Integrating Natural Wetlands and Improving the Design of Naturalized Stormwater Management Facilities

Edmonton

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Day 1

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The goal of today's workshop is to …

Set the stage for an open discussion on the opportunity, and the considerations for incorporating natural wetlands into urban landscapes

Provide an overview on the types of wetlands in Alberta, with a discussion on the importance of climate, topography, and surrounding land-use in wetland development and long-term function

Look at wetland hydrology and the role of hydroperiod in determining productivity/function and wetland type

Wetland classification and delineation: timing, data collection, anthropogenic considerations

The wetland team: considerations for who to involve and when to begin

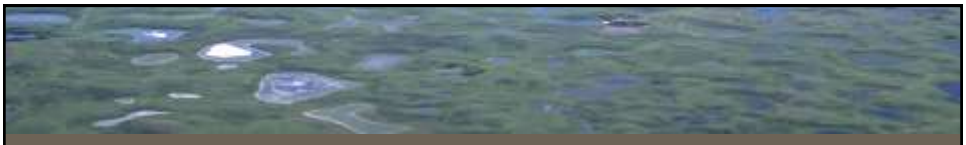
Our intention is to provide…

An awareness of how wetlands function and what they need to function properly.

A clearer insight into what wetlands you can protect from impact and which wetlands you cannot.

A recognition that wetlands do not function in isolation from the surrounding landscape. When changes to these habitats are many there can be cumulative affects that are not readily evident.

The goal is to use this information today as the benchmark for how to incorporate these environments. Think watersheds and design and manage with the big (and small) picture in mind.



The main objective in maintaining existing wetlands or constructing new storm water wetlands should be to preserve or construct them in a way that interventions are kept to a minimum over the lifespan of the pond. This requires project planners to identify and clearly define measurable goals from the beginning.

The most common causes of the failure of a natural or constructed wetland system in an urban setting is often related to unrealistic expectations, undefined objectives, or a poor understanding of wetland ecology or hydrology.

What is a wetland?

" … land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation, and various kinds of biological activity which are adapted to the wet environment."

(Wetlands of Canada, 1988, page 416)

What is a wetland?

" … land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation, and various kinds of biological activity which are adapted to the wet environment."

"… lands saturated with water long enough to promote the formation of water altered soils, growth of water tolerant vegetation, and various kinds of biological activity that are adapted to the wet environment"

Three Characteristics of Wetlands

hydrology: presence of water, either at the surface (< 2 m depth) or in the plant root zone so soil is *saturated* at some point during the growing season



Three Characteristics of Wetlands

soil: uniquely *hydric* soil conditions, different from adjacent uplands, that are associated with low oxygen conditions


Three Characteristics of Wetlands

vegetation: plants with specific adaptations to these hydrological conditions and hydric soils

Canadian wetland area

% of total provincial area

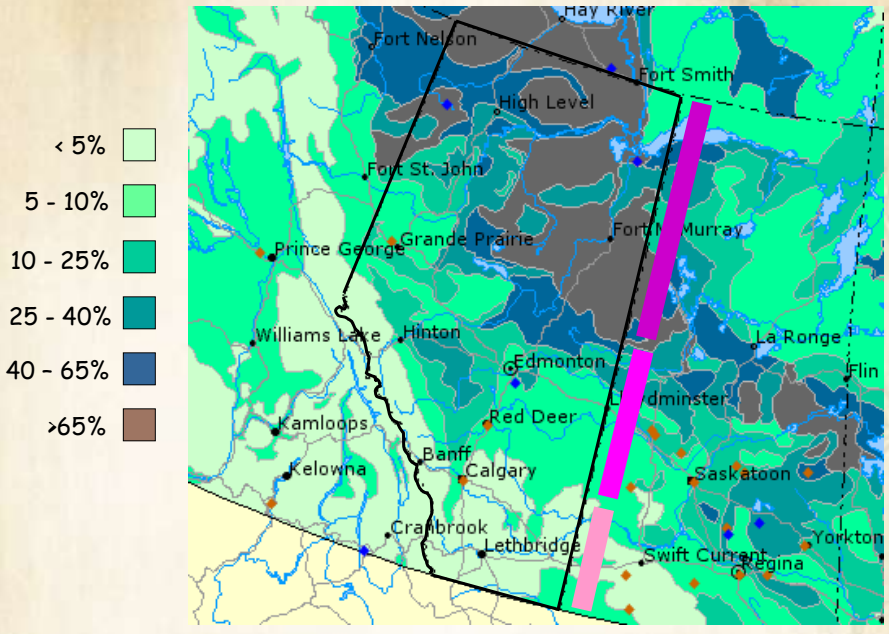
	%		%
BC	3	Nova Scotia	3
Alberta	21	New Brunswick	8
Sask.	17	Newfoundland	18
Manitoba	41	NWT	9
Ontario	33	Yukon	3
Quebec	9	CANADA (ha)	127,199,000
PEI	1	USA (ha)	41,800,000

- Canada has almost 3x the amount of wetlands as the U.S.

Wetland facts - Alberta

- 137,400 km^2 or 21% of Alberta covered in wetlands
- Alberta accounts for 11% of Canada's wetlands
- Wetland density varies from south to north
- Approximately 92% of AB wetlands are peatlands = 10.3 million ha
- 9% or 23,100 km^2 of wetlands are located in the white zone of AB. Small wetlands account for 809,400 ha

(Strong et al. 1993)
(Wilson et al. 2001)
(Bilyk et al. 1996)
(Vitt et al. 1996)



Natural Resources Canada at http://atlas.gc.ca

Wetlands are not all the same …

Marshes:

- Mainly mineral based wetlands
- Waterlogged soil in plant rooting zones, often with standing water at some point in the growing season
- Nutrient rich water results in greater plant diversity: emergent reeds, rushes, cattails, bulrushes and sedges
- Surface water levels often fluctuate seasonally and between years
- Areas of high biological productivity

North American Prairie Pothole Region:

covers approximately 715,000 km^2, extending from north-central Iowa to central Alberta

The landscape of the PPR is largely the result of glaciation events during the Pleistocene Epoch.

The retreat of glaciers (12,000 yrs ago) left behind a landscape dotted with many small depressional wetlands called potholes

Types of Prairie Marshes

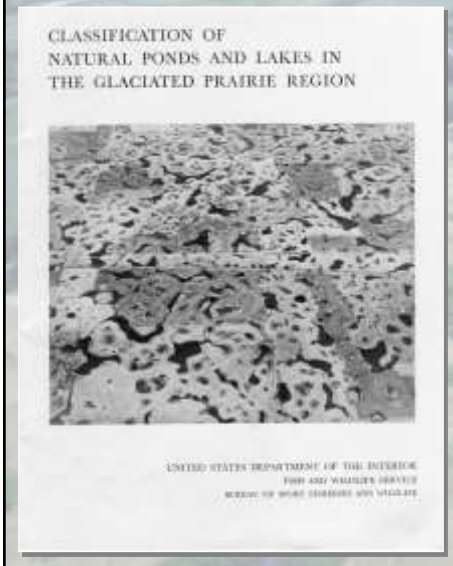
Surface water fed

Semi-permanent or Permanent

Wetland Classification

Why do we classify wetlands?

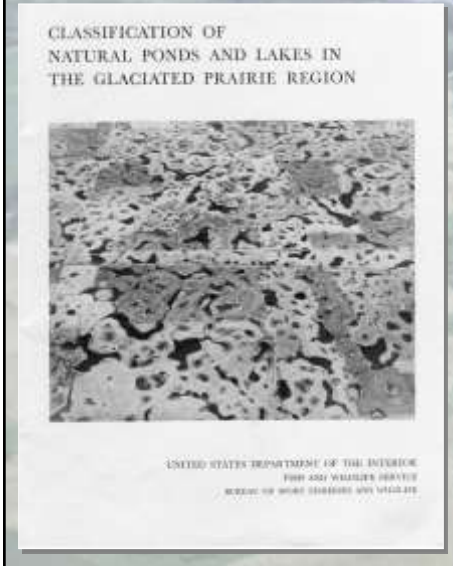
- Canada and Alberta has a great diversity of wetland types
- A classification system organizes this array of wetlands with a common set of names and descriptors that everyone can recognize so that conservation and mitigation strategies can be applied in a practical and consistent manner



Stewart and Kantrud (1971)

- Regional system based on vegetative growth
- Designed for use on the glaciated prairie region of the United States and Canada
- Allows for a detailed classification of a prairie wetland

Stewart, R. E. and H. A. Kantrud. 1971. *Classification of Natural Ponds and Lakes in the Glaciated Prairie Region.* Resource Publication 92, Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, U.S. Department of the Interior. 57 pp.



- The entire classification system is based on the premise that wetland vegetation can be grouped into zones
- These zones are closely related to differences in water permanence and water depths
- It recognizes that these zones may change seasonally and/or annually
- An additional feature of the Stewart and Kantrud (1971) system is the recognition of agriculture as a "disturbance" feature

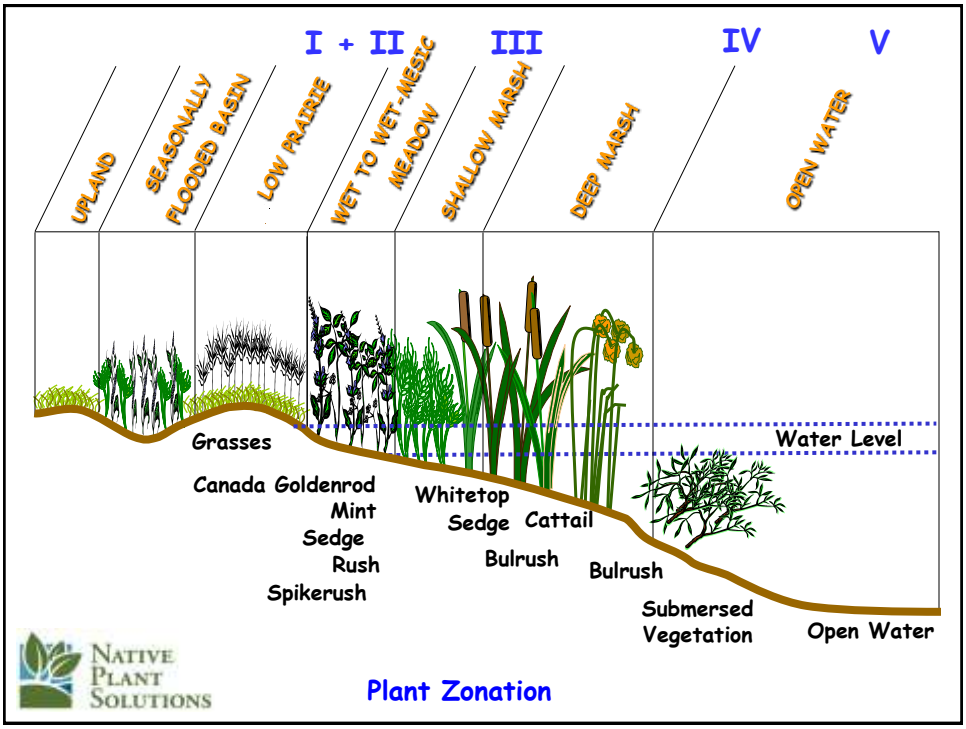
- **7 classes of wetlands**

Class I – Wetland low-prairie zone	
Class II – Wet meadow zone	A, B
Class III – Shallow marsh zone	A, B, C
Class IV - Deep-marsh zone	A, B, C, D, E
Class V– Permanent open-water zone	B, C, D, E
Class VI – Intermittent alkali zone	
Class VII - Fen zone	

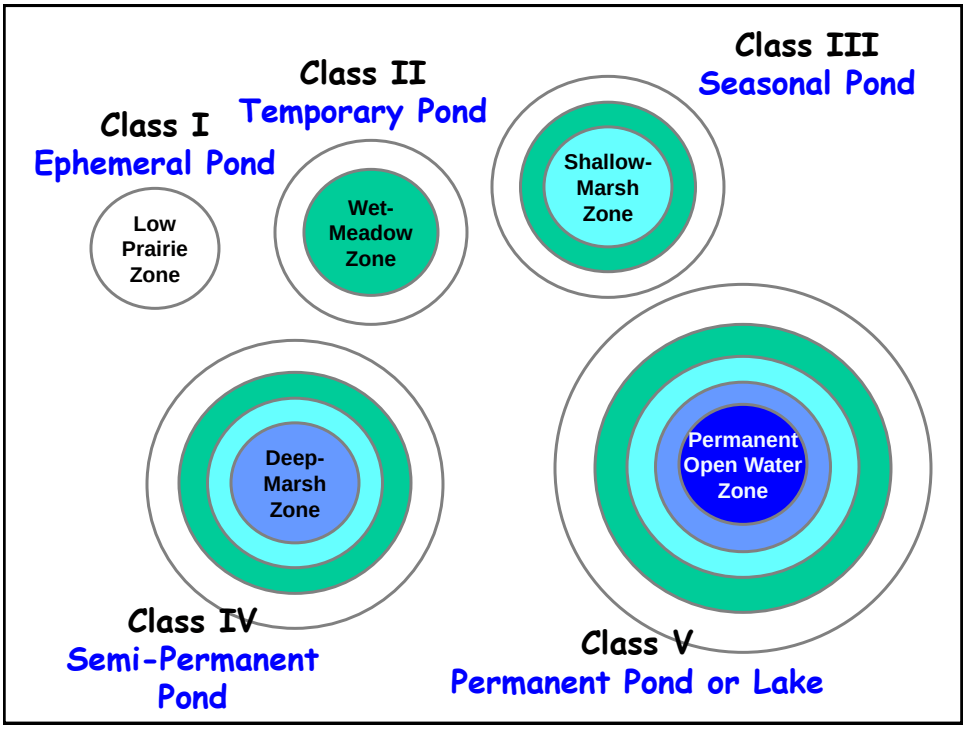
- **5 subclasses**

Subclass A-fresh
Subclass B-slightly brackish
Subclass C-moderately brackish
Subclass D-brackish
Subclass E-subsaline

- **4 cover types**



Plant Zonation



Low Prairie Zone

Ephemeral Ponds (Class 1)

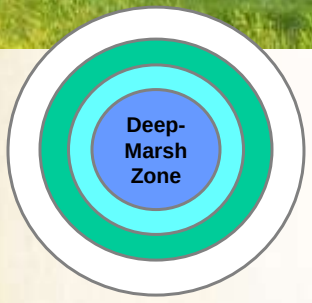
Class	Name	Characteristics
I	Ephemeral (low prairie zone)	▪ free surface water for short time, usually after snowmelt or storm events ▪ rapid water seepage because of local soils ▪ may establish some wetland or aquatic processes

Temporary Ponds (Class II)

Class	Name	Characteristics
II	Temporary (wet meadow zone)	▪ standing water usually in spring ▪ more rapid soil infiltration but may linger after heavy rain or colder spring conditions ▪ may establish some wetland or aquatic processes

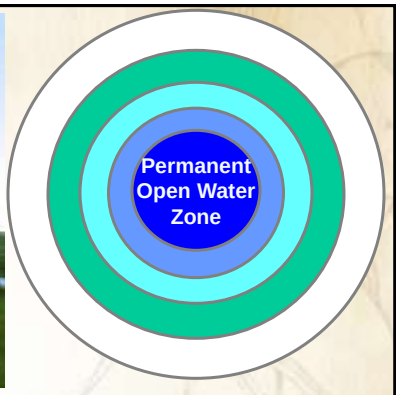
Seasonal Ponds (Class III)

Class	Name	Characteristics
III	Seasonal (shallow marsh zone)	▪ surface water 1-3 months in spring ▪ shallow marsh vegetation ▪ typically dry up during mid- to late summer



Semi-permanent Ponds (Class IV)

Class	Name	Characteristics
IV	Semi-permanent (May – Sept) (deep marsh zone)	▪ frequently maintains water throughout growing season ▪ tends to hold water at least 4 out of 5 years



Permanent Ponds (Class V)

Class	Name	Characteristics
V	Permanent ponds and lakes (central open water zone)	▪ permanent open water ▪ central pond area generally devoid of emergent vegetation ▪ can be confused with semi-permanent ponds

Common Plants of the Wet Meadow Zone:

Normal Emergent Phase (Fresh):

Primary Species:
Poa palustris (x)
Carex praegracilis
Carex sartwellii
Carex lanuginosa
Boltonia latisquama
Aster simplex (x)

Normal Emergent Phase (Brackish):

Primary Species:
Hordeum jubatum (x)
Calamagrostis inexpansa (x)
Spartina pectinata (x)
Carex sartwellii
juncus balticus (x)
Aster simplex

Common Plants of the Deep Marsh Zone (fresh):

Normal Emergent Phase:

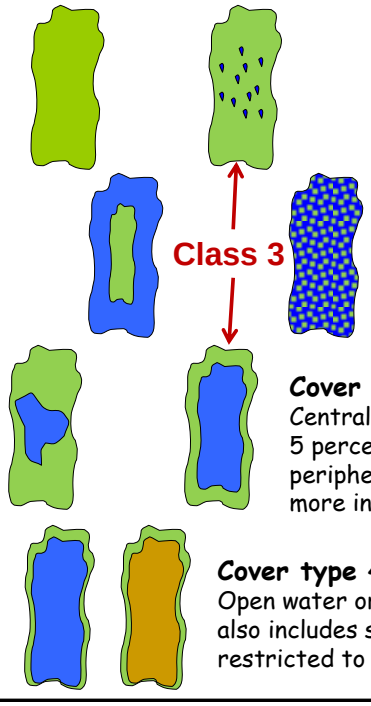
Dominants:

Primary Species:
Scirpus heterochaetus

Secondary Species:
Typha latifolia
Scirpus fluviatilis

Normal Open Water Phase:

Primary Species:
Potamogeton pusillus
Utricularia vulgaris



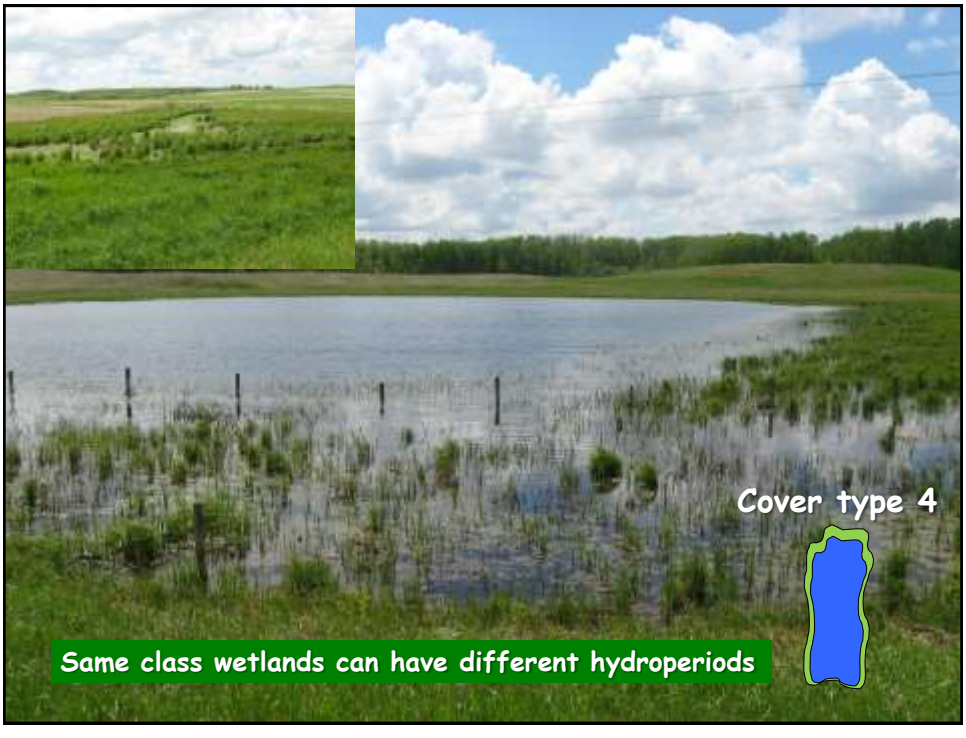
Cover type 1:
Closed stands of emergents with open water or bare soil covering less than 5 percent of the wetland area

Cover type 2:
Open water or bare soil covering 5 to 95 percent of the wetland area, with scattered patches of emergent cover, or closed stands of emergents in the central portion of a pond

Cover type 3:
Central expanses of open water or bare soil (more than 5 percent of the wetland area) surrounded by peripheral bands of emergent cover averaging 6 feet or more in width

Cover type 4:
Open water or bare soil covers more than 95 percent. This also includes small ponds in which emergent cover is restricted to marginal bands less than 6 feet in width


Cover type 3


Cover type 4
Same class wetlands can have different hydroperiods

Wetland Classification - what can it provide?

