Applicant Information

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Applicant Background

Dr. Burton, of Michigan State University, and his students conducted research from 1982-1984 on plant communities and nutrient cycling in Pentwater Marsh, a Lake Michigan drowned river-mouth wetland. Dr. Burton and his students have conducted research on water quality and plant, invertebrate, and fish communities of Lake Huron wetlands since 1989. Dr. Burton's students have written five Ph.D. dissertations (V. Brady, J. Kelley, J. Gathman, S. Riffell, K. Ulrich) and four M.S. theses (V. Brady, B. Cardinale, D. Kashian, A. Vaara) on Great Lakes coastal wetland invertebrates, plants, birds, and water quality; and two more Ph.D. dissertations should be completed in 2001 (C. Stricker on response of biota to chemical gradients in Saginaw Bay and B. Keas on snail biology in northern Lake Huron marshes). Much of this research has been published or is in press in refereed journals and symposium proceedings. Dr. Uzarski , currently at Grand Valley State University, has been involved in the statistical analyses of some of these data while he was a Visiting Assistant Professor at Michigan State University. Drs. Burton and Uzarski have conducted joint research on Great Lakes coastal wetlands since 1997 and published several papers on these systems in peer reviewed journals, conference proceedings, and book chapters, and submitted another this year. They plan to publish at least three more papers on these systems next year. They developed an IBI for Lake Huron and published it in *Wetlands* in 1999. Since that time they have submitted and/or published three additional manuscripts concerning IBI development for wetlands.

Dr. Rediske has conducted sediment quality assessments (chemistry, toxicity and benthic macroinvertebrates) of drowned river-mouth lakes for the Great Lakes National Program Office. Assessments were conducted in Muskegon Lake, White Lake, and Manistee Lake in addition to the channel and wetland areas of the Grand River.

Dr. Dennis Albert has conducted extensive research on plants in Great Lakes coastal marshes with the Michigan Natural Features Inventory. He and his colleagues at MNFI have sampled plant communities along transects for over 100 wetlands around all five Great Lakes. These data have been published in peer reviewed literature, reports to funding agencies, and summaries are available in SOLEC reports and on the world wide web. Draft aquatic macrophyte IBIs have been developed on the basis of these data (Albert 1999) and will be tested as part of this proposed study. In addition, he and Dr. Burton have sampled plant communities in six northern Lake Huron wetlands quantitatively every year since 1996 over major changes in water levels. Gathman, Albert, and Burton will be submitting papers on the Lake Huron aquatic macrophyte research during 2002.

Project Title
A test of the variability and usefulness of SOLEC indicators in wetlands of Lakes Huron and Michigan.

Project Narrative/Work Plan

Introduction: Development of indicators of "ecosystem health" for the Great Lakes was recognized as a major need and was the emphasis of the State-of-the-Lakes Ecosystem Conferences (SOLEC) held in 1998 in Buffalo, New York and in 2000 in Hamilton, Ontario. Dr. Burton was selected to present the progress report for the wetland indicators task force at SOLEC 2000. Among the indicators listed by the task force at SOLEC 98 were indices of biotic integrity (IBI) based on macroinvertebrates, fish and plants.. Our progress in implementing these IBIs were presented by Dr. Burton as part of the wetlands indicators report at SOLEC 2000. Dr. Albert was a co-author of a summary report on coastal wetland ecosystems that was prepared for SOLEC 2000 (Chow-Fraser and Albert 1998).

We have developed a macroinvertebrate based bioassessment procedure for coastal wetlands in Michigan (e.g. Burton et al. 1999, Kashian and Burton 2000) and are developing such IBI's for inland forested wetlands (Doshi et al. (Submitted); also see summary report from the BAWWG web site (http://www.epa.gov/owow/wetlands/bawwg/case.html, the bioassessment wetlands working group organized by U.S. EPA). Wilcox et al. (Submitted, Dr. Uzarski is a co-author) attempted to develop wetland IBIs for the upper Great Lakes using macrophytes, fish, and microinvertebrates. Some of their metrics showed promise, but they concluded that natural water level changes were likely to alter communities and invalidate metrics. We have developed a method to adjust IBI's as water levels change for macroinvertebrates by sampling by plant community zones and basing the IBI on inundated zones, and are confident that our macroinvertebrate IBI is valid under a wide range of water levels. We are also confident that fish and plant based metrics can be adjusted over water level changes so that a viable IBI can be developed based on these taxa as well. Our ultimate goal is to develop metrics based on all three taxonomic groups and integrate metrics from all three groups into an overall IBI, and we propose to test this approach as part of the proposed research.

