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Measuring Wetland Health Using Bioassessment Tools

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Presentation Layout

1. What is a wetland?
2. Alberta Wetlands
3. Alberta Wetland Policy
4. Wetland Health
5. Bioassessment Methods
6. Existing Bioassessment Programs

Wetland Definition

"*Any land saturated with water long enough to promote aquatic processes as indicated by poorly drained soils, hydrophytic vegetation, and various kinds of biological activities that are adapted to wet environments*"
(National Wetlands Working Group 1988)

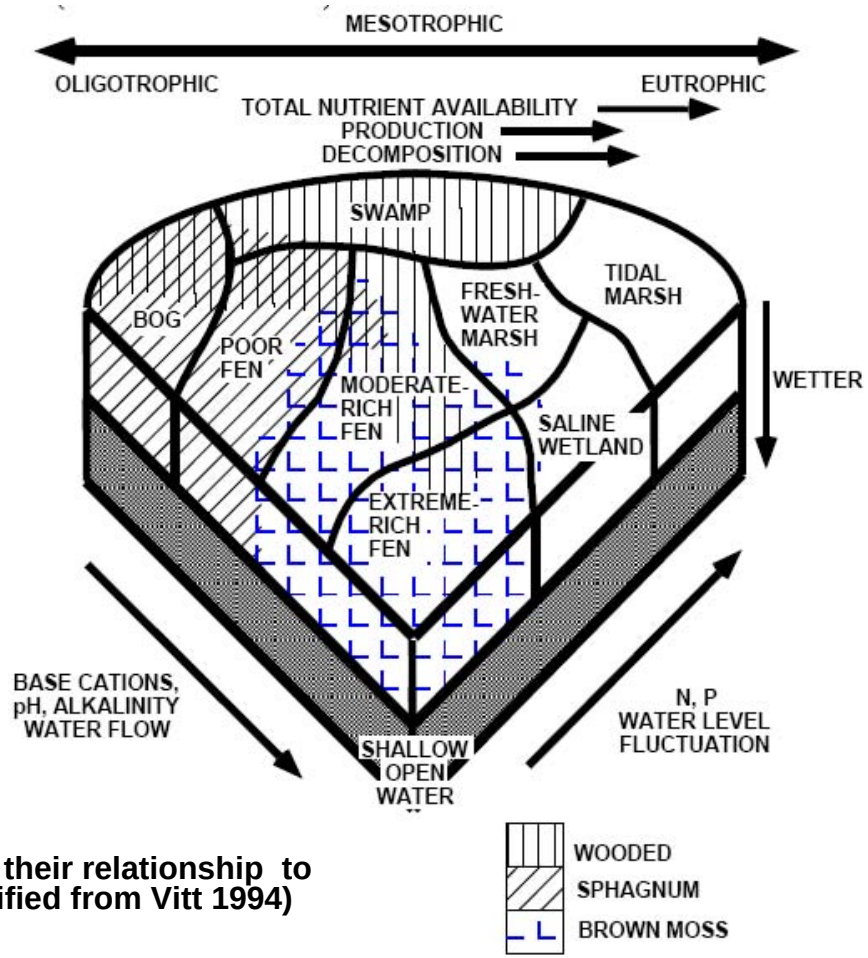
Wetland Functions

- Valuable physical, chemical and biological functions:
  - Improve water quality
  - Recharge groundwater
  - Store water
  - Buffer flooding
  - High biodiversity
  - Buffer shorelines
  - Provide fish habitat
  - Release nutrients
  - Store carbon