- Characterization of the physical state of the wetland (size, water depth, surrounding slope, catchment characteristics)
- Assessment of the vegetation communities and sensitive species (biodiversity, production, density, general health, presence of pathogens, pests, or exotic species)
- Insight into present and past hydrological conditions (surface, water levels, hydrological regime)
- Assessment of the wildlife biodiversity and possible sensitive species (birds, mammals, fish, reptiles, invertebrates, micro-organisms)
- Insight into anthropogenic impacts

Wetland Classification and Methodology:

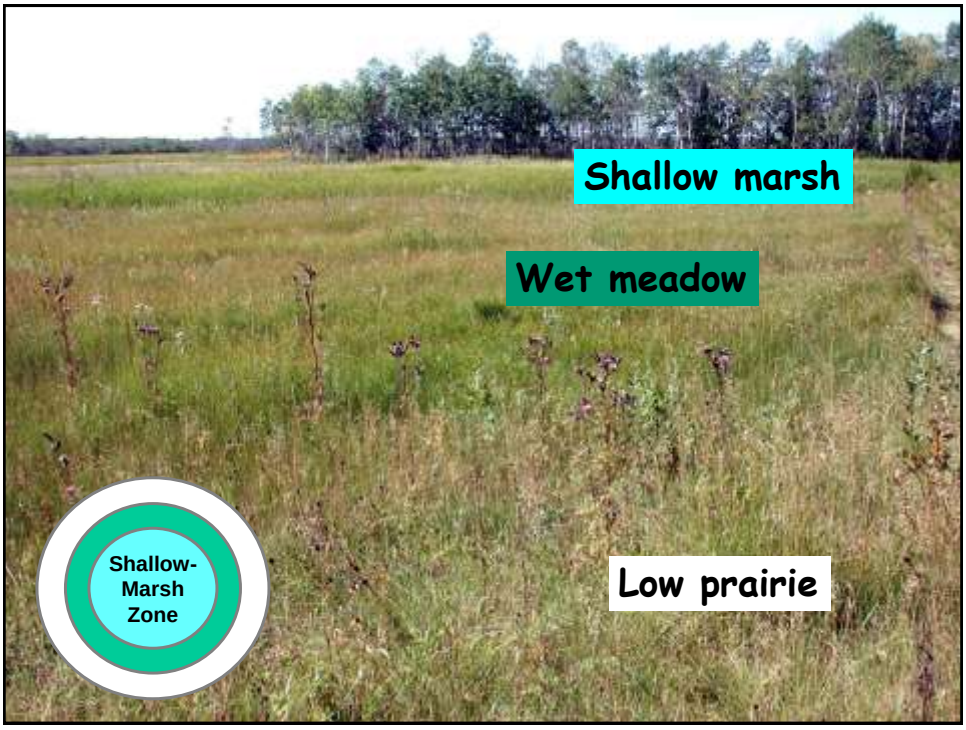
- Time of year
- Present conditions compared to past years
- Data Collection
  - What to Collect
  - When to Collect
  - How Often to Collect

Time of Year

April/May = spring water conditions

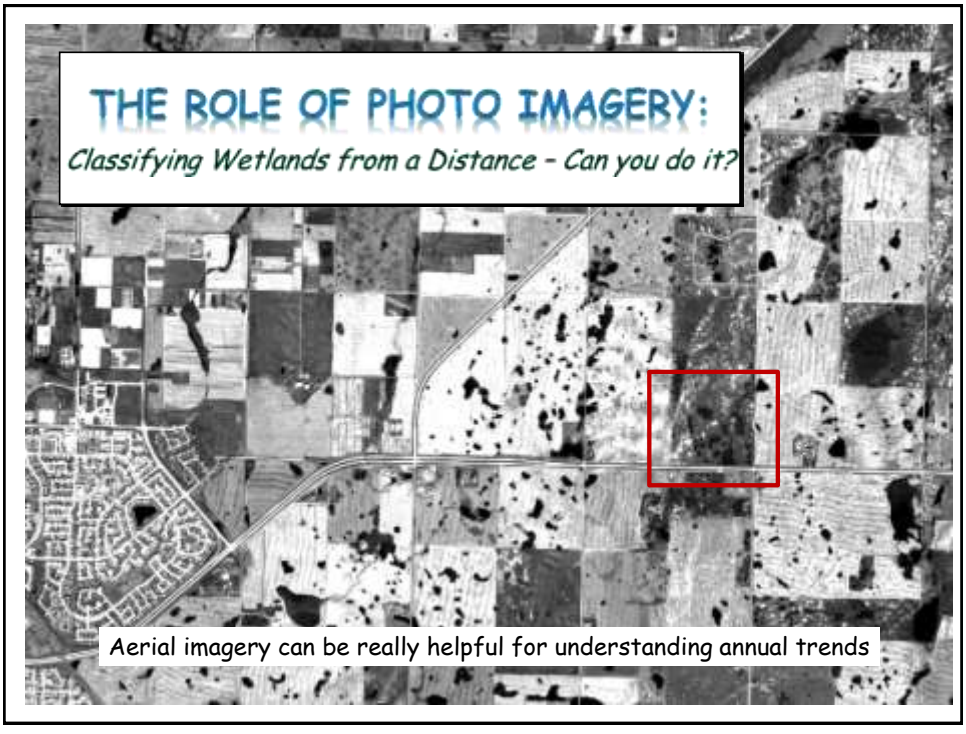
Late July/August = good plant conditions

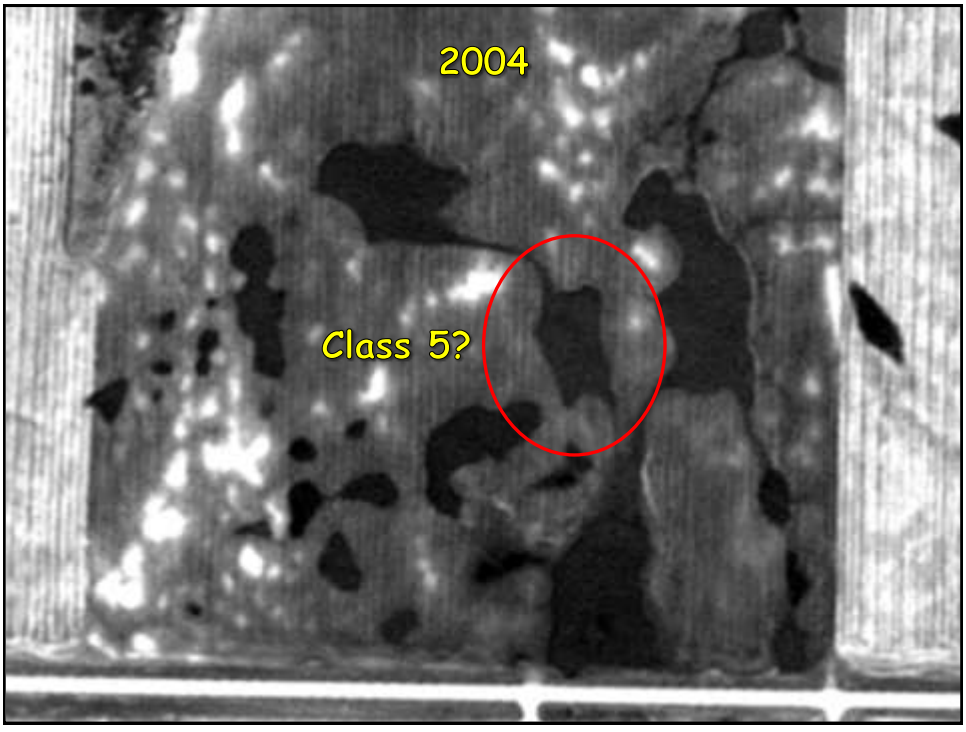
August conditions showing the yellow color of Phragmites

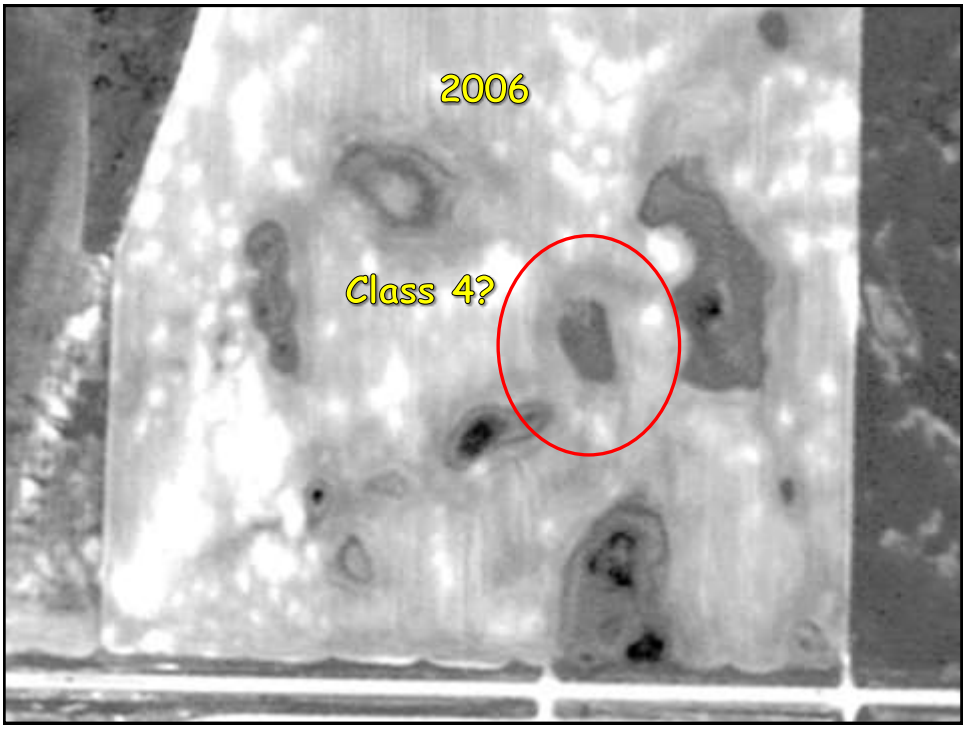


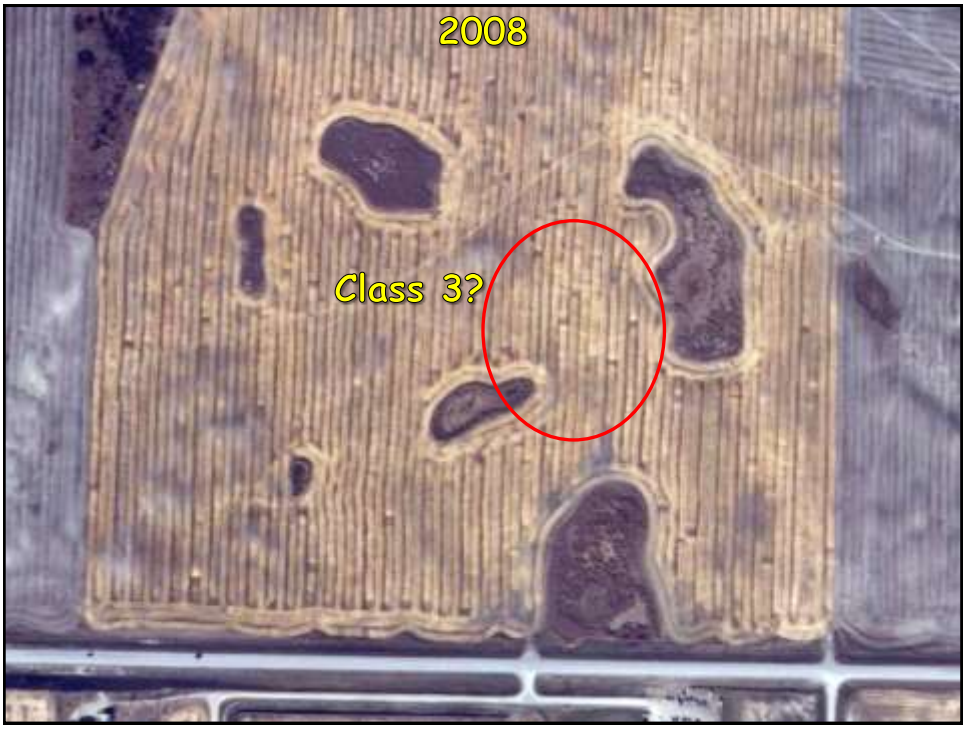
Present Hydrological Conditions versus Past Years

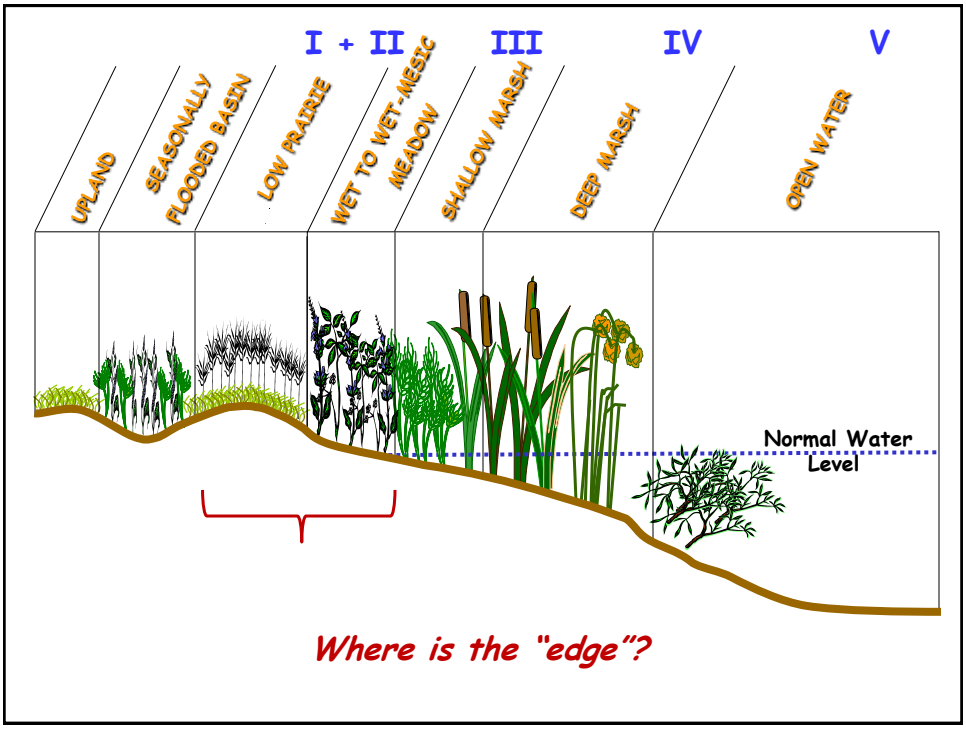

1988
1991
1992
1993


THE ROLE OF PHOTO IMAGERY:
Classifying Wetlands from a Distance - Can you do it?
Aerial imagery can be really helpful for understanding annual trends

