: Focus on hydrological and hydrogeological issues.
Keywords: European Union, impact assessment, management, U.K.
Abstract: This technical report covers Phase 1 of a two part scoping study. The objectives of Phase 1 were to identify basic and applied research needs that are required in order to be able to assess the impact of anthropogenic activities such as water abstraction, operation of sluices, drainage on the hydrology and ecology of individual wetlands. By means of questionnaires and meetings held with staff of the Environment Agency (United Kingdom) problems in current practices of wetland assessment and research needs were identified. The issues raised fell into 8 main areas: 1. Many impact assessments are hampered by lack of conceptual understanding of how wetlands work hydrologically. 2. Assessment objectives are not always clear. 3. There is a lack of wetland monitoring data. 4. Although many tools are available to interpret wetland data, it is not clear when and how these should be used. 5. There is no currently agreed procedure in the Environment Agency for impact assessment of wetlands, nor (6.) for when restoration is appropriate. 7. Wetland projects are multi-disciplinary and require funding from a range of organization. 8. It is not always easy to find relevant information and best practice guidelines. Key recommended areas for research include: -relationships between plant communities, soil moisture and micro-topography. -evaporation processes in grasses, reeds and wetland trees. -hydraulic connectivity between aquifers and wetlands. -methods and tools for restoring wetlands. -conceptualising and modeling connectivity between aquifers and wetlands. -the role of wetland functions in achieving 'good ecological status' of the Water Framework Directive.
Notes: Not particularly useful with regard to the development of assessment methods, but some background information.
URL: http://www.eareports.com/ea/rdreport.ns

Reference Type: Book Section
Record Number: 4
Author: Adamus, P.R.
Year: 1988
Title: The FHWA/Adamus (WET) method for wetland functional assessment.
Editor: Hook, D.D., (*et al*.)
Book Title: The Ecology and Management of Wetlands. Volume 2: Management, Use and Value of Wetlands.
City: Portland, OR.
Publisher: Timber Press.
Pages: 128-133.
Source: BiblioLine
Keywords: Functional assessment, USA.
Abstract: Many laws in the United States, require that the decision of whether to preserve or develop a specific wetland be based also on the wetlands ability to improve water quality, stabilize shorelines, exchange groundwater, retain floodwaters or to provide recreation. However people in government who make these decisions are seldom trained in all these topics or functions. In response to this a wetland rapid assessment method has been developed that is usable by any environmental professional. This paper describes the WET functional assessment methods for wetlands. It attempts to make decision making explicit, accountable, objective and systematic. A very brief description of the method is given including the different assessment levels and a copy of the field scoring sheet.
Note: This paper was extracted from a two-volume work presenting selected papers from a symposium on wetlands organised by the International Society of Anaerobiosis, held in June 1986 in Charleston, South Carolina. Volume one covers the general ecology of wetlands,

whereas volume two covers more applied topics. This book is available in South Africa, but is rather dated. See also other records below by Adamus.

Reference Type: Book
Record Number: 5
Author: Adamus, P.R.; Batie, S.; Darnell, R.; Famous, N.; Hynson, J.
Year: 1983
Title: Method for wetland functional assessment.
Series Title: Federal Highway Administration assessment method.
City: South Gardiner, ME (USA).
Publisher: Center for Natural Areas.
Number of Pages: 141pp
Source: BiblioLine
Keywords: Functional assessment, USA.
Abstract: The manual provides a rapid assessment procedure for screening functional values of wetlands. Functions covered include groundwater recharge and discharge, flood storage and desynchronization, shoreline anchoring and dissipation of erosive forces, sediment trapping, nutrient retention and removal, food chain support (detrital export), habitat for fish and wildlife, and active and passive recreation. The method can be used for all wetland types in the 48 coterminous states, and uses the U.S. Fish and Wildlife Service definition and classification scheme. The method also can be used to evaluate functions of many rivers and lakes.
Notes: This (and other documents by Adamus) represent the seminal research carried out by this author and co-workers on assessing the functioning of wetlands. Many methods, including the South African "Wetland-Assess" (Kotze *et al.* 2004) have evolved from this.

Reference Type: Book
Record Number: 6
Author: Adamus, P.R.; Clairain, E.J.; Smith, D.; Young, R.E.
Year: 1987
Title: Wetlands research program. Wetland evaluation technique. Volume 2. Methodology.
Series Title: Technical Report. U.S. Army Engineer waterways experiment station.
Volume: 2
Number of Pages: 262pp
Source: BiblioLine
Keywords: Functional assessment, resource economics, social importance, USA.
Abstract: This manual outlines a Wetland Evaluation Technique (WET) for the assessment of wetland functions and values. WET is a revision of the method developed for the Federal Highway administration (FHWA) that has often been referred to as the Federal Highway Method or the Adamus Method. Wetland functions are the physical, chemical, and biological characteristics of a wetland. There are several different modules in the method. "Wetland" evaluates: ground water stabilization, sediment/toxicant retention, nutrient removal/transformation, production export, wildlife diversity/abundance, aquatic diversity/abundance, uniqueness/heritage, and recreation. "WET" evaluates functions and values in terms of social significance, effectiveness, and opportunity. "Social significance" assesses the value of a wetland to society in terms of its special designations, potential economic value, and strategic location. "Effectiveness" assesses the capability of a wetland to perform a function because of its physical, chemical or biological characteristics. "Opportunity" assesses the opportunity of a wetland to perform a function to its level of capability.
Notes: The evaluation method makes use of structured questions which are then used in a computerised Decision Support System (a stiffy disk is included). Note that socio-economic aspects are also considered. See other records by Adamus.

Reference Type: Book
Record Number: 7
Author: Adamus, P.R.; Clairain, E.J.; Stockwell, L.T.; Morrow, M.E.; Rozas, L.P.
Year: 1991
Title: Wetlands research program. Wetland evaluation technique. Volume 1. Literature review and evaluation rationale.
Series Title: Wetlands Res. Program Rep. U.S. Army Eng. Waterways.
Volume: 1
Number of Pages: 299pp
Source: BiblioLine
Keywords: Functional assessment, USA.
Abstract: This is volume 1 of a two-volume manual on the Wetland Evaluation Technique. Volume 1 provides a detailed review of 11 functions and values commonly ascribed to wetlands, including ground water recharge and discharge, floodflow alteration, sediment stabilization, sediment/toxicant retention, nutrient removal/transformation, production export, aquatic diversity/abundance, wildlife diversity/abundance, recreation, and uniqueness/heritage. Each function is examined with respect to important processes and interactions with other functions. Volume 1 also cites reference material for predictors of these wetland functions as used by the Wetland Evaluation Technique in Volume 2.
Notes: It is not clear if this is an update of, or the first volume to, the previous manuals. (Record no. 6)

Reference Type: Report
Record Number: 8
Author: Adamus, P.R.; Brandt, K.
Year: 1998
Title: Impacts on quality of inland wetlands of the United States: A survey of indicators, techniques, and applications of community-level biomonitoring data.
City: Corvallis, Oregon.
Institution: US EPA Environmental Research Station.
Report Number: EPA600/3-90/073
Source: DWAF (2004)
Keywords: Bioassessment, biocriteria, microbes, stressor effects, USA.
Abstract: Based on a synopsis of the literature prior to 1990, this report describes the potential effects upon wetland community structure of eutrophication, organic loading, contaminant toxicity, acidification, salinization, sedimentation, turbidity/shade, vegetation removal, thermal alteration, dehydration, inundation, and fragmentation of habitat. Information is provided concerning the effect of each stressor on potential indicators of wetland condition, such as microbes, algae, vascular plants, invertebrates, fish, amphibians, reptiles, birds, mammals, and selected biological processes. This report identifies data gaps and provides guidance that describes how ambient biological criteria for wetlands might be developed or modified, and how wetlands might be periodically sampled to estimate their relative ecological condition.
Notes: This is a useful document, although at the time of this review only excerpts were available from the website.
URL: http://www.epa.gov/owow/wetlands/wqual/introweb.html

Reference Type: Report
Record Number: 9
Author: Adamus, P.R.; Danielson, T.J.; Gonyaw, A.
Year: 2001
Title: Indicators for monitoring biological integrity of inland, freshwater wetlands. A survey of North American technical literature (1990-2000)
City: Washington D.C.
Institution: USA Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds.
Source: DWAF (2004)
Keywords: Algae, amphibians, bioassessment, birds, fish, invertebrates, microbes, plants, review, USA.
Abstract: This document has been written for wetland managers, researchers, and monitoring specialists. For wetland managers, it serves as a resource for identifying and understanding biological impacts that could result from regulated and unregulated activities in wetlands. For researchers and monitoring specialists, it facilitates interpretation of collected data by providing a context of what we already know. In preparing this, our sole focus has been to update a literature review on the same topic sponsored and published previously by the USEPA (Adamus and Brandt, 1990). As such, this document is not intended as stand-alone guidance for persons wishing to learn how to develop wetland biomonitoring programs, or for persons seeking to prioritize research.

For additional wetland monitoring information, databases, publications, and guidance, readers should see: http://www.epa.gov/owow/wetlands/bawwg/. This document has the following primary foci: · Literature from the period 1990-2000. · Literature from North American wetlands. · Literature from inland freshwater wetlands. · Literature on impacts to assemblages of species, rather than single species · Literature in peer-reviewed journals is referenced almost exclusively. Not every paper fitting the above descriptions could be reviewed. However, we believe this document -- based on review of over 1500 publications -- covers a majority of the relevant literature. The largest numbers of publications are cited in the Invertebrates and Vascular Plants sections of this document, but for these two topics we also excluded the largest numbers of relevant papers, due to limited time for review relative to the enormous number that were published in the last decade. The past decade has seen predictable diversification of wetland research into an enormous array of subdisciplines and subtopics. Our approach in preparing this document has been to emphasize wide coverage of the wetlands biological literature, rather than cover any particular topic or subtopic in depth. Because of the enormous number of studies that have been published, time constraints, and our stated goals for the effort, we have sought primarily to organize the recent literature in a helpful way, not to interpret or synthesize it. The document is structured around 11 categories of human-related disturbances to which wetlands are commonly exposed, and the effects of these "stressors" on the following groups, each the focus of a separate section: microbes, algae, vascular plants, invertebrates, fish, amphibians, and birds. This document does not attempt to summarize our understanding of each combination of stressor and biological group, but instead simply describes literature published since 1989 on each pairing of stressor with biological group. In addition to addressing the above for each biological group, this report briefly summarizes published information most relevant to monitoring the particular group. Within each group and under a subheading "Wetland Monitoring," recent information is compiled on spatial and temporal variation, techniques and equipment for monitoring the group, and biological metrics that have or have not been found to correlate with individual or cumulative disturbances to wetlands. Ideally, it would be best to separate the published results by wetland type (e.g., Cowardin class, hydrogeomorphic class). Due to the lack of information on many groups, however, it was not practical to do so in this document. Thus, readers should be cautious when attempting to extrapolate the reported results.
Notes: A key starter document. See also previous record by Adamus *et al.* which summarises the literature prior to 1990.
URL: http://www.epa.gov/owow/wetlands/bawwg/monindicators.pdf

Reference Type: Book
Record Number: 10
Author: Adaya, A.L.; Bdliya, H.; Bitrus, H.; Danjaji, M.; Eaton, D.; Gambo, M. B.; Goggobe, M.; Makinta, A.; Okali, D.; Omoluabi, A.D.; Polet, G.; Salisu, M.; Sanusi, S.S.; Sarch, M.T.; Shuaibu, M.
Year: 1993
Title: Local-level assessment of the economic importance of wild resources in the Hadejia-Nguru Wetlands, Nigeria.
Series Editor: International Institute for Environment and Development.
Series Title: Research Series - International Institute for Environment and Development, UK.
City: London, UK
Publisher: International Institute for Environment and Development.
Volume: 3 (3)
Keywords: Africa, resource economics, rural livelihoods.
Abstract: The results of a field study undertaken in the Hadejia-Nguru Wetlands in northern Nigeria during 1995 are presented. The study covered two aims: to strengthen the capacity of local organizations working in the Hadejia-Nguru Wetlands in conducting resource valuation at a community level. The project consisted primarily of a training workshop lasting three weeks in July 1995 and involving 13 participants from a range of conservation, development and academic organizations. Through the workshop and its associated field study, the participants undertook the second objective: to assess the economic importance of the major wild resources harvested from within the Wetlands using participatory appraisal techniques. The report is divided into four chapters: an introductory chapter describes the objectives of the study the 'Hidden Harvest' project and the principal organizations involved in the study. It also provides some background to issues of wild resource use in the region and gives an overview of the methodology used and the research questions addressed. The second and third chapters provide detailed results from the two villages studied. Chapter four provides a more general synthesis of the role of wild resources in the economy of the Wetlands.
Notes: See also Acharya (2000).

Reference Type: Journal Article
Record Number: 11
Author: Agnello, G.; Manneville, O.; Asta, J.
Year: 2004
Title: Mosses and lichens as bioindicators of a wetlands state: example of four protected areas in the Isere Department (France).
Journal: Revue d Ecologie- La Terre et La Vie.
Volume: 59
Pages: 147
Source: ISI Web of Science
Keywords: Bioassessment, European Union, lichens, mosses.
Abstract: In four protected wetland areas of the department of Isere (marshes and alluvial forests), epiphytic lichens and bryophytes were studied in order to evaluate the floristic diversity (inventories and relations with plant communities) and set a monitoring programme of the diffuse atmospheric pollution (by analysis of Cl, N, P, Hg, Pb contents). The diversity of these cryptogams is lowered whereas, especially for lichens, the percentage of nitrophilous species augments with increasing anthropization and eutrophization. The important sensitiveness of these groups of plants to environmental changes would permit to use them to adapt conservation management and also to foresee some ecosystem alterations not easily detected by the mere observation of vascular plants. In spite of a low number of analyses, results of the present study show a low total pollution, except for a trend towards contamination by phosphorus in agricultural areas and by nitrogenous compounds nearly everywhere. It will be necessary to increase measurements in these four areas and extend them to other areas, in order to develop a biomonitoring network.

Notes: Full paper not available. Not clear if available in English or French. Potentially useful - few other papers have been found during this literature review that use this floral group as indicator species.

Reference Type: Conference Proceedings
Record Number: 12
Author: Anderson, J.T.; Balcombe, C.; Fortney, R.; Kordek, W.
Year of Conference: 2004
Title: Biotic response to wetland mitigation methods.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: West Virginia University, Division of Forestry, Wildlife and Fisheries Resources Program, PO Box. 6125, Morgantown, WV 26506-6125, USA.
Keywords: Amphibians, bioassessment, birds, invertebrates, plants, USA.
Abstract: Most studies evaluating wetland mitigation success (i.e., the creation of wetlands to replace those lost due to development) have focused on hydrology, soils, and vegetation. However, studies evaluating wildlife populations, invertebrates, plant communities, soils, hydrology, and construction design simultaneously have been few. We evaluated invertebrate, plant, avian, and anuran communities, habitat suitability, soil nutrients, hydrology, and construction design for 11 mitigation and 4 reference wetlands throughout West Virginia, USA. Mitigated wetlands were created by either impounding surface water or by excavating to intercept the water level. Avian species richness, diversity, and abundance were similar between mitigation and reference wetlands ($P > 0.05$). However, waterbird and waterfowl abundance were higher in mitigation than reference wetlands ($P < 0.05$). Anuran species richness, call intensity, and abundance also were higher in mitigation than reference wetlands ($P < 0.05$). Plant species richness, evenness, and diversity were higher in mitigation than reference wetlands ($P < 0.05$). Overall macroinvertebrate familial richness, diversity, density and biomass were similar between mitigation and reference wetlands ($P > 0.05$), but individual taxa varied. Soil parameters varied between construction methods, but the construction method used was generally appropriate for the site. Wildlife, plant, and invertebrate communities are different from natural wetlands and also vary by construction method. Differences in hydrology appear to be the driving factor for these differences in biotic communities.
Notes: It would appear that whilst abundance and even species richness is as high in the created wetlands as at the reference sites, there are differences in the species found. This would have implications for conservation of rare species.

Reference Type: Conference Proceedings
Record Number: 13
Author: Assogbadjo, A.E.; Sinsin, B.; Missikpode, A.
Year of Conference: 2004
Title: Impact of local populations economical activities on the functioning and ecology of the swamp forest of Lokoli in Benin (West Africa).
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Laboratory of Applied Ecology, FSA-UAC, Cotonou, Benin.
Keywords: Africa, resource economics, rural livelihoods.
Abstract: The study was carried out in the swampy forest of Lokoli in Benin. It has shown the impact of economical activities of the bordering population on the functioning and ecology of the forest. A total of 64 individuals were surveyed for the different economical uses study, their impact and per-hectare forest potential values. Furthermore, the structure, dynamic and biological diversity of different stand types were studied on the basis of phytosociological survey. Results show that a professional fisherman, hunter and carpenter

can earn monthly the equivalent of US$ 15, US$165 and US$195 respectively from the forest activities. The forest supply of polewood is valued to US$4 440/year and that for building has a value US$4 435/year. Extraction of alcohol from *Raphia hookeri* provided for the 165 people involved in this activity the total amount of US$279 685 per year. These activities have some negative consequences on the functioning of the forest. In fact, three stands types were identified in the forest along gradient degradation. All these stands present low species richness and the Shannon diversity indices varies from 2.43 to 2.99 with a strong Pielou Equitability values. Stands types density vary from 383 stems/ha in the degraded dense forest to 600 stems/ha in the intact dense forest. Basal area of different groupings studied increased from the degraded forest to the dense one from 91.41 to 150.59 m3/ha and the diameter of the average basal area varies from 56.99 to 59.5 from the dense to the degraded forest.

Reference Type: Book
Record Number: 14
Author: Atkins, H.G.
Year: 2003
Title: Scoping study on guidance for the monitoring of wetlands under the requirements of the Water Framework Directive.
Series Title: Environment Agency R & D Technical Summary EMC(02)01TR.
Keywords: European Union, management, monitoring, UK.
Abstract: Current EU guidance documents and R&D work sponsored by the Environment Agency were studied to identify the position of wetlands within the Water Framework Directive given that discussion on guidance for the Directive was still ongoing. The habitats classification scheme of the Habitats Directive was used to type the range of wetlands within the U.K. if they could be classified as a wetland under the Ramsar definition. The water related factors included both water quantity and water quality. Guidance is given on monitoring wetlands along with an assessment of the monitoring currently being undertaken. There was a lack of coordination and guidance for undertaking monitoring and uncertainty over data analysis techniques to highlight trends. Recommendations are given to overcome these problems for future work.
Notes: Not of direct relevance to the assessment of wetland ecological condition, but gives background information on monitoring. Full document can be ordered from website below.
URL: http://www.eareports.com/ea/rdreport.ns

Reference Type: Book
Record Number: 15
Author: Barbier, E. B.; Acreman, M. C.; Knowler, D.
Year: 1996
Title: Economic valuation of wetlands: a guide for policy makers and planners.
City: Gland, Switzerland.
Publisher: Ramsar Convention Bureau.
Keywords: Impact assessment, resource economics, review.
Abstract: The aim of this book is to provide guidance to policy makers and planners on the potential for economic valuation of wetlands and how such valuation studies should be conducted. Although a number of economic valuation studies of wetlands have been undertaken around the world and economists have developed methodologies for valuing more intangible aspects of the environment, such as amenity or aesthetic factors, no one has synthesised from this literature a common approach to show its overall usefulness to wetland management worldwide. Consequently, this book provides details of the various techniques and examples of wetland valuation studies together with guidance on planning and managing a study and putting the result into a wider decision-making framework. Wetlands are amongst the Earth's most productive ecosystems. They have been described both as "the kidneys of the landscape", because of the functions they perform in the hydrological and chemical cycles,

and as "biological supermarkets" because of the extensive food webs and rich biodiversity they support. In Chapter 1, the features of the system are grouped into components (soil, water, plants and animals), functions (nutrient cycling and groundwater recharge) and attributes (biological diversity). Chapter 2 explains the role of valuation in decision-making. Many development decisions are made on economic grounds. By providing a means for measuring and comparing the various benefits of wetlands, economic valuation can be a powerful tool to aid and improve wise use and management of global wetland resources. In the past, wetlands have been undervalued because many of the ecological services, biological resources and amenity values they provide are not bought and sold and hence are difficult to price. In Chapter 3, an appraisal framework is developed for assessing the net economic benefits of various wetland use options. Stage one of the framework involves determining the overall objective or problem and choosing the correct economic assessment approach from three broad categories, i.e., impact analysis, partial valuation or total valuation. Stage two requires definition of the scope and limits of the analysis and the information required for the chosen assessment approach. Stage three necessitates determining the evaluation techniques and data collection methods required for the economic appraisal including any analysis of distributional impacts. To guide the policy maker on how to undertake a wetland valuation study, six examples are given in Chapter 4. These are: the Hadejia-Nguru floodplain in northern Nigeria; prairie wetlands in North America; the Norfolk Broads and Scottish flow country in the UK; nitrogen abatement using Swedish wetlands; coastal wetlands in southeastern USA and mangrove conservation in Indonesia. These case studies provide practical demonstrations of the use of various valuation methods in the field, in different types of wetlands, using a range of valuation methods and covering diverse geographical areas. Although their coverage cannot be claimed as exhaustive, several observations emerge from reviewing these studies. First, the importance of integrating ecological and economic approaches is critical, especially when the valuation of ecological functions is the objective. This requires more than complex mathematical techniques, but extends to continual collaboration between economists and ecologists. The studies also demonstrate that valuation should not be conceived of as an end in itself, but needs to be directed towards some policy issue. These issues may range from simply raising awareness of the importance of wetlands to choices among alternatives to meet some stated policy goal, with protecting wetlands representing just one option. Chapter 5 provides guidance on planning and conducting a study. These include a seven-step guide to undertaking a study. The steps are: choosing the appropriate assessment approach; defining the wetland area; identifying and prioritising components, functions and attributes; relating these components, functions and attributes to use value; identifying and obtaining information required for assessment; quantifying the economic values; and putting the economic values in the appropriate framework (e.g., cost-benefit analysis). Guidance is also given on resources needed and on compiling Terms of Reference for technical consultants using a fictitious example of a floodplain in Africa. In addition, emphasis is placed upon the need to consider other factors (political, social, historical or ecological), which may be considered alongside the economic valuation results when a decision is being made. Finally, an alternative methodology for decision-making is presented where rare species are at risk. In Chapter 6, recommendations are made for future actions. These highlight the need to: undertake site-specific economic valuation studies; ensure appropriate interdisciplinary collaboration; provide training and institutional capacity building; undertake research on economic valuation theory and practice; and establish networks for the exchange of ideas and experience of applying valuation methods. After the main text there is a glossary of terms, a list of references and further reading. The appendices contain details of different wetland components, functions and products; a table comparing economic appraisal methods; and a table detailing advantages and disadvantages of valuation techniques used in the economic appraisal of wetlands.

Notes: This is a key document for valuing the "goods and services" produced by an individual wetland.

URL: http://www.ramsar.org/lib_valuation_e.htm

Reference Type: Journal Article
Record Number: 16
Author: Barbier, E.B.
Year: 2000
Title: Valuing the environment as input: Review of applications to mangrove-fishery linkages.
Journal: Ecological Economics.
Volume: 35
Issue: 1
Pages: 47-61
Keywords: Fish, resource economics.
Abstract: The following paper reviews recent developments in the methodology for valuing the role of wetlands in supporting economic activity. The main focus will be on mangroves serving as a breeding ground and nursery habitat in support of coastal and marine fisheries. As this particular ecological function of a mangrove system means that it is effectively an unpriced 'environmental' input into fisheries, then it is possible to value this contribution through applying the production function approach. The first half of the paper overviews the procedure for valuing the environment as an input, applied to the case of a wetland supporting a fishery. Both the 'static' Ellis–Fisher–Freeman approach and the 'dynamic' approach developed by Barbier and Strand, incorporating the intertemporal bioeconomic fishing problem, are reviewed. The second half of the paper discusses briefly two recent case studies of mangrove-fishery valuation. An application in South Thailand, which is based on the static Ellis–Fisher–Freeman model, and an application in Campeche, Mexico, which is based on the dynamic approach.

Reference Type: Report
Record Number: 17
Author: Barbour, M.T.; Gerritsen, J.; Snyder, B.D.; Stribling, J.B.
Year: 1999
Title: Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates and fish.
City: Washington D.C.
Institution: US EPA Office of Water.
Report Number: EPA 841-B-99-002.
Source: DWAF (2004)
Keywords: Algae, bioassessment, fish, invertebrates, USA.
Abstract: In December 1986, U.S. EPA's Assistant Administrator for Water initiated a major study of the Agency's surface water monitoring activities. The resulting report, entitled "Surface Water Monitoring: A Framework for Change" (U.S. EPA 1987), emphasizes the restructuring of existing monitoring programs to better address the Agency's current priorities, e.g., toxics, nonpoint source impacts, and documentation of "environmental results." The study also provides specific recommendations on effecting the necessary changes. Principal among these are: 1. To issue guidance on cost-effective approaches to problem identification and trend assessment. 2. To accelerate the development and application of promising biological monitoring techniques. In response to these recommendations, the Assessment and Watershed Protection Division developed the rapid bioassessment protocols (RBPs) designed to provide basic aquatic life data for water quality management purposes such as problem screening, site ranking, and trend monitoring. Although none of the protocols were meant to provide the rigor of fully comprehensive studies, each was designed to supply pertinent, cost-effective information when applied in the appropriate context. As the technical guidance for biocriteria has been developed by EPA, states have found these protocols useful as a framework for their monitoring programs. The implementation by state water resource agencies has contributed to refinement of the original RBPs for regional specificity. This

revision reflects the advancement in bioassessment methods since 1989 and provides an updated compilation of the most cost-effective and scientifically valid approaches.
Notes: Although this report is concerned principally with rivers and streams, rather than wetlands, it does present some useful background information. A comparison between biosurveys, bioassays and chemical monitoring is given. Practical advice on sampling methods and habitat assessment is provided.
URL: http://www.epa.gov/owow/monitoring/rbp/wp61pdf/

Reference Type: Journal Article
Record Number: 18
Author: Barbour, M.T.; Yoder, C.O.
Year: 2000
Title: The multimetric approach to bioassessment, as used in the United States of America.
Journal: Freshwater Biological Association.
Pages: 281-292
Source: BiblioLine
Keywords: Algae, bioassessment, fish, invertebrates, USA.
Abstract: The multimetric approach to bioassessment is the technique most frequently used by the state water resource agencies in the USA, because it provides a means of integrating ecological information relating to the elements and processes of naturally functioning aquatic assemblages and our current knowledge about those relationships. The detection and evaluation of impairment from the various pollutant sources and other impacts attributable to human activities has required a technique that is (1) applicable to all waterbody types and different aquatic assemblages, (2) readily adaptable to state water resource protection programs, and (3) easily translatable to non-technical managers and the general public. The multimetric approach has been developed, to varying degrees, for streams, rivers, lakes, estuaries and wetlands, and for the periphyton, benthic macroinvertebrate and fish assemblages. It has been most universally applied to streams in the USA. More than 90% of the state water resource agencies use a multimetric approach. The translation of biological data into meaningful results and the subsequent communication to a non-technical audience have been enhanced by the use of multimetrics. Both the USEPA and several states have developed technical guidance for the development and implementation of a multimetric approach to bioassessment. While further development and refinement of multimetric strategies are warranted, this approach has been successfully implemented in the USA.
Notes: Gives insight into the development of biotic indices and how they should be combined to give a "multimetric" approach. Examples of metrics that could be used for periphyton, fish and benthic macroinvertebrates are included.

Reference Type: Journal Article
Record Number: 19
Author: Barbour, M.T.; Swietlik, W.F.; Jackson, S.K.; Courtemanch, D.L.; Davies, S.P.; Yoder, C.O.
Year: 2000
Title: Measuring the attainment of biological integrity in the USA: A critical element of ecological integrity.
Journal: Hydrobiologia.
Volume: 422/423
Pages: 453-464
Source: ISI Web of Science
Keywords: Bioassessment, biocriteria, USA.
Abstract: The concept of ecological integrity has become a worldwide phenomenon and is firmly entrenched into the regulatory structure of environmental law in the United States of America (USA). The attainment of ecological integrity requires the attainment of its three

elements: physical, chemical, and biological integrity. In the USA, measures of chemical integrity were implemented first into monitoring programs and were effective in reducing pollutant loadings to the nation's surface waters. Because biological communities integrate the effects of different stressors such as reduced oxygen, excess nutrients, toxic chemicals, increased temperature, excessive sediment loading, and habitat degradation, the advent of bioassessment in regulatory programs has provided a more comprehensive and effective monitoring and assessment strategy. Measures of biological integrity clearly have become a priority in the USA. The development of biological criteria (biocriteria) within regulatory programs to serve as thresholds by which to judge the attainment of designated aquatic life conditions of surface waters is a major focus of states and Indian tribes within the USA. The derivation of reference conditions for the nation's surface waters (i.e., streams, rivers, lakes, wetlands, estuaries, and marine waters) across different physiographic regions is a critical element in the design of biocriteria and is currently a primary initiative in the USA. Nearly all state water resource agencies have developed bioassessment approaches for streams; 1600 to 75 000 km of streams require assessment in each state. Bioassessment development for other water body types is not as advanced to date. The US Environmental Protection Agency (USEPA) has produced technical guidance for developing effective bioassessment programs; they include crucial elements such as defining objectives, classifying water bodies according to expected biological attributes, deriving the reference condition of the site classes, developing standardized protocols for sampling and data analysis, and implementing a quality assurance plan. Approaches to bioassessment in the USA follow a basic design of incorporating various attributes of the elements and processes of the aquatic community, which is either an aggregation into a multimetric index or a series of multivariate analyses using the attributes as input variables. The Clean Water Act of 1972 and its subsequent amendments mandate maintaining, restoring, and protecting the ecological integrity of surface waters. Through use of robust bioassessments and other measures of ecological integrity, the USA has developed a strategic plan to establish priorities to meet this goal.
Notes: Not specifically for wetlands, but does give general advice as to how to develop a multimetric index of aquatic resource integrity. A history of the development of ecological assessment and a case study indicating the value of bioassesment is given, although not the specific details of how to carry out an assessment.

Reference Type: Book
Record Number: 20
Author: Bartoldus, C.C.
Year: 1999
Title: A comprehensive review of wetland assessment procedures: a guide for wetland practitioners.
City: St Michaels, MD.
Publisher: Environmental Concern Inc.
Source: LexisNexis
Keywords: Bioassesment, functional assessment, review, USA.
Abstract: This publication is an invaluable reference document, essential to wetland scientists who are confronted with selecting and/or reviewing results of wetland assessment procedures. Not long ago, wetland assessment was simple, as there were only a few procedures from which to choose. Today, this process is complicated by the ever increasing number of procedures, differing approaches, and new terminology. This manual provides sufficient detailed information about 40 procedures to help the user determine which best meets their specific needs. For example, consultants and project managers can use it to identify procedures that are applicable to a particular wetland type, region, and/or function/value. It can also be used to obtain a quick overview of a particular procedure including the outline of the steps involved and examples of models. Thus, it is a valuable tool for regulators who are responsible for reviewing assessment results, but need a concise summary of how a procedure works. It can also be used by individuals who are developing

new procedures/models and are interested in incorporating aspects of the available methods. While similar reports have been prepared in the past, this Review differs in content and it contains the variety of recently developed assessment procedures. These include the HGM Approach, MNRAM, IBI, MDE Method, EPW, WRAP, PFC, IVA, and the Descriptive Approach. The primary purpose is to serve as a reference document for individuals seeking to decide what procedure applies to their particular project. The Review profiles each of 40 procedures by first identifying basic information (e.g. references, contact person, expertise needed, definitions of key terminology, applicable habitat types, list of function/values categories). This is followed by a 1-2 page outline that includes the procedure steps, sample of the model format, and time requirements. Several summary tables are provided at the end to facilitate a comparison of the procedures. These tables include geographic application, types of categories addressed, data requirements, procedure output (e.g., functional capacity, wetland quality), units of measure (e.g., functional capacity index, performance score), list of states where procedure has been applied, use on mitigation banks, and list of corresponding terminology. The Review was finalized and improved upon by incorporating comments received from the authors who reviewed information pertaining to their own individual procedures.
Notes: Not available in South African libraries. Can order from website below.
URL: http://www.umassextension.org

Reference Type: Conference Proceedings
Record Number: 21
Author: Bene, C.
Year of Conference: 2004
Title: Can improved valuation techniques for aquatic ecosystems and fisheries lead to improved management?
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Worldfish Center, Regional Office - Africa and West Asia Programme - Cairo, Egypt.
Keywords: Fish, resource economics, rural livelihoods.
Abstract: In November 2002, a panel of 8 international experts conducted a worldwide review on River Fisheries Valuation. Drawing upon this review and a special workshop held in association with the International Large River Symposium in Phnom Penh (February 2003), the panel concluded that in a significant number of developing countries in Africa, Asia or South America, governments and institutions have failed to design governance mechanisms and policy processes which truly encompass and account for the inspirations and needs of the rural populations depending upon inland aquatic resources for their livelihoods. Among the most important factors explaining this, is the failure to properly account for the contributions that inland aquatic resources play in providing income and nutrition to resource-poor households. This difficulty to adequately evaluate inland fisheries by the decision-makers is itself related, to a large extent, to the failure by academics and researchers to establish the true socio-economic values of these resources. The presentation will first discuss these various issues in the context of weak state and poor governance characterizing a large number of developing countries, and the consequences that these induce at the national level on the policy decision making processes and at the local level on the livelihoods of the populations. The presentation will then propose a review of the concepts and methods currently used for valuation of wetlands (and more generally natural resources) and discuss the potential roles and limits of these techniques in contributing to water management policy improvement.

Reference Type: Conference Proceedings
Record Number: 22
Author: Bertram, P.E.; Stadler-Salt, N.
Year of Conference: 2001
Title: Monitoring and research for indicators of Great Lake Ecosystem Health.
Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 6
Address: U.S Environmental Protection Agency, Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604.
Keywords: Indicators, lakes, USA.
Abstract: Through the SOLEC (State of the Lakes Ecosystem Conference) process, a suite of indicators has been identified as necessary, sufficient and feasible to assess the health of Great Lakes basin ecosystem components. The information generated is targeted toward making better management decisions concerning the restoration and maintenance of Great Lakes ecosystem health. Of the 80 indicators currently on the list, information was presented at SOLEC 2000 on 31 of the 43 indicators for which data are believed to exist. Funded projects are in place for the development and testing of 5 others. The remaining 32 indicators require further refinement of the indicator itself, identification and testing of methodology, data collection, establishment of monitoring programs, or other efforts to bring the information forward for reporting at SOLEC. Collaboration between research, monitoring, and management groups will facilitate the progression from indicator development, to implementation and reporting, to management decisions and activities.
Notes: Only abstracts available for this and the following record. Other work by these authors needs to be accessed to examine the list of indicators used.

Reference Type: Conference Proceedings
Record Number: 23
Author: Bertram, P.; Shear, H.; Horvatin, P.
Year of Conference: 2003
Title: Applying Great Lakes Indicators: Setting the stage.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 53
Address: U.S. EPA, Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604.
Keywords: Impact assessment, indicators, lakes, USA.
Abstract: At the State of the Lakes Ecosystem Conference (SOLEC) 2002, information was reported on 45 indicators of Great Lakes ecosystem components. Based on these indicators, overall assessments were made of the state of ecosystem components, the pressures being imposed, and human responses to alter the pressures. The most frequent subjective description of indicator findings was "mixed," although the range extended from "poor" to "good." Although the indicators reported for SOLEC are intended to assess whole lake or Great Lakes basin scales, other indicators may be important for other scales or users
Notes: See above.

Reference Type: Conference Proceedings
Record Number: 24
Author: Boix, D.; Gascon, S.; Sala, J.; Martinoy, M.; Gifre, J.; Quintana, X.
Year of Conference: 2004
Title: QAELS & ECELS: tools to evaluate wetland quality.

Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Institute of Aquatic Ecology and Department of Environmental Science, University of Girona, Spain.
Keywords: Bioassessment, biotic index, crustacea, European Union, water quality.
Abstract: According to the Water Framework Directive (2000/60/CE) tools to evaluate the ecological quality in wetlands are required. In this context, a biological index to evaluate the water quality (QAELS) and an index to evaluate the conservation status (ECELS) have been obtained for wetlands in Catalunya (NE Iberian peninsula). The study has been carried out in two phases: in the first one the index QAELS was elaborated by a data set of monthly samples of 20 wetlands; in the second one the index QAELS was validated by means of the information obtained in a biannual sampling of 40 additional wetlands. In each sampling point we measured water parameters (temperature, conductivity, pH, dissolved oxygen, Chl-a, dissolved nutrients and total nutrients) and the invertebrate species composition (captures by dip net of 250 mm mesh size). A previous typification of wetlands in that area has been required to obtain QAELS. The index QAELS is obtained by: (1) the relative abundance of each microcrustacean taxon (cladocera, copepoda and ostracoda) weighted by a quality coefficient, which is obtained for each taxon by means of partial canonical correspondence analysis; and (2) the taxonomic richness of crustaceans and aquatic insects. The taxonomic resolution required has been determined comparing the results obtained in several scenarios (each one with a different taxonomic resolution) with the results obtained with the identifications at species level. The ECELS index is based on five subjects: (1) basin littoral morphology, (2) human activity, (3) water characteristics, (4) helophytic and/or halophytic vegetation, and (5) hydrophytic vegetation.
Notes: This approach appears to be promising, although more information is needed.

Reference Type: Conference Proceedings
Record Number: 25
Author: Brady, V.J.; Johnson, L.B.; Breneman, D.H.; Ciborowski, J.J.H.; Hrabik, T.R.; Richards, C.; Schuldt, J.
Year of Conference: 2003
Title: Relative influence of landscape characteristics and anthropogenic stress on fish communities in Great Lakes Coastal Wetlands.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 59
Address: Natural Resources Research Institute, University of Minnesota - Duluth, Duluth, MN, 55811.
Keywords: Fish, impact assessment, lakes, USA.
Abstract: We evaluated the fish communities in 43 wetlands ordinated along gradients of anthropogenic stress from the U.S. coastal margins of the 5 Great Lakes. To select sites, we used principal components analysis to summarise the influence of 214 GIS-based environmental and human disturbance variables for 731 stream watersheds across the Great Lakes basin. Wetlands sampled spanned the resultant stress scales. Fish were sampled using 48-h fyke net sets during summer 2002. For analysis, sites were separated into northern and southern groupings due to latitudinal influences on fish community composition. Ordinations of fish relative abundances with the independent variables accounted for more than 60% of observed variation in the first three axes for both northern and southern sites. Different types of wetlands (lacustrine, protected, or river-influenced) did not appear to support distinctive fish communities. Both northern and southern wetlands supporting communities with high nonindigenous fish species richness were correlated with land uses and environmental variables characteristic of human disturbance and agricultural activities. We propose that the

number of nonindigenous fish taxa is a robust indicator of the influence of anthropogenic stress that applies to a broad range of latitudes and geomorphic classes of wetlands.

Reference Type: Conference Proceedings
Record Number: 26
Author: Brazner, J.C.; Tanner, D.K.; Batterman, S.L.
Year of Conference: 2003
Title: Fish Assemblages as indicators of Lake Superior coastal wetland condition.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 59
Address: U.S. EPA, NHEERL, MED - Duluth, 6201 Congdon Blvd., Duluth, MN, 55804
Keywords: Bioassessment, fish, lakes, USA.
Abstract: Fish assemblages associated with coastal wetlands in Lake Superior are poorly described. Understanding the environmental factors structuring the biota in these habitats is essential to developing robust indicators of their condition. To identify key environmental influences structuring fish assemblages and begin developing indicators of condition for these ecosystems, we sampled fish, and water, sediment and habitat quality at 10 western Lake Superior coastal wetlands in May, July, and September, 2000. These wetlands were selected from three hydro-geomorphic classes (estuary, lagoon, and riverine) and spanned a gradient of land-uses within their watersheds. Over 34,000 fish comprised of 46 different species were captured. Assemblage structure in the spring was different than in summer and fall, highlighting the importance of timing of sampling. Wetland hydrogeomorphology significantly influenced the number, diversity and dominance of the fishes suggesting indicators will have to be developed by wetland type. Ordinations suggest that proportion of mature forest and agriculture in watersheds along with sediment organic matter, dissolved nutrients, water temperature, and macrophyte diversity were among the most important environmental factors structuring our assemblages.

Reference Type: Conference Proceedings
Record Number: 27
Author: Brinson, M.M.; Smith, R.D.
Year of Conference: 1993
Title: Development of logic trains in hydrogeomorphic assessments of wetland functioning
Conference Name: ASLO AND SWS 1993 annual meeting.
Source: BiblioLine
Keywords: Functional assessment.
Abstract: If functional assessment methods are to be useful, they must be based on science, easy to learn and use, and take advantage of logical thinking. Based on the experience of applying a hydrogeomorphic assessment to riverine wetlands, a team of scientists identified functions as part of a logic train. In order to qualify, a function must: be clearly defined; have recognizable sustaining forces; have hydrologic, geomorphic, or ecologic significance either on the site or off the site, and have indicators that can be documented and combined into a functional index that is scaled to reference wetlands. An assessment format is proposed, utilizing examples, that ensures scientific documentation, serves as a teaching tool, and follows a straightforward train of logic. The format allows the components of each function to be assembled and disassembled as new information becomes available and improvements are made.
Notes: This is an early development of the Hydrogeomorphic approach. See also other records by this author (below).

Reference Type: Book Section
Record Number: 28
Author: Brinson, M.M.; Kruzynski, W.; Lee, L.C.; Nutter, W.L.; Smith, R.D.; Whigham, D.F.
Year: 1994
Title: Developing an approach to assessing the functions of wetlands.
Editor: Mitsch, W.J.
Book Title: Global Wetlands: Old World and New.
Publisher: Elsevier Science.
Pages: 615-624
Keywords: Functional assessment, indicators, USA.
Abstract: We present a five-step proposal for developing an approach to assess the functions of wetland ecosystems. The first is to classify wetlands based on hydrogeomorphic (HGM) properties. The major properties are geomorphic setting, the sources of water supplying the wetland, and the hydrodynamics of water within the wetland. By first grouping the wetlands into HGM classes with shared properties, assessments can be tailored to address the functions most relevant to each HGM class. Step two is to define the relationship between HGM properties and the functions; the goal is to select functions that are linked, clearly and logically, to wetland HGM properties, and that have hydrologic, geomorphic, and ecological significance on site or off site. This step is critical because it represents the scientific basis for the presence of the function. The linkage between HGM properties and wetland functions can be improved with new research findings. The third step is to develop functional profiles of each wetland class. Profiles can range from descriptive narrative of a single site to detail multivariate data sets for numerous sites. The fourth step is to develop a scale for expressing functions by using indicators and profiles from the reference wetlands; these must be developed for each wetland class in order to serve as benchmarks for the HGM classes. References wetlands should include the full range of natural and human-induced variations due to stress and disturbance. The final step is to develop the assessment methodology itself. The assessment relies on indicators to reveal the likelihood that the functions being evaluated are present in the wetland and depends upon reference populations to scale the assessment. Reference wetlands are critical also to the setting of goals for compensatory mitigation. The task of goal setting is greatly simplified because reference wetlands become a standard for which goals can be chosen and success can be measured.
Notes: This is a key paper that discusses the rationale for the "hydrogeomorphic" approach that is used extensively in the USA for assessment of wetland condition.

Reference Type: Journal Article
Record Number: 29
Author: Brinson, M.M.; Rheinhardt, R.
Year: 1996
Title: The role of reference wetlands in functional assessment and mitigation.
Journal: Ecological Applications.
Volume: 6
Pages: 69-76
Keywords: Functional assessment, USA.
Abstract: Compensatory mitigation for damages to wetlands in the United States occurs largely without explicit analysis and replacement of wetland functions. We offer an approach to standardize such analyses and strengthen the connection between ecological principles and policies for wetland resources. By establishing standards from reference wetlands chosen for their high level of sustainable functioning, gains and losses of functions can be quantified for wetlands used in compensatory mitigation. Advantages of a reference wetland approach include (1) making explicit the goals of compensatory mitigation through identification of reference standards from data that typify sustainable conditions in a region, (2) providing templates to which restored and created wetlands can be designed, and (3) establishing a

framework whereby a decline in functions resulting from adverse impacts or a recovery of functions following restoration can be estimated both for a single project and over a larger area accumulated over time. To establish reference standards, conditions inherent to highly functioning sites must be identified for classes of wetlands that share similar geomorphic settings. Ecological functions are then identified, and variables used to model the functions are employed in developing reference standards. Variables range from the highest levels of sustainable functioning to the complete absence of functions when a wetland ecosystem is displaced. An example given for wet pine flats in the North Carolina coastal plain illustrates how to determine the loss of a given function for an impacted wetland, how to calculate recovery (gains) in function through compensatory mitigation, and how to use the relationships between the two (loss vs. gain in function) to set minimum replacement ratios of restored to impacted area. In all cases, data from reference wetlands provide the benchmarks for making these estimates and for directing restoration or creation of wetlands toward the standards established for the wetland class. Programs to implement the use of reference wetlands require regional efforts that build upon the knowledge base of existing wetlands and their functioning.
Notes: Another paper on the "hydrogeomorphic" approach to wetland assessment. Gives a lot of detail on how to quantify the impact of a (hypothetical) development in a pine flat wetland.

Reference Type: Conference Proceedings
Record Number: 30
Author: Brooks, R.P.; Hughes, R.M.
Year of Conference: 1986
Title: Guidelines for assessing the biotic communities of freshwater wetlands.
Editor: J.A. Kusler, M.L. Quammen, and G. Brooks.
Conference Name: Proc. National Wetland Symposium: Mitigation of Impacts and Losses.
Conference Location: Berne, NY.
Pages: 272-268
Source: BiblioLine
Keywords: Bioassessment, management.
Abstract: This paper discusses the need for standardized guidelines for evaluating a system, and determining appropriate functions and values for that region. Provides specific monitoring and sampling techniques to standardize data collection.
Notes: Proceedings and full abstract not available in South Africa.

Reference Type: Conference Proceedings
Record Number: 31
Author: Brooks, R.P.; Wardrop, D.H.; Perot, J.K.
Year of Conference: 1999
Title: Development and application of assessment based protocols for determining the ecological condition of wetlands in the Juniata River watershed.
Conference Name: Environmental monitoring and assessment program.
Page: 42
Source: BiblioLine
Keywords: Bioassessment, indicators.
Abstract: This study contributes to the development of a means to accurately, efficiently, and fairly assess a wetland's condition in the context of the surrounding watershed, which can then be used to implement protective and restorative strategies that are appropriate for both the individual wetland and the watershed. The objectives for the study are: to determine and report on the ecological condition of wetlands in the Juniata River watershed using a series of assessment tools; evaluate the feasibility of integrating a series of bioindicators into the wetland condition assessments for the two sub-watersheds; and evaluate the feasibility of

using citizen volunteers to apply the wetland monitoring protocols throughout the Juniata River watershed.
Notes: This paper is interesting in that to some extent the biotic indices that are developed will be aimed at citizen volunteers

Reference Type: Conference Proceedings
Record Number: 32
Author: Brooks, R.P.; Wardrop, D.H.; Bishop, J.A.
Year of Conference: 2004
Title: Integrating biological, physical and landscape indicators for wetlands, streams and riparian areas of the mid-Atlantic region.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Penn State Cooperative Wetlands Center, Department of Geography, 302 Walker Building, Pennsylvania State University, University Park, PA 16802 USA (rpb2@psu.edu; dhw110@psu.edu; jab 190@psu.edu).
Keywords: Amphibians, bioassessment, biotic index, birds, functional assessment, invertebrates, plants.
Abstract: We compare correspondence across a set of biological, physical, and landscape indicators building on multiple approaches for assessing the condition of aquatic ecosystems, especially wetland, stream, and riparian components. By using this approach, we are trying to encourage the development of indicators of ecological structure and function, and to facilitate their holistic application. Our intent is to erase the boundaries among assessment approaches, so that the derived information can be applied across waters in an integrated manner. The Penn State Cooperative Wetlands Center is developing and testing a series of methods for assessing wetland, stream, and riparian condition, which combine elements of hydrogeomorphic (HGM) functional modelling of wetlands, indices of biological integrity (IBI) for vascular plants, aquatic macroinvertebrates, amphibians, and birds, and GIS spatial analysis of landscape patterns. HGM models and GIS analyses appear to be most reliable for the physical and landscape aspects of condition assessment, whereas IBIs address biotic responses to disturbance, whether the target habitat is aquatic or terrestrial. When comparing the responses of these indicators along a standard human disturbance gradient ranging from reference sites with the best attainable conditions to severely disturbed sites, we find remarkably close agreement within a habitat type, and reasonable correspondence among habitat types. To facilitate cross-method comparisons and integration, we propose that a standard, consistent scoring scale of 0.0-1.0 be used for each attribute. Striving to integrate assessments across waters will prove beneficial to managers.
Notes: Appears to be potentially a useful paper. Abstract only available.