Minns et al. (1994) applied Karr's approach of using fish as indicators of stream biotic integrity (e.g., Karr 1981, Karr et al. 1986) to marshes of the Great Lakes' Areas of Concern. The metrics employed by Minns et al. (1994) were sensitive to impacts on ecosystem integrity by exotic fishes, water quality changes, physical habitat alteration, and changes in piscivore abundance related to fishing pressure and stocking. Even though several authors and SOLEC 1998 have suggested use of fish as indicators of wetland ecosystem health for Great Lakes coastal wetlands, no widely accepted system for wetland evaluation based on fish has been developed. The work of Brazner (1997), Brazner and Beals (1997), Minns et al. (1994) and Thoma (1999) suggests that IBI development should be relatively straight-forward. We are currently working on such a system for drowned river mouth wetlands of Lake Michigan and have sampled 8 such wetlands with fyke nets in both 2000 and 2001. We are also aware of efforts and preliminary metrics developed by Doug Wilcox and others at the Great Lakes Science Center (USGS) in Ann Arbor, Michigan, by Paul Webb and his students from the University of Michigan for northern Lake Huron coastal wetlands, and by Tom Simon and the Re-Map Program of EPA. We are also actively working to develop a fish based IBI based on unpublished data we have collected from Saginaw Bay, northern Lake Huron, and eastern Lake Michigan. We propose to collect fish data from all sites proposed below to be sampled in 2002 and combine these data with existing data collected on open lacustrine and protected embayment marshes to test the validity of proposed fish metrics, and adjust use of these metrics across these types of wetlands in Lakes Huron and Michigan.

IBIs based on aquatic macrophytes have not been widely developed. The only detailed sets of aquatic macrophyte metrics are those presently being developed for depressional wetlands in Minnesota (Gernes 1998) and Ohio (Mack et al. 2000). The aquatic-macrophyte metrics developed for depressional wetlands in Minnesota were evaluated for Great Lakes coastal wetlands by Albert (1999). Most of the proposed metrics were not appropriate for Great Lakes coastal wetlands, probably because of the very different physical environment of these large coastal wetlands. The task force on Great Lakes coastal wetlands from SOLEC 98 identified two potential metrics based on aquatic macrophytes, 1) area of wetland by type and 2) presence and areal coverage of invasive or exotic plants. We propose to calculate these metrics for open and protected lacustrine wetlands in Lakes Huron and Michigan using previously collected data where feasible. We will also collect these types of data for each wetland sampled in 2002. In addition, we think that several other plant based metrics have potential based on our previous research (Albert, unpublished report), utilizing plant coverage, water depth, and substrate data collected along transects from over 100 coastal wetlands (Minc 1997, Minc and Albert 1998) and will examine these parameters for their potential use in an IBI. In the 1997 and 1998 studies, clustering algorithms identified plant community types that were strongly correlated with different geomorphological wetland types and climatic regions. These geomorphic/climatic wetland types provide a basic framework for identifying aquatic macrophyte IBIs as well as provide insight for classification of wetlands for invertebrate sampling.

Brown bullhead (*Ameiuris nebulosus*) catfish are used as indicator species for water and sediment contamination because they have been found to be susceptible to deformities, eroded fins, lesions, and tumors (DELTs) in areas with elevated contaminant levels (Baumann et al. 1996, Sindermann 1979, and Pyron et al. 2001). This fish species, which is common to all the lower Great Lakes, is an excellent organism for monitoring environmental health effects because of its benthic and philopatric life history (Leadley et al. 1998). Brown bullheads are primarily benthic feeders consuming a wide range of aquatic organisms and will forage deep in the soft sediments in search of food, ingesting quantities of organic detritus along with prey items. As a result of this feeding behavior and a characteristic habit of remaining motionless on the bottom during periods of inactivity, these animals are thoroughly exposed to contaminated sediments by both dietary and dermal routes (Leadley et al. 1998). Direct dermal exposure to the sediment has also been found to be related to the high frequency of external lesions (Sherwood and Mearns 1979). While specific IBI metrics have not been developed to evaluate of the number of DELTs observed in a population and contaminant concentrations in sediments, the occurrence of these abnormalities in a useful indicator of ecosystem health. The collection of paired sediment chemistry and DELT frequency can provide important insight as to the significance of anthropogenic contaminants in a system. We propose to examine all fish captured during IBI sampling in 2002 for the presence of DELTs. From each wetland sampled for fish, sediment samples will be collected and analyzed for a suite of contaminants as a means of correlating numbers of DELTs with sediment chemistry across all sites sampled for fish. These data should provide insight into usefulness of this approach in open lacustrine and protected embayment wetlands.