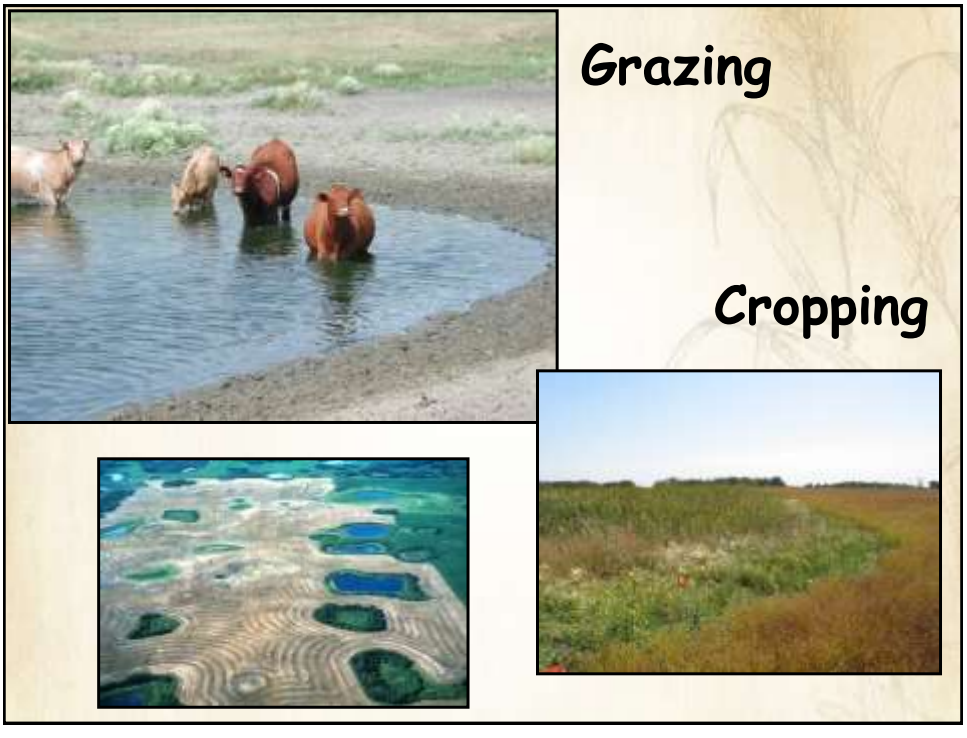

2004
Class 5?


2006
Class 4?


2008
Class 3?

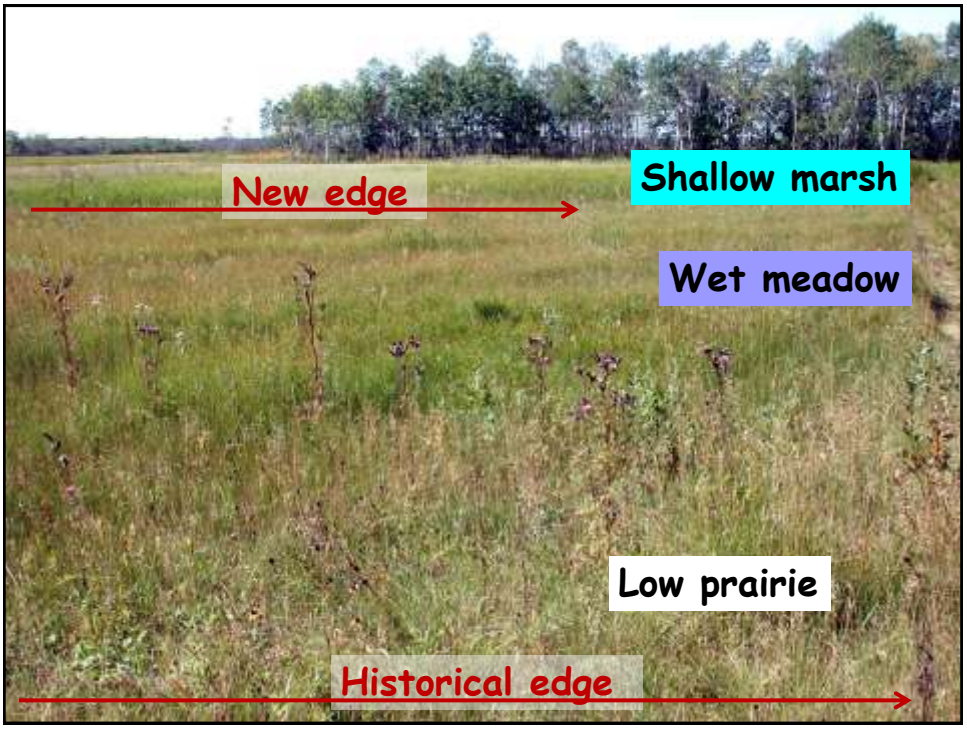

I + II
III
IV
V
UPLAND
SEASONALLY FLOODED BASIN
LOW PRAIRIE
WET TO WET-MESIC MEADOW
SHALLOW MARSH
DEEP MARSH
OPEN WATER
Normal Water Level
Where is the "edge"?


Edge effects


Grazing
Cropping

Recognizing how land-use impacts wetland edges and hydrology is important … especially when delineating and planning for preservation

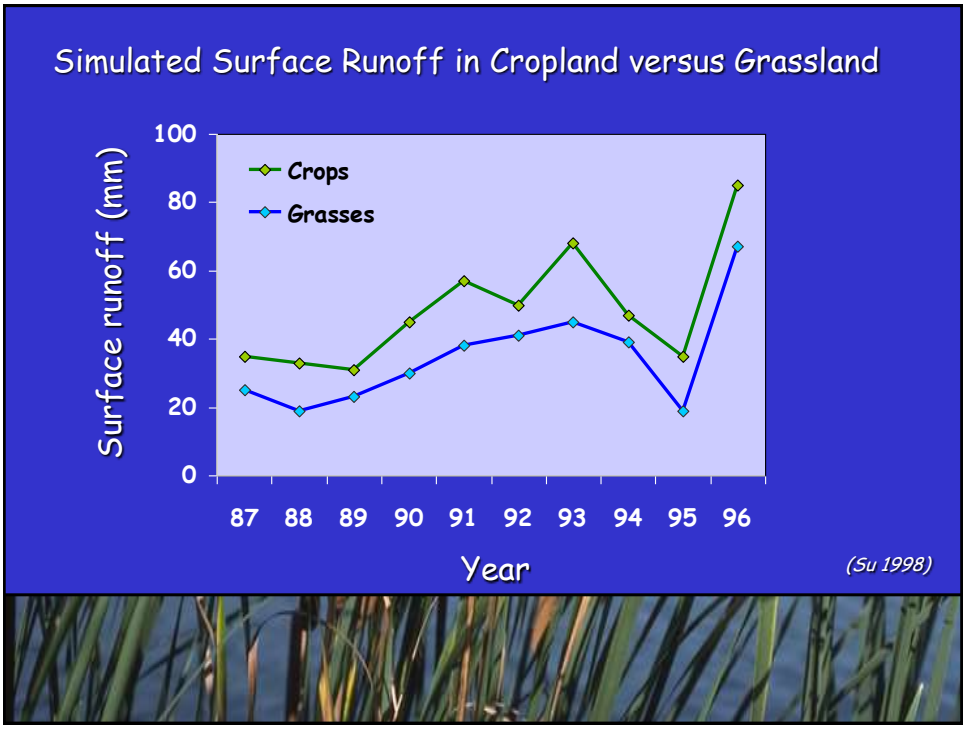
Wetland	Class 4	Class 3	Deep Marsh	Shallow Marsh	Wet Meadow	Low Prairie	
Common 1	X		X	X		X	WM
Common 2		X		X	X	X	
Common 3		X		X	X		LP
Fraser 1	X		X	X	X		LP
Fraser 2		X		X		X	WM
Fraser 3		X		X		X	WM
McInnis 1		X		X		X	WM
McInnis 2	X		X	X		X	WM
McInnis 3	X		X	X		X	WM
Wilkins 1		X		X	X		LP
Wilkins 2		X		X	X		LP
Wilkins 3		X		X	X		LP
MZT 232	X		X	X	X	X	
MZT 222	X		X	X	X	X	
MZT 216	X		X	X	X	X	
StD 109		X		X	X	X	
StD 117		X		X	X	X	
StD 120		X		X	X	X	
StD 65	X		X	X	X	X	
StD 66	X		X	X	X	X	
StD 67	X		X	X	X	X	
Total:	10	11	10	21	15	16	11



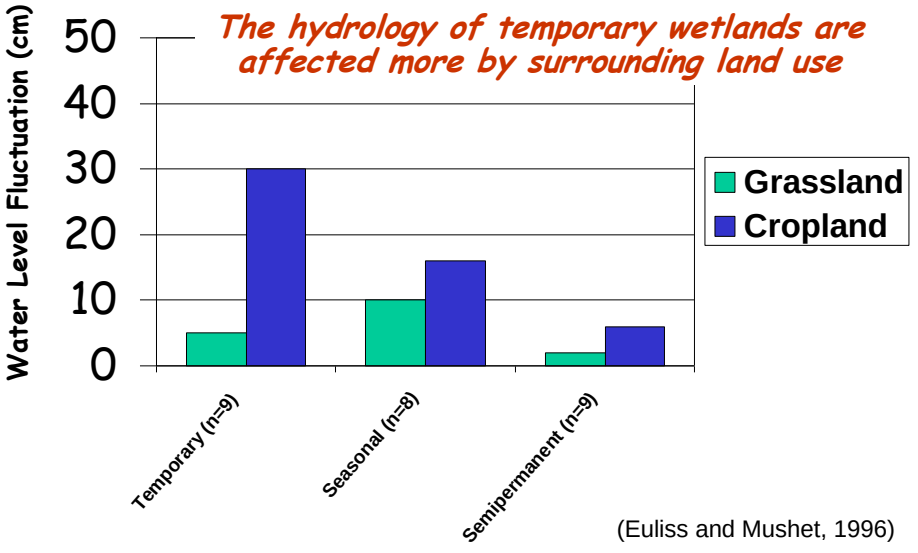
What Role do buffer zones play?

- The highest plant diversity and the greatest number of native plant species tend to be located in the low prairie (LP) and wet meadow (WM) zones of wetlands
- 99% of wetlands in traditional farming landscapes are missing either their WM or LP zones
- For wetlands in cropped landscapes – the SM zone functions like the LP zone in native wetlands
- Healthy "edge" zones decrease the # of invasive species present


How does land-use affect hydrology?

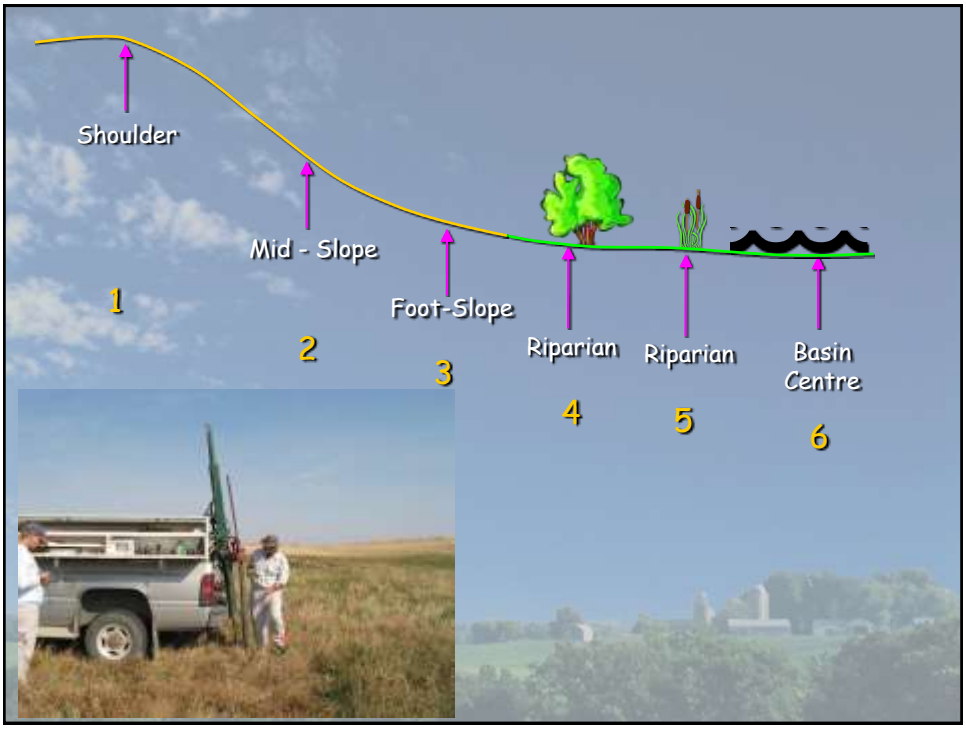

Simulated Surface Runoff in Cropland versus Grassland
Surface runoff (mm)
100
80
60
40
20
0
Crops
Grasses
87
88
89
90
91
92
93
94
95
96
Year
(Su 1998)

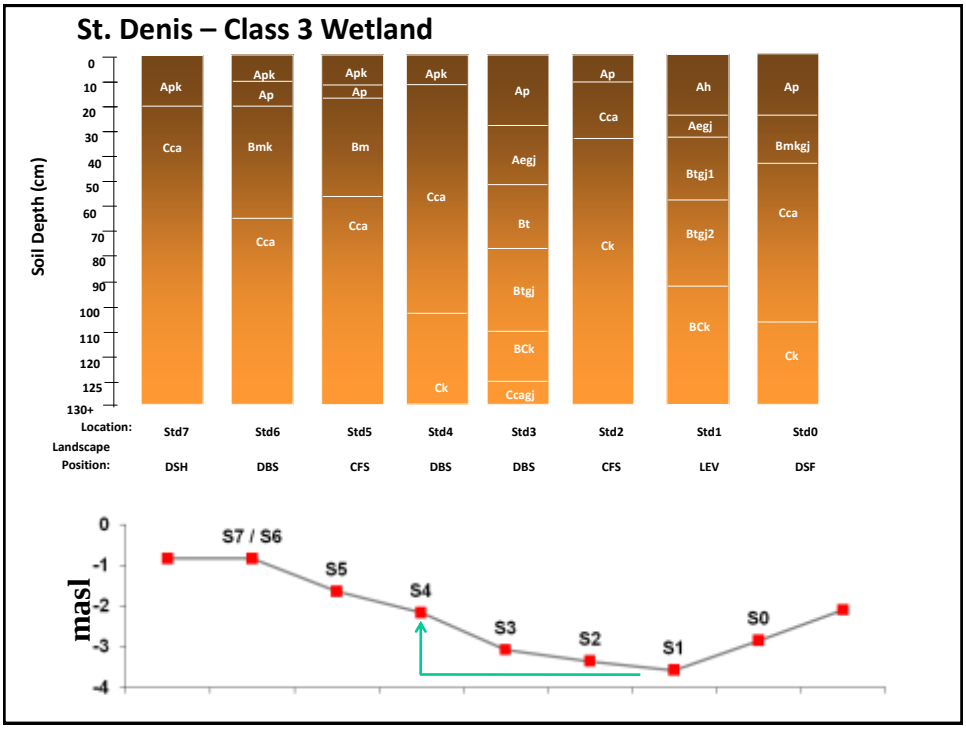
Water level fluctuation as a function of landscape position



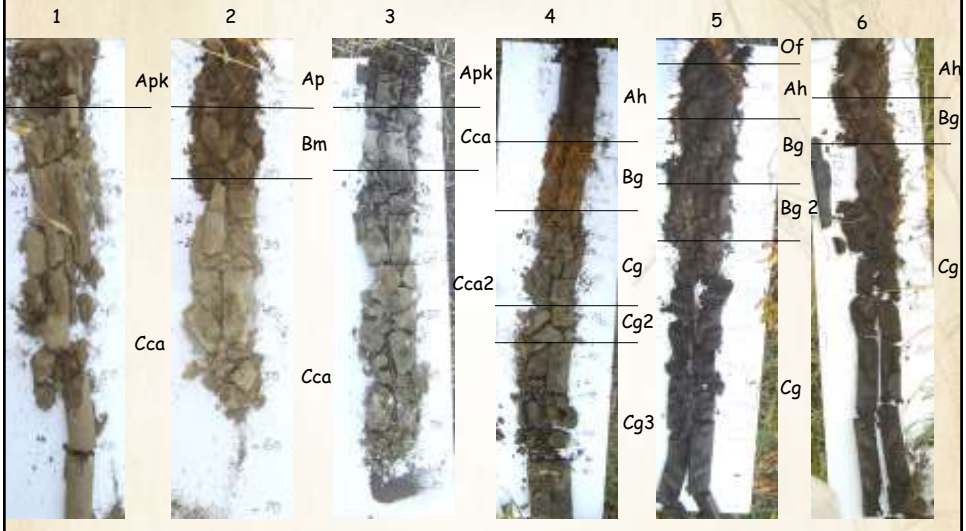
(Euliss and Mushet, 1996)

For locating the "edge" … soils may be your best bet

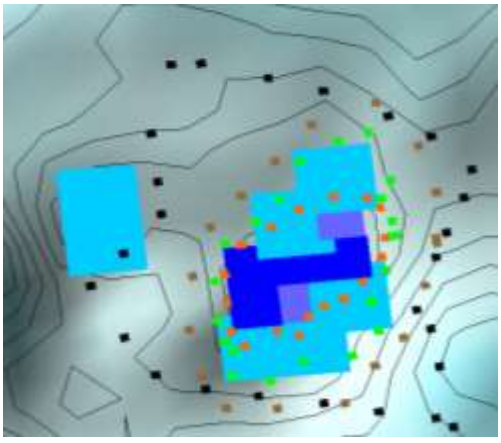

Shoulder
Mid - Slope
Foot-Slope
Riparian
Riparian
Basin Centre
1
2
3
4
5
6


St. Denis – Class 3 Wetland
Soil Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
110
120
125
130+
Std7 Apk Cca
Std6 Apk Ap Bmk Cca
Std5 Apk Ap Bm Cca
Std4 Apk Cca Ck
Std3 Ap Aegj Bt Btgj BCk Ccagj
Std2 Ap Cca Ck
Std1 Ah Aegj Btgj1 Btgj2 BCk
Std0 Ap Bmkgj Cca Ck
Location:
Landscape Position:
Std7 Std6 Std5 Std4 Std3 Std2 Std1 Std0
DSH DBS CFS DBS DBS CFS LEV DSF
masl
0
-1
-2
-3
-4
S7 / S6
S5
S4
S3
S2
S1
S0

Class 4 Wetland



Pond 117 – St. Denis, SK



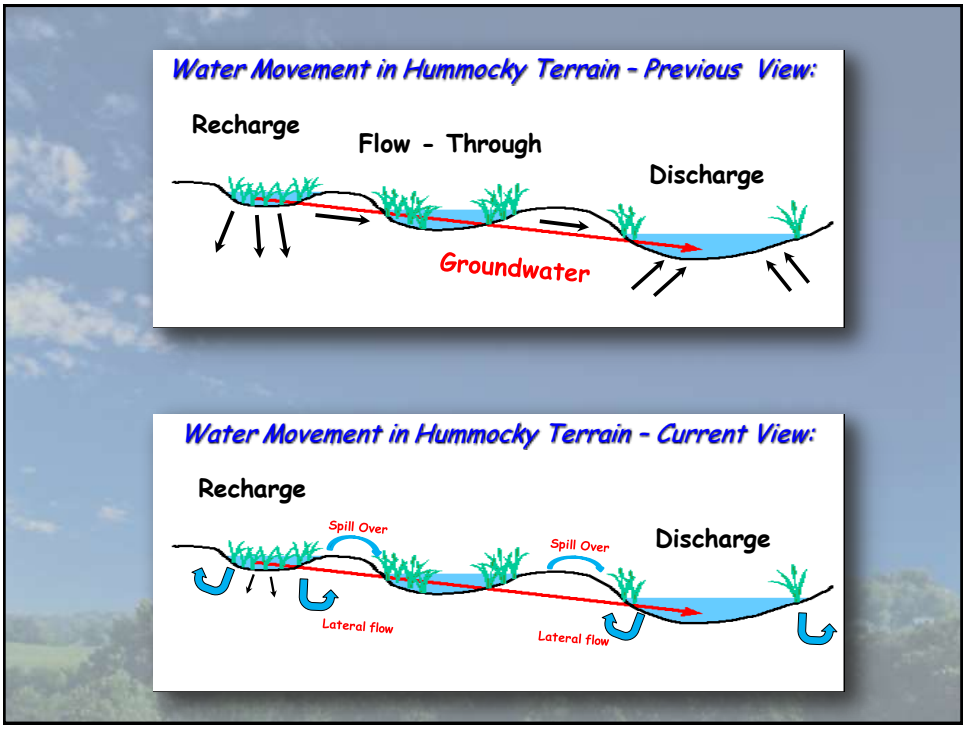
Wetland Vegetation Zones:

