THE ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM (EMAP): ITS OBJECTIVES, APPROACH, AND STATUS RELATIVE TO WETLANDS

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Abstract
The United States Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) was initiated in 1989 to provide improved information on the status and long-term trends in the condition of the nation's ecological resources. EMAP is described briefly, followed by a description of EMAP-Wetlands. Program objectives include: measuring the status and trends of wetland conditions on a regional basis with known statistical confidence, determining the distribution and extent of wetlands, seeking associations between response indicators of wetland condition and environmental stressors, and providing statistical summaries and interpretive reports on the nation's wetlands. This paper focuses on the status of a pilot project evaluating indicators of wetland condition in the Prairie Pothole Region of the upper midwestern United States. Preliminary results indicate that agricultural practices strongly influence wetland condition. The best biological indicator of wetland condition might be plant species richness in wet meadow zones. Other condition indicators include sedimentation rates, phosphorus in sediments and miles of drainage pipe/ditch per acre.

Peterson, S.A.: **Das Umweltmonitoring- und Umweltprüfungsprogramm (EMAP): Grundlagen, Methoden und Status bezogen auf Feuchtgebiete**
Das Umweltmonitoring- und Umweltprüfungsprogramm (EMAP) des Umweltschutzamtes der Vereinigten Staaten wurde 1989 begonnen, um verbesserte Informationen über den Status und die langfristigen Veränderungen der ökologischen Ressourcen zu erhalten. EMAP und die betroffenen Feuchtgebiete werden beschrieben. Programmziele beinhalten Messungen des Status und der Trends von Feuchtgebieten auf regionaler Basis, Bestimmung der Verteilung und des Ausmaßes von Feuchtgebietsressourcen und die Suche nach geeigneten Indikatoren und Umwelt- Stressfaktoren, Publikation von statistischen Jahresberichten und periodischen Auswertungen. Die vorliegende Arbeit bezieht sich auf die Bewertung von Indikatoren in der Prairie Pothole Region im nördlichen Mittleren Westen der Vereinigten Staaten. Vorläufige Ergebnisse weisen darauf hin, daß landwirtschaftliche Bewirtschaftungsformen einen starken Einfluß auf den Zustand von Feuchtgebieten haben. Derzeit ist der Artenreichtum von Pflanzenarten der beste biologische Indikator für Feuchtwiesen. Andere Güteindikatoren sind Sedimentationsraten, Phosporgehalt in Sedimenten und Länge der Drainage pro Fläche.

Peterson, S.A.: **Program monitorování stavu životního prostředí (EMAP): cíle, cesta a stav mokřadů**
V roce 1989, Organizace ochrany životního prostředí Spojených států amerických zahájila program pod názvem monitorování stavu životního prostředí (EMAP), jehož cílem je získat informace o stavu zdrojů národního přírodního bohatství a jejich dlouhodobého směru vývoje. Článek uvádí stručný popis tohoto programu se zaměřením na EMAP - mokřady.
Cílem programu je: sledování stavu a trendu vývoje mokřadů na úrovni regionů s určitou statistickou průkazností, sledování rozmístění a rozsahu mokřadů, hledání souvislosti mezi reakcí indikátorů prostředí a stresy a poskytnutí statistik a interpretovatelných zpráv o stavu národních mokřadů. Tento článek se soustřeďuje na popis indikátorů prostředí v oblasti prérijních krasových propastí na středozápadě USA. Předběžné výsledky ukazují výrazné změny stavu mokřadů v důsledku zemědělského hospodaření. Nejlepším biologickým indikátorem stavu mokřadů se zdá být druhová bohatost rostlinstva mokrých luk. Dalšími vhodnými ukazateli je rychlost sedimentace, obsah fosforu v sedimentech a délka drenážního potrubí na plošnou jednotku.

INTRODUCTION

The purpose of this paper is to describe the Environmental Monitoring and Assessment Program (EMAP) in general. More specifically, however, the purpose is to describe the EMAP-Wetlands part of the program, including its approach to indicator development and evaluation through pilot studies. Preliminary results from a two-year palustrine emergent wetland indicator evaluation project are described briefly.

William K. Reilly, Administrator of the U.S. Environmental Protection Agency in 1989, while testifying before Congress said,

> "I have some good news and some bad news. The good news is that, based on my years in the environmental movement, I think the Agency (EPA) does an exemplary job of protecting the nation's public health and the quality of the environment. The bad news is, I can't prove it."

Part of the reason that Mr. Reilly couldn't "prove it" comes from our (EPA and other organizations) preoccupation with local problems such as a single waste treatment plant discharge, landfill, or manufacturing plant discharge, with little consideration for the cumulative effects of all these impacts. Another, and perhaps more serious concern, is the heavy focus on a single chemical approach to assessing environmental effects. Although the single chemical approach has provided important information for screening the relative toxicity of many chemicals, the information is not readily transferable to the field, there is no hope of keeping abreast of the toxicity of all new chemicals, and there has been no realistic means of using the single chemical, site specific information to provide regional estimates of overall environmental condition. The site specific, single chemical approach has given us good information on some sites, but it also has contributed to a misconception concerning environmental conditions. We have been too close to the problem, making the old cliché of "not being able to see the forest for the trees" almost real. Thus, despite considerable ecological toxicology and monitoring work, there was good reason for Mr. Reilly's sense of frustration. This points out that if we look only at natural resource problems where we know them to be, we never really gain a sense of their severity relative to the overall resource.
At about the same time, EPA's Science Advisory Board was examining the types of issues it believes EPA needs to address in the 1990's and beyond. The Board identified the issues of (1) multiple pollutants and cumulative impacts and (2) non-point source regional-scale pollution, along with complex ecological issues such as forest decline, estuary degradation, and clash between sustainable development and agriculture. The Board also submitted several recommendations to the Agency for addressing these issues. The Agency responded to the challenge by developing the Environmental Monitoring and Assessment Program (EMAP).

