Wetland Hydrology: Hydroperiods & Seiche/Tide

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Guest Lecture for Wetlands Ecology class
7 Sept. 2017

PART 1: TIME SCALES OF HYDROLOGIC INFLUENCES

Day

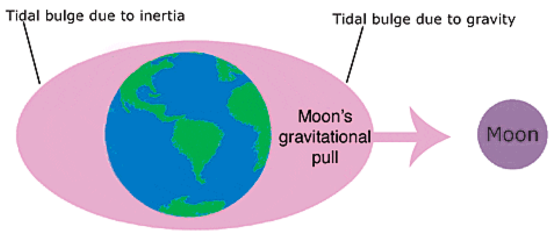
Month

Seasonal

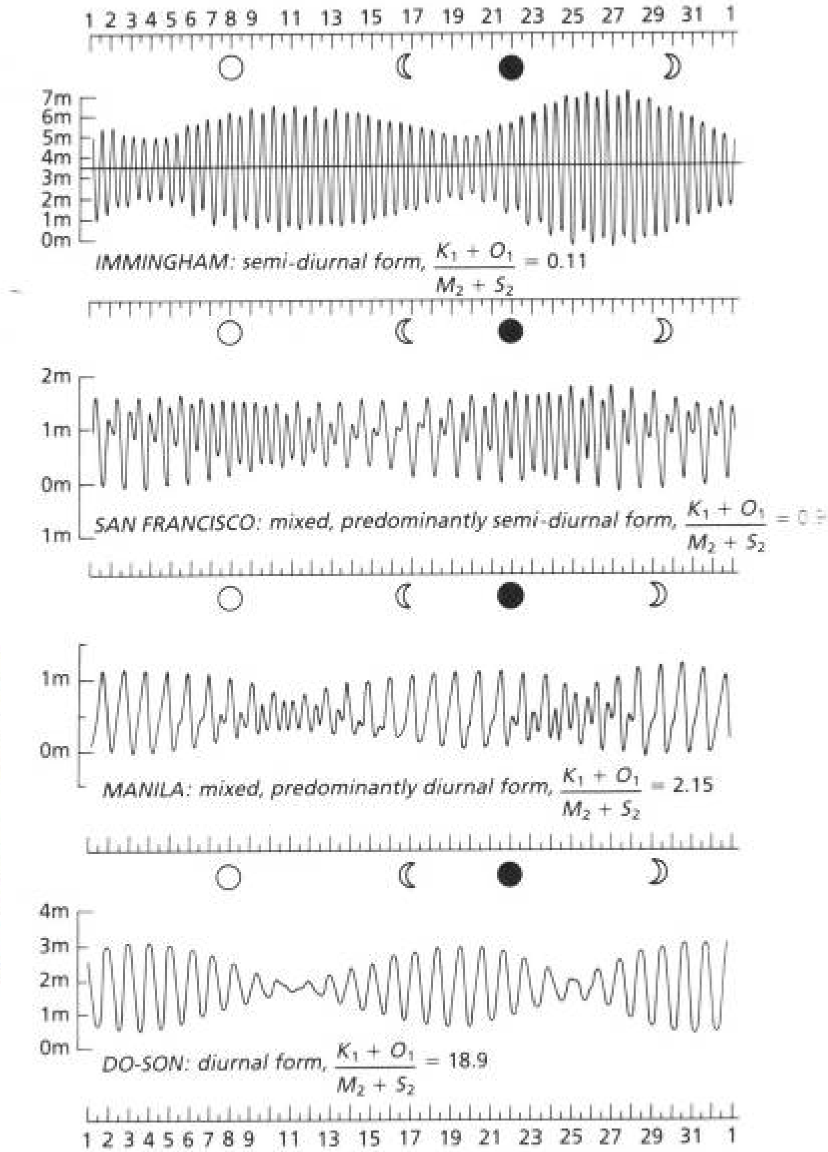
Inter-annual

Episodic

Artificial



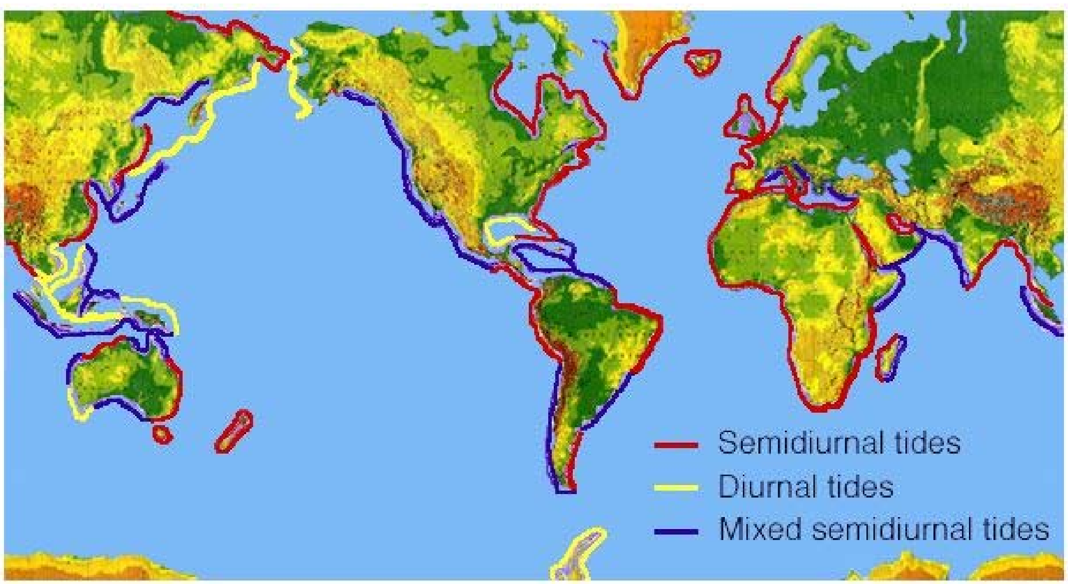
TIDE: day and month time scales



Lunar cycle superimposed on daily or twice-daily highs and lows

Affect both salt- and fresh-water wetlands (tidal bore can travel 100+ km).