- Shallow marsh
- Wet meadow
- Low prairie
- Carbonate ring

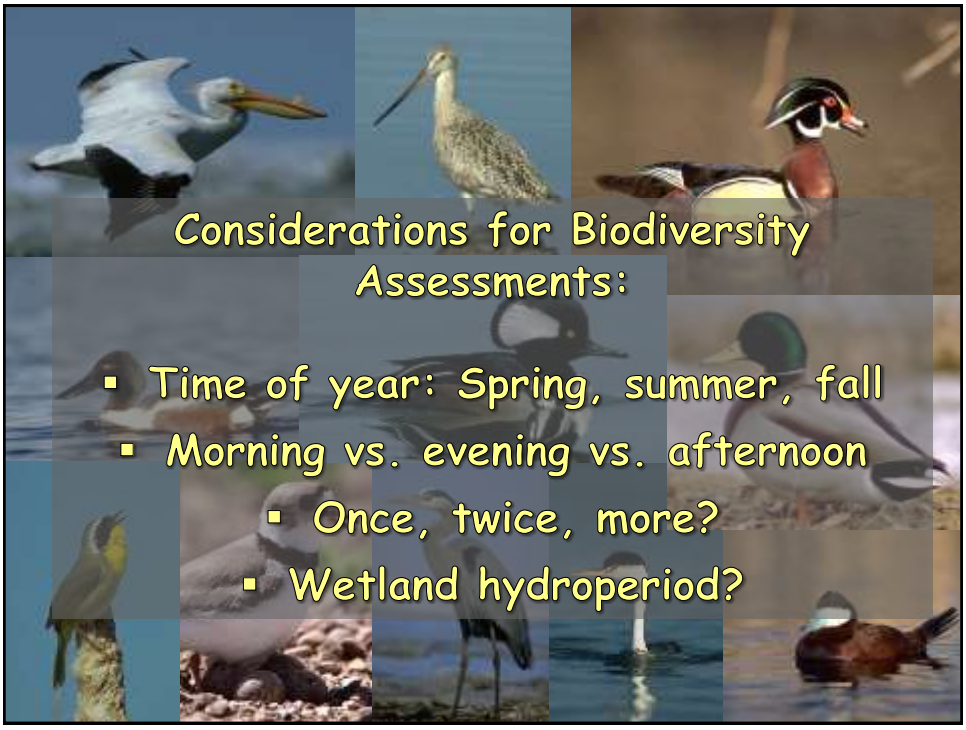
Water Depths:

- 10 to 30 cm
- 31 to 50 cm
- 51 to 100 cm

Seasonal, Class 3 wetland


Water Movement in Hummocky Terrain – Previous View:
Recharge
Flow - Through
Discharge
Groundwater
Water Movement in Hummocky Terrain – Current View:
Recharge
Spill Over
Spill Over
Discharge
Lateral flow
Lateral flow

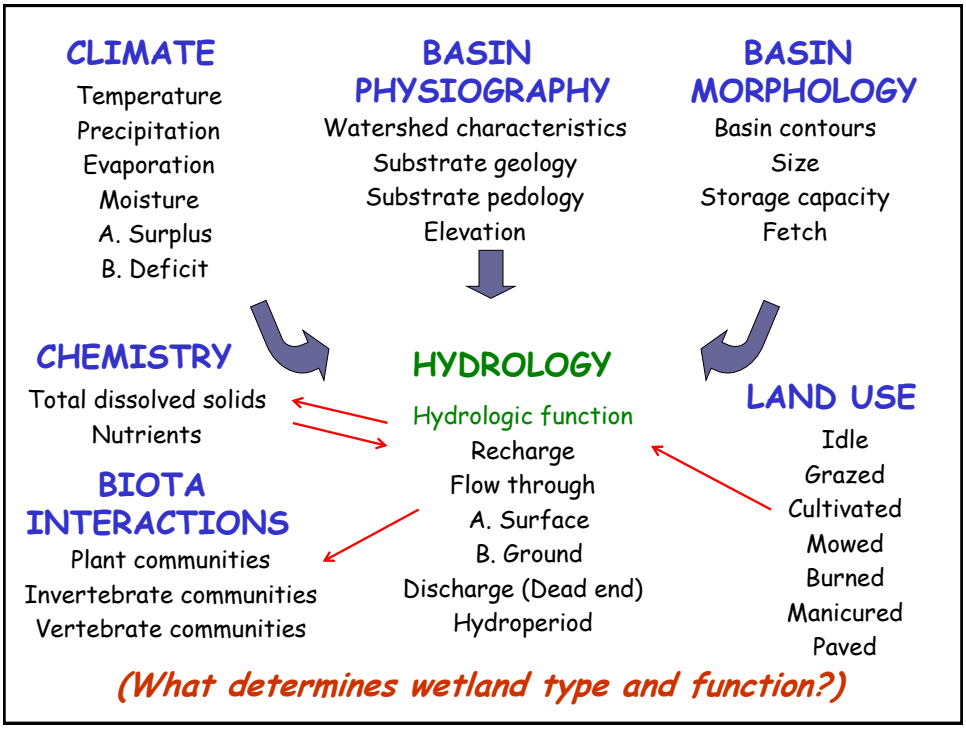

Wetlands as habitat …



Wetland Classification and Site Assessments:

- Time of Year
- Present Conditions compared to past Years
- Data Collection
  - What to Collect – soil, vegetation, hydrology, fauna
  - When to Collect – spring, summer, fall
  - How Often to Collect – depends on data
- Understanding Anthropogenic Impacts


Three key hydrological considerations:
How often is the wetland flooded?
How deep is it flooded?
How long is it flooded?
Highs … lows … and averages are all important


CLIMATE
Temperature
Precipitation
Evaporation
Moisture
A. Surplus
B. Deficit
BASIN PHYSIOGRAPHY
Watershed characteristics
Substrate geology
Substrate pedology
Elevation
BASIN MORPHOLOGY
Basin contours
Size
Storage capacity
Fetch
CHEMISTRY
Total dissolved solids
Nutrients
HYDROLOGY
Hydrologic function
Recharge
Flow through
A. Surface
B. Ground
Discharge (Dead end)
Hydroperiod
LAND USE
Idle
Grazed
Cultivated
Mowed
Burned
Manicured
Paved
BIOTA INTERACTIONS
Plant communities
Invertebrate communities
Vertebrate communities
(What determines wetland type and function?)

CHEMISTRY

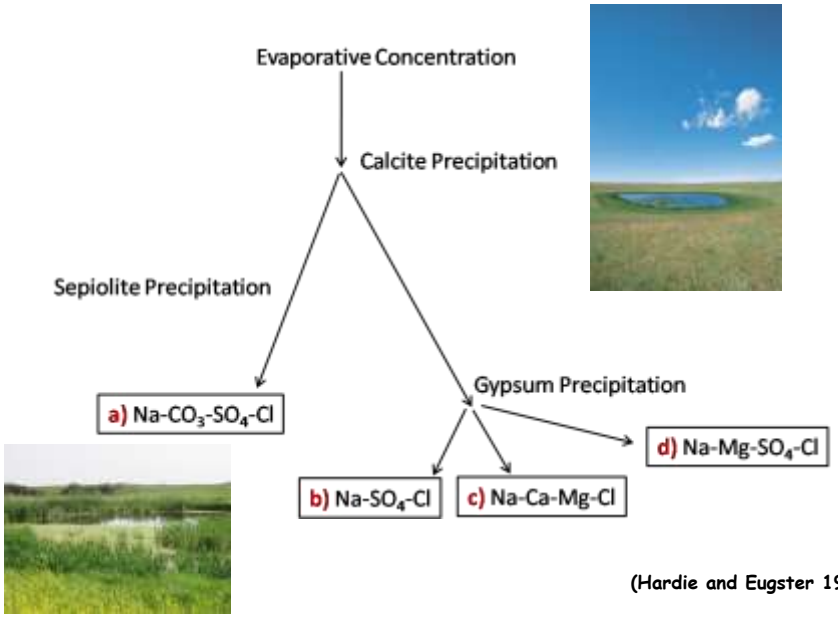
Total dissolved solids
Nutrients

HYDROLOGY

Hydrologic function
Recharge
Flow through
A. Surface
B. Ground
Discharge (Dead end)
Hydroperiod

Key considerations for maintaining natural wetlands …

Closed Basin Brine Evolution



(Hardie and Eugster 1970)

Summary of Water Chemistry from St. Denis Wetlands

Pond #	TN	TP	PO_4^{3-}	HCO_3	SO_4^{-}	Cl^{-}	Na^{+}	Mg^{2+}	K^{+}	Ca^{2+}	TDS	EC	Source	Max H_2O level
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	uS/cm		cm
65	1.83	0.17	0.07	561.8	1619.1	48.1	262.2	322.4	43.8	109.90	2603	2395[y]	1[z]	143.9[x]
66	4.32	0.41	0.02	528.5	24318.5	833.8	4656.4	3576.6	284.2	232.02	38916	35803	1	94.0
67	2.55	0.14	0.02	610.9	3320.0	97.9	496.1	616.9	70.7	158.59	4216	3879	1	154.0
120	3.60	0.89	0.95	144.2	10.0	29.5	1.4	8.2	47.2	27.80	187	313	2	103.0
117	1.83	1.30	0.90	167.7	11.5	38.0	1.3	10.3	64.0	30.33	234	473	2	136.5

[z]Sources:

1: WEVS data from Dr. M. Waiser. The WEVS data are means of all sampling days gathered during the study (i.e., 12 days in 1993 (29 April to 14 Oct), 10 days in 1994 (11 May to 12 Oct), and 14 days in 1995 (30 May to 15 Oct).

2: Data provided by Ducks Unlimited Canada. The DUC data are means of all sampling days (i.e., 2 days in 2004 (April 16, June 16) and 3 days in 2005 (April 27, June 8, July 19).

[y]The EC values for the WEVS data were calculated as EC ($\mu S\ cm^{-1}$) = 1.087 * TDS (ppm)

From Chang et al. (1983) Can. J. Soil Sci. 63: 79-86.

[x]Data from 1968 to 2005 data (provided by Dr. Van der Kamp, NWRI)

HYDROLOGY

Hydrologic function

Recharge

Flow through

A. Surface

B. Ground

Discharge (Dead end)

Hydroperiod

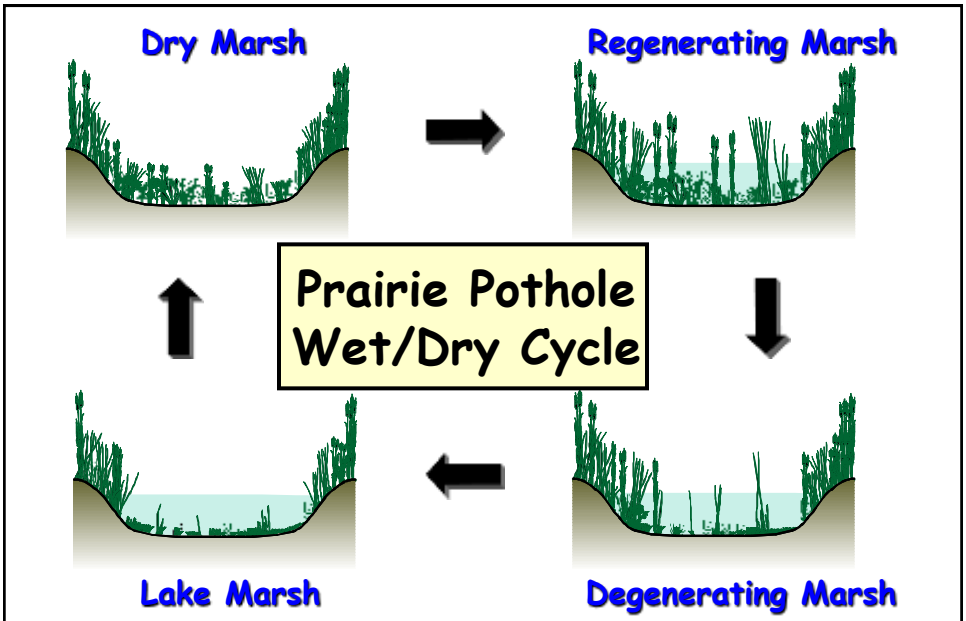
BIOTA INTERACTIONS

Plant communities

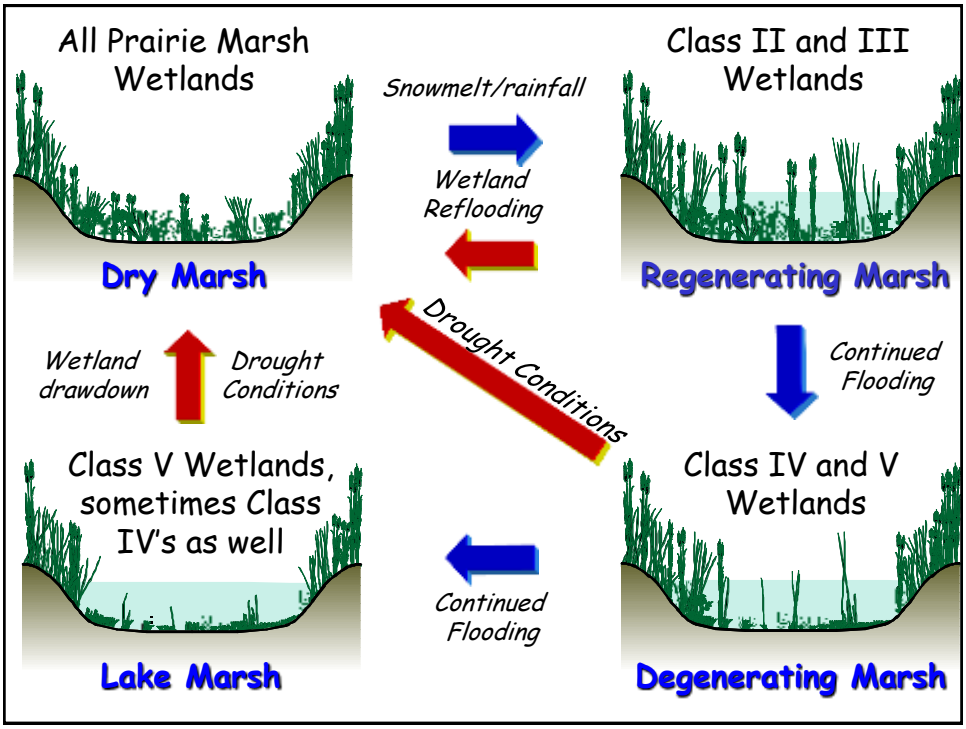
Invertebrate communities

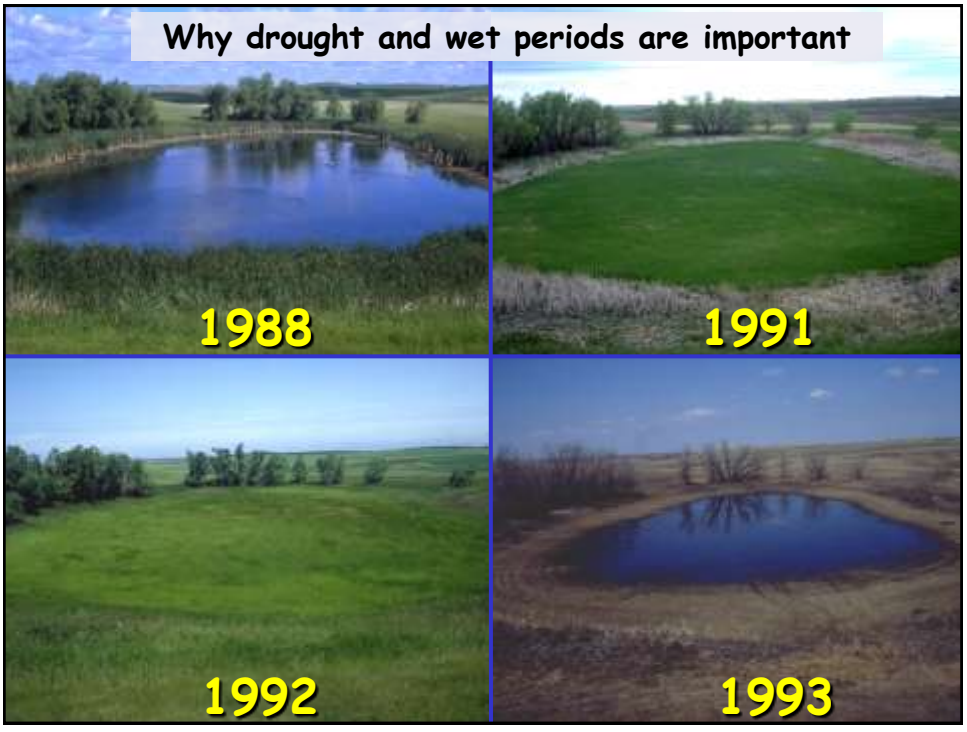
Vertebrate communities

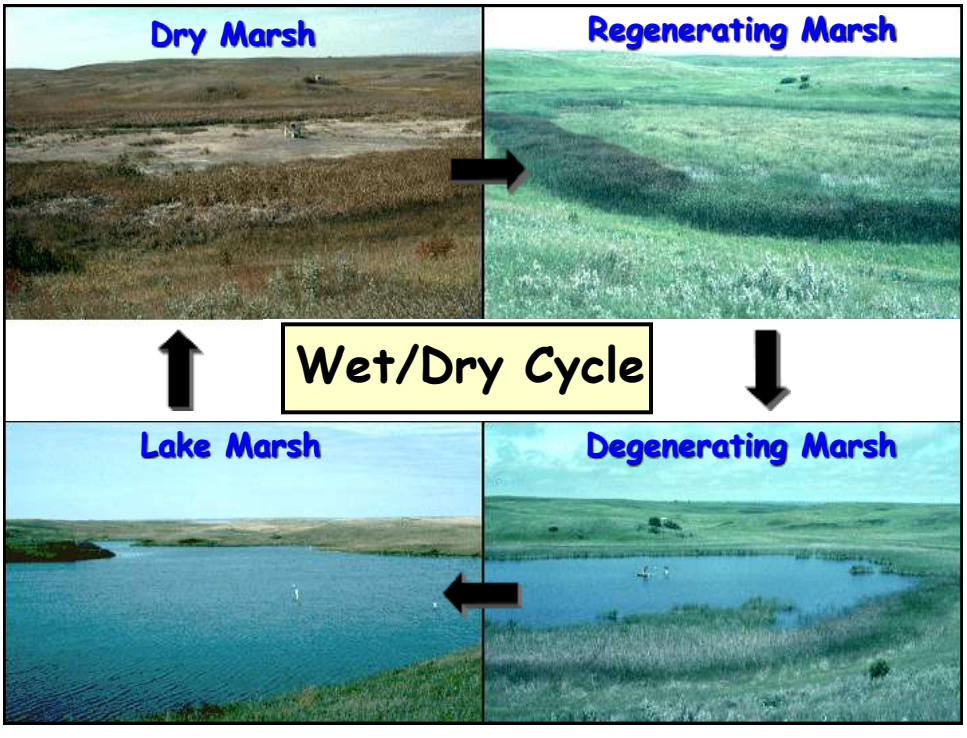
(What determines wetland type and function?)



van der Valk, A.G., and Davis, C.B. 1978. The role of seed banks in the vegetation dynamics of prairie glacial marshes. Ecology 59:322-335.