EMAP OBJECTIVES

The objectives of EMAP are as follows:

- Estimate the current status, trends and changes in indicators of condition of the nation's ecological resources on a regional basis with known confidence.
- Estimate the distribution and extent of the nation's ecological resources.
- Seek associations between stress indicators and indicators of ecological resource condition.
- Provide annual statistical summaries and periodic assessments of the nation's ecological resources.

To accomplish these objectives, the products of the program (e.g., estimates of status, trends, and changes) must be based on sound statistics, so that uncertainty can be represented explicitly in terms of confidence. The program must emphasize regional populations of ecological resources, not individual ecosystems.
These aspects require EMAP to be based on probability samples of regional populations defined to ensure complete spatial and ecological coverage. EMAP has taken two steps to guarantee that the program addresses all the nation's ecological resources. The first of these was to establish an organizational structure that partitions all ecological resources into categories and creates a resource group for each category. The second was to create a sampling design that uses an integrated sampling frame with a spatial basis that fosters complete geographical coverage (STEVENS, in press).

EMAP ECOLOGICAL RESOURCE CLASSES

The partitioned EMAP ecological resource classes consist of forests, agricultural ecosystems (agro-ecosystems), arid ecosystems, surface waters, wetlands (sensu COWARDIN et al., 1979), near-coastal estuarine systems, coastal waters, and the Great Lakes. The remainder of this paper focuses on the wetlands resource class, the objectives of which parallel the EMAP objectives above, except for the second. The U.S. Fish and Wildlife Service (USFWS) is mandated by law to assess the distribution and extent of wetlands (DAHL & JOHNSON, 1991). Thus, EMAP-Wetlands accepts the USFWS estimates of distribution and extent, leaving the group free to concentrate on the assessment of wetland condition. This focus prompts a strong emphasis on the development and evaluation of indicators of wetland condition.

SAMPLING DESIGN

The sampling design is based on a permanent national sampling framework consisting of a systematic triangular point grid placed randomly, one time, over the conterminous United States (Figure 1), according to OVERTON et al. (1990).
An in-depth description of the sampling design relative to site selection methods, regional inference, discrete resource sampling, extensive resource sampling, stratification, grid density variations, and sampling schedules relative to each EMAP ecological resource class has been furnished by STEVENS (in press) and will not be elaborated on here, except to identify the base grid coverage (Figure 1) and EMAP-Wetlands' primary study area in the upper midwestern United States, the Prairie Pothole Region (PPR) (Figure 2).
The base grid in Figure 1 consists of approximately 12,600 grid points.
The basic grid has been evaluated statistically to determine its adequacy for detecting wetlands of all classes, given their high frequency variability. LEIBOWITZ et al. (1993) reported that the design was adequate accept for some rare and riverine classes of wetlands. In these cases, the grid density can be intensified by factors of 3, 4, or 7, or increments thereof (LEIBOWITZ et al., 1991). The EMAP-Wetlands group intends to catalog the numbers, classes, and sizes of wetlands for the area within a 40 km^2 hexagon centered on each grid point for major areas of the United States. One of these is the PPR of the upper midwestern United States, more specifically that part of North Dakota east of the Missouri River (Figure 2), which is emerging as the area of focus for the design of a regional demonstration project. The demonstration will be based on results of a two-year pilot project conducted to evaluate indicators of wetland condition.

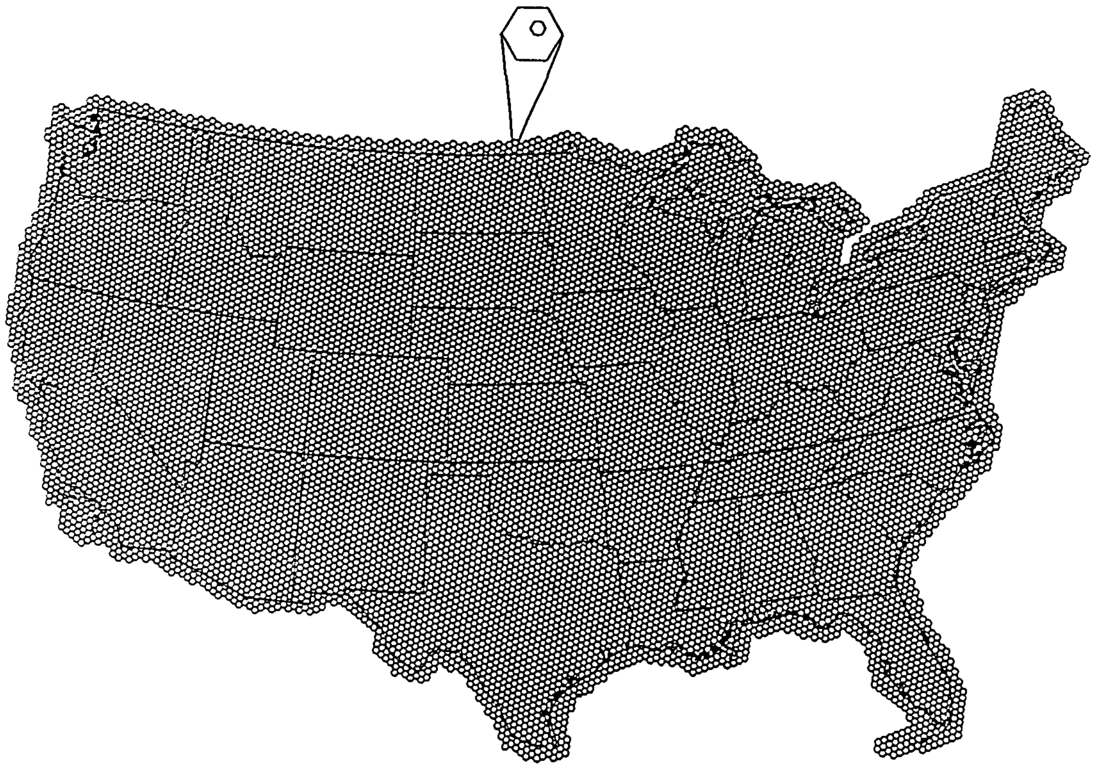

Fig. 1: The base 12,600 hexagon EMAP national grid; distance from centre point to centre point between hexagons is about 27 km and each hexagon has an area of 640 km^2. The blow-up depicts one of 16, 40 km^2 hexagons within each EMAP base hexagon. The 40 km^2 hexagons will serve as the basis for EMAP-Wetlands probability studies described under Regional Demonstrations (modified from OVERTON et al. 1990).