Magnitude and frequency are broadly predictable (can be forecast)



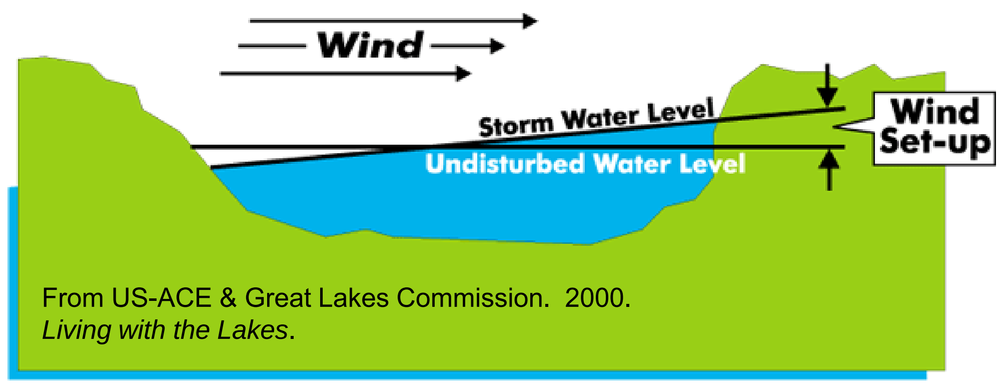
From Mann & Lazier. 1991. Dynamics of Marine Ecosystems. Blackwell.

From NOAA. https://oceanservice.noaa.gov/education/tutorial_tides/media/supp_tide07b.html

SEICHE (wind tide): hour to day time scale

Wind- & barometric pressure-driven water-level oscillations

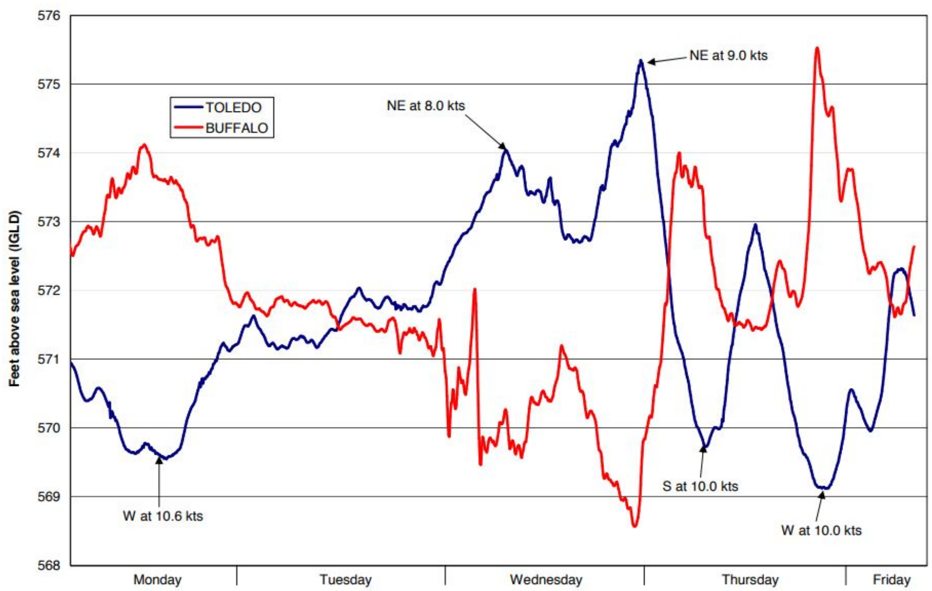
Internal seiche occurs at thermocline in many lakes;
surface seiche is significant only in very large bodies of water.



From US-ACE & Great Lakes Commission. 2000. *Living with the Lakes*.

Lake profile showing wind set-up


MN Sea Grant, photos from 2002



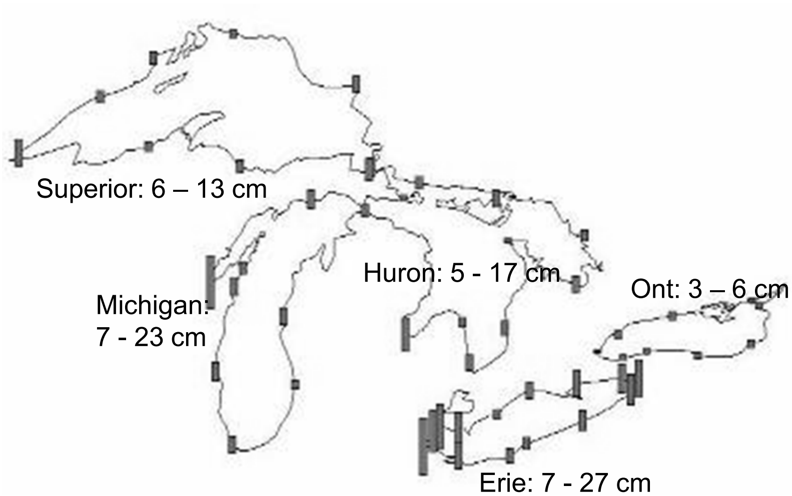
Lake Erie seiche activity from October 17–21, 2011. Notes with arrows indicate the wind speed and direction.