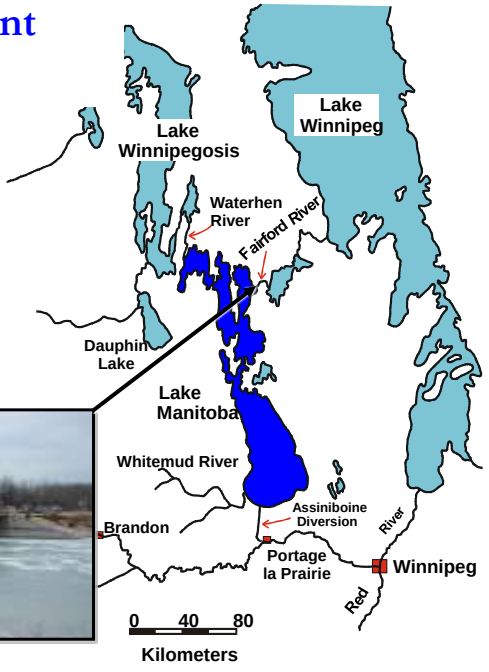



Why drought and wet periods are important
1988
1991
1992
1993

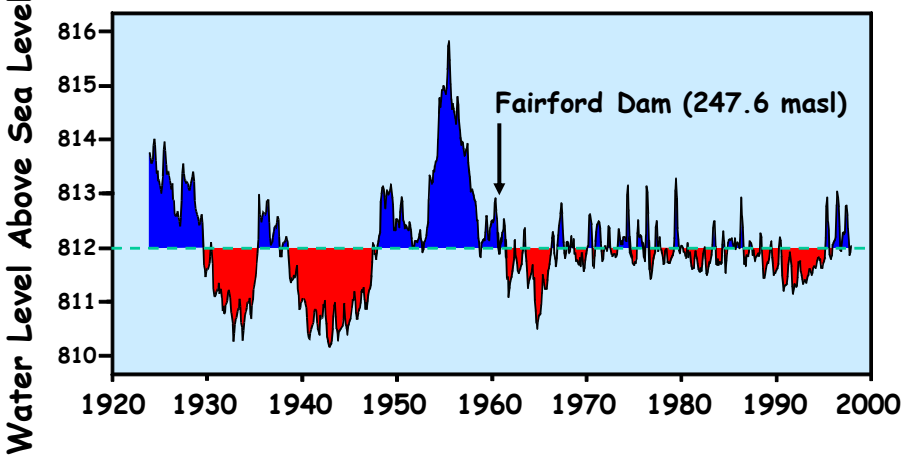

Dry Marsh
Regenerating Marsh
Wet/Dry Cycle
Lake Marsh
Degenerating Marsh

Water level management on Lake Manitoba

- severe flooding on Lake Manitoba during mid-1950s was incentive for construction of Fairford Dam in 1961



Lake Manitoba Water Levels



The Delta Marsh

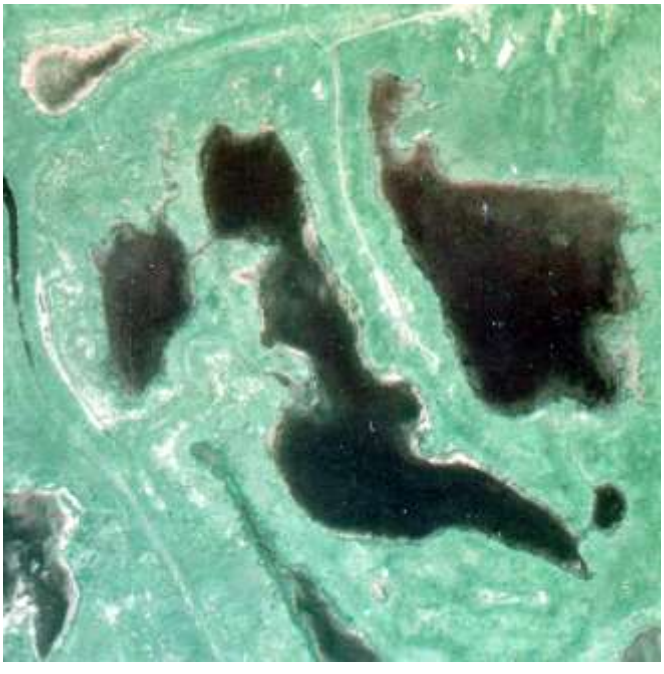
Simpson Bay 1965

Simpson Bay

1997

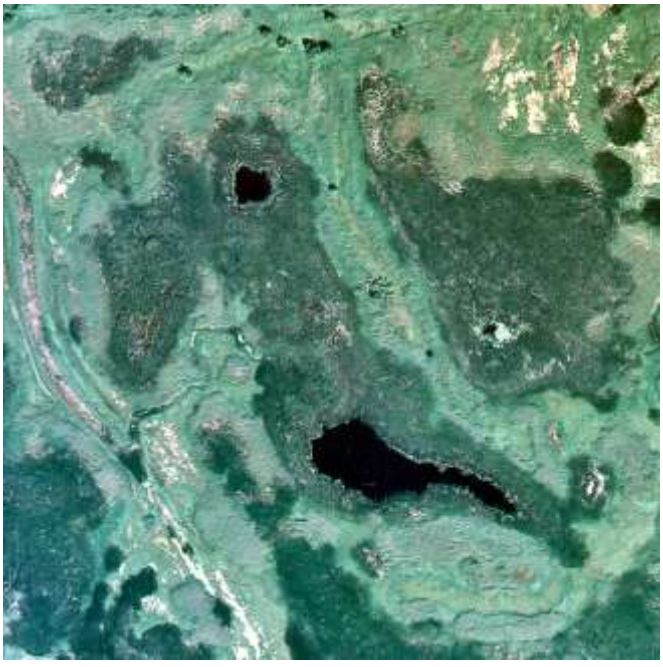
Hutchinson's Pothole

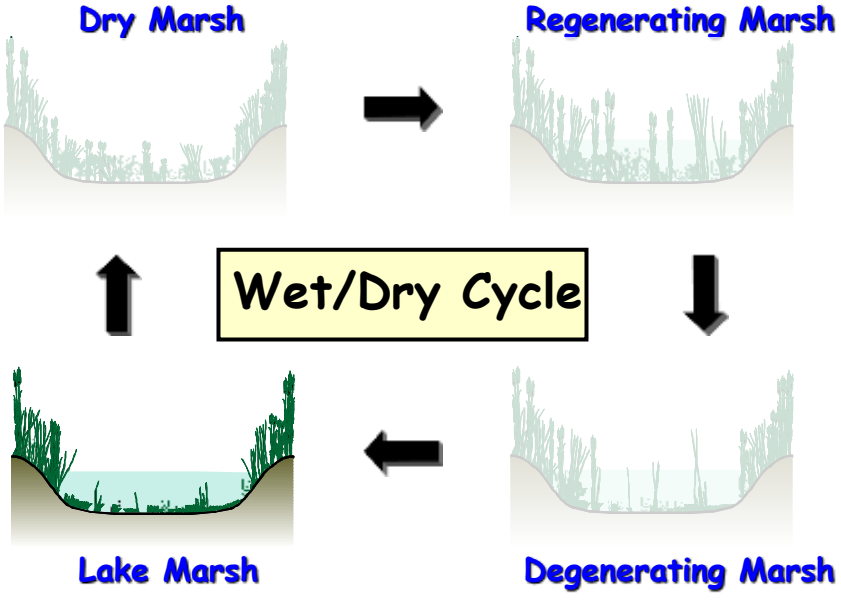
1965

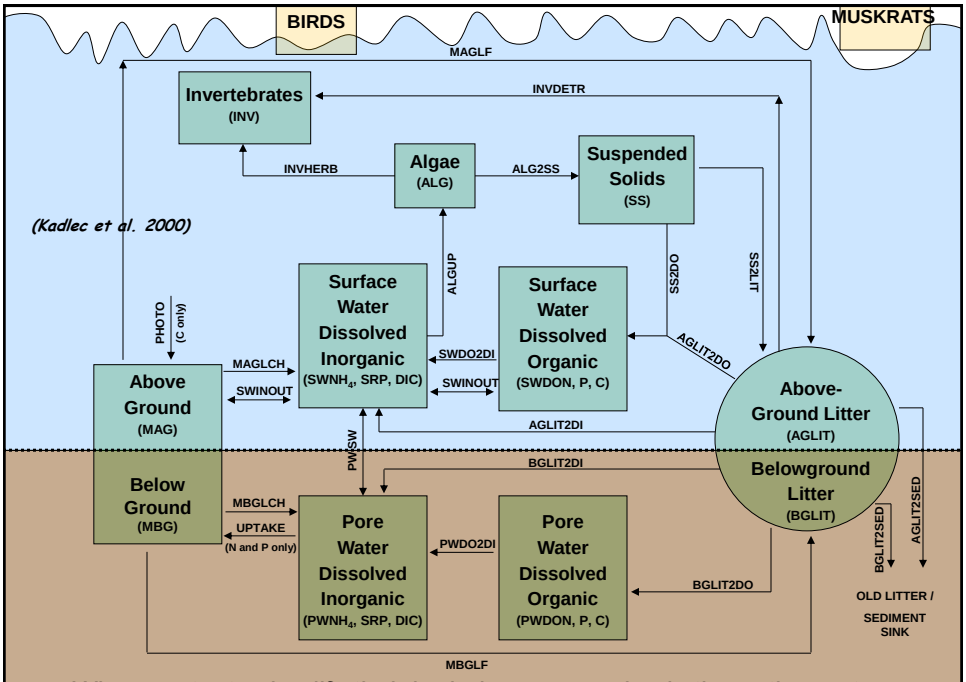


Hutchinson's Pothole

1997

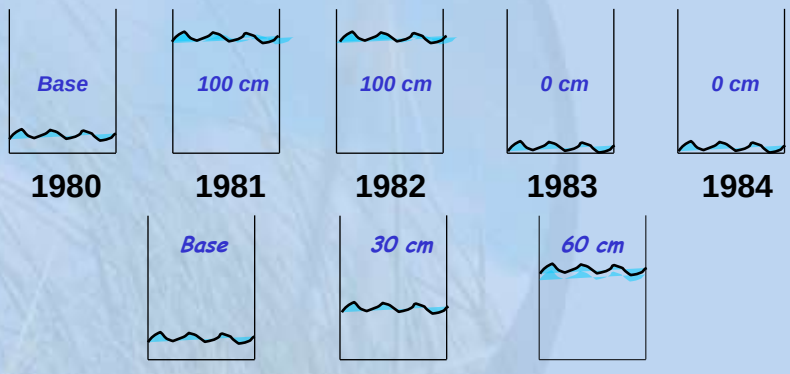


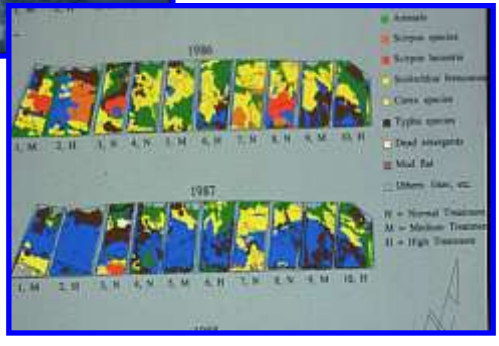




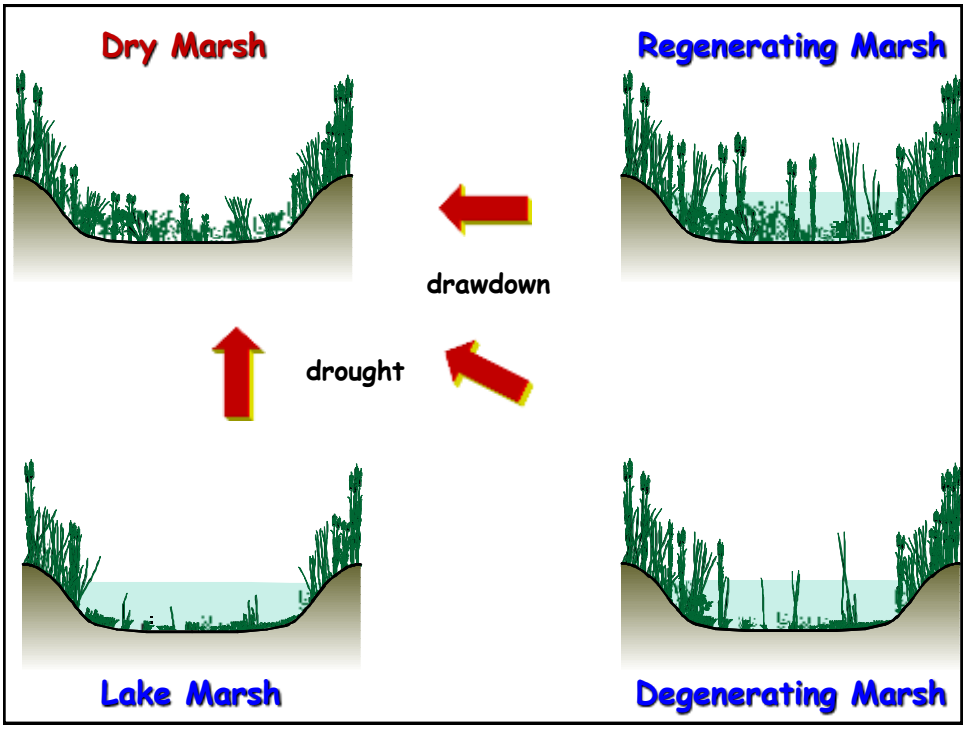
When we try to simplify their hydrology … we simply the entire system

Flooding Schedule for the MERP Cells



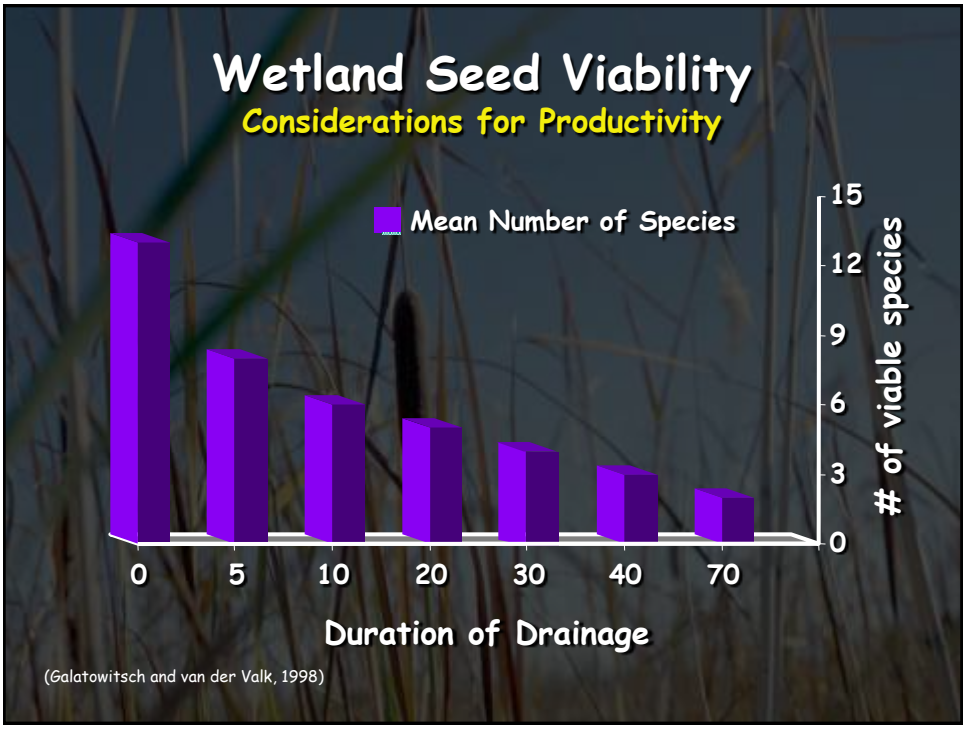


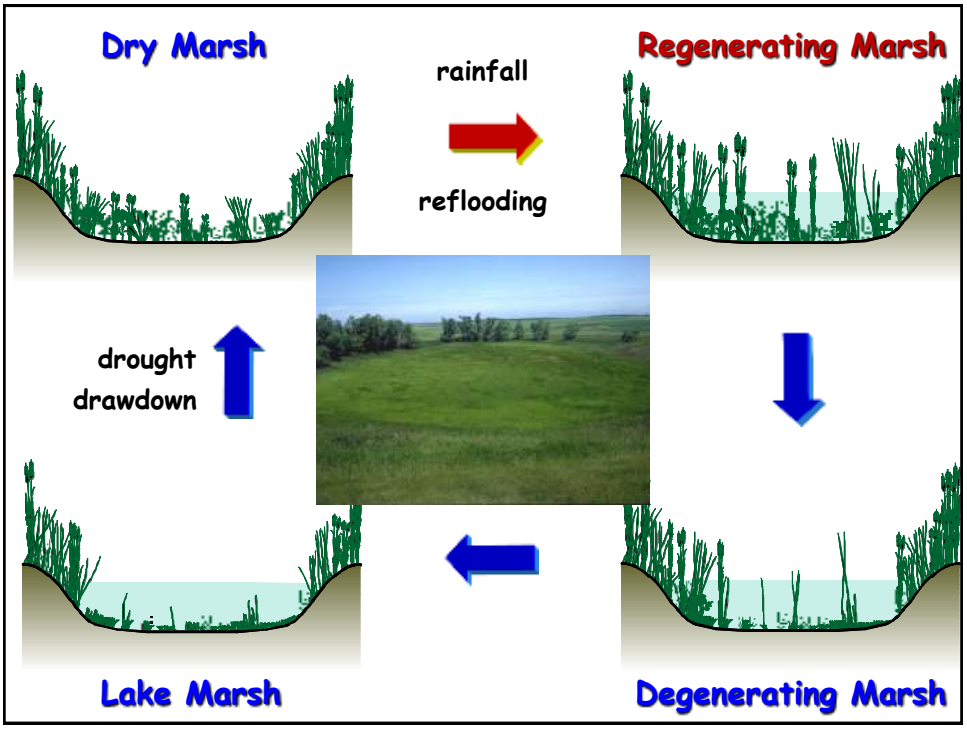
Key Components =
Hydrology
Plants / Algae
Invertebrates
Vertebrates