We plan to disseminate this information in several ways. For example, in cooperation with MDEQ, we organized a workshop in December 1998 and again in 2001 for researchers and managers from academic, federal, and state agencies interested in IBI development and utilization for the Great Lakes region. We plan to organize an additional workshop on IBI development for wetlands in cooperation with MDEQ within the next two years. We also presented our IBI at several scientific societies and at meetings of wetlands managers (e.g. Association of State Wetlands Managers meeting, MDEQ Land and Water Management training session in Mt. Pleasant MI in March of 2001). Further, in cooperation with The Nature Conservancy (TNC), we developed a simplified version of the IBI for use by citizen volunteers and plan to continue to work with TNC staff to train volunteers from the Les Cheneaux Islands area of northern Lake Huron in use of the IBI. Drs. Uzarski and Burton are currently members of the Biological Assessment of Wetlands Work Group (BAWWG). The work group is made up of members from across the USA involved in developing wetland bioassessment procedures. Information about members and their projects can be found at http://www.epa.gov/owow/wetlands/bawwg/case.html. While we plan to publish results in peer reviewed scientific journals, the purpose of our work is to provide management agencies with a risk assessment tool. Therefore, we will continue to work with interested agencies directly. Our goal is to ensure that the IBIs we develop are implemented.

General Approach: We developed and published a preliminary invertebrate index of biotic integrity (Invertebrate IBI) based on samples taken from 11 Lake Huron wetlands in 1997 and 1998 (Burton et al. 1999). We did not subdivide lacustrine wetlands into open and protected embayment wetlands as called for in the RFP. While such subdivision might make sense ecologically, we have assumed that a broader based IBI would be of more interest to management agencies, since personnel would have to learn fewer sub-system IBI's. We can certainly segregate our wetlands into these sub-categories, and use existing data to test whether IBI precision would be enhanced by this subdivision or not. We have continued to fine-tune the Lake Huron IBI (Burton et al. 1999) with additional samples taken in 1999, 2000 and 2001 from some of the same wetlands and from additional sites as lake levels have declined from above average levels in 1998 to levels approaching historical lows in 2001. With relatively minor changes, which we plan to publish soon, we are confident that our invertebrate IBI will work for Lake Huron protected and open embayment wetlands across conditions from the low to above average lake levels that have occurred over this time period. Our hypothesis is that the IBI will also work for these same types of wetlands in Lake Michigan. We sampled 6 wetlands along Lake Michigan's northern shoreline in 2001 in order to test this hypothesis and plan to test our hypothesis prior to the start of the 2002 sampling season. If this hypothesis proves to be correct, we can extend the invertebrate IBI and use it for both Lakes Michigan and Huron. These 6 Lake Michigan wetlands plus the 16 Lake Huron wetlands we have sampled provide a reference data base for 22 wetlands on which to base our proposal with several of these wetlands having been sampled annually since 1997.

We are also working to develop a fish based IBI for these types of wetlands with a grant from the Michigan Great Lakes Protection Fund and using data collected as part of fish habitat research funded by the Great Lakes Fishery Commission and earlier in Saginaw Bay with grants from the U.S. Geological Survey and the Michigan Department of Natural Resources. We sampled fish from 10 open lacustrine and protected embayment wetlands (5 each in Lakes Michigan and Huron) in 2001 in support of this goal and plan to analyze these and earlier collected data and use them to develop a preliminary fish based IBI before the start of the 2002 field season. We have also sampled invertebrates and fish from 9 drowned river-mouth wetlands in Lake Michigan with 8 of these wetlands sampled in both 2000 and 2001. We plan to develop both invertebrate and fish-based IBI's for drowned river mouth wetlands before the start of the 2002 field season as well and will have these data for comparison with data collected from open lacustrine and protected embayment wetlands.