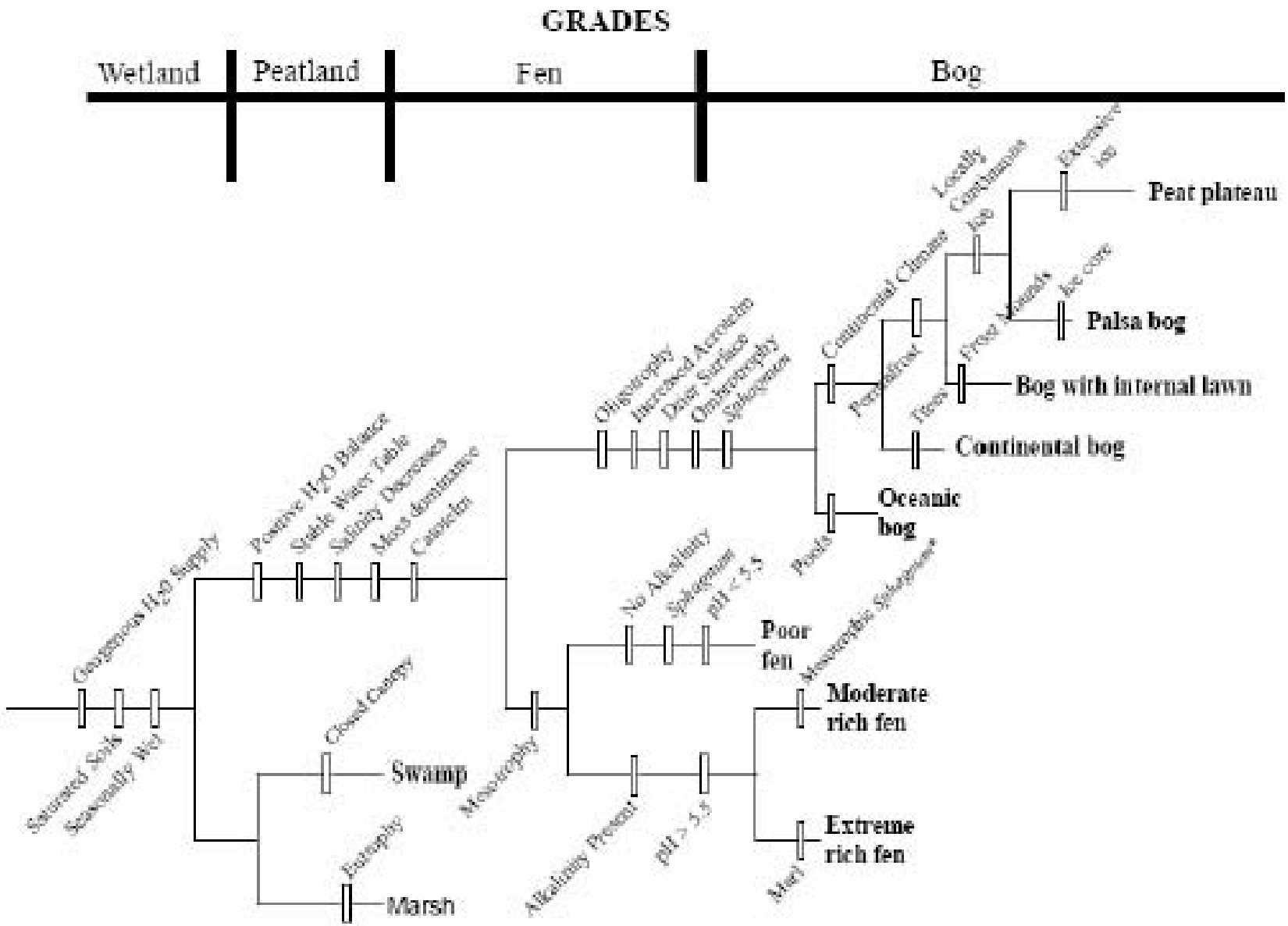
Functions	Optimal / preferred wetland	Key limiting landscape-scale elements (S. 4.1)	Key limiting wetland-scale elements (S. 4.2)
Storage of water	fens, marshes, open water	▪ catchment size	▪ size & depth profile ▪ soil saturation ▪ beaver activity
Groundwater recharge	bogs, fens, marshes	▪ elevated topography	▪ permeability of sediment, substrate
Storm runoff generation	fens, swamps	▪ slope ▪ groundwater discharge	▪ vegetation density ▪ size
Flood control[b]	marshes, fens	▪ aquatic complexes ▪ elevation & slope	▪ size & shape ▪ soil saturation ▪ vegetation density
Shoreline stabilization	marshes, open water	▪ shoreline setting ▪ high energy waves ▪ inverted shoreline	▪ fetch ▪ soil cohesion ▪ emergent density
Water treatment	marshes, open water, fens[c]	▪ shoreline setting ▪ water sources	▪ hydraulic retention time (HRT) & flow path ▪ anaerobiosis, microbial community
Carbon storage	bogs, fens	▪ watershed : wetlands ratio[d]	▪ peat volume ▪ peat saturation
Indigenous cultural use	bogs, fens, marshes	▪ connectivity	▪ plant community ▪ contaminants
Trapping of fur-bearers	fens, marshes, open water	▪ connectivity ▪ aquatic complexes	▪ emergent & riparian vegetation
Fishing	open water	▪ shoreline setting ▪ access barriers	▪ contaminants ▪ spawning habitat
Low-impact recreation	all classes	▪ access	▪ ecological sensitivity