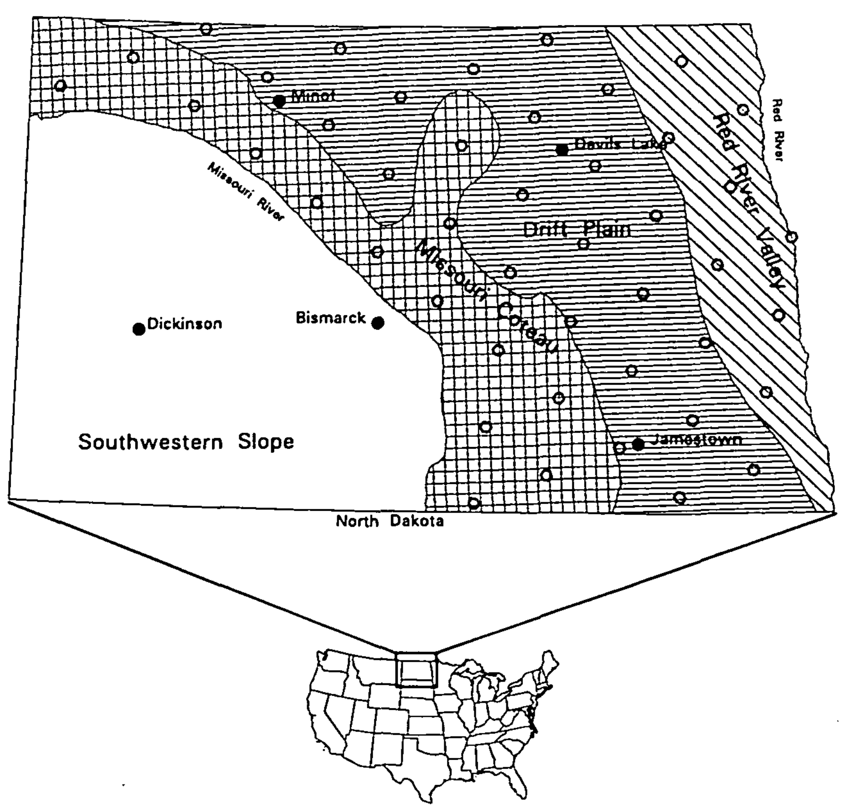

Fig. 2: Location of 45 randomized, 40 km^2 hexagons of base level grid density for Eastern North Dakota.

THE EMAP-WETLANDS APPROACH

The approach for wetlands parallels that of EMAP in general, in that it is regional in scope, oriented towards assessing the biological / ecological condition of wetlands, based on probability sampling (long term), dependent on partnerships with other federal and state agencies, and designed towards long-term monitoring (25-50 years). For the short term, however, the wetlands group developed an approach for indicator development and evaluation that differed from other EMAP groups. Specifically, this approach included:

- Adopting a wetland classification system.
- Focusing on wetland classes of major interest.
- Establishing a set of values of importance to society (herafter referred to as values or wetland values) for the various wetland classes.
- Developing assessment questions relative to the wetland values.
- Selecting appropriate condition indicators of the wetland values.
- Developing a conceptual model for the specific wetland classes of interest.
- Developing a condition assessment model relating wetland values, indicators, and indicator measurements.
- Conducting indicator evaluation pilot studies in selected high and low quality wetland sites.
- Beginning development of a regional demonstration study based on results of pilot studies.

WETLAND CLASSIFICATION SYSTEM

The development or adoption of a wetlands classification system is fundamental to the development of an approach for evaluating inland wetlands indicators.

The classification system is important for two reasons. First, it permits us to properly organize and scope or frame the evaluation. Secondly, a classification system allows us to focus limited resources on the most important wetland classes. Because we chose to affiliate with the USFWS, and because they are using it to conduct an inventory of wetlands of the United States, we elected to adopt the Classification of Wetlands and Deepwater Habitats of the United States (COWARDIN et al., 1979) as the primary EMAP classification framework.

This system defines wetlands by plants (hydrophytes), soils (hydric soils), and flood frequency. Using the Cowardin classification system, EMAP-Wetlands selected three major wetland classes, encompassing 80% of the wetlands of the United States, to emphasize for initial evaluation. These included the estuarine emergent, palustrine forested, and palustrine emergent classes, of which only the latter is discussed here for reasons of space and relevance to the workshop.

VALUES OF PRAIRIE POTHOLE REGION WETLANDS

As in other systems, a variety of values is associated with the PPR wetlands. However, some of these values stand out as particularly significant, based on the experience and understanding of wetland scientists and managers.

Technical workshops in 1991 identified the following values as the most significant for the Prairie Pothole Region:

- **Biological Integrity**. The sustainability of a balanced, integrative, adaptive community of organisms having a species composition, diversity, habitat, and functional organization comparable to that of natural wetlands in the region (adapted from KARR & DUDLEY, 1981).

- **Harvestable Productivity**. The quantity and/or quality of any service or product that wetlands provide to society (e.g., wildlife, recreation, and food production).
- **Water Quality Improvement**. The ability of wetlands to assimilate nutrients, trap sediments, or otherwise reduce downstream pollutant loads.
- **Flood Attenuation**. The ability of wetlands to temporarily intercept and store surface water run-off, thus changing sharp run-off peaks to slower discharges over longer periods of time (MITSCH & GOSSELINK, 1986).