We also have an extensive data base on wetland plants for Lakes Huron and Michigan open lacustrine and protected embayment wetlands. Dr. Albert and his colleagues sampled 30 sites on these two lakes in the late 1980's (23 in Lake Huron, 7 in Lake Michigan- see lists of lacustrine wetlands in Chow-Fraser and Albert (1998) and the summary of this research by Minc and Albert posted at http://www.epa.gov.glnpo/ecopage/wetland/glc/glctext.html), and these data are available to us. In addition, Drs. Albert, Burton, and Uzarski have quantitatively sampled plant communities along permanent transects in six of the northern Lake Huron wetlands used in developing the invertebrate IBI's every year since 1996, and these data provide extensive documentation of changes that have occurred as lake levels changed from above average lake levels to the low lake levels today. Anne Vaara, a M.S. student with Dr. Burton, also quantitatively sampled plant communities along six transects in 1995 and 1996 for two Saginaw Bay wetlands used in IBI development and documented changes that occurred as lake levels dropped over this two year period. Thus, we have extensive quantitative plant data available for 8 wetlands that have also been sampled for invertebrates and fish. We have less detailed data on these and more than 22 other wetlands collected in the late 1980s by the Michigan Natural Features Inventory. This existing data base on Lake Huron and Michigan wetlands will be useful in testing many of the SOLEC flora and fauna indicators (4501, 4502, 4503, 4513) over changes that have occurred from above average to very low lake levels.

In our opinion, the most productive way for us to proceed with developing wetland indicators involves three approaches. These three approaches or tasks include: (1) sampling 10 randomly selected wetlands in Lakes Huron and Michigan (5 each of open lacustrine and protected embayment) for all the flora and fauna indicators listed in

Table 1 of the RFP following procedures already developed and/or agreed on with the PMT and other investigators funded through this RFP. We chose to work in Lakes Huron and Michigan for logistical reasons and because these lakes contain the most wetlands of the types listed in the RFP (see Table 1 of this proposal), (2) development of as many of the SOLEC indicators as can be calculated from existing data bases and/or from aerial photographs and other data sources for the 10 wetlands already sampled for fish and/or the 22 wetlands sampled for invertebrates in Lakes Huron and Michigan with selected sampling to accomplish the goal of back calculating all indicators possible for these wetlands, and (3) paired wetland and/or gradient sampling of changes in flora and fauna that occur downstream from different types of pollutants to link indicator response to specific types of pollution. We propose to emphasize tasks one and three in 2002 while accomplishing as much of task two as possible.

Table 1. Protected and Open Embayments of the Great Lakes: Protected and open embayments are concentrated in several parts of the Great Lakes. Other Great Lakes areas may have wetlands, but these are different in character . The following section summarizes where these wetland types are concentrated:

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1. *Lake Huron – Les Cheneaux Islands*. This area is one of the largest concentrations of protected and open embayments in the Great Lakes. Most of its wetlands have been sampled for aquatic plants as part of state-wide and Great Lakes-wide sampling efforts (Albert etal. 1987, 1988, 1989; Minc 1997, 1998, Minc and Albert 1998, Chow-Fraser and Albert 1998). Several have also been more intensively sampled with Dr. Thomas Burton and his students for plants, fish, and invertebrates.
2. *Lake Huron – Saginaw Bay*. This area also contains several protected and open embayments, including sand-spit embayments. Plant sampling has been conducted by D. Albert (Albert etal. 1987, 1988, 1989; Minc 1997, 1998, Minc and Albert 1998, Chow-Fraser and Albert 1998), while Dr. Burton and his students have sampled fish, invertebrates, and some water chemistry variables as well. Most of these wetlands are modified by input of agricultural runoff and/or urban centers, while several wetlands in the Wildfowl Bay Island group have been less influenced by these.
3. *Northern Lake Michigan*. This area, consisting of both Michigan's north shore of Lake Michigan and Green Bay, contains several open embayments, with some protected sand-spit embayments on Green Bay. Most of the protected embayments have been heavily modified by agricultural and urban runoff, while most of the open embayments have been less modified.
4. *Western Lake Erie*. Sand spit embayments and other protected wetlands occur at the western end of Lake Erie, where all have been heavily impacted by either urban or agricultural runoff. Most of these wetlands occur in Michigan, but there are also several diked wetlands in Ohio. The Erie Islands, north of Sandusky, offer a group of small, protected embayments which have been much less degraded by human activities. Plant sampling has been conducted in most of the wetlands, with the exception of the Erie Islands (Albert etal. 1988, 1989; Minc 1997, 1998, Minc and Albert 1998, Chow-Fraser and Albert 1998). Albert has done no plant sampling of the Erie Islands, but there are researchers from U of Ohio's biological station who

could either cooperate with sampling or provide locations for Albert to sample wetland plants.