Reference Type: Journal Article
Record Number: 33
Author: Brouwer, R.; Georgiou, S.; Turner, R.K.
Year: 2003
Title: Integrated assessment and sustainable water and wetland management. A review of concepts and methods.
Journal: Journal of Integrated Assessment.
Volume: 4
Issue: 3
Pages: 171-183
Keywords: European Union, management, social importance.
Abstract: This paper reviews and examines the potential of systematic and formalised interdisciplinary research concepts and methods for sustainable water and wetland policy and management, as advocated by the recently adopted European Water Framework Directive.

Such potential lies in the integration of insights, methods and data drawn from natural and social sciences. The concept of integrated assessment is first defined in a preliminary way and is then reviewed from a range of methodological and policy analysis viewpoints. This overview addresses issues such as (1) the need for vertical and horizontal integration when linking information demand and supply; (2) procedural steps in integrated assessment; (3) useful frameworks to structure and handle complexity and uncertainty; (4) the distinction and correlation between ecological and social values of aquatic ecosystems; (5) available evaluation methods and techniques. Socially and politically sensitised forms of integrated assessment are an important step towards: (a) increasing awareness about the complex nature of the interdependency between our physical and socially constructed environment; (b) greater recognition that uncertainties and risk of irreversible change require careful consideration (precautionary principles) in decision-making, which may be facilitated by prior agreement on a sensible, preferably social learning based, evaluation process; (c) recognition that costs and benefits in complex decision-making circumstances are dynamic, as knowledge and experiences progress; (d) increasing public support for and trust in decisions because of greater transparency in the *ex ante* evaluation phase.
Notes: This paper discusses the importance of considering not only environmental concerns, but also economic and social aspects during wetland management. The philosophy behind creating an integrating framework is discussed.

Reference Type: Conference Proceedings
Record Number: 34
Author: Bullock, A.; Acreman, M.
Year of Conference: 2004
Title: A re-assessment of the water quantity functions of wetlands.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Address: Ledbury, Herefordshire, HR8 2DX, United Kingdom.
Keywords: Functional assessment.
Abstract: It is widely accepted that wetlands have a significant influence on the hydrological cycle. Wetlands have therefore become important elements in water management policy at national, regional and international level. There are many examples where wetlands reduce floods, recharge groundwater or augment low flows. Less recognised are the many examples where wetlands increase floods, act as a barrier to recharge, or reduce low flows. This paper presents a database of 439 published statements on the water quantity functions of wetlands from 169 studies worldwide. Emphasis is placed on water balance, groundwater recharge, base flow, flood response and river flow variability. A synthesis of functional statements establishes the balance of scientific evidence for particular hydrological measures. The evidence reveals strong concurrence for some hydrological measures for certain wetland types. For example, flood plain wetlands generally reduce downstream flood risk. In contrast, the evidence for headwater wetlands is ambiguous, with many studies showing that these wetlands generate flood runoff. For other hydrological measures, there is diversity of functions for apparently similar wetlands. The balance of scientific evidence that emerges gives only limited support to the generalised model of flood control, recharge promotion and flow maintenance by wetlands portrayed throughout the 1990s as one component of the basis for wetland policy formulation. This paper provides the first step towards a more scientifically defensible functional assessment system.

Reference Type: Conference Proceedings
Record Number: 35
Author: Burgess, D.; Jackson, N.; Hadley, D.; Turner, K.; Georgiou, S.; Day, B.
Year of Conference: 2004
Title: Assessing the value of a scientifically important wetland ecosystem: the case of the Culm grasslands.

Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Address: Centre for Social and Economic Research on the Global Environment (CSERGE), School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ. (diane.burgess@uea.ac.uk)
Keywords: Resource economics, social importance, UK.
Abstract: In this poster, we report the findings of one of the first studies to examine the value of a scientifically important wetland ecosystem that is largely unrecognised by the general public. In the course of this study, a mixed-methodological approach was undertaken using both stakeholder analysis and economic valuation techniques to evaluate this habitat. The Culm Grasslands are semi-natural wet grasslands in South West England, which have resulted from traditional low intensity farming practises. These marshy grasslands support a high biodiversity and are a nationally recognised habitat. Pressure from intensification of agriculture has lead to conversion or neglect of much of the grasslands, leaving the remaining grasslands highly fragmented and vulnerable to adjacent land use. A strategy has been proposed to increase the grasslands ecological viability by reconnecting the remaining grasslands through the use of agri-environmental schemes and land purchase. This study aimed to test not only whether the public can perceive benefits in these little known wetland habitats, but also whether societal benefits would result from the implementation of a scheme to increase the existing area of the grasslands by 10%. A contingent valuation (CV) survey was used to value the biodiversity and landscape benefits of expanding the grasslands. The results of the CV survey were incorporated into a cost-benefit analysis to assess whether society would benefit from the implementation of this scheme. The results suggest that people do value the grasslands, and on the basis of economic efficiency, a scheme to increase the Culm Grasslands by 10% should be implemented.

Reference Type: Journal Article
Record Number: 36
Author: Burton, T.M.; Uzarski, D.G.; Gatham, J.P.; Genet, J.A.; Keas, B.E.; Stricker, C.A.
Year: 1999
Title: Development of a preliminary invertebrate index of biotic integrity for Lake Huron coastal wetlands.
Journal: Wetlands.
Volume: 19
Issue: 4
Pages: 869-882
Source: BiblioLine
Keywords: Bioassessment, biotic index, invertebrates, lakes, USA.
Abstract: The biota of aquatic systems are integrators of overall habitat quality, revealing both episodic as well as cumulative disturbance, and therefore are able to serve as natural monitors of the systems they inhabit. Invertebrate communities from three relatively pristine coastal wetlands located along the northern shore of Lake Huron were compared to those from three relatively impacted Saginaw Bay coastal wetlands in Lake Huron to identify components of the community that could ordinate wetlands according to anthropogenic disturbance. A total of 24 potential metrics were examined for each of four vegetation zones at the study sites. Of these, 14 successfully discriminated between sites and were used to generate a preliminary index of biotic integrity (IBI) for Lake Huron coastal wetlands. This IBI was then tested by assessing coastal wetlands, including five additional sites, based on invertebrate data collected the following year. The preliminary IBI seemed to provide an accurate depiction of the wetlands used to generate the IBI as well as the five additional wetlands. We do not recommend use of the presented IBI as the definitive assessment tool for Lake Huron coastal wetlands. Instead, we suggest that it be tested further on a series of wetlands with known degrees of anthropogenic disturbance.
Notes: This paper was not available through the internet or in South African libraries. It may well be worthwhile to try and obtain a copy through other channels.

Reference Type: Report
Record Number: 37
Author: Butcher, R.
Year: 2003
Title: Options for the assessment and monitoring of wetland condition in Victoria, Australia.
City: State of Victoria, Australia.
Institution: Report prepared for the State Water Quality Monitoring and Assessment Committee (SWQMAC).
Source: DWAF (2004)
Keywords: Australia, bioassessment, impact assessment, review, water quality.
Abstract: The State Water Quality Monitoring and Assessment Committee (SWQMAC), under the auspices of the Victorian Catchment Management Council, has a mandate to facilitate the establishment of a wetland assessment and monitoring program in Victoria. As no comprehensive program currently exists to assess the ecological condition of Victoria's wetlands, the first step in this process was to produce a discussion document that reviews the present situation, with regard to existing wetland projects, at the state, national and international level. This included a review of the scientific literature on wetland condition and indicators and provides options for a statewide wetland condition-monitoring program for Victoria. The specific objectives for the discussion document were: • Briefly review the current situation in Victoria regarding wetland assessment and monitoring. • Review state-of-the-art wetland assessment and monitoring literature and programs elsewhere (interstate & overseas). • Scope options for a statewide wetland assessment and monitoring program for Victoria. • Provide an assessment on the applicability, success or difficulties associated with the various methods identified. The discussion document is structured into 6 sections and 4 appendices. This first section is a brief introduction of the objectives of the document. Section 2 deals with major concepts and definitions, and Section 3 with existing wetland programs at various scales (state, National, International, regional and wetland type). Section 4 looks at the physical, chemical and biological variables used in the assessment of wetland condition. Section 5 provides a general framework for assessment and monitoring wetland condition in Victoria. Section 6 is a summary chapter that includes an example scenario of how the suggested framework put forward in section 5 could be used. Throughout the discussion document key points and recommendations are highlighted. These have been largely reproduced here so as to provide an understanding of the major issues and recommendations.
Notes: This is a key review paper and was referred to extensively in DWAF (2004).
URL: http://www.vcmc.vic.gov.au/Web/SWQMACPublications.htm

Reference Type: Journal Article
Record Number: 38
Author: Castella, E.; Speight, M.C.D.; Obrdlik, P.; Schneider, E.; Lavery, T.
Year: 1994
Title: A Methodological approach to the use of terrestrial invertebrates for the assessment of alluvial wetlands.
Journal: Wetlands Ecological Management.
Volume: 3
Pages: 17-36
Source: BiblioLine
Keywords: Bioassessment, invertebrates.
Abstract: We review progress toward developing a data-analysis system using invertebrate species lists in wetland evaluation procedures. Species lists for Mollusca, Carabidae (Coleoptera), Empidoidea and Syrphidae (Diptera), derived from samples collected at six stations along a transect established at a site on the floodplain of the River Loire (France) provide the raw data. An initial analysis using a traditional ordination method (Correspondence Analysis) is carried out. A database was established for the 118 mollusc, carabid and syrphid species recorded, and each species was then treated not as a simple

integer, but as an amalgam of digitised attributes deemed responsive to wetland conditions, in a correspondence analysis on instrumental variables. Despite the generalized nature of the attributes as defined for this example, the approach demonstrates a marked increase in interpretability of the output of analysis, in respect of the relation between the species and the floodplain environment. It also highlights the value of use of data pertaining to more than one taxonomic group and of selecting these taxonomic groups on the basis of complementarity of their 'bioindicator' potential.
Notes: Not available in South African Libraries

Reference Type: Journal Article
Record Number: 39
Author: Cedfeldt, P.T.; Watzin, M.C.; Richardson, B.D.
Year: 2000
Title: Using GIS to identify functionally significant wetlands in the Northeastern United States.
Journal: Environmental Management.
Volume: 26
Pages: 13-24
Source: ISI Web of Science
Keywords: Functional assessment, USA
Abstract: Of the several automated wetland assessment methods currently available, none are comprehensive in considering all of the primary functions a wetland can perform. We developed a methodology particularly suited to the Northeastern United States that enumerates spatial predictors of wetland function for three primary wetland functions: flood flow alteration, surface water quality improvement, and wildlife habitat. Predictors were derived from several wetland assessment techniques and directly from the literature on wetland structure and function. The methodology was then automated using a Geographic Information System (GIS). The resulting Automated Assessment Method for Northeastern Wetlands (AMNEW) consists of a suite of eight Arc Macro Language (AML) programs that run in the ARC/INFO GRID module. Using remotely sensed land use information and digital elevation models (OEMs), AMNEW produces three separate grids of wetlands that perform each function. The method was tested on four watersheds in Vermont's Lake Champlain Basin. Results and preliminary verification indicate that the method can successfully identify those wetlands in the Northeastern region that have the potential to be functionally important.
Notes: An interesting approach to functional assessment. Could be of use in South Africa in conjunction with the national wetlands inventory GIS coverage. Also of use for evaluating wetlands at the landscape level (i.e. multiple wetlands), rather than for individual wetlands.

Reference Type: Conference Proceedings
Record Number: 40
Author: Charbonneau, J.J.
Year of Conference: 2001
Title: Economic methods used to measure ecological restoration.
Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 18
Address: U.S. Fish and Wildlife Service, 4401 N. Fairfax Drive, Arlingtion, VA, 22203.
Keywords: Resource economics, restoration, USA.
Abstract: The primary focus of this paper is to explore the economic methods used to estimate the benefits of restoring the ecosystem components that have been damaged. The examples used come from the Ashtabula River restoration proposal that was submitted to the Corps of Engineers. Traditional economic measures of benefits do not adequately portray all

the values associated with a functioning ecosystem. Most economic analyses focus on the goods and services that the public receives and not the infrastructure that produces the goods and services. The many interrelationships between species that are required for a fully functioning ecosystem are not independently recognized and valued by the public. For example, the value of catching game fish has been the focus of many studies, but seldom has the value of the prey species sought by game fish been estimated. In an economic context, the demand for game fish generates a derived demand for the ecosystem components that produce the game fish. It is fairly easy to estimate the economic value of game fishing. It is very difficult to estimate the economic value of the ecological infrastructure that supports game fish.
Notes: A full-length version of this paper is not available, but it may be useful to contact the author. Evaluation of species that support other, commercially important species is often over-looked.

Reference Type: Journal Article
Record Number: 41
Author: Chessman, B.C.
Year: 1995
Title: Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index.
Journal: Australian Journal of Ecology.
Volume: 20
Pages: 122-129
Keywords: Australia, bioassessment, invertebrates, rivers.
Abstract: This paper describes a simple and inexpensive procedure for the rapid biological assessment of water quality in rivers and streams in eastern Australia. The procedure involves the standardized collection of samples of 100 macroinvertebrates from defined habitat types within a water body. Specimens are identified to family level only and a biotic index is calculated. Proposed future testing and evaluation are described, and the limitations of the rapid approach are discussed.
Notes: Although this paper pertains to rivers, it gives useful insight into the steps necessary to develop a biotic index. The approach shows potential for extrapolation to wetlands. See also other papers by this author - Chessman *et al.* 1997 and 2002.

Reference Type: Journal Article
Record Number: 42
Author: Chessman, B.C.; Growns, J.E.; Kotlash, A.R.
Year: 1997
Title: Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: Application to the Hunter River system, New South Wales.
Journal: Marine and Freshwater Research.
Volume: 48
Issue: 2
Pages: 159-172
Source: DWAF (2004)
Keywords: Australia, bioassessment, invertebrates, rivers, water quality.
Abstract: Chessman's SIGNAL-95 biotic index was modified on the basis of data from spring and autumn surveys of macroinvertebrates at 42 sites in the Hunter River and tributaries. An iterative algorithm was used to derive improved grade numbers reflecting the pollution sensitivities of individual families of river macroinvertebrates. The new grades were used to calculate values of the modified index (SIGNAL-HU97). These values were highly correlated with SIGNAL-95 values but were more widely spread, giving better discrimination between the sites of higher environmental quality and the more degraded sites. SIGNAL-

HU97 values were also more highly correlated than were SIGNAL-95 values with environmental variables such as the conductivity of the water and a riparian, channel and environmental inventory. There was little difference in values between spring and autumn, but riffles consistently had higher mean values than other habitats.
Notes: Although this paper pertains to rivers, it gives insight into the steps necessary to develop a biotic index. A standardised description of adjacent land and the condition of the banks is included as are pollution-sensitivity grade numbers for common macroinvertebrate families.

Reference Type: Journal Article
Record Number: 43
Author: Chessman, B.C.; Trayler, K.M.; Davis, J.A.
Year: 2002
Title: Family- and species-level biotic indices for macroinvertebrates of wetlands on the Swan Coastal Plain, Western Australia.
Journal: Marine and Freshwater Research.
Volume: 53
Pages: 919-930
Source: ISI Web of Science
Keywords: Australia, bioassessment, biotic index, invertebrates, water quality.
Abstract: SWAMPS (Swan Wetlands Aquatic Macroinvertebrate Pollution Sensitivity) was developed as a biotic index for wetlands near Perth, Western Australia. Numerical grades between 1 and 100 were assigned to wetland macro-invertebrate taxa, generally at the family and species levels, to reflect the sensitivities of these taxa to anthropogenic disturbance, primarily nutrient enrichment. Index scores for individual wetlands were calculated as abundance-weighted or unweighted means of the grades of all taxa present in standard samples. Scores calculated at both the family and species levels showed a strong correlation with independent measures of cultural eutrophication and other anthropogenic disturbances, but such correlations were generally higher for the species-level index. The species index also discriminated more between individual wetlands. SWAMPS should be useful in routine and rapid assessment and monitoring of wetland condition in the Perth region and could be easily adapted to other regions and continents.
Notes: A key paper in developing a biotic index using macroinvertebrates. Scores are given for species/morphospecies. It would be interesting to compare these with ratings for South African species (once enough is known about local fauna to do this). There is an interesting discussion with regard to the use of species versus families.

Reference Type: Conference Proceedings
Record Number: 44
Author: Chow-Fraser, P.
Year of Conference: 2003
Title: Development of the wetland water quality index for assessing the quality of the Great Lakes Coastal Wetlands.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 176
Address: McMaster University, Biology Dept., 1280 Main St. West, Hamilton, ON, L8S V4K 1
Keywords: Impact assessment, USA, water quality.
Abstract: 93 wetlands were included in the development of the Wetland Water Quality Index (WQI), and were visited during 1998, 2000, 2001 and 2002. Over 40 wetlands were visited at least twice over the period, for a total of 128 wetland-years. Measurements included primary

nutrient concentrations (TP and TN), water clarity (turbidity, light extinction, CHL and TSS), and physical parameters (TEMP, pH, COND and DO). A Principal Component Analysis (PCA) was used to ordinate the 128 wetland-years; of the 21 water and sediment variables, only 12 emerged as being important and were included in the final analysis. Although the first 7 axes explained 90% of the total variation, the first 4 were the most important ones, together explaining almost 75% of the variation in the dataset. PC 1, which explained over 44% of the overall variation ordinated wetlands from the most degraded (turbid, nutrient-rich and high COND) to the least degraded (clear water, low nutrients and suspended solids), while the second axis, which accounted for 11 % of the variation, was significantly correlated with temperature and pH, reflecting in part the large geographic range in our database. I will show how results of the PCA were used to develop the WQI, which was then used to rank wetlands into 6 categories according to degree of anthropogenic disturbance.
Notes: A potentially useful paper for assessing wetland water quality status.

Reference Type: Conference Proceedings
Record Number: 45
Author: Ciborowski, J.J.H.; Schuldt, J.; Johnson, L.B.; Host, G.E.; Richards, C; Hollenhorst, G.
Year of Conference: 2003
Title: Reference conditions, degraded areas, stressors, and impaired beneficial uses: Conceptual integration of approaches to evaluating human-related environmental pressures.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 54
Address: Dept. of Biological Sciences & Great Lakes Inst. for Environ. Research, University of Windsor, Windsor, ON, N9B 3P4.
Keywords: Impact assessment, lakes.
Abstract: Various models have been developed to provide a conceptual framework within which to classify areas and assess the effects of human activity on the environmental condition of those areas. We show that locations can be ordinated along independent hypothetical axes representing specific types of anthropogenic disturbance ('pressure' sensu SOLEC). The ends of an axis represent minimum and maximum pressure, respectively. Axes converge to a common hyperdimensional point, representing the absence of pressure (pristine conditions). The Reference Condition is the suite of locations within a hypergeometric volume extending from the common point to locations along each axis at which the biotic community is meaningfully different than the community at the 'apex'. The diverging pressure axes form the edges of a pyramid, the base of which represents classes of "degraded condition". Correlation (r) between values of two different classes of pressure among locations define the angle of divergence of the axes (arc-cos[r]), hence a pyramid shape. A "pressure pyramid" of Great Lakes coastal margin habitats was constructed using 6 GIS-based measures of human activity from the Great Lakes Environmental Indicator database of land use values - agricultural land (%), urban land (%), road density, distance from an NPDES point source, population density.

Reference Type: Thesis
Record Number: 46
Author: Clement, B.
Year: 1986
Title: Wetlands of Brittany: An investigation towards bioindicators.
Academic Dept.: University of Rennes (France).
Number of Pages: 151pp
Keywords: Bioassessment, indicators, plants, water quality.

Abstract: The wetlands of Brittany are characterized by different types of vegetal associations. The salt-marshes, peat-bogs, lagoons, are classified in relation to their water content, salinity, pH, acidity and flora. Some examples of botanical cartography are given.
Notes: Not available in South African libraries.

Reference Type: Journal Article
Record Number: 47
Author: Cui, LiJuan; Zhang, MingXiang.
Year: 2002
Title: Review on the study wetland assessment.
Journal: World Forestry Research.
Volume: 15
Issue: 6
Pages: 46-53
Source: BiblioLine
Keywords: China, impact assessment.
Abstract: Wetlands are one of the critically important global ecosystems. However, many wetlands are now under increasing threat from development projects such as agricultural improvement schemes, housing and industrial sites, pollution and unsustainable use. This paper reviews the worldwide status of wetland assessment. There are two methods of wetland assessment classification. Different assessment studies are being used in North America, Europe, Asia, and China. In North America, the study begins earlier and the researchers pay more attention to practice needs and so their assessment is more operable. In Europe, the assessment is more modern and innovative. In Asia, the researchers are more interested in theoretical study and they explain wetland benefits concept. In China, wetland assessment started late and is making slow progress.

Reference Type: Book Section
Record Number: 48
Author: D'Avanzo, C.
Year: 1990
Title: Longterm evaluation of wetland creation projects.
Editor: Kusler, A. and Kentula, M.E.
Book Title: Wetland Creation and Restoration: The status of the Science.
City: Washington, D.C.
Publisher: Island Press.
Pages: 74-84
Source: LexisNexis
Keywords: Plants, restoration.
Abstract: A review and evaluation of changes in created wetlands is conducted to understand how artificial wetlands have evolved and what the changes imply to the feasibility of creating wetlands with long-term functions. Six criteria were used for wetland assessment. They include: comparison of vegetation growth in artificial and natural wetlands after two or more growing seasons; habitat requirements of invading plants in created wetlands; success of planted species; comparison of animal species and biomass in created and natural wetlands; soil chemical analysis of both types of wetlands; and evidence of geologic or hydrologic changes. It is concluded that evaluating projects for their long-term success should be based on the basis of monitoring.
Notes: Available in South Africa.

Reference Type: Book Section
Record Number: 49
Author: Danielson, T.L.
Year: 1998
Title: Assessment of biological integrity of surface waters. Wetland Bioassessment Fact Sheet 1.
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division.
Keywords: Bioassessment, biotic index, USA, water quality.
Abstract: The objective of the Clean Water Act is to "maintain and restore the chemical, physical, and biological integrity of our Nation's waters." When the Clean Water Act was passed in 1972, the discharge of chemicals was commonly viewed as the primary threat to the health of our Nation's waterbodies. To track progress in reducing this threat, the Nation focused on developing chemical criteria which set numerical limits for safe levels of chemicals in waterbodies. During the past 25 years, the Nation has been largely successful in reducing the number and quantity of chemicals discharged into waterbodies by factories, wastewater treatment plants, and other point sources. During this same period of time, it has become increasingly clear that aquatic ecosystems are impacted by more than just chemicals. Aquatic ecosystems are altered by nonpoint source runoff, habitat alteration and fragmentation, introduced species, changes in the quantity and flow of water, and land use within a watershed. Traditional chemical criteria alone are unable to measure the impacts caused by these stressors. The EPA is now focusing on developing biological criteria in addition to chemical criteria to help track progress in maintaining and restoring the health of our waters. In most cases, the most direct and effective way to assess the "health" or biological condition of waterbodies is to: (1) directly measure the condition of their biological communities, and (2) support those data when necessary by measuring the physical and chemical condition of waterbodies and their watersheds.
Notes: The bioassessment fact sheets (there are 10 in the series) give rather simplistic explanations but, nevertheless, are a good starting point to understanding the field of wetland bioassessment. Fact sheet 5 is especially useful as it explains how to develop an index of biotic integrity in simple steps. Fact sheet 10 gives a glossary of terms which is useful for navigating the US literature in this field. See also the other nine factsheets by the same author (below)**.**
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact1.html

Reference Type: Book Section
Record Number: 50
Author: Danielson, T.L.
Year: 1998
Title: Application of Biological Assessments in Wetlands. Wetland Bioassessment Fact Sheet 2.
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division.
Keywords: Bioassessment, biotic index, USA, water quality.
Abstract: In most cases, the most direct and effective way of evaluating the ecological "health" or condition of a wetland is (1) to directly measure the condition of a wetland's biological community and (2) to observe and measure the chemical and physical characteristics of a wetland and its surrounding landscape. After developing and testing

bioassessment methods, states, tribes, and federal agencies can use them for the following activities.
Notes:The bioassessment fact sheets (there are 10 in the series) give rather simplistic explanations but, nevertheless, are a good starting point to understanding the field of wetland bioassessment. Fact sheet 5 is especially useful as it explains how to develop an index of biotic integrity in simple steps. Fact sheet 10 gives a glossary of terms which is useful for navigating the US literature in this field. See also the other nine factsheets by the same author.
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact2.html

Reference Type: Book Section
Record Number: 51
Author: Danielson, T.L.
Year: 1998
Title: Biological Assessment of Wetlands Working group (BAWWG). Wetland Bioassessment Fact Sheet 3.
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division
Keywords: Bioassessment, biotic index, USA, water quality.
Abstract: The Biological Assessment of Wetlands Workgroup (BAWWG, pronounced "bog") was formed in 1997 with the objective of improving methods and programs to assess the biological integrity of wetlands. The workgroup consists of wetland scientists from federal agencies, states, and universities and is coordinated by the EPA Office of Wetlands, Oceans, and Watersheds in partnership with the EPA Office of Science and Technology. BAWWG provides a forum for wetland scientists and professionals to discuss and develop assessment methods.
Notes: The bioassessment fact sheets (there are 10 in the series) give rather simplistic explanations but, nevertheless, are a good starting point to understanding the field of wetland bioassessment. Fact sheet 5 is especially useful as it explains how to develop an index of biotic integrity in simple steps. Fact sheet 10 gives a glossary of terms which is useful for navigating the US literature in this field. See also the other nine factsheets by the same author.
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact3.html

Reference Type: Book Section
Record Number: 52
Author: Danielson, T.L.
Year: 1998
Title: Wetland Bioassessment Projects. Wetland Bioassessment Fact Sheet 4.
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division.
Keywords: Algae, amphibians, bioassessment, biotic index, birds, invertebrates, plants, USA.
Abstract: A list of some wetland biological assessment projects conducted by members of the Biological Assessment of Wetlands Workgroup (BAWWG) (See also Factsheet 3) in wetlands is given. In general, individual BAWWG members are still in the preliminary stages of identifying and testing potential metrics, particularly for birds, amphibians, plants, and algae. Most current research is being conducted on macroinvertebrates and vascular plants in depressional wetlands with emergent and submerged vegetation. Further research is needed in

other wetland types, especially in wetlands that have saturated soils but lack standing water for most of the year.
Notes: The bioassessment fact sheets (there are 10 in the series) give rather simplistic explanations but, nevertheless, are a good starting point to understanding the field of wetland bioassessment. Fact sheet 5 is especially useful as it explains how to develop an index of biotic integrity in simple steps. Fact sheet 10 gives a glossary of terms which is useful for navigating the US literature in this field.
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact4.html

Reference Type: Book Section
Record Number: 53
Author: Danielson, T.L.
Year: 1998
Title: Developing an Index of Biological Integrity. Wetland Bioassessment Fact Sheet 5.
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division.
Keywords: Bioassessment, biotic index, USA.
Abstract: One method to assess biological integrity of wetlands is to develop an index of biological integrity (IBI) for an assemblage of wetland plants or animals. An IBI is made by combining several biological indicators, called metrics, into a summary index. A well-constructed IBI that can allow scientists to: (1) measure condition, (2) diagnose the type of stressors damaging a wetland's biota, (3) define management approaches to protect and restore biological condition, and (4) evaluate performance of protection and restoration activities.
Notes: The bioassessment fact sheets (there are 10 in the series) give rather simplistic explanations but, nevertheless, are a good starting point to understanding the field of wetland bioassessment. Fact sheet 5 is especially useful as it explains how to develop an index of biotic integrity in simple steps. Fact sheet 10 gives a glossary of terms which is useful for navigating the US literature in this field. See also the other nine factsheets by the same author.
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact5.html

Reference Type: Book Section
Record Number: 54
Author: Danielson, T.L.
Year: 1998
Title: Wetland Biological Assessments and HGM Functional Assessments. Wetland Bioassessment Fact Sheet 6.
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division.
Keywords: Bioassessment, biotic index, functional assessment, USA.
Abstract: The purpose of this fact sheet is to provide a comparison of a functional assessment method, the Hydrogeomorphic (HGM) Approach, and biological assessments based on an index of biological integrity (IBI). Our intention is not to advocate one particular approach, because each was developed for a different purpose and has many strengths. Rather, our intention is to identify their similarities and differences and to identify ways that the two approaches can be supportive of each other. The functional assessment column was written primarily by Mark Brinson (East Carolina University).

Notes: The bioassessment fact sheets (there are 10 in the series) give rather simplistic explanations but, nevertheless, are a good starting point to understanding the field of wetland bioassessment. Fact sheet 5 is especially useful as it explains how to develop an index of biotic integrity in simple steps. Fact sheet 10 gives a glossary of terms which is useful for navigating the US literature in this field. See also the other nine factsheets by the same author.
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact6.html

Reference Type: Book Section
Record Number: 55
Author: Danielson, T.L.
Year: 1998
Title: Water Quality Standards. Wetland Bioassessment Fact Sheet 7.
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division.
Keywords: Biocriteria, USA, water quality.
Abstract: The main objective of the Clean Water Act (CWA) is to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." To help meet these objectives, states must adopt water quality standards (WQS) for all "waters of the U.S." within their boundaries, including wetlands. Water quality standards, at a minimum, consist of three major components: 1) designated beneficial uses, 2) narrative and numeric water quality criteria for supporting each use, and 3) an antidegradation statement.
Notes: The bioassessment fact sheets (there are 10 in the series) give rather simplistic explanations but, nevertheless, are a good starting point to understanding the field of wetland bioassessment. Fact sheet 5 is especially useful as it explains how to develop an index of biotic integrity in simple steps. Fact sheet 10 gives a glossary of terms which is useful for navigating the US literature in this field. See also the other nine factsheets by the same author.
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact7.html

Reference Type: Book Section
Record Number: 56
Author: Danielson, T.L.
Year: 1998
Title: Evaluating Performance of Wetland Restoration Activities. Wetland Bioassessment Fact Sheet 8.
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division.
Keywords: Bioassessment, restoration, USA.
Abstract: Perhaps the most commonly neglected component of wetland restoration projects is a clearly defined approach to evaluate the success of the restoration activities. How well do current wetland restoration techniques work? Are they effective at restoring a balanced, adaptive community of plants and animals? How do the conditions in restoration sites compare to conditions in minimally impaired sites?
Notes: Useful background information. See also the other nine factsheets by the same author.
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact8.html

Reference Type: Book Section
Record Number: 57
Author: Danielson, T.L.
Year: 1998
Title: Involvement of Volunteers in Wetland Monitoring. Wetland Bioassessment Fact Sheet 9.
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division.
Keywords: Bioassessment, monitoring, USA.
Abstract: The involvement of volunteers in ecological monitoring programs is a realistic, cost-effective, and beneficial way to obtain important information which might otherwise be unavailable due to lack of resources at government agencies. Initiatives such as Riverwatch, Adopt-a-Stream, and the Izaak Walton League's Save-Our-Streams program have been highly successful in maintaining groups of interested volunteers as well as in yielding data useful to scientists, planners, and concerned citizens. Although many programs aim to assess the health of streams and lakes, relatively few volunteer programs have attempted to monitor and document the biological condition or functional values of wetlands. The diversity of wetland types can also complicate efforts to monitor wetlands. It is nevertheless feasible to use volunteers to help collect valuable data on wetlands, such as water levels, vegetation types, water quality, and composition of plant and animal assemblages. It is also feasible for volunteers to monitor specific plants or animals, such as non-native weeds or amphibians
Notes: Useful background information. See also the other nine factsheets by the same author.
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact9.html

Reference Type: Book Section
Record Number: 58
Author: Danielson, T.L.
Year: 1998
Title: Glossary of Bioassessment Terms. Wetland Bioassessment Fact Sheet 10
Editor: Danielson, T.L.
Book Title: Wetland Bioassessment Fact Sheets. EPA843-F-98-001.
City: Washington, D.C.
Publisher: U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division.
Keywords: Bioassessment, USA.
Abstract: This Fact Sheet provides a glossary of terms used in the Fact Sheet series.
Notes: Background information that is very useful for understanding the wealth of literature on wetland assessment in USA. See also the other nine factsheets by the same author.
URL: http://www.epa.gov/owow/wetlands/wqual/bio_fact/fact10.html

Reference Type: Conference Proceedings
Record Number: 59
Author: Danz, N.; Regal, R.; Niemi, G.J.; Hollenhorst, T.; Brady, J.V.
Year of Conference: 2003
Title: Using multiple anthropogenic stressors to characterize Great Lake ecosystems.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 53

Address: Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, Duluth, MN, 55811.
Keywords: Impact assessment, lakes, stressor effects.
Abstract: Coastal ecosystems in the Great Lakes were undegraded prior to human influence. Both natural processes and human activities have influenced ecosystem properties; adverse changes (degradations) are attributed to human activity. The goal of our work is to develop diagnostic ecological indicators by investigating the relationship between anthropogenic stresses and ecosystem properties. We used a GIS approach to characterize anthropogenic stressors in the Great Lakes coastal region. Public sources were used to compile over 200 data layers representing six types of stress: agriculture, atmospheric deposition, land cover, human populations, point source pollution, and shoreline modification. We divided the coastal region into units using geomorphological criteria and calculated stressors for each unit. Principal components analysis was used to remove redundancy within the stress categories, and cluster analysis was used to create groups of sites having similar stress profiles. The clusters were mapped to identify coastal ecosystems with high potential influence of stress and ecosystem degradation. The clusters were also used to distribute sampling effort for the collection of biological response data.

Reference Type: Report
Record Number: 60
Author: Davies, S.P.; Tsomides, J.L.; DiFranco, J.L.; Coutemanch, D.L.
Year: 1999
Title: Biomonitoring retrospective: Fifteen-year summary for Maine rivers and streams.
City: Augusta, Maine.
Institution: Division of Environmental Assessment.
Source: DWAF (2004)
Keywords: Bioassessment, biocriteria, invertebrates, rivers, USA.
Abstract: The following Report provides a summary of the results of biological monitoring of benthic macroinvertebrates in rivers and streams, between 1983 and 1998, in the State of Maine, by the Maine Department of Environmental Protection (MDEP). Part I Chapter 1 is a description of various developmental and implementation aspects of the State's biocriteria program, including development of analytical methods and resulting numeric biocriteria, as well as regulatory and reporting applications of the information. Part I Chapter 2 is a synopsis of biomonitoring activities for other waterbody types (e.g., wetlands, lakes and estuaries) and for specific applications (e.g., assessment of non-point source impacts). Part II of the Report includes nine chapters, organized by major river basin(s), providing an overview of historical findings, biomonitoring activities and results, current status and planned future activities. Each Basin Chapter has an associated basin map and basin table that present station location information and biocriteria results. Also provided are eleven case studies that elaborate upon biological and water quality findings and management activities for specific sampling locations, over time. For most of the State's river basins, biological monitoring has demonstrated significant site-specific improvements in the condition of aquatic life since the early 1980's, as the result of improved point source treatment technologies and management (Case Studies 4 and 7). However, in recent years it has become apparent that significant impairment of aquatic life is occurring as a result of nonpoint source impacts, particularly in urban streams (Part I Chapter 2; Case Studies 1, 2 and 10). Future priorities for the Biological Monitoring Program include an expanded emphasis on the assessment of non-point source biological impacts, development of periphyton indicators of nutrient, aesthetic and biological impacts, and expanded reliance on spatial data integration and analysis.
Notes: This report is concerned primarily with rivers, although some wetland data is given. A useful background document.
URL: http://www.maine.gov/dep/blwq/docmonitoring/biomonitoring/biorep2000.htm

Reference Type: Journal Article
Record Number: 61
Author: de la Rey, P.A.; Taylor, J.C.; Laas, A.; van Rensburg, L.; Voslo, A.
Year: 2004
Title: Determining the possible application value of diatoms as indicators of general water quality: A comparison with SASS5.
Journal: Water SA.
Volume: 30
Issue: 3
Pages: 325-332
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, diatoms, rivers, South Africa, water quality.
Abstract: The applicability of a European numerical diatom index, the Specific Pollution sensitivity Index (SPI), was tested in a river system where the SPI scores were compared both to chemical water quality and to scores yielded using a macro-invertebrate index of riverine health namely the South African Scoring System (SASS 5). This investigation showed that the SPI reflects certain elements of water quality with a high degree of accuracy. Due to the broad species base of SPI, few problems were encountered when using this system in the Southern Hemisphere. The conclusion is that SPI or a similar diatom index will provide a valuable addition to the suite of biomonitoring tools currently in use in South Africa.
Notes: Useful basis for investigations into the use of diatoms in wetlands as opposed to rivers.
URL: http://www.wrc.org.za/publications/watersa/2004/July-04/1660a.pdf

Reference Type: Journal Article
Record Number: 62
Author: Decamp, O.; Warren, A.; Sanchez, R.
Year: 1999
Title: The role of cilliated protozoa in subsurface flow wetlands and their potential as bioindicators.
Journal: Water Science and Technology.
Volume: 40
Pages: 91-98
Source: ISI Web of Science
Keywords: Bioassessment, biotic index, microbes, protozoa, water quality.
Abstract: The role of ciliated protozoa in the root zone method of wastewater treatment was assessed by analyzing ciliate community structure in four experimental subsurface flow wetlands (planted or unplanted in either soil or gravel) and estimating *Escherichia coli* removal due to ciliate predation. A total of 22 different ciliate taxa were isolated from the four reed beds. The first third of each bed contained a higher abundance and diversity than the final third of the bed. There was a qualitative correlation between physico-chemical conditions and ciliate community structure: microaerophilic species dominated the organic-rich and oxygen-poor environment of the unplanted soil bed; aerobic and facultative bacterivorous species dominated the better oxygenated gravel beds; a combination of these two communities was found in the planted soil bed. The average grazing rates of ciliates was around 5 times higher in the planted gravel bed (49 bacteria/ciliate/hour) than in the unplanted soil bed (9.5 bacteria/ciliate/hour). Taking into account the retention time and ciliate abundance, it was calculated that ciliates, by their predatory activities, are capable of removing up to 2.35×10^5 and 0.45×10^5 *E. coli* in the first third of the planted gravel bed and unplanted soil bed, respectively. These results are discussed in relation to variation in *E. coli* removal kinetics. The potential for using ciliate communities as indicators of conditions within constructed wetlands is also assessed.
Notes: Probably of limited relevance to assessment of ecological condition of naturally occurring wetlands.

Reference Type: Conference Proceedings
Record Number: 63
Author: Declerk, S.
Year of Conference: 2004
Title: Aim and outline of the BIOMAN project. Patterns of biodiversity and community structure across trophic levels.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Steven Declerck; Laboratory of Aquatic Ecology, KULeuven, Ch. de Bériotstraat 32, 3000 Leuven, Belgium (Steven.Declerck@bio.kuleuven.ac.be)
Keywords: Bioassessment, European Union, impact assessment, lakes.
Abstract: "Biodiversity and human impact in shallow lakes" (BIOMAN) was an EU-funded project that focused on biodiversity patterns in shallow lakes along a North-South gradient in Europe. In three geographic regions of Europe (Denmark, Belgium/The Netherlands, Spain), we simultaneously studied the communities of organism groups at different trophic levels of the food chain (bacterioplankton, ciliates, phytoplankton, zooplankton, fish, macroinvertebrates and macrophytes). In addition, genetic diversity of some key zooplankton taxa was assessed. The studied lakes were selected along four mutually independent gradients of submerged water plant cover, total phosphorus content, lake size and degree of connectedness with other water bodies. The major goals of the project were (1) to assess whether community structure and diversity are concordant across different aquatic organism groups; (2) to study the association of these community characteristics with the studied gradients and other potentially important variables (related to physico-chemistry, morphometry, food web structure and land-use); (3) to explore for reliable and cost-effective indices for overall ecosystem diversity in shallow European lakes; and (4) to develop mathematical tools that allow prediction of the effects of human impact on biodiversity in shallow lakes.

Reference Type: Journal Article
Record Number: 64
Author: DeKeyser, E.S.; Kirby, D.R.; Ell, M.J.
Year: 2003
Title: An index of plant community integrity: Development of the methodology for assessing prairie wetland plant communities.
Journal: Ecological Indicators.
Volume: 3
Issue: 2
Pages: 119-133
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, plants.
Abstract: We developed an Index of Plant Community Integrity (IPCI) for quantitatively assessing the quality of seasonal wetland plant communities. In 1998 and 1999, we sampled the plant communities of 46 seasonal wetlands in the Prairie Pothole Region (PPR) of central North Dakota, USA. We selected wetlands that represented a range of disturbance from well-managed native rangeland to heavily disturbed cropland. We delineated plant data into metrics of the data set (e.g. species richness, percentage of introduced and annual plants) and analyzed these metrics using principal components (PCs) and cluster analyses. Through analyses, five quality classes (Very good, Good, Fair, Poor, and Very poor) were determined. We then assigned ranges and scores for each metric based on the statistical analyses. By using this classification system, the plant communities of additional seasonal wetlands in the PPR can now be assessed and placed in quality classes for mitigation or ecological purposes, such as tracking the improvement of restored or reclaimed wetlands, wildlife habitat evaluation, hydrogeomorphic (HGM) assessment, and evaluation of other ecological functions.

Notes: A useful paper for development of biotic indices in temporary wetlands, which explains the metrics that were measured and the statistical techniques employed. These authors recommend the identification of a system of reference wetlands that are monitored over long time-periods.

Reference Type: Conference Proceedings
Record Number: 65
Author: Depinto, J.V.; Redder, T.M.; Kaur, J.
Year of Conference: 2003
Title: An integrated ecological response model for assessing the effects of water levels and flows in the Lake Ontario/St Lawrence River System.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 48
Address: 501 Avis Drive, Suite #1, Ann Arbor, MI, 48108.
Keywords: Bioassessment, EWR, impact assessment, lakes, USA.
Abstract: An ongoing study to evaluate existing and alternative water regulation plans for the Lake Ontario/St. Lawrence system is bringing together research from several interest groups to develop a "Shared Vision Model" to be used in the decision-making process. One of the interests of high importance in this study is the ecological response of the system to hydrologic and hydraulic regulation. Therefore, a technical working group has been formed to study a range of environmental performance indicators related to wetland quantity/quality, fish and wetland bird habitat, and other components of the ecosystem. An integrated ecological response model is being developed in parallel with these research efforts to synthesize the data and sub-models from each study into a single framework. This framework will permit the evaluation of the entire range of environmental performance indicators for each spatial component of the system for a series of water level regulation scenarios. The value added by the model will be its ability to represent the linkages and feedbacks among the various indicators and to allow a direct evaluation of competing responses among indicators. Once completed, the integrated ecological response model will be incorporated into the Shared Vision Model to facilitate the decision-making process.
Notes: This paper links environmental water requirements (EWR) of the lake with biotic indicators.

Reference Type: Conference Proceedings
Record Number: 66
Author: Desgranges, J.-L.; Ingram, J.W.; Savage, C.; Borchard, D.
Year of Conference: 2003
Title: Elaboration of wetland bird criteria for water level regulation in Lake Ontario-St. Lawrence Freshwater River System.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 47
Address: Canadian Wildlife Service, Quebec Region, Sainte-Foy, QC, GIV 4H5.
Keywords: Bioassessment, birds, EWR, lakes, USA.
Abstract: We studied the impact of inter-annual variation in late spring water levels on breeding bird assemblages in different parts of the Lake Ontario - St. Lawrence River. First, we identified bird species that rely on specific types of wetland habitat (step 1), by monitoring the abundance of some 175 bird species at 425 point counts along the St. Lawrence hydrosystem over 3 summers. Habitat characterization in 2.5 ha circular plots was based on the 3 dominant species of tree, shrub and herb, as well as on several landscape metrics that

reflect the vertical and horizontal spatial heterogeneity of the palustrine habitat complexes (step 2). We then examined the variability in the surface area of each avian habitat type as a function of water level changes (step 3). Finally, we linked bird species or bird assemblages with water levels, and relationships between univariate bird assemblage attributes (species richness, rarity and various diversity and integrity indices) and hydrological variables (e.g. water levels) are developed (step 4). These relationships will allow us to determine which water regulation plan criteria are associated with the highest values of bird species richness or diversity (step 5).
Notes: This paper links environmental water requirements (EWR) of the lake with biotic indicators, namely birds. See also previous paper.

Reference Type: Journal Article
Record Number: 67
Author: Dickens, C.W.S.; Graham, P.M.
Year: 2002
Title: The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for rivers.
Journal: African Journal of Aquatic Science.
Volume: 27
Pages: 1-10
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, invertebrates, rivers, South Africa, water quality.
Abstract: The assessment of biota in rivers is a widely recognised means of determining the condition or 'health' of rivers. Benthic macroinvertebrates, in particular, are recognised as valuable organisms for bioassessments, due largely to their visibility to the naked eye, ease of identification, rapid life-cycles often based on the seasons and their largely sedentary habits. Numerous bioassessment techniques have been developed over the last three decades, varying in complexity and region of implementation. South Africa has an exemplary history in this field, culminating in the refinement of invertebrate and other techniques and their application in a National River Health Programme. The method presented here is a refinement of the highly successful SASS (South African Scoring System) method developed by Chutter (1994), which forms the backbone of this programme. This paper takes the method to a level where it can, and has been, accredited to ISO standards. The principal changes made, include the tighter definition of the technique and the sampling and analytical methods, as well as the introduction of quality control procedures. Some changes have also been made to the list of invertebrates used in this method. Field trials were conducted to test the variability of the method. Of the various indices available to the method, the Average Score per Taxon (ASPT) is the most consistent over all biotopes (lowest CV%). On the other hand, of the biotopes examined the Gravel/Sand/Mud (GSM) combination is the most variable with respect to the SASS Score and number of taxa encountered. The spatial variability on a reach of river with similar water quality characteristics was found to be statistically negligible. However, one generally finds that statistically significant differences occur between the SASS Scores and the number of taxa counted by different operators. The ASPT, on the other hand, is a more consistent and repeatable measure of river health assessment and, within a given reach of river and considering all biotopes, the differences in results produced by different operators were statistically negligible. The results highlight the need for appropriate competency-based training and consistent application of the method.
Notes: Altough SASS was developed for rivers this paper contains many points concerning training, and quality control, amongst other issues that would also be relevant to a wetland assessment method.

Reference Type: Book
Record Number: 68
Author: Dickens, C.; Kotze, D.; Mashigo, S.; MacKay, H.; Graham, M.
Year: 2003
Title: Guidelines for integrating the protection, conservation and management of wetlands into catchment management planning.
City: Pretoria, South Africa.
Publisher: Water Research Commission, WRC Report TT 220/04.
Keywords: Bioassessment, functional assessment, management, social importance, South Africa.
Abstract: The legal framework that exists in South Africa provides every incentive to ensure that the water resources of this country, including its wetlands, are used sustainably. From the Constitution to legislation such as the National Water Act, the National Environmental Management Act, the Conservation of Agricultural Resources Act and others, an environment is created whereby the protection, conservation and management of wetlands could and should happen in order to ensure the sustainable use of natural resources of this country. Already suffering from years of abuse and over-utilisation, wetlands remain under threat as part of the water resource. So what are the problems? Why are the water resource contributions of wetlands not appreciated by society? Why are procedures not in place to protect them to ensure the ongoing supply of benefits they provide? Essentially there are three main problems: 1) Protection of wetlands requires protection of both the land uses around and within wetlands, as well as the water which feeds them and maintains their essential character. Generally, these two critical aspects are the responsibilities of different agencies, resulting in a lack of alignment of objectives and priorities, which in turn leads to one not being adequately addressed. 2) The web of legal and institutional responsibilities is complex and confusing. Wetlands are an issue for so many legal instruments and government departments that there is a tendency to hand over responsibility of dealing with them to someone else. The result is that wetlands tend to be ignored. 3) The technical tools needed to protect, conserve and manage wetlands as an important water resource are generally deficient. So, while there may be a strong desire to manage wetlands, as well as adequate (albeit fragmented) legislation and policy support, the wherewithal to ensure that the efforts invested are well spent, is inadequate. This guideline sets out to chart a way through the complexity that exists in the hope that the responsible agencies can incorporate wetlands into their catchment management planning processes. The Guideline provides a template (summarised in the Critical Path figure) which CMAs and other agencies responsible for water management in their areas can use. The Critical Path intends to help agencies navigate from (a) planning at catchment level for wetlands management and protection, to (b) implementation of wetland protection, rehabilitation and management strategies at site level. The Guideline provides these agencies with the following information: 1) Summarised information on the International Conventions that give support to the protection of wetland resources. 2) Summarised information on the laws within South Africa that create the environment necessary for effective wetland management, and that can be used to strengthen the implementation of plans and strategies. 3) An introduction to social and technical issues such as: a. Involving Stakeholders in the process. b. The survey and inventory of wetlands. c. Determination of the health of wetlands. d. Setting of objectives and priorities for wetlands. 4) The guideline also provides template style Terms of Reference that CMAs and other agencies can use in order to direct teams to the necessary tasks. It is important for those individuals and organisations who have responsibility for the management of water resources, especially wetlands, to crystallise a vision for the future of wetlands as an important part of the water resource in South Africa, and begin to take the steps that will lead to the fulfillment of that vision. This Guideline is an aid to achieving this aim.
Notes: The document is primarily directed, at giving practical guidance on how wetlands can be integrated into catchment management planning. Consequently only limited information is given on wetland assessment methods. Nonetheless the importance of assessment of wetland

condition and how the information generated could be used in management is very usefully discussed.