The biological integrity value, more than any other, assumes the reality of reference conditions, since it requires that sample site conditions be compared with those of natural wetlands in the region. Also, because of this requirement, biological integrity represents a set of conditions more basic and less disturbed by human activity (i.e., unmanaged), compared to the other three values. Indeed, the other values are nearly always managed for "improvement."

Thus biological integrity, as defined here, might represent the only reasonable set of reference conditions from which the state of all wetland conditions could be measured. Wetland condition indicators for the values of water quality improvement, harvestable productivity, and flood attenuation are more likely to be skewed due to management practices. Therefore, the only meaningful estimate of overall condition relative to the population of concern should be made relative to the least disturbed (unmanaged) natural wetlands in the region.

They more than any others, represent background conditions.

ASSESSMENT QUESTIONS

Assessment questions direct wetland evaluations toward policy and management issues. These questions help to establish wetland values of relevance to society and to guide selection of appropriate wetland condition indicators of those values.

An example might be, "What proportion of the wetlands in region Z have a species richness less than 75% that of reference wetlands in the region?" Another might be, "What proportion of the wetlands in region Z have sedimentation rates greater than those of reference wetlands in the region?" Whereas the first question imposes a value of 75% relative to reference conditions, the second question imposes no such value. These are merely examples of the kinds of assessment questions that could be posed. In fact, EMAP has no preconceived notions relative to the ecological significance of values it will report. Rather, EMAP will describe regional conditions in the form of cumulative distribution

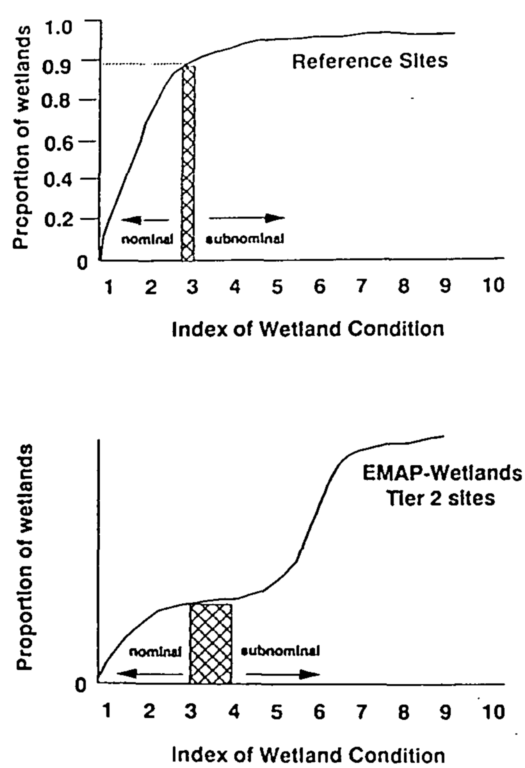

Fig. 3: A generic example of a cumulative distribution function for any index (indicator) of wetland condition and how reference sites (a) could be used with probability based samples (b) to help define regional nominal and subnominal wetland conditions (LEIBOWITZ et al., 1991).