5. *Eastern Lake Ontario*. Several islands in eastern Lake Ontario contain protected and open embayments, including Prince Edward Island and Wolfe Island. Plant sampling has been conducted by D. Albert, along with students of Pat Chow-Fraser on several marshes, including Hay and Presqu'isle Bays on Prince Edward Island, as well as another small embayment of Wolfe Island. The same wetlands were sampled for fish, invertebrates, water chemistry, and algae by Chow-Fraser's students. This sampling is not identical to that being done by Dr. Burton's students, but may be comparable. Wetlands may be identified with different levels of human impact for the purpose of testing IBIs. We have an agreement to work with Joel Ingram (Wetlands Monitoring Biologist, Canadian Wildlife Service, Environment Canada, Ontario Region, 4905 Dufferin Street, Downsview, ON M3H 5T4). Ingram and his technicians and colleagues have agreed to use our sampling protocol or the one that the PMT agrees upon to collect invertebrate samples. We will then process these samples along with those that we collect.
6. *Lake Erie sandspit-embayments*. While central and eastern Lake Erie has no major concentration of protected embayments, there are several sand-spit embayments, including those at Pt. Pelee and Long Point, Ontario and Presque Isle Pennsylvania. These may provide a gradient of nutrient enrichment. We propose to work with Steve Timmerman on more extensive sampling in this area. Sampling of plants, invertebrates, fish, water quality, and algae have been conducted by D. Albert or students of Chow-Fraser. This sampling may be compatible with data collected by Dr. Burton and his students.

There are extensive protected embayments along both the St. Marys and St. Lawrence Rivers, but these are excluded from the proposed G.L. Consortium RFP. We are not proposing to sample Lake Superior wetlands, as open and protected wetlands along the Lake Superior shoreline are few, and those identified and sampled in previous research were small (Albert 1987, Minc 1997).

TASK 1: The first task will be to test the invertebrate and fish IBI's using randomly selected open lacustrine and protected embayment wetlands selected from the U.S.A. shoreline of Lake Huron and the northern shoreline of Lake Michigan. We will list all potential sites using lists compiled in Chow-Fraser and Albert (1998) and/or open lacustrine and protected embayment sites listed by Herdendorf et al. (1981a-f) that are easily accessible (wetlands too far from an access point will be eliminated from consideration). Since many small lacustrine wetlands are no longer inundated, we will make site visits to all potential sites in June 2002 to determine which sites still have inundated wetlands present. We will randomly select the 10 sites to be sampled from the list of inundated, accessible sites that remain. We expect to have a list of more than 30 sites to choose from in this selection process. We have included a description of our IBI development methodologies below. Sample collection will follow these procedures and/or those agreed on with the PMT and other investigators funded through this RFP.

We plan to coordinate our research with Joel Ingram of EC. Joel and his collegues will sample plants and invertebrates in 10 wetlands on the Canadian side of Lake Huron. We will process the invertebrate samples in our laboratory and include these data in testing and development of our IBI for these two lakes.

Description of Our IBI Development Methodologies Used from 1997-Present

Wetland Classification - Wetlands of the Great Lakes were classified into geomorphological classes that reflect location in the landscape and exposure to waves, storm surges and lake level changes. We will continue to develop indicators from biological attributes unique to each class for each lake and/or ecoregion. However, those metrics that can extend across classes, lakes, and ecoregions will be deemed most robust and weighted the heaviest, since our goal is to keep the number of IBI's required to cover all five lakes to a minimum.

Open (lacustrine) wetlands may have to be subdivided or analyzed along a continuum of exposure to wind and waves (Burton et al. 2001). These wetlands form along bays and coves and leeward of islands or peninsulas. The more open the shoreline, the more energy the wetland is exposed to from waves and storm surges until a threshold is reached where wetlands can no longer persist. Our initial faunal research in Lake Huron suggests that a system can be developed that applies to all lacustrine wetlands despite the natural exposure gradient. The location of the shoreline with respect to longshore current and wind fetch determine the type of wetland found along the shoreline (Burton et al. 2001), and there are marked differences in the preponderance of wetland types from Great Lake to Great Lake that will be considered during development of indicators.

Great-Lakes wide studies of aquatic macrophytes indicate that similar geomorphic wetland types support distinctively different plant assemblages in geographically distinct ecoregions (Minc 1997, Minc and Albert 1998, Chow-Fraser and Albert 1998). Since our macroinvertebrate IBI is based on sampling all existing plant zones, we may need to refine or adjust our IBI based on plant community distribution. Further resolution of classification will be defined within the IBI by including metrics to be used only under specific circumstances. For example, a suite of metrics will be developed for use in wave swept zones of unprotected coastal wetlands, and these metrics may or may not vary from those to be used where dense vegetation or a peninsula dampens direct wave action in the same class of wetlands.