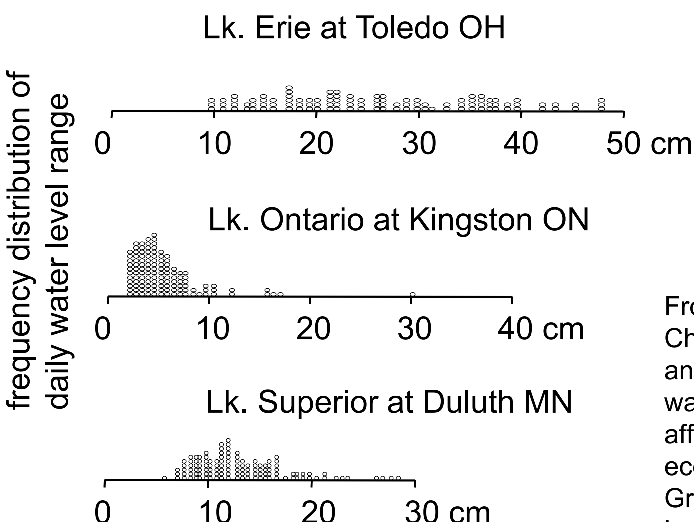
From Ohio DNR: http://geosurvey.ohiodnr.gov/extra-news-archives/2011-articles/lake-erie-seiche-or-wind-tides

SEICHE continued

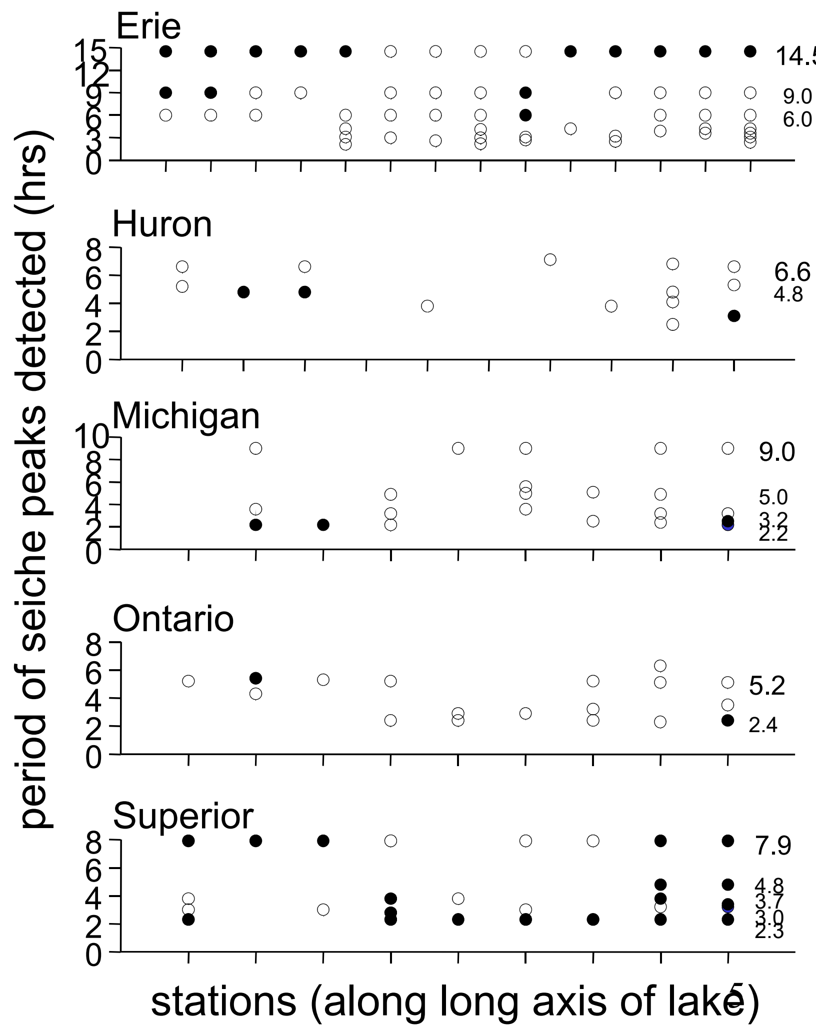
magnitude: variable over both space (somewhat predictable) and time (not predictable)

frequency: spatially predictable (basin shape/size); temporally somewhat predictable (interval but not re-set)