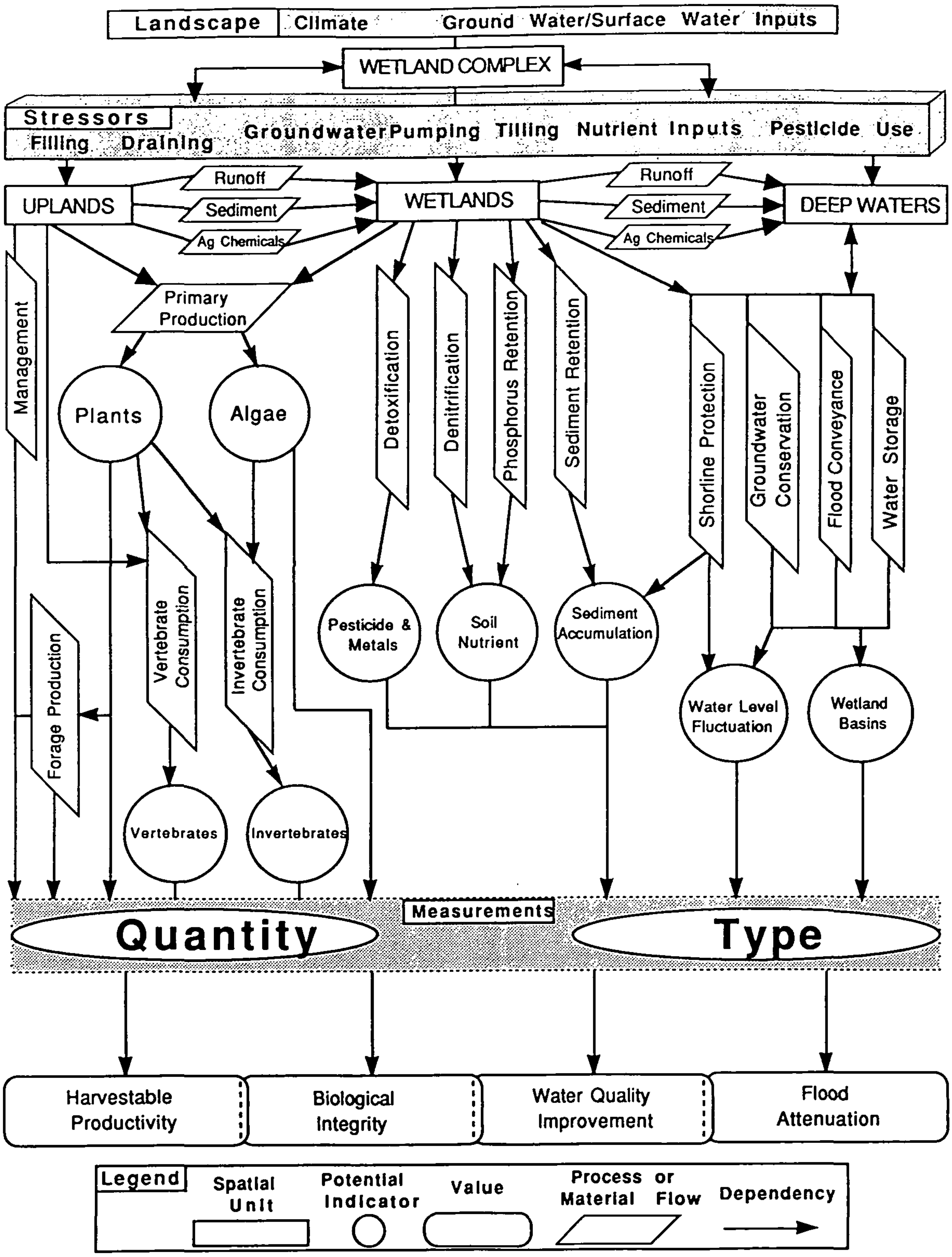

Fig. 4: Conceptual model for the Prairie Pothole Region in the upper midwestern United States (ROSEN et al. 1994).

functions (CDFs) (Figure 3), such that a variety of management and policy personnel might ascertain ecological significance for a variety of purposes. The major goal of EMAP is to develop a database of known quality (bracketed by statistical confidence limits) such that management and policy decisions can be made on the basis of reliable information.

CONCEPTUAL MODEL DEVELOPMENT

One reason for developing a conceptual model of any system is to help us understand the key elements of the system and how they interact. The model helps us see the connections among the various components. We can then pose assessment questions that are more meaningful relative to the overall condition of wetlands and we can more effectively select indicators of the condition of interest.

A conceptual model was developed for the PPR through a workshop process. A draft model was distributed to a group of 10 wetlands experts who then met to discuss and refine the model. Their comments were incorporated into a new draft conceptual model (Figure 4) with supporting narrative (ROSEN et al., 1994). This model is being used to help delineate important linkages among wetland values, wetland condition indicators, and stressors that affect the wetland condition. The model serves two primary purposes. The first is to explicitly define a framework within which to interpret the ecological significance of key indicator responses, i.e. how the indicators relate to wetland values and stressors. The second is to identify any ecological system gaps not covered by indicators that might improve our ability to assess wetland condition.

INDICATOR SELECTION AND EVALUATION

Indicator selection took place in a workshop forum based on expert opinion concerning the type and specific indicators thought to be most appropriate, given the goals of EMAP, the assessment questions posed that were relevant to policy and management, and the conceptual model of the PPR. Although biological/ecological indicators were emphasized, certain chemical and physical indicators were recognized as being extremely important in the region. Not the least of these was the mere presence or absence of water. Budget dictated that choices had to be made. Therefore, a variety of vegetative, faunal, chemical, and physical indicators, at both wetland basin and landscape scales, were selected. They included open water area, upland land use characteristics, vegetation types and amounts, sediment accumulation, soil and sediment characteristics, waterfowl populations, amphibian stress, and invertebrate types and numbers. While the primary focus of EMAP is directed towards biological and ecological (response) indicators of condition, the wetlands group, while pursuing biological indicators, has moved towards landscape level physical (stressor) indicators of condition. This has been prompted by two realities.

The first is that access authorization to privately owned wetlands is extremely difficult (sections on preliminary results and conclusions, below). The second is that ground sample collection and analysis is expensive.

CONCEPTUAL CONDITION ASSESSMENT MODEL

We wish to describe wetland condition. We have indicated that the perception of condition is dictated by a set of values to

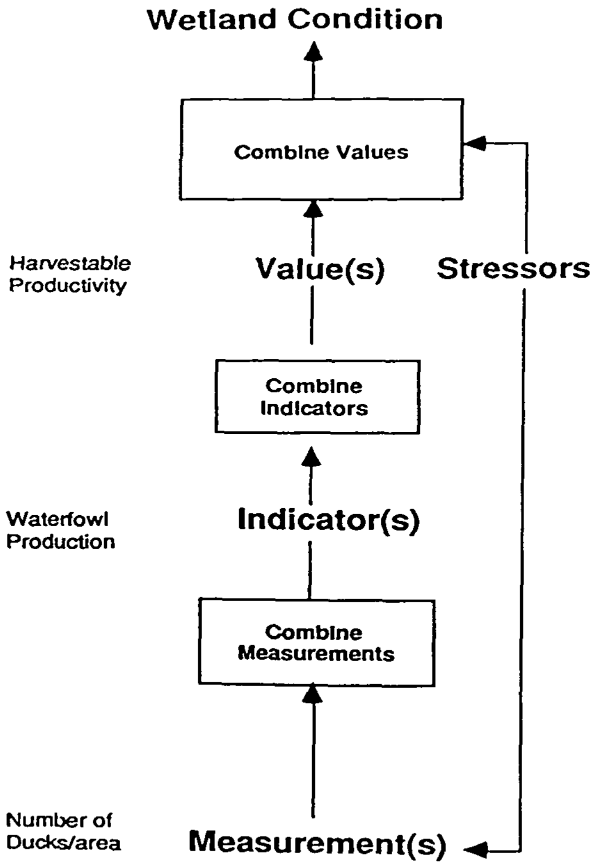

Fig. 5: Conceptual assessment model illustrating an example of the relationships among measurements, indicators, and values relevant to society associated with resource condition (ROSEN et al., 1994).

society associated with wetlands. These values influence which indicators of condition are selected and what actual measurements are made.
Figure 5 illustrates how we perceive wetland condition to be related to the various values, indicators, and measurements made in pilot and demonstration studies. Although we would like to combine the various indicators into some type of index similar to the aquatic Index of Biotic Integrity (IBI) for streams (KARR, 1981), no such wetland index exists at present. At this time, therefore, wetland condition will be described on the basis of individual indicators while we examine their correlative relationships.