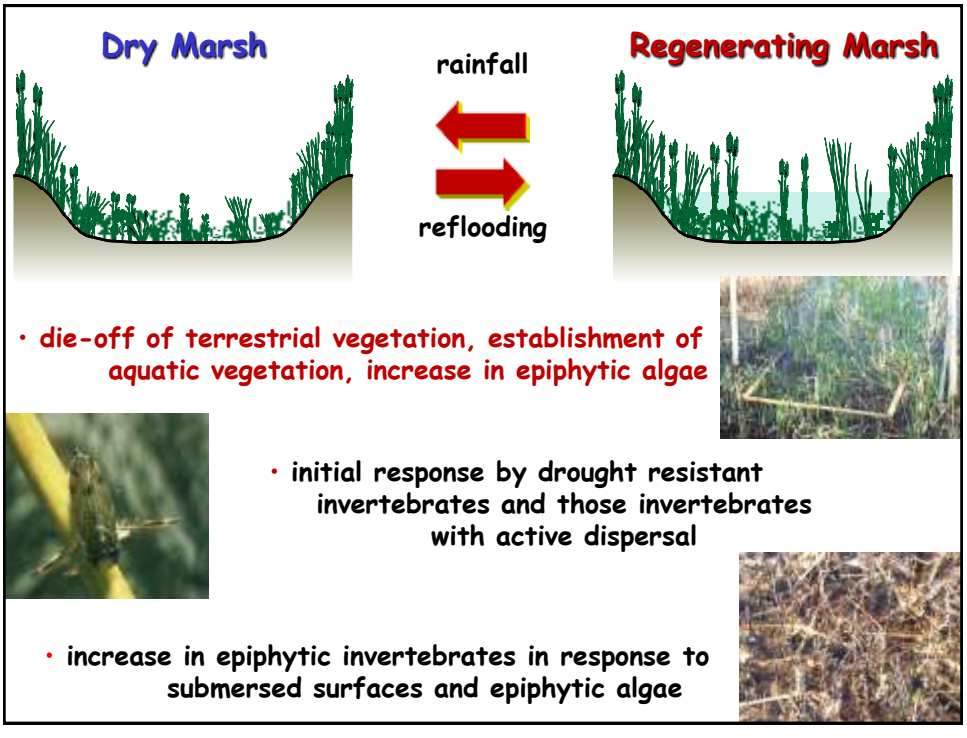

Dry Marsh
Regenerating Marsh
drawdown
drought
Lake Marsh
Degenerating Marsh

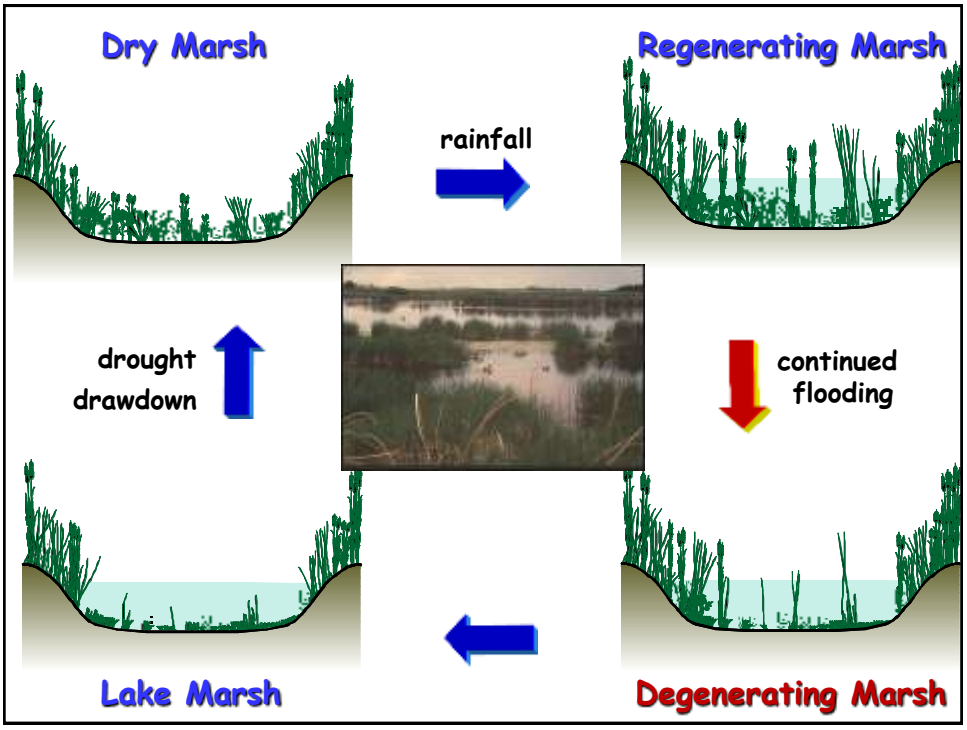

Every Year
1 in 5
1 in 25
Dry Marsh
➢ Critical for every wetland

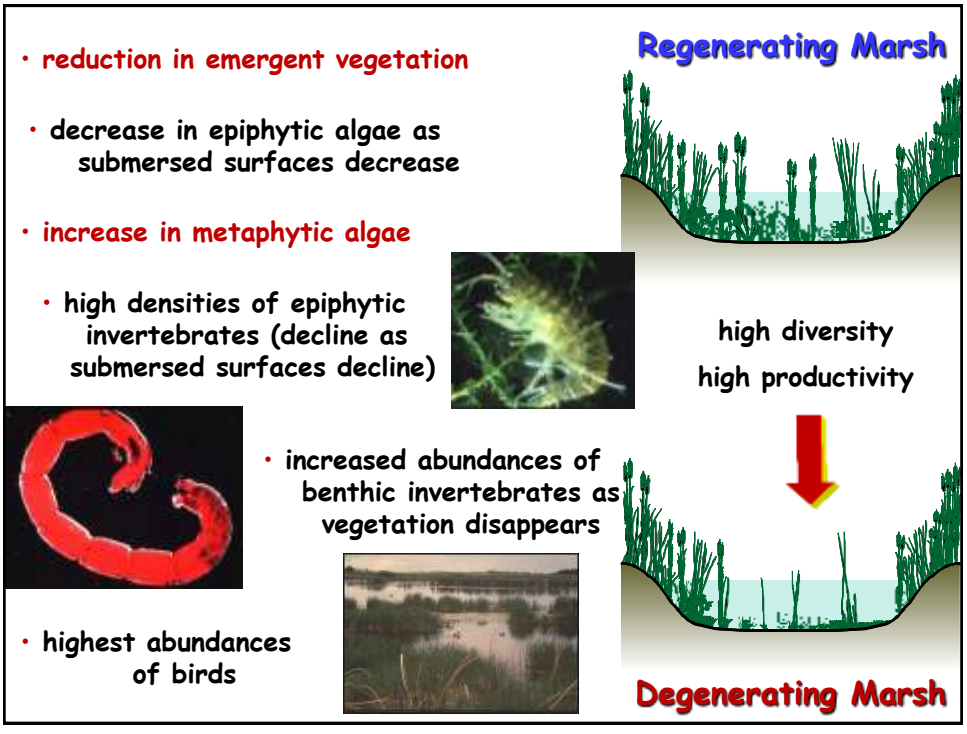
- death of remaining aquatic vegetation
- establishment of epipelon algae on moist mudflat surfaces
- germination of terrestrial and emergent vegetation
- invertebrates with active dispersal move out of the wetland
- drought-resistant invertebrates move to dormant stages
- elimination of all other aquatic invertebrates
- colonization by terrestrial invertebrates
- abundance of mudflats

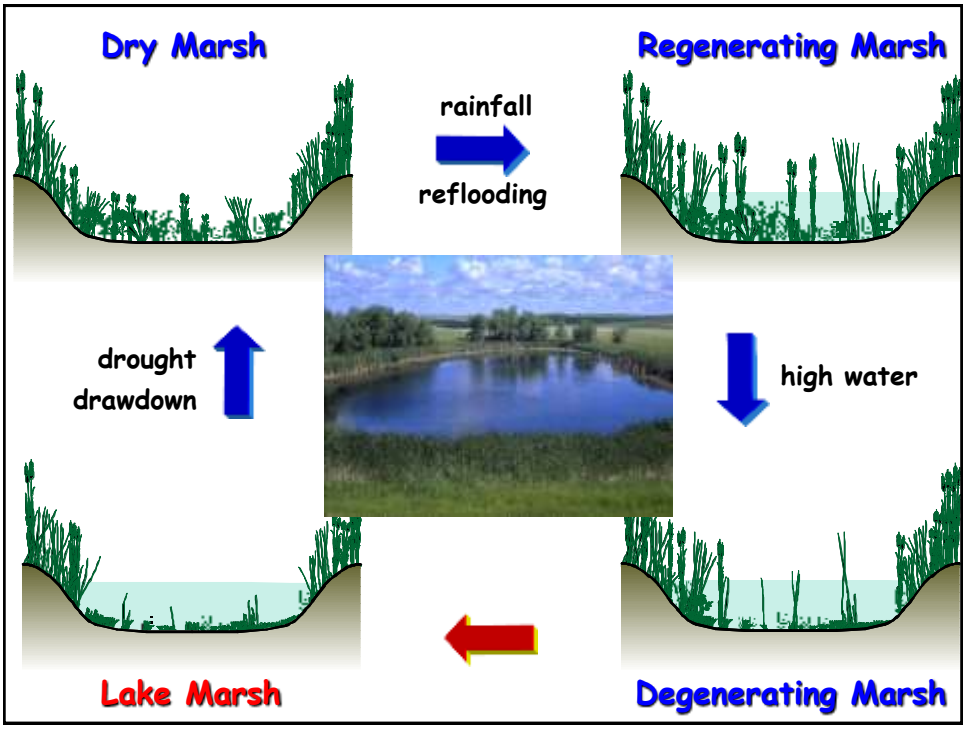



Dry Marsh
rainfall
Regenerating Marsh
reflooding
drought
drawdown
Lake Marsh
Degenerating Marsh

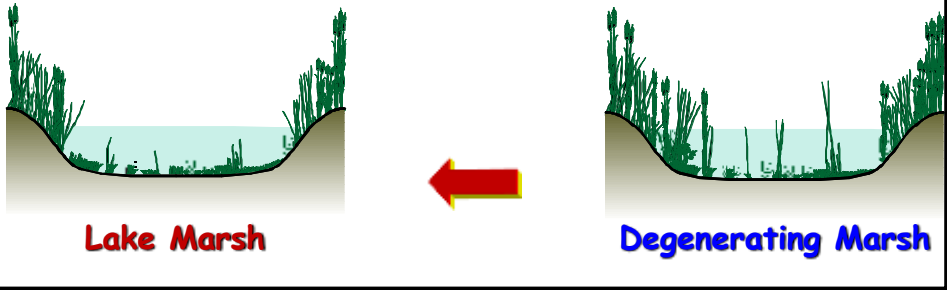

Dry Marsh
rainfall
Regenerating Marsh
reflooding
• die-off of terrestrial vegetation, establishment of aquatic vegetation, increase in epiphytic algae
• initial response by drought resistant invertebrates and those invertebrates with active dispersal
• increase in epiphytic invertebrates in response to submersed surfaces and epiphytic algae

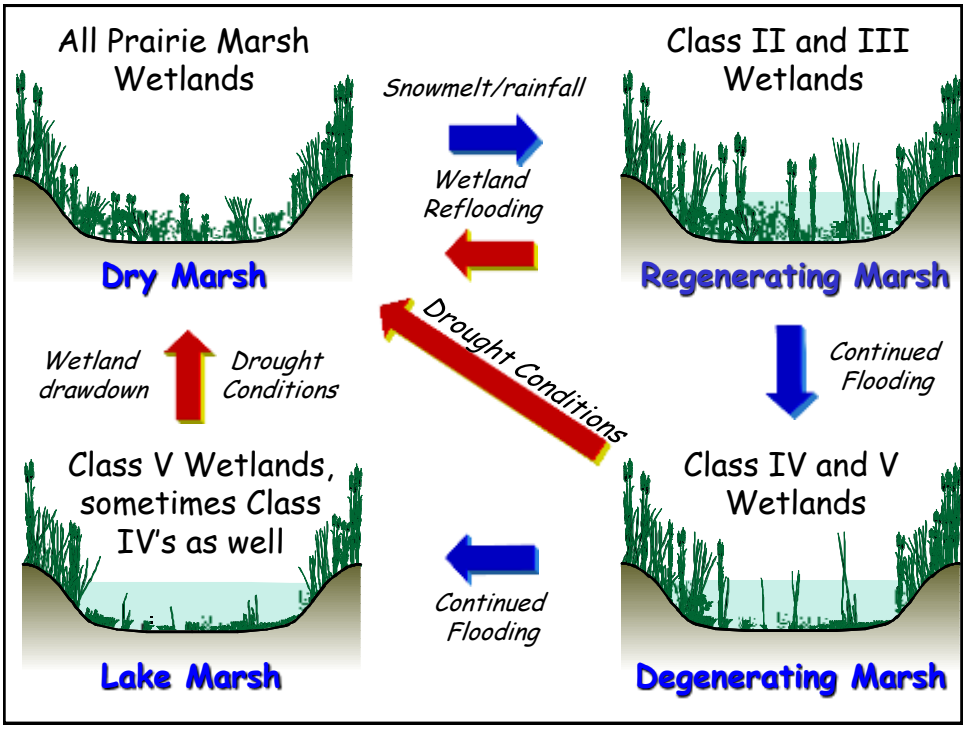

Dry Marsh
Regenerating Marsh
rainfall
drought
drawdown
continued
flooding
Lake Marsh
Degenerating Marsh


• reduction in emergent vegetation
• decrease in epiphytic algae as submersed surfaces decrease
• increase in metaphytic algae
• high densities of epiphytic invertebrates (decline as submersed surfaces decline)
Regenerating Marsh
high diversity
high productivity
• increased abundances of benthic invertebrates as vegetation disappears
• highest abundances of birds
Degenerating Marsh



- vegetation in deeper parts of the basin disappear, increase in submersed/floating vegetation
- decrease in metaphytic algae, increase in phytoplankton
- decrease in epiphytic invertebrates, continued increases in benthic invertebrates
- highest abundances of diving birds
- decreasing biodiversity





WETLAND ASSESSMENTS: PRE-DEVELOPMENT AND POST-DEVELOPMENT

- Wetland classification
- Wetland delineation
- Characterization of the physical setting of the wetland (size, water depth, surrounding slope, catchment characteristics)
- Characterization of the wetland watershed (size, topography, geology, ecological linkages, connectivity)
- Characterization of water quality and sediment quantity (entering and leaving)
- Wetland hydrology (surface water, groundwater, spring/summer/fall water levels, hydroperiod)
- Assessment of the vegetation communities and sensitive species (biodiversity, production, density, general health, presence of exotic species)
- Assessment of the wildlife biodiversity and sensitive species (birds, mammals, fish, reptiles, invertebrates, micro-organisms)

When to Begin?

- Before high level design plans are even proposed

When to End?

- Link pre- to post-data collection
- Site investigation and monitoring will be most intense at the beginning of the process
- Consider collecting 2 years of pre-development data, and 3 to 5 years of post-development data

Who to Include?