Chemical and Physical Measurements -Basic chemical/physical parameters will be sampled each time biological samples are taken. Analytical procedures will follow procedures recommended in Standard Methods for the Examination of Water and Wastewater (APHA 1985). These measurements will include soluble reactive phosphorus (SRP), nitrate-N, nitrite-N, ammonium-N, turbidity, alkalinity, temperature, DO, chlorophyll a, redox potential, and specific conductance. Quality assurance/quality control procedures will follow protocols recommended by U.S. EPA.

Sediment Sampling (Contamninants) and DELTs - Unconsolidated sediments will be sampled with a petite Ponar dredge (Downing 1984) and transferred to 4 L glass jars. Up to five samples per vegetative zone will be collected from each wetland. The discrete samples will be composited in the laboratory for analysis. If any of the composite samples exceed the Threshold Effect Level (MacDonald et al 2000), the individual samples will be analyzed to determine the spatial distribution of the contaminants. Pearson's Correlation will be used to explore relationships between contaminants and DELTs.

Sediments will be analyzed for heavy metals (arsenic, cadmium, lead, chromium, mercury, and copper), polychlorinated byphenyls, DDT homologs, PAH compounds, Total Organic Carbon, grain size distribution, and ammonia by USEPA (1996) methods.

Determination of Anthropogenic Disturbance - Wetlands that experience a wide range of anthropogenic stressors will be chosen from each class or subclass. The extent of disturbance will be determined using surrounding land use data in conjunction with limnological data and site-specific observations of evidence of dredging, point-source pollution, etc. The extent to which land use impacts a given wetland will depend on the wetland classification. For example, land use from upper areas of a watershed are important in determining anthropogenic disturbance to a riverine or estuarine wetland, whereas only local conditions may be important for a coastal or barrier beach wetland.

Land use data will be obtained from existing digitized maps, topographic maps, and personal observations. These data will include such basic parameters as: percent urban and agricultural area, number of adjacent dwellings, percent impervious surface, and number of connecting drainage ditches.

Macroinvertebrates sampling - Macroinvertebrate samples will be collected with standard 0.5 mm mesh, D-frame dip nets from late July through August. Samples taken from ice-out through mid-July generally contain less diversity and a greater proportion of early instars of aquatic insects, making identification very difficult. The July-August time period corresponds to the time when emergent plant communities achieve maximum annual biomass.

Macroinvertebrates will be sampled in all major plant zones at each site, including an emergent zone and a wet meadow zone if present and inundated. If certain depths contain more than one dominant plant species or plant association, invertebrates will be sampled in each.

Dip net sampling entails sweeps through the water at the surface and middle of the water column and above the sediment surface to ensure that an array of microhabitats are included. In the field, samples will be placed in grided white enamel pans, and 150 invertebrates will be collected by picking all specimens from one area of the grid before moving on to the next grid area until 150 invertebrates are sampled. Special consideration will be made to ensure that smaller organisms are not missed, as there is a bias towards larger, more mobile individuals using this technique. Plant detritus will be sorted for a few additional minutes to ensure that sessile species are included in the sample. As a means of semi-quantifying samples, picking of specimens will be timed. Individual replicates will be picked for one-half -person-hour, after which, if 150 specimens have not been obtained, organisms will be tallied and picking will continue to the next multiple of 50. Three replicate samples will be collected within each plant community zone in order to obtain a measure of variance associated with sampling.

Specimens will be sorted to lowest operational taxonomic unit; usually genus or species. Taxonomic keys such as Thorp and Covich (1991) and Merritt and Cummins (1996), along with mainstream literature for species level, will be used for identification. Accuracy will be confirmed by expert taxonomists when possible. (*Please Note: We will* *also include additional sampling methods, if necessary, once standard protocols are determined.*)

Fish sampling - Fish sampling will be conducted with six fyke nets with 12.5 mm or smaller mesh nets and with six 'minnow' or smaller fish traps being fished in each vegetation zone for 24-48 hrs. Two sizes of fyke nets will be used, 0.5 m x 1.0 m and 1.0 m x 1.0 m. Smaller nets will be set in water approximately 0.25 m deep to 0.75 m, the larger nets will be set in water depths greater than 0.75 cm. Nets are set adjacent to vegetation zones of interest with leads extending into the vegetation. Small fish or 'minnow traps' will be placed in the vegetation itself. The occurrence of DELTs will be noted. (*Please Note: We will also include additional sampling methods, if necessary, once standard protocols are determined.*)

Plant Sampling –Past plant sampling was conducted along transects, with several samples taken in each vegetation zone (Albert etal. 1987, 1988, 1989, Minc 1997, Minc and Albert 1998). Water depth and substrate were also described for each sampling point. These data were then analyzed to develop a regional classification of wetland veetation types (Minc 1997, Minc and Albert 1998, Chow-Fraser and Albert 1998). These data were then utilized, along with a review of aquatic macrophyte literature, to develop proposed IBIs for aquatic macrophytes (Albert 1999).