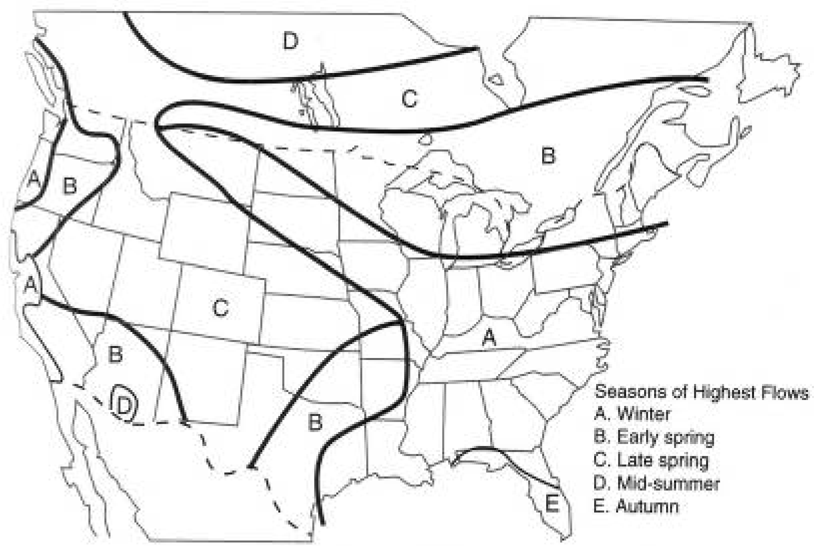




From Trebitz. 2006. Characterizing seiche and tide-driven daily water level fluctuations affecting coastal ecosystems of the Great Lakes. J. Great Lakes Res. 32:102-116.

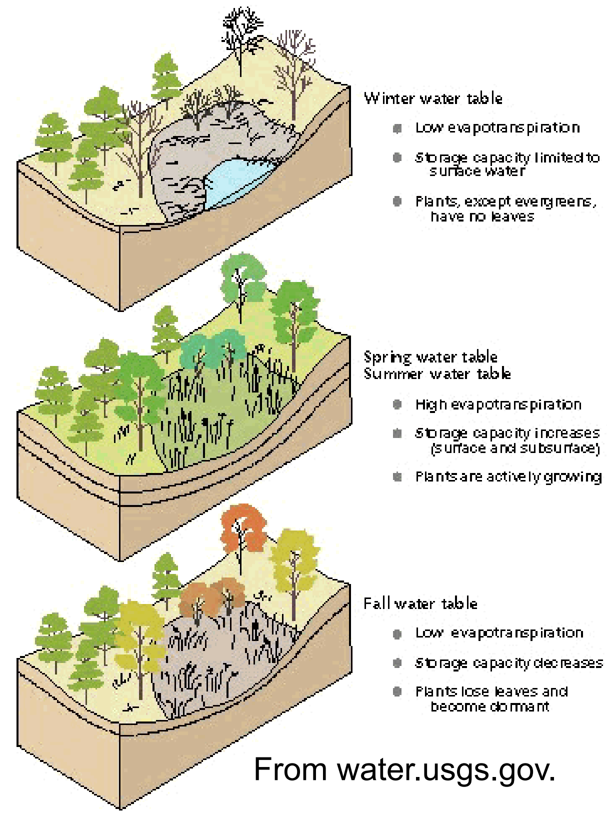


SEASONAL (annual) time scale

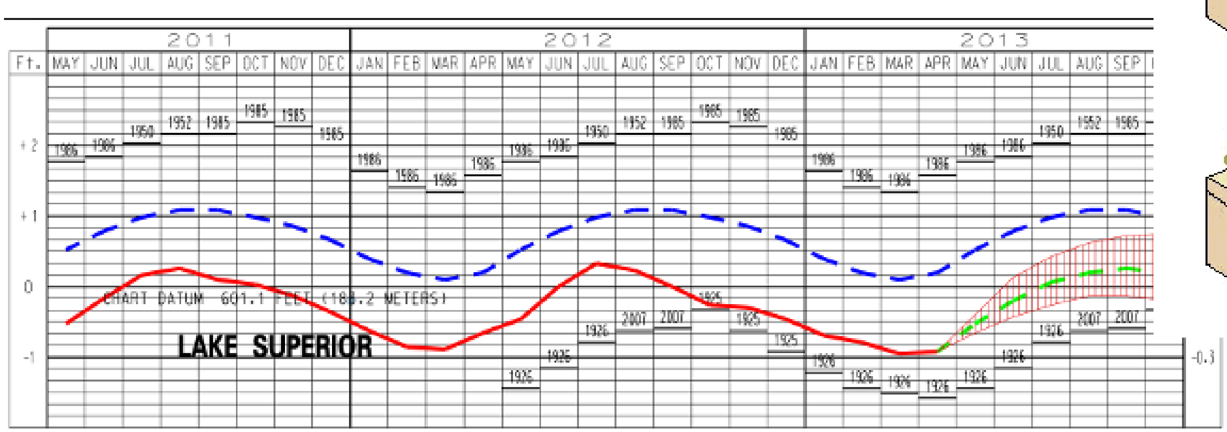


from Mitsch & Gosselink. 2000. *Wetlands*. John Wiley & Sons.

Combination of precipitation & temperature (which drives evaporation and snow accumulation and melt) impose seasonal cycles of water depth and flow across broad regions.