Reference Type: Conference Proceedings
Record Number: 69
Author: DuBowy, P.J.
Year of Conference: 2004
Title: Performance measures, ecosystem benefits and habitat units: Evaluating Everglades restoration alternatives.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: U.S. Army Corps of Engineers, CESAJ-PD-ES, PO Box 4970, Jacksonville Florida 32232 USA (paul.j.dubowy@usace.army.mil)
Keywords: Functional assessment, resource economics, restoration, USA.
Abstract: Wetland restoration is a complex integration of ecological and economic analyses to develop realistic project outcomes. As such, the U.S. Army Corps of Engineers has developed an iterative process based on hydrological and ecological models to evaluate Everglades restoration alternatives. Performance measures (ecological, hydrological and water quality) assess project alternatives in terms of single-factor wetland services recreated or enhanced as part of the restoration process in relation to pre-development and future without-project baseline conditions. As such, performance measures indicate proximity to restoration targets or goals. By extension, ecosystem benefits are defined as the sum total of performance measures and are used to compare and contrast project alternatives with respect to baseline conditions. Consequently, ecosystem benefits can be viewed as an n-dimensional hypervolume that encompasses wetland structure and function. The development of habitat units allows for a spatially explicit quantification of ecosystem benefits, which is necessary for the economic analysis of project alternatives given that USACE's planning and programmatic regulations stipulate that quantified ecosystem benefits are necessary in order to do cost effectiveness and incremental cost analyses. The Comprehensive Everglades Restoration Plan is an integrated set of over 60 projects with the goal of returning south Florida to some semblance of pre-drainage conditions. As such, it is the first largescale comprehensive program that integrates these ecological and economic processes in a unified manner to achieve ecosystem targets.

Reference Type: Journal Article
Record Number: 70
Author: Duel, H.; Specken, B.P.M.; Denneman, W.D.; Kwakernaak, C.
Year: 1995
Title: The habitat evaluation procedure as a tool for ecological rehabilitation of wetlands in the Netherlands.
Journal: Water Science and Technology.
Volume: 31
Pages: 387-391
Keywords: European Union, habitat, impact assessment, restoration.
Abstract: In the USA, the Habitat Evaluation Procedure (HEP) has become a standard approach for impact assessment and evaluation of measures and management activities causing changes in the environmental conditions of the habitats for faunal species. Recently, the method was implemented in the Netherlands. HEP is used to predict the ecological impact of measures and management activities concerning the ecological rehabilitation of rivers, tidal wetlands, lakes and marshes. For more than 30 faunal species the habitat requirements and preferences have been modelled. Examples of species-habitat relationships are presented. First results of the application of the method in ecological rehabilitation projects of rivers,

lakes and marshes are presented. The results show that the HEP approach is a useful tool in ecological water management.
Notes: A brief review of a Habitat Evaluation procedure for a variety of animal species in the Netherlands; 'suitability indices'.

Reference Type: Book
Record Number: 71
Author: DWAF, Draft Report No. N/0000.
Year: 2004
Title: Development of a Framework for the Assessment of Wetland Ecological Integrity in South Africa. Phase 1: Situation Analysis.
Series Editor: Uys, M.C.; Marneweck, G.; Maseti, P.
City: Pretoria, South Africa.
Publisher: Resource Quality Services, Department of Water Affairs and Forestry.
Keywords: Bioassessment, biotic index, South Africa.
Abstract: This report is the outcome of Phase I of a Department of Water Affairs and Forestry (Directorate: Resource Quality Services) project to develop an integrated method for the assessment of wetland condition in South Africa. The three phases of the project are; Phase I Situation Analysis; Phase II Development of the integrity index; and Phase III Testing, refinement, implementation and evaluation of the assessment method. The requirement for wetland assessment stems initially from an international and national focus on addressing the extensive global loss of wetland surface due to unsustainable growth and development. Nationally, the DWAF is mandated via the National Water Act (NWA 1998) to ensure conservation and protection of aquatic resources. The NWA requires that the environmental water requirements or the "Ecological Reserve" be determined for all significant water resources in the country (including wetlands) and that Resource Quality Objectives be set for these systems. It is necessary to address the current lack of a standard approach to the assessment of ecological character and biological condition of wetland systems. The report has the following layout. Chapter 1 explains the legal requirements and the necessity for development of methods to assess wetland ecological integrity. Chapter 2 provides definitions and insight into many of the key terms, approaches and concepts relevant to the theme of the study. Chapter 3 describes the three broad approaches to wetland evaluation namely; functional assessment, bioassessment and habitat assessment. A situation assessment of wetland evaluation in South Africa is presented in Chapter 4 and the activities in this regard of the major role-players (e.g. DEAT, DWAF, Mondi Wetlands Project) are discussed. In Chapter 5 international approaches to wetland assessment are described, including the work of the Ramsar Convention, the various agencies of the USA, and developments in Australia, Asia and around the the Mediterranean sea. Chapter 6 is a key section of the report in which the variables commonly used in wetland assessment are discussed. The chapter focuses primarily on the biotic variables that are used nationally and internationally as indicators of wetland condition. Their role in wetlands, their value as indicators and a series of methods associated with each biotic variable are presented. The variables considered are: plants, algae and diatoms, aquatic macrophytes, fish, amphibians and birds. Chapter 7 considers the topic of environmental water requirements of wetlands and the integral role that assessment of wetland ecological condition needs to play in this process. The final chapter (Chapter 8) presents the major conclusions and recommendations for the development of an integrated assessment protocol for use in evaluating wetland condition.
Notes: A key document (see preface).

Reference Type: Report
Record Number: 72
Author: DWAF
Year: 2004b

Title: Thukela system resource economics report. Reserve Determination study – Thukela River system.
Address: Report No. PBV000-00-10311. Prepared by IWR Source-to-sea as part of the Thukela Water Project decision support phase. Compiled by Mander, M.; Williams, C.; Veck, A.; Mullins, D.; Huggins, G.
Keywords: EWR, resource economics, social importance, South Africa.

Reference Type: Conference Proceedings
Record Number: 73
Author: Edsall, T.A.; Bur, M.T.; Gorman, O.T.; Schaeffer, J.S.
Year of Conference: 2003
Title: Burrowing mayflies as indicators of ecosystem health in western Lake Eire, Sanigaw Bay, and Green Bay.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 58
Address: U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105.
Keywords: bioassessment, invertebrates, lake, USA.
Abstract: We sampled with a standard Ponar grab at 117 stations covering about 1,870 km^2 of lake bed in spring 2001 to determine the status of nymphal populations of Hexagenia in western Lake Erie, Saginaw Bay, and Green Bay, and to provide information that would further the development of an indicator of ecosystem health based on Hexagenia. Our sampling showed that nymphs were generally abundant throughout the offshore waters in most of western Lake Erie and were less abundant or absent in some nearshore areas. Abundance was highest on mud or mud and fine sand substrates and the low abundance of nymphs seen on these preferred substrates at some locations suggested the substrate there was polluted. Nymphs were virtually absent from Saginaw Bay, where only one nymph was collected. Nymphs were also absent from most of lower and middle Green Bay, but were abundant in Big Bay De Noc at the northern end of Green Bay. Polluted sediments are likely responsible for the low abundance or absence of Hexagenia in Saginaw Bay and Green Bay.

Reference Type: Journal Article
Record Number: 74
Author: Ehrenfeld, J.G.
Year: 2000
Title: Evaluating wetlands within an urban context.
Journal: Ecological Engineering.
Volume: 15
Pages: 253-265
Source: ISI Web of Science
Keywords: Functional assessment, impact assessment, restoration, social importance.
Abstract: Coastal regions are among the most rapidly urbanizing places on earth. The numerous effects of urbanization on hydrology, geomorphology, and ecology make wetlands in urban regions function differently from wetlands in non-urban lands. Furthermore, wetlands in urban regions may take on human-related values that they lack in non-urban areas, as they provide some contact with nature, and some opportunities for recreations that are otherwise rare in the urban landscape. Evaluations of the success of restorations in urban regions require criteria first to determine the kinds, and intensities of urban influence on the site, and secondly to assess functional performance. The development of success criteria, at both the levels of assessment, depends on the proper definition of a reference domain (the set of wetlands to which success criteria will apply), and the documentation of a set of reference sites within the domain; both must be based within the urban context appropriate for the

region of interest. An example is presented from a study of urban wetlands in New Jersey of a procedure for establishing the reference domain, the reference set of wetlands, and criteria for the assessment of urban influence.
Notes: This is an interesting paper in that it stresses the importance of urban wetlands and explains why different criteria may need to be applied when carrying out an assessment of functions or social importance for these types of systems. Likely effects of urbanization on hydrology, geomorphology and ecology of wetlands are presented as well as indicator variables for assessing the degree of urban impact.

Reference Type: Journal Article
Record Number: 75
Author: Ernst, T.L.; Leibowitz, N.C.; Roose, D.; Stehman, S.; Urquhart, N.S.
Year: 1995
Title: Evaluation of US EPA environmental monitoring and assessment programs (EMAP) - Wetlands sampling design and classification.
Journal: Environmental Management.
Volume: 19
Pages: 99-113
Source: ISI Web of Science
Keywords: Bioassessment, management, monitoring, USA.
Abstract: The United States Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) will monitor the nation's resources by evaluating the status and trends of selected indicators of condition using a probability-based sampling design. The EMAP-wetlands program will monitor the condition of the nation's wetlands. The EMAP classification system is an aggregation of the many subclasses of the US Fish and Wildlife Service's National Wetland Inventory (NWI) classification system. This aggregation results in fewer wetland classes with more wetlands per class than the NWI system. Aggregation of the NWI classification was based primarily on dominant water vegetation cover, flooding regimes, dominant water source, and adjacency to rivers and lakes. We evaluate the EMAP classification system and sampling design using NWI digital wetlands data for portions of Illinois, Washington, North Dakota, and South Dakota. Relative numbers of wetlands, total areas, average areas, and common versus rare classes were compared between the EMAP and NWI classification systems. As expected, the EMAP classification provided fewer wetlands polygons, each with larger areas, without altering total wetland area. Summarising statistics comparing sample estimates to true population parameters (represented by the NWI data) demonstrated the effectiveness of the EMAP sampling design with the exception of rare EMAP classes in the selected regions. Although simple random sampling is inadequate for both large and small wetlands, the EMAP sampling design is readily adapted to provide better estimates for these categories. Aggregating the NWI classification to the EMAP classification provides fewer wetland classes, with more wetlands per class, for EMAP's annual reports and statistical summaries.
Notes: Gives information on how to set up a national monitoring programme. See also Leibowitz *et al*. 1991, Novitzki 1994, Moffet *et al*. 2001 and Kingston 2002.

Reference Type: Journal Article
Record Number: 76
Author: Euliss, N.H.; Mushet, D.M.
Year: 2004
Title: Impacts of water development on aquatic macroinvertebrates, amphibians and plants of a semi-arid landscape.
Journal: Aquatic Ecosystem Health and Management.
Volume: 7
Issue: 4

Pages: 73-84
Source: DWAF (2004)
Keywords: Amphibians, impact assessment, invertebrates, plants, stressor effects, USA.
Abstract: We compared the macroinvertebrate and amphibian communities of 12 excavated and 12 natural wetlands in western North Dakota, USA, to assess the effects of artificially lengthened hydroperiods on the biotic communities of wetlands in this semi-arid region. Excavated wetlands were much deeper and captured greater volumes of water than natural wetlands. Most excavated wetlands maintained water throughout the study period (May to October 1999), whereas most of the natural wetlands were dry by June. Excavated wetlands were largely unvegetated or contained submergent and deep-marsh plant species. The natural wetlands had two well-defined vegetative zones populated by plant species typical of wet meadows and shallow marshes. Excavated wetlands had a richer aquatic macroinvertebrate community that included several predatory taxa not found in natural wetlands. Taxa adapted to the short hydroperiods of seasonal wetlands were largely absent from excavated wetlands. The amphibian community of natural and excavated wetlands included the boreal chorus frog (*Pseudacris maculata*), northern leopard frog (*Rana pipiens*), plains spadefoot (*Scaphiopus bombifrons*), Woodhouse's toad (*Bufo woodhousii woodhousii*), and tiger salamander (*Ambystoma tigrinum*). The plains spadefoot occurred only in natural wetlands while tiger salamanders occurred in all 12 excavated wetlands and only one natural wetland. Boreal chorus frogs and northern leopard frogs were present in both wetland types; however, they successfully reproduced only in wetlands lacking tiger salamanders. Artificially extending the hydroperiod of wetlands by excavation has greatly influenced the composition of native biotic communities adapted to the naturally short hydroperiods of wetlands in this semi-arid region. The compositional change of the biotic communities can be related to hydrological changes and biotic interactions, especially predation related to excavation.
Notes: Of general relevance

Reference Type: Journal Article
Record Number: 77
Author: Farber, S.; Costanza, R.
Year: 1987
Title: The economic value of wetlands systems.
Journal: Journal of Environmental Management.
Volume: 24
Issue: 1
Pages: 41-45
Keywords: Resource economics, social importance, USA.
Abstract: This study uses both an economic willingness-to-pay and an energy analysis method of establishing the social value of a wetlands system. The economic approach considers the commercial, recreational, and storm protection value of wetlands. The energy analysis evaluates the energy processed by the wetlands system. These methods are applied to the wetlands system in South Louisiana.

Reference Type: Book
Record Number: 78
Author: Finlayson, C.M.; Spiers, A.G.
Year: 1999
Title: Techniques for enhanced wetland inventory, assessment and monitoring.
Series Title: Supervising Scientist Report 147.
City: Environment Australia.
Publisher: Supervising Scientist Group.
Number of Pages: 1-152
Source: DWAF (2004)

Keywords: Australia, bioassessment, monitoring.
Abstract: In recent years Australian governments have directed more and more attention towards the wise use and conservation of wetlands. This has resulted in a number of international initiatives such as hosting the 1996 Conference of the Ramsar Wetlands Convention, supporting the Ramsar Scientific and Technical Review Panel and initiating an Asia/Pacific wetland management training program. At a national level it has resulted in the development of specific federal and state wetland policies and a National Wetlands Program. The latter has provided support for a number of wetland projects, including the development of management plans for individual Ramsar sites and a directory of nationally important wetlands. During the 1996 Ramsar Conference Australia strongly supported the adoption of Resolution 6.1 'Working Definitions of Ecological Character, Guidelines for Describing and Maintaining the Ecological Character of Listed Sites, and Guidelines for Operation of the Montreux Record'. This resolution called for a greater effort in wetland monitoring and a review of early warning systems for detecting adverse ecological change in wetlands. In order to further develop the National Wetland Program and abide by Resolution 6.1 serious consideration has been given to the development of national approaches for wetland inventory and monitoring. As a consequence, the ANZECC Wetlands and Migratory Shorebirds Taskforce, consisting of representatives from all state/territory and the federal conservation/environment agencies, issued a recommendation supporting the development of a draft protocol for a national wetland inventory. In response, the Environment Australia (EA) Biodiversity Group obtained funding under the National Wetlands Program for a project aimed at developing a draft national wetland inventory proposal. The project, Technique Development and Databases for Enhanced Wetland Inventory in Northern Australia - Designing the Scope of the National Wetlands Inventory, is currently being undertaken by the Environmental Research Institute of the Supervising Scientist.
Notes: This document is concerned with wetland inventory in Australia and to a lesser extent with assessment of wetland condition. However it does illustrate how closely the two are linked. An abstract was available at the website, full document can be ordered.
URL: http://www.deh.gov.au/ssd/publications/ssr/147.html

Reference Type: Journal Article
Record Number: 79
Author: Finlayson, C.M.; Eliot, I.
Year: 2001
Title: Ecological assessment and monitoring of coastal wetlands in Australia's wet-dry tropics: A paradigm for elsewhere?
Journal: Coastal Management.
Volume: 29
Pages: 105-115
Source: ISI Web of Science
Keywords: Australia, impact assessment, monitoring.
Abstract: The Alligator Rivers Region in northern Australia is renowned for its habitat values but is under threat as a consequence of predicted climate change and sea level rise. In order to determine the likely extent and rate of change an assessment and monitoring framework for the coastal floodplain wetlands was designed. This resulted in a paradigm for developing a wetland assessment and monitoring program that included consultation with and involvement of local stakeholders. The components of the paradigm are: • establishment and empowerment of an expert assessment and monitoring center, • consultation with and empowerment of key stakeholders, • identification of major processes and causes of ecological change, • collation and coordination of available data and information, • identification of potential collaborators and partners, • design and implementation of technical assessment and monitoring projects, • audit and, if necessary, termination of assessment and monitoring projects, • implementation of management prescriptions based on results of the assessment and monitoring projects.

Notes: This document looks more at how to go about setting up a regional (or national) wetland assessment monitoring programme, rather than at the details or philosophy of the assessment methods themselves.

Reference Type: Book Section
Record Number: 80
Author: Finlayson, C.M.; Davidson, N.C.
Year: 2001
Title: Wetland inventory, assessment and monitoring - Practical techniques and identification of major issues: Introduction and review of past recommendations.
Editor: Finlayson, C.M.; Davidson, N.C.; Stevenson, N.J.
Book Title: Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues. Proceedings of workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 14 November 1998. Supervising Scientist Report.
City: Darwin.
Publisher: Supervising Scientist.
Pages: 1-10
Source: DWAF (2004)
Keywords: Monitoring.
Abstract: A review of recommendations from previous international conferences and workshops on wetland inventory, assessment and monitoring is provided. This lists the main recommendations from each meeting and summarises them as: Collection of long-term data on wetlands; Standardisation of techniques, guidelines and manuals; Provision of training; Reviewing gaps and co-ordination of data collection; Developing and making greater use of networks; and Developing means to audit existing effort. In many cases, however, the recommendations have not been enacted and little progress made. An exception is the inventory project that was developed under the Mediterranean wetland program known as MedWet. This program received institutional and financial backing and was able to achieve its objectives through participation of technical experts from a number of countries and organisations. The lessons learnt from these experiences are given as examples in developing further programs.
Notes: General background information.

Reference Type: Book
Record Number: 81
Author: Finlayson, C.M.; Davidson, N.C.; Stevenson, N.J.
Year: 2001
Title: Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues. Proceedings of workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 14 November 1998. Supervising Scientist Report.
City: Darwin.
Publisher: Supervising Scientist.
Source: DWAF (2004)
Keywords: Monitoring.
Abstract: The 2nd International Conference on Wetlands and Development aimed to review progress in wetland conservation and development since the 1st Conference (Malaysia, 1995). The conference reviewed trends in wetland development and management, and identified issues and solutions which could benefit agencies and individuals concerned with the wise use of wetlands at all levels. Special focus was given to Africa, with the aim of developing new partnerships, networks and programs for the future. Endorsements for the conference were received from the Convention on Biological Diversity, the Convention to Combat Desertification, the Convention on the Conservation of Migratory Species of Wild Animals,

the Ramsar Convention on Wetlands, the UN Economic Commission for Africa, and the World Heritage Convention. More than 40 donors provided funds to the conference. The Conference included 5 workshops covering: Strategies for wise use of wetlands: Best practices in participatory management Strategies for conserving migratory waterbirds Integrated wetlands and water resources management Wetland inventory, assessment, monitoring and valuation Mechanisms for financing the wise use of wetlands. The proceedings of workshop 4 are presented in this report.
Notes: This is a useful website to monitor - see also other papers by Finlayson.
URL: http://www.deh.gov.au/ssd/publications/ssr/161.html

Reference Type: Book
Record Number: 82
Author: Finlayson, C.M.; Begg, G.; Humphrey, C.; Bayliss, P.
Year: 2002
Title: Developments in wetland inventory, assessment and monitoring. Proceedings of a workshop on developing a framework for a wetland assessment system.
City: Kuala Lumpur, Malaysia.
Source: DWAF (2004)
Keywords: Management, monitoring.
Abstract: The main challenge that wetland managers and policy makers face today is to make choices that are sensible, pragmatic and defensible, particularly against a background of ecological and socio-economic complexity and uncertainty, due in large part to a lack of reliable knowledge. However, recent developments in wetland inventory, assessment and monitoring methods may provide an essential framework of knowledge for the wise use of wetlands, whether for conservation, sustainable use or multiple use objectives. Collectively known as a WIAMS (Wetlands Inventory, and Assessment, Monitoring System), we argue that this approach is more comprehensive and, hence, more effective than the conventional WAS (Wetlands Assessment System). It involves a multi-scalar (hierarchical) approach to inventory, best practice assessment protocols within a risk management framework, and a focused monitoring programme which provides feedback on performance in order to obtain outcomes. Wetlands throughout the world are under increasing threats and pressures from both local and global changes. Hence, over the past two decades, WIAMS are rapidly becoming an indispensable part of the decision-making tool box for wetland managers and policy makers operating from local to global scales. We first review past recommendations and considerations for wetlands inventory, monitoring and assessment, and then identify practical steps for developing effective programmes to obtain reliable information in a cost-effective and timely fashion. We recommend strongly that the WIAMS framework be adopted because it will, at the least, standardise terminology and approaches for obtaining and reporting information which can then be shared with those who cannot afford the luxury of such programmes. We recommend also, that this robust working framework be constantly reviewed and improved.
Notes: Nothing specific on techniques for assessing wetland condition. But the importance of including assessment in a structured framework of which also includes inventorising and monitoring is emphasized.
URL: http://www.wetlands.org/awi/Key_Ref/My-wiam.pdf

Reference Type: Journal Article
Record Number: 83
Author: Finlayson, C.M.
Year: 2003
Title: Editorial: The challenge of integrating Wetland inventory, assessment and monitoring
Journal: Aquatic Conservation: Marine and Freshwater Ecosystems.
Volume: 13

Pages: 281-286
Keywords: Management, monitoring.
Abstract: Wetland inventory, assessment and monitoring have been increasingly addressed in international and national fora. This has reflected concern expressed through the Ramsar Wetland Convention that the extent and quality of wetland information were, on the whole, insufficient to support effective management of a dwindling resource. In fact, at a global scale, the information base for wetland management is often outdated, inaccurate, and contains many gaps. Steps to overcome such problems culminated with the adoption by the Ramsar Wetland Convention in 2002 of a resolution that supported the development of an integrated framework for wetland inventory, assessment and monitoring. A basis for such a framework is presented in this paper. Distinctions between wetland inventory, assessment, monitoring and surveillance, and the importance of scale are discussed. A hierarchical framework for wetland inventory is presented. In addition, necessity for the adoption of early-warning indicators of ecosystem stress is (briefly) discussed.
Notes: Useful to give a broad view of how the activities of wetland inventorisation, assessment and monitoring should all compliment and support each other. An interesting figure is given showing a hierarchical arrangement of inventories at different scales and the attributes that would be measured at each level. No details of assessment techniques are given.

Reference Type: Conference Proceedings
Record Number: 84
Author: Forst, C.L.
Year of Conference: 2003
Title: Societal Response Indicators: Bearers of encouraging news?
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 184
Address: 177 W. Jackson Blvd., Chicago, IL, 60604; 2179 South Street, Boston, MA, 02111.
Keywords: Lakes, social importance, stressor effects, USA.
Abstract: To achieve a complete picture of the status of Great Lakes ecosystem components, effects caused by societal pressures must be considered. Some first steps have already been taken to quantitatively examine some of the ways in which society not only alters but also attempts to have positive effects on the health of the Great Lakes ecosystem. For example, a study was carried out to examine the amount of cosmetic pesticides applied to lawns in the Great Lakes Basin, in addition to determining the number of municipalities that have engaged in the proactive campaign to reduce/control toxic pesticide use. Early results reveal that Quebec is in the process of implementing a province-wide ban on cosmetic pesticides, and approximately 3.5% of municipalities in Ontario are in various stages of passing a pesticides by-law. Another societal response indicator study measures the amount of environmental education currently being incorporated into secondary (high school) curricula in the Great Lakes Basin, highlighting the link between education and environmental awareness/action. These and other similar studies are relevant to identifying emerging societal priorities, which often become the background and impetus for related public policy initiatives.

Reference Type: Journal Article
Record Number: 85
Author: Fustec, E.; Boët, P.; Amezal, A.; Fauchon, N.
Year: 1999
Title: Methodology for multifunctional assessment of riverine wetlands in the Seinie river.
Journal: Hydrobiologia.
Volume: 410

Pages: 213-221
Keywords: European Union, functional assessment, rivers.
Abstract: A new policy for wetlands conservation in France induced the development of research on the main functions of these ecosystems. This paper summarizes the results of four studies initiated in the Seine River basin by scientists, the regional water agency and a water supply syndicate to assess some of the functions of wetlands, mainly of riverine wetlands. One was directly conducted at the scale of the whole basin, focusing on the role of wetlands in water supply, flood control and nutrient retention. A second one was centred on the importance of waterbodies more or less connected to the channel for fish communities and on the role of flooded grasslands for the reproduction of pike. From the results obtained in large sectors of the fluvial corridor, a method is proposed for a regionalization of the hydrosystem. Two other approaches were tested in large areas of fluvial corridors to classify nitrate removal capacities of riverine wetlands through the identification of physical and biological indicators or modelling. What emerges from these studies is the necessity to undertake a common classification of wetlands on a hydrogeomorphic basis and then to develop multifunctional assessment in reference zones from the identified indicators or tested models.
Notes: This paper is interesting in that it looks at wetland functioning at the landscape (basin) level and also at a finer scale.

Reference Type: Journal Article
Record Number: 86
Author: Galastowitsch, S.M.; Whited, D.C.; Teser, J.R.; Power, M.
Year: 1998
Title: Development of community metrics to evaluate recovery of Minnesota wetlands.
Journal: Journal of Aquatic Ecosystem Stress and Recovery.
Volume: 6
Pages: 217-234
Source: DWAF (2004)
Keywords: amphibians, bioassessment, biotic index, birds, fish, invertebrates, plants, restoration, USA.
Abstract: Monitoring wetland recovery requires assessment tools that efficiently and reliably discern ecosystem changes in response to changes in land use. The biological indicator approach pioneered for rivers and streams that uses changes in species assemblages to interpret degradation levels may be a promising monitoring approach for wetlands. We explored how well metrics based on species assemblages related to land use patterns for eight kinds of wetlands in Minnesota. We evaluated land use on site and within 500 m, 1000 m, 2500 m and 5000 m of riverine, littoral, and depressional wetlands (n = 116) in three ecoregions. Proportion of agriculture, urban, grassland, forest, and water were correlated with metrics developed from plant, bird, fish, invertebrate, and amphibian community data collected from field surveys. We found 79 metrics that relate to land use, including five that may be useful for many wetlands: proportion of wetland birds, wetland bird richness, proportion of insectivorous birds, importance of *Carex*, importance of invasive perennials. Since very few metrics were significant for even one-half of the wetland types surveyed, our data suggest that monitoring recovery in wetlands with community indicators will likely require different metrics, depending on type and ecoregion. In addition, wetlands within extensively degraded ecoregions may be most problematic for indicator development because biotic degradation is historic and severe.
Notes: Useful paper, highlighting some of the pitfalls of developing biotic indices.

Reference Type: Journal Article
Record Number: 87
Author: Gannon, J.E.; Stemberger, R.S.
Year: 1978

Title: Zooplankton (especially crustaceans as rotifers) as indicators of water quality.
Journal: Transactions of the American Micros. Society.
Volume: 97
Pages: 16-35
Keywords: Bioassessment, biotic index, crustacea, zooplankton.
Abstract: Zooplankton have potential value as assessors of tropic conditions. They respond quickly to environmental change and may be effective indicators of subtle alterations in water quality. Since many species are widely distributed in diverse environments, those with greatest value are ones limited to extremes of trophic lake types (i.e., oligotrophy, eutrophy, and dystrophy). In the wide range of intermediate lake types, quantitative data on zooplankton community composition offers more potential than qualitative information on the presence or absence of crustacean species. The ratio of calanoid copepods to other major groups of zooplankton appears to be of value in identifying relative differences in trophic conditions. Multivariate analyses based on distribution and abundance of rotifer and crustacean species have proved useful in delineating major water masses of different trophic condition in large lake systems. But caution must be exercised in establishing one-to-one causal relationships between zooplankton composition and trophic conditions since other factors, especially toxic pollutants and size-selective predation, may exert considerable influence on changes in the community composition.
Notes: This paper was written several decades ago, but nevertheless gives important information that is useful in the development of a biotic index using zooplankton.

Reference Type: Book
Record Number: 88
Author: Germes, M.C.; Helgen, J.
Year: 2002
Title: Indexes of Biological Integrity for large depressional wetlands.
City: Final Report to US EPA. Federal Assistance # CD995525-01.
Publisher: Minnesota Pollution Control Agency.
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, invertebrates, USA.
Abstract: This report presents the invertebrate Index of Biological Integrity (IBI) for large depressional wetlands based on work from the 1999 field season in the North Central Hardwood Forest Ecoregion in Minnesota. The study design was based on sampling of 44 wetlands selected to meet *a priori* criteria as either high quality, least impaired reference sites (14 sites), or wetlands receiving various degrees of human disturbance from agriculture (14 sites) or urban influences (16 sites). The invertebrates were sampled within the shallow emergent vegetation zone during the seasonal index period of June. Standardized replicate samples were taken with dipnets, and sets of five pairs of activity trap samplers were used to collect a wide range of invertebrates. Water and sediments were analyzed for several analytes and the data were used in linear regressions against the biological data. In addition, biological data was plotted and regressed against a broader measure of human disturbance to the wetlands that included estimates of disturbances to the buffer and near landscape area around the wetland, and factors that disturb the wetland substrate, vegetation or water and sediment quality. The Human Disturbance Score (HDS) is described in this report. Invertebrates are richly represented in depressional wetlands: there were 203 taxa observed with 187 genera. The invertebrate IBI is composed of ten metrics, each is scored and added into the total IBI score. The metrics include measures of taxa richness, invertebrates that are intolerant of disturbance, and longer-lived invertebrates. Three metrics are based on proportions of certain more tolerant invertebrates that tend to increase under conditions of disturbance. The regressions of the data for each metric against the chemical factors and the Human Disturbance Score are given, and plots of metric data with several disturbance factors are shown. The metrics based on taxa richness tend to show the great significance in relation to human disturbance factors, and the proportion metrics tend to be less significantly related.

The overall IBI scores for the 44 wetlands show the most significant relationship with the HDS scores: with $p < .0000005$ and r of .715. Likewise, the IBI shows the greatest significance with other factors, particularly turbidity and concentrations of phosphorus and chloride in the water. This report gives details of the chemical and disturbance measurements. Overall, the mean of HDS scores for the reference wetlands (18.25) was considerably lower than that for the impaired wetlands (65.7 and 77.7 for agricultural and urban sites, respectively). Overall, the urban influenced wetlands had the highest levels of chloride in the water, and the highest concentrations of copper, lead and zinc in the sediments. Both categories of impaired wetlands had greater concentrations of total nitrogen, phosphorus and chlorophyll *a* than did the reference sites.
Notes: A key report that gives details of the development of a biotic index using invertebrates.
URL: http://www.pca.state.mn.us/water/biomonitoring/bio-wetlands-invert.html.

Reference Type: Journal Article
Record Number: 89
Author: Glaser, M.
Year: 2003
Title: Interrelations between mangrove ecosystems, local economy and social sustainability in Caete estuary, North Brazil.
Journal: Wetlands Ecology and Management.
Volume: 11
Issue: 4
Pages: 265-272
Keywords: Fish, marine, resource economics, social importance.
Abstract: Various types of subsistence and commercial extraction of mangrove products are identified on the North Brazilian coast. Of 2500 households in 21 rural communities (about 13.000 people) near the Caete estuary, 83% derive subsistence income, and 68% cash income through use of mangrove resources. The mangrove crab (*Ucides cordatus*) is collected and sold by 42% of households, and constitutes a main income source for 38%. Including processing and trading occupations, over half of the investigated population depend on the mangrove crab for financial income. Mangrove fishery occupies the lower rural income groups in the fisheries sector. About 30% of households engage in commercial fishing in or near the mangrove. Illegal commercial and subsistence use of mangrove wood and bark maintains a considerable number of rural households. In the context of widespread rural poverty in coastal North Brazil, it is important for mangrove management to take into account subsistence production, which has a central socio-economic function for the rural poor who live close to the mangroves. Socio-economic priorities in mangrove villages were, in order of importance, educational quality, occupational options, medical care, the low level of mangrove product prices, access to electricity and local leadership quality.

Reference Type: Conference Proceedings
Record Number: 90
Author: Grapentine, L.C.
Year of Conference: 2001
Title: Enhanced identification of biological impairment by use of habitat-benthic community structure models in assessments of disturbed sites.
Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 47
Address: National Water Research Institute, 867 Lakeshore Road, Burlington, ON, L7R 4A6.
Keywords: Bioassessment.

Abstract: Assessments of biological condition in disturbed sites often must be performed without pre-disturbance data. In such cases, direct determination of impairment is not possible because the undisturbed condition specific for each site is not known. Impairment must instead be inferred by comparison to the expected undisturbed condition, which is defined by observations from other similar, but undisturbed reference sites. Definition of the undisturbed condition can be improved by the use of predictive, multiple regression- type models that relate environmental variables to community structure. Expected community structure for a test site is obtained by first determining the relationship between community structure descriptors and habitat variables for the reference sites, then applying the models to the test site. If the observed community structure significantly deviates from that expected for an undisturbed condition corresponding to the test site, the community is considered impacted. By accounting for variability related to differences in natural environmental conditions among sites, the expected undisturbed condition is more precisely defined, and the power to detect impairment is increased. This approach performed well for assessing benthic community conditions of nearshore contaminated sites in the Great Lakes.
Notes: This is the same kind of approach used in RIVPACS, the riverine invertebrate biomonitoring system used in U.K. and parts of Europe.

Reference Type: Journal Article
Record Number: 91
Author: Gren, I-M.; Groth, K-H.; Sylven, M.
Year: 1995
Title: Economic Values of Danube Floodplains.
Journal: Journal of Environmental Management.
Volume: 45
Pages: 333-345
Keywords: European Union, resource economics, social importance.
Abstract: The Danube floodplains are shared by several countries and provide a complex ecosystem with various habitats or biotopes. Three of them have been selected, forests, grasslands and wetlands, which produce services of value to society. Examples of the ecosystem's services are water purification, biodiversity, flood control, wind protection and food supply. In order to make appropriate estimates of these services, ecosystem models are needed to describe how these services are produced and how they are linked to the economies of the countries concerned. Such models are not currently available. Therefore, this study makes rough calculations of values by transferring results obtained in other studies to the Danube floodplains. The services subjected to valuation are provision of input resources, recreation and nutrient purification. The estimated total annual value of the existing Danube floodplains amounts to ECU 374/ha. The total annual value of the entire actual area of Danube floodplains corresponds to ECU 650 million per year. Approximately two-thirds of this value is obtained in Romania. The value of the land as a nutrient sink accounts for about one-half of the total value. It should be noted that the calculations are based on several simplified assumptions and the results must therefore be interpreted with caution.

Reference Type: Journal Article
Record Number: 92
Author: Griffith, J.A.; Jackson, P.L.
Year: 1990
Title: A practical assessment of the Wetland Evaluation Technique (WET) as a tool for meeting Oregon's land use planning "goal 5" requirements.
Journal: Northwest Science.
Volume: 64
Source: BiblioLine
Keywords: Functional assessment.

Abstract: This paper discusses the use of the Wetland Evaluation Technique (WET) as a practical, rapid assessment methodology for meeting the policy directives set forth in Oregon's LCDC Goal 5 concerning natural area inventory and analysis. The issue of practicality was addressed from the standpoint of time, manpower, and the relative value of the results obtained from its use. A case study evaluated the Jackson-Frazier Wetland near Corvallis and concluded that WET produces wetland significance values comparable to other methodologies requiring greater time and expertise. However, to take the evaluation beyond the first level ratings requires significant time and expertise. This situation could pose considerable practical difficulties for those county landuse planning agencies with large numbers of wetlands within their jurisdictions.
Notes: Full paper not available in South Africa. See also for example Adamus (1988) and other records by the same author.

Reference Type: Journal Article
Record Number: 93
Author: Growns, J.E.; Davis, J.A.; Cheal, F.; Schmidt, L.G.; Rosich, R.S.; Bradley, S.J.
Year: 1992
Title: Multivariate pattern analysis of wetland invertebrate communities and environmental variables in Western Australia.
Journal: Australian Journal of Ecology.
Volume: 17
Pages: 275-288
Source: DWAF (2004)
Keywords: Australia, bioassessment, biotic index, invertebrates, water quality.
Abstract: Macro-invertebrates, zooplankton and water quality variables were sampled at 33 wetlands near Perth, Western Australia, in January-February 1989. Wetlands were classified and ordinated using the invertebrate data. Correlations of environmental variables with the ordination were calculated and the importance of seasonality and geomorphology of the wetlands were investigated. The wetlands were also classified and ordinated using the chemical data. Analysis of variance was used to compare species richness, abundance of all invertebrates, macro-invertebrates, copepods and total phosphorus levels amongst groups. Six groups of wetlands were identified from the invertebrate data, two of which were outliers on the basis of very low pH and high salinity, respectively. The majority of the wetlands grouped on the basis of their degree of nutrient enrichment and colour. The analyses of chemical data gave similar groups. The coloured wetlands and the least nutrient enriched non-coloured wetlands were identified as being the closest to the probable state of wetlands prior to European settlement. The greatest numbers of rare species were found in wetlands from these two groups. Species richness was significantly higher in the moderately enriched wetlands than in any other group but decreased in the most enriched wetlands where abundances of invertebrates were highest. Changes in community composition among the groups of wetlands are discussed. The most highly nutrient enriched wetlands were dominated by cosmopolitan species with high abundances, whereas less enriched and coloured wetlands had species with more restricted distributions and lower abundances.
Notes: Useful background paper for development of a biotic index using invertebrates. See also other work carried out on the Swan Coastal Plain (e.g. Chessman *et al*. 2002).

Reference Type: Journal Article
Record Number: 94
Author: Guntenspergen, G.R.; Peterson, S.A.; Leibowitz, S.G.; Cowardin, L.M.
Year: 2002
Title: Indicators of condition for the Prairie Pothole region of the United States.
Journal: Environmental Monitoring and Assessment.
Volume: 78

Pages: 229-252
Source: ScienceDirect
Keywords: Birds, impact assessment, plants, USA.
Abstract: We describe a study designed to evaluate the performance of wetland condition indicators of the Prairie Pothole Region (PPR) of the Dakotas, Montana, and Minnesota (USA). Basin and landscape scale indicators were tested in 1992 and 1993 to determine their ability to discriminate between the influences of grassland dominated and cropland dominated landscapes in the PPR. Paired plots were selected from each of the major regions of the PPR. Among the landscape scale indicators tested, those most capable of distinguishing between the two landscapes were: (1) frequency of drained wetland basins, (2) total length of drainage ditch per plot, (3) amount of exposed soil in the upland subject to erosion, (4) indices of change in area of wetland covered by water, and (5) number of breeding duck pairs. Basin scale indicators including soil phosphorus concentrations and invertebrate taxa richness showed some promise; however, plant species richness was the only statistically significant basin scale indicator distinguishing grassland dominated from cropland dominated landscapes. Although our study found a number of promising candidate indicators, one of our conclusions is that basin scale indicators present a number of implementation problems, including: skill level requirements, site access denials, and recession of site access by landowners. Alternatively, we suggest that the use of landscape indicators based on remote sensing can be an effective means of assessing wetland integrity.
Notes: This paper is valuable because it demonstrates that different indicators operate at different scales. Several approaches to assessment at the landscape scale are identified, for example the cropland:upland ratio.

Reference Type: Journal Article
Record Number: 95
Author: Halse, S.A.; Cale, D.J.; Jasinka, E.J.; Sheil, R.J.
Year: 2002
Title: Monitoring change in aquatic invertebrate biodiversity: Sample size, faunal elements and analytical methods.
Journal: Aquatic Ecology.
Volume: 36
Pages: 395-410
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, invertebrates.
Abstract: Replication is usually regarded as an integral part of biological sampling, yet the cost of extensive within-wetland replication prohibits its use in broad-scale monitoring of trends in aquatic invertebrate biodiversity. In this paper, we report results of testing an alternative protocol, whereby only two samples are collected from a wetland per monitoring event and then analysed using ordination to detect any changes in invertebrate biodiversity over time. Simulated data suggested ordination of combined data from the two samples would detect 20% species turnover and be a cost-effective method of monitoring changes in biodiversity, whereas power analyses showed about 10 samples were required to detect 20% change in species richness using ANOVA. Errors will be higher if years with extreme climatic events (e.g. drought), which often have dramatic short-term effects on invertebrate communities, are included in analyses. We also suggest that protocols for monitoring aquatic invertebrate biodiversity should include microinvertebrates. Almost half the species collected from the wetlands in this study were microinvertebrates and their biodiversity was poorly predicted by macroinvertebrate data.
Notes: Potentially useful information for development of a biotic index using invertebrates.

Reference Type: Journal Article
Record Number: 96
Author: Hamilton, R.I.; Kourtev, P.S.; Ehrenfeld, J.G.
Year: 2001
Title: Effects of water quality and habitat modification on benthic macroinvertebrates in urban forested wetlands in northeastern New Jersey.
Journal: ASB Bulletin (Association of Southeastern Biologists) (Philadelphia).
Volume: 48
Issue: 2
Pages: 165-166
Source: BiblioLine
Keywords: Invertebrates, stressor effects, USA, water quality.
Abstract: As New Jersey's population increases, urban landscapes and watersheds experience an increase in degradative anthropogenic affects. The issue to be addressed concerns ecological integrity in urban forested wetlands, which is almost completely overlooked. As benthic macroinvertebrate abundance and diversity directly affect the presence of larger organisms, ecological integrity is affected. The hypothesis to be explored opines that heterogeneity within wetland water channels, and substrate morphology combined with organic input from riparian vegetation can provide near optimum habitat for benthic macroinvertebrates despite degraded water quality and anthropogenic channel modifications. Baseline data about physical and water quality parameters will be gathered; seasonal dynamics of the benthic macroinvertebrate community in wetland channels will be analyzed. Macroinvertebrate abundance and diversity will be correlated with channel morphology, substrate heterogeneity and water quality.

Reference Type: Journal Article
Record Number: 97
Author: Hannaford, M.J.
Year: 1999
Title: Development and comparison of biological indicators of habitat disturbance for streams and wetlands.
Journal: Dissertation abstracts international part B: Science and engineering.
Volume: 59
Pages: 38-55pp
Source: BiblioLine
Keywords: Bioassessment, USA.
Abstract: Rapid biological assessment methods for streams have been established throughout the industrialized world. Five of these approaches were compared by applying them to biological data from streams in South Indiana. All methods were highly correlated but UK and USA approaches were the best predictors of habitat quality and population density, and had the fewest physical habitat influences. The US EPA's Rapid Bioassessment Protocol-III consistently identified an obviously impacted site in a California stream; however, repeated assessments of a restored stream site were highly variable. Natural differences among collection sites and biases in sub-sampling likely influenced result variability. Evaluation of stream habitat is an important component of rapid assessment programs. A group trained to do habitat assessments had less variable results than an untrained group at the same site. Differences in variability were attributed to a greater disparity in the interpretation of individual habitat features by untrained observers. After equal training and experience, both groups' assessments were not significantly different at a second stream site; however, results from the second site were more variable for both groups. This indicates that one training event may not be effective across all habitat types. Two types of all terrain vehicles (ATV) used in a San Francisco Bay salt marsh caused damage to the vegetation (*Salicornia virginica*) by breaking stems and reducing canopy height. Stem damage was greater for the Lightfoot ATV, with steel blade tracks, than the Argo ATV, with flat plastic tracks. Canopy

height recovered after one year from Argo damage but not from the Lightfoot. Heavy use (20 passes) increased the stem breakage caused by both types of vehicles. Growth of *Salicornia* was significantly reduced by both vehicles but standing crop biomass recovered within one year. Grazing by the dominant caddisfly *Dicosmoecus gilvipes* creates a natural habitat disturbance to the stream benthos in northern California streams, inhibiting the colonization of sessile macroinvertebrates. Fewer sessile organisms colonized cages stocked with *D. gilvipes* larvae; established sessiles were dislodged or consumed. Upstream-downstream differences in degree-days caused downstream *D. gilvipes* to diapause earlier than upstream ones, enabling sessiles to colonize downstream sites before upstream sites.
Notes: The full document was unavailable in South Africa. Not clear how useful this document would be for development of biotic indices. The experimentation on the reproduceability of habitat assessment by trained and untrained observers is interesting.

Reference Type: Personal Communication
Record Number: 98
Author: Harding, W.R.
Year: February 2005
Title: Wetland Assessment Protocol (WAP)
Address: Dr Bill Harding, D.H. Environmental Consulting; (info@dhec.co.za).
Keywords: Functional assessment, impact assessment, social importance, South Africa, water quality.
Abstract: WAP (Wetland Assessment Protocol) originated in 2001 as a qualitative method aimed at assessing the PES (Present Ecological State) and the EIS (Ecological Importance and Sensitivity) of a wetland. It was based on a hierarchical query and information assessment approach addressing functional (hydraulic and water quality), ecological and at a later stage, social and economic importance factors. Initially the approach was uni-weighted but gradually was adapted to become more versatile depending on the type of system being evaluated - i.e. ecological weights were higher (generally) for slope and upland systems, with increasing hydraulic value, economic and social values as one approached the floodplain. For systems such as Nylsvlei and parts of the Okavango a criterion analysis was first followed to set the weightings prior to use - based on identified importances and needs. WAP (c) has since (2002-2004) morphed into WETRAM (c) ("Wetland Response to Anthropogenic Modification") – and now uses a quantitative rather than qualitative approach. Currently it is a DHEC-owned and copyrighted in-house tool, and has 18 component modules ranging from the basic WETTYPE, delineation WETEDGE, WETCATCH (which sets up the landuse-cover and runoff export loading elements), WETLITH (still in infancy but which addresses soil versus botany issues - integrated with WETPLANT - a relatively small component which currently deals with nutrient cycling per major macrophyte type), WETSIZE/WETASSIM - which can be used two ways, either to determine the size of wetland required to deal with a particular challenge, or to back-model (linked to WETCATCH) the assimilatable capacity of the system - i.e. what can "Wetland A" cope with and how is it coping? This addresses much of the so-called wetland water quality arguments by employing a performance-based approach much as is used in lake modelling but with more complex cycling paths. WETQUAL will remain on hold until we see the outcome of the DAP (Diatom Assessment Protocol), WETLOAD (a sub-component of WETSIZE and which draws from WETCATCH), WETHYDRO (which still requires much further development), WETMETAL - which determines trace metal uptake capacity for a wetland type and draws on WETPLANT as well as WETLITH, WETSALINE (for the ephemeral environments, still in development), WETGWDE - groundwater dependent systems (currently the only qualitative component in operation), WETMIX - mixing model for lacustrine environments, WETINDEX - still being developed into ARRIVE - indexing based on irreplaceability and vulnerability, and finally WETTRAIN AND WETTRAINER - training and user modules. Future development needs will target integration of WETRAM with products such as DRIFT to accommodate riverine

assessments where in-line wetlands are nodal on a river reach. In short WETRAM is a developmental, quantitative, wetland assessment tool.

Reference Type: Conference Proceedings
Record Number: 99
Author: Haslam, S.M.
Year of Conference: 2004
Title: The significance of water type in the assessment and management of wetlands.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Department of Plant Sciences, University of Cambridge CB2 3EA, England (tina@one.co.uk)
Keywords: European Union, plants, water quality.
Abstract: Wetland water types vary. Extremes include bog, calcium dominated, nutrient-rich and, regrettably, now contaminants of many kinds. Plants are very sensitive to habitat chemistry, and vegetation reflects the waters of the present and of the lifetime of the plants present. To maintain reproducing communities, the water needed by those communities now, must be understood: understood in its quality and movement as well as quantity. Management must then ensure this. The Netherlands have led in this field, and others are partially following. However, far too many still consider adding water, of any natural or polluted type, is enough to create or sustain any wetland. A protocol should be devised and publicised, so that planners and managers are automatically provided with suitable questions before policies are implemented.

Reference Type: Journal Article
Record Number: 100
Author: Hauer, F.F.; Smith, R.D.
Year: 1998
Title: The hydrogeomorphic approach to functional assessment of riparian wetlands: Evaluating impacts and mitigation on river floodplains in the USA.
Journal: Freshwater Biology.
Volume: 40
Pages: 517-530
Source: CSA-Ebsco
Keywords: Functional assessment, restoration, rivers, USA.
Abstract: The 'hydrogeomorphic' approach to functional assessment of wetlands (HGM) was developed as a synthetic mechanism for compensatory mitigation of wetlands lost or damaged by human activities. The HGM approach is based on: (a) classification of wetlands by geomorphic origin and hydrographic regime (b) assessment models that associate variables as indicators of function, and (c) comparison to reference wetlands that represent the range of conditions that may be expected in a particular region. In this paper, we apply HGM to riparian wetlands of alluvial rivers. In the HGM classification, riverine wetlands are characterized by formative fluvial processes that occur mainly on flood plains. The dominant water sources are overbank flooding from the channel or subsurface hyporheic flows. Examples of riverine wetlands in the U.S.A. are: bottomland hardwood forests that typify the low gradient, fine texture substratum of the south-eastern coastal plain and the alluvial flood plains that typify the high gradient, coarse texture substratum of western montane rivers. Assessment (logic) models for each of fourteen alluvial wetland functions are described. Each model is a composite of two to seven wetland variables that are independently scored in relation to a reference data set developed for alluvial rivers in the western U.S.A. Scores are summarized by a 'functional capacity index' (FCI), which is multiplied by the area of the project site to produce a dimensionless 'functional capacity unit' (FCU). When HGM is properly used, compensatory mitigation is based on the FCUs lost that must be returned to the

riverine landscape under statutory authority. The HGM approach also provides a framework for long-term monitoring of mitigation success or failure and, if failing, a focus on topical remediation. We conclude that HGM is a robust and easy method for protecting riparian wetlands, which are critically important.
Notes: See also other papers on the HGM e.g. Rheinhardt *et al*. 1997, Stevenson and Hauer 2002.