In the proposed aquatic macrophyte sampling, the focus will be on evaluation of the proposed aquatic macrophyte IBIs. Five randomly located samples will be taken from each vegetation zone. Percent cover will be estimated for each plant species within the sample plots and substrate, water depth, and water clarity (using secchi disk) will be recorded.

Aquatic-macrophyte data will be summarized and proposed IBIs will be evaluated for effectiveness in identifying gradients of human disturbance. The environmental gradients that will be evaluated will include amount of urgan and industrial development, nutrient enrichment, and water clarity.

Matching funds will also be sought to include aquatic-macrophyte community analysis and aquatic-macrophyte tissue analysis along a nutrient-enrichment gradient associated with a sewage outflow from Pearson Creek in Cedarville Bay in northern Lake Huron. Sampling at Pearson Creek will be paired with nearby streams in Hessel or Prentiss Bays, where no sewage outflow is present. Study of this nutrient-enrichment gradient provides a unique opportunity, as nutrient and sediment enrichment is low enough to not be confounded with high turbidity, yet high enough to cause a response in aquatic-macrophyte community structure and composition. Sediment analyses ares already being proposed as part of this research proposal.

Identify and combine metrics into an IBI - Initially, correspondence analyses of invertebrate and fish community composition will be used to determine if reference sites separate from impacted sites. When they do, individual taxa containing the most inertia responsible for the separation will be deemed potential metrics. Mann-Whitney U tests will then be used to determine if densities of these taxa at reference sites are significantly different from densities at impacted sites.

Attributes that show an empirical and predictable change across a gradient of human disturbance will be chosen as metrics to be included in a multi-metric IBI. Regression analysis will also be used to link state with stressor by relating potential metrics to specific parameters impacted by anthropogenic disturbance. Finally, stressor-land use relationships will be explored to aid in management decisions. Since N is likely to be low for any one regression analysis within a single classification, data will be graphically analyzed by constructing box plots including the 10th, 25th, 50th, 75th, and 90th percentiles. These will also be used to detect differences among wetlands with respect to individual metrics. The variance of each metric will be used to predict the robustness and the resolution that can be obtained using a given metric. The resolution obtained from a given metric will be established by the amount of interquartile overlap of box plots between impacted and unimpacted sites (Barbour et al. 1996). Metrics with no overlap of interquartile range will be considered to have very high resolution, while those with considerable overlap will be considered to have very low or no resolving power. Also, a metric that distinguishes between two sites with relatively similar exposure to anthropogenic disturbance will have high resolution.

We plan to use medians in place of means for measuring assemblages of invertebrates, since invertebrate parameters are expected to be highly variable. Medians are more resistant to effects of outliers. Our goal is to typify the wetland. If an area is sampled that is depleted or concentrated in the constituents of a metric, the area may be isolated from anthropogenic disturbance, receiving a dose of disturbance not typical of the entire wetland or vegetation zone, or may contain some "natural" chemical/physical component that is unique. Regardless of the cause, the area is not representative of the entire wetland. The influence of these outliers can be dampened by using the median in place of mean as a measure of central tendency.

Testing and Validation of IBI - We will continue to collect data from sites of known anthropogenic disturbance and use them to generate potential metrics to be incorporated into preliminary IBIs. Following development of a preliminary IBI for a given system, we will continue to test the model by collecting data from a subset of the original sites, providing an indication of temporal variability, and additional wetlands experiencing a range of anthropogenic disturbance. Data collected from additional wetlands will be used to calculate all metrics developed initially. When collective metrics are able to continuously ordinate sites according to anthropogenic disturbance, the index will be deemed a success and be ready for implementation. We have completed this process for our Lake Huron IBI with some adjustments to the model. The adjustments have been incorporated in the final operational index of biotic integrity for Lake Huron and we feel confident that IBI can be implemented. However, since water levels are reaching historic lows, we will continue to test this IBI as we develop and validate the others.

Project Team

Dr. Uzarski will lead the sampling effort. He will schedule meetings to coordinate sampling, establish databases, and coordinate synthesis. Dr Uzarski will take the lead in invertebrate and water chemistry sampling as well as play a large role in statistical analyses of all of the data to be included in the final report. Dr Burton will serve as a consultant to the effort while playing a limited roll in invertebrate and water chemistry data collection and analysis. Dr. Albert will head the plant sampling group. Dr. Rediske will analyze DELTS and lead the contaminants portion of the proposal. John Genet will lead the field crew in the absence of Drs. Uzarski, Burton, Albert, and Rediske. John competed a Masters of Science under Dr. Burton in 1999 and has worked as a technician since. John has co-authored several papers as well. The rest of the field crew will be made up of technicians and graduate and undergraduate students.