PILOT STUDY

As indicated in the section, "Values of Prairie Pothole Region Wetlands," wetlands are valued for their biological integrity, harvestable productivity, water quality improvement, and flood atteenuation along with a host of less tangible characteristics. A major concentration of wetlands remaining in the United States includes those in the Prairie Pothole Region of the upper midwest. These wetlands are of major significance to the health and well-being of North American waterfowl populations. The region produces at least half of North America's waterfowl (KANTRUD et al., 1989). As such, this area became a focus for pilot studies carried out to evaluate the performance of wetland condition indicators. A brief description of the study objectives, and findings based on preliminary results follow.

OBJECTIVES

The primary study objectives of the PPR pilot study were as follows:

- Determine the ability of selected indicators to distinguish between good condition and poor condition wetlands.
- Evaluate the variability of each indicator in each biogeographical area in the Prairie Pothole Region.
- Develop correlative relationships among indicators.

Workshop findings showed that the performance of indicators of wetland condition across a wide range of wetland types was relatively unknown. We wanted to evaluate indicators of wetland condition at extreme conditions. We reasoned that indicators incapable of distinguishing between selected sites in good and poor condition (good and poor condition is the determined relative to the condition of relatively undisturbed/unmanaged sites in region) would have no chance of distinguishing between wetlands in intermediate ranges of condition. This will become an important consideration when probability sampling is used eventually over a large region to assess the condition of the wetland population at large. Therefore, to accomplish the first goal it was necessary to determine what constituted wetlands in good condition and poor condition in the PPR. Regional wetlands experts discussed the issue extensively in a workshop forum. Concensus was that agricultural practices in the region played the major role in influencing wetland conditions. Still, deciding how to identify good from poor condition wetlands remained difficult. Eventually, workshop participants agreed that intensive cropping practices probably imposed more adverse effects on wetlands than hay lands, pasture and Crop Reserve Program (CRP) lands. It followed from this that indicator evaluation test sites should be located both in areas dominated by crops (poor condition) and in areas dominated by pastures, hay fields and CRP lands (good condition) (Figure 6).

Figure 7 illustates the types of land use mixtures found in areas with wetlands in good condition and in poor condition in the Prairie Pothole Region. Indicator evaluation sites were purposely selected from these two extreme conditions. This method of selection provides a sound basis for evaluating indicators, but no basis for evaluating condition of wetlands across the population of interest. For that reason, probability sampling will be used in the condition assessment demonstration project.

The indicator evaluation pilot project was initiated in the summer of 1992 and scheduled to run through the summer of 1993. The summer of 1992 was the end of a five-year drought cycle. Beginning in July 1993, record rains fell in the Prairie Pothole Region. Where potholes had been dry for two years, there now stood 2 - 4 feet (60-120 cm) of water. While most sampling was completed before the rains fell, some invertebrate traps were very difficult to recover.

STUDY SITES

To achieve the second objective, study sites were selected in each of the four biogeographical regions of the PPR (Figure 8). Since these sites were selected solely to evaluate the performance of indicators and not to develop any assessment of wetland conditions in the area, the sites were located within USFWS plots (4 mi^2 or 10,36 km^2) used in previous studies. Thus background information was available and logistical problems in getting to the sites were reduced.

PRELIMINARY RESULTS

The following preliminary results are based on partial analysis of the 1992 pilot study data set. In some cases they were selected to illustrate extreme conditions and are thus not necessarily representative of results for the entire study.

- Obtaining access to privately owned study sites is a major problem, requiring almost 1 man/year of effort for the 16 sites. Access to some sites was revoked before the study ended (L. COWARDIN, pers. comm.).
- The surface area of water in poor condition wetlands is much more variable (flashy) than in those of good condition (Figure 9).
- Plant species richness is much greater in wet meadow, shallow marsh, and deep marsh zones in good condition than those in poor condition (Table 1).

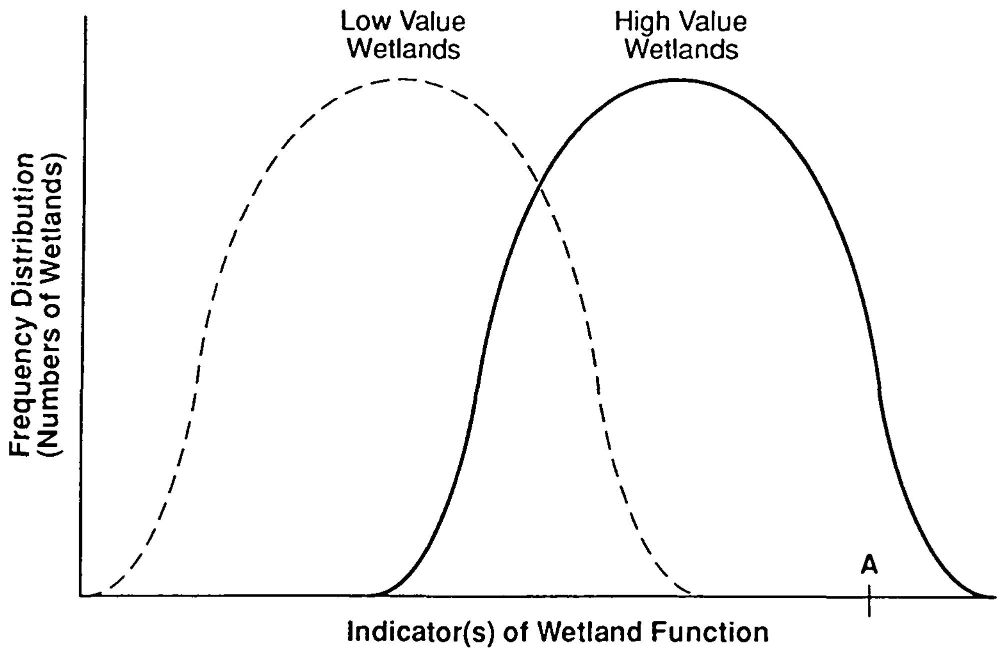

Fig. 6: Frequency distributions for an indicator of wetland condition for wetlands considered to be in good condition by policy-makers or a specific user group (solid line) and wetlands considered in poor condition by the same group (dashed line). A wetland located at "A" would be classified as a good condition wetland. During the pilot study, multiple indicators were evaluated in both good and poor condition wetlands (modified from LEIBOWITZ et al. 1992). (NOTE: Good and Poor Condition used throughout this paper are equivalent to High Value and Low Value, respectively, in this Figure from LEIBOWITZ et al.).