Reference Type: Journal Article
Record Number: 101
Author: Havens, K.J.; Varnell, L.M.; Bradshaw, J.G.
Year: 1995
Title: An assessment of ecological conditions in a constructed tidal marsh and two natural reference tidal marshes in coastal Virginia.
Journal: Ecological Engineering.
Volume: 4
Pages: 117-141
Source: BiblioLine
Keywords: Bioassessment, fish, marine, plants, restoration, USA, water quality.
Abstract: A comparison of a constructed tidal marsh with two adjacent natural tidal marshes was conducted. The marshes were sampled for fish, shellfish, benthic infauna, marsh surface utilization, vegetation community type, stem density and cover, salinity, temperature, dissolved oxygen, organic carbon, bird utilization, and zooplankton. The proximity of study sites permitted simultaneous sampling to test for marsh preference by fish and shellfish. Subsurface organic carbon, *Spartina alterniflora* stem density, low marsh zone surface utilization, zooplankton abundance and bird nesting sites were all greater in the natural marshes. Other attributes such as stem density of the high marsh, high marsh zone surface utilization, surface organic carbon, and benthic infauna community structure and abundance were similar between the constructed and natural marshes. Seasonal differences were observed for fish and shellfish abundance between the constructed and natural marshes. The study is among the first to use simultaneous sampling techniques to investigate fish and shellfish use between constructed and adjacent natural reference wetlands.

Reference Type: Journal Article
Record Number: 102
Author: Helgen, J.
Year: 1998
Title: Wetland Bioassessment: - Volunteers on the cutting edge.
Journal: The Volunteer Monitor: National Newsletter for Volunteer Water Quality Management.
Volume: 10
Pages: 14-16
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, invertebrates, monitoring, plants, USA.
Abstract: Wetland bioassessment is a new science. Wetland ecologists are just beginning to develop methodologies. And volunteer monitors are right there, on the cutting edge. In Minnesota, volunteers are already using macroinvertebrate and plant bioassessments to monitor wetland health. And in New England, a new wetland bioassessment manual designed for volunteers has just been published. A caveat: Readers will note that the New England and Minnesota macroinvertebrate bioassessments use different metrics. This is due, in part, to differences between the two regions. Metrics must be custom-developed for different regions and different types of wetlands. Volunteer programs that want to do wetland bioassessments will need to work closely with ecologists in their region.

Notes: The fact that methods have been developed for volunteers suggests that some are relatively rapid, simple and robust.
URL: http://library.marist.edu/diglib/EnvSci/archives/phytozoo/hicks/hicks-bioassessment.html

Reference Type: Conference Proceedings
Record Number: 103
Author: Helgen, J.C.; Ferrington, L.C.; Steffenson, C.
Year of Conference: 2002
Title: An invertebrate Index of Biotic Integrity (IBI) for large depressional wetlands.
Conference Name: NABS Annual meeting, La Crosse, Wisconsin, 2001.
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, invertebrates, USA, water quality.
Abstract: An invertebrate index of biotic integrity (IBI) has been modified to assess the condition of wetlands based on analysis of 46 large (>4 ha), permanent depressions in the North Central Hardwood Forest Ecoregion of Minnesota. To ensure a gradient of human disturbance, the wetlands were about equally divided among reference, agricultural and stormwater affected sites. The ten invertebrate metrics, whose scores compose the IBI score, were evaluated against common water quality factors (chloride, phosphorus, nitrogen, turbidity, chlorophyll a, sediment metals) and against a gradient of human disturbance composed of physical and landscape elements. Significant relations were found with individual metrics and the IBI regressed on several water quality factors. This indicates a sensitive response of invertebrates to wetland impairment. The ten metrics are: total invertebrate taxa, number of genera of Odonata, of Chironomidae, of Hirudinoidea, of Gastropoda, the number of genera of mayflies plus caddisflies plus presence of Sphaeriidae and Anisoptera, the number of intolerant taxa, the proportion of tolerant taxa to the sample count, the proportion of Erpobdella to sample count, and the proportion of Corixidae to Coleoptera and Hemiptera abundance in bottletraps. Additional metrics were explored, such as the proportion of malformations in the Chironomidae.
Notes: Although only an abstract of this paper was available, it appears to be very useful for the development of a biotic index using macroinvertebrates.

Reference Type: Journal Article
Record Number: 104
Author: Hemming, J.M.; Turner, P.K.; Brooks, B.W.; Waller, W.T.; La Point, T.W.
Year: 2002
Title: Assessment of toxicity reduction in wastewater effluent flowing through a treatment wetland using *Pimephales promelas, Ceriodaphnia dubia*, and *Vibrio fischeri.*
Journal: Archives of Environmental Contamination and Toxicology (New York).
Volume: 42
Issue: 1
Pages: 9-16
Source: BiblioLine
Keywords: Bioassays, fish.
Abstract: Effluent toxicity is regularly assessed with *Ceriodaphnia dubia* short-term chronic and *Vibrio fischeri* toxicity tests. Condition factor and hematocrit of fish have recently been used to assess fish health following exposure to xenoestrogens in complex municipal effluents. To assess the ability of a treatment wetland to reduce or remove toxicity of a municipal effluent, we compared *C. dubia* and *V. fischeri* bioassays to *Pimephales promelas* responses *in situ*. Final whole effluent was diverted to a constructed wetland and effluent samples were taken daily from four sites, at incremental distances from the inflow, for a 3-week study. Overlapping 7-day *C. dubia* tests and *V. fischeri* assays were conducted with samples from each wetland site concurrent with a 3-week fish exposure. *C. dubia* survival and

fecundity were significantly (< 0.0001) reduced at the inflow, but steadily improved with distance from the inflow. Fish condition and hematocrit were lower (alpha < 0.05) at wetland sites closer to the inflow than other wetland sites and laboratory controls. However, effluent toxicity was not detected by *V. fischeri* bioassays. Our findings indicate that 7-day *C. dubia* bioassays were most sensitive to effluent toxicity and suggest that other bioassays should be used concurrent with *V. fischeri* assays for municipal effluent toxicity testing.
Notes: May be useful in some wetlands for monitoring of chronic effects due to effluents.

Reference Type: Journal Article
Record Number: 105
Author: Hemond, H.F.; Benoit, J.
Year: 1988
Title: Cumulative impacts on water quality functions of wetlands.
Journal: Environmental Management.
Volume: 12
Pages: 639-653
Source: LexisNexis
Keywords: Functional assessment, water quality.
Abstract: The total effect of cumulative impacts on the water quality functions of wetlands cannot be predicted from the sum of the effects each individual impact would have by itself. The wetland is not a simple filter; it embodies chemical, physical, and biotic processes that can detain, transform, release, or produce a wide variety of substances. Because wetland water quality functions result from the operation of many individual, distinct, and quite dissimilar mechanisms, it is necessary to consider the nature of each individual process. Sound knowledge of the various wetland processes is needed to make guided judgements about the probable effects of a given suite of impacts. Consideration of these processes suggests that many common wetland alterations probably do entail cumulative impact. In addition to traditional assessment methods, the wetland manager may need to obtain appropriate field measurements of water quality-related parameters at specific sites; such data can aid in predicting the effects of cumulative impact or assessing the results of past wetland management.
Notes: Probably not of direct relevance, but useful for a more detailed understanding of the water quality purification function of wetlands.

Reference Type: Journal Article
Record Number: 106
Author: Herath, G.
Year: 2004
Title: Incorporating community objectives in improved wetland management: the use of the analytic hierarchy process.
Journal: Journal of Environmental Management.
Volume: 70
Issue: 3
Pages: 263-273
Keywords: Australia, social importance.
Abstract: Wetlands in Australia provide considerable ecological, economic, environmental and social benefits. However, the use of wetlands has been indiscriminate and significant damage to many Australian wetlands has occurred. During the last 150 years one third of the wetlands in Victoria have been lost. A conspicuous problem in wetland management is the paucity of involvement by stakeholders. This paper uses the Analytic Hierarchy Process (AHP) to incorporate stakeholder objectives in the 'Wonga Wetlands' on the Murray River. The study shows that the AHP can explicitly incorporate stakeholder preferences and multiple

objectives to evaluate management options. The AHP also provides several approaches for policy makers to arrive at policy decisions.

Reference Type: Book
Record Number: 107
Author: Hicks, A.L.
Year: 1997
Title: New England Freshwater Wetlands Invertebrate Biomonitoring Protocol (NEFWIBP).
City: Amherst, MA
Publisher: The Environmental Institute, University of Massachusetts.
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, invertebrates, USA.
Abstract: A substantial revision of the 1997 manual, it includes many illustrations of representative wetland invertebrates, and user-friendly field sheets and data forms. Designed for wetland scientists, environmental consultants, watershed associations, and volunteer monitoring groups.
Notes: Not available in SA libraries. Order from website below.
URL: http://www.umassextension.org

Reference Type: Conference Proceedings
Record Number: 108
Author: Hogan, D.V.; Pasley, R.S.; Maltby, E.
Year of Conference: 2004
Title: Wetland functional assessment at the landscape scale.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Royal Holloway Institute for Environmental Research, Huntersdale, Callow Hill, Virginia Water, Surrey, GU25 4LN, UK (david.hogan@bbsrc.ac.uk)
Keywords: Functional assessment, resource economics, social importance, UK.
Abstract: The widespread loss and degradation of wetland ecosystems has resulted in a consequent loss of functional capacity to deliver a wide range of environmental benefits, which are also recognised as having wider social and economic values. In England and Wales, the Countryside Agency has been developing a programme of 'land management initiatives' (LMIs) to demonstrate opportunities for sustainable land management to deliver wider benefits within the rural context. One such area is the Humberhead Levels in the north of England, which comprises an extensive flat and lowlying former wetland landscape, now largely drained and reclaimed for highly productive agricultural use. Royal Holloway Institute for Environmental Research (RHIER) has been working with the Countryside Agency and other collaborating organisations in an initiative called 'Value in Wetness', which aims to demonstrate the benefits available from changes in land and water management including wetland re-establishment. Through a series of EU-funded collaborative projects, RHIER has been developing procedures for wetland functional assessment. This approach has been applied to current wetlands within distinctive landscape sub-sets of the Humberhead Levels, and to alternative management scenarios involving the raising of water levels. This has enabled assessments to be made of potential gains and losses in a range of functions, capable of interpretation in social and economic terms within a decision support system currently under development in the EU-funded project EVALUWET (European Valuation and Assessment tooL sUpporting Wetland Ecosystem legislaTion).
Notes: This may be a useful approach to determining Environmental Water Requirements for wetlands. See also Janssen *et al*. 2005 and Maltby *et al.* (2004).

Reference Type: Journal Article
Record Number: 109
Author: Holmes, V.R.; Cable, T.T.; Brack, V. Jr.
Year: 1985
Title: Avifauna as indicators of habitat quality in some wetlands of Northern Indiana.
Journal: Proceedings of the Indiana Academy of Science.
Volume: 95
Pages: 523-528
Source: BiblioLine
Keywords: Bioassessment, birds, USA.
Abstract: With the variety of habitat assessment methods available, any new procedure must provide viable improvements or alternatives. Many procedures suffer from such problems as: cumbersomeness, excessive training requirements before implementation, time consumption, and a limited range of application. The method presented here contains the integral features of many sophisticated evaluation procedures, but it circumvents these problems. The key is simplicity. Simplicity is stressed because it avoids the major shortcoming of many methods currently used.
Notes: The full article was not available in South Africa.

Reference Type: Journal Article
Record Number: 110
Author: Hruby, T.
Year: 1999
Title: Assessments of Wetland functions: What they are and what they are not.
Journal: Environmental Management.
Volume: 23
Pages: 75-85
Source: LexisNexis/ScienceDirect
Keywords: Functional assessment.
Abstract: Many methods have been developed over the last two decades to provide information about wetland functions, but there has been little discussion of the models and algorithms used. Methods for generating information about wetlands were analysed to understand their similarities, differences, and the type of information provided. Methods can first be grouped by the type of information they provide; classifications, characterizations, ratings, assessments, and evaluations. Methods that characterize, rate, or assess wetlands may generate information using one of two conceptual approaches - logic and mechanistic. Most methods that generate a numeric assessment of performance or value of wetland functions rely on the mechanistic approach to constructing models. Rapid assessment methods based on mechanistic models, however, do not assess the rates or dynamics of ecological processes occurring in wetlands. Rather, they provide a clear and concise way of organizing our current, and often subjective, knowledge about wetland functions. This is one limitation of current methods that is often misunderstood both by wetland managers and the scientific community. The advantages and limitations of the assumptions and the computational elements inherent in these approaches are discussed to provide wetland managers and regulators a better understanding of the information they are using.

Reference Type: Conference Proceedings
Record Number: 111
Author: Ingram, J.; Patterson, N.; DesGranges, J.L.
Year of Conference: 2004
Title: Lake Ontario-St Lawrence river water level regulation review: Use of wetland breeding bird evaluation criteria within an integrated environmental response model.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.

Conference Location: Utrecht.
Address: Environment Canada, Canadian Wildlife Service, Ontario Region (nancy.patterson@ec.gc.ca)
Keywords: Bioassessment, birds, EWR, fish, lake, plants, USA.
Abstract: The International Joint Commission is presently undertaking an International Lake Ontario-St. Lawrence River study to assess and evaluate the current criteria used to regulate outflows from Lake Ontario through the St. Lawrence River. The study is evaluating the impacts of changing water levels on shoreline properties, water uses, commercial navigation, hydropower, the environment, and recreational boating. The impacts of current and alternate water regulation plans on near shore biological communities are a high priority of this study. Within the near shore, wetland breeding bird habitat requirements are very sensitive to hydrology and as such, are being used as environmental evaluation criteria within an integrated environmental response model. Wetland breeding bird abundance, diversity and reproductive success indicators were developed as environmental performance measures based upon quantitative associations with wetland habitat abundance, diversity, structure, and hydrological conditions. The integrated model incorporates evaluation criteria for birds and additional near shore biological communities including wetland plants, fish and other wetland dependant fauna. This model will be used to evaluate water level scenarios resulting from alternate regulation plans and recommend hydrologic criteria important to minimizing the environmental impacts of water level regulation.
Notes: This paper links Environmental Water Requirements of the lake with biotic indicators, principally birds, but also plants and fish. See also Depinto, Redder *et al.* (2003) and Degranges, Ingram *et al.* (2003).

Reference Type: Journal Article
Record Number: 112
Author: Innis, S.A.; Naiman, R.J.; Elliot, S.R.
Year: 2000
Title: Indicators and assessment methods for measuring the ecological integrity of semi-aquatic terrestrial environments.
Journal: Hydrobiologia.
Volume: 422/423
Pages: 111-131
Source: LexisNexis
Keywords: Bioassessment, indicators, review, rivers.
Abstract: Knowledge concerning assessment methods addressing ecological integrity in wetlands and riparian zones is summarized, with an emphasis on riparian areas. This article examines which indicators (abiotic parameters, species, faunistic and floristic communities and functional assemblages) are used, how they are applied (single or integrative indicator), and which assessment algorithms and models have been successful to date. Overall, the review shows that despite the relatively recent emergence of riparian ecology, riparian assessments are better developed than the wetland functional assessments currently employed. In general, it is recommended that useful methods be updated and cross-calibrated, that new rapid assessment methods provide reasonable levels of accuracy for a variety of users in a variety of situations, that assessment be developed for specific applications (with identified users), that uncertainty be explicitly acknowledged, that the policy implications of specific assessment methods be openly discussed, and that methods be formally tested for accuracy, cost and practicality. A revised protocol is offered for the effective and rapid assessment of functional integrity in riparian environments associated with freshwater ecosystems. This protocol encourages the use of terrestrialization, canopy development, biodiversity, microclimate and seston as integrative indicators of integrity. Our objective is to summarize scientific knowledge concerning assessment methods addressing ecological integrity in wetlands and riparian zones, with an emphasis on riparian areas.

Notes: Gives an interesting figure showing the relationship between various forms of ecological information (inventory, classification, indicators, assessment) and the direction of development of wetland science. The paper considers both wetlands and riparian ecosystems, but the emphasis is on the latter.

Reference Type: Conference Proceedings
Record Number: 113
Author: James, C.S.; Kleynhans, M.T.; Birkhead, A.L.
Year of Conference: 2004
Title: Predicting hydro-ecological impact in a seasonal floodplain.
Conference Name: Proceedings, Fifth International Symposium on Ecohydraulics, Aquatic Habitats: Analysis & Restoration.
Conference Location: Madrid.
Pages: 1373-1378
Keywords: EWR, indicators, plants, rivers, South Africa.
Abstract: The Nyl River floodplain is an important nature reserve and bird refuge in the Limpopo Province, South Africa. Its ecological functioning depends on water supplied by catchment areas which are experiencing continuing water resources development. Hydrological and hydraulic models have been compiled to assist in future planning by predicting impacts of development on ecologically relevant flood characteristics. Wild rice is used as a key plant species, and its requirements of flooding depth, duration and timing are known. The models have been used to predict the effects of different development scenarios on the area of floodplain satisfying these requirements. The results show that historical development has already reduced the suitable area. Dam construction would reduce the suitable area further, particularly in average to dry years, and would reduce the frequency of occurrence of suitable conditions.
Notes: The environmental flow requirements of a floodplain system are examined using a key plant species. Although not of direct relevance for the development of a biotic index, useful background information.

Reference Type: Journal Article
Record Number: 114
Author: Janssen, R.; Goosen, H.; Verhoeven, M.L.; Verhoeven, J.T.A.; Omtzigt, A.Q.A.; Maltby, E.
Year: 2005
Title: Decision support for integrated wetland management.
Journal: Environmental Modelling & Software.
Volume: 20
Pages: 215-229
Source: ScienceDirect
Keywords: European Union, EWR, impact assessment, management, social importance.
Abstract: Wetlands perform functions that support the generation of ecologically, socially and economically important values. European legislation has increasingly recognised the importance of preserving wetland ecosystems. The Water Framework Directive (WFD) embodies many of the existing directives that have implications for wetlands. The EU funded EVALUWET project (European valuation and assessment tool supporting wetland ecosystem legislation) aims to develop and implement an operational wetland evaluation decision support system to support European policy objectives. A multidisciplinary approach is adopted combining expertise from natural and social scientists. The region of Noord-Hollands Midden is selected as the Dutch case study within EVALUWET. This region north of Amsterdam is a typical Dutch landscape with drained peat meadows in polders below sea level. Important stakeholders are: agricultural organisations, recreation, nature conservation organisations, and provincial/regional authorities. Water levels are controlled in the area.

Changes in water regimes are proposed (National Policies, WFD) which will have an impact on the performance of functions such as agriculture, nature and residential and recreation opportunities. In this case study, three alternatives will be compared: (1) modern peat pasture (current), (2) historical peat pasture and (3) dynamic mire. Impacts of these alternatives on a number of criteria relevant to EU policy are assessed. Spatial evaluation techniques in combination with multicriteria methods are used to support evaluation. This provides a better insight into the consequences of alternative water regimes on the performance of the wetland functions and is used to support stakeholders participating in the decision process. The system is based on the following software components: impact assessment is performed by a rule-based knowledge base implemented in NetWeaver. Spatial evaluation and map presentation are handled in ArcView and ArcMap. Multicriteria analysis is performed using the software package DEFINITE.
Notes: The EVALUWET approach requires further examination to see if it would be relevant to South Africa. See also Hogan *et al*. 2004 and Maltby *et al*. 2004.

Reference Type: Unpublished report
Record Number: 115
Author: Joska, M.A.P.; Day, J.A.; Boulle, L.; Archibald, S.
Year: 2001
Title: Draft final report: Development of a biomonitoring method, using protozoans, for assessment of water quality in rivers and ground waters and seasonal/ephemeral waters**.**
Keywords: Bioassessment, protozoans, South Africa, water quality.
Abstract: The aims of this project were as follows: 1. To investigate and identify those protozoans that could be used as biomonitoring tools and water quality indicators especially for seasonal/ephemeral rivers. 2. To establish whether certain groups within the protozoans e.g. ciliates are particularly suitable for water quality assessment. 3. To establish whether local taxa are cosmopolitan or at least whether or not they respond to water quality variables in the same way that northern hemisphere taxa do or are specifically endemic. 4. To establish preliminary methods for collecting protozoans for the biomonitoring of groundwaters. Our findings suggest that the major species, used for establishing the saprobic index, are indeed cosmopolitan. Results show that where water is lentic, underground or present only as a film on subsurface sediments, the use of protozoans as a biomonitoring tools, in tandem with the Saprobic System, may become of major importance in water-poor countries such as Africa. From the ephemeral water samples examined it would appear that many species are able to encyst to avoid unsuitable conditions. Thus, soil and sediment sampling also has potential as a biomonitoring tool. However, a new worker would have to become familiar with the identification of organisms and learn the special method of sampling. A key to the identification of species would enable non-biologically trained personnel to undertake biomonitoring. It is recommended that further studies be undertaken to establish which species can encyst and whether they travel down into the soil and what factors promote their excystment. Soils should be examined at different depth and moisture levels in order to establish which protozoan communities are present and whether specific protozoan groups are more prevalent. Despite the fact that we found the same species as are used as indicators for the Saprobic System in Europe it would be interesting to establish whether or not these species have their own genetic integrity.
Notes: This was a preliminary project (WRC K5/1017) but the approach appears to be promising. More research is needed, however.

Reference Type: Conference Proceedings
Record Number: 116
Author: Kane, D.D.; Culver, D.A.
Year of Conference: 2001
Title: Development of a plankton index of biotic integrity for Lake Eire.

Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 65
Address: Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH, 43210.
Keywords: Bioassessment, biotic index, diatoms, plankton, USA.
Abstract: Biological integrity, which is a measure of the "health" of an ecosystem, has been quantified through the development of Indices of Biotic Integrity (IBI). To date, IBis have been developed for such diverse taxa as stream and lake fishes, macroinvertebrates, periphyton, and sedimented diatoms, but not for planktonic communities. Given the importance of the plankton to Great Lakes resources, we are developing a P- IBI based on phytoplankton and zooplankton abundances and species composition data for these lakes. When completed, the P-IBI may be used for management decisions and for communicating lake status to the public. We will discuss progress in constructing the P-IBI, calibrated using data from approximately 1,300 samples taken from all three basins of Lake Erie during 1995 - 1999. Phytoplankton metrics used in the construction in the P-IBI include presence of cyanobacteria and colonial greens, relative abundance of centric and pennate diatoms, as well as diversity and percentage dominance metrics. The zooplankton component will include such metrics as percentage large *Daphnia*, number of taxa, and percentage dominance. We will incorporate spatial and temporal patterns when creating the P-IBI, and the final index will be validated statistically.

Reference Type: Conference Proceedings
Record Number: 117
Author: Kangalawe, R.Y.M.; Liwenga, E.T.
Year of Conference: 2004
Title: Livelihoods in the wetlands of Kilombero Valley in Tanzania: Opportunities and challenges to integrated water resource management.
Conference Name: Proceedings of 5th Waternet/WARFSA annual symposium, 2-4 November 2004.
Conference location: Windhoek, Namibia
Page: 14
Address: Institute of Resource Assessment, University of Dar es Salaam, Box 35097, Dar es Salaam. (kangalawe@ira.udsm.ac.tz; liwenga@ira.udsm.ac.tz).
Keywords: Africa, resource economics, rural livelihoods, social importance.
Abstract: Wetlands contribute in diverse ways to the livelihood of many people in Africa. One of the major constraints to the wise use of African wetlands is lack of knowledge by government planners and natural resource managers on the benefits that they provide and techniques by which they can be utilised in a sustainable manner. This paper presents the findings from a study undertaken in Kilombero Valley on the dynamics and benefits of natural resource use in the wetlands. The paper specifically focuses on opportunities and challenges related to integrated water resource management. The study was conducted in two villages, Idete and Signali located in Kilombero District, Morogoro Region. Participatory assessment was employed as a way to obtain qualitative and quantitative information pertaining to biophysical, agronomic and socio-economic facts that influence community access to, and utilisation of the wetland resources. In addition, to validate and to further quantify the information obtained from the participatory assessments and to provide further insights, household surveys were undertaken. The findings show that Kilombero Valley wetland has high potential for a diversity of livelihood activities. Wetlands also serve as a source of water for farming, livestock keeping and for domestic use. However, over the last two decades use of the Kilombero wetlands has increased due high influx of people (pastoral and agro-pastoral communities) from various parts of Tanzania and major developments upstream and around the wetland. The dynamics of wetland use in the study area is much

influenced by the socio-economic factors and conservation factors/policies as related to the surrounding protected areas e.g. the Udzungwa National Park and Selous Game Reserve. The main conclusion is that sustainable livelihood development of wetland communities requires multidisciplinary and integrated efforts in addressing constraints in the various sectors such as agriculture, natural vegetation use, water resources and fishing.

Reference Type: Thesis
Record Number: 118
Author: Kareko, J.K
Year: 2004
Title: The interaction between vegetation and near-surface water in a wetland system, Stellenbosch, South Africa.
Publisher: MSc thesis (in ecological assessment), Department of Botany, University of Stellenbosch.
Keywords: Bioassessment, plants, South Africa, water quality.
Abstract: Understanding the responses of individual plant communities to variations in near-surface water levels and to water quality is a step towards determining the critical or important factors applicable to a Rapid Wetland Assessment System. This thesis describes and discusses factors associated with wetland plant communities, in an attempt to predict changes in a wetland system. These changes may be as a result of variations in environmental factors (physical and chemical) or human related activities. It is important to note from this initial stage that although plant communities are good indicators of wetland condition, a lag may occur or may be expected in the response time to stressors, especially in the long-lived species, hence an early warning criterion is crucial to short-term monitoring. This study was initiated with a primary aim of establishing the relationship between plant communities and the variation in near-surface water levels in a natural wetland system in Stellenbosch. A second aim was to assess whether water quality had an influence on the plant communities. Most of the water quality constituents measured in this study are the result of multiple complex relationships, with constituent variations occurring differently between communities. However, remarkable seasonal distinctions in amount of a constituent between communities occurred. Direct gradient analysis (CCA) was used to determine the relationship between plant communities and environmental variable gradients. The water table and the pH gradients play a key role in determining the community distribution; however, when all the environmental gradients are considered together, no explicit, clear trends, are displayed. This is an indication that each factor affects the communities in a unique way. It is, however, not very practical to distinguish the relationship boundaries for each factor between different communities, but a combination of these factors can be associated to a particular community. Despite the complexity involved in sorting out the interrelationships between plant communities and environmental factors, the low species diversity, the tendency for single species dominance in wetland plant communities and the strong association of these communities with particular environmental variables adds value to wetland vegetation as a good indicator of wetland condition. An effort to understand wetland plant communities in relation to determining environmental factors would promote the use of plant communities as user-friendly tools for wetland monitoring and assessment.
Notes: Some preliminary work towards developing an index based on macrophytes which highlights some of the problems likely to be encountered.

Reference Type: Book
Record Number: 119
Author: Karr, J.R.; Chu, E.W.
Year: 1999
Title: Restoring life in running waters: Better biological monitoring.

City: Washington D.C.
Publisher: Island Press.
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, review, rivers, USA.
Abstract: Despite nearly three decades of efforts intended to protect the nation's waters, and some success against certain forms of chemical and organic contamination, many of our nation's waterways continue to be seriously degraded. The call of the 1972 Clean Water Act – "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" – remains unanswered. "Restoring Life in Running Waters" discusses freshwater ecosystems in the United States and the need for using biology to understand their present condition. The book makes a case for using indexes that integrate measurements of many biological attributes to assess and communicate environmental health. In a unique and innovative format, the authors present 37 premises and 7 myths that explore the theory and practice of biological monitoring and the use of multimetric indexes. The book explains: - why biological monitoring and assessment are needed, - the historical evolution of biological monitoring, - how and why living systems give the best signals for diagnosing environmental degradation, - what multimetric indexes do and why they are effective, - how multimetric indexes can be used and common pitfalls to avoid in using them, - why many criticisms of biological indexes are not valid, - how the principles of biological monitoring and multimetric indexes can be expanded beyond aquatic systems to other environments, - how information from indexes can be integrated into the regulatory and policy framework. "Restoring Life in Running Waters" provides practical and effective tools for managers and scientists seeking to understand the impact of human activities on natural systems and to determine proper action to remedy problems. It is an essential handbook for conservation biologists; agency personnel at all levels, including technical staff, policymakers, and program managers; and for anyone working to protect and restore the health of the nation's waters.
Notes: Concerned with rivers rather than wetlands, but a useful document. Available from libraries in SA.

Reference Type: Book Section
Record Number: 120
Author: Keddy, P.A.; Lee, H.T.; Wisheu, I.C.
Year: 1993
Title: Choosing indicators of ecosystem integrity: Wetlands as a model system.
Editor: Woodley, S.; Kay, J.; Francis, G.
Book Title: Ecological integrity and the management of ecosystems.
City: Boca Raton, FL (USA).
Publisher: Press
Pages: 61-79
Source: BiblioLine
Keywords: Bioassessment, indicators.
Abstract: Defining ecosystem integrity and choosing indicators for it would be a relatively simple task if the science of ecology was able to provide us with simple, rigorous models for describing and predicting these states of ecosystem. Unfortunately, a major problem in modern ecology is that we do not know which state variables are important and which ones are not. Neither do we have simple quantitative models to describe relationships among these state variables. Lewontin calls this the "agony of community ecology." Determining the important state variables and describing the quantitative relationships among them is a key step for escaping many of the sterile controversies which detract from progress in ecology. In contrast, in assessing human health, we already know that some state variables, like height and hair colour, are unimportant in assessing state of health whereas others, like blood pressure and heart rate, are important and diagnostic. Given that we lack the necessary rigorous ecological models, we need (1) to define integrity in an operational way, (2) to select those state variables which indicate integrity and (3) to identify levels of those state variables

which indicate integrity or lack thereof. We also, need a system of feedback so that as we monitor our success or failure, we can modify the indicators and their levels. The difficulty in coming up with potential indicators of wetland integrity is illustrated by two huge symposium volumes which have just been published. In spite of their size, these two volumes show that wetland biologists are collecting fragments of information from a wide array of vegetation types without a unifying conceptual framework which could guide a search for ecosystem integrity.
Notes: Gives a good overall perspective on the problem of assessing ecological integrity of wetlands. The analagy with human health is illuminating.

Reference Type: Conference Proceedings
Record Number: 121
Author: Kim, K.
Year of Conference: 2004
Title: Spatial and economic analytical tools for wetlands management.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: University of Hawaii at Manoa, Dept. of Urban & Regional Planning; 2424 Maile Way, # 1 07, Honolulu, HI. 96822. (karlk@hawaii.edu)
Keywords: Impact assessment, resource economics.
Abstract: Using comprehensive economic and spatial data from Hawaii, the various threats to wetlands from industry, residential development, and government investment in infrastructure (canals, roads, etc.) are described. A model of the state's economic structure using input-output data on 131 different economic sectors along with an urban growth model showing long-range development patterns are described. In addition to demonstrating relationships between the economic base and wetlands, the impacts of alternative development patterns and policies are mapped and analysed. Hawaii presents an ideal case for examining the interactions between the natural environment and economic and social forces, both because of its isolation from other places and because of its dependency on tourism, which in turns relies on the prudent management of its unique natural and cultural assets. The economic and environmental consequences of alternative development scenarios and sustainable development policies are considered. The contributions of this research are in terms of the development of analytical tools for measuring and understanding the economic and spatial impacts of wetlands preservation and also in terms of understanding the relationships between tourism, industrial development, and wetlands management.

Reference Type: Journal Article
Record Number: 122
Author: King, R.S.; Nunnery, K.T.; Richardson, C. J.
Year: 2000
Title: Macroinvertebrate assemblage response to highway crossings in forested wetlands: implications for biological assessment.
Journal: Wetlands Ecology and Management.
Volume: 8
Issue: 4
Pages: 243-256
Source: BiblioLine
Keywords: bioassessment, biotic index, invertebrates, USA.
Abstract: Despite the mandate of the Clean Water Act to protect the physical, chemical, and biological integrity of wetlands in the USA, the use of biota to assess wetland condition has not been explored in detail. During June 1996, the response was evaluated of macroinvertebrate assemblages in fill-culvert highway crossings in two bottomland forested wetlands in North Carolina. Vegetation in both study sites was dominated by bald cypress

(*Taxodium distichum*) and swamp tupelo (*Nyssa sylvatica var. biflora [N. biflora]*) trees, with a herbaceous layer comprising the invasive Asian spiderwort (*Murdannia keisak*) and cutgrass (*Leersia oryzoides*), with duckweed (*Spirodela polyrhiza*) abundant in open canopy areas near the highway crossings. The objective was to apply biological assessment methods and metrics that have been effectively used in streams to explore their applicability in forested wetlands. Significant changes were found in several metrics as a function of distance from the highway crossings. Areal and numerical taxon richness increased within at least 40 m of highway when compared to control locations. Percentage dominant taxon values were lowest within 10 m of the highway. Percentage herbivores also increased significantly within at least 40 m of the highway, reflecting the lower % crown closure and associated shift in primary production from trees to herbaceous macrophytes and algae. The North Carolina Biotic Index, a metric of tolerance, did not reflect assemblage changes near the highway. Ordination and permutation tests revealed that assemblage composition was significantly different from controls at 10 and 40 m distances from the highway crossings. In particular, algal grazers such as the mayflies *Caenis sp*. and *Callibaetis sp*. responded positively and the damselflies *Ischnura spp*. and the fingernail clams *Sphaerium spp*. responded negatively to the crossings. Favorable algal and herbaceous detrital resources, greater patchiness and habitat complexity, and overall high tolerance to natural stressors probably contributed to the increase in taxon richness near the highway. However, significant deviation from control locations indicated the highway was a source of perturbation. Results illustrate the potential utility of macroinvertebrate assemblages for wetland assessment, but suggest the importance of defining the reference condition as well as the need for development of metrics for specific classes of wetlands.
Notes: Useful for development of a biotic index using macroinvertebrates.

Reference Type: Journal Article
Record Number: 123
Author: King, R.S.; Richardson, C.J.
Year: 2002
Title: Evaluating subsampling approaches and macroinvertebrate taxonomic resolution for wetland bioassessment.
Journal: Journal of the North American Benthological Society.
Volume: 21
Pages: 150-171
Keywords: bioassessment, invertebrates, USA.
Source: ISI Web of Science
Abstract: Methods for wetland bioassessment using macroinvertebrates are not well developed. Two of the most controversial issues in stream bioassessment, subsampling and taxonomic resolution, have yet to be quantitatively addressed for wetlands. Using a multivariate approach, we evaluated the efficacy of family-, genus-, and species-level assemblage data in reflecting the environment and distinguishing impaired sites from the reference condition. We used 5 basic levels of subsampling (100-, 200-, and 300-organism fixed counts; 10% and 25% fixed areas), an integrated subsample requiring a minimum fixed count and fixed area (100&10%), and 100-count and 10%-area subsamples coupled with a supplementary large-rare (LR) search. Data were obtained from 1.5-m^2 composite samples collected from 126 plots along a 10-km-long eutrophication gradient in the Florida Everglades. Our results suggest that effectiveness of subsampling depended more upon the minimum number of individuals retained than minimum area or proportion of the sample picked. Fixed-area subsamples were generally less efficient than fixed counts, with 200- and 3OO-individual fixed counts resulting in significantly greater assemblage-environment relationships and much higher accuracy in detecting impairment than 10% fixed area, despite averaging similar numbers of individuals. The greatest improvement with increasing subsample size was observed between fixed counts of 100 and 200 individuals; detecting impairment, in particular, was not markedly improved with subsample sizes >200 individuals. Supplementing subsamples with a LR search resulted in only very slight improvements in

assemblage-environment relationships, but was effective in improving prediction accuracy, particularly for family-level data. However, family-level assemblage-environment relationships and abilities to detect impairment were inferior to genus- and species-level data, regardless of subsample size. Species-level data performed best, primarily because of the large proportion (>20%) of total species belonging to Chironomidae. The potential importance of Chironomidae to wetland bioassessment was further revealed through an evaluation of a tiered-taxonomic approach, which showed that non-Chironomidae family-level data tiered with species-level Chironomidae data produced results very similar to those obtained using genus- or species-level data exclusively. Our results suggest that fixed counts 2:200 or integrated fixed-area/fixed-count approaches that consistently obtain a minimum of 200 individuals should be considered as minimum subsample sizes for wetlands. We additionally advocate LR searches and recommend genus- or species-level taxonomy, particularly for the Chironomidae.
Notes: This paper discusses the efficacy of familial, generic and specific data for wetlands bioassessment methods in the Everglades (Florida, USA). It presents the results of very detailed sampling programme for the US EPA (Florida mostly uses chironomids to species level for invertebrate bioassessments). A useful paper.

Reference Type: Journal Article
Record Number: 124
Author: King, R.S.; Richardson, C.J.
Year: 2003
Title: Integrating bioassessment and ecological risk assessment: an approach to developing numerical water-quality criteria.
Journal: Environmental Management.
Volume: 31
Pages: 795-809
Source: ISI Web of Science
Keywords: Bioassessment, biotic index, invertebrates, stressor effects, water quality.
Abstract: Bioassessment is used worldwide to monitor aquatic health but is infrequently used with risk-assessment objectives, such as supporting the development of defensible, numerical water-quality criteria. To this end, we present a generalized approach for detecting potential ecological thresholds using assemblage-level attributes and a multimetric index (Index of Biological lntegrity-IBI) as endpoints in response to numerical changes in water quality. To illustrate the approach, we used existing macroinvertebrate and surface-water total phosphorus (TP) datasets from an observed P gradient and a P-dosing experiment in wetlands of the south Florida coastal plain nutrient ecoregion. Ten assemblage attributes were identified as potential metrics using the observational data, and five were validated in the experiment. These five core metrics were subjected individually and as an aggregated Nutrient-1BI to nonparametric changepoint analysis (nCPA) to estimate cumulative probabilities of a threshold response to TP. Threshold responses were evident for all metrics and the IBI, and were repeatable through time. Results from the observed gradient indicated that a threshold was >50% probable between 12.6 and 19.4 μg/L TP for individual metrics and 14.8 μg/L TP for the IBI. Results from the P-dosing experiment revealed >50% probability of a response between 11.2 and 13.0 μg/L TP for the metrics and 12.3 μg/L TP for the IBI. Uncertainty analysis indicated a low (typically >5%) probability that an IBI threshold occurred at < 10 μg/L TP, while there was >95% certainty that the threshold was < 17 μg/L TP. The weight-of-evidence produced from these analyses implies that a TP concentration> 12-15 μg/L is likely to cause degradation of macroinvertebrate assemblage structure and function, a reflection of biological integrity, in the study area. This finding may assist in the development of a numerical water-quality criterion for TP in this ecoregion, and illustrates the utility of bioassessment to environmental decision-making.
Notes: An interesting application of a macroinvertebrate biotic index. Potentially useful for future research in South Africa when more is known about the taxa found here.

Reference Type: Conference Proceedings
Record Number: 125
Author: Kingston, J.C.
Year of Conference: 2002
Title: Great lakes environmental indicators: diatom-based assessment tools in coastal wetlands.
Conference Name: International Association for Great Lakes Research.
Page: 65
Source: BiblioLine
Keywords: Bioassessment, diatoms, USA, water quality.
Abstract: As part of a larger U.S. Environmental Protection Agency STAR grant program to develop ecological indicators for the nearshore and coastal regions of the United States, we are developing diatom indicators for wetlands, bays, and nearshore portions of the Laurentian Great Lakes. Our design follows from EMAP program sampling suites and detailed methods developed for offshore areas of the Great Lakes and for large sets of smaller lakes in EMAP - Surface Waters. The Great Lakes Environmental Indicators (GLEI) project pilot collections from the 2001 field season (over 400 diatom samples and 200 Water Quality samples and field profiles) are initially being evaluated to show the potential for diatoms to provide paleolimnological baselines in depositional zones and to perform power analyses to define efficient sampling to discriminate different ecological condition based on diatom indicators. Some of the protected wetlands provide habitats for diatoms rarely found in the Great Lakes proper, and this will greatly expand the number of indicator organisms developed for the project.
Notes: It would appear from the abstract that diatoms are being used to indicate the water quality of both existing conditions as well as historic conditions (from paleolimnological examination of sediments). See also next record.

Reference Type: Conference Proceedings
Record Number: 126
Author: Kingston, J.C.; Domzal, K.S.; Sgro, G.V.; Johansen, J.R.; Stoermer, E.F.; Axler, R.P.; Kireta, A.R.
Year of Conference: 2003
Title: Diatom indicators of ecological condition for the coastal zone of the Laurentian Great Lakes.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 57
Address: University of Minnesota - Dulluth, NRRI, 1900 E. Camp St., Ely, MN, 55731.
Keywords: Bioassessment, diatoms, USA, water quality.
Abstract: The Great Lakes Environmental Indicators (GLEI) project is a cooperative agreement with U.S. EPA Office of Research and Development, and is one of five major U.S. EPA STAR projects designed to develop indicators of condition for the Nation's coastal zones. In one subproject, we are using direct gradient analysis of diatom (Bacillariophyceae) species in periphyton and depositional assemblages to develop ecological response models of controlling environmental variables such as salinity, nutrients, siltation, and water clarity - a novel approach in the Great Lakes. During pilot research from field year 2001, we showed that significant relationships exist between Great Lakes diatoms and specific conductance, dissolved oxygen, and temperature. As we expand the sample coverage throughout the Great Lakes during 2002 and 2003, we expect to develop other significant models for nutrient loading. We will use these gradient analyses to describe baselines and trends in wetlands, bays, and nearshore high-energy zones. Our paleolimnological approach in nearshore depositional zones can be useful in placing current ecological condition in a long-term context

and may be helpful in promoting the discussion of appropriate reference conditions for Great Lakes coastal sites.
Notes: See also previous record.

Reference Type: Journal Article
Record Number: 127
Author: Kitner, M.; Poulícková, A.
Year: 2003
Title: Littoral diatoms as indicators for the eutrophication of shallow lakes.
Journal: Hydrobiologia
Volume: 506-509
Pages: 519-524
Keywords: Bioassessment, diatoms, lakes, water quality.
Abstract: The littoral zone of shallow water bodies in the Czech Republic has been studied quite consistently at several fishponds. The use of algae, especially diatoms, for the monitoring of the state of lotic freshwater also has a long tradition. The main objective of the presented paper is to validate the feasibility of the use of littoral periphyton communities for the biomonitoring of standing waters. At the investigated sites, littoral periphytic were studied together with selected environmental variables (pH, conductivity, nutrients - especially total phosphorus) on three types of natural substrates (epilithon, epiphyton, epipelon). The evaluation of the diatom community was performed on the basis of the checklists of algal indicator species published by authors from the Czech Republic, Austria and the Netherlands. The data were subjected to statistical software NCCS 2000 (GLM Anova and "Ward's minimum" variance cluster analysis). Littoral periphytic diatoms appear to be good indicators of the fishpond water quality. The selected substrates show non-significant differences, and therefore the average values from all substrates were used. The best indicatory system for the evaluation of Czech fishponds was van Dam's index.
Notes: A useful paper for the development of a biotic index using diatoms.

Reference Type: Journal Article
Record Number: 128
Author: Kleynhans, N.
Year: 1999
Title: The development of a fish index to assess the biological integrity of South African rivers.
Journal: Water SA.
Volume: 25
Issue: 3
Pages: 265-278
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, fish, rivers, South Africa.
Abstract: A biological integrity index that uses attributes of fish assemblages was developed and applied to a part of the Crocodile River (Incomati System, Mpumalanga Province). Fundamentally, the fish assemblage integrity index (FAII) is based on the fish species expected to be present in biological (fish habitat) segments which are sections of river with relatively homogeneous fish habitat. Within this framework fish are categorised according to an intolerance index which takes into account trophic preferences and specialisation, habitat preferences and specialisation, requirement for flowing water during different life-stages and association with habitats with unmodified water quality. This intolerance index, the expected frequency of occurrence and expected health of fish species in a particular fish habitat segment was used to formulate an index for the situation expected under minimally impaired conditions which was used as the comparative basis for the observed (sampled) situation. The observed situation was expressed as a fraction of the expected situation to arrive at a relative

FAII index value which was grouped into one of six descriptive fish assemblage integrity index classes. It was found that the index reflected several aspects of the modifications that have occurred in the Crocodile River, i.e. water quality modifications, flow modifications and introduction of alien fish. However, flow releases from Kwena Dam hampered fish sampling while the floods that occurred in the summer prior to the survey, extensively modified physical habitat conditions that existed for some years. It was concluded that the index provides a broad, synoptic estimation of the biological integrity of the river. It is highly likely that the index in its current form provides an underestimation of the biological integrity due to the species expected to be present, being based on all species listed for a segment, and not on the fish species expected to be present in the habitats actually sampled. It is suggested that refinement of the index should include development of improved methodology to determine not only the fish species expected per segment, but also species expected per habitat type. In its current form, the index has the potential to provide qualitative, descriptive criteria for the desired ecological condition or integrity of rivers for management purposes in terms of the new South African Water Law. The development of numerical criteria will, however, require development in terms of the statistical properties (i.e. statistical power) of the index.
Notes: Developed for rivers, but it may be possible to expand this approach to wetlands or floodplain systems.

Reference Type: Book
Record Number: 129
Author: Kotze, D.C.; Marneweck, G.C.; Batchelor, A.L., Lindley, D.; Collins, N.
Year: 2004
Title: Wetland-Assess. A Rapid assessment procedure for describing wetland benefits. First Draft.
Publisher: Report prepared for Mondi Wetland Project.
Source: DWAF (2004)
Keywords: Functional assessment, impact assessment, social importance, South Africa.
Abstract: The overall goal of WETLAND-ASSESS is to assist decision makers, government officials, planners, consultants and educators in undertaking rapid assessments of wetlands and revealing the benefits that they supply, so as to highlight their importance and allow for more informed planning and decision making. Whilst a host of different wetland functional assessment techniques have been developed, none of these are directly transferable to the South African situation. Many of the systems are geared primarily to the developed world situation and mainly to wetlands in the northern temperate regions, rather than to wetlands in the developing world, where livelihoods tend to be more directly dependent on wetlands. Recognizing the tremendous need for a wetland assessment system for South Africa, the Mondi Wetlands Project commissioned the development of a prototype WETLAND-ASSESS. A collaborative approach was used, involving the following organizations in the core team: University of KwaZulu-Natal, Mondi Wetlands Project, Wetland Consulting Services and Free State Nature Conservation. Rather than re-inventing the wheel, considerable use was made of existing wetland assessment techniques, including international methods (e.g. those of Adamus, or the US Army Corps of Engineers) and existing South African approaches.
Notes: This document appears to be a very useful field-tool. It does however require verification in other regions of the country (e.g. Western Cape). It may form a useful basis from which more accurate resource economic studies can be carried out.

Reference Type: Journal Article
Record Number: 130
Author: Kusler, J.
Year: 1998
Title: The importance of wetland assessment.

Journal: Wetlands: The newsletter of Wetlands International.
Volume: No. 5.
Page: 5
Source: ScienceDirect
Keywords: Bioassessment, functional assessment, impact assessment.
Abstract: The outcome of wetland protection/destruction conflicts is increasingly determined by the information available to decision-makers. What is assessed and what is not assessed in a given instance and the methods used, including scale and accuracy of assessment often determine whether wetlands and related ecosystems will be protected or destroyed. Because of the bugetary, staffing and other limitions of wetland decision-makers, assessment approaches must be selectively applied as part of hierarchical assessment processes which begin with relatively simple analysis, and progress, where necessary to more detailed analysis of particular project-related issues.
Notes: Despite the fact that this article is only one page long, it makes some very useful comments.

Reference Type: Journal Article
Record Number: 131
Author: Kwandrans, J.; Elotanta, P.; Krzsysztof, W.
Year: 1998
Title: The use of benthic diatom communities to evaluate water quality in the rivers of southern Poland.
Journal: Journal of Applied Phycology.
Volume: 10
Pages: 193-201
Source: DWAF (2004)
Keywords: bioassessment, biotic index, diatoms, European Union, indicators, monitoring, rivers, water quality.
Abstract: Biological and chemical data were processed to estimate trophic stage and degree of pollution in several streams and rivers in southern Poland. The majority were eutrophic and some of them heavily polluted; only a few were oligo-meso trophic. The differences in the water quality of the rivers were reflected by different types of diatom community and also by the values for some diatom indices, which were calculated using the latest version of the 'Omnidia' database software. Except for the Sladocek's index, all diatom indices correlated significantly with organic load (COD), oxygen concentration, conductivity and most of the measured ions. Some indices showed a significant negative correlation with trophic level (expressed by NH_4-N and PO_4-P). In general, IPS (Specific Pollution Sensitivity Index) and GDI (Generic Diatom Index) indices gave the best results. Among the investigated diatom communities, only a few taxa indicated oligo-meso trophy and oligo-mesosaprobity. Most of the sites were characterised by a greater relative contribution of eutraphent and tolerant ones as well as a-mesosaprobic and polysaprobic diatoms. This study suggests that the structure of benthic diatom communities and diatom indices, especially GDI, can be applied for monitoring rivers in Poland.
Notes: This paper, although specifically for rivers, does give information on using diatoms to assess water quality. It does not, however, give details of the various diatom indices (calculated using the database software). The influence of sampling strategy (use of epilithic, epiphytic or epipelic communities) as well as habitat on the results are noted.