Wetland / GIS specialists
Engineers
Hydrologists
Urban planners
Landscape architects
Technicians
Regulators
Land Developers
Local Community

Wetland Hydrology

David Martz, P.Eng.
National Manager Engineering Services
Ducks Unlimited Canada

Ducks Unlimited Canada
Conserving Canada's Wetlands

75 YEARS OF CONSERVATION EXCELLENCE

Wetland Hydrology

- Prairie/Parkland Wetlands
  - Water Balance
  - Wetland Permanency
  - Gross and Effective Drainage Basins
  - Groundwater Interactions
- Impacts of Urbanization
  - Drainage Basin
    - Size
    - Permeability
  - Timing

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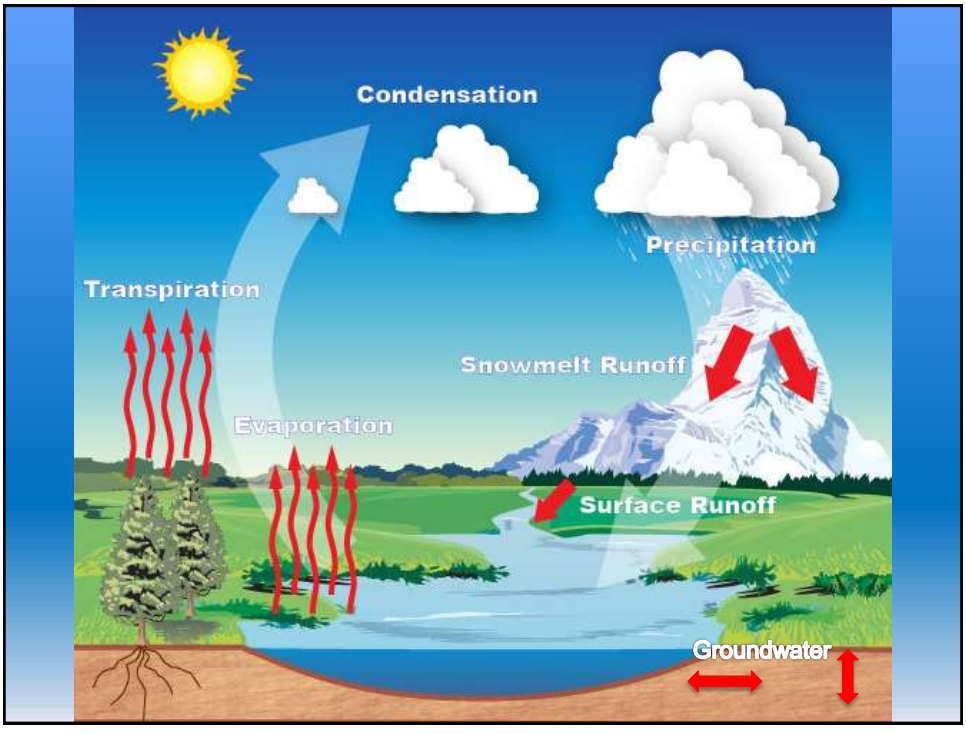
75 YEARS OF CONSERVATION EXCELLENCE

Water Balance

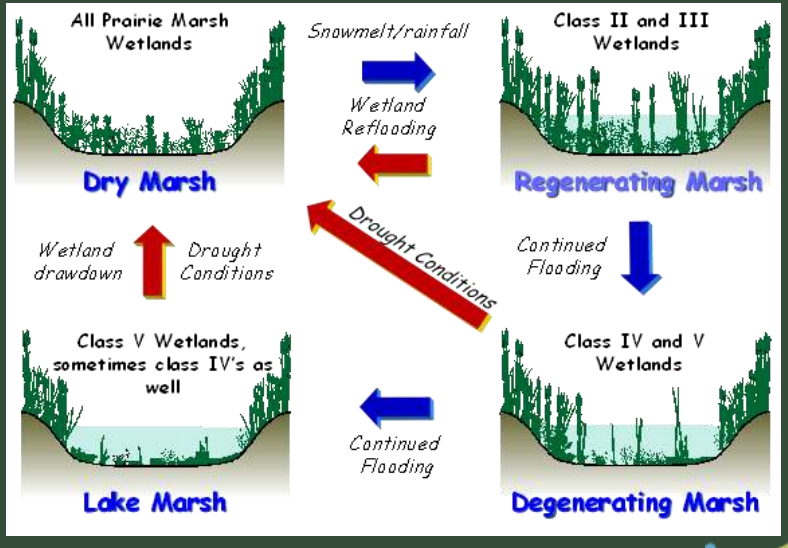
Inputs
- Precipitation
- Runoff
- Groundwater Discharge

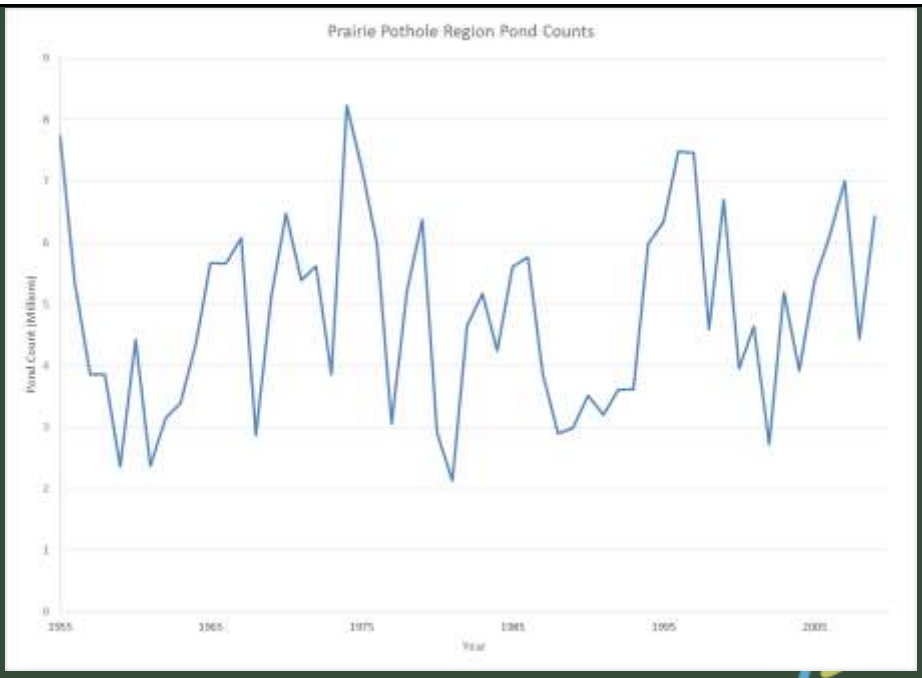
Outputs
- Overflow
- Evapotranspiration
- Groundwater Recharge



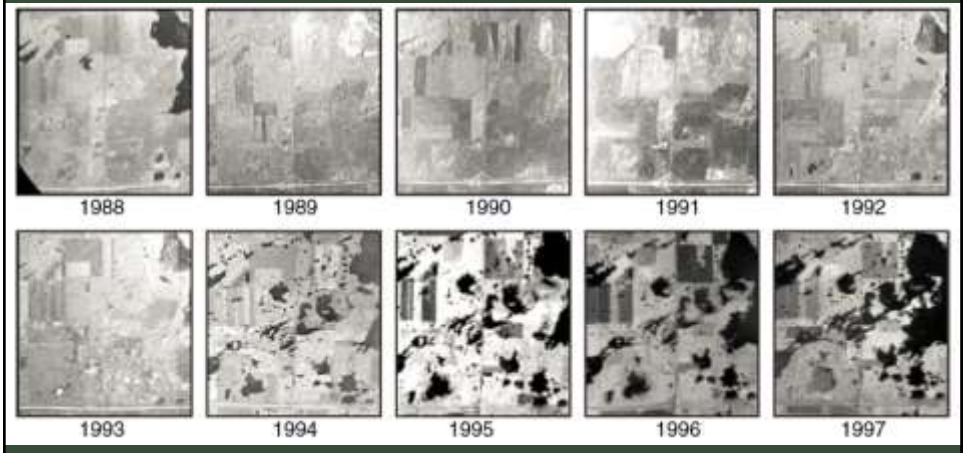
Wetlands are neither wet NOR dry – they are BOTH

- Wetlands Need Elbow Room
  - a wetland does not stop at the waters edge
- Wetland Water levels fluctuate through out the year and over a period of years

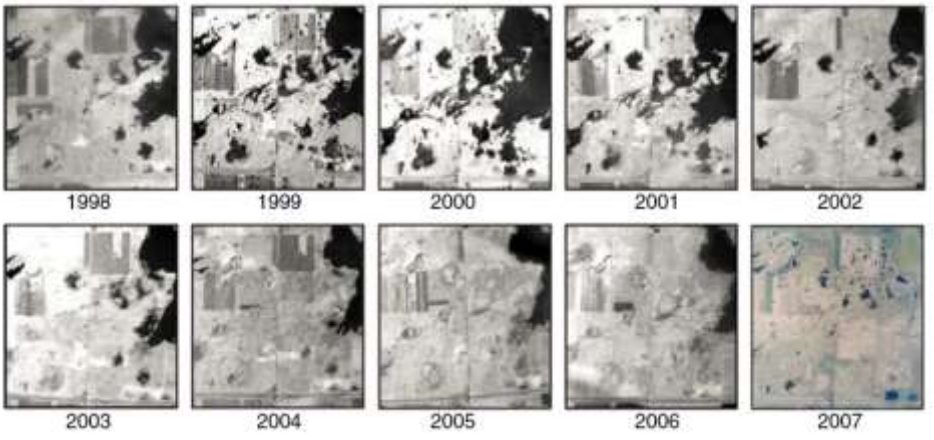




Historical Wetland Photos



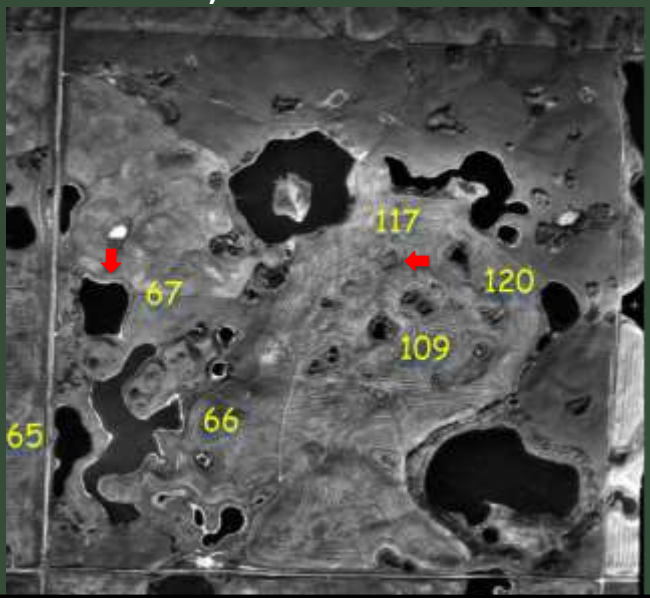
Historical Wetland Photos



Types of Wetland

- **Nearly yearly discharge - Freshwater**
- **Infrequently discharge (~1:10 years) - Brackish**
- **Never discharge (<1:100 years) – Saline, Akali flats**

St. Denis National Wildlife Area near Saskatoon, SK



Pond 117

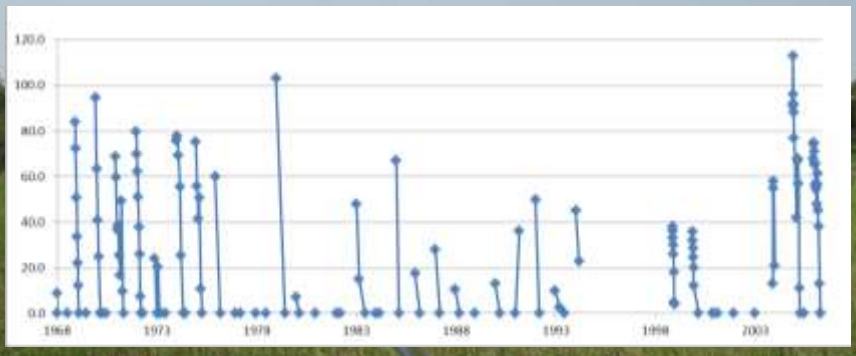
- Class 3 Wetland (Seasonal)
- Dries out almost every summer

Catchment area:	16,500 m^2
Wetland area:	4,000 m^2
Ratio:	4:1
Pond volume:	1,303 m^3

Pond 117

- Class 3 Wetland (Seasonal)
- Dries out almost every summer

Catchment area:	16,500 m^2
Wetland area:	4,000 m^2
Ratio:	4:1
Pond volume:	1,303 m^3



St. Denis - Pond 67

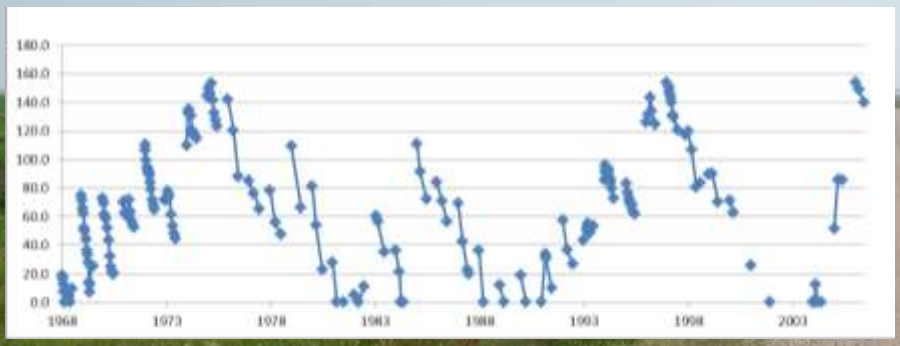
Class 4/5 Wetland (Semi-Permanent/Permanent)
Hardly ever dries out

Catchment area:	129,800 m^2
Wetland area:	22,100 m^2
Ratio:	6:1
Pond volume:	15,396 m^3

St. Denis - Pond 67

Class 4/5 Wetland (Semi-Permanent/Permanent)
Hardly ever dries out

Catchment area:	129,800 m^2
Wetland area:	22,100 m^2
Ratio:	6:1
Pond volume:	15,396 m^3



Why all this variability?

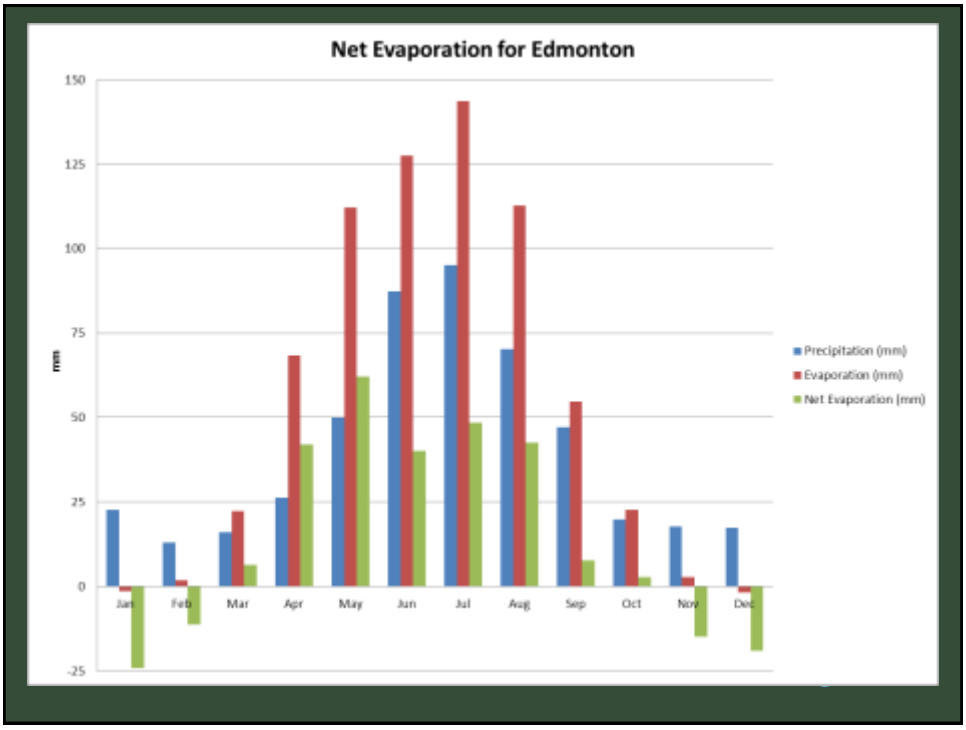
Let's consider the most simplistic method for estimating the relationship between precipitation and runoff. The rational equation:

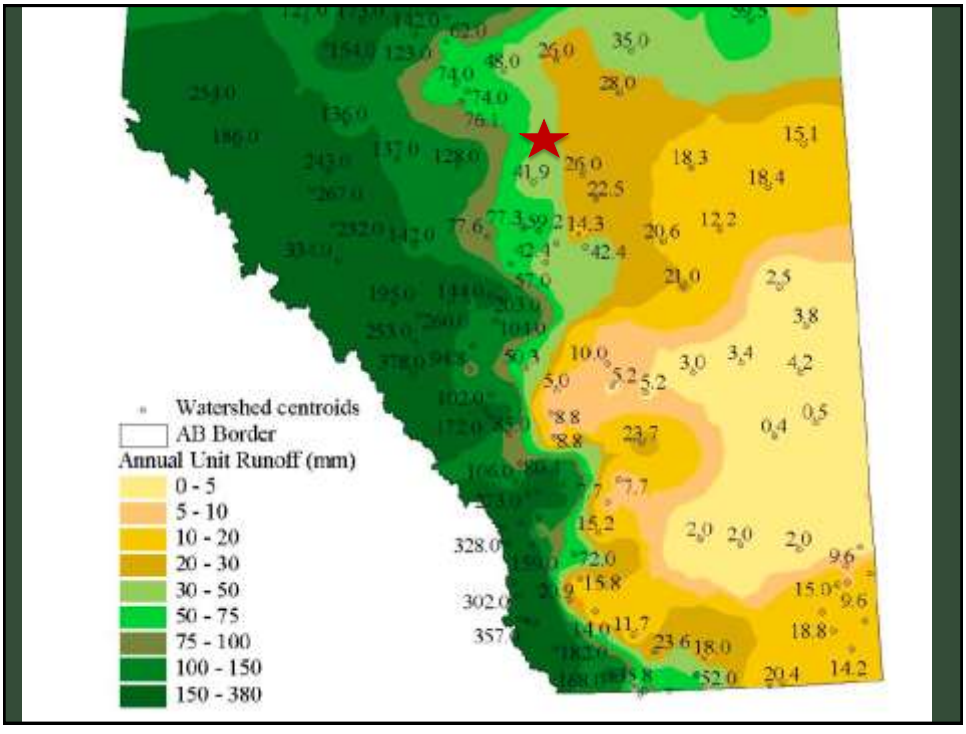
$$Q = ciA$$

If we were to integrate the flow over time we would get the volume of runoff.

$$v = \int_0^t Q$$

- **C – Coefficient that is used to estimate the portion of the precipitation that will become runoff.**
  - **Usually estimated as a percentage of impermeability**
  - **Ignores initial wetting, changes through time**
  - **Soil types**
  - **Land cover**
  - **Slope**
  - **Concept of frost seal?**
- **i – Intensity of precipitation.**
  - **Spatial distribution**
  - **Snowmelt**
    - Temperature
    - Solar radiation
    - Aspect
- **A – Area.**
  - **Effective vs Gross**
    - Drainage
    - Precedents
- **Variation**
  - **Spatially**
  - **Temporally**
  - **Groundwater interaction**


Net Evaporation for Edmonton
mm
150
125
100
75
50
25
0
-25
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Precipitation (mm)
Evaporation (mm)
Net Evaporation (mm)


Watershed centroids
AB Border
Annual Unit Runoff (mm)
0 - 5
5 - 10
10 - 20
20 - 30
30 - 50
50 - 75
75 - 100
100 - 150
150 - 380

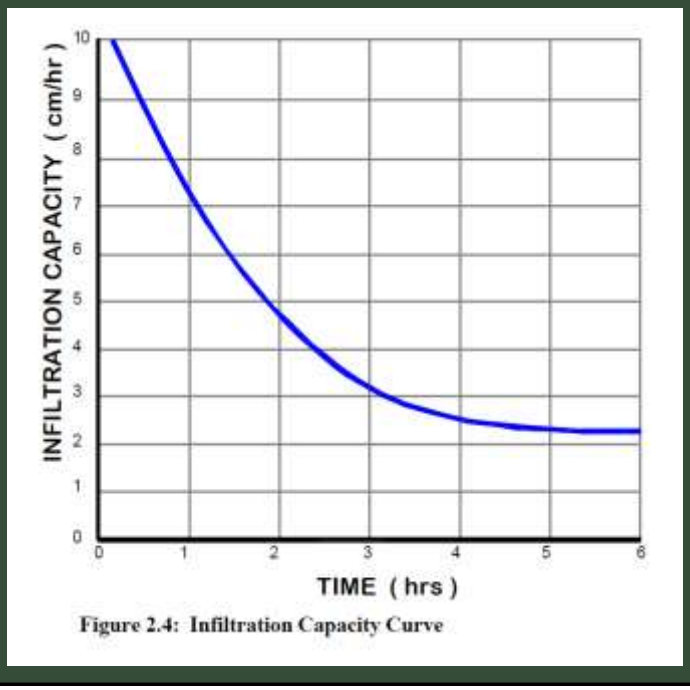


Figure 2.4: Infiltration Capacity Curve

Gross and Effective Drainage Basins

Gross

Determined by the elevation divide and includes the full area that would drain through a point

Effective

The area that would contribute in an average event (50%)

Ranges from <10 to 100%

Groundwater

Minimal impact on many wetlands but not all.
Generally small enough that it can be ignored.