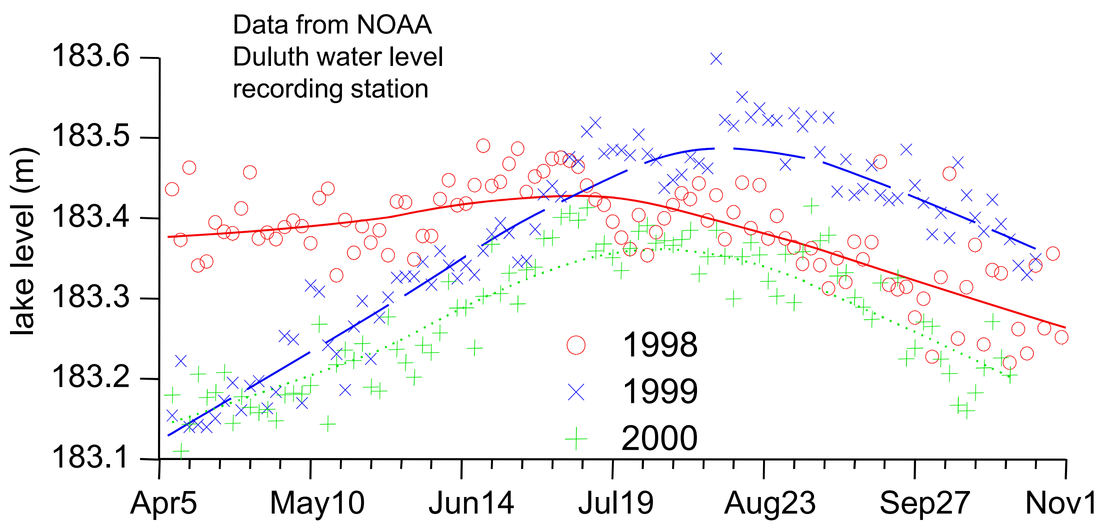


From water.usgs.gov.



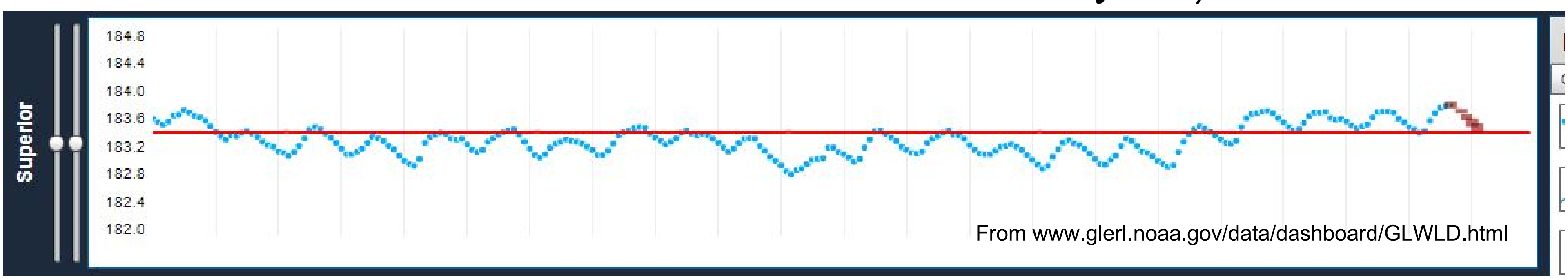
from NOAA Great Lakes water level website

INTERANNUAL time scale



Because precip and temp vary across years, so does timing and magnitude of seasonality.

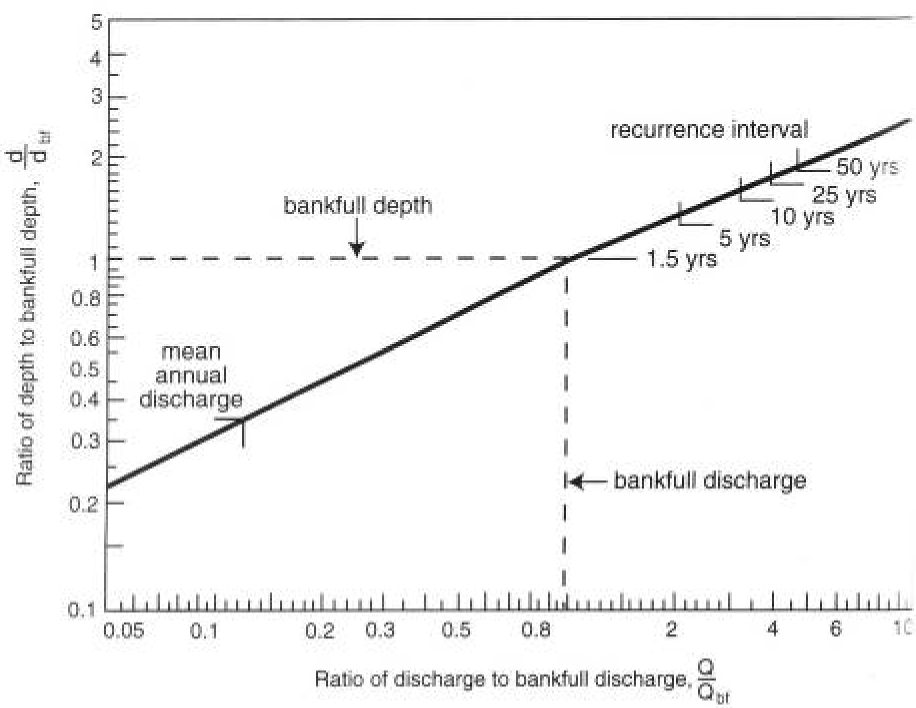
Predictability of this varies from fairly high (e.g., for ENSO cycles), to moderate (e.g., wet-dry climate cycles) to low.



EPISODIC HYDROLOGIC EVENTS (unpredictable)

- often cast in terms of statistical frequency of occurrence (return interval).
- examples: storm surges, floods.