Wetland Classification

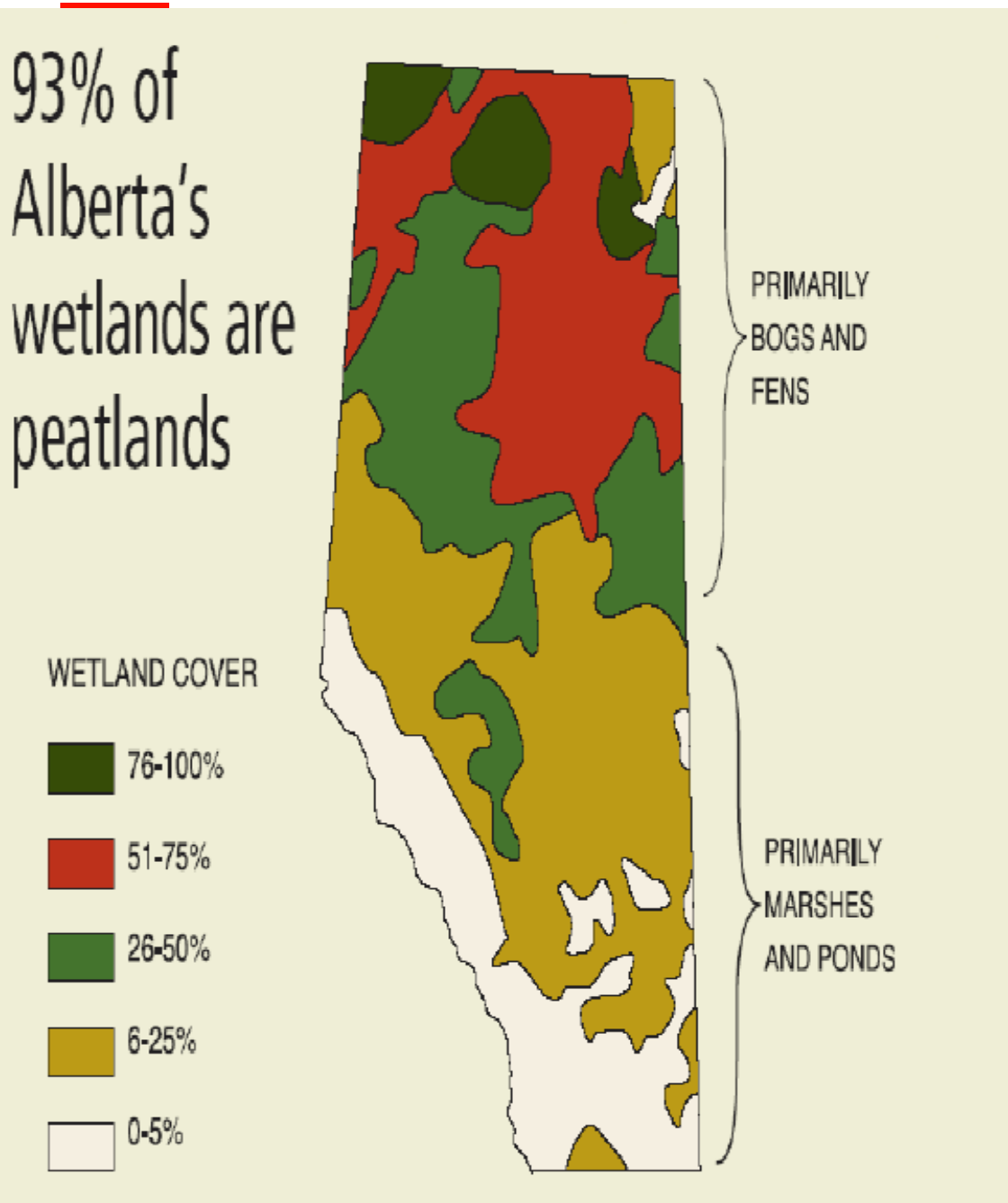
- Wetlands need to be classified in order to be assessed properly
- Wetlands are subdivided into categories based on several factors (e.g., water retention time, water depth, water quality and presence of specific species of plant)



Ternary diagram of wetland classes and their relationship to chemical and biotic gradients (modified from Vitt 1994)



A clade of wetlands naturally occurring in boreal ecosystems of North America (Wieder and Vitt, 2006)



Alberta's Wetlands

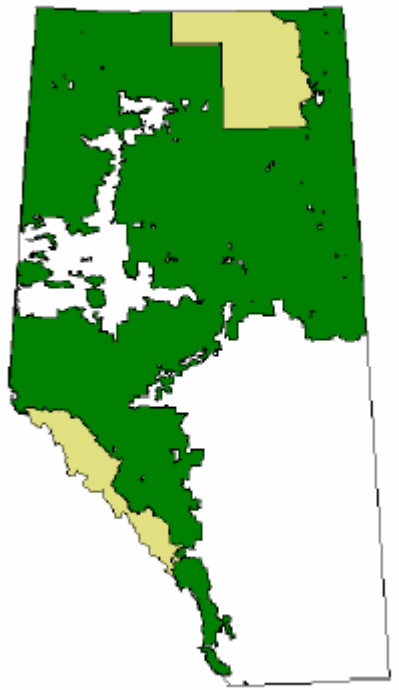
- Wetlands cover 21% of Alberta's landbase
- Two categories:
  - Peatlands - organic, peat-based soils, such as bogs and fens.
  - Non-peatlands - mineral-based soils including marshes, swamps, and shallow open water
- 93% of Alberta's wetlands are peatlands

Alberta's Wetlands

- ~ 65% of the wetlands in Alberta's settled area have been drained or altered over the past 100 years
- The current estimated rate of wetland loss in the settled area is between 0.3 and 0.5% per year
- The rate of wetland loss in the boreal peatland zone is unknown.