Collaborating Project Teams

i. **Joel Ingram (Environment Canada), Ontario**

- indicator research at ten sites on the shore of Lake Ontario, ten sites at Long Point, and ten sites on Ontario's side of Lake Huron.
- will partner with BSC to collect data on marsh birds and amphibians, floristics, plant community health, macro invertebrates, and physical characteristics at Long Point wetlands.
- will collect marsh bird/amphibian data at sites on Ontario's side of Lake Ontario using MMP protocol.
- will partner with BSC to collect data on marsh birds and amphibians, floristics, plant community health, macro invertebrates, and physical characteristics at unspecified sites on Ontario's side of Lake Huron.

ii. **Ferenc DeSzalay (Kent State University), Ohio**

- will coordinate efforts to collect data on macro invertebrate communities, floristics, and fish communities with those of our team and BSC's team.
- indicator research at six of twelve specified sites on Ohio's side of Lake Erie.
- Expressed willingness to coordinate efforts to collect marsh bird and amphibian indicator data at sites described above (pending field personnel availability).

iii. **Phil Ryan and Tom McDougall (Lake Erie Fisheries Assessment Unit, Ontario Ministry of Natural Resources), Ontario**

- provide existing data and to collect any additional required fish community data (as per selected protocol) at Long Point study site wetlands.
- not submitting research proposal to the Consortium.

iv. **Steve Timmermans (Bird Studies Canada, (519) 586-3531, stimmermans@bsc-eoc.org)**

- submit a proposal to sample at Long Point Marsh in Lake Erie.
- collect data on bird and amphibian indicators in Lake Erie.

Project Schedule/Timeline

We will schedule an organizational meeting with our collaborators in December of 2001. Standard protocols will be decided upon at this time. Further, we will begin to identify our 'sample population' by identifying all open lacustrine and protected embayment wetlands in the Great Lakes (Table 1). After the population is determined, potential study sites will selected randomly. In June of 2002, potential study sites will be visited to determine if theses sites will be inundated throughout the field season and decide whether or not these sites can be accessed by field crews. An additional meeting or conference call between collaborators will be scheduled to finalize site selection and protocol standardization. Sampling/indicator testing included in this proposal will begin in July of 2002. All of the sites will be sampled over a two to three-week period. Sample possessing will begin immediately following sample collection. In September of 2002 data analysis will begin following a conference call between collaborators to exchange/share data where applicable. A final report, including appendices of all raw data, will be submitted to the Great Lakes Wetlands Consortium in November of 2002.

Project Budget

	Category	GLC	Match	Total
1.	Personnel/Salaries	$51,250	$9,737	$60,987
2.	Benefits	$13,528		$13,528
3.	Travel			
a)	Staff	$8,600		$8,600
b)	Other travel			
4.	Equipment	$5,600		$5,600
5.	Office Supplies	$26		$26
7.	Phone			
8.	Postage			
10.	Subcontracts			
11.	Indirect Cost Recovery (not to exceed 30% of salary and benefits)	$18,359		$18,359
12.	**Total**	$97,363		$107,100

Itemized Budget

	Personnel	*Benefits*	*Travel*	*Equipment/Supplies*
Uzarski				
% Salary	$ 4,500	$ 1,395	$ 3,000	$ 2,000
6 Months Tec.	$12,500	$ 3,875		
Undergrads.	$ 4,000			
Burton				
Summer Salary	$ 6,500	$ 2,015	$ 1,000	
Undergrads.	$ 4,000			
Albert	$13,750	$ 4,263	$ 4,000	$ 600
Rediske				
% Salary	$ 6,000	$ 1,980	$ 600	$ 3,026

Other Funding

We are partners with Pat Chow-Fraser from McMaster University in Hamilton, Ontario, Dennis Albert of Michigan Natural Features Inventory, and Kofi Fynn-Aikens of U.S. Fish & Wildlife Service on a project to develop a data base for fish use of 50 Great Lakes coastal wetlands through a proposed grant from the Great Lakes Fishery Commission (GLFC). This research will not include collection of data on macroinvertebrates but will include limited funding for collection of data on fish, plant communities and zooplankton.

We have completed sampling for a one-year Great Lakes Protection Fund grant. We submitted a continuation proposal but have no indication of whether or not it will be funded.

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