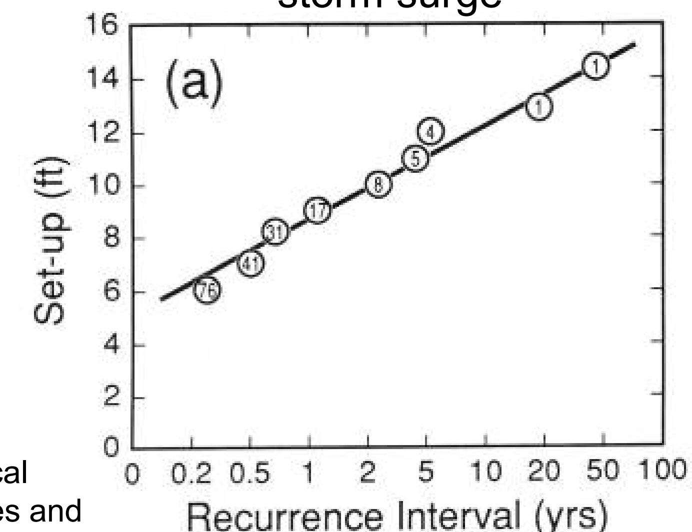
flood



From W.J. Mitsch & J.G. Gosselink. 2000. *Wetlands*. John Wiley & sons.

1999 flood on Iron River upstream from a coastal wetland on Lake Superior

storm surge



From K.W. Bedford. 1992. The physical effects of the Great Lakes on tributaries and wetlands. J. Great Lakes Res. 18:571-589.

ARTIFICIAL HYDROPERIOD

- un-natural time-cycles: e.g., level raised in fall for waterfowl habitat, reduced overwinter for future storage, daily cycle imposed by hydropower

- altered amplitude: e.g., reduced for flood control, increased by hydropower generation (“peaking” generation)

- normal cycles absent: e.g., diked wetlands cut off from hydrologic exchange

A diked wetland. From W.J. Mitsch. 1992. Combining ecosystem and landscape approaches to Great Lakes wetlands. J. Great Lakes Res. 18:552-570.

PART 2: HYDROLOGY as WETLAND "SIGNATURE"

Hydroperiod and hydrodynamics:

- Are the temporal pattern of inundation, water source, water movement

– Result from the interaction between hydrologic cycles and wetland morphology and landscape position

- Are predictive of a wetland's structure and function yet can be temporally quite variable

Externalities:		Wetland setting:		Hydrologic features:
Precipitation	→	Elevation	→	Water table depth
Temperature		Morphology		Inundation period
Cloudiness		Connectivity		Lake level
		Opening size		Inundated surface area

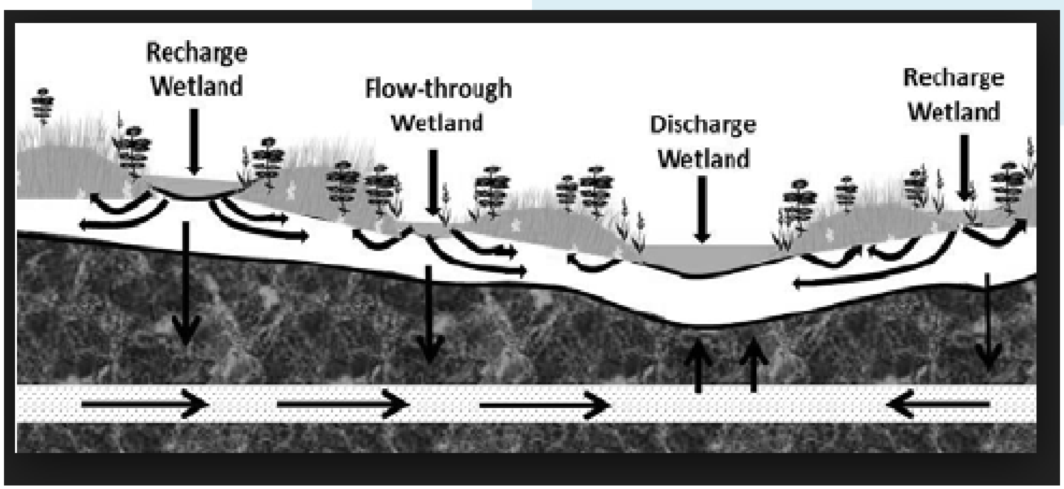
HYDROLOGY is an important element of wetland classification

- **Basin Wetlands** (lakes and ponds)
  - Physical: Water flow is vertical (precipitation)
  - Hydroperiod: Long with floods during periods of high rainfall.

Basin Wetlands

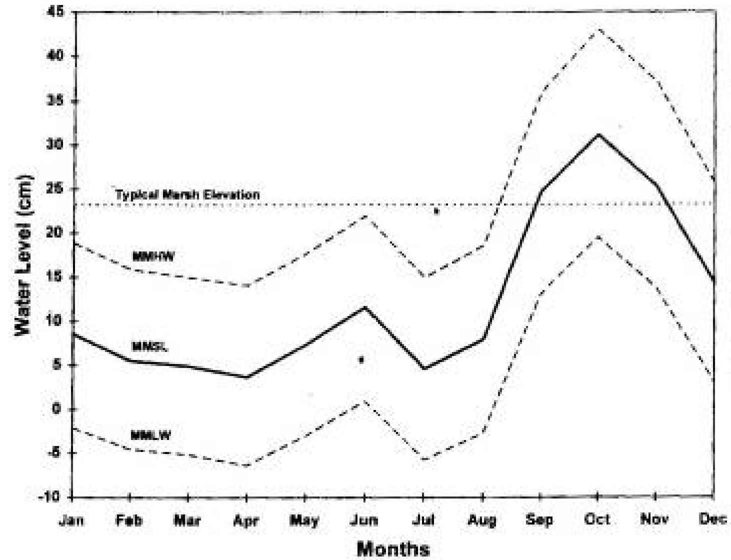
- **Riverine Wetlands** (periodically flooded banks of rivers and streams)
  - Physical: Water flow is both vertical and horizontal (precipitation and stream/river flow)
  - Hydroperiod: Have short periods of flooding with stream/river flow.