Alberta Wetland Policy

- 1993 interim policy passed for settled (white) area
- Draft policy for non-settled (green) area released in 1994
- 1999 Water Act made attempts at combining policies
- New wetland policy, when developed, would affect the entire province and would require developers to replace any wetlands they drain
- The council will send a draft policy to the cabinet this summer
- CEMA and WASG – Oil sands – Guidance document on establishment of reclaimed wetlands- Dec 2007



Wetland Health

- Wetlands exist because of very specific hydrological, biological, geological, chemical, and climatic conditions
- Disturbances to wetlands can be direct and indirect
- Largest impact to wetlands in Alberta has been from agricultural activities, urbanization and resource extraction

Wetland Health

- Wetland health or condition can be determined by observing the wetland's structure (its parts) and function (what it's doing).
  - wetland structure - water quality, soil condition, geology, hydrology, topography, morphology, carrying capacity, species composition, food web support, and nutrient content.
  - wetland function - surface and ground water storage, recharge, and supply, floodwater and sediment retention, nutrient cycling, biomass production, reduction of erosion, and purification of water.

Objectives & Approaches

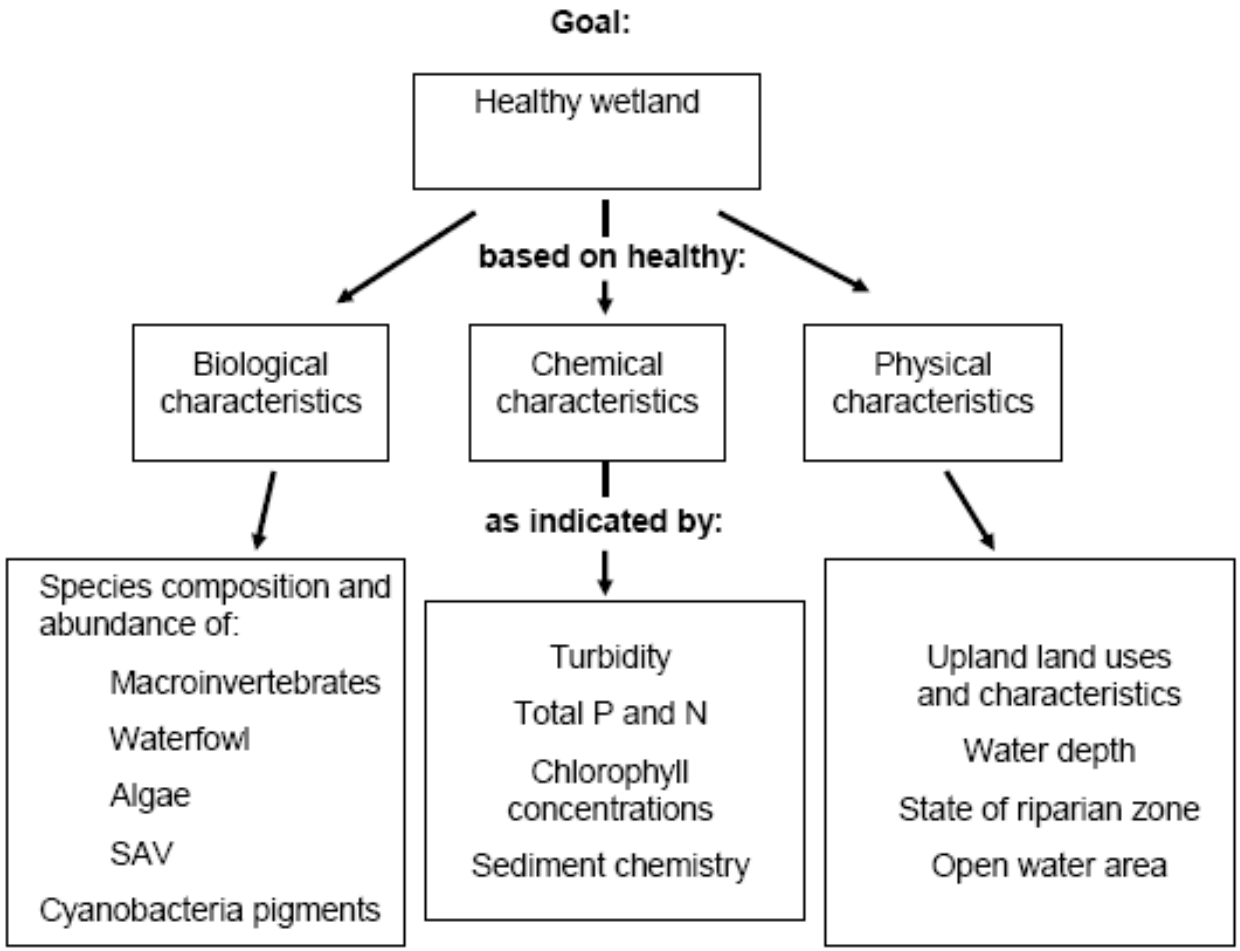
HGM Assessments

1. Assess wetland functions
2. Mostly measure structural attributes in field that are known to change with human disturbance
3. Calculate multimetric Functional Capacity Indices
4. Some functions are "support biodiversity"