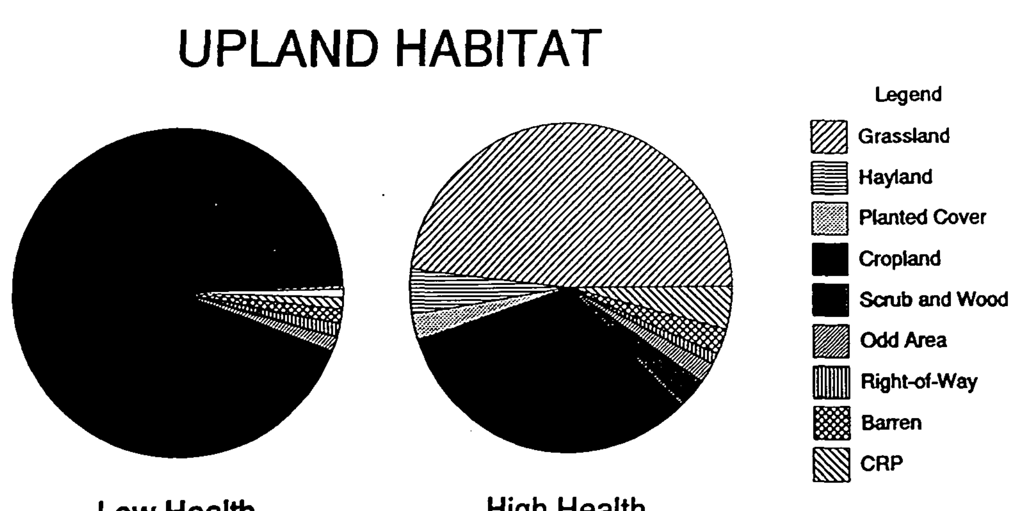

Fig. 7: Example of the various proportions of land use around good condition and poor condition wetlands in the Prairie Pothole Region (redrawn from COWARDIN & SKLEBAR, 1993). (NOTE: Good Condition and Poor Condition in this paper are equivalent to High Health and Low Health, respectively, shown in this Figure from COWARDIN & SKLEBAR).

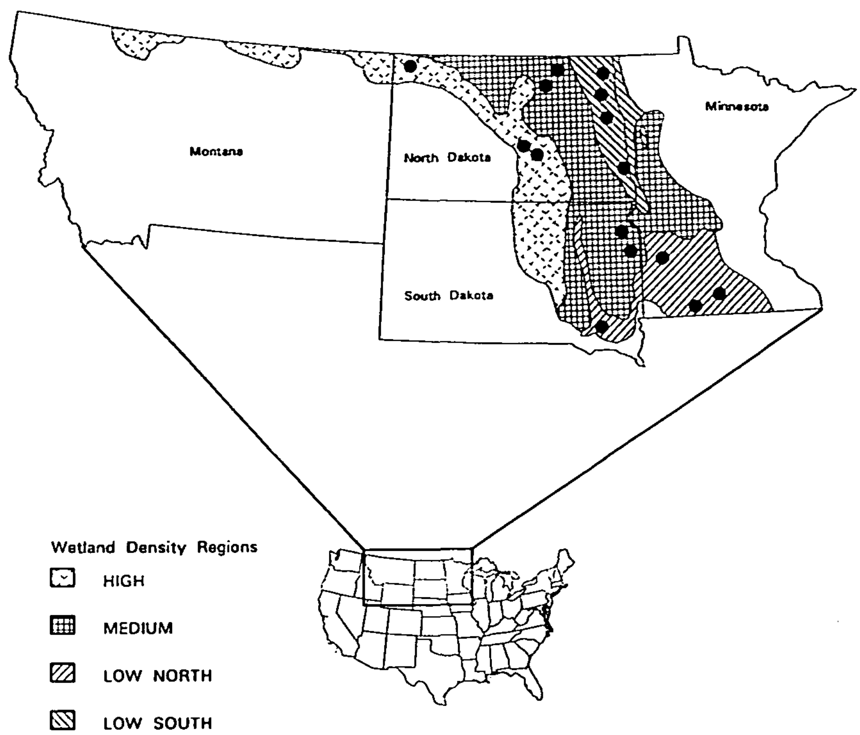

Fig. 8: Map of the Prairie Pothole Region showing wetland density regions (Modified from MANN, 1974). Black dots show the locations of sites where indicators were evaluated during pilot studies in 1992 and 1993.