Reference Type: Conference Proceedings
Record Number: 132
Author: Laughland, A.S.
Year of Conference: 2001
Title: Habitat equivalency analysis in natural resource damage cases.

Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 72
Address: Eastern Research Group, 110 Hartwell Ave., Lexington, MA, 02421.
Keywords: Functional assessment, lakes, resource economics, social importance.
Abstract: A major issue in natural resource damage settlements is scaling the compensation required from the responsible parties to the size of the loss suffered by society. One approach to this problem is habitat equivalency analysis (HEA) which equates ecosystem services lost in the past with ecosystem services to be gained from compensatory restoration projects in the future. As HEA has been applied to real world situations, the difficulties of integrating ecological and economic measures has become apparent. Ecological measures do not, typically, translate easily into economic values. Solutions to this problem can be discovered by carefully considering the theory and data needs from both perspectives. This presentation will discuss some of the variations and recent theoretical development of HEA which contribute to a better integration of knowledge about Great Lakes ecosystems and the scaling of natural resource damage compensation.

Reference Type: Journal Article
Record Number: 133
Author: Laurans, Y.
Year: 2001
Title: Economic evaluation of the environment in the context of justification conflicts: development of concepts and methods through examples of water management in France.
Journal: International Journal of Environment and Pollution.
Volume: 15
Issue: 1
Pages: 94-115
Keywords: Resource economics, social importance.
Abstract: This paper develops an account of practices of 'economic valuation of the environment' as contingent social processes that find their place - implicitly or explicitly - within debates of justification. Following work by French analysts Boltanski and Thevenot, it is suggested that these justification requirements may involve confrontation between different value systems and views of the world or conflict of interests within a common value system. The role of valuation analysts, of those interacting with them and providing information, and of the data and figures that they produce, is framed in terms of this 'argumentative' process. An empirical example is given, concerning the assessment of the importance of the water resource management 'services rendered' to society by wetlands, in a region close to Paris, France. It is shown how the valuation figures obtained are context-specific, depending on geographical situation but also, and more particularly, the preoccupations of the stakeholders involved and their interactions.

Reference Type: Conference Proceedings
Record Number: 134
Author: Leibowitz, N.C.; Squires, L.; Baker, J.P.
Year of Conference: 1991
Title: Environmental monitoring and assessment program: Research plan for monitoring wetland ecosystems.
Conference Name: Ecological Research Series.
Page: 191
Address: BiblioLine
Keywords: Bioassessment, monitoring, USA.

Abstract: The overall goal of Environmental monitoring and assessment Program-Wetlands is to provide a quantitative assessment of the current status and long-term trends in wetland condition on regional and national scales. The specific, long-term objectives of EMAP-Wetlands are as follows: Quantify the regional status of wetlands by measuring indicators of ecological condition and also hydrology, pollution exposure, and other major factors known to influence or stress wetlands; Monitor changes through time, on a regional scale, in the condition of wetlands and in hydrology, pollution exposure, and other factors that influence or stress wetlands; and identify plausible causes for degraded or improved conditions, by evaluating associations between wetland condition and hydrology, pollution exposure, and other factors that affect wetland condition.
Notes: Although this paper is relatively old, it does include useful information on setting up a national monitoring program. See also other documents on EMAP e.g. Ernst *et al.* 1995.

Reference Type: Report
Record Number: 135
Author: Leitch, J.A.; Fridgen, P.
Year: 2004
Title: Functions and values of prairie wetlands: economic realities.
Institution: Department of Agricultural Economics, P.O. Box 5636, North Dakota State University, Fargo, ND 58105-5636.
Keywords: Resource economics, USA.
Abstract: Land and water resources of the Prairie Pothole Region support important economic and ecologic activities. Scarce resources, such as wetlands, should be allocated among these activities such that society's well-being is enhanced. Such allocation requires knowledge of the relative values of resouces, something that has been largely missing in the wetland literature. This paper describes the practical realities of wetland economics, using the Prairie Pothole Region as an example. Ongoing human and economic activities in the PPR are presented as an introduction to the economy of the area. The purpose for economic valuation of wetlands - achieving the "greatest good" - is briefly discussed. The connection between wetlands and human values is described. Five types of wetland valuation methods are discussed: market, surrogate/proxy, revealed preference, stated preference, and benefits transfer. Finally some suggestions are made to add value to all types of wetland science by enhancing the collaboration among wetland scientists.
Note: Appears to be a useful paper.
URL: http://www.ag.iastate.edu/centers/iawetlands/Economic.html

Reference Type: Book Section
Record Number: 136
Author: Leitch, J.A.; Shabman, L.A.
Year: 1988
Title: Overview of economic assessment methods relevant to wetland evaluation.
Editor: Hook, D.D., (*et al*.)
Book Title: The Ecology and Management of Wetlands. Volume 2: Management, Use and Value of Wetlands.
City: Portland.
Publisher: Timber Press.
Pages: 95-102
Source: BiblioLine
Keywords: Resource economics.
Abstract: The past two and a half decades have seen considerable interest, worldwide in the environment in general and in wetlands in particular. Because many goods and services of wetlands are difficult to allocate through economic markets, wetlands management has become, to a degree, a shared responsibility of government and wetland owners. However, in

order for government policy makers to design effective, efficient and equitable wetland review programs, the relative social merits of alternative wetland allocation choices need to be known. An overview is given of wetland assessment methods and implications for wetland management in order to focus the role of economics in the wetland policy arena.
Note: This paper was extracted from a two-volume work presenting selected papers from a symposium on wetlands organised by the International Society of Anaerobiosis, held in June 1986 in Charleston, South Carolina. Volume one covers the general ecology of wetlands, whereas volume two covers more applied topics. Only the above paper, which is rather short, covers economic assessment. This book is available from libraries in South Africa, but is rather dated.

Reference Type: Book
Record Number: 137
Author: Leitch, J.A.; Ekstrom, B.L.
Year: 1989
Title: Wetlands economics and assessment: An annotated Bibliography.
City: New York.
Publisher: Garland Pub.
Number of Pages: 439pp
ISBN: 0824036484.
Keywords: Management, resource economics, social importance.
Abstract: An annotated bibliography with chapters on management, regulations, policies and programs, social values. Some 500 (nearly all annotated) citations cover theoretical and applied economics, nonmonetary valuation techniques, legal and regulatory issues, management concerns, assessment methods.
Notes: This is available from libraries in SA.

Reference Type: Journal Article
Record Number: 138
Author: Lemly, A.D.; King, R.S.
Year: 2000
Title: An insect-bacteria bioindicator for assessing detrimental nutrient enrichment in wetlands.
Journal: Wetlands.
Volume: 20
Pages: 91-100
Source: ISI Web of Science
Keywords: Bioassessment, invertebrates, microbes, USA.
Abstract: Field and laboratory studies were conducted in Beaverdam and Kill swamps, Sampson County, North Carolina, USA, to evaluate the use of bacterial growth on aquatic insects as a metric for determining the existence of nutrient impacts in wetlands. Results from field investigations indicated that elevated concentrations of nitrate and phosphate were associated with growth of filamentous bacteria on insect body surfaces and that there were significantly fewer Ephemeroptera (*Ephemerella sp*. and *Drunella sp*.) in the nutrient-enriched wetland. Laboratory investigations confirmed a strong linkage between bacterial growth (*Sphaerotilus sp*. and *Leptothrix sp*.) and reduced survival of mayflies. Survival was examined for individuals with bacterial infestation ranging from 0 to 60% body coverage. A threshold for catastrophic mortality was present at about the 25% level of coverage; there were very few survivors above that level. Based on these findings, the diagnostic endpoint for the bioindicator is 25% body coverage by bacterial growth, a level that signifies major differences in insect populations in the field and is also easy to detect visually. This study provides evidence that the insect-bacteria bioindicator is a reliable tool for assessing nutrient impacts on wetland macroinvertebrate communities.

Notes: An interesting use of bioassessment. Potentially useful for future use in South Africa once more is known about our wetland invertebrates.

Reference Type: Conference Proceedings
Record Number: 139
Author: Leuven, R.S.; Geerling, G.W.; Gerrits, S.; Lenders, H.J.; Nooij, R.; Poudevigne, I.
Year of Conference: 2004
Title: Cumulative effect assessment of physical reconstruction and land use changes on riverine biodiversity in floodplains.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Department of Environmental Studies, Faculty of Science, Mathematics and Computing Science, University of Nijmegen, P.O. Box 9010, 6500 GL Nijmegen, The Netherlands (rleuven@sci.kun.nl; Gertjan.Geerling@sci.kun.nl).
Keywords: European Union, impact assessment, rivers.
Abstract: The coming decades the physical structure of river basins of north-western Europe will undergo significant changes as a result of large-scale reconstruction measures that are currently planned (e.g. flood risk abatement, ecological rehabilitation, infrastructure facilities). The physical reconstruction and land use changes will have far-reaching impacts on several functions and characteristics of river basins, including biodiversity. The measures involved may offer opportunities to increase biological diversity, but can also endanger present natural values and biodiversity potentials of river ecosystems. Environmental impact assessments generally concern effects of individual projects or plans. However, sustainable river management will also require regional assessments of cumulative effects on biodiversity (i.e. impacts of actual combinations of measures). The present paper outlines a procedure for assessing cumulative effects of physical reconstruction and land use changes on riverine biodiversity (protected and endangered species). The procedure combines a GIS-based scenario approach with model algorithms predicting species distributions based on habitat suitability and configuration (e.g. BIOSAFE). The procedure will be applied to floodplains along the river Waal, a branch of the river Rhine. Three scenarios project expectations onto the future riverine landscape in 2015. The preserving scenario is restricted to ecological rehabilitation. In the utilising scenario, the available space is largely used for human purposes. In the saving scenario, available space is spared and measures are implemented in accordance with their 'best' spatial alternatives.

Reference Type: Journal Article
Record Number: 140
Author: Lopez, R, D.; Fennessy, M.S.
Year: 2002
Title: Testing the floristic quality assessment index as an indicator of wetland condition.
Journal: Ecological Applications.
Volume: 112
Pages: 487-497
Source: ISI Web of Science
Keywords: Bioassessment, biotic index, plants, restoration, USA.
Abstract: Biological indicators of ecosystem integrity are increasingly being sought for use in ecosystem assessment and goal-setting for restoration projects. We tested the effectiveness of a plant community-based bioassessment tool, the floristic quality assessment index (FQAI) in 20 depressional wetlands in Ohio, USA. *A priori*, the 20 depressional wetlands were classified by type and ranked to form a disturbance gradient according to the local landscape condition. Ranks were based on surrounding land cover characteristics, vegetated buffer characteristics, and the extent of human-induced hydrologic alteration at the wetland site. The index was negatively correlated with the disturbance rank of a wetland and with the distance

to neighboring wetlands (P = 0.01). Index values were lower for wetlands surrounded by agricultural or urban land use, wetlands with less vegetation on the wetland perimeter, and wetlands with more hydrologic modification, and at sites with greater distances to other wetlands. The wetlands with lower FQAI values tended to be dominated by plants that are typical of heavily cultivated landscapes or urban regions. Thus, the index is interpreted as a measure of environmental factors that maintain and control plant communities. The index was correlated with differences in wetland surface water chemistry, but was positively correlated with soil total organic carbon (p = 0.01), phosphorus (P = 0.05), and calcium (p = 0.05). Repeated wetland sampling in the summer and autumn revealed that the floristic quality assessment index could be useful for the assessment and monitoring of wetland ecosystems and for tracking wetland restoration projects over time.
Notes: A useful paper for development of a biotic index based on macrophytes. An interesting finding is that the index was negatively correlated with the distance to neighboring wetlands.

Reference Type: Journal Article
Record Number: 141
Author: Lougheed, V.L.; Chow-Fraser, P.
Year: 2002
Title: Development and use of a zooplankton index of wetland quality in the Laurentian Great Lakes basin.
Journal: Ecological Applications.
Volume: 12
Pages: 474-486
Source: ISI Web of Science
Keywords: Bioassessment, plankton, USA, water quality, zooplankton.
Abstract: Recent interest in biological monitoring as an ecosystem assessment tool has stimulated the development of a number of biotic indices designed to aid in the evaluation of ecosystem integrity; however, zooplankton have rarely been included in biomonitoring schemes. We developed a wetland zooplankton index (WZI) based on water quality and zooplankton associations with aquatic vegetation (emergent, submergent, and floating-leaf) that could be used to assess wetland quality, in particular in marshes of the Laurentian Great Lakes basin. Seventy coastal and inland marshes were sampled during 1995-2000; these ranged from pristine, macrophyte-dominated systems, to highly degraded systems containing only a fringe of emergent vegetation. The index was developed based on the results of a partial canonical correspondence analysis (pCCA), which indicated that plant-associated taxa such as chydorid and macrothricid cladocerans were common in high-quality wetlands, while more open-water, pollution-tolerant taxa (e.g., Brachionus, Moina) dominated degraded wetlands. The WZI was found to be more useful than indices of diversity (species richness) and measures of community structure (mean cladoceran size, total abundance) for indicating wetland quality. Furthermore, an independent test of the WZI in a coastal wetland of the Great Lakes, Cootes Paradise Marsh, correctly detected moderate improvements in water quality following carp exclusion. Since wetlands used in this study covered a wide environmental and geographic range, the index should be broadly applicable to wetlands in the Laurentian Great Lakes basin, while further research is required to confirm its suitability in other regions and other vegetated habitats.
Notes: As the authors of this paper conclude, a biotic index based on zooplankton, should not be used as a sole indicator of wetland quality but to complement chemical monitoring and biomonitoring using higher trophic levels. This is a useful paper.

Reference Type: Personal Communication
Record Number: 142
Author: Low, A.B.
Year: March 2005

Title: Western Cape floristics initiative
Address: COASTEC, Coastal and environmental consultants, PO box 370, Rondebosch, 7701; (coastec@mweb.co.za).
Keywords: Bioassessment, plants, rivers, South Africa.
Abstract: The River Dancers, an informal conservation group, is studying ten major Western Cape rivers. Aims of the study include providing an account of the flora and vegetation of major Western Cape rivers, and promoting the value, understanding and conservation of these systems. Data from these as well as several lowlands systems sampled in independent studies were entered into Coastec's SaSFlora database for the Cape & Karoo floras. A contextual analysis of riverine floras and their respective sections was undertaken using PRIMER (cluster and MDS analysis). In addition, certain river plot data were analysed to determine whether there was any patterning in vegetation. Key findings were the following:
1. Lowland and montane systems have distinct floras.
2. Montane systems show a clear gradation from perennial rivers in the south to more seasonal systems in the north. The Thee represents a roughly transitional system, with elements of both northern and southern rivers. The Palmiet is also a very different system, despite it being a wet southern river.
3. River sections, too, possess distinctive floras, with a progressive change in flora from source to end.
4. Lowland systems show major differences between north and south, with the Sandveld, West Coast and Cape Flats indicating distinct floristic patterns.
5. Riverine versus wetland character also varies. The systems with the wetter, more perennial rivers are dominated by species with riverine and riverine-wetland habitat preferences; correspondingly the more seasonal montane rivers and the lowland systems (in reality "longitudinal wetlands") in particular display greater wetland characteristics.
6. The vegetation analysis indicates there is also variation in riverine versus wetland character as one moves from river source to end, with altitude and substrate playing key roles. The ratio of sand to rock plays a key role in plant community distribution.
7. Finally, where alteration to water quality and amount leads to increased salinity and draw-down of the water table, major shifts in plant species composition occur, coupled with a reduction in species diversity.
Further work, primarily developed during a WRC-funded project in the northern Sandveld project, has been directed towards determining the extent of the wetland character of a system. In the arid area of the Sandveld, rivers can be described as longitudinal wetlands. Each plant species in a given system was accorded a wetland (W) and/or riverine (R) habitat character (i.e. it can be one of R, R/W or W) based upon the known occurrence of that species in aquatic systems of the Cape Floristic Region. For each site, percentages are calculated of each habitat character present. Thus a wetland would have a strong W and R/W component, and a river a strong R and R/W component. Although the above approach has not been designed to assess ecological condition *per se*, this can be implicit. Where there has been a loss of species, or more importantly where the species assemblage changes significantly due to non-natural conditions it can be inferred that this is due to agricultural and related impacts. For example in the Sandveld, an over-abstracted freshwater eye (spring) may well have the species characteristic of a brackish wetland due to the water becoming brackish from years of over-abstraction.
Notes: This work needs to be taken into account when developing a wetland biotic index based on plants for the Cape Floristic Region.

Reference Type: Conference Proceedings
Record Number: 143
Author: Lupi, F.; Kaplowitz, M.; Hoehn, J.
Year of Conference: 2001
Title: Incorporating public perceptions and knowledge into economic valuation of Great Lakes coastal wetland ecosystems.

Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 78
Address: Dept. of Agricultural Economics, and Dept. of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824-1039.
Keywords: Lakes, resource economics, social importance, USA.
Abstract: This paper reports on phase one of a project to estimate economic values for Great Lakes coastal wetlands. Economic valuation of non-market ecosystem services provided by Great Lake wetlands presents researchers with the challenge of effective communication of complex scientific information about ecosystem functions. Valuation efforts must address individuals' misperceptions (e.g., "trees don't grow in wetlands"), as well as the type and extent of scientific information to give respondents. To begin the economic valuation, qualitative research was conducted to test hypotheses concerning people's i) knowledge about linkages between wetlands and valued services, ii) perceptions about technological ability to .replicate services, and iii) ability to understand scientific information about different wetland types and functions. The research is based upon a series of focus groups with randomly selected members of the lay public in Michigan. Though some misperceptions exist, most respondents had prior knowledge of, and experience with, wetlands, and they rated the importance of habitat functions very highly. The results show varying degrees of efficacy associated with the use of different media for informing participants about wetland ecosystem functions and improving their knowledge of wetland ecosystems.
Notes: This paper considers aspects that may be especially relevant to the valuation of urban systems.

Reference Type: Personal Communication
Record Number: 144
Author: Macfarlane, D.M.; Walters, D.; Koopman, V.; Kotze, D.; Goodman, P. *et al.*
Year: March 2005
Title: Wet-HAT (Wetland Health Assessment Technique)
Address: SHEQ Manager, Sappi Forests (PTY) Ltd., PO box 13124, Cascades, 3202. (Douglas.macfarlane@sappi.com).
Keywords: Bioassessment, habitat, impact assessment, plants, South Africa.
Abstract: This technique is essentially a modular-based approach for evaluating and monitoring the present ecological state of South African wetlands. It takes cognizance of the broad set of functions and processes that take place within a wetland and attempts to synthesize this information by evaluating a measurable set of wetland components. A brief summary of each component is given below:

(a) Water Inputs. This module focuses on evaluating what effect changes in input volumes and pattern (timing and periodicity) have on wetland condition. This evaluation is undertaken at a wetland catchment level and therefore reflects the impacts from altered catchment characteristics.
(b) Water Distribution and Retention. This wetland-based module focuses on evaluating the effect of human activities on the movement of water within and through a wetland. Impacts evaluated include direct water losses; impounding features, canalization and changes in surface roughness.
(c) Geomorphology. While still under development, this approach attempts to evaluate the effects of changed sediment and erosion distribution and retention patterns on wetland geomorphology.
(d) Vegetation. This key indicator of wetland health is evaluated by evaluating changes in vegetation characteristics associated with clear vegetation changes associated with habitat destruction and invasive plants and more subtle changes associated with changes in ruderal and terrestrial species.

Each of these modules follow a broadly similar approach in that firstly, key components (indicators) are identified, secondly, human impacts are identified and evaluated and finally, resultant scores are computed within a common range that reflects the current state (health) of each wetland component. This approach not only provides an indication of health across a suite of wetland characteristics, but highlights the key causes of wetland degradation. This technique is therefore also designed to both direct and monitor the effects of management interventions.

Reference Type: Book Section
Record Number: 145
Author: Maltby, E.; Hogan, D.V.; Immirzi, C.P.; Tellam, J.H.; van der Peijl, M.J.
Year: 1994
Title: Building a new approach to the investigation and assessment of wetland ecosystem functioning.
Editor: Mitsch, W.J.
Book Title: Global Wetlands: Old World and New.
Publisher: Elsevier Science.
Pages: 637-658
Keywords: European Union, functional assessment, rivers.
Abstract: This paper examines some of the problems of wetland conservation and describes interdisciplinary, international research being undertaken towards their resolution. Wetlands have long been the subject of reclamation to what was been perceived as a more productive land use or development options. It is now increasingly evident that wetland ecosystems perform an important role in the provision, maintenance and enhancement of many environmental benefits. Nevertheless, the destruction and degradation of wetlands continues to take place on a significant scale, indicating the failure of policies, based on traditional nature conservation criteria, to prevent or reverse the decline. The Europen Commission (DG XII Science, Research and Development) has been funding a major research initiative under the STEP (Science and Technology for Environmental Protection) program to develop science-based procedures for evaluating the functional characteristics of European wetland ecosystems. Focusing initially on river marginal types, investigations have established key processes controlling functioning and the degrees to which human activities have impacted functions by altering hydrology and floodplain sedimentation and by fertiliser use. The results from study sites in France, Ireland, Spain and the UK have underpinned the development of functional analysis procedures, designed to help resolve dilemmas in planning, management and the impact assessment involving wetlands.

Reference Type: Conference Proceedings
Record Number: 146
Author: Maltby, E.; Thorne, R.; Chen, H.
Year of Conference: 2004
Title: EVALUWET, WEDSS and the European WFD - Using functional assessment to enhance integrated water management.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Royal Holloway, University of London, London, UK (E.Maltby@rhul.ac.uk).
Keywords: European Union, functional assessment, resource economics, social importance.
Abstract: Despite increasing scientific knowledge of how wetlands work in the landscape, there are still very inadequate considerations of functioning in the new legislation and political thinking. There is similarly limited public acknowledgment of the importance of water flows in maintaining the significant goods and services provided by wetland ecosystems. The new WFD in itself does not provide any specific definition of what a wetland is nor does it clearly state the extent to which wetlands should be used for the

achievement of environmental objectives. The EU Water Directors meeting in November 2002 acknowledged the pressures on wetlands and highlighted their potential role in river management and in helping to achieve the wider WFD environmental objectives. They recommend the preparation of a Horizontal Guidance document on wetlands as part of Common Implementation Strategy to assist member states in interpreting the WFD with respect to wetlands. The EVALUWET project has sought to develop a key functional tool to assist in the delivery of the WFD and implementation of the Horizontal Guidance. One of the key outputs is the development of a wetland evaluation decision support System (WEDSS). In simple terms the WEDSS links a functional assessment knowledge base with wetlands of socio-economic valuation within a GIS environment. In the paper we define the structure of the WEDSS and how the knowledge base carries out assessments of hydrological, biogeochemical and ecological wetland functions using data which can be rapidly gathered in desk studies or field visits. By integrating functional and valuation information within a single tool, decision- makers can consider all the relevant information within wetland management and more fully consider wetlands within Integrated Catchments management.
Notes: The linking of economic valuation of wetlands with functional assessments is an important area of wetland research that needs to be pursued. See also Janssen *et al*. 2005 and Hogan *et al*. 2004.

Reference Type: Personal Communication
Record Number: 147
Author: Marneweck, G.C.
Year: March 2005
Title: Soil moisture/plant distribution method
Address: Wetland Consulting Services (Pty.) Ltd., PO box 72295, Lynnwood Ridge, 0040. (wetland@smartnet.co.za.).
Keywords: Bioassessment, impact assessment, plants, South Africa.
Abstract: A plant-based method for assessing wetland health has been under development in South Africa for some time already. The focus has been predominantly on aquatic plant life history response to changes in hydrology. The method is built on initial work on wetland plant indicators (carried out in conjunction with D. Kotze) and has been expanded based on more recent work on the Highveld grasslands, lowveld and bushveld regions. This method considers the plant-soil-hydrozone relations such that one is able to allocate different species to indicator categories. One is then able to use either individual species or the number of species in the different indicator categories as a measure of the current state relative to a reference state. If used in conjunction with soil profiling, inferences can then be made about wetland "health" or degradation (overgrazing, drying etc.). This also provides a quantitative method of informing the PES (Present Ecological State) categories when applying the Reserve methodology. One limitation is that the method is region specific with, for example, some species moving up or down an indicator category depending on the rainfall region in particular. *Eragrostis plana*, for example, is an obligate wetland species in most areas of Mpumalanga but is facultative in the higher rainfall areas along the escarpment. Although not published, the list contains some 300 odd species that have been allocated to indicator categories. For 100 or so species, there are very good data to support the classification. For the rest, there is mostly anecdotal evidence and field experience. The list will eventually be finalised and published.

Reference Type: Journal Article
Record Number: 148
Author: Matthews, J.W.
Year: 2003
Title: Assessment of the floristic quality index for use in Illinois, USA, wetlands.
Journal: Natural Areas Journal.

Volume: 23
Pages: 53-60
Source: ISI Web of Science
Keywords: Bioassessment, biotic index, indicators, plants.
Abstract: The Floristic Quality Index (FQI) is being used in the United States and Canada to assess natural communities. Each native plant species is assigned a coefficient of conservatism, a subjective rating that describes the species' affinity for undisturbed natural areas. To calculate FQI, mean coefficient of conservatism at a site is multiplied by the square root of native species richness. Use of FQI is problematic for several reasons, mainly because FQI incorporates species richness. I assessed FQI based on data gathered between 1992 and 2000 while surveying wetlands in Illinois, USA, for the purpose of jurisdictional determinations. Month of survey affected species richness and FQI even after analysis was restricted to surveys conducted during the growing season. Species number significantly increased with area in all wetland types combined, as well as in floodplain forests, marshes, wet meadows, wet shrublands, and sedge meadows. This significant species-area relationship resulted in a significant increase in FQI with area in all wetland types combined, and in floodplain forests, marshes, wet meadows, and sedge meadows. Furthermore, because the relationship between species number and area varied among community types, the relationship between FQI and area also varied among community types. Specifically, FQI was affected more by area in sedge meadows than in other wetland types investigated. Mean coefficient of conservatism increased with species richness, further increasing the effect of species richness on FQI. Comparisons based on FQI among sites of different community types or among sites surveyed at different times of year may be invalid.
Notes: This paper gives useful insight into some of the potential problems in developing a biotic indes based on plants - namely the effect of the area sampled, time of year in which sampling is carried out and the variation between different wetland types.

Reference Type: Journal Article
Record Number: 149
Author: Mayer, P.; Galatowitsch, S.M.
Year: 2002
Title: Assessing ecosystem integrity of restored prairie wetlands from species production-diversity relationships.
Journal: Hydrobiologia.
Volume: 443
Pages: 177-185
Keywords: Bioassessment, diatoms, restoration, USA.
Abstract: We assessed ecosystem integrity in restored prairie wetlands in eastern South Dakota, U.S.A., by examining the relationship between diatom diversity and production. We asked three questions: (1) Is production related to species diversity? (2) Can production-diversity relationships be used to distinguish between restored and reference wetlands with the purpose of assessing ecological integrity? (3) Are production-diversity relationships influenced by species composition? Eight undisturbed, unrestored wetlands were chosen as references to compare to eight wetlands restored after drainage. Diatoms were collected from artificial substrates that allowed communities to be transplanted from restored to reference wetlands and visa versa. Production was measured as total cell biovolume and diversity as species richness. Neither diversity nor production alone differed between restored and reference wetlands. However, production was negatively related to diversity at restored wetlands, whereas production at reference wetlands was not. Communities transplanted from reference to restored wetlands exhibited a production-diversity relationship like that observed among the control samples in restored wetlands. Likewise, communities transplanted from restored to reference wetlands apparently lost any such relationship after they were relocated. Production was dependant on species composition. Furthermore, production of some species differed by restored and reference wetland type. The negative relationship observed between

diversity and production was strongly influenced by *Rhopalodia gibba* and *Epithemia* species, suggesting that these species were superior competitors under the conditions found in some restored wetlands. We consider restored wetlands displaying the highest production: diversity ratio to be the most impaired sites, based on the extreme deviation from reference wetlands. We conclude that the relationships between diversity and production provided a rapid measure of restored wetland integrity with respect to baseline conditions observed in reference sites.
Notes: Interesting background information for development of a biotic index using diatoms.

Reference Type: Personal Communication
Record Number: 150
Author: McCartney, M.
Year: 2004
Title: Sustainable development and management of wetlands in Tanzania and Zambia.
Institute: IWMI, Pretoria, South Africa; (m.mccartney@cgiar.org).
Keywords: Africa, resource economics, rural livelihoods, social importance.
Abstract: Four case studies were undertaken in Tanzania and four in Zambia to investigate issues of: i) the monetary and non-monetary value of goods and services provided by wetland systems, ii) the factors that influence peoples' access to and control over wetland resources. Methods of participatory assessment, in conjunction with a detailed household questionnaire were used to obtain information relating to the biophysical and socio-economic factors the influence community use, management and access to wetlands. The study compared wetlands to other sources of economic value (e.g. dryland farming and wage income) and investigated the links between wetland utilization and differences in the socio-economic status of households.

Reference Type: Journal Article
Record Number: 151
Author: McCormick, P.V.; Stevenson, R.J.
Year: 1998
Title: Periphyton as a tool for ecological assessment and management in the Florida Everglades.
Journal: Journal of Phycology.
Volume: 34
Issue: 5
Pages: 726-733
Source: BiblioLine
Keywords: Algae, bioassessment, biotic index, USA.
Abstract: In this paper, we evaluate the use of periphyton as a tool for assessing current ecological conditions in the Everglades and for gauging the success of restoration efforts. We show how human alterations to the Everglades have affected periphyton and, specifically, relate these changes to P enrichment. In addition, we discuss how periphyton can be used to set restoration goals and, thereby, provide input for management decisions by developing a periphyton index of biotic integrity and a biological index of P availability.
Notes: Useful paper for development of a biotic index using this floral group.

Reference Type: Conference Proceedings
Record Number: 152
Author: McDaniel, T.L.; Harris, M.L.; Bishop, C.A.; Struger, J.
Year of Conference: 2001
Title: Assessing the impact of water quality on development and survivorship of leopard frogs (*Rana pipens*) in the St. Lawrence Area of Concern.

Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 88
Address: Canadian Wildlife Service, Environment Canada, 867 Lakeshore Rd., Burlington, ON, L 7R 4A6.
Keywords: Amphibians, bioassay, bioassessment, USA, water quality.
Abstract: High levels of contamination in the aquatic environment and wildlife (Bonin *et al*. 1995) within the St. Lawrence Area of Concern have raised concerns about potential impacts on wildlife health. We raised leopard frog (*Rana pipiens*) embryos in enclosures in two reference wetlands and two wetlands within the St. Lawrence Area of Concern. We assessed survivorship and deformity rates at hatching and metamorphic transformation. Organochlorine contaminants (total polychlorinated biphenyls, pesticides), polycyclic aromatic hydrocarbons, nutrients and heavy metals were measured in the sediment and water. The early stages of tadpole development appeared to be the most sensitive to water quality. Early stage survivorship was slightly, but significantly lower at wetlands within the St. Lawrence AOC, while deformity rates were slightly, but significantly higher. Survivorship and deformity rates of frogs at transformation did not differ significantly between sites. Tadpoles raised in wetlands within the St. Lawrence AOC transformed significantly sooner and faster than those from the reference wetlands.

Reference Type: Conference Proceedings
Record Number: 153
Author: McNair, S.A.; Chow-Fraser, P.
Year of Conference: 2001
Title: Algal primary producers as indicators of Great Lakes wetland quality.
Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 18
Address: McMaster University, 1280 Main St. West, Hamilton, ON, L8S 4K1.
Keywords: Algae, bioassessment, USA, water quality.
Abstract: Periphytic algae can make up a large portion of primary production in wetland ecosystems. High periphyton growth can limit light availability to submergent macrophytes, contributing to their decline and a loss of habitat for grazers and fish. Periphyton was measured in 10 wetlands in Lakes Ontario, Erie, and Huron. Acrylic rods were placed within submergent macrophyte beds at each site for a period of 4 weeks. Sections of submergent macrophytes and attached epiphyton were also collected. Mean chlorophyll-*a* biomass ranged from 1.6 to 66.1 $\mu g/cm^2$ on rods and 1.05 to 72.2 $\mu g/cm^2$ on plants. Periphyton biomass on rods was similar to that on plants at 8 of 10 sites. Low biomass occurred in wetlands with low nutrients, low turbidity and diverse and abundant submergent macrophytes, whereas high biomass was found in wetlands with high nutrients, high turbidity and few submergent macrophytes. Preliminary results indicate that algal species composition and diversity of periphytic algae tended to vary among wetlands.

Reference Type: Conference Proceedings
Record Number: 154
Author: Miller, C.; Stroom, K.; Richards, C.; Niemi, G.J.; Hanowski, J.M.
Year of Conference: 2003
Title: Negative response of birds and aquatic macroinvertebrates to urban development in Western Lake Superior.
Editor: International Association for Great Lakes Research..

Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 60
Address: Natural Resources Research Institute, 5013 Miller Trunk Hwy., Duluth, MN, 55811.
Keywords: Bioassessment, biotic index, birds, impact assessment, indicators, invertebrates, stressor effects.
Abstract: Bird and macroinvertebrate communities are frequently employed to judge the status of terrestrial and aquatic water bodies. In the upper Midwest these communities have been shown to exhibit strong responses to a variety of environmental stressors. Two similar data sets, using bird community data from shoreline areas and macroinvertebrate data from small coastal streams, were compared to examine the response of communities to indicators of urban development. Both studies utilized available land use/cover data from stream watersheds or shoreline segments. An Index of Biotic Integrity (IBI) from macroinvertebrate data showed a negative response to decreasing proportion of forested land cover, increasing road density and increasing proportion of developed land cover. Change in IBI was most influenced by taxa richness decrease. Decreases in the IBI were most pronounced when forested land cover was under 75%. Based on 200 samples of breeding bird communities in coastal upland habitats, native Neotropical birds declined proportionally to available forest cover. A threshold (e.g., nearly complete absence) of Neotropical birds was found when forested area was less than 30%. Since these regions were historically forested, the results suggest that managers, planners and citizens should retain a high proportion of forests to maintain native fauna.

Reference Type: Journal Article
Record Number: 155
Author: Milon, J.W.; Kiker, C.F.; Lee, D.J.
Year: 1997
Title: Ecosystem management and the Florida Everglades: the role of social scientists.
Journal: Journal of Agricultural and Applied Economics.
Volume: 29
Issue: 1
Pages: 99-107
Keywords: Restoration, social importance, USA.
Abstract: Recently, many state and federal agencies in the USA have embraced an ecosystems management approach to environmental protection and regulation. This approach requires a high degree of cooperation between natural and social scientists to translate policy objectives into research hypotheses, models, and evaluation procedures to guide implementation decisions. An adaptive procedure to guide interdisciplinary research is described and illustrated with highlights of recent progress and pitfalls from the restoration initiative for the Everglades/South Florida ecosystem.

Reference Type: Report
Record Number: 156
Author: Minnesota Pollution Control Agency (PCA)
Year: 2004
Title: Wetlands: Monitoring aquatic invertebrates.
Institution: Minnesota PCA.
Source: DWAF (2004)
Keywords: Bioassessment, invertebrates, monitoring, plants, USA.
Abstract: Macroinvertebrates are useful indicators of wetland health for several reasons. As in streams, invertebrates found in wetlands integrate the entire spectrum of available aquatic wetland habitats and conditions. They are found in the sediment, in the water column, on and

amongst the submerged and emergent vegetation. They are found in abundance in large and small, and permanent and seasonal wetlands.
I. PURPOSE To describe the methods used by Minnesota Pollution Control Agency's (MPCA) Biological Monitoring Program to collect macroinvertebrate community information at wetland monitoring sites for the purpose of assessing water quality and developing biological criteria. II. SCOPE/LIMITATIONS This procedure applies to all monitoring sites for which an integrated assessment of water quality is to be conducted. An integrated assessment involves the collection of biological (macroinvertebrate and plant) and chemical data to assess wetland condition. III. GENERAL INFORMATION Sites may be selected for assessment for a number of reasons including: 1) sites randomly selected for condition monitoring as part of the Environmental Monitoring and Assessment Program (EMAP), 2) sites selected for the development and calibration of biological criteria (e.g., Index of Biological Integrity), and 3) sites selected to evaluate a suspected source of pollution.
Notes: This is a useful website containing several documents on biomonitoring. See also Germes and Helgen 2002, and Helgen 1998.
URL: http://www.pca.state.mn.us/water/biomonitoring/bio-wetlands-invert.html

Reference Type: Conference Proceedings
Record Number: 157
Author: Mitchell, E.; Charman, D.
Year of Conference: 2004
Title: The usefulness of testate amoebae analysis in ecological and paleoecological studies of wetlands: past, present and future.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Swiss Federal Research Institute WSL, Antenne Romande, Case postale 96, CH-1015 Lausanne, Switzerland, and Laboratoire des Systèmes Écologiques – LECOS, Ecole Polytechnique Fédérale de Lausanne (EPFL), Case postale 96, CH-1015 Lausanne-Ecublens, Switzerland (afeam@uaa.alaska.edu).
Keywords: Bioassessment, protozoa.
Abstract: Testate amoebae are an abundant and diverse polyphyletic group of shelled protozoans living in aquatic to moist habitats ranging from estuarine environments to lakes, rivers, wetlands, soils, litter, and moss habitats. Their shells are preserved in sediments and, in combination with the known ecological preferences of the taxa, allow paleoenvironmental reconstruction. Testate amoebae are thus useful proxy indicators complementary to classical indicators such as pollen and spores or macrofossils. Their primary use so far has been for inferring past moisture conditions in peatlands, and indirectly, in the case of ombrotrophic bogs, past climate. To a lesser extent they have also been used to infer pH in peatlands and the trophic or nutrient status of lakes. Recent research on these organisms suggests other possible uses in paleoecology and ecology. Examples of these applications include sea-level reconstruction in estuarine environments, as indicators of soil or air pollution, and monitoring recovery of peatlands following restoration management. However, significant challenges remain before the potential of these organisms can be fully realized. Establishing the occurrence and major environmental gradients affecting taxa distribution is critical and this needs to be linked to research on the biology and functioning of the group. The development of practical and widely accepted taxonomies is a further priority. We will review the past and present use of testate amoebae, the challenges in current research, and provide some ideas on future research directions.
Notes: See also Vickery and Charman 2004.

Reference Type: Book
Record Number: 158
Author: Mitsch, W.J.

Year: 1994
Title: Global Wetlands: Old World and New.
Publisher: Elsevier Science.
Number of Pages: 615-967
Notes: This comprehensive book covers most aspects of wetland science. Several papers on the assessment of wetland condition are in the book and are included as separate entries in this bibliography. See records; Brinson *et al*. 1994, Maltby *et al*. 1994, Murphy *et al*. 1994, Novitzki 1994, Young 1994. Available in SA libraries.

Reference Type: Journal Article
Record Number: 159
Author: Mitsch, W.J.; Gosselink, J.G.
Year: 2000
Title: The value of wetlands: Importance of scale and landscape setting.
Journal: Ecological Economics.
Volume: 35
Issue: 1
Pages: 25-33
Keywords: Functional assessment, resource economics, social importance.
Abstract: Wetlands have value because their functions have proved to be useful to humans. The unit value for some wetlands also increases with human development (agriculture and urban) because of increased use and/or increased scarcity. Yet, paradoxically, its functions can easily be overwhelmed in areas of heavy human development, thus lessening those values. Thus wetlands appear to work best in the landscape as spatially distributed systems. Also, the value is partially dependent on where they are found in the landscape, e.g., the degree to which a wetland is open to hydrologic and biological fluxes with other systems, including urban and agricultural landscapes. A paradox of assigning values to wetlands and other ecosystems is that it can argue for the replacement of one system with another if a landscape view is not taken. Estimates of percent of landscape for various functions, e.g. water quality or flood control, are presented. It is suggested that a range of 3–7% of temperate-zone watersheds should be in wetlands to provide adequate flood control and water quality values for the landscape.
Notes: This is a key paper for evaluating the importance of wetlands. It gives discussion on the philosophy of conservation of wetlands, including the relationship between function and scale. It is relevant to both developed and developing countries.

Reference Type: Conference Proceedings
Record Number: 160
Author: Moffett, M.F.; Detenbeck, N.E.; Jicha, T.M.; Elonen, C.M.; Anderson, L.E.; Taylor, D.L.; Snarski, V.M.; Simon, T.P.
Year of Conference: 2001
Title: Development of indicators of exposure and response to sediment and habitat alteration in Lake Michigan coastal riverine wetlands.
Editor: International Association for Great Lakes Research.
Conference Name: 44th conference on Great Lakes Research. Great Lakes science: Making it relevant
Page: 94
Address: US Environmental Protection Agency, Mid-Continent Ecology Division, Dulluth, MN, 55804.
Keywords: Bioassessment, fish, habitat, impact assessment, indicators, invertebrate, plants, USA.
Abstract: Measures are being assessed to quantify the relationship of land-use in upstream watersheds to the habitat and biota in downstream coastal wetlands. Twenty-two sites were

randomly drawn from a pool of 125 identified riverine coastal wetlands of Lake Michigan. Wetlands ranged in size from a few acres to >1, 000 acres and cut across five ecoregions. During the 2000 growing season, stressors measured were land-use, nutrients, tributary hydrology, and sediment load. Habitat features of coastal wetlands including wetland shoreline complexity, seiche amplitude and periodicity, substrate composition, and thermal regimes were measured to relate to fish, macroinvertebrate and plant communities and water quality. The degree to which land-use metrics can predict habitat features in these wetlands will be assessed. In 2001, a probabilistic sampling design of coastal wetlands will be used across Lakes Superior, Michigan, Huron, and Erie as part of the U.S.EPA Regional Environmental Monitoring and Assessment Program (R-EMAP) to assess fish communities; a subset of sites will be used to further test exposure and response measures across a gradient of degraded habitats. For future work a GIS approach to identification and classification of hydrogeomorphic types of Great Lakes coastal wetlands for basinwide monitoring is being tested.

Reference Type: Conference Proceedings
Record Number: 161
Author: Morrice, J.A.; Thompson, J.A.; Batterman, S.L.; Cotter, A.M.; Peterson, G.S.; Danz, N.
Year of Conference: 2003
Title: Algal rsponses to nutrient loading in Great Lakes coastal wetlands.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 57
Address: U.S. Environmental Protection Agency, 6201 Congdon Blvd., Duluth, MN, 55804.
Keywords: Algae, bioassessment, plankton, water quality.
Abstract: We are evaluating the influence of nutrient loading on phytoplankton and periphyton in coastal wetlands of the Great Lakes as part of an EPA study associated with the Great Lakes Environmental Indicators (GLEI) project. A primary goal is to assess the role of wetland morphology (protected vs. riverine wetlands) and biogeography (upper vs. lower lakes) as factors controlling biological responses to nutrient loading. For the 2002 field season, GIS-based data was used to select 6 sites in each of these 4 classes spanning a gradient in watershed-scale metrics of nutrient loading. A suite of water samples were collected from each site for nutrient and chlorophyll analysis. At two sites in each class, colonization rods and nutrient diffusing assays were used to measure periphyton biomass, community composition, and response to nutrient loading. Data show significant differences in inorganic nitrogen, SRP and chlorophyll *a* concentrations between geomorphic and geographic classes and provide insight into utility of site selection, classification approaches, and determine sensitivity of algal responses to nutrient loading.

Reference Type: Book Section
Record Number: 162
Author: Murphy, K.J.; Castella, B.; Hills, J.M.; Obrdlik, P.; Pulford, I.D.; Schneider, E.; Speight, M.C.D.
Year: 1994
Title: Biotic indicators of riverine wetland ecosystem functioning.
Editor: Mitsch, W.J.
Book Title: Global Wetlands: Old World and New.
Publisher: Elsevier Science.
Pages: 659-682
Keywords: Bioassessment, functional assessment, invertebrates, plants, rivers.

Abstract: An analysis is provided of the relationship between strategies of species as indicators of environmental conditions and independently-defined (in hydrological and geomorphic terms) units of riverine wetlands in Europe. Two contrasting groups of organisms were targeted: wetland plants and wetland hoverflies (Syrphidae). The strategy concept was used to classify each group of target organisms on the basis of their possession of sets of similar or analogous genetic traits which permit tolerance of similar sets of environmental pressures affecting their survival in riverine wetlands. The results of these strategy analyses were then linked to analyses of distribution data for the groups of species concerned, to permit definition of functional groupings of organisms in relation to habitat characteristics. Both plant and adult Syrphid assemblages showed some potential for distinguishing independently-defined hydrogeomorphic units of the target wetlands. The use of functionally defined groupings, which linked trait and distribution data for each set of organisms, proved effective in indicating differing hydrogeological and geomorphic conditions likely to produce differing intensities of stress affecting plants and invertebrates occurring within a riverine wetland. There was a reasonable degree of congruity between the results obtained using plants and those obtained using hoverflies to indicate riverine wetland ecosystem functioning at the target sites.
Notes: This paper gives interesting background information that will aid in developing wetland condition indices based on plants or macroinvertebrates.

Reference Type: Conference Proceedings
Record Number: 163
Author: Nasirwa, O.; O'Connell, M.; Buckton, S.
Year of Conference: 2004
Title: Wetland biodiversity monitoring scheme for eastern Africa.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Keywords: Africa, birds, monitoring, social importance.
Address: Unknown.
Abstract: Eastern Africa holds some of the most significant wetlands in the world. They support internationally important assemblages of plants and animals, and are a vital source of livelihood and water for many societies. The combined human population of Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda is estimated to be about 200 million. The region has an area of about 5.6 million km^2 of which 4.5% is open water/wetlands. Wetland conversion to agriculture often provides only short-term benefits and can pose long-term problems. In 2002, a project was implemented to develop the capacity to establish a regional waterbird and wetland monitoring scheme. This poster describes process issues in relation to the capacity building elements of the projects, and evaluates how increased capacity can be used to underpin conservation and resource management.
Notes: Not of direct relevance to development of wetland assessment methods.

Reference Type: Report
Record Number: 164
Author: Natural Resource Land Management
Year: 2004
Title: Wetland ecosystem condition: Macroinvertebrate index.
Institution: Australian Government.
Source: DWAF (2004)
Keywords: Australia, bioassessment, biotic index, invertebrates.
Abstract: Macroinvertebrates are very useful in monitoring as: 1. they are ubiquitous (i.e. they are likely to be present in all wetlands studied); 2. the number of taxa present offers a range of responses to environmental stresses; 3. their sedentary nature allows effective spatial analysis of point-source pollutants or other impacts; and 4. their relatively long life cycles

compared to other groups helps in monitoring temporal changes caused by environmental impacts. A biotic index using macroinvertebrates can be used to provide an assessment of the health of a selected wetland. Chessman, Trayler and Davis (in press) developed the SWAMPS macroinvertebrate index (Swan Wetlands Aquatic Macroinvertebrate Pollution Score) for wetlands on the Swan Coastal Plain. It was developed using the objective iterative method of Chessman *et al*. (1997) for macroinvertebrate families of rivers in eastern Australia. This work may be widely applicable across Australia, but may require minor adjustment to reflect species distributions. Macroinvertebrates should not be measured in isolation, but combined with physical and chemical assessments to gain an overall picture of wetland condition.
Notes: This paper gives details of how to carry out an asessment using macroinvertebrates as detailed in SWAMPS. The sampling method, the scores for each family and how to calculate the final aggregate score (SWAMP index scores) are explained. It would be interesting to compare the macroinvertebrate community structure and scores with those of some South African wetland systems. See also other records by Chessman (Chessman 1995; Chessman *et al*. 1997; Chessman *et al*. 2002).
URL: http://www.nrm.gov.au/monitoring/indicators/wetlands/pubs/wetland-condition-index.pdf

Reference Type: Journal Article
Record Number: 165
Author: Newman, S.; McCormick, P.V.; Backus, J.G.
Year: 2003
Title: Phosphatase activity as an early warning indicator of wetland eutrophication: problems and prospects.
Journal: Journal of Applied Phycology.
Volume: 15
Pages: 45-59
Source: BiblioLine
Keywords: Bioassay, stressor effects, water quality.
Abstract: A phosphorus (P) loading experiment conducted in the oligotrophic P-limited Everglades (Florida, USA) was used to assess the utility of phosphatase activity (PA) of periphyton as an early warning (EW) indicator of wetland eutrophication. Phosphorus loads of 0, 0.4, 0.8, 1.6, 3.2, 6.4 and 12.8 g P $m^{-2}yr^{-1}$ were applied to mesocosms placed in a slough community consisting of *Cladium jamaicense*, *Eleocharis* spp. and calcareous periphyton mats. Phosphatase activity, expressed on a biomass-specific basis, was not a sensitive indicator of P enrichment for epiphytic periphyton growing on acrylic dowels or floating mat periphyton. However, surface-area-specific PA was a sensitive indicator of P enrichment, responding within 2-3 weeks of the initiation of dosing. Surface-area-specific PA of unenriched periphyton ranged from 0.42 to 0.7 nmol $cm^{-2}min^{-1}$, while PA of periphyton growing in the highest load (12.8 g P $m^{-2}yr^{-1}$), ranged from 0.11 to 0.29 nmol $cm^{-2}min^{-1}$. Conclusions drawn from PA analyses were consistent with those obtained from periphyton primary productivity and P content. Phosphatase activity is a potentially valuable EW indicator when used in conjunction with other complementary indicators.