IBI Assessments

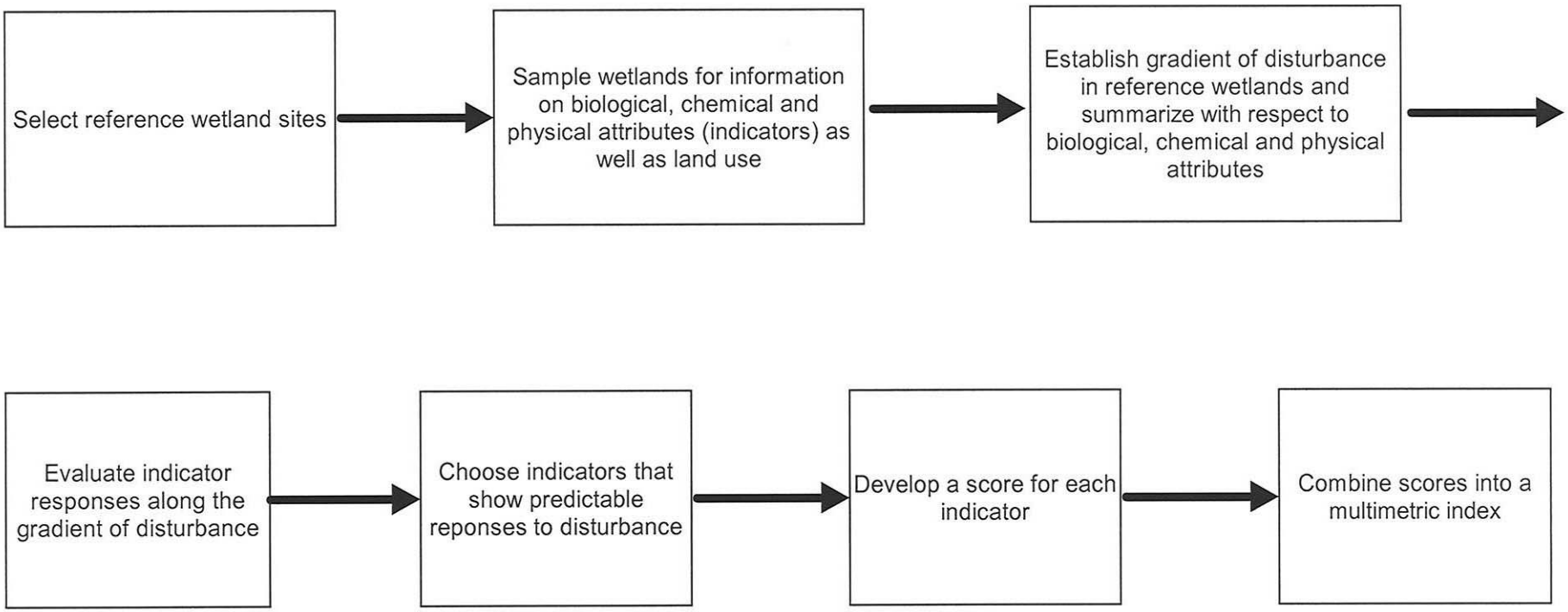
1. Assess "balance of flora and fauna"
2. Measure structural attributes in field and lab that are known to change with human disturbance
3. Calculate multimetric Indices of Biotic Integrity
4. Assume function maintained if structural biotic integrity supported

Wetland Health Indicators



Suite of indicators potentially useful for determining wetland health in Alberta's prairie, aspen parkland and boreal dry mixedwood regions (from Bayley, 2006)

Framework for Choosing Potential Indicators



Bioassessments

- **Bioassessments** are based on the premise that the community of plants and animals living in a wetland will reflect the health of a wetland.

- **Biological assemblages** provide temporally integrated assessment of environmental conditions that more precisely represents ecosystem functioning and significant environmental change compared to direct measures of function (i.e., chemical sampling)

Bioassessments

Bioassessments can be used to:

1. detect ecological damage to wetlands;
2. identify sources and causes of wetland degradation;
3. measure the success of wetland protection activities and restoration projects;
4. study ecological links between wetlands and other water bodies;
5. improve wetland management and regulatory tools; and
6. track wetland condition over time.

Biological Integrity

The ability to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organization comparable to those of natural habitats within a region.

Indicators of Biological Integrity (IBI)

- Used by most wetland bioassessment projects to evaluate the health of wetlands.
- Similar to the economic indicators used to evaluate the condition of our economy.
- Multiple indicators (metrics) of biological condition are combined into an easy-to-understand index value.
- This value is compared to reference values and helps managers assess the relative health of individual wetlands.
- Analyses performed to date show significant relationships between a number of candidate invertebrate metrics and watershed development.

Developing an IBI

- Classify wetlands and select reference sites.
- Select sampling sites across a gradient of human disturbance for each wetland group.
- Select wetlands that range from minimally impaired reference sites to severely degraded wetlands, and everything in between;
- Sample at least 2-4 assemblages— algae, amphibians, birds, fish, macroinvertebrates, and vascular plants.