Riverine Wetlands

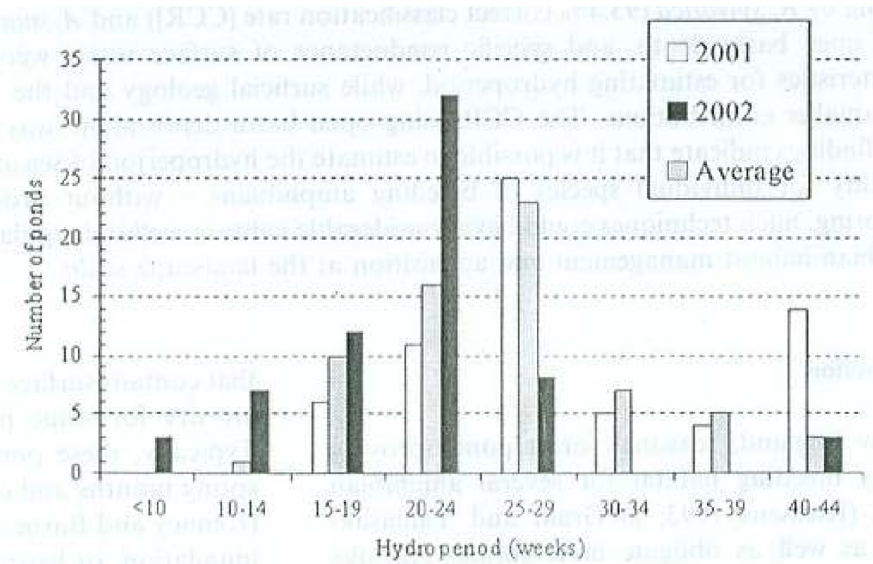


HYDROPERIOD can be quite variable

- Some wetlands are alternately wet or dry; others are inundated year-round but with varying depth/extent
- Can vary considerably, even within wetland types or the same wetland over time



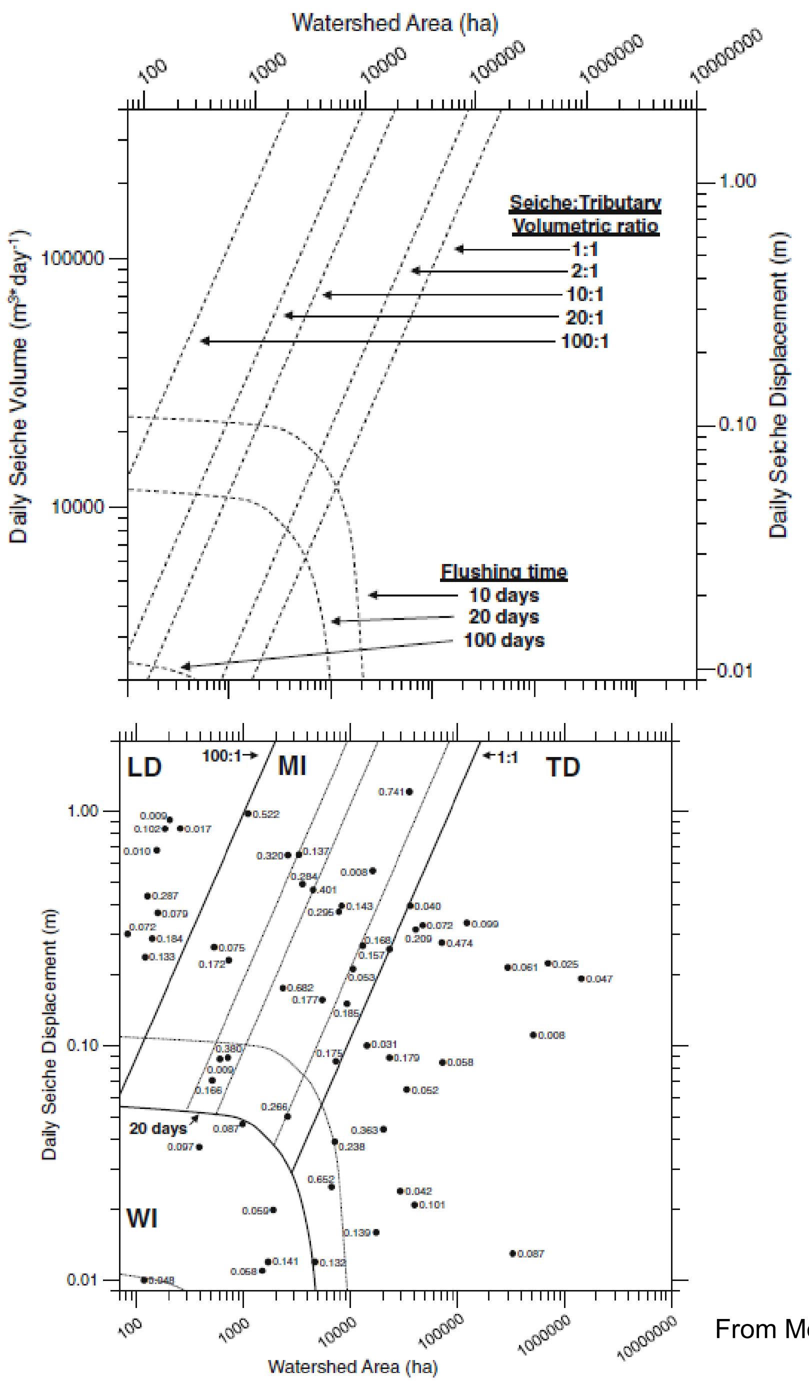
From Brockmeyer et al. 1997. Rehabilitation of impounded estuarine wetlands by hydrologic reconnection to the Indian River Lagoon, FL. Wetl. Ecol. Manage. 4:93-109.