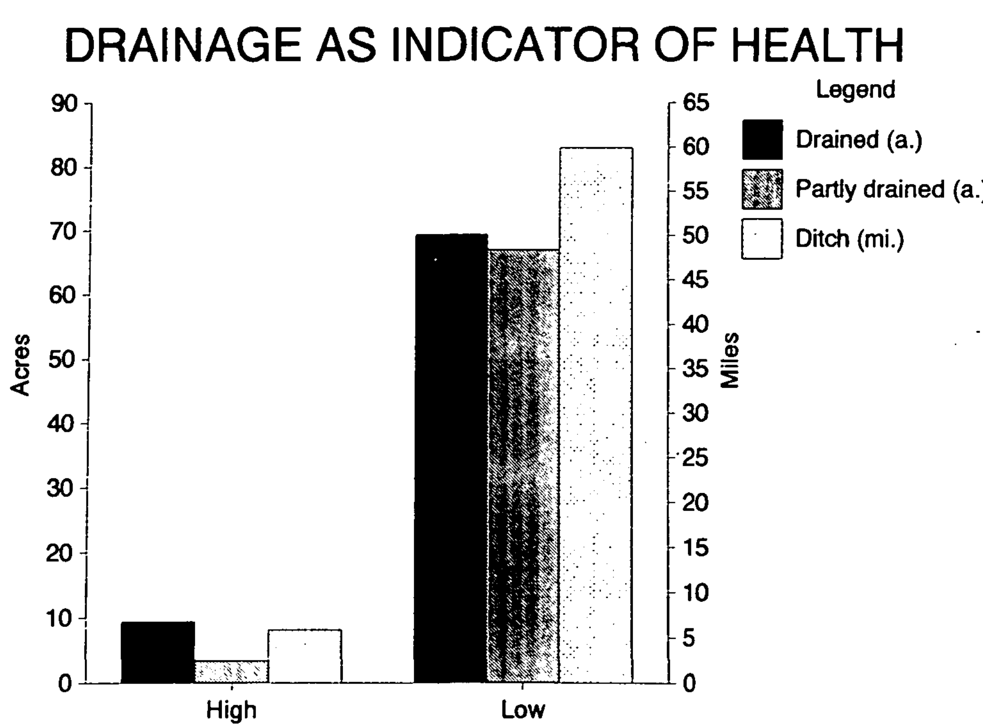

Fig. 9: Drainage as an indicator of wetland condition (from COWARDIN & SKLEBAR, 1993). (Note: 1 acre=0,405 hectares; 1 mile=1,61 kilometres)

Table 1. Example of Extreme Conditions in the Wet Meadow, Shallow Marsh, and Deep Marsh Areas of High Health and Low Health Wetlands in the Prairie Pothole Region (data courtesy of H. Kantrud, National Biological Survey, Jamestown, ND)

	Wet meadow		Shallow Marsh		Deep marsh	
	High	Low	High	Low	High	Low
Mean water depth (cm)	0.4	0.0	31.2	0.0	59.0	35.6
Mean % standing dead vegetation	7.0	N/A[a]	0.2	2.0	19.0	13.0
Mean length (cm) litter core	1.0	N/A[a]	0.8	15.9	0.0	18.0
Mean % bare soil	0.0	N/A[a]	0.0	0.0	0.0	0.0
Mean % open water	0.0	N/A[a]	21.0	0.0	0.0	0.0
Plant species richness	32	Corn	15	4	13	5
Dominant land use	G[b]	C[c]	G[b]	I[d]	G[b]	I[d]

[a] = Wet Meadow areas destroyed by siltation from adjacent uplands
[b] = Grazed
[c] = Cropped
[d] = Idle

- Sedimentation rates in poor condition wetlands greatly exceed those in good condition (L. COWARDIN, pers. comm.).
- Soil (sediment) concentrations of phosphorus are much greater in poor condition wetlands than in those of good condition (L. Cowardin, pers. comm.).

CONCLUSIONS

The precaution stated for the results above is equally appropriate here. While these conclusions appear to be supported by the partially analyzed data, final conclusions await throrough analysis of the entire 1992 and 1993 data sets by the National Biological Survey at Jamestown, North Dakota.

- Some of the most robust indicators of wetland condition appear to be landscape level stress indicators collected by remote videography.
- Wetlands in areas of intense cropping appear to be much more variable and of generally poorer condition than those in areas of pasture, hay land, and CRP.
- Access problems might force a greater reliance on remote sensing of landscape characteristics such as the occurrence of deltas or ploughed wetland meadows. While PATIENCE & KLEMAS (1993) reported vegetative abundance (biomass) and species composition (biodiversity), to be the most practical remotely sensed wetland indicators, Cowardin (pers. comm.) indicates they are so variable in the Prairie Pothole

Region as to be nearly impossible to determine remotely.

REGIONAL DEMONSTRATION

Planning for a regional demonstration project in the Prairie Pothole Region in 1995 is just beginning. The project will be based on results from the indicator pilot testing project conducted in 1992 and 1993.

Some of the indicators mentioned in this paper appear to be very promising. However, it is still necessary to determine variability among the various indicators before making final recommendations for using them in the regional demonstration. During the demonstration project, it is very likely that a few new indicators will be evaluated while development of databases using proven indicators from the pilot projects takes place. Indeed, we view indicator development and evaluation as an ongoing process in EMAP.

One aspect of the regional demonstration that has been decided is that we will conduct landscape characterization of each base grid, 40 km^2 hexagon in the demonstration area (most likely in North Dakota east of the Missouri River). Expert opinion indicates that wetland condition in the PPR is so closely associated with upland condition and land use that to attempt to assess wetland condition without assessing the surrounding upland characteristics would be meaningless. Therefore, upland landscape characteristics will play an important role in defining wetland condition during regional demonstration studies. Evidence of this is already forthcoming from the pilot study results.

The National Wetlands Inventory of the USFWS will be responsible for the upland characterization using an upland classification system devised and used earlier by COWARDIN et al. (1988).

ACKNOWLEDGEMENTS

Since 1989, many people have contributed to the concepts and approaches described in this paper. Unfortunately, they are too numerous to mention. I want to acknowledge those who preceded me in EMAP for their thoughts and their dedication to the program. At the same time, I do not wish to burden others with responsibility for the ideas expressed in this paper. I am solely responsible for its content. I wish to thank Richard Sumner, Scott Urquhart, Mark Brinson, Richard Novitzki, and Lewis Cowardin for their technical comments. Also, I thank Susan Christie for her editorial comments, insights, and, in some instances, reconstruction of the manuscript format.

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