Reference Type: Journal Article
Record Number: 166
Author: Nichols, J.D.; Perry, J.E.
Year: 2003
Title: Evaluating wetland biological integrity through floristic quality assessments.
Journal: Southeastern Biology.
Volume: 50
Pages: Unknown
Source: BiblioLine

Keywords: bioassessment, biotic index, plants.
Abstract: Given the continuing degradation of freshwater wetland ecosystems throughout the Southeast, there has been significant interest in developing methods and indices to evaluate and monitor wetland biological integrity. We sought to adapt a vegetation-based survey known as the floristic quality assessment and test its ability to assess the level of naturalness and human impact in hardwood flat wetlands of southeastern Virginia. At eleven sites we measured plant species diversity and composition within each vertical strata of the wetland (herbaceous, understory, and canopy) to calculate the floristic quality index (FQI) of each layer. We then tested index scores in each layer for their relationship to land-use disturbance patterns within site buffer and watershed areas. We found the floristic quality of the herbaceous and understory layers to be negatively correlated with the level of land-use disturbance at both the buffer and watershed scale, suggesting that FQI scores within these strata can serve as a useful reflection of current anthropogenic stress. While the FQI of the canopy layer was not a reliable indicator of current land-use disturbance, we found that a comparison of the floristic quality of the understory and canopy layers gave insights into the historical vs. recent integrity of a site. Overall these findings support the use of floristic quality assessments in evaluating wetland biological integrity when survey and index calculation methodology are carefully adapted to local flora and community types.
Notes: This journal is not available in South Africa. Useful paper to read for development of a biotic index using macrophytes.

Reference Type: Journal Article
Record Number: 167
Author: Norris, R.H.; Norris, K.R.
Year: 1994
Title: The need for biological assessment of water quality: Australian perspective.
Journal: Australian Journal of Ecology.
Volume: 20
Pages: 1-6
Keywords: Australia, bioassessment, bioassay, monitoring, rivers.
Abstract: Biological assessment of water quality in Australia is entering a stage of rapid development largely because of the inclusion of biological indicators in water quality guidelines and growing concern for ecological values. Approaches to water quality assessment include toxicity testing, use of biomarkers and several methods using community structure. For assessment, diverse organisms such as fish, algae and (the most commonly used) macro-invertebrates are used. Interaction of data analysis with methods of data collection requires co-ordinated research on both fronts. Recent developments in the use of multivariate statistics to produce models for predicting water quality are likely to be useful in Australia. Much innovative work is still needed in Australia on the use of algae and fish, defining tolerance categories and establishing monitoring programmes performed in time-frames equivalent to those in use for physical and chemical methods.
Notes: This paper is fairly old and is not wetland-specific. Nevertheless, it gives valuable background insight into the different forms of bioassessment that are potentially available.

Reference Type: Book Section
Record Number: 168
Author: Novitzki, R.P.
Year: 1994
Title: EMAP-wetlands: A program for assessing wetland condition.
Editor: Mitsch, W.J.
Book Title: Global Wetlands: Old World and New.
Publisher: Elsevier Science.
Pages: 691-709

Keywords: Bioassessment, indicators, monitoring, USA.
Abstract: The Environmental Monitoring and Assessment Program (EMAP) for wetlands will assess current status and long-term trends in wetland condition. The program builds upon existing research and ongoing programs in conducting research to develop indicators and protocols for assessing wetland condition. EMAP has focused on estuarine emergent, palustrine emergent, and palustrine forested wetlands, representing approximately 79% of the nation's wetland resources. For each wetland class a region will be selected, potential indicators will be identified, and pilot studies will be conducted to evaluate the ability of the indicators to discriminate between good and degraded wetlands. Pilot studies of estuarine emergents in the Gulf of Mexico and palustrine emergents in the prairie pothole region are underway. Assessment protocols will be developed to relate wetland condition to reference wetlands in the region. The EMAP sample design is based on a probability sample so that observations made of the sample relate to the entire resource.
Notes: See also other documents on EMAP e.g. Leibowitz *et al*. 1991, Moffet *et al*. 2001, and Kingston 2002.

Reference Type: Conference Proceedings
Record Number: 169
Author: Novitzki, R.P.; Smith, D.; Fretwell, J.
Year of Conference: 1996
Title: Wetland Functions, Values and assessment.
Conference Name: USGS Water - supply paper 2425: National Water Summary on Wetland Resources.
Page: 79
Source: LexisNexis
Keywords: Functional assessment, social importance, USA.
Abstract: Wetlands, or the lack thereof, were a significant factor in the severe flooding in the Upper Mississippi and Missouri River Basins in the summer of 1993. Damages associated with the flooding were undoubtedly worse than they would have been if flood-plain wetlands had still been in place. Human modification of the original wetlands (a common practice in the early part of this century) had destroyed the ability of the wetlands to modify flooding. Flood control, however, is only one of the values that wetlands have for society. In order to protect wetlands, the public first must recognize the values of wetlands. People need to understand what is lost when a wetland is changed into an agricultural field, a parking lot, a dump, or a housing development. Understanding the functions of wetlands will make it easier to evaluate wetlands when other uses are considered.
Notes: Gives general background information on the functions carried out by wetlands, the need for conserving them, and the need for the public to value them.
URL: http://water.usgs.gov/nwsum/WSP2425/functions.html

Reference Type: Journal Article
Record Number: 170
Author: Ortega, M.; Velasco, J.; Millan, A.; Guerrero, C.
Year: 2004
Title: An ecological integrity index for littoral wetlands in agricultural catchments of semi-arid Mediterranean regions.
Journal: Environmental Management.
Volume: 33
Pages: 412-430
Source: ScienceDirect/ISI Web of Science
Keywords: European Union, impact assessment, invertebrates, plants, resource economics, social importance, water quality.

Abstract: The main goal of the present study was to develop an ecological integrity index for littoral wetland management and conservation in semi-arid Mediterranean areas that have been highly impacted by agriculture. This included the selection of pressure and state indicators at landscape and wetlands scales that reflect the status, condition, and trends of wetlands ecosystems. We used a causality framework based on the relationship between pressure of anthropogenic activities and the ecological state of wetlands and their catchments, integrating environmental, biologic, economic, and social issues. From the application of 51 indicators in 7 littoral wetlands in the southeastern Iberian Peninsula, we selected 12 indicators (5 at catchment scale and 7 at wetland scale) to constitute the ecological integrity index proposed. The potential nitrogen export per area at catchment scale and the potential relative nitrogen export from the area surrounding the wetlands were the best single pressure predictors of state indicators with a causal relationship with environmental meaning. Wetlands in catchments with more agriculture had less ecological integrity than those in less impacted areas. A wide riparian zone in some wetlands acts as a buffer area, diminishing the effects of intensive agriculture. The index of ecological integrity developed here has a number of essential characteristics that make it a useful tool for ecosystem managers and decision-makers. The index can be used to (1) assess and control ecological integrity, (2) diagnose probable causes of ecological impairment, (3) establish criteria for protecting and restoring wetland ecosystems, and (4) integrate catchment management.
Notes: This approach has merit and is useful in that it distinguishes between external threats ("pressure indicators") and the condition of the wetland itself ("state indicator"). They also distinguish between indicators that are relevant at the catchment (landscape) scale and at the level of individual wetlands. The authors suggest that with modification the method could be used in other Mediterranean areas such as the Western Cape.

Reference Type: Journal Article
Record Number: 171
Author: Ouder, P.
Year: 2003
Title: Getting a handle on wetland health.
Journal: Coast and Sea.
Volume: 11
Pages: 8-9
Source: LexisNexis
Keywords: Bioassessment, restoration.
Abstract: Resiliency is a new criterion for environmental health, as applied in measurements of the health and sustainability of Louisiana wetlands. The resilience factor is important in determining which wetland is most likely to respond to restoration measures. Past measurements of ecosystem health have used indicator species, or key processes such as primary productivity. Researchers are now looking at a more holistic approach which focuses on measures of resilience, organization, and vigor.
Notes: This is a popular article about the work of I. Mendelssohn and colleagues (Lousiana State University) who are looking at assessing wetland health by using resilience (the rate of recovery from disturbance), vigour (rate of functional metabolism and of key processes) and organization (biodiversity, community structure).
URL: http://www.laseagrant.org/communications/coastsea/year2003.htm

Reference Type: Book
Record Number: 172
Author: Palmer, R.W.; Turpie, J.; Marneweck, G.C.; Batchelor, A.L.
Year: 2002
Title: Ecological and Economic Evaluation of Wetlands in the upper Olifants River Catchment, South Africa.

Publisher: Water Research Commission Report No K5/1162.
Keywords: Functional assessment, resource economics, South Africa.
Abstract: This report provides a preliminary assessment of the ecological and economic values of wetlands in the Upper Olifants River Catchment. In so doing the report provides the basis for developing a strategic framework for the conservation and management of these wetlands. The need to assess the values of these wetlands arose because so many of these systems in the area are facing irreversible degredation. At the same time, neither the ecological nor economic value of these wetlands was known. A broad-level study was carried out with regard to various aspects of the wetlands including; classification and an examination of the soils, geology, plants, aquatic invertebrates, fish, amphibians, reptiles, birds. Ecosystem services of the wetlands were assessed in terms of water balance, water purification and sediment trapping. It was found that the main ecological value of the wetlands in this area lies in the sheer abundance of wetland habitat. Taken alone, most of the wetlands are small and disjunct and this is probably the single most important factor that has promoted their degradation. They represent a diversity of types (17 in total). A crude estimate was made of wetland values in the study. Despite the low indirect use values of the wetlands their direct use value was found to be considerable (R1 000 to R32 000 per ha in present terms).
Notes: Useful document which highlights the difficulties of valuing numerous small wetlands that are spread over a large area, and for which few data are available.

Reference Type: Journal Article
Record Number: 173
Author: Pan, Y.; Stevenson, R.J.
Year: 1996
Title: Gradient analysis of diatom assemblages in Western Kentucky wetlands.
Journal: Journal of Phycology.
Volume: 32
Pages: 222-232
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, diatoms, USA.
Abstract: Diatom and water chemistry data from 35 wetland sites in western Kentucky were used to assess diatoms as indicators of ecological conditions in wetlands. The wetlands were affected by different degrees of acid mine drainage and agriculture. Canonical correspondence analysis indicated that the distribution of diatoms was highly correlated with conductivity and total phosphorus (TP), two variables commonly associated with acidic mine drainage and agriculture, respectively.

Reference Type: Conference Proceedings
Record Number: 174
Author: Pardo, M.T.; Esteve, M.A.; Martinez, J.; Carreno, M.; Serrano, J.; Gimenez, A.
Year of Conference: 2004
Title: Ground beetles (Carabidae and Tenebrionidae) as bioindicators of habitat alteration on coastal wetlands of the Mar Menor Lagoon (SE Spain).
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Dept. de Ecologia e Hidrologia, Facultad de Biologia, Universidad de Murcia, Campus de Espinardo, 30100-Murcia, Spain.
Keywords: Bioassessment, European Union, impact assessment, invertebrates, water quality.
Abstract: The Mar Menor is a hypersaline coastal lagoon located at the SE of Spain. Wetlands in the shore of the lagoon constitute ecological systems with high ecological and natural values acting as intermediate multifunctional systems, which mitigate the impacts from the watershed. The increase of irrigated lands and nutrient inputs due to the Tagus-Segura diversion has led to an increase of surface and subsurface fluxes. Bioindicators based

on composition and structure of ground beetle communities (Carabidae and Tenebrionidae) on these fluctuating systems constitute a useful tool to assess the impacts of the rising phreatic levels: We analyse the changes generated in ground beetle communities from 1984 to the present time using them as bioindicators of effects of impacts generated by agricultural activities. Sampling of ground beetles by nine grids of ten pit fall traps in 1984, 1992 and 2003 shows an increase in the ratio Carabidae/Tenebrionidae abundance explained by the small tolerance of tenebrionid beetles to inundation. The rising piezometric levels and the temporal inundation events have led to an increase of species richness of the Carabidae family and communities of carabid and tenebrionid beetles dominated by generalist species. Halobiont species practically absent in 1984 and 1992 communities become dominant in 2003, revealing the increase of the edaphic salinity. The rising abundance of halobionts or halophilous carabid indicator species such as *Anisodactylus virens* and *Pogonus chalceus* and the decreasing one of tenebrionid beetles such as *Pimelia baetica* can be used to assess the effect of externalities of agriculture intensification.

Reference Type: Book
Record Number: 175
Editor(s): Parikh, J.; Datye, H.
Year: 2002
Title: Sustainable management of wetlands: biodiversity and beyond.
City: New Delhi.
Publisher: India: Sage Publications India Pvt Ltd.
ISBN: 81-7829-205-X.
Source: BiblioLine
Keywords: Management, resource economics, social importance.
Abstract: This volume is a comprehensive and multidisciplinary study of wetlands, which unites the natural science perspective with strong social concerns and economic and other approaches in order to design a practical national wetlands conservation strategy and action plan in India. The 12 chapters of the book are grouped into 4 sections. The first section starts with an overview of wetlands, covers the remote-sensing approach to wetland mapping, and discusses specific ecosystems such as coral reefs, mangroves, and man-made wetlands. The second section deals with managerial and economic approaches. A set of structural indicators for planning and maintaining wetlands is described. The economic valuation approaches are also explained. The third section takes a case-study approach with three chapters analysing Keoladeo National Park (KNP) from three very different perspectives. These are, respectively, (1) the ecological perspective, with a discussion of the interrelationships among species, (2) the participatory approach that emphasizes education and training of local people, and (3) the economic approach that estimates and ranks the value of KNP's services to different stakeholders. The fourth section looks at the larger picture and deals with the need for protected area networks of wetlands and for criteria selection of the same. The book has a subject index.
Notes: This book was not available in libraries of South Africa during the literature search. It is potentially useful in that it views wetland conservation and management from the point of view of a developing country. Order from website below.
URL: http://www.irade.res.in/book_wetlands.htm

Reference Type: Journal Article
Record Number: 176
Author: Patil, G.P.; Brooks, R.P.; Myers, W.L.; Rapport, D.J.; Taillie, C.
Year: 2001
Title: Ecosystem health and its measurement at landscape scale: Toward the next generation of quantitative assessments.
Journal: Ecosystem Health.

Volume: 7
Issue: 4
Pages: 307-316
Keywords: Impact assessment, resource economics, social importance, USA.
Abstract: The purpose of this paper is twofold: (1.) to describe the challenges of reporting on changes in ecosystem health at landscape scales, and (2.) to review the statistical and mathematical techniques that allow the derivation of landscape health assessments from a variety of data consisting of remote sensing imagery, demographic and socio-economic censuses, natural resource surveys, longterm ecological research, and other geospatial information that is site specific. We draw upon seven innovative and integrative concepts and tools that together will provide the next generation of ecosystem health assessments at regional scales. The first is the concept of ecosystem health, which integrates across the social, natural, physical, and health sciences to provide the basis for comprehensive assessments of regional environments. The second consists of innovative stochastic techniques for representing human disturbance and ecosystem response in landscapes, and the corresponding statistical tools for analyzing them. The third constitutes representation of spatial biocomplexity in landscapes through application of echelon analysis to assessment. The fourth concerns innovative combination techniques of upper-echelon-based spatial scan statistic to detect, delineate, and prioritize critical study areas for evaluating and prioritizing causal factors and effects. The fifth involves the capability of comparing and prioritizing a collection of entities in light of multiple criteria, using poset mathematics of partial order with rank frequency statistics, to provide multicriterion decision support. The sixth lies in extending data mining and visualization techniques to determine associations between geospatial patterns and ecosystem degradation at landscape scales. The seventh encompasses comprehensive studies conducted on different types of regional ecosystems. Our focus is to show how the integration of recent advances in quantitative techniques and tools will facilitate the evaluation of ecosystem health and its measurement at a variety of landscape scales. The challenge is to characterize, evaluate, and validate linkages between socio-economic drivers, biogeochemical indicators, multiscale landscape pattern metrics, and quality of human life indicators. Initial applications of these quantitative techniques and tools have been with respect to regions in the eastern United States, including the U.S. Atlantic Slope and mid-Atlantic region.
Notes: This paper is interesting because it recognizes that wetland assessment needs to be carried out at different scales and that these can usefully be linked to socio-economic factors. Potential approaches are highlighted for wetland assessment at the landscape scale.

Reference Type: Book
Record Number: 177
Author: Phillips, B.; Begg, G.; Finlayson, M.; Lane, B.; Bezuijen, M.; Lukacs, G.
Year: 2002
Title: Pilot testing, an approach for describing the ecological character of Australia's Ramsar sites.
Publisher: Report prepared for Environment Australia under the National Wetlands Programme of the Natural Heritage Trust.
Source: DWAF (2004)
Keywords: Australia, impact assessment, monitoring.
Abstract: Australia, as a Contracting Party to the Ramsar Convention on Wetlands, has designated to date 57 Wetlands of International Importance. The act of designating a wetland as a Ramsar site carries with it certain obligations, including managing the site to retain its 'ecological character' and to have procedures in place to detect if any threatening processes are likely to or have already altered the 'ecological character'. Therefore, describing the 'ecological character' of a Ramsar site is a fundamental management tool for Parties which should form the baseline or benchmark for management planning and action, including site monitoring to detect negative impacts. In response to these obligations, this project was

undertaken to 'pilot test' an approach for preparing 'ecological character' descriptions for Australia's Ramsar sites. A datasheet was designed and then improved through application for eight of Australia's Ramsar sites. The project team developed a draft datasheet for assembling site information, which covered a range of biotic and abiotic parameters thought to be of direct relevance for gaining a better understanding of the "biological, physical, and chemical components of the wetland ecosystem, and their interactions" (as per the Ramsar Convention's formal definition of 'ecological character'). For each of the chosen sites, desktop data reviews were undertaken to populate, and in the process help fine tune the datasheet. The proforma presented in the report, the so-called Ecological Character Datasheet (ECD), provides a comprehensive and uniform framework for 'ecological character' data to be assembled. It also allows current information gaps to be identified. The ECD, as proposed in the report, is designed to be flexible and to accommodate, on a site-by-site basis, the differing situations and management needs. It can be used as a 'rolls royce' model whereby all or most parameters are measured and monitored, or it can be equally useful as the cut-down, 'economy model' that focuses upon using an appropriate sub-set of parameters that are considered most relevant to the management aspirations for the site or the threats it may be facing. The report concludes that application of the proposed ECD should help guide and form the basis for determining management prescriptions for Ramsar sites, in accordance with the EPBC Act's Australian Ramsar Management Principles. It should also help to identify those attributes of greatest value for establishing early warning systems within overall monitoring frameworks for Wetlands of International Importance.

Reference Type: Conference Proceedings
Record Number: 178
Author: Portier, K.M.; Corstanje, R.; Reddy, K.R.
Year of Conference: 2004
Title: Multivariate selection of sensitive indicators of eutrophication.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Department of Statistics, University of Florida-IFAS, FL, USA (portier@ufl.edu; corstanje@mail.ifas.ufl.edu; krr@ufl.edu).
Keywords: Bioassessment, indicators, microbes, USA, water quality.
Abstract: Eutrophication of wetland ecosystems such as the Florida Everglades can lead to extensive displacements of vegetative communities and as a result changes in overall environmental conditions. This has generated a demand for a set of sensitive indicator(s) that prelude the structural changes in vegetative communities in response to nutrient enrichment. In this study, we used the extensive data base collected by researchers at the Wetland Biogeochemistry Laboratory over two wetland systems in Florida: i) along the eutrophic gradient in the Water Conservation Area 2A (WCA 2A) in the Everglades and ii) contrasting nutrient impacted and unimpacted areas in the Blue Cypress Marsh, located in the Upper St. Johns River Basin, Florida. Analysis on the WCA 2A dataset demonstrated that using a comprehensive set of soil physico-chemical variables, observations clustered naturally into multivariate groups that identified closely with eutrophication gradients. Stepwise discrimination of chemical soil characteristics produced two discriminant functions that best describe eutrophication. Microbiological soil characteristics were projected on the physicochemical clusters, selecting microbial indicators that best predicted impact classes from which the observations originated. The discriminant functions as well as the variables selected to form these functions are applied as indicators. Discrimination by microbial parameters is moderately successful when contrasted to soil chemical variables and acts more as integrative functions with associated stability and robustness. This method of indicator identification was subsequently validated on the data from Blue Cypress Marsh.

Reference Type: Journal Article
Record Number: 179
Author: Poulícková, A.; Duchoslav, M.; Dkulil, M.
Year: 2004
Title: Littoral diatom assemblages as bioindicators of lake trophic status: A case study from perialpine lakes in Austria.
Journal: European Journal of Phycology.
Volume: 39
Keywords: Bioassessment, biotic index, diatoms, European Union, lakes.
Abstract: Littoral diatom assemblages from different natural substrates (stones, mud, reeds) were used for estimating trophic status in seven perialpine lakes near Salzburg (Austria). Four trophic status indices were compared with actual chemical data and the annual averages of total phosphorus concentrations. Diatom assemblages on different substrates indicated significantly different trophic status for the site. Indicators based on epiphytic diatoms from young reed stalks correlated strongly with the concentrations of total phosphorus, so that reeds were found to be the most suitable for bioindication. Bioindication based on three of the four indices studied (Rott's TDIA, Schönfelders TS, van Dam's TDW) was positively correlated with actual phosphorus concentration at each site. While other indices indicated higher trophic status than expected according to the annual averages of total phosphorus, Rott's TDIA was found to be the most applicable to perialpine lakes.
Notes: Useful information for developing a biotic index based on diatoms. See other papers in this bibliography also using diatoms.

Reference Type: Book
Record Number: 180
Author: Ramsar Convention Secretariat
Year: 2004
Title: Ramsar handbooks for the wise use of wetlands.
City: Gland, Switzerland.
Publisher: Ramsar Convention Secretariat.
Edition: 2nd
Keywords: Bioassay, impact assessment.
Abstract: This series has been prepared by the Secretariat of the Convention following the 7th and 8th Meetings of the Conference of the Contracting Parties (COP7 and COP8) held, respectively, in San José, Costa Rica, in May 1999 and Valencia, Spain, in November 2002. These guidelines have been prepared as a series of handbooks to assist those with an interest in, or directly involved with, implementation of the Convention at either the international, regional, national, sub-national or local levels. The handbooks have been prepared in the three working languages of the Convention (English, French and Spanish) and incorporate, where appropriate, material from case studies designed to illustrate key aspects of the guidelines. The full text of most case studies can be found on the Web site of the Convention. The table on the inside back cover illustrates the full scope of the subjects covered by this handbook series at present, though other handbooks may be added at a later date. The Ramsar Convention promotes an integrated package of actions to ensure the conservation and wise use of wetlands. In recognition of these integrated approaches, the reader will find that within each handbook there are numerous signposts or crossreferences to others in the series.
Notes: Of the series of handbooks, number 11 ("Impact assessment") appears to be the most useful from the point of view of assessing the ecological condition of a wetland. Also "Wetland risk assessment framework" (http://www.ramsar.org/key_guide_risk_e.htm) - although both give only general comments. The latter document does give some information on early-warning indicators and the attributes they should display. Additional volumes are planned however, and thus this website should be monitored.
URL: http://ramsar.org/wurc_index.htm

Reference Type: Journal Article
Record Number: 181
Author: Reicholf, J.
Year: 1976
Title: The possible use of aquatic bird communities as indicators for the ecological condition of wetlands.
Journal: Landschaft und Stadt (Germany).
Volume: 8
Pages: 125-129
Source: BiblioLine
Keywords: Biotic index, birds.
Abstract: Paper not available in South Africa

Reference Type: Journal Article
Record Number: 182
Author: Reid, M.A.; Tibby, J.C.; Penny, D.; Gell, P.A.
Year: 1995
Title: The use of diatoms to assess past and present water quality.
Journal: Australian Journal of Ecology.
Volume: 20
Pages: 57-64
Keywords: Australia, bioassessment, diatoms, monitoring, review, water quality.
Abstract: Diatoms possess a number of attributes which contribute to their suitability as biological indicators. They are highly sensitive to water chemistry changes, abundant in aquatic environments, largely cosmopolitan in distribution, less habitat dependent than macroinvertebrates and have a well-studied taxonomy and ecology. Furthermore, the preservation of diatom valves in lake sediments means that they can provide otherwise unavailable baseline data which can be used to assess and contextualize human impacts on aquatic ecosystems. The value of diatoms as bioindicators in contemporary and palaeolimnological studies has been well established overseas. Despite this, they have been under-utilized in Australia. This paper outlines some of the applications and potential for the use of diatoms as biological indicators in Australia.
Notes: This is a very useful review paper of the limitations and advantages of using diatoms as biological indicators of water quality.

Reference Type: Journal Article
Record Number: 183
Author: Reid, M.A.; Brooks, J.J.
Year: 2000
Title: Detecting effects of environmental water allocations in wetlands of the Murray-Darling Basin, Australia.
Journal: Regulated Rivers: Research and Management.
Volume: 16
Pages: 479-496
Keywords: Amphibians, Australia, bioassessment, birds, EWR, fish, indicators, invertebrates, plants, plants.
Abstract: River regulation has significantly altered the hydrology and ecology of floodplain wetlands throughout the Murray-Darling Basin, Australia. Management plans proposed for rivers in the Murray-Darling Basin incorporate environmental water allocations (EWAs) designed to redress some of the damage caused by regulation, via partial restoration of the natural hydrological regime that used to be experienced by associated floodplain wetlands. Monitoring and scientifically rigorous adaptive management practices are the key to the long-

term success of EWAs, and successful monitoring relies on the well-informed selection of a variety of hydrologically sensitive indicators. In this paper, we recommend a range of physical, chemical and biological indicators for use for monitoring change in wetland health in response to EWAs. Physical and chemical variables suggested include wetland depth, wetland area and salinity. Aquatic macrophytes and macroinvertebrates are recommended as the primary biological indicators for monitoring change within the Murray-Darling Basin, although the indicator potential of macroinvertebrates still has to be confirmed by planned and ongoing research. Information is also presented for a variety of other components of wetland ecosystems, including biofilms, zooplankton, birds, fish, mammals, reptiles, amphibians and fringing vegetation. Our current knowledge of the relationships of these variables with wetland hydrology and ecosystem health is relatively limited. Further research is required to investigate the nature of these relationships and determine the utility of these parameters as indicators within wetlands of the Murray-Darling Basin.
Notes: This paper discusses the potential use of biological indicators in monitoring the effectiveness of Environmental Water Allocations/Requirements for wetlands. This is an important topic that needs further investigation in South Africa.

Reference Type: Conference Proceedings
Record Number: 184
Author: Reynoldson, T.B.
Year of Conference: 2001
Title: The dilemma of rare species in bioassessment: To be included or not to be included, that is the question.
Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 111
Address: National Water Research Institute, 867 Lakeshore Rd., Burlington, ON, L 7R 4A6.
Keywords: Bioassessment, impact assessment, invertebrates, USA.
Abstract: There is some debate in the current literature concerning both the level of appropriate taxonomic resolution and whether or not to include rare species when conducting biological assessments using benthic invertebrate community structure. In this paper we have addressed the importance and contribution of rare species to assessments conducted at sites in several Areas of Concern in the Laurentian Great Lakes. These sites represent stresses from various types of contaminants including Hg, an array of metals and organic contaminants. While more conventional assessment methods correctly point out the importance and often greater sensitivity to stress of rare species there is a fundamental dilemma in basing site assessments on the presence or absence of those species, as obviously rare species are by definition usually absent. So while the presence of rare species is informative, their absence is not necessarily so, and the effort required to estimate rare species is considerable. In this paper we have examined the effect of sequentially excluding rare species on the assessment of several sites using predictive models of taxon occurrence derived from a reference database for the Great Lakes. Sites are defined as being impaired or not by their distance from reference sites in ordination space.
Notes: The inclusion/omission of rare species is an important topic that needs to be considered in the development of a biotic index using any faunal or floral group, not just invertebrates.

Reference Type: Journal Article
Record Number: 185
Author: Rheinhardt, R.D.; Brinson, M.M.; Farley, P.M.
Year: 1997
Title: Applying wetland reference data to functional assessment, mitigation and restoration.

Journal: Wetlands.
Volume: 17
Pages: 195-
Keywords: Functional assessment, impact assessment, restoration, USA.
Abstract: This study demonstrates an approach for rapidly collecting quantitative field data on reference wetland sites and using those data to assess functions (ecological processes) in wetlands. We demonstrate the hydrogeomorphic (HGM) assessment procedure by identifying ecological functions performed by mineral soil wet flats, obtaining quantitative field data from 19 wet flats (reference sites) in southeastern North Carolina, and modeling wetland functions using variables derived from those field data. We chose a subset of the 19 reference sites to demonstrate how HGM assessment can be used to measure ecosystem functions before and after a project site is altered and the degree to which ecosystem restoration can compensate for a reduction in functions caused by a project's impact. We also illustrate how HGM assessment can be used to determine the minimum area over which restoration should be applied to achieve a no-net-loss in function objective. This minimum area can be determined by dividing the degree to which a function is reduced through project alteration by the degree to which a function is increased through restoration. The ratio of wetland area restored to wetland area altered by a project impact (compensatory mitigation ratio) varies among functions and is influenced by (1) the magnitude to which any given function occurs at a project site both before and after the site is altered, (2) the magnitude to which any given function occurs at a compensatory mitigation site both before and after restoration is applied, and (3) the rate at which any given function is restored.
Notes: The paper is interesting in that it demonstrates the sophistication (if not the effectiveness) of wetland restoration/mitigation activities in the USA. For the time-being at least, the extent of wetland mitigation (ie. the creation of new wetlands to compensate for natural ones that are destroyed by development) is limited in South Africa.

Reference Type: Conference Proceedings
Record Number: 186
Author: Rinoveanu, G.; Nistorescu, M.; Ciubuc, C.
Year of Conference: 2004
Title: Leaf litter breakdown rates as tool for assessing functional stream integrity: preliminary results from Romanian streams.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: University of Bucharest, Department of Systems Ecology, Spl. Independentei 91-95, 76201 Bucharest, Romania (rgeta@bio.bio.unibuc.ro).
Keywords: Bioassessment, bioassay, European Union, functional assessment, rivers.
Abstract: Assessment and monitoring of the ecological status of water bodies represent the prerequisite for any attempt to maintain or improve the water quality. RIVFUNCTION, a EU-funded project, both addresses the effects of major human impacts on water resources and targets the development of a monitoring tool that comprises all aspects of the ecological quality of surface waters, including the functional component. To assist in developing this tool we examine the stream ecosystem function in response to eutrophication based on litter decomposition experiments under field conditions. It was hypothesised that nutrient enhancement through eutrophication alters the functioning of the stream ecosystems. The results obtained in low order streams in the Carpathian region suggest that the eutrophication-produced stream impairment could be detected, quantified and evaluated by changes in the performance of the litter decomposition as a key ecosystem-level process.
Notes: Of possible interest for use in South Africa.

Reference Type: Journal Article
Record Number: 187
Author: Risser, P.G.
Year: 1988
Title: General concepts for measuring cumulative impacts on wetland ecosystems.
Journal: Environmental Management.
Volume: 12
Pages: 585-
Source: LexisNexis
Keywords: Impact assessment.
Abstract: Because environmental impacts accumulate over space and time, analysis is difficult, and we must incorporate the most recent scientifically defensible information and methods into the process. Methods designed to deal specifically with cumulative impacts include checklists of characteristics or processes, matrices of interactions (rated according to their level of importance) between disturbance activities and environmental conditions, nodal networks or pathways that depict probable effects of disturbances, and dynamic system models. These methods have been tested over the past decade and have proven generally successful. Landscape perspectives have emerged as especially helpful in analyzing cumulative effects, and have focused specific attention on questions of spatial and temporal scale, while leading to recognition of the complexity of ecosystem processes in general. An evaluation of several cases studies by the Commission on Life Sciences of the U.S. National Academy of Sciences emphasizes the importance of interactions and cumulative effects, but recognizes that current knowledge of the processes involved is insufficient to make specific recommendations for conceptual frameworks. The conceptual approach suggested by Preston and Bedford (1988) addresses many critical issues, such as the need to define dimensions of scale, and the importance of wetland size, shape, and location in the landscape. This approach and similar ones must be tested and evaluated so that a consensus may eventually emerge. A cumulative impact matrix is proposed that sets up additive, synergistic, and indirect categories, each capable of variation in space and time. Every interaction would be carefully examined to determine the likelihood of cumulative impact in any of the six categories. Because of its "magnifying glass" approach, such a matrix could be a very useful analytical tool, using existing methods to uncover all the information presently available about the behavior of the ecosystem of concern.

Reference Type: Book
Record Number: 188
Author: Roux, D.J.; Thirion, C.; Smidt, M.; Everett, M.J.
Year: 1994
Title: A procedure for assessing biotic integrity in rivers - application to three river systems flowing through the Kruger National Park, South Africa.
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, habitat, invertebrates, rivers, South Africa.
Abstract: Recognising the potential role of bioassessment in aquatic resource evaluations, the Department of Water Affairs and Forestry (DWAF) is currently developing the necessary capacity and infrastructure to conduct routine biosurveys on priority rivers. A rapid bioassessment index focusing on benthic macroinvertebrates, and an associated habitat assessment matrix which qualitatively and semi-qualitatively evaluates habitat suitability, have been used by the IWQS in a number of pilot studies. The current study aims to integrate these protocols in a complementary way to derive numeric values reflecting relative ecosystem integrity. To avoid misinterpretation resulting from naturally occurring spatial variation, the results obtained from field surveys were integrated with a classification approach whereby physically similar geographic or physiographic regions (also known as ecoregions) were delineated. It was found that the procedure enabled the integration of ecological data in a way that allowed the derivation of a single qualitative value for each

sampling site. Another important conclusion was that whilst regulatory actions are governed by point-source permits and chemical-specific guidelines, many perturbations that degrade water resources will be overlooked. Assessment of biotic integrity bridges this limitation by focusing holistically on the condition and status of water resources.
Notes: Although this report applies to rivers, it discusses some of the early deliberations from the River Health Programme and has some useful insights that would also be relevant to an equivalent programme for wetlands.

Reference Type: Conference Proceedings
Record Number: 189
Author: Ruthrock, P.E.; Albert, D.; Simon, T.P.
Year of Conference: 2003
Title: Using plant IBI to assess habitat quality of submerged river mouth wetlands, Lake Michigan, U.S.A.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 177
Address: Unknown.
Keywords: Bioassessment, biotic index, plants, USA.
Abstract: Indices of Biotic Integrity (IBI) for fish and aquatic invertebrate communities have proven valuable in monitoring stream quality and its change over time. Equivalent indices utilizing higher plants are finding some success in assessing wetland communities but still need refinement and testing. Recently, using traditional ecological techniques, a thorough biotic assessment of submerged river mouth coastal wetlands was completed around the Great Lakes. Fifteen sites from Lake Michigan, varying widely in size and covering 5 ecoregions, were re-assessed in 2002 using a rapid plant IBI. We shall report on the comparability of assessment regimes, advantages/disadvantages of each, including efficiencies of data collection and handling, and unresolved issues in using plant IBIs in the wetland setting.

Reference Type: Conference Proceedings
Record Number: 190
Author: Schuldt, J.; Ciborowski, J.J.H.; Johnson, L.B.; Host, G.E.; Hollenhorst, G.; Richards, C.
Year of Conference: 2003
Title: Identifying reference areas at Great Lakes coastal margins: Application of an *a priori* classification system derived from spatial data and anthropogenic stressors.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 54
Address: Department of Biology, University of Wisconsin - Superior, Superior, WI, 54880
Keywords: Fish, habitat, impact assessment, invertebrates, USA.
Abstract: It is difficult to identify reference conditions for large, heterogeneous areas. We developed a method to characterize disturbance in coastal ecosystems using remotesense data. Within ecological sections bordering the U.S. Great Lakes coast, classes of shoreline reaches were defined: high energy, embayment, coastal marsh, river-influenced wetland, protected wetland. The degree of anthropogenic disturbance contributing areas to these ecosystems was assessed using a 'moving window' (high-energy shoreline or embayment) or a 'watershed' approach (wetlands). We tabulated proportions of land used for agriculture or cities, population and road density data, and distance from Areas of Concern within a $1km^2$ window around 30-m Landsat pixels adjacent to the coast. Disturbance to wetlands was summarized for each watershed, delineated by elevation data. Cumulative distributions of each variable

were used to rank pixels based on minimal disturbance across all axes. Adjacent pixels were agglomerated into polygons, and polygons >2 km wide were ranked to identify candidate reference areas. The same approach was used for each wetland type. We characterized fish, invertebrate and habitat attributes within the areas. These data will help us set benchmarks reflecting best attainable conditions, and evaluate the best scale to identify reference areas.
Notes: Another technique for assessing wetland condition at the landscape/catchment scale. Might be useful for linking to the South African national wetland inventory.

Reference Type: Journal Article
Record Number: 191
Author: Schultz, E.J.; Hoyer, M.V.; Canfield, D.E.
Year: 1999
Title: An index of Biotic Integrity: A test with limnological and fish data from 60 Florida Lakes.
Journal: Transaction of the American Fisheries Society.
Volume: 128
Pages: 564-577
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, fish, lakes, USA, water quality.
Abstract: An index of biotic integrity (IBI) that used eight fish assemblage metrics was examined for effectiveness in estimating anthropogenic impacts to 60 Florida lakes ranging in size from 2 ha to more than 12,400 ha. The lakes ranged in trophic status from oligotrophic to hypereutrophic and had aquatic macrophyte abundances (percent lake volume infested) ranging from less than I % to 100%. Fish species were classified by trophic feeding guild and tolerance to increases in turbidity or warming and decreases in dissolved oxygen concentration. Fish assemblage metrics tested were as follows: number of fish species, number of native fish species, number of *Lepomis* species, number of piscivorous species, number of generalist species, number of invertivore species, number of species intolerant of increased turbidity or warming and decreased dissolved oxygen concentration, and number of species tolerant of increased turbidity or warming and decreased dissolved oxygen concentration. The total IBI scores and the data used to calculate individual metrics were unable to accurately predict the degree of anthropogenic impact to 60 Florida lakes, as estimated by personal observations of local limnologists, lake chloride concentrations, and road densities in the watersheds. Lake surface area and lake trophic status have a dominant influence on the fish assemblage metrics tested in this study. Thus, the IBI approach may be of limited usefulness for predicting anthropogenic impact in lake data sets that have wide ranges of surface areas and trophic status classifications.
Notes: This paper illustrates potential problems using a biotic index based on fish.

Reference Type: Conference Proceedings
Record Number: 192
Author: Schutten, J.
Year of Conference: 2004
Title: Using wetland knowledge in ecological impact assessment.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: English Nature, Environment Impacts Team, 60 Bracondale, Norwich, NR 1 2BE (johan.schutten@english-nature.org.uk).
Keywords: EWR, impact assessment, UK, water quality.
Abstract: Understanding the functioning of wetland systems is crucial in transparent and robust ecological impact assessment. English Nature, England's governmental nature conservation organization, is dedicated to using the most up-to date scientific understanding to underpin decisions on acceptable levels of impact from human activities. The current

appraisal of the impact of licensed activities, such as water abstraction, under the Birds and Habitats Directives has generated a clear framework for impact assessment and highlighted areas where current knowledge is not sufficient. The Wetland Framework Project, a joint project with the Environment Agency and the Countryside Commission for Wales, has conceptualised the water-supply mechanisms for various wetland types. It has also resulted in values for quality and quantity of water that are associated with good examples of particular wetland types. These values are translated in seasonal water quality and quantity requirements. Linking these water requirements to hydrological and hydro-geological knowledge enables transparent and robust decision-making with respect to the impacts of human activities in changes to the water-supply of wetlands.

Reference Type: Journal Article
Record Number: 193
Author: Schweiger, E.W.; Leibowitz, S.; Hyman, J.; Foster, W.; Downing, M.
Year: 2002
Title: Synoptic assessment of wetland function: a planning tool for protection of wetland species biodiversity.
Journal: Biodiversity and Conservation.
Volume: 11
Pages: 379-406
Keywords: Functional assessment, impact assessment, social importance, USA.
Abstract: We present a synoptic assessment intended to maximize the benefits to wetland species biodiversity gained through Clean Water Act regulatory efforts within 225 sub-basins in Missouri, Iowa, Nebraska and Kansas (US Environmental Protection Agency, Region 7), USA. Our assessment provides a method for prioritizing sub-basins potentially critical for supporting wetland species biodiversity and may assist environmental managers and conservationists constrained by limited resources. We prioritize sub-basins based on the projected increase in the risk of wetland species extirpation across Region 7 that would be avoided by applying a unit of regulatory protection effort within a sub-basin. Because the projected increase in risk avoided per unit effort has not been directly measured, we represent this quantity with an index of indicators drawn from readily available data. A conceptual model incorporating landscape and anthropogenic factors guides index development via a series of simple benefit-cost equations. We rank and map the final index scores to show the relative priority among sub-basins for protection effort. High priority sub-basins appear to be concentrated along the major river systems within the region, where sensitive wetland species and intensive agriculture tend to coincide. Protection of wetland species biodiversity is an important, but not exclusive, attribute around which priorities should be set. Nevertheless, incorporation of our results into management strategies should allow managers to cast their local decisions in the context of regional scale maintenance of wetland species biodiversity, increasing ecological benefits for a given protection effort.
Notes: Although not of direct relevance to the development of assessment tools, this paper does show how assessment scores can be used in the systematic prioritization of wetlands for conservation.

Reference Type: Conference Proceedings
Record Number: 194
Author: Seilheimer, T.; Chow-Fraser, P.
Year of Conference: 2003
Title: Developing the wetland Fish Index: A method for assessing the quality of Great Lakes coastal wetlands.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.

Page: 179
Address: McMaster University, Biology Dept., 1280 Main St. West, Hamilton, ON, L8S 4K1.
Keywords: Bioassessment, biotic index, fish, USA, water quality, zooplankton.
Abstract: We have developed the Wetland Fish Index (WFI) as a tool to assess wetland quality, based on the approach used to generate the Wetland Zooplankton Index (WZI) for 70 coastal wetlands in the Great Lakes basin. In this paper, we use canonical correspondence analysis (CCA) on data from 50 sites, and use another 17 to validate the index. The CCA was used to ordinate fish species along multidimensional environmental axes that accounted for the latitude of the sites, as well as the degree of anthropogenic disturbance based on physico-chemical parameters such as temperature, conductivity, pH, dissolved oxygen, and the presence of pollutants such as suspended solids and primary nutrients. The second axis, which reflected the degree of anthropogenic disturbance was used to calculate WFI parameters for fish species based on their observed 'optimum' and 'tolerance' for environmental degradation. We validate the model and show how this index compares with other indices such as the WZI and IBI in its overall effectiveness for habitat assessment.

Reference Type: Journal Article
Record Number: 195
Author: Shuman, C. S.; Ambrose, R. F.
Year: 2003
Title: A comparison of remote sensing and ground-based methods for monitoring wetland restoration success.
Journal: Restoration Ecology.
Volume: 11
Issue: 3
Pages: 325-333
Source: BiblioLine
Keywords: Monitoring, plants, restoration, USA.
Abstract: Efficient and accurate vegetation sampling techniques are essential for the assessment of wetland restoration success. Remotely acquired data, used extensively in many locations, have not been widely used to monitor restored wetlands. We compared three different vegetation sampling techniques to determine the accuracy associated with each method when used to determine species composition and cover in restored Pacific coast wetlands dominated by *Salicornia virginica* (perennial pickleweed). Two ground-based techniques, using quadrat and line intercept sampling, and a remote sensing technique, using low altitude, high resolution, colour and colour infrared photographs, were applied to estimate cover in three small restoration sites. The remote technique provided an accurate and efficient means of sampling vegetation cover, but individual species could not be identified, precluding estimates of species density and distribution. Aerial photography was determined to be an effective tool for vegetation monitoring of simple (i.e., single-species) habitat types or when species identities are not important (e.g., when vegetation is developing on a new restoration site). The efficiency associated with these vegetation sampling techniques was dependent on the scale of the assessment, with aerial photography more efficient than ground-based sampling methods for assessing large areas. However, the inability of aerial photography to identify individual species, especially mixed-species stands common in southern California salt marshes, limits its usefulness for monitoring restoration success. A combination of aerial photography and ground-based methods may be the most effective means of monitoring the success of large wetland restoration projects.

Reference Type: Journal Article
Record Number: 196
Author: Silvius, M.J.; Oneka, M.; A. Verhagen, A.

Year: 2000
Title: Wetlands: Lifeline for People at the Edge.
Journal: Physics and Chemistry of the Earth: Part B: Hydrology, Oceans and Atmosphere.
Volume: 25
Issue: 7-8
Pages: 645-652
Keywords: Functional assessment, resource economics, social importance.
Abstract: Communities with livelihood strategies that combine subsistence agriculture with utilisation of wetland resources constitute a significant proportion of the population in developing countries. Their livelihood depends to a large extent on the productivity of the natural systems, in particular wetlands that provide a great variety of functions and benefits. This includes their role as hydrological buffers and the provision of food, water, construction materials, as well as many other products. In addition, wetlands may provide options for additional developments such as tourism. Many of the amenities, functions and values of wetlands are crucial, not only for the food security of these people, but also for the survival of their cultures. To safeguard, and possibly enhance, the benefits of development for many communities who subsist on wetlands it is imperative that the benefits of the natural wetland ecosystems including their values for subsistence economies are recognised when planning and implementing development projects. Unfortunately, the importance of wetlands for these communities has been and continues to be too often ignored. While developments may bring economic prosperity or improved food security for the urban populations, often it is the poorer and marginalised people who subsist at the edge of wetlands and who are not involved the development planning that suffer from the negative environmental impacts of such developments. For many of these communities the loss of the wetlands would be tantamount to losing their lifeline. Emerging integrated wetland and water resources management approaches offer mechanisms to involve all stakeholders, to reconcile otherwise conflicting interests and to incorporate in the development plans the intrinsic natural values of wetlands. International conventions (e.g. the Ramsar Convention, Convention on Combating Desertification), and current vision building initiatives (e.g. World Water Vision) contribute to and promote the development of integrated development of policies at the international, national and local levels.
Notes: Of general interest, although no clearly defined procedures for valuing wetlands are described.

Reference Type: Conference Proceedings
Record Number: 197
Author: Simbotwe, M.P.
Year of Conference: 1992
Title: Economic value of the herpetofaunal resources in wetland areas of Zambia.
Editor: Jeffery, R.C.V.; Chabwela, H.N.V.; Howard, G; Dugan, P.J.V.
Conference Name: Managing the Wetlands of Kafue Flats and Bangweulu Basin, Proceedings of the WWF-Zambia Wetlands Project Workshop, 5-7 November 1986, Kafue National Park, Zambia.
Pages: 65-69
Keywords: Africa, amphibians, resource economics, social importance.
Abstract: The Zambezi drainage area includes the following significant wetland areas: the Kafue Flats, and the Lukanga and Busanga Swamps. This paper discusses the possibilities of exploiting economically the reptile resources of both the Bangweulu Basin and the Kafue Flats wetland areas. Emphasis is placed on the possibilities of exploiting crocodiles because they are considered to be of greater commercial value than any other reptile groups.
Notes: This paper is only of indirect interest. It describes the "pros and cons" to exploiting this resource rather than methods for valuing it.

Reference Type: Journal Article
Record Number: 198
Author: Simon, T.P.
Year: 1998
Title: Modification of an index of biotic integrity and development of reference condition expectations of dunal, palustrine wetland fish communities along the southern shore of Lake Michigan.
Journal: Aquatic Ecosystem Health and Management.
Volume: 1
Issue: 1
Pages: 49-62
Source: BiblioLine
Keywords: Bioassessment, biotic index, fish, USA.
Abstract: I modified and calibrated an index of biotic integrity (IBI) to assess wetland quality of dunal, palustrine wetlands along the southern shore of Lake Michigan. Fish communities were sampled using a combination of electrofishing and seining techniques to collect a representative sample. A combination of 50 historical and recent sites were sampled from northeast Illinois and northwest Indiana to develop reference expectations for dunal wetlands of less than 35 ha in surface area. I examined 36 attributes of wetland fish communities to derive a dunal, palustrine IBI. Several metrics from the original IBI were retained including: total number of species, number of sensitive species, and percent tolerant species. Trophic composition characters included the percentage of omnivores and insectivores. Fish condition was evaluated using the catch-per-unit of effort and the percentage of deformities, eroded fins, lesions, and tumours (DELT). Several metrics were modified from the original IBI to better reflect water resource quality in dunal wetlands. The number of darter species was replaced by a combination of the ecologically similar number of darter and madtom species; number of sunfish species was modified to the number of centrarchid species, which included the black bass species; number of sucker species was replaced by the number of minnow species since few sucker species were anticipated in dunal wetlands; and I substituted percent carnivores with percent pioneer species. Pioneer species reflect wetland stability and water permanence. Hybrids were not important constituents of wetland communities and did not show a relationship with wetland degradation, so I substituted the percentage of lake-obligate species to reflect species that were dominant in lentic waters.
Notes: This paper gives useful insight into how biotic indices need to be refined and modified to suit different wetland types.