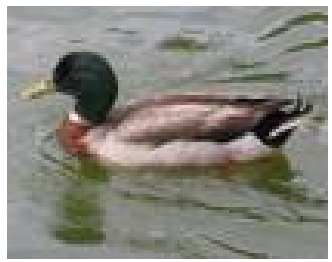
Developing an IBI

1. **Select an Assemblage**
2. **Test and Evaluate Metrics**
3. **Combine Metrics into an IBI**
4. **Test and Validate IBI**


Step 1 - Select an Assemblage

- **VASCULAR PLANTS**
- **AMPHIBIANS**
- **BIRDS**
- **ALGAE**
- **MACROINVERTEBRATES (snails, insects, clams, crayfish, etc.)**



Step 2 – Test and Evaluate Metrics

- A metric is a measurable component of a biological system with an empirical change in value along a gradient of human disturbance
- biological attributes that can be measured - diversity of amphibians, # pollution-tolerant insects, invertebrate abundance/richness.

Figure 1: Macroinvertebrate Taxa Richness of 40 Wetlands

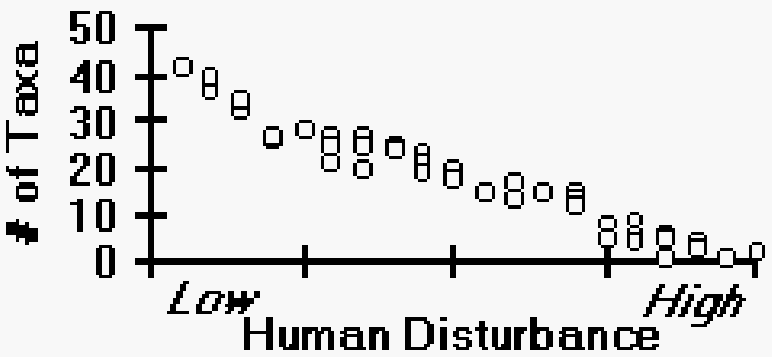
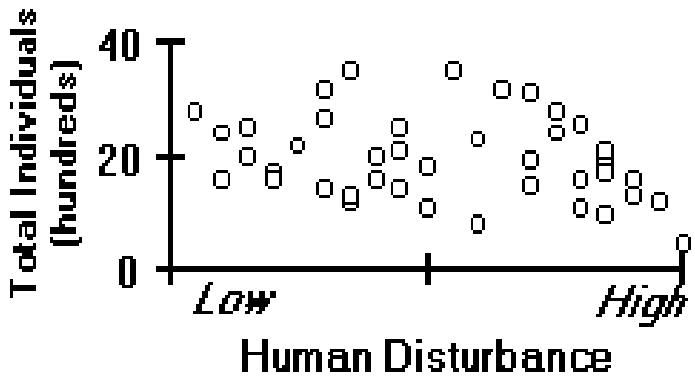


Figure 2: Total Macroinvertebrate Abundance of 40 Wetlands



Developing an IBI

Step 3 - Combine Metrics into an IBI

- Combine at least 7 metrics from one biological assemblage.
- Assign scores of 1, 3, or 5 to the metrics according to how they respond to human disturbances.

Figure 3: Macroinvertebrate Taxa Richness of 40 Wetlands

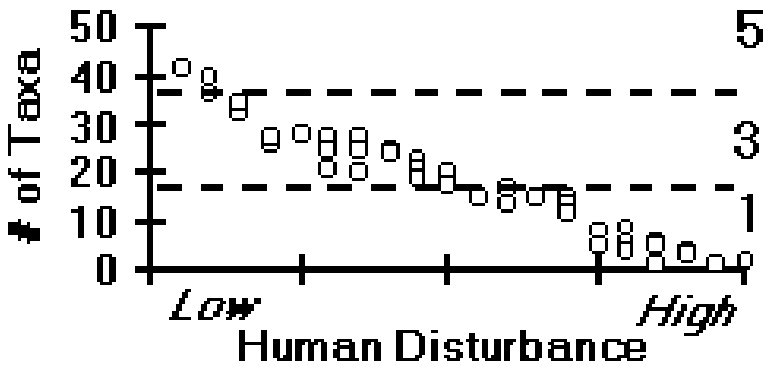
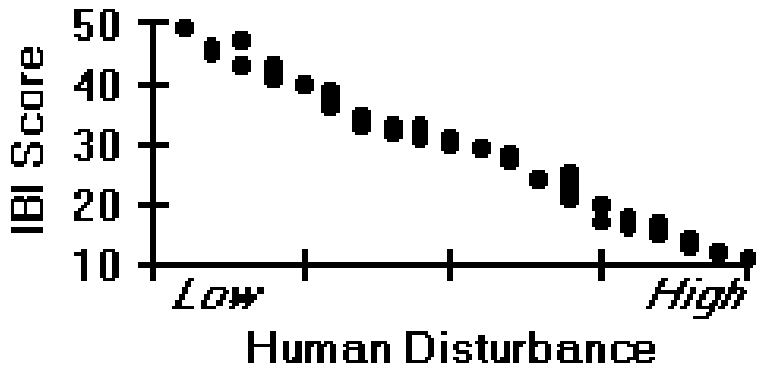