Indications of groundwater discharge:
- Water chemistry
- Stable water regime
- Vegetation

Indications of Groundwater recharge:
- Faster than predicted drawdown

Some wetlands can be highly impacted by groundwater discharge or recharge. There is potential to dramatically increase recharge by disturbing basin seals.

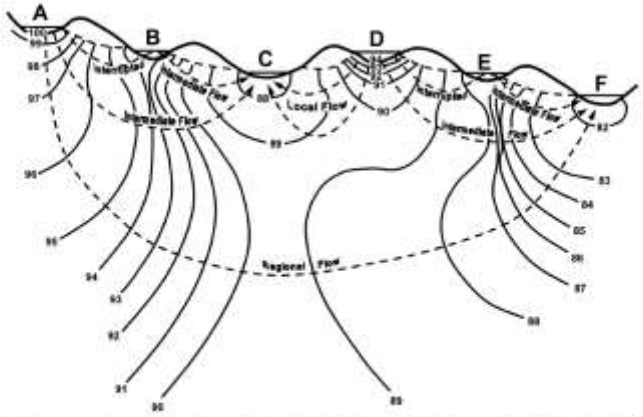


Figure 2. Schematic diagram of ground-water continuum. Solid lines are lines of equal hydraulic head; dashed lines indicate ground-water flow paths. A and D are recharge wetlands, B and E are flow-through wetlands, C is a discharge wetland for local and intermediate flow systems, and F is a discharge wetland for local, intermediate, and regional flow systems. (Modified from Lissey 1971)

Impacts of Urbanization

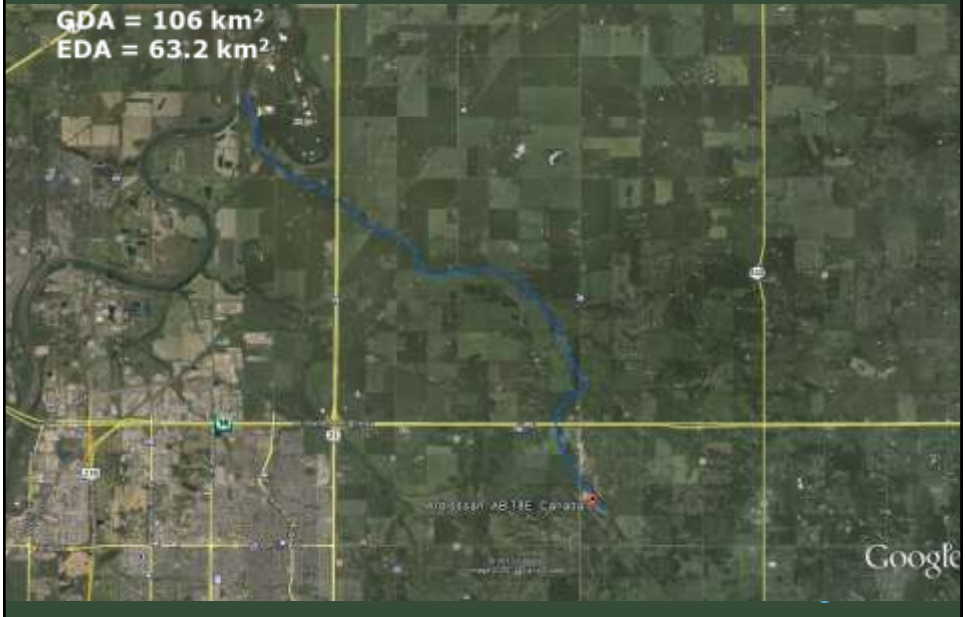
A Comparison of Developed and Undeveloped Basins

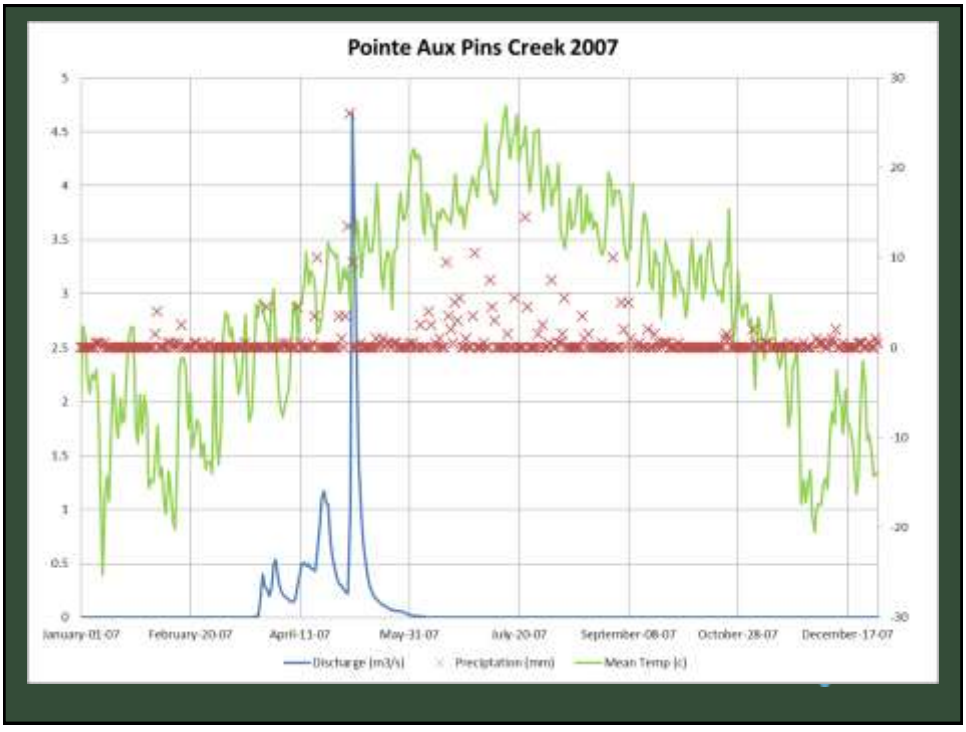
Ducks Unlimited Canada
Conserving Canada's Wetlands

75 YEARS OF CONSERVATION EXCELLENCE

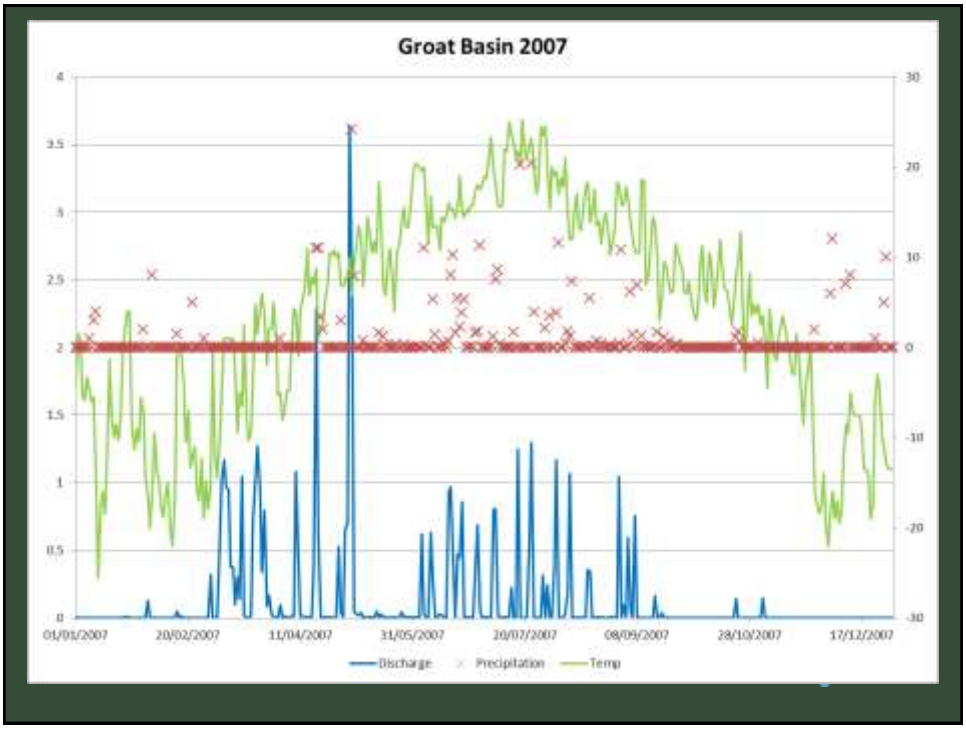
Pointe-aux-Pins Creek

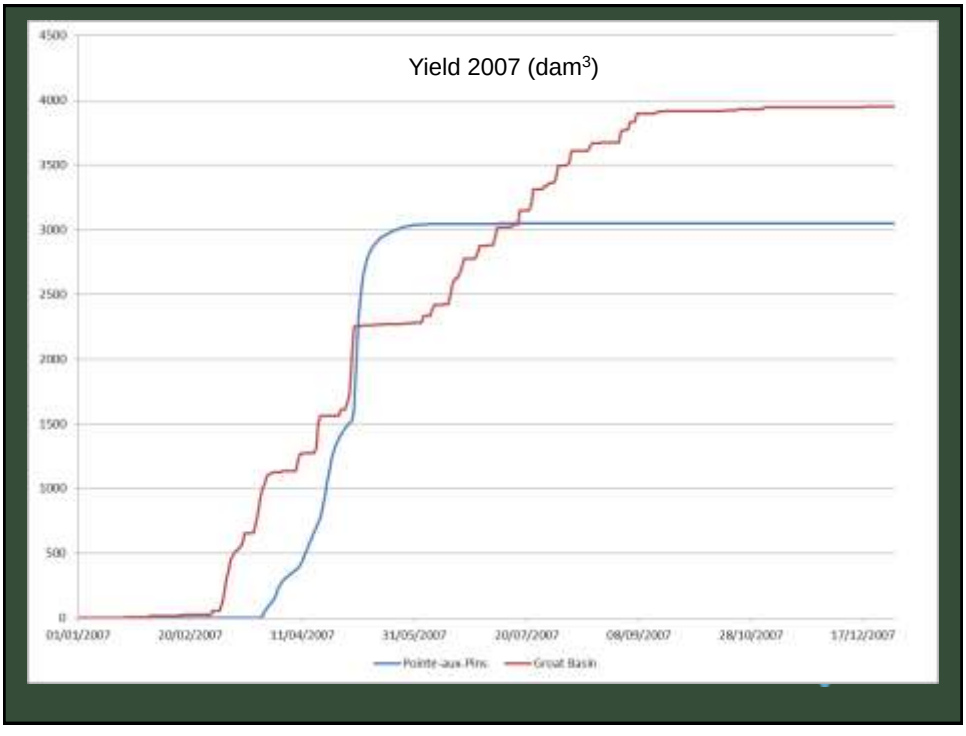
GDA = 106 km²
EDA = 63.2 km²

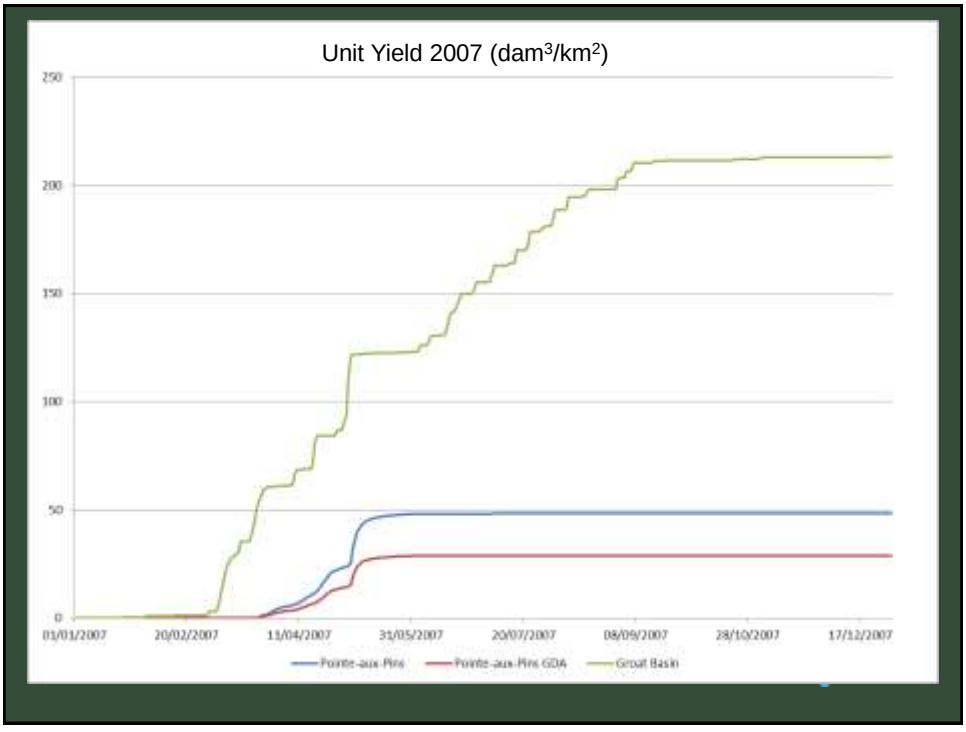


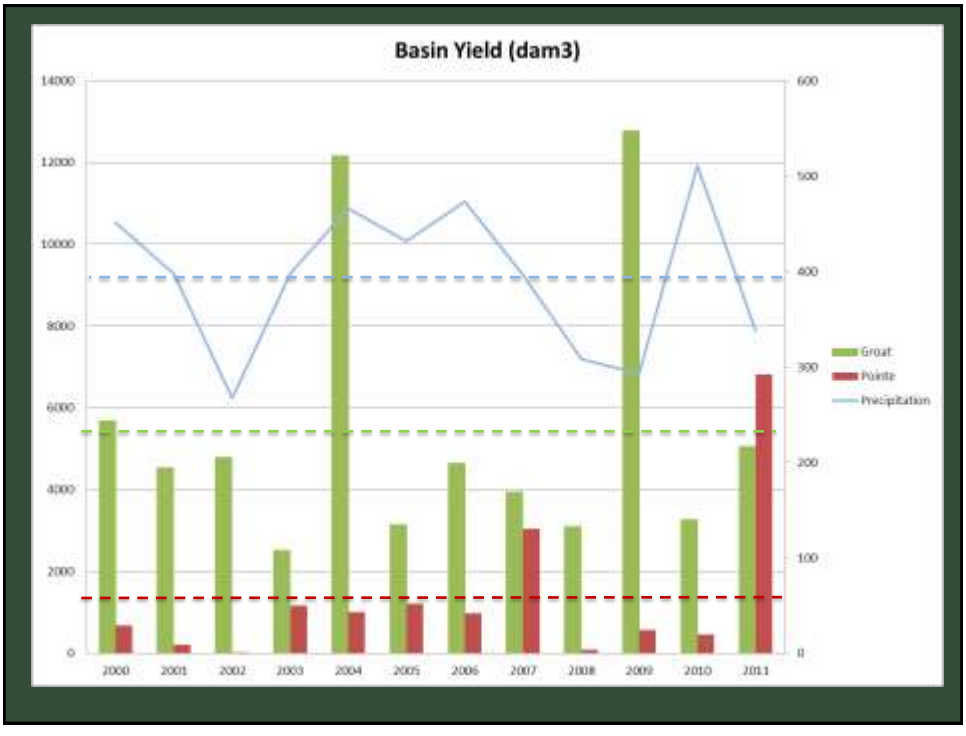

Pointe Aux Pins Creek 2007
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
30
20
10
0
-10
-20
-30
January-01-07
February-20-07
April-11-07
May-31-07
July-20-07
September-08-07
October-28-07
December-17-07
Discharge (m3/s)
Precipitation (mm)
Mean Temp (c)


Groat Basin
GDA=EDA=18.5 km²
Google earth


Groat Basin 2007
4
3.5
3
2.5
2
1.5
1
0.5
0
30
20
10
0
-10
-20
-30
01/01/2007
20/02/2007
11/04/2007
31/05/2007
20/07/2007
08/09/2007
28/10/2007
17/12/2007
Discharge
Precipitation
Temp


Yield 2007 (dam3)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
01/01/2007
20/02/2007
11/04/2007
31/05/2007
20/07/2007
08/09/2007
28/10/2007
17/12/2007
Pointe-aux-Pins
Groat Basin


Unit Yield 2007 (dam3/km2)
250
200
150
100
50
0
01/01/2007
20/02/2007
11/04/2007
31/05/2007
20/07/2007
08/09/2007
28/10/2007
17/12/2007
Pointe-aux-Pins
Pointe-aux-Pins GDA
Great Basin


Basin Yield (dam3)
14000
12000
10000
8000
6000
4000
2000
0
600
500
400
300
200
100
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Great
Pointe
Precipitation

How often is the wetland flooded?
How deep is it flooded?
How long is it flooded?

Highs … lows … and averages are all important

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Questions?

Thank You

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