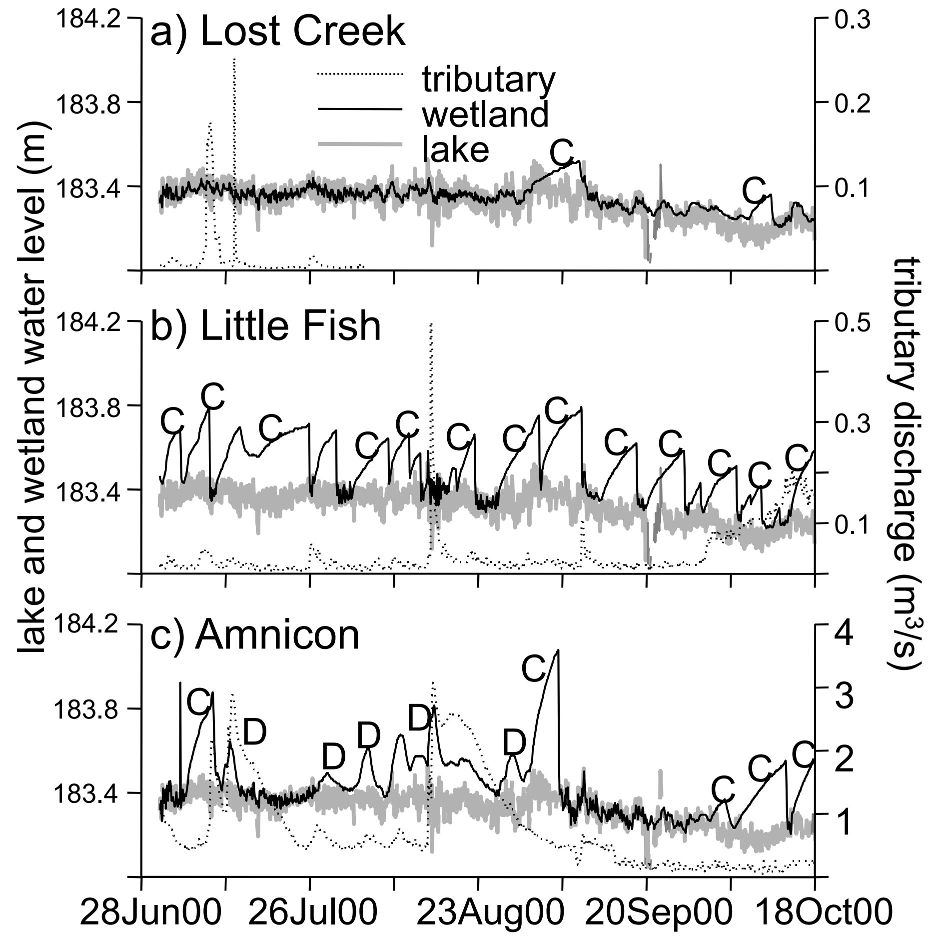
From Skidds and Golet. 2005. Estimating hydroperiod suitability for breeding amphibians in southern Rhode Island forest ponds. Wetl Ecol & Manage 13:349-366.

photo: Dale Wrubleski, Institute for Wetland and Waterfowl Research

HYDROLOGY EXAMPLE from Great Lakes coastal wetlands

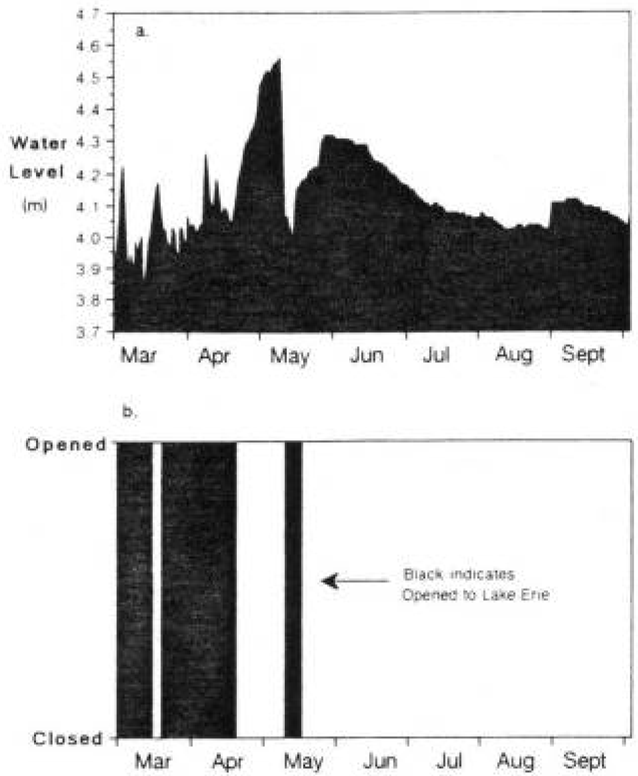