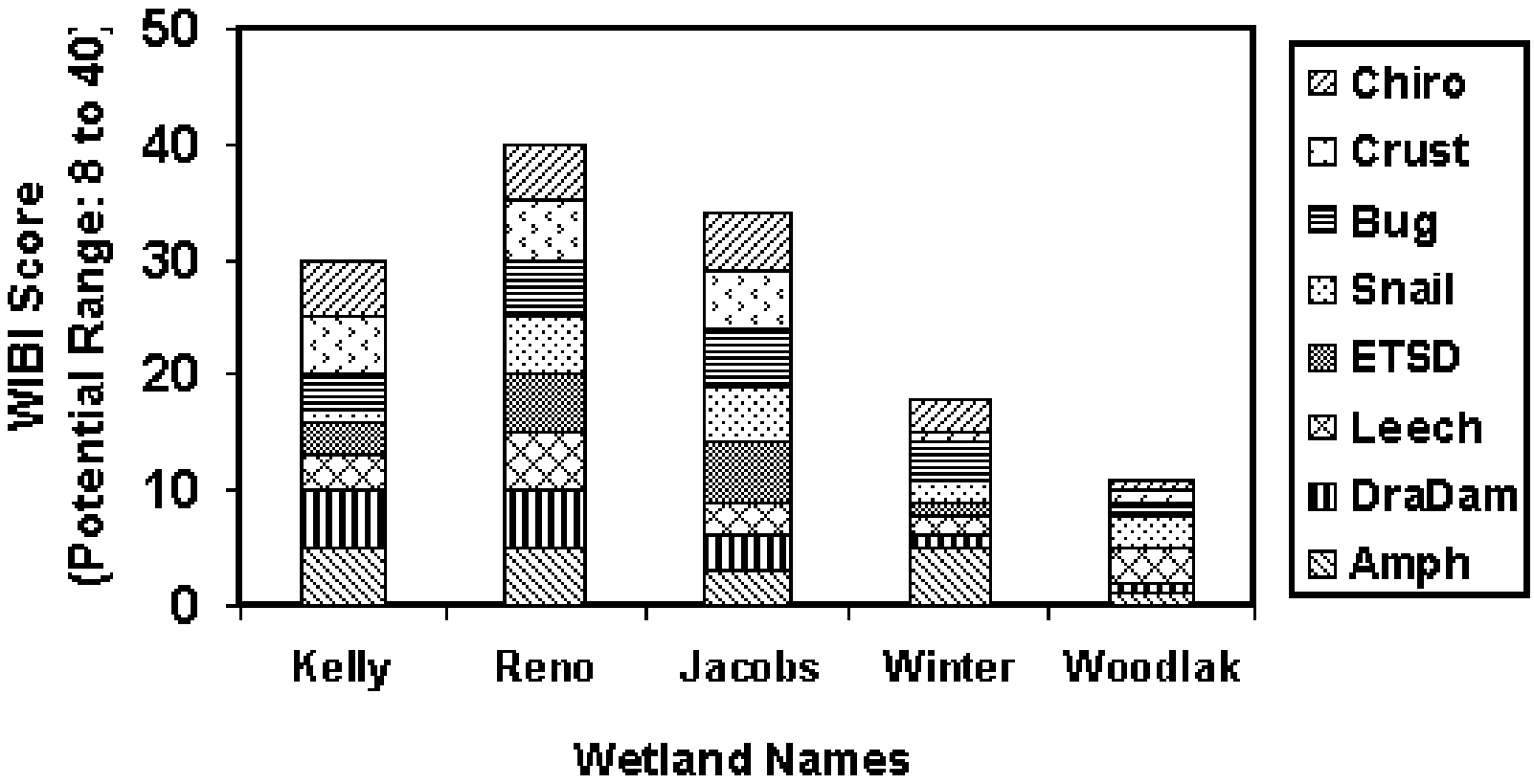
Figure 5: Index of Biological Integrity Scores of 40 Wetlands



Step 4- Test and Validate IBI

- One approach is to
  - randomly split the data into two halves,
  - develop the IBI on one half of the data, and
  - test the IBI on the other half of the data. The results should be similar.
  - can also test the IBI on more than one gradient of human disturbance.

Multimetric Approach



Wetland Index of Biological Integrity (WIBI) scores of five Minnesota wetlands using Macroinvertebrates.