Reference Type: Journal Article
Record Number: 199
Author: Simon, T.P.
Year: 2000
Title: The use of biological criteria as a tool for water resource management.
Journal: Environmental Science and Policy.
Volume: 3
Issue: Supplement 1
Pages: 43-49
Keywords: Bioassessment, biocriteria, monitoring, restoration, USA.
Abstract: The status of biological criteria in state and federal water quality programs suggest that the majority of North American resource types have at least a single multimetric index developed. Large rivers, wetlands, and lakes are in the process of being studied and reference conditions are being developed but have primarily been developed for the Midwest and Northeastern United States. Biological criteria can include a variety of biological indicators ranging from multimetric indices, univariate indices, standard zoological and botanical indicators, and predictive models. The use of biological models to predict local conditions can result in a variety of spatial scales that biological criteria can address. Biological criteria will

be applied as a measure of water resource condition, as biological restoration goals, for enforcement and compliance, for establishing baseline for Natural Resource Damage Assessments (NRDA), for formulating predictive models, and by the Environmental Protection Agency (EPA) for meeting the Government Performance and Results Act Goal 2b.
Notes: This paper does not consider wetland specifically but rather water resources in general. It gives a broad perspective of the current and prospective type and use of bioassessment techniques.

Reference Type: Journal Article
Record Number: 200
Author: Simon, T.P.; Jankowski, R.; Morris, C.
Year: 2000
Title: Modification of an index of biotic integrity for assessing vernal ponds and small palustrine wetlands using fish, crayfish and amphibian assemblages along Southern Lake Michigan.
Journal: Aquatic Ecosystem Health and Management.
Volume: 3
Issue: 3
Pages: 407-418
Source: BiblioLine
Keywords: Amphibians, bioassessment, biotic index, crustacea, fish, USA.
Abstract: We developed an index of biotic integrity (IBI) based on crayfish, fish, and amphibian assemblages to assess vernal ponds and palustrine wetland habitats of less than 5 ha along the southern shore of Lake Michigan. We found that the modified IBI based on three crayfish, twelve fish, and seven amphibian species collected during our surveys provided a more complete assessment than one based on any single taxonomic group. The new scoring criteria included the number of amphibian and fish species, number of benthic species, percent of individuals as pioneer species, percent of individuals as exotic species and percent of individuals with complex reproductive modes for metrics developed for larger palustrine wetlands. Low-end scoring procedures were not required; however, species composition metrics that did not possess the specified attribute received a `0' score rather than a `1'. Correlation coefficients suggest that the reference conditions developed during this study of IBI metrics are able to differentiate high-quality biological assemblages from disturbance gradients that lowered biological integrity in small palustrine wetlands and vernal ponds. We found that the distribution of the index scores for Miller Woods was skewed to the low end of biological integrity with increased distance from Lake Michigan and proximity to edges.
Notes: See also Simon 1998 for adaptation of an existing biotic index.

Reference Type: Journal Article
Record Number: 201
Author: Simon, T.P.; Stewart, P.M.; Rothrock, P.E.
Year: 2001
Title: Development of multimetric indices of biotic integrity for riverine and palustrine wetland plant communities along Southern Lake Michigan.
Journal: Aquatic Ecosystem Health and Management.
Volume: 4
Issue: 3
Pages: 293-309
Source: BiblioLine
Keywords: Bioassessment, biotic index, plants, rivers, USA.
Abstract: Riverine and palustrine wetland plant communities were examined in order to propose a multimetric plant index of biotic integrity. The objectives were to determine the structural and functional attributes of these wetland plant communities, calibrate reference

conditions in assessing aquatic plant communities, provide methods for further development and testing of the index, and present a case study. The index is based on a rapid assessment method using the information collected from a species list and cover estimates. Sampling was done using a modified releve sampling approach with a modified Braun-Blanquet Cover Abundance Scale Method for estimating percent cover. More than 20 characteristics of aquatic plant communities were evaluated and 12 metrics in five categories were developed. Structural metrics focused on community composition, key indicator species such as number of *Carex* and *Potamogeton* species, and guild type. Functional metrics included sensitivity and tolerance measures; percent emergent, pioneer, and obligate wetland species; and the number of weed species as a substitute metric. Abundance was estimated based on evenness of average cover densities. Individual condition was suggested as a measure of the lowest extremes of biotic integrity. Palustrine study sites ranged across a disturbance gradient from `least-impacted' to `poor'; riverine study sites ranged from high quality to some of the most degraded riverine sites in the Great Lakes region. Ninety-five species of aquatic vascular plants were found in 42 families. The most common families were Cyperaceae (15 species), Polygonaceae (9 species), and Juncaceae (6 species). Fourteen submergent, four floating, two woody and 75 emergent aquatic plant taxa were found. Five species were on the endangered, threatened, or rare list for the State of Indiana. Sites receiving the highest index scores included several of the *a priori* least-impacted sites while the lowest scores were located near to a large industrial landfill. The index will need to be further validated and tested but shows potential as a rapid index of biotic integrity using aquatic plant assemblages.
Notes: This is a key paper for the development of a wetland biotic index using macrophytes.

Reference Type: Conference Proceedings
Record Number: 202
Author: Simon, T.P.; Exl, J.A.; Moffett, M.F.
Year of Conference: 2001
Title: Efficacy of various sampling approaches for determining biological indicators of condition of Great Lakes coastal wetlands during a low water year.
Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 124
Address: US Fish and Wildlife Service, Bloomington Field Office, Bloomington, IN, 47403-2121.
Keywords: Bioassessment, fish, habitat, invertebrates, USA.
Abstract: A variety of sampling methods were tested to evaluate drowned-river mouth and flooded-delta coastal wetlands in Lake Michigan. Our purpose was to objectively evaluate sampling methods for determining fish and macroinvertebrate assemblage and habitat condition. Three fish procedures were tested including fyke nets and day versus night electrofishing. Macroinvertebrate assemblages were assessed using a 24-h activity trap set and sweep netting. Habitat was assessed using a riverine and lacustrine qualitative method (i.e., QHEI). The 24-h fyke net set (using size appropriate nets and two mesh sizes) and day electrofishing collected equivalent species richness at large sized wetlands (> 1, 000 acres), however was significantly different from night collections. Fyke nets were not effective in small wetlands (< 10 m in width) since water depths precluded proper set. The single best method for sampling Great Lakes drowned-river and flooded-delta wetlands during low water conditions was day electrofishing, since it had the broadest application to the coastal wetlands encountered. Sweep nets were a better estimator of invertebrate assemblage diversity and relative abundance. Habitat assessment showed that coastal wetlands were best assessed using a combination of procedures.
Notes: Useful paper because the efficacy of various sampling techniques for fish and macroinvertebrates are investigated and these results may well be relevant in South African wetlands.

Reference Type: Conference Proceedings
Record Number: 203
Author: Simon, T.P.; Carlson, D.; Dufour, R.L.
Year of Conference: 2003
Title: Development of an index of biotic integrity for coastal wetlands of Lake Ontario and the Niagara River.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 175
Address: US Fish and Wildlife Service, Bloomington Field Office, Bloomington, IN, 47403-2121.
Keywords: Bioassessment, biotic index, lakes, USA.
Abstract: An index of biotic integrity was calibrated for the open lake embayment wetlands of Lake Ontario and drowned river mouth-flooded estuary wetlands of the Niagara and St. Lawrence Rivers. Twelve metrics were selected from 35 candidate metrics based on targeted site data from about 275 embayment sites and 89 drowned river mouth wetlands. Indices were calibrated separately for each wetland type. Only a single metric was different between the Niagara and St. Lawrence Rivers. Metric selection included tests for kurtosis, range, and sensitivity. Metrics chosen for each wetland type showed changes associated with anthropogenic disturbance.
Notes: It is not clear from the abstract what biological aspects were actually measured and how.

Reference Type: Journal Article
Record Number: 204
Author: Skinner, R.; Sheldon, F.; Walker, K.F.
Year: 2001
Title: Propagules in dry wetland sediments as indicators of ecological health: effects of salinity.
Journal: Regulated Rivers: Research and Management.
Volume: 17
Pages: 191-197
Source: LexisNexis
Keywords: Australia, bioassessment, water quality.
Abstract: Indicators of ecological health are problematic for wetlands in dry regions because distinctive communities are associated with dry and wet phases of indefinite duration. The propagule bank, including the resting stages of aquatic animals and plants, maintains the community's capacity to recover from drought or disturbance. This paper records observations of invertebrates, protists and algae emerging in laboratory microcosms following the inundation of dry sediments from two temporary lakes on the River Murray floodplain in South Australia. A simple experiment carried out on the sediment from one lake showed that increased salinity was associated with lower diversity (richness) but higher abundance of emergent organisms. The effect on diversity was evident at salinities above 11-17 $mScm^{-1}$, and the effect on abundances was evident above 6-11 $mScm^{-1}$ (salinity here is indicated by electrical conductivity at 25 deg C). These data suggest that propagule banks may be useful as complementary indicators of wetland health.
Notes: 'Hatching' of propagules of invertebrates, protists and algae from dry sediments of temporary lakes as 'indicators of ecological health for dry regions'. Potentially useful for arid areas of South Africa.

Reference Type: Book Section
Record Number: 205
Author: Skourtos, M.S.; Troumbis, A.Y.; Kontogianni, A.; Langford, I.H.; Bateman, I.J.; Georgiou, S.
Year: 2003
Title: Ecological and socio-economic evaluation of wetland conservation scenarios.
Book Title: Managing wetlands: an ecological economics approach.
City: Cheltenham, UK.
Publisher: Edward Elgar Publishing.
Pages: 198-222
Keywords: European Union, resource economics, social importance.
Abstract: This paper describes in detail the analysis of the social, environmental and economic impacts of future development options in Kalloni. The Kalloni wetland complex belongs to the Prefecture of Lesvos, Greece, and is one of the most important wetland sites in the Aegean archipelago. Three main techniques were used to evaluate the management options for Kalloni Bay, these are ecological analysis performed using an ecosystem valuation model, contingent valuation survey, and focus group analysis. The findings are presented on the contingent valuation survey and focus group analysis. In the contingent valuation survey, the respondents were asked to rate the four development/conservation scenarios, while the four focus group interviews were undertaken in the summer of 1998, comprising representatives of local fishermen, building constructors, hotel owners and elected representatives of villages in the Kalloni Bay area.
Notes: Book not available in South Africa.

Reference Type: Journal Article
Record Number: 206
Author: Spencer, C.; Robertson, A.I.; Curtis, A.
Year: 1998
Title: Development and testing of a rapid appraisal wetland condition index in south-eastern Australia.
Journal: Journal of Environmental Management.
Volume: 54
Pages: 143-159
Keywords: Australia, habitat, impact assessment, plants, water quality.
Abstract: The high costs and lengthy time commitments associated with traditional monitoring, and the remoteness of many wetlands have necessitated the development of techniques for rapid wetland appraisal. A rapid appraisal condition index based on four attributes of wetlands, soil, fringing vegetation, aquatic vegetation and water quality, was developed for assessing the health of permanent floodplain wetlands in the Murray-Darling Basin of south-eastern Australia. The index, composed of 13 indicators related to wetland function, was tested in the field for scientific validity relative to an independent long-term monitoring data set, replicability of indicator scores by different investigators and the responses to the seasonality in wetland processes. Indicator values were based on a mixture of visual estimates and measurements using simple instruments or procedures and all data could be collected in the field in less than 3 h. There was a significant positive correlation between rankings of the condition of 10 wetlands based on an independent long-term monitoring data set and the wetland condition index. There were also highly significant positive correlations between indicator scores collected by different investigators. Indicator scores for physical factors and fringing vegetation did not differ between autumn and winter, but winter rainfall had a significant impact on aquatic vegetation and water quality indicators. The results indicate that the wetland condition index is a valuable and reliable tool for the rapid surveying of the condition of permanent floodplain wetlands.
Notes: A rapid assessment method - uses similar approach to Wetland-Assess (Kotze *et al.* 2004) and others in that scores are allocated (but this is much simpler). Faunal biodiversity is

not taken into account. Designed for floodplain wetlands and therefore may not be applicable to other wetland types. Possibly of use in assigning ecological importance and sensitivity scores.

Reference Type: Journal Article
Record Number: 207
Author: Stapanian, M.A.; Waite, T.A.; Krzys, G.; Mack, J.J.; Micacchion, M.
Year: 2004
Title: Rapid assessment indicator of wetland integrity as an unintended predictor of avian diversity.
Journal: Hydrobiologia.
Volume: 520
Pages: 119-126
Source: ISI Web of Science
Keywords: Bioassessment, biotic index, birds, USA.
Abstract: Rapid assessment of aquatic ecosystems has been widely implemented, sometimes without thorough evaluation of the robustness of rapid assessment metrics as indicators of ecological integrity. Here, we evaluate whether the Ohio Rapid Assessment Method (ORAM) for Wetlands Version 5.0 is a useful indicator of ecological integrity beyond its intended purpose. ORAM was developed to categorize natural wetlands for regulatory purposes and to contribute to the development of indicators of biotic integrity. It was never intended for use as an index of the quality of habitat for wetland birds. Nonetheless, it is conceivable that ORAM scores could serve as adequate predictors of avian diversity. We evaluated whether avian species richness in wetlands could be reliably predicted from each of the following variables: (1) total ORAM score, (2) total score minus the score for one metric that did not apply to all wetlands, and (3) sum of scores for the four ORAM components (of 16 scored) with the highest potential point total. These four components corresponded to aquatic vegetation communities, microtopography, modifications to natural hydrologic regime, and sources of water. All three variables were significant predictors of both total species richness and mean species richness of birds of conservation concern. Variable (3) was a significant predictor of mean species richness of wetland-dependent birds. Variable (2) was a weak predictor of both total and mean species richness of all birds combined. These results extend the robustness of ORAM as an indicator of the ecological integrity of wetlands.
Notes: Of use in the development of a wetland biotic index using birds.

Reference Type: Journal Article
Record Number: 208
Author: Stein, E.D.; Ambrose, R. F.
Year: 1998
Title: A Rapid impact assessment method for use in a regulatory context.
Journal: Wetlands.
Volume: 18
Pages: 379-392
Source: BiblioLine
Keywords: Habitat, impact assessment.
Abstract: A Rapid Impact Assessment Method (RIAM) was presented that can be used to assess impacts to aquatic resources in a manner that is scientifically defensible, yet easy to implement by regulators, planners, and resource managers. The RIAM provides a framework for assessing impacts while allowing for specialization of evaluation criteria based on the habitat type, region of interest, and specific regulatory, planning, or management goal. Site-specific impacts are assessed by comparing the conditions present at each site prior to project implementation to conditions present after implementation of the project. A set of evaluation criteria was defined to reflect the important ecological characteristics to be evaluated. Each

project site was given a pre- and post-project rating for each evaluation criterion, ranging from A for site conditions similar to those present at reference sites to E for the most degraded condition. Impact scores for each criterion, ranging from -4 to +4, were based on the difference between the pre- and post-project rating levels at each site. The application of the RIAM was demonstrated by using it to assess the impacts of projects permitted under Section 404 of the Clean Water Act on the following six evaluation criteria: endangered species habitat, structural diversity of habitat, spatial diversity of habitat, open space habitat, linear contiguity of habitat, and adjacent habitats. The method developed in this study can be used as a predictive tool to monitor impacts on an ongoing basis.
Notes: This is potentially a useful approach for testing the effectiveness of rehabilitation activities in South Africa. However, this journal is not available in South African libraries, and so the full paper could not be studied.

Reference Type: Journal Article
Record Number: 209
Author: Stein, E.D.; Tabatabai, F.**;** Ambrose, R. F.
Year: 2000
Title: Wetland mitigation banking: A Framework for crediting and debiting.
Journal: Environmental Management.
Volume: 26
Pages: 233-
Source: LexisNexis
Keywords: Impact assessment, restoration.
Abstract: Wetland mitigation banking as a resource management tool has gained popular support for its potential to provide an ecologically effective and economically efficient means to fulfill compensatory mitigation requirements for impacts to aquatic resources. Although this management tool has been actively applied within the past 10 years, assessment of credits and determination of a compensation ratio that reflects existing and/or potential functional condition in a mitigation bank has been a formidable task. This study presents a framework for a systematic approach for determination of credits and debits and subsequently the compensation ratio. A model for riparian systems is developed based on this framework that evaluates credits and debits for spatial and structural diversity, contiguity of habitats, invasive vegetation, hydrology, topographic complexity, characteristics of flood-prone areas, and biogeochemical processes. The goal of developing this crediting and debiting framework is to provide an alternative to the current methods of determining credits and debits in a mitigation bank and assigning mitigation ratios, such as best professional judgement or use of preset ratios. The purpose of this crediting and debiting framework is to develop a method that (1) can be tailored to evaluate ecological condition based on the target resources of a specific mitigation bank, (2) is flexible enough to be used for evaluation of existing or potential ecologic condition at a mitigation bank, (3) is a structured and systematic way to apply data and professional judgment to the decision-making process, (4) has an ecologically defensible basis, (5) has ease of use such that the level of expertise and time required to employ the method is not a deterrent to its application, and (6) provides a semiquantitative measure of the condition of aquatic resources that can be translated to a mitigation ratio.
Notes: Of indirect relevance to wetland assessment in South Africa

Reference Type: Journal Article
Record Number: 210
Author: Steinman, A.D.; Conklin, J.; Bohlen, P.J.; Uzarski, D.G.
Year: 2003
Title: Influence of cattle grazing and pasture land use on macroinvertebrate communities in freshwater wetlands.
Journal: Wetlands.

Volume: 23
Pages: 877-889
Source: ISI Web of Science
Keywords: Bioassessment, impact assessment, invertebrates, plants, stressor effects.
Abstract: Responses of wetland abiotic variables and aquatic invertebrate community structure to cattle stocking density, pasture type, and dominant vegetation were evaluated in subtropical pastures. Cattle were stocked at four treatment levels on improved (fertilized) and semi-native (unfertilized) pastures in south-central Florida, USA. Improved pasture wetlands were dominated either by *Panicum hemitomon* (maidencane) or by a mixture of *Polygonum spp*. (smartweed) and *Juncus effusus*; semi-native pasture wetlands were dominated mainly by maidencane. Cattle stocking density had few significant effects on water-column nutrient concentration or invertebrate community structure. However, water-column nutrient concentrations were significantly greater in the wetlands on improved pastures compared to semi-native pastures. Invertebrate richness and diversity were greater in wetlands on semi-native pastures than on improved pastures, despite lower nutrient concentrations in the former. Overall, the cattle stocking treatment had little impact on invertebrate community structure in these systems relative to prior pasture landuse. However, vegetation type influenced invertebrate communities and explained some of the differences between pasture types. Semi-native (lower nutrient) wetland pastures dominated by maidencane had significantly greater invertebrate richness and diversity than improved (higher nutrient) wetland pastures dominated by mixed vegetation but showed no difference when compared to improved wetland pastures dominated by maidencane. Chironomids were the dominant invertebrate in wetlands of both pasture types. Correspondence analysis revealed that ostracods and Culicidae larvae might be useful as bioindicators of subtropical wetlands that are experiencing cultural eutrophication.
Notes: This journal is not available in South African libraries.

Reference Type: Journal Article
Record Number: 211
Author: Stevenson, R.J.
Year: 1998
Title: Diatom indicators of stream and wetland stressors in a risk management framework.
Journal: Environmental Monitoring and Assessment.
Volume: 51
Pages: 107-118
Source: BiblioLine
Keywords: Bioassessment, biotic index, diatoms, reviews, USA.
Abstract: Developments in diatom assessment of ecological conditions in streams and wetlands are reviewed and a framework of ecological metrics (ecological attributes that respond to human influence) that can be used to quantify risk assessment and risk management options is proposed. The framework calls for use of metrics of ecosystem stressors to infer the human activities that stress ecosystems and metrics of ecosystem sustainability and restorability that relate to stressor levels, human activities, and ecosystem integrity. It provides objectives for indicator/metric development with which management decisions can be expected to better protect and restore ecosystem services.
Notes: A review of the utility and potential of periphyton, specifically diatoms, as tools in bioassessment of biotic integrity, ecosystem 'health', 'stressor effects' and ecological risk management (mostly USA)

Reference Type: Journal Article
Record Number: 212
Author: Stevenson, R.J.; Hauer, F.R.
Year: 2002

Title: Integrating Hydrogeomorphic and index of Biotic integrity approaches for environmental assessment of wetlands.
Journal: North American Benthological Society.
Volume: 21
Issue: 3
Pages: 502-513
Source: ISI Web of Science
Keywords: Bioassessment, functional assessment, management, USA.
Abstract: Wetlands are the only land type to be regulated comprehensively across both public and private lands within the United States. Two approaches to environmental assessment of wetlands have been developed, building upon experiences from a long history of aquatic ecosystem assessment. The Hydrogeomorphic (HGM) approach is a functional assessment, whereas the Index of Biotic Integrity (IBI) approach emphasizes community structure. Stevenson and Hauer conclude that these approaches are complementary and should be linked in a nationally consistent, unified framework for assessing wetlands.
Notes: This is an important paper because it discusses and compares both functional assessment and bioassessment of wetlands and how both approaches can be used to obtain a more complete understanding of ecological condition. Specific to legislation and policy in USA, but useful background information.

Reference Type: Conference Proceedings
Record Number: 213
Author: Stevenson, R.J.; Gage, S.H.; Hough, R.A.; Long, D.T.; Pijanowski, D.C.; Qi, J.; Wiley, M.J.; Bonnell, P.; Lougheed, V.L.; Riseng, C.M.
Year of Conference: 2003
Title: Integrated assessment of a Great Lakes Watershed to protect and restore valued ecological attributes.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 56
Address: Michigan State University, East Lansing, MI, 48824.
Keywords: Biocriteria, impact assessment, indicators, stressor effects, USA.
Abstract: An ecological assessment of the streams, lakes, and rivers of the Muskegon River Watershed has been initiated to develop the information necessary to protect and restore valued ecological attributes (VEAs). Quantitative, stressor-response relations are being developed between VEAs, contaminant habitat alterations, and human activities. Stressor-response relations and characterizations of near natural conditions will provide information to recommend numeric environmental criteria for indication of VEAs (usually but not always biological indicators) and contaminants. Stressor-response relation and environmental criteria are being developed for multiple groups of organisms (algae, zooplankton, benthic invertebrates, fish, plants) in streams, lakes, and wetlands to increase certainty of assessments, diagnose stressors, and to delineate multiple corresponding biological and water quality criteria along gradients of human disturbance. Multiple (tiered) criteria along human disturbance gradients enable protection of high quality waters and provide incremental targets for restoration of impaired water. Response of algae and zooplankton across ecosystem types and along nutrient gradients will be used to illustrate development of tiered criteria during this presentation.
Notes: This appears to be a potentially useful paper, but it is not clear exactly what the outputs of the project are. Possibly of use in setting sensible biocriteria for wetlands in South Africa.

Reference Type: Conference Proceedings
Record Number: 214
Author: Stewart, P.M.; Simon, T.P.
Year of Conference: 2003
Title: Comparison of ecoregion discriminative ability of macroinvertebrate assemblages in Great Lakes coastal wetlands.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003..
Page: 177
Address: Department of Biological and Environmental Sciences, Troy State University, Troy, AL, 36082
Keywords: bioassesssment, biotic index, invertebrates, lakes, USA.
Abstract: There are five ecoregions in Lake Michigan covering generally a north-south gradient. In order to adequately develop macroinvertebrate reference conditions for the Great Lakes coastal wetlands, the effect of ecoregion must be examined. Two sampling procedures were used to sample coastal wetland macroinvertebrates, D-net and activity trap sampling. This research will determine if the two sampling procedures can adequately discriminate ecoregional differences among macroinvertebrate assemblages, and will determine if one method more clearly discriminates ecoregion over the other. We expect that one method may more clearly discriminate ecoregions over the other, but that both will serve to separate ecoregions by examination of the macroinvertebrate community. Results suggest that neither sampling method clearly showed ecoregional differences among sites and that either method could be used in setting up a macroinvertebrate index of biotic integrity for Lake Michigan without regard to ecoregion.

Reference Type: Conference Proceedings
Record Number: 215
Author: Stromborg, K.L; Martin, P.A.
Year of Conference: 2003
Title: The Bald Eagle as an ecosystem health indicator: Progressing from toxic pollutants to habitat quality.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 183
Address: U.S. Fish & Wildlife Service, 2661 Scott Tower Dr., New Franken, WI, 54229.
Keywords: Bioassessment, birds, monitoring, USA.
Abstract: The bald eagle (*Haliaeetus leucocephalus*) is used as an indicator of persistent bioaccumulative chemicals in the Great Lakes because it is at the top of the trophic pyramid and was severely affected by these chemicals in the mid-twentieth century. As DDT use in North America declined in the early 1970s, bald eagle reproduction began to improve dramatically and populations on the various lakes now are increasing at varying rates. At present, the overall outlook for the Great Lakes population is positive, but several local populations seem to be recovering very slowly. In addition to its utility as a sentinel species for bioaccumulative chemicals it may be a good indicator of developmental pressures along Great Lakes shorelines because it requires relatively undeveloped habitats. The charismatic qualities of this species make it particularly useful in outreach programs. Despite all of these positive attributes, the utility of the bald eagle as an indicator is compromised by the lack of a formal monitoring structure. The informal network of scientists now in existence could disappear quickly if agency budgets are redirected.

Reference Type: Book Section
Record Number: 216
Author: Steedman, R. and Haider, W.
Year: 1993
Title: Applying notions of ecological integrity.
Editor: Woodley, S.; Kay, J.; Francis, G.
Book Title: Ecological integrity and the management of ecosystems.
City: Boca Raton, FL (USA).
Publisher: St Lucie Press.
Pages: 47-60
Source: BiblioLine
Keywords: Indicators, social importance.
Abstract: Although there are still significant differences of opinion as to the meaning and relevance of "ecological integrity" we feel however that this disagreement is largely irrelevent to the practical and beneficial application of the concept. In our opinion, lessons from applications indicate that scientific management approaches remain ill equipped to deal with socio-economic or perceptual values of aquatic ecosystems. We believe that an integrated management framework which combines the normative "scientific" aspects of ecological integrity with social perspectives on ecosystem health is desirable. The objective of this essay therefore is to outline some strengths and limitations of ecological integrity as a concept to assist monitoring and management of aquatic and terrestrial systems.
Notes: A general paper discussing ecological integrity and public perceptions. A tool (the Strategic Choice Model) is presented to help increase the understanding of public perceptions with regards to issues in natural resource management.

Reference Type: Journal Article
Record Number: 217
Author: Tamiseier, A.; Boubdoresqu, C.
Year: 1994
Title: Aquatic bird populations as possible indicators of seasonal nutrient flow at Ichkeul Lake, Tunisia.
Journal: Hydrobiologia.
Volume: 279-280
Pages: 149-156
Source: BiblioLine
Keywords: Bioassessment, birds, stressor effects.
Abstract: Lake Ichkeul is fed in autumn and winter by 7 main freshwater oueds (rivers) which create an overflow towards the Mediterranean Sea. Conversely, seawater enters the lake after the end of the rainy season. Thus, strong inverse variations occur twice a year both in water depth and salinity level, with a major hydraulic flow to the sea between October and January. Waterbirds exploit the lake (ca 50 species belonging to 13 families) with a marked seasonal variation in specific richness and diversity; in winter, population size (200,000 ducks, coots and geese) and biomass are much higher: 92.2% of the trophic impact occurs between October and March, because of both numbers and size of the wintering birds. The bird community is phytophagous for 96.2% of its annual biomass. The data, related to the hydraulic regime of the lake, support the hypothesis of an energetic input (N and P) which is mostly linked to the freshwater flow and an export brought about by migrating birds and the harvesting of fish. Nutrients would be a limiting factor for both plant and animal communities, Ichkeul being an atypic (rather oligotrophic) mediterranean lake. New dams around the lake (for drinking and irrigation water) are changing drastically this energetic balance and will lead to an important loss of the main characteristics of the lake, making Ichkeul an ordinary man-managed wetland.

Reference Type: Conference Proceedings
Record Number: 218
Author: Tawfik, M.A.A.
Year of Conference: 2004
Title: Biomarkers in fish from polluted water.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: National Research Center, Tahrir st., Dokki, Cairo, Egypt.
(adel_a_tawifik20032003@yahoo.com).
Keywords: Bioassay, fish, water quality.
Abstract: Water is occasionally exposed to different pollutants mainly microbial (viral, bacterial, parasitic, etc.) and chemical (insecticides, fertilizers, heavy metals) which cause radical changes in water quality. The present investigation is aimed at using biomarkers in fish from polluted water as means of biological assessment of water quality. Determining and evaluating alterations in the structural and biochemical components of organs of fish exposed to various pollutants represent these biomarkers. *Tilapia sp*. and *Clarias luzera* were fish of choice for experimentation. They were exposed to various doses of benzo-a-pyrine and/or cadmium chloride for several intervals. The obtained results were as follows: 1. Structural alterations were concentrated on gross changes and tissue reactions which were limited to gills, liver, spleen, gonads and kidney. They showed toxic, neoplastic and degenerative changes. Examination of gills gave information regarding acute effects and liver concerning chronic ones. Kidney and spleen showed responses to toxic and parasitic infection. 2. Parasitological evaluation indicated that pollutants not harsh enough to kill the parasites stress the host immune system and produce excess mucous secretion and epithelial growth which provoked optimal conditions for growth and reproduction of parasites that multiply asexually as monogeneans. 3. Induction of cytochrome P450 1A oxidase enzyme has been detected among fish exposed to the used pollutants. This enzyme is responsible for metabolising those compounds. Antibodies to cytochrome P450 oxidase have been isolated from fish tissue which were identified by immunohistochemical technique. These parameters could be used for biological assessment for water quality and determine the capacities of fish to adapt water pollution.

Reference Type: Personal Communication
Record Number: 219
Author: Taylor, J.C.
Year: 2002
Title: Diatom community analysis as a tool of environmental assessment in ephemeral waters.
Address: Potchefstroom University for Higher Christian Education. (Andre Vosloo DRKAV@puknet.puk.ac.za; Jonathan Taylor PLBJCT@puknet.puk.ac.za).
Keywords: Bioassessment, biotic index, diatoms, South Africa, water quality.
Abstract: The aim of this study was to establish whether meaningful information could be gained on the trophic status of wetland habitats from diatom indices developed in Europe. Although diatom species are cosmopolite it has been suggested that they may demonstrate completely different ecological requirements across continents. This was found not to be the case. The OMNIDIA database (9000 species) was used from which both ecological and autecological indices trends were established that bore a definite similarity to those established by chemical and physical analysis of the sites. Ecological spectra were demonstrated by classifying species into their preferences e.g. for nutrients, oxygen level etc. Autecological indices yielded better results than standard diversity indices. A major discrepancy noted was in the pH values generated by the indices. The extreme alkaline nature of some South African waters needs to be calculated into a pH index specific for the Southern African region. The need for autecological index correlation to find the best fit, comparison of sampling habitats and production of an identification guide specific to wetland species is highlighted.

Notes: This abstract comes from a report submitted to WRC as an addendum to a project proposal in 2002 (Taylor, J. *pers. com*. 2004).

Reference Type: Journal Article
Record Number: 220
Author: Taylor, J.C.; de la Rey, P. A.; van Rensburg, L.
Year: 2005
Title: Recommendations for the collection, preparation and enumeration of diatoms from riverine habitats for water quality monitoring in South Africa.
Journal: African Journal of Aquatic Science
Volume: *In press*
Keywords: Bioassessment, diatoms, rivers, South Africa, water quality.
Abstract: Water is most likely to be one of the limiting factors in the social and economic development of South Africa. Water has been and is being polluted from a number of activities. Monitoring water resources and water pollution has traditionally been carried out using chemical techniques but now, in addition, includes biological techniques. Diatoms have become important organisms for monitoring freshwaters and their value has been recognised for cross-border water quality monitoring in the European Union. If South Africa is to include diatoms in the current suite of bioindicator methods, then thorough testing of diatom-based techniques is required. Without adequate methodology for all stages of diatom sample analysis, from collection to the final examination of the communities, efforts to validate and test diatom-based techniques are in vain. This paper provides guidance on methodology through all stages of diatom collection, preparation and examination for the purposes of water quality assessment.

Reference Type: Journal Article
Record Number: 221
Author: Taylor, J.C.; Harding, W.R.; Archibald, C.G.M.; van Rensburg, L.
Year: 2005
Title: Diatoms as indicators of water quality in the Jukskei-Crocodile river system in 1956 and 1957, a re-analysis of diatom count data generated by BJ Cholnoky.
Journal: Water SA
Volume: *In press(April 2005 edition)*
Keywords: Bioassessment, diatoms, rivers, South Africa, water quality.
Abstract: South Africa has a long legacy of diatom research. The eminent diatomist Dr BJ Cholnoky spent much of his working life examining and enumerating diatom communities found in Southern Africa. Most if not all of Cholnoky's collected diatom material in the form of mounted material on glass slides accompanied by diatom analysis sheets is stored in the South African Diatom Collection currently housed at the CSIR in Durban. As Cholnoky only employed enumeration methods yielding a margin of error of 2% or less, Cholnoky's results should provide an accurate reflection of the structure of the diatom communities that he examined. It is the aim of the present study to demonstrate the value of these historical diatom analyses for inferring past water quality conditions using the diatom-based index method. Data for the Jukskei-Crocodile River system were obtained from the South African Diatom Collection for the period 1956/1957. The nomenclature of the diatoms listed on Cholnoky's data sheets was modernised and the data then entered into OMNIDIA v3.1. Diatom index scores generated from OMNIDIA v3.1 were in general in agreement with Cholnoky's own assessment of water quality (especially with reference to organic pollution). It is concluded that the diatom analysis records housed in the South African Diatom Collection constitute a valuable resource for the assessment of past conditions of rivers and streams.

Reference Type: Book Section
Record Number: 222
Author: Theising, M.A.
Year: 2001
Title: An evaluation of wetland assessment techniques and their applications to decision making.
Editor: Finlayson, C.M.; Davidson, N.C.; Stevenson, N.J.
Book Title: Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues. Proceedings of workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 14 November 1998. Supervising Scientist Report.
City: Darwin.
Publisher: Supervising Scientist.
Pages: 87-96
Source: DWAF (2004)
Keywords: Functional assessment, impact assessment, review.
Abstract: In the United States, wetland assessment, or the evaluation of the ecological condition and/or function of wetlands, most frequently occurs when those wetlands are proposed to be either impacted or lost as a result of development. The need to consider ecological value and function in the decision making process has led to the development of a wide variety of techniques for wetland assessment. The earliest techniques which were developed were considered to be rapid assessment procedures, which are most often used to evaluate single sites and to provide project-specific analyses. Some rapid assessment procedures, such as the Wetland Evaluation Technique (WET), which was developed by the US Army Corps of Engineers, considered broad groups of functions which included fish and wildlife habitat value, but also included flood control, groundwater recharge/discharge and value of the site for recreation and education. All of these techniques, however, are limited in their application. Most involve either qualitative results with little predictive value, or include subjective considerations based on best professional judgement. More recent techniques, such as the Hydrogeomorphic Method for Wetland Assessment (HGM) are based on peer-reviewed mechanistic models which are data-based, but which are difficult to apply and consider. All of the methods evaluated ignored macro-scale, landscape and system-level functions, which are critical for cumulative impacts assessment and for the conservation of biodiversity. More recent assessment efforts are being driven by efforts to protect watersheds as a whole, rather than the specific sites within these watersheds. As a result, more current assessment techniques evaluate populations of wetlands against identified reference wetlands in that landscape, which allows more objective comparisons of functional performance. This paper examines the most commonly used wetland assessment procedures and compares their uses for resource management, restoration and landscape-level conservation.
Notes: This is an important document because it considers conservation of wetlands at the landscape-level. See also papers by Finlayson for other documents arising from this conference.
URL: http://www.deh.gov.au/ssd/publications/ssr/161.html

Reference Type: Conference Proceedings
Record Number: 223
Author: Thoma, R.F.
Year of Conference: 2001
Title: Using fish communities and the index of biotic integrity to estimate natural resource damage.
Editor: International Association for Great Lakes Research.
Conference Name: 44th Conference on Great Lakes Research - Great Lakes Science: Making it relevant. 10-14 June 2001.
Page: 135

Address: Ohio Environmental Protection Agency, 44087, Twinsburg, OH, 44087.
Keywords: Bioassessment, biotic index, fish, USA.
Abstract: Fish communities and the Index of Biotic Integrity (IBI) have long been used by the Ohio Environmental Protection Agency (OEPA) to monitor environmental conditions. OEPA has found that fish community data at varying levels of analysis can be used to assess impacts of many forms of pollution on the environment. Habitat alterations, eutrophication, toxic chemical releases, municipal sewage releases, and exotic species introductions are some impact types that can be evaluated using fish communities. Since 1993, OEPA has taken over 1,200 fish community samples from the waters of lake Erie. These data are now being used to evaluate environmental impacts for NRDA efforts in Areas of Concern (AOC). Baseline conditions can be established using upstream and/or least impacted reference sites and degree of impact can be determined for areas affected by pollution discharges. This paper will present examples of the use of fish community data, OEPA's lake Erie IBI and its metrics to assess impacts in NRDA studies from Ohio AOCs.

Reference Type: Conference Proceedings
Record Number: 224
Author: Tockner, K.; Stanford, J.A.
Year of Conference: 2004
Title: Biocomplexity of floodplains: Defining reference conditions.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004..
Conference Location: Utrecht.
Address: Department of Limnology, EAWAG, Switzerland (klement.tockner@eawag.ch).
Keywords: Impact assessment, restoration, rivers.
Abstract: Natural floodplains are among the Earth's most distinctive landscape features covering a total area of about 2 x 10^6 km^2. In the natural state they are characterised by high biodiversity and productivity, and corresponding recreational and aesthetic values. Nowadays, floodplains are among the most endangered ecosystems. During the past decades, however, restoration activities have increased rapidly. Although a huge amount of detailed environmental knowledge has been compiled, up to 60% of all restoration projects are still ineffective. A main reason for project failure is the lack of reference data from near-pristine ecosystems, which constrains our understanding and mimicking of ecosystem processes. Therefore, our main intent is to propose reference domains that encompass the variation of different floodplain classes. We introduce the shifting habitat mosaic of semi-natural floodplains, which is composed of aquatic and terrestrial habitats and gradients that possess biotic distributions and biogeochemical cycles that change in response to fluvial processes. Further, we present guidelines on how to apply indicators for assessing floodplain ecosystems. Much emphasis will be on the parameterisation of novel indicators to assess ecosystem functions. In particular river shores are very sensitive areas for creating and maintaining biodiversity across floodplain gradients.

Reference Type: Journal Article
Record Number: 225
Author: Turner, R.K.; van den Bergh, J C.J.M.; Soderqvist, T.; Barendregt, A.; van der Straaten, J.; Maltby, E.; van Ierland, E.C.
Year: 2000
Title: Ecological-economic analysis of wetlands: scientific integration for management and policy.
Journal: Ecological Economics.
Volume: 35
Issue: 1
Pages: 7-23
Keywords: Management, resource economics, review, social importance.

Abstract: Wetlands all over the world have been lost or are threatened in spite of various international agreements and national policies. This is caused by: (1) the public nature of many wetlands products and services; (2) user externalities imposed on other stakeholders; and (3) policy intervention failures that are due to a lack of consistency among government policies in different areas (economics, environment, nature protection, physical planning, etc.). All three causes are related to information failures, which in turn can be linked to the complexity and 'invisibility' of spatial relationships among groundwater, surface water and wetland vegetation. Integrated wetland research combining social and natural sciences can help in part to solve the information failure to achieve the required consistency across various government policies. An integrated wetland research framework suggests that a combination of economic valuation, integrated modelling, stakeholder analysis, and multi-criteria evaluation can provide complementary insights into sustainable and welfare-optimizing wetland management and policy. Subsequently, each of the various components of such integrated wetland research is reviewed and related to wetland management policy.
Notes: This is a key paper for linking wetland ecology and resource economics. It avoids the use of "jargon", making the message understandable to both social scientists and ecologists. It is a useful source for economic tools that can be used to value wetlands.

Reference Type: Book
Record Number: 226
Author: Turner, R K.; van den Bergh, J.C.J.M.; Brouwer, R.
Year: 2003
Title: Managing wetlands: an ecological economics approach.
City: Cheltenham, UK.
Publisher: Edward Elgar Publishing.
ISBN: 1-84376-130-0
Keywords: Resource economics.
Abstract: This book contains an introduction and 11 major chapters addressing the critical issues surrounding environmental changes, employing a range of analytical methods drawn from a variety of disciplines connecting social and natural sciences. Introductory chapter provides the definition and losses of wetlands, as well as a framework for ecological-economic analysis and evaluation of wetlands. The ECOWET research project is also discussed. The major chapters are divided into two sections: (i) methodological issues (e.g. decision support process) and wetland ecosystem management; and (ii) case studies of ecological-economic approaches to wetland ecosystem management, focusing on the identification of conflicts concerning use, value and interest groups to be most common in the context of wetland management versus development.
Notes: Book not available in South African Libraries.

Reference Type: Report
Record Number: 227
Author: Turpie, J.
Year: 1996
Title: A preliminary economic assessment of De Hoop Nature Reserve.
Address: FitzPatrick Institute, Dept Zoology, University of Cape Town, Rondebosch 7701.; (jturpie@botzoo.uct.ac.za.).
Keywords: South Africa, social importance, resource economics.
Abstract: De Hoop Nature Reserve, a 36 000 ha provincial reserve on the Overberg coast, Western Cape is rich in natural resources. A preliminary economic assessment was made of the reserve, based on information collected during a short visit and surveys undertaken by a group of 18 participants, mainly postgraduate students. All available financial data for the 5 year period up to 1995/6 were collated and summarised. This included budget and expenditure data for the reserve, its education centre at Potberg, and expenditure by other

CapeNature departments on building maintenance and research, as well as any revenues generated. The recreational use value of the reserve was estimated using a zonal Travel-Cost analysis of existing visitor data. The non-use (existence) value of the reserve was investigated by means of a Contingency Valuation study in which over 400 people were interviewed locally and on the Cape Peninsular in order to elicit their Willingness to Pay towards continued existence of the reserve. Impacts in the form of direct expenditure in the local economy were also investigated. The reserve also provides indirect benefits to neighbouring areas, some of which also impact on the local economy. This includes wildlife which roam into adjacent property and are sold, and fish which are "exported" from the marine reserve and improve recreational fishing in adjacent coastal areas. This preliminary study demonstrates that the reserve carries a considerable value to society. Nevertheless, the reserve's efficiency in terms of resource allocation needs to be addressed, particularly with regard to balancing investment in tourism and conservation.

Reference Type: Report
Record Number: 228
Author: Turpie, J.
Year: 2000
Title: The use and value of natural resources of the Rufiji floodplain and delta, Tanzania.
Address: Report prepared for the Rufiji Environmental Management Project and IUCN-Eastern African Regional Office by Ecological and Resource Economics Consulting, FitzPatrick Institute, Dept Zoology, University of Cape Town, Rondebosch 7701; (jturpie@botzoo.uct.ac.za).
Keywords: Africa, social importance, resource economics, rural livelihoods.
Abstract: The Rufiji floodplain and delta area is rich in wildlife and plant resources, which form an important part of the livelihoods of the population, in addition to their agricultural activities. However, there is concern that the area's biodiversity is under threat from unsustainable use of these resources, necessitating a sound management plan which will maximise the value of the area without compromising its ecological integrity and conservation importance. The 720 000 ha study area was divided into three ecoregions, the floodplain area (8700 households), delta area (5093 households), and a 'transition' area between the two (2300 households), where people have access to both floodplain and delta resources. In order to estimate the direct consumptive use value of natural resources (from direct harvesting and value added), a survey was carried out in nine villages across these three ecoregions. In each village, survey methodology involved meetings with village government representatives, village mapping, focus group discussions on a range of natural resources, key informant interviews and informal discussions, and household questionnaire surveys. A total of 128 households were surveyed. The various methods aimed to ascertain the different types of natural resources used, the numbers of users, quantities of different resources used, and a number of other details needed to determine the value of natural resource use. Indirect use values could not be estimated with any accuracy in this study, but are broadly considered on the basis of available information. Value estimates were assigned to different broad habitat types in the study area, using a GIS coverage of the study area to estimate the area of different habitat types within each of the ecoregions. All quantities and values are expressed as annual values. Values are expressed as gross financial value (the total market value of production), net financial value (the total subsistence plus cash value to households net of input costs but not labour costs), cash income, and net economic value (using shadow prices and net of labour inputs).

Reference Type: Book
Record Number: 229
Author: US EPA
Year: 1998

Title: Lake and reservoir bioassessment and biocriteria. Technical Guidance Document.
City: Washington D.C. EPA-841-S-90-011.
Publisher: Office of Wetlands, Oceans, and Watersheds (4503F); Office of Science and Technology (4304); Office of Water; U.S. Environmental Protection Agency
Source: DWAF (2004)
Keywords: Bioassessment, biocriteria, lakes, review, USA.
Abstract: This technical guidance document is based on the concept that bioassessment and biocriteria programs for lakes and reservoirs are interrelated and critical components of comprehensive water resource protection and management. The United States has approximately 40 million acres of lakes, ponds, and reservoirs. For the decade following the passage of the Clean Water Act in 1972, the Nation's lake acreage that experienced a decline in water quality was four times the acreage that experienced improvement. Managing, protecting, and restoring these waterbodies has been, and will continue to be, a challenge requiring the balancing of human and environmental health concerns with economic feasibility. Our increased understanding of how lake systems function and respond to human activity has led to the recognition that environmental protection requires a holistic approach to lake management and protection. It has been necessary to expand our thinking in regard to lake monitoring approaches, incorporating biological assessments into traditional chemical and physical evaluations. In 1992, the National Research Council of the National Academy of Sciences, calling for improved assessment programs to more effectively target lake restoration efforts, recommended the following: "There is a great need for cost-effective, reliable indicators of ecosystem function, including those that will reflect long-term change and response to stress." Research on indicators should include traditional community and ecosystem measurements, paleoecological trend assessments, and remote sensing. Many natural resource agencies throughout the country have begun the process of developing and implementing biological assessment and criteria programs primarily for rivers and streams. This document is part of the effort to advance the use of these strategies with regards to lakes and reservoirs, thereby fostering the development of credible and practical bioassessment programs. The goal of this guidance is to assist in protecting the ecological integrity of the Nation's lake and reservoir resources. This guidance was developed through the experience of existing state, regional, and national lake monitoring programs. Several existing lake programs are used as case studies and examples throughout the document illustrating specific concepts or methods. The orientation of this document is toward practical decision making rather than research. It is intended to provide managers and field biologists with functional methods and approaches that will facilitate the implementation of viable lake bioassessment and biocriteria programs that meet their needs and resources. The methods, or protocols, presented here are organized in a tiered framework, ranging from trophic state surveys to more detailed bioassessment, allowing users flexibility in designing programs appropriate to their needs and resources. Procedures for program design, reference condition determination, field biosurveys, biocriteria development and data analysis are detailed. The appendices of the document include a glossary of terms, summaries of existing programs and protocols, detailed descriptions of biological assemblages, and procedures for statistical analysis of biological data.
Notes: This document is a comprehensive treatment of bioassessment in lakes. It consists of 10 chapters and 7 appendices. The chapters range from an overview of bioassessment and biocriteria, to index developmant, quality assurance and biocriteria implementation.
URL: http://www.epa.gov/owow/monitoring/tech/lakes.html

Reference Type: Book
Record Number: 230
Author: US EPA
Year: 2001
Title: Nutrients Factsheet: Methods for evaluating wetland condition.
City: EPA-822-F-01-008.

Publisher: US EPA. Office of Water.
Keywords: Bioassessment, biocriteria, USA, water quality.
Abstract: The U.S. Environmental Protection Agency (EPA) is publishing a series of modules, collectively titled "Methods for Evaluating Wetland Condition," to help states and tribes build their capacity to monitor and assess the biological and nutrient conditions of wetlands. Few states monitor wetland health or have fully incorporated wetlands into their water quality programs. These modules will provide information to state and tribal water quality managers on how to conduct ecological assessments of wetland health. The modules focus on biological and nutrient assessment techniques and can be used for the development of biological and nutrient criteria for wetlands. These modules also will serve as a basis for developing future EPA guidance for wetlands water quality.
Notes: See also Danielson 1998 (the wetland assessment "factsheets").
URL: http://www.epa.gov/waterscience/criteria/wetlands/facts.html

Reference Type: Book
Record Number: 231
Author: US EPA
Year: 2002
Title: Methods for evaluating wetland condition: Using Algae to assess environmental condition of wetlands.
City: Washington D.C.
Publisher: Office of Water, U.S. Environmental Protection Agency.
Edition: EPA-822-R-02-021.
Source: DWAF (2004)
Keywords: Algae, bioassessment, biotic index, diatoms, review, USA, water quality.
Abstract: Algae play important roles in wetland function and can be valuable indicators of biological integrity and ecological condition of wetlands. Sampling designs for algal assessment vary with objectives of programs and the algal characteristics that are measured. Both structural and functional attributes of algae can be measured, including diversity, biomass, chemical composition, plus productivity and other metabolic functions. Species composition of algae, particularly diatoms, is commonly used as an indicator of biological integrity of wetlands and the physical and chemical conditions in wetlands. These latter conditions can be inferred based on species environmental preferences and species composition of algae in wetlands. Sampling methods for algae on plants and sediments and floating in the water are well established, are reviewed in detail in another chapter of this book, and are used in streams and lakes as well. Laboratory methods are also well established for most algal characteristics with relatively standard protocols used in several national stream programs. Guidelines for data analysis are also reviewed in this chapter, which includes basic metric development and also the development and application of indices that infer physical and chemical conditions in wetlands. Case studies are presented on the development of algal indicators for Maine wetlands and use of algae to assess ecological conditions in the Everglades.
Notes: An important document for development of indices using algae or diatoms.
URL: http://www.epa.gov/waterscience/criteria/wetlands.