Alberta Wetland Programs

Two major programs exist:

1. Development of IBI for Oilsands Wetlands
2. Alberta Biodiversity Monitoring Program (ABMP)

Alberta Wetland Programs

1) Development of IBI for Oilsands Wetlands

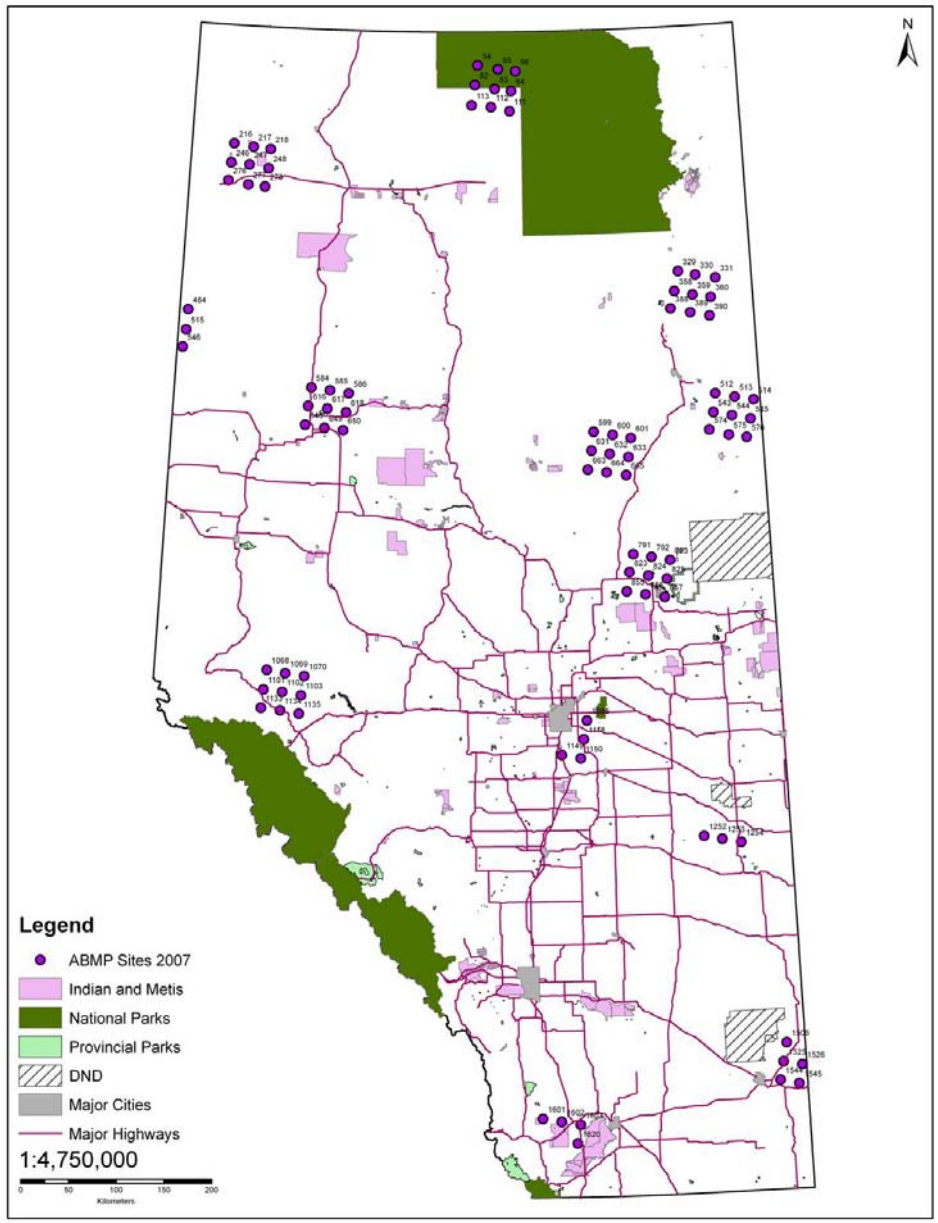
- U of A- funded by CEMA/CONRAD/Suncor/Syncrude
- Purpose is to develop multimetric IBI to assess success of oil sands wetland reclamation using 50 wetlands and include wetlands used to treat tailings
- Presently working on selecting specific indicators (macrophytes, algae, benthic invertebrates) to be contrasted among wetlands across impact gradient

2) Alberta Biodiversity Monitoring Program (ABMP)

- Organized by Alberta Biodiversity Monitoring Institute (ABMI)
- province wide, long term (100 years) monitoring program to provide information to natural resource decision-makers (terrestrial and aquatic)
- Board of directors include industry, government, first nations, UofA and NGOs
- Plan to assess ~1,500+ wetlands – indicators include macrophytes, riparian vegetation and macroinvertebrates
- Sites are randomly selected and will include pristine as well as impacted wetlands
- Goal is to eventually develop a multimetric IBI

ABMP cont.

- Measuring: water quality (nutrients only), macrophytes, riparian characteristics, human disturbance, bathymetry, water column macroinvertebrates



The End

Objectives & Approaches

Step	HGM (Hydrogeo-morphic) Approach	IBI (Biological) Approach
Objective	Assess Function	Assess Structure
Classification	HGM Classes	HGM Classes
Measures	Structural attributes that change with human disturbance	Structural attributes that change with human disturbance
Calculations	"multimetric" functional capacity indices	multimetric indices of biotic integrity (IBI)
Assumptions	structure infers function	function supported if structure supported

Wetland Health

- **Climate change** is predicted to have significant impacts especially in the northern peatlands