Reference Type: Book
Record Number: 232
Author: US EPA
Year: 2002
Title: Methods for evaluating wetland condition: Using vegetation to assess environmental conditions in wetlands.
City: Washington D.C.
Publisher: Office of Water. U.S. Environmental Protection Agency.

Edition: EPA-822-R-02-020.
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, plants, review, USA.
Abstract: Vegetation has been shown to be a sensitive measure of anthropogenic impacts to wetland ecosystems. As such it can serve as a means to evaluate best management practices, assess restoration and mitigation projects, prioritize wetland related resource management decisions, and establish aquatic life use standards for wetlands. The basic steps necessary for developing a vegetation-based wetland biological assessment and monitoring program are relatively straightforward, but their simplicity belies their effectiveness. By building upon such monitoring tools, we will be able to more fully incorporate wetlands into water quality assessment programs.
Notes: An important document for development of indices using plants.
URL: http://www.epa.gov/waterscience/criteria/wetlands/

Reference Type: Book
Record Number: 233
Author: US EPA
Year: 2002
Title: Methods for evaluating wetland condition: Developing an invertebrate Index of Biotic Integrity (IBI) for wetlands.
City: Washington D.C.
Publisher: Office of Water. U.S. Environmental Protection Agency.
Edition: EPA-822-R-02-019.
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, invertebrates, review, USA.
Abstract: The invertebrate module gives guidance for developing an aquatic invertebrate Index of Biological Integrity (IBI) for assessing the condition of wetlands. In the module, details on each phase of developing the IBI are given. First, in the planning stage, invertebrate attributes are selected, the wetland study sites are chosen, and decisions are made about which stratum of the wetland to sample and what is the optimal sampling period or periods. Then, field-sampling methods are chosen. The module describes field methods used in several States, and gives recommendations. Laboratory sampling procedures are reviewed and discussed, such as whether and how to subsample, and what taxonomic level to choose for identifications of the invertebrates. Specific categories of attributes, such as taxa richness, tolerance, feeding function, and individual health are discussed, with examples. Appendices to the invertebrate module give details about the advantages and disadvantages of using invertebrates, of the different attributes, of various field sampling methods, and of lab processing procedures as used by several State and Federal agencies. The module and appendices give a detailed example of one State's process for developing an invertebrate IBI, with a table of metrics with scoring ranges, and a table of scores of individual metrics for 27 wetlands. A glossary of terms is provided.
Notes: This is a key document for the development of a South African index using invertebrates.
URL: http://www.epa.gov/waterscience/criteria/wetlands/

Reference Type: Book
Record Number: 234
Author: US EPA
Year: 2002
Title: Methods for evaluating wetland condition: Using amphibians to assess environmental conditions in wetlands.
City: Washington D.C.
Publisher: Office of Water. W.S. Environmental Protection Agency.

Edition: EPA-822-R-02-022.
Source: DWAF (2004)
Keywords: Amphibians, bioassessment, biotic index, review, USA.
Abstract: Amphibians are important ecological components of both wetlands and dry land. Among vertebrates they are distinctive in many ways. For biological assessments, they are especially promising because of their capability of linking wetlands with surrounding landscapes. Surveying amphibians and obtaining reliable data on community characteristics may require multiple samplings of each wetland within a year because of differences in breeding and developmental phenology among species and the complex life histories of amphibians. Thus, more work may be necessary to conduct an adequate monitoring program for this assemblage than for macrophytes, fish, algae, or aquatic invertebrates. Published studies using amphibians in developing indices of biological integrity currently do not exist. However, such studies are in progress with several attributes proposed, and more can be developed from a thorough search of literature dealing with limiting factors in amphibians. Most of the specific metrics will have to be developed on a regional basis owing to differences in continent-wide distributions of amphibian species.
Notes: An important document for development of indices using amphibians.
URL: http://www.epa.gov/waterscience/criteria/wetlands

Reference Type: Book
Record Number: 235
Author: US EPA
Year: 2002
Title: Methods for evaluating wetland condition: Using birds to assess environmental conditions in wetlands.
City: Washington D.C.
Publisher: Office of Water. W.S. Environmental Protection Agency.
Edition: EPA-822-R-02-023.
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, birds, review, USA.
Abstract: Birds potentially detect aspects of wetland landscape condition that are not detected by the other groups commonly used as indicators. Moreover, birds are of high interest to a broad sector of the public. When using birds as indicators, one must pay particular attention to issues of spatial scale. This requires an understanding of home range sizes of the bird species being surveyed. The development of wetland and riparian bird indices of biological integrity is still in its infancy, but holds considerable promise.
Notes: An important document for development of indices using birds.
URL: http://www.epa.gov/waterscience/criteria/wetlands/

Reference Type: Report
Record Number: 236
Author: US EPA
Year: 2004
Title: Wetland Monitoring and Assessment Website.
City: Washington, D.C.
Institution: US Environmental Protection Agency.
Source: DWAF (2004)
Keywords: Bioassessment, biotic index, functional assessment, impact assessment, mangement, monitoring, USA.
Abstract: The mission of The National Wetland Monitoring and Assessment Work Group is to help states and tribes build their capacity to implement and sustain wetland monitoring and assessment programs that support wetland restoration and protection, through policy and guidance development, and technical and programmatic support. The goal of the workgroup

is to ensure that wetland monitoring and assessment is integrated in the state monitoring strategy along with rivers, streams, and lakes in a watershed approach to monitoring and assessment. The Work Group supports the requirements of the Clean Water Act, which calls for protection and restoration of waters of the U.S., including wetlands. Specifically, the Section 101(a) objective directs us to "restore and maintain the chemical, physical and biological integrity of the Nation's waters" and the interim goal (Section 101(b)(2)) directs us "to provide for protection and propagation of fish, shellfish, and wildlife and recreation in and on the water." Further, Section 305(b) calls for states to assess the condition of all navigable waters, including wetlands, the requirements of which are described in 40 CFR 130.8 which states that the §305(b) report must include, in part: (1) A description of the water quality of all waters of the United States and the extent to which the quality of waters provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allows recreational activities in and on the water. The Work Group is comprised of agency managers and scientists working for the USEPA, the states and tribes. A technical subcommittee operates within the informal structure of the Work Group. The Technical Subcommittee supports the science interests of the broader Work Group, including assumption of past work conducted by the Biological Assessment of Wetlands Work Group (BAWWG). The Technical Committee maintains a liaison with colleagues in other federal agencies, academia and the private sector.
Notes: A useful website to monitor.
URL: http://www.epa.gov/owow/wetlands/monitor/

Reference Type: Book
Record Number: 237
Author: US Fish and Wildlife Service.
Year: 1981
Title: Standards for the development of Habitat Suitability Index Models.
City: Washington D.C.
Publisher: Department of the Interior.
Source: DWAF (2004)
Keywords: Habitat, impact assessment, USA.
Abstract: The application of HEP will implement standardized procedures for evaluating project impacts, on both terrestrial and inland aquatic habitats, and for comparing alternative plans or projects.
URL: http://policy.fws.gov/ESMindex.html

Reference Type: Journal Article
Record Number: 238
Author: Vadas, R.G.; Garcia, L.A.; Labadie, J.W.
Year: 1995
Title: A methodology for water quantity and quality assessment for wetland development.
Journal: Water Science and Technology.
Volume: 31
Pages: 293-300
Keywords: EWR, impact assessment, water quality.
Abstract: A methodology is presented for water quantity and quality assessment for wetland development which enables planners to evaluate the results of restoring and managing a large wetland complex based on a set of criteria developed under multi-disciplinary guidelines. The methodology includes addressing temporal and spatial variability of climatic data for determination of wetland water requirements; determination of wetland evapotranspiration; determination of critical areas for wetland and agricultural development using GIS; modelling the water delivery system (quantity, quality, location, and timing) of a wetland complex using HEC-5 and WASP; and water management using the GAMS/MINOS optimization program.

The methodology is applied through the use of a Decision Support System (DSS). The goal of the DSS is to provide tools for spatial and temporal simulation for evaluation and management of a wetland system. The user has access to a common analysis environment consisting of models and data within a Graphical User Interface (GUI). Simulation and optimization modules, combined with a graphical user interface, permit efficient and convenient study of various resource management scenarios.

Reference Type: Journal Article
Record Number: 239
Author: Van Dam, R.A.; Camilleri, C.; Finlayson, C.M.
Year: 1998
Title: The potential of rapid assessment techniques as early warning indicators of wetland degradation: A review.
Journal: Environmental Toxicity and Water Quality.
Volume: 13
Issue: 4
Pages: 297-311
Source: ISI Web of Science
Keywords: Algae, bioassay, bioassessment, invertebrates, monitoring, plankton, review.
Abstract: In recent years, the need to develop assessment techniques that could provide advanced warning of significant wetland stress or degradation has been recognized. Rapid, yet realistic and reliable methods for the early detection of pollutant impacts on wetland ecosystems, particularly those in the wet-dry tropics of northern Australia, were identified. The ideal attributes of early warning indicators and their subsequent selection for wetland research are described. The potential of existing methods of assessment as early warning indicators of wetland degradation due to pollutant impacts are evaluated. Particular attention is paid to rapid assessment techniques, covering a range of trophic levels and levels of biological organization. Phytoplankton were considered to be potentially the most promising indicators of wetland degradation, and thus the scope of application of toxicity assessment and monitoring methods warrants further investigation. Rapid toxicity bioassays using invertebrates and vertebrates were also considered to be an essential part of an early detection program for wetlands, while biomarkers represented a promising tool for achieving true 'early warning' of potential pollutant impacts. Given further refinement and development, rapid methods of monitoring aquatic community assemblages were also considered potentially useful tools for the early detection of wetland degradation. Finally, to gain effective use from an early warning system for wetlands, its incorporation into an ecological risk assessment framework was recommended.
Notes: This is a key paper for consideration of rapid "early warning" indicators of pollution in wetlands.

Reference Type: Journal Article
Record Number: 240
Author: Van Eeden, P.H.
Year: 2003
Title: Towards a rapid bio-assessment method for aquatic habitats using bird fauna.
Journal: Bird Numbers.
Volume: 12
Pages: 11-14
Keywords: Bioassessment, biotic index, birds, South Africa.
Abstract: There has recently been a proliferation of techniques for the rapid bio-assessment of rivers and other aquatic habitats. In South Africa through the National River Health Programme, several indices have been developed or are in the process of being tested. This paper briefly describes the progress that has been made in South Africa with regard to the

development of the Aquatic Avian Richness Index (AARI). The AARI is being developed upon the same format as used by the SASS5 index. A score sheet with lists of appropriate bird species (that either live or frequent aquatic, or semi-aquatic habitats) has been drawn up. Total AARI scores can be calculated as well as Average Score Per Taxon. Attributes taken into account include: 1. Current conservation status, 2. Endemic, exotic or migrant status. 3. Species that are hunted. 4. Degree of abundance. 5. Degree of dependency on aquatic habitats. 6. Taxonomic uniqueness.
Notes: This paper presents preliminary developments in this biotic index.

Reference Type: Conference Proceedings
Record Number: 241
Author: Vandekerkhove, J.; Brendonck, L.; De Meester, L.
Year of Conference: 2004
Title: Biodiversity of zooplankton assessed from the dormant propagule bank.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Laboratory of Aquatic Ecology, De Beriotstraat 32, 3000 Leuven, Belgium;
(Jochen.Vandekerkhove@bio.kuleuven.ac.be; Luc.Brendonck@bio.kuleuven.ac.be;
Luc.Demeester@bio.kuleuven.ac.be).
Keywords: Bioassessment, crustacea, European Union.
Abstract: Accurate assessments of species richness are a prerequisite in many types of ecological research. For short-lived organisms, measurement error is often high as their communities tend to be highly variable in space and time. In aquatic environments, populations of a variety of short-lived organisms periodically produce large quantities of long-lived dormant propagules. Accumulations of these dormant propagules are believed to integrate to some extent the variability encountered in active communities as a result of sediment focussing and resuspension events. Within the framework of the Bioman project, we developed a standardized protocol for cladoceran species richness assessments in shallow lakes through analysis of dormant egg banks. Hatching success and rate was compared among isolated and non-isolated eggs, among eggs incubated at different temperature and photoperiod conditions, and among eggs collected at different locations within the lake. This protocol was applied to 95 European lakes and the acquired species lists were compared with lists obtained through analysis of active community samples. For lakes with a well developed egg bank, the hatching method allowed detection of 35 % more species than the traditional approach, whereas the associated effort is in nearly all cases lower. Cladoceran egg bank species richness was for almost all lakes higher, but not well correlated with the cladoceran species richness observed in the active community. We hypothesize that this is mainly due to the biased assessment of contemporary community structure inherent to snapshot active community analysis.

Reference Type: Conference Proceedings
Record Number: 242
Author: Vickery, E.; Charman, D.
Year of Conference: 2004
Title: Biomonitoring of peatland restoration using testate amoebae.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: School of Geography, University of Plymouth, Plymouth, UK.
(e.vickery@plymouth.ac.uk; d.charman@plymouth.ac.uk).
Keywords: Bioassessment, protozoa, restoration, UK.
Abstract: Peatlands in the UK have been extensively damaged over the last century by drainage, forestry and peat cutting. More recently, the conservation value of these sites has been recognised and efforts have been made to halt damaging activities and restoration work

has been carried out in many cases. Monitoring and assessing the hydrological and ecological impact of restoration works is an important part of site management. However, many bog sites in the UK are remote and repeatedly accessing the sites for hydrological monitoring can be both expensive and potentially damaging. A major aim of the project was to assess the possibility of using testate amoebae as indicator organisms for the success of restoration work. The potential advantage of this technique is to reduce the number of visits required and therefore cut costs and reduce the possibility of damaging sites through repeated access for monitoring. This project monitored the testate amoebae populations in experimental sites on three bogs across Britain, which have been damaged and have undergone recent restoration work. At Coom Rigg Moss, England, the impact of ditch blocking was assessed. Second, at Flanders Moss, Scotland, the effects of different tree removal procedures were compared. Finally, at Fenn's and Whixall Mosses on the Welsh/English border, recovery from peat extraction following restoration was monitored. Summary results of these three experiments are presented as an overall evaluation of the potential of testate amoebae for biomonitoring of restored peatlands.
Notes: See also Mitchell and Charman 2004.

Reference Type: Report
Record Number: 243
Author: Vlok, W.; van Vuren, J.H.J.; Cook, C.L.; Greenfield, R.G.; Hoare, D.; Victor, J.
Year: 2005 (*in prep*)
Title: A biophysical framework for the sustainable management of wetlands in the Limpopo Province with Nylsvley as a reference model.
City: Pretoria, South Africa.
Publisher: Water Research Commission, WRC Report no. 1258/1/05
Keywords: Amphibians, bioassessment, biotic index, fish, invertebrates, plants, South Africa.
Abstract: Nylsvley as a RAMSAR site is under threat. Recent studies have shown that the water quality is poor and that during the last ten seasons water bird numbers have shown a decline of 80-90%, and that there has been a decline in the numbers of frogs, indicating deterioration in the wetland. The Nylsvley project is proposed in an attempt to obtain a holistic perspective of the current state of the vlei area and to identify impacts that could lead to further degradation and also identify areas where restoration could be effective. The specific objectives of the project are as follows:
1. To develop draft water quality guidelines in vlei areas for key variables/parameters.
2. To develop potential biomonitoring indices specific to vlei areas.
3. To compile a draft sustainable management programme, focussing on the biophysical aspects, for Nylsvley.
4. To propose a strategic management plan for sustainable utilization of wetlands in the Waterberg region.
Current indices used in the River Health Programme (RHP) were tested for applicability as monitoring tools in Nylsvley and similar wetlands. Results obtained using SASS5 were evaluated for their suitability in wetlands. The potential of frogs for use in a biomonitoring programme was also investigated. With regard to the use of plants, it was found that the current Riparian Vegetation Index (RVI) used in the RHP is not practical and a more specific index must be developed. The Fish Assemblage Integrity Index (FAII) was also evaluated as a tool to monitor Nylsvley and similar floodplain areas. In the final chapter of this report a proposed method is presented for using the various indices from this project to obtain an overall picture of the health of wetlands.

Reference Type: Book Section
Record Number: 244
Author: Weber, P.B.
Year: 1985

Title: Wetland valuation: Policy versus perceptions.
Editor: Prince, H.H.; D'Istri, F.M.
Book Title: Coastal wetlands.
Pages: 159-174
Keywords: Resource economics, social importance.
Abstract: Traditional wetland valuation strategies have been based upon financial models expanded to frame resource economics issues. Finance-based models are credible evaluation tools for investment alternatives which possess identifiable cash flows or streams of benefit. However, their applicability to land use problems which require estimation of social value rather than private values is less than complete because of at least two shortcomings: (1) traditional financial models offer no provision for the measurement or estimation of affective, nonmonetary values attached to alternative uses; and (2) the comparison of benefit streams or returns on investment are estimates of the variable costs and returns to the parcel in use and do not reflect the land owner's perceptions of the worth of a parcel.

Reference Type: Conference Proceedings
Record Number: 245
Author: Wepener, V.; Moolman, L.; Chatiza, F.P.; Mbizi, Z.; Mlambo, S.S.; Slabert, L.; Masola, B.
Year: 2004
Title: Active biomonitoring in freshwater environments: early warning signals from biomarkers in assessing biological effects of diffuse sources of pollutants.
Conference Name: 5th WATERNET/WARFSA symposium. 2-4 November 2004.
Conference Location: Windhoek, Namibia.
Address: Department of Zoology, RAU, Auckland Park, South Africa. (vw@na.rau.ac.za).
Keywords: Bioassay, bioassessment, fish, invertebrates, South Africa.
Abstract: Since effluents are a main source of direct and continuous input of pollutants in aquatic ecosystems, the study of the effects of effluent exposure on organisms has a high ecological relevance. However, relating observed effects to specific pollutants or even classes of pollutants remains a very difficult task due to the usually unknown, complex and often highly variable composition of effluents. It is recognized that toxicants interfere with organism integrity at at the biochemical level and give rise to effects at the individual level, which in turn will become manifest in reduced ecologically relevant characteristics such as growth, reproduction and survival and ultimately at the ecosystem level. By integrating multiple endpoints at different ecologically relevant levels of organization within one test organism, it should be possible to gain understanding in how different levels of organisation within one test organism respond to toxic exposure and how responses at these different levels are interrelated. This presentation presents results from a field study in the Rietvlei Wetland system, Gauteng, South Africa using the freshwater mollusc (*Melanoides tuberculata)* and freshwater fish (*Oreochromis mossambicus*) as bioindicator organisms. Active biomonitoring exposures were conducted where organisms were exposed for more than 28 days in an effluent dominated river during high flow conditions in April 2003. The river receives effluent from a wastewater treatment plant and an industrial complex, so that up to 75% of the total flow of the stream at the confluence with another stream is effluent-based. Effects of field exposure were determined on a biochemical (using biomarkers e.g. anti-oxidant enzymes, metallothionein, DNA damage, acetylcholine esterase, lactate dehydrogenase), cellular (fish gill histopathology), physiological (Cellular Energy Allocation) and organism (condition indices) level within the same batch of test organisms. Our results clearly indicate that although the traditional mortality-based whole effluent toxicity testing did not indicate any toxicity, the *in situ* exposed organisms were stressed. A multivariate statistical approach was used to differentiate in the degree of stress response. The advantages of using active biomonitoring and biomarker responses over traditional passive biomonitoring and whole effluent toxicity testing will be discussed based on the results from this study. The application of this technique within water resource management will be addressed as well.

Notes: This could be a useful addition to monitoring of South African wetlands, providing that the ecological significance of the effects can be established.

Reference Type: Journal Article
Record Number: 246
Author: Whigham, D.F.
Year: 1999
Title: Ecological issues related to wetland preservation, restoration, creation and assessment.
Journal: Science of the Total Environment.
Volume: 240
Pages: 31-40
Source: ScienceDirect/ISI Web of Science
Keywords: Bioassessment, functional assessment, restoration, USA.
Abstract: A wide range of local, state, federal, and private programs are available to support the national (USA) policy of wetland 'No Net Loss'. Implementation of programs, however, has resulted in the continued loss of natural wetlands on the premise that restored or created wetlands will replace the functions and values lost by destruction of natural wetlands. What are the ecological implications and consequences of these programs from a biodiversity and ecosystem perspective? From a biodiversity perspective, ongoing wetland protection policies may not be working because restored or created wetlands are often very different from natural wetlands. Wetland protection policies may also be inadequate to preserve and restore ecological processes such as nutrient cycling because they mostly focus on individual wetlands and ignore the fact that wetlands are integral parts of landscapes. Wetland mitigation projects, for example, often result in the exchange of one type of wetland for another and result in a loss of wetland functions at the landscape level. The most striking weakness in the current national wetlands policy is the lack of protection for 'dry-end' wetlands that are often the focus of debate for what is and what is not a wetland. From an ecological perspective, dry-end wetlands such as isolated seasonal wetlands and riparian wetlands associated with first order streams may be the most important landscape elements. They often support a high biodiversity and they are impacted by human activities more than other types of wetlands. The failings of current wetland protection and mitigation policies are also due, in part, to the lack of ecologically sound wetland assessment methods for guiding decision making processes. The ecologically based Hydrogeomorphic (HGM) approach to wetland assessment has the potential to be an effective tool in managing biodiversity and wetland ecosystem function in support of the national 'No Net Loss' policy.
Notes: This paper gives insight into the policy of wetland mitigation in the USA and its benefits and limitations. The authors highlight the vulnerability of wetlands in arid areas.

Reference Type: Conference Proceedings
Record Number: 247
Author: Whigham, D. F.; Jacobs, A.D.; Weller, D.E.
Year of Conference: 2004
Title: Using the hydrogeomorphic approach to assess wetlands at the watershed scale.
Conference Name: Intecol 7th International Wetlands Conference. 25-30 July 2004.
Conference Location: Utrecht.
Address: Smithsonian Institution, Box 28, Edgewater, MD 21037, USA. (whighamd@si.edu; wellerd@si.edu).
Keywords: Functional assessment, habitat, impact assessment, USA.
Abstract: A number of protocols have been developed to assess the condition of wetlands, and most protocols are designed to evaluate individual wetlands. Wetland managers are also interested in characterizing the condition of wetlands at larger scales to determine where limited resources should be allocated to monitor, conserve, and restore wetland resources. We have applied the hydrogeomorphic (HGM) approach to assess the condition of wetlands at the

catchment scale. Our study was conducted in the Nanticoke River watershed of Chesapeake Bay (Maryland and Delaware, USA). We assessed the condition of wetlands in the non-tidal riverine and mineral flats subclasses, the two most abundant and widespread types of wetlands in the catchment. Sampling procedures developed by the EPA Environmental Monitoring and Assessment programs were used to select a set of assessment sites that were representative of the entire catchment. We found that the HGM functions (hydrology, biogeochemistry, habitat, vegetation, landscape) of the majority of wetlands in both HGM subclasses have been degraded from reference conditions, and there are differences in wetland conditions among the drainage subsystems in the catchment. The primary stressors were hydrologic modifications and vegetation alteration. We also developed significant multiple regression relationships that predict field-measured HGM functions from land use and stream condition maps stored in a geographic information system (GIS). These models are more suitable for estimating average condition of groups of wetlands than for assessing individual wetlands.
Notes: An important paper for assessing wetland condition at the landscape scale. The predictive capabilities of this approach need to be investigated. See also previous paper.

Reference Type: Journal Article
Record Number: 248
Author: Wilcox, D.A.
Year: 1995
Title: Wetland and aquatic macrophytes as indicators of anthropogenic hydrologic disturbance.
Journal: Natural Areas Journal.
Volume: 15
Pages: 240-248
Source: BiblioLine
Keywords: Bioassessment, impact assessment, plants, USA.
Abstract: Hydrologic disturbance can affect wetland and aquatic macrophyte communities by creating temporal changes in soil moisture or water depth. Such disturbances are natural and help maintain wetland diversity; however, anthropogenic changes in wetland hydrology may have negative effects on wetlands. Since plant communities respond to habitat alterations, observations of plant-community changes may be used to recognize effects of hydrologic disturbances that are otherwise not well understood. A number of plants, including *Typha angustifolia* (narrow-leaf cattail) and *Lythrum salicaria* (purple loosestrife), are recognized as disturbance species; they are often found in roadside ditches, in wetlands that have been partially drained, or in low areas that have been flooded. Other species commonly occur on mudflats exposed by lowering of water levels. In addition, wetland shrubs and trees invade or die as a result of draining or flooding. In more subtle terms, the relative composition of plant communities can change without the addition or loss of species, and zonation patterns may develop or change as a result of altered hydrology. Remote sensing (photointerpretation) and field vegetation studies, coupled with monitoring of water levels, are recommended for gaining an understanding of hydrologic disturbances in wetlands. Site-specific examples of macrophyte changes are examined to identify potential clues that can be used in investigations of anthropogenic hydrologic changes in natural areas. While the examples are from studies conducted in the Great Lakes Region, the concepts and methods are applicable to other regions, and are applied to a data set from Little Lake in Indiana Dunes National Lakeshore to demonstrate their use.
Notes: Useful information for development of a biotic index using plants. Journal not available in South African Libraries.

Reference Type: Conference proceedings.
Record Number: 249
Author: Wilcox, D.A.
Year: 2001
Title: Ecosystem health and wetlands of Lake Michigan.
Journal: 44th conference on Great Lakes Research. Great Lakes science: Making it relevant.
Pages: 147
Source: BiblioLine
Keywords: Bioassessment, biotic index, fish, invertebrates, plants, USA.
Abstract: Wetlands of Lake Michigan occur in several geomorphic settings that provide protection from wave energy. Included are drowned river mouths that have been flooded by rising lake levels as a result of isostatic rebound. Plant, fish, and invertebrate communities of six of these wetlands along the eastern shore of the lake were studied to develop indicators of wetland health. The results of this effort were conflicting. Some indicators might suggest that a given wetland was of high quality, while other indicators suggested that it was of poor quality. This conflict was resolved by recognizing that the types of disturbance affecting these wetlands were varied and sometimes very localized, with the responses of specific indicators tied closely to disturbance type. Thus, individual indicators may prove useful in identifying specific degradation of a wetland, but a suite of indicators may not be meaningful. In addition, the great natural variability in Lake Michigan water levels causes dramatic changes in wetland vegetation and resultant changes in habitat for fish and invertebrates. Therefore, any attempt to use indicators to define wetland quality must be tempered by assessment of natural variability that may exceed the changes caused by human disturbance.

Reference Type: Journal Article
Record Number: 250
Author: Wilcox, D.A.; Meeker, J.E.; Hudson, P. L.; Armitage, B. J.; Black, M. G.; Uzarski, D. G.
Year: 2002
Title: Hydrologic variability and the application of index of biotic integrity metrics to wetlands: a Great Lakes evaluation.
Journal: Wetlands.
Volume: 22
Issue: 3
Pages: 588-615
Source: ISI Web of Science
Keywords: Bioassessment, biotic index, fish, invertebrates, plants, USA.
Abstract: Interest by land-management and regulatory agencies in using biological indicators to detect wetland degradation, coupled with ongoing use of this approach to assess water quality in streams, led to the desire to develop and evaluate an Index of Biotic Integrity (IBI) for wetlands that could be used to categorize the level of degradation. We undertook this challenge with data from coastal wetlands of the Great Lakes, which have been degraded by a variety of human disturbances. We studied six barrier beach wetlands in western Lake Superior, six drowned-river-mouth wetlands along the eastern shore of Lake Michigan, and six open shoreline wetlands in Saginaw Bay of Lake Huron. Plant, fish, and invertebrate communities were sampled in each wetland. The resulting data were assessed in various forms against gradients of human disturbance to identify potential metrics that could be used in IBI development. Our results suggested that the metrics proposed as potential components of an IBI for barrier beach wetlands of Lake Superior held promise. The metrics for Lake Michigan drowned-river-mouth wetlands were inconsistent in identifying gradients of disturbance; those for Lake Huron open embayment wetlands were yet more inconsistent. Despite the potential displayed by the Lake Superior results within the year sampled, we concluded that an IBI for use in Great Lakes wetlands would not be valid unless separate scoring ranges were derived for each of several sequences of water-level histories. Variability

in lake levels from year to year can produce variability in data and affect the reproducibility of data collected, primarily due to extreme changes in plant communities and the faunal habitat they provide. Substantially different results could be obtained in the same wetland in different years as a result of the response to lake level change, with no change in the level of human disturbance. Additional problems included limited numbers of comparable sites, potential lack of undisturbed reference sites, and variable effects of different disturbance types. We also evaluated our conclusions with respect to hydrologic variability and other major natural disturbances affecting wetlands in other regions. We concluded that after segregation of wetland types by geographic, geomorphic, and hydrologic features, a functional IBI may be possible for wetlands with relatively stable hydrology. However, an IBI for wetlands with unpredictable yet recurring influences of climate-induced, long-term high water periods, droughts, or drought-related fires or weather-related catastrophic floods or high winds (hurricanes) would also require differing scales of measurement for years that differ in the length of time since the last major natural disturbance. A site-specific, detailed ecological analysis of biological indicators may indeed be of value in determining the quality or status of wetlands, but we recommend that IBI scores not be used unless the scoring ranges are calibrated for the specific hydrologic history pre-dating any sampling year.
Notes: This (and the previous paper) are significant because they identify potential problems in using and developing an IBI. Journal not available through South African libraries.

Reference Type: Conference Proceedings
Record Number: 251
Author: Wiley, M.J.; Seelbach, P.W.; Riseng, C.M.; Stevenson, R.J.; Pijanowski, B.C.
Year of Conference: 2003
Title: Ecological status of the Great Lakes tributary rivers of the Michigan Peninsula: A regional normalisation approach to multi-agency data sets.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003..
Page: 55
Address: School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109.
Keywords: Bioassessment, biotic index, fish, USA.
Abstract: We present a regional assessment of the status of the major Great Lakes tributary rivers of Lower Michigan based on a linear normalization of fish community data collected by several different state and university research groups. Normalization with modeled indicator reference conditions provided a statistical basis for pooling methodologically disparate data sets and for producing a region-wide assessment of tributary system status. Based on analyses to date river systems of the Huron - Erie Lake.

Reference Type: Journal Article
Record Number: 252
Author: Wilson, M. A.; Carpenter, S. R.
Year: 1999
Title: Economic valuation of freshwater ecosystem services in the United States: 1971-1997.
Journal: Ecological Applications.
Volume: 9
Issue: 3
Pages: 772-783
Keywords: Resource economics, review, USA.
Abstract: The paper provides ecologists and resource managers with a sense of where the economic science of ecosystem valuation has come from and where it might go in the future. To accomplish this, it provides a comprehensive synthesis of peer-reviewed economic data on

surface freshwater ecosystems in the USA and examines major accomplishments and gaps in the literature. Economic value has been assigned to nonmarket goods and services provided by surface freshwater systems in the USA by 30 published, refereed articles in the scientific literature from 1971 to 1997. These studies have used variations of three approaches for a quantitative assessment of economic value: travel cost methods, hedonic pricing methods, and contingent valuation methods. To determine the economic value of nonmarket ecosystem goods and services, each method focuses on a different aspect of social benefit associated with lakes, streams, rivers, and wetlands. Valuation methodologies work from different underlying assumptions while possessing unique limitations and uncertainties. Dollar benefit estimates derived for nonmarket freshwater ecosystem goods and services from these studies tend to be specific to a particular method, ecosystem, and socioeconomic circumstance. Creative interdisciplinary research is needed on the quantitative measurement of surface freshwater ecosystem goods and service values, the relation of these values to key limnological variates, and communication of limnological insights to the public and social scientists in ways that facilitate and improve future management and research.
Notes: A useful review paper.

Reference Type: Journal Article
Record Number: 253
Author: Woodward, R.T.; Wui, Yong-Suhk
Year: 2001
Title: The economic value of wetland services: a meta-analysis.
Journal: Ecological Economics.
Volume: 37
Pages: 257-270
Keywords: Resource economics, review.
Abstract: The number of studies that quantify the value of wetlands and the services provided by these ecosystems is rapidly expanding. The time is ripe for an assessment of what has been learned from this literature. Using results from 39 studies, we evaluate the relative value of different wetland services, the sources of bias in wetland valuation and the returns to scale exhibited in wetland values. While some general trends are beginning to emerge, the prediction of a wetland's value based on previous studies remains highly uncertain and the need for site-specific valuation efforts remains large.

Reference Type: Book
Record Number: 254
Author: Wyatt, J.
Year: 1993
Title: WETLAND FIX: assessment, management and rehabilitation of South African wetlands. An illustrate field guide for practical use by land agency extension services.
Keywords: Functional assessment, impact assessment, South Africa.
Abstract: This guide is in six parts, of which only the first is of direct relevance to assessment of wetland condition. It is very simply and clearly written and is suitable for managers - giving as it does practical advice. The basic wetland functions (hydrological and biological) are explained as well as the benefits to society from wetlands. A basic assessment form is given which provides "a simple method of wetland evaluation for use by land agency extension officials and others who are unfamiliar with wetlands and who are not wetland specialists". The assessment form aims to assess if wetland functioning has been significantly altered - both at the individual wetland level as well as cumulative effects at the catchment level. For each type of impact (e.g. pipelines, planted pastures, effluent disposal) the guide recommends further reading (e.g. another volume of Wetland Fix) or the relevant government authority that should be consulted.

Notes: A very useful tool for people directly involved with managing wetlands, although not particularly relevant for researchers. The "Assessment form", however is well thought-out and could form the basis of a more sophisticated approach. A fore-runner to Wetland-Assess.

Reference Type: Journal Article
Record Number: 255
Author: Xiang, Zhou Fei
Year: 2003
Title: Sustainable utilization of wetland in Lixiahe region in north Jiangsu Province.
Journal: Rural Eco-Environment.
Volume: 19
Issue: 3
Pages: 61-64
Keywords: Social importance.
Abstract: Sustainable utilization is now being considered as a leading thought and a common principle with regards to the ecological system of wetland. The environmental problem in wetland utilization has also seriously affected the equilibrium of related regional ecosystems. This paper provides a systematic pathway to find a reasonable measure for the sustainable utilization of wetlands in Lixiahe region, north Jiangsu, China. The present utilization of wetlands has resulted in some serious environmental problems in the region, including shrinkage of the area of wetland, frequent natural disasters, deterioration of the environment, serious pollution caused by production and domestic life, degradation of wetland in terms of function, decline in benefit of agricultural production and resultant decrease in farmers' production input. For keeping the equilibrium of the ecological system of wetlands, the following strategies for sustainable utilization of wetland in the study area are put forward in light of the above problems: (1) establish new indexes and standards for evaluation of sustainable utilization; (2) establish an early warning and analysis system; and (3) increase overall comprehensive social, economic and environmental benefits, based on modern wetland ecological engineering technique.
Notes: Journal not available in South African Libraries.

Reference Type: Journal Article
Record Number: 256
Author: Yoder, C.O.; Rankin, E.T.
Year: 1998
Title: The role of biological indicators in a state water quality management process.
Journal: Environmental Monitoring and Assessment.
Volume: 51
Pages: 61-88
Keywords: Bioassessment, biocriteria, management, monitoring, rivers, USA, water quality.
Abstract: State water quality agencies are custodians of water quality management programs under the Clean Water Act of which the protection and restoration of biological integrity in surface waters is an integral goal. However, an inappropriate reliance on chemical/physical stressor and exposure data or administrative indicators in place of the direct measurement of ecological response has led to an incomplete foundation for water resource management. As point sources have declined in significance, the consequences of this flawed foundation for dealing with the major limitations to biological integrity (nonpoint sources, habitat degradation) have become more apparent. The use of biocriteria in Ohio, for example, resulted in the identification of 50% more impairment than a water chemistry approach alone and other inconsistencies of a flawed monitoring foundation are illustrated in the national 305(b) report statistics on waters monitored, aquatic life use attainment, and habitat degradation. Biological criteria (biocriteria) incorporates the broader concept of water resource integrity to supplement the roles of chemical and toxicological approaches and

reduces the likelihood of making overly optimistic estimates of aquatic life condition. A carefully conceived ambient monitoring approach comprised of biological, chemical, and physical measures ensures all relevant stressors to water resource integrity are identified and that the efficacy of administrative actions can be directly measured with environmental results. New multimetric indices, such as the IBI, ICI, and BIBI represent a significant advancement in aquatic resource characterization that have allowed the inclusion of biological information into many States water quality management programs. Ohio adopted numerical biocriteria in the Ohio water quality standards regulations in May 1990 and, through multiple aquatic life uses that reflect a continuum of biological condition, represents a tiered approach to water resource management. Biocriteria provide the impetus and opportunity to recognize and account for natural, ecological variability in the environment, something which previously was been lacking in state water quality management programs. The upper Great Miami River in Ohio illustrates a case study where bioassessment data documented the efficacy of efforts to permit, fund, and construct municipal treatment systems in restoring aquatic life. In contrast, in the Mahoning River similar administrative actions were inadequate to restore aquatic life in an environment with severe sediment contamination and impacts from combined sewer overflows. A biocriteria-based goal of restoring 75% of aquatic life uses by the year 2000 in Ohio has led to the use of biological data to identify trends and forecast the status and the causes and sources of impairment to Ohio streams, an effort that should affect the strategic focus of our water resource management efforts. A biocriteria-based approach has profoundly influenced strategic planning and priority setting, water quality based permitting, water quality standards, basic monitoring and reporting, nonpoint source assessment, and problem discovery within Ohio EPA.
Notes: This paper deals with incorporation of the results of bioassessment into management to ensure more effective protection of aquatic resources. Not specifically directed towards wetlands.

Reference Type: Book Section
Record Number: 257
Author: Young, D.A.
Year: 1994
Title: Wetlands are not wastelands: A study of functions and evaluation of Canadian wetlands.
Editor: Mitsch, W.J.
Book Title: Global Wetlands: Old World and New.
Publisher: Elsevier Science.
Pages: 683-689
Keywords: Resource economics, social importance.
Abstract: Methods to evaluate wetland functions inadequately portray their true environmental and economic value. In response, a multi-year study was commissioned by the Canadian Government to demonstrate that wetlands are not wastelands. One of these studies was undertaken in the prairie pothole region. Three evaluation methodologies were employed, the first of which was used to screen important wetland functions. Relative costs and benefits of developing and conserving wetlands were examined in terms of opportunity costs of various development scenarios and willingness-to-pay to conserve wetlands. A benefit/cost analysis was then performed to identify optimal wetland use from a social perspective. Using this approach, a full range of wetland issues was explored and the study demonstrated the importance of preserving wetlands. Based on the results, a quantitative wetlands evaluation guide was developed to assist land use planners across Canada with decisions that affect wetlands.

Reference Type: Conference Proceedings
Record Number: 258
Author: Yurista, P.M.; Kelly, J.R.; Miller, S.M.
Year of Conference: 2003
Title: Zooplankton size-spectra in Great Lakes Coastal Waters.
Editor: International Association for Great Lakes Research.
Conference Name: 46th Conference on Great Lakes Research - Global threats to large lakes. 22-26 June 2003.
Page: 58
Address: U.S. EPA Mid-continent Ecology Division, 620 Congdon Blvd., Duluth, MN, 55804
Keywords: Bioassessment, biotic index, USA, zooplankton,.
Abstract: Zooplankton mean size and size-distribution are affected by planktivore pressure and potentially reflect the condition of trophic interactions and ecosystem health. We used an optical plankton counter (OPC) to survey and assess zooplankton size-spectra for twenty locations in Lakes Superior, Michigan Huron and Erie. The surveys were conducted in near-shore regions (5 m to 20 m depth) and/or associated transects to offshore regions (>8 km from shore or > 1 00 m depth). The near-shore regions were randomly chosen across a land-use stress gradient based on seven PCA axes composed of >200 parameters (GLEI Star project). The mean size and statistical distribution of zooplankton size were determined from OPC measurements for all locations. Differences in mean size and the slope and shape of size-spectra were observed between lakes. Characteristic parameters associated with spectra shape may have potential for refining zooplankton-mean-size as a metric for a biological indicator of ecosystem health.

Reference Type: Journal Article
Record Number: 259
Author: Zhang, Zheng; Zhu, Lin; Zhang, Jian Wen; Wang, Xin; Zhang, Tao; Zhu, Tong
Year: 2000
Title: Study on Ecological quality evaluation method for wetland in China.
Journal: China Environmental Science.
Volume: 20
Issue: Supplement
Pages: 55-58
Source: BiblioLine
Keywords: China, Resource economics, social importance.
Abstract: At present, there is no generally accepted standard for wetland assessment in China. In this paper, based on the theory of ecological evaluation of nature reserves, a wetland ecological assessment method suitable for national conditions is established. The method consists of the index system and value-determined standard.

Reference Type: Journal Article
Record Number: 260
Author: Zorini, L. O.; Contini, C.; Jiddawi, N.; Ochiewo, J.; Shunula, J.; Cannicci, S.
Year: 2004
Title: Participatory appraisal for potential community-based mangrove management in East Africa.
Journal: Wetlands Ecology and Management.
Volume: 12
Issue: 2
Pages: 87-102
Keywords: Africa, rural livelihoods, social importance.

Abstract: Mangroves are among the most threatened ecosystems in the world and the coastal forests of East Africa are no exception to this trend. Although conservation, rehabilitation and sustainable management plans have been developed in various tropical regions, only a few locally based approaches have been launched along the Indian Ocean coast of Africa. In order to identify possible conditions for sustainable management of mangroves based on socio-economic and ecological considerations, we present a participatory approach designed to evaluate the relationships between mangroves and human activities and the use of multi-criterion analysis to identify management solutions. To achieve this goal, all the subjects involved in mangrove management (local communities, institutions and researchers) took an active part in the process. The research was carried out in three communities relying on mangrove swamps: Kisakasaka village on the island of Zanzibar, Mida Creek in Kenya, both relying on mangrove forests known to be endangered by over-exploitation, and Inhaca Island in Mozambique, where mangroves are more pristine. Families were the hub of the research and the importance of each of their economic activities was assessed. We then examined the methods by which mangroves are exploited by the local community and by other stakeholders working in the study areas. Our results show that the mangroves in Inhaca are exploited only for household needs and the pressure on the forests is still ecologically sustainable. In contrast, there is a well-established demand for mangrove products in Kisakasaka and Mida Creek and the mangroves represent an essential source of income for the families, resulting in an ecologically unsustainable rate of exploitation. Therefore, possible alternatives to the current management practices were identified in the two areas by means of a participatory approach. Multi-criterion analysis was then used to compare and discuss the alternatives in terms of social, economic and ecological criteria.

Key words	Record numbers
Africa……..	1 2 10 13 117 150 163 197 228 260
Algae……..	9 17 18 52 151 153 161 231 239
Amphibians……	9 12 32 52 76 86 152 183 197 200 234 243
Australia…….	37 41 42 43 78 79 93 106 164 167 177 182 183 204 206
Bioassay……..…	104 152 165 167 180 186 218 239 245
Bioassessment…….	8 9 11 12 17 18 19 20 24 26 30 31 32 36 37 38 41 42 43 46 49 50 51 52 53 54 56 57 58 60 61 62 63 64 65 66 67 68 71 73 75 78 86 87 88 90 93 95 97 101 102 103 107 109 111 112 115 116 118 119 120 122 123 124 125 126 127 128 130 131 134 138 140 141 142 144 147 148 149 151 152 153 154 156 157 160 161 162 164 166 167 168 171 173 174 178 179 182 183 184 186 188 189 191 194 198 199 200 201 202 203 204 207 210 211 212 214 215 217 219 220 221 223 229 230 231 232 233 234 235 236 239 240 241 242 243 245 246 248 249 250 251 256 258
Biocriteria ……..	8 19 55 60 199 213 229 230 256
Biotic index ……...	24 32 36 43 49 50 51 52 53 54 61 62 64 67 71 86 87 88 93 95 102 103 107 116 119 122 124 128 131 140 148 151 154 164 166 173 179 181 188 189 191 194 198 200 201 203 207 211 214 219 223 231 232 233 234 235 236 240 243 249 250 251 258
Birds……	9 12 32 52 66 86 94 109 111 154 163 181 183 207 215 217 235 240
China……..	47 255 259
Crustacea…….	24 87 200 241
Diatoms……...	61 116 125 126 127 131 149 173 179 182 211 219 220 221 231
EWR……...	65 66 72 111 113 114 183 192 238
European Union…….	3 11 14 24 33 63 70 85 91 99 114 131 139 145 146 170 174 179 186 205 241
Fish…….	1 9 16 17 18 21 25 26 86 89 101 104 128 160 183 190 191 194 198 200 202 218 223 243 245 249 250 251
Functional assessment…….	2 4 5 6 7 20 27 28 29 32 34 39 54 68 69 74 85 92 98 100 105 108 110 129 130 132 145 146 159 162 169 172 185 186 193 196 212 222 236 246 247 254
Habitat…….	70 144 160 188 190 202 206 208 237 247
Impact assessment……...	3 15 23 25 37 44 45 47 59 63 65 70 74 76 79 94 98 114 121 129 130 139 144 147 154 160 170 174 176 177 180 184 185 187 190 192 193 206 208 209 210 213 222 224 236 237 238 247 248 254
Indicators…….....	22 23 28 31 46 112 113 120 131 148 154 160 168 178 183 213 216
Invertebrates……	9 12 17 18 32 36 38 41 42 43 52 60 67 73 76 86 88 93 95 96 102 103 107 122 123 124 138 154 156 160 162 164 170 174 183 184 188 190 202 210 214 233 239 243 245 249 250

EWR = Environmental water requirements.

Key Words	**Record numbers**
Lakes……..	22 23 25 26 36 45 59 63 65 66 73 84 111 127 132 143 179 191 203 214 229
Lichens……...	11
Management……..	3 14 30 33 68 75 82 83 114 137 175 212 225 236 256
Marine……	101
Microbes……	8 9 62 138 178
Monitoring……..	14 57 75 78 79 80 81 82 83 102 131 134 156 163 167 168 177 182 195 199 215 236 239 256
Mosses……...	11
Plankton……..	116 141 161 239
.	9 12 32 46 48 52 64 76 86 94 99 101 102 111 113 118 140 142 144 147 148 156 160 162 166 170 183 189 195 201 206
Plants…….....	210 232 243 248 249 250
Protozoa……..……...	62 115 157 242
Resource economics….....	1 2 6 10 13 15 16 21 35 40 69 72 77 89 91 108 117 121 132 133 135 136 137 143 146 150 159 170 172 175 176 196
	197 205 225 226 227 228 244 252 253 257 259
Restoration……..	40 48 56 69 70 74 86 100 101 140 149 155 171 185 195 199 209 224 242 246
Review……	9 15 20 37 112 119 182 211 222 225 229 231 232 233 234 235 239 252 253
Rivers……..	41 42 60 61 67 85 100 112 113 119 128 131 139 142 145 162 167 186 188 201 220 221 224 256
Rural livelihoods…….....	10 13 21 117 150 228 260
Social importance……	1 6 33 35 68 72 74 77 84 89 91 98 106 108 114 117 129 132 133 137 143 146 150 155 159 163 169 170 175 176 193
	196 197 205 216 225 227 228 244 255 257 259 260
South Africa……	61 67 68 71 72 98 113 115 118 128 129 142 144 147 172 188 219 220 221 227 240 243 245 254
Stressor effects……	8 59 76 84 96 124 154 165 210 213 217
UK……...	3 14 35 108 192 242
USA……..…	4 5 6 7 8 9 12 17 18 19 20 22 23 25 26 28 29 36 39 40 44 49 50 51 52 53 54 55 56 57 58 60 65 66 69 73 75 76 77 84 86
	88 94 96 97 100 101 102 103 109 111 116 119 122 123 125 126 134 135 140 141 143 149 151 152 153 155 156 160
	168 169 173 176 178 184 185 189 190 191 193 194 195 198 199 200 201 202 203 207 211 212 213 214 215 223 229
	230 231 232 233 234 235 236 237 246 247 248 249 250 251 252 256 258
Water quality……..…….	24 37 42 43 44 46 49 50 51 55 61 62 67 93 96 98 99 101 103 105 107 115 118 124 125 126 127 131 138 141 152 153
	161 165 170 174 178 182 191 192 194 204 206 218 219 220 221 230 231 238 256
Zooplankton……..	87 141 183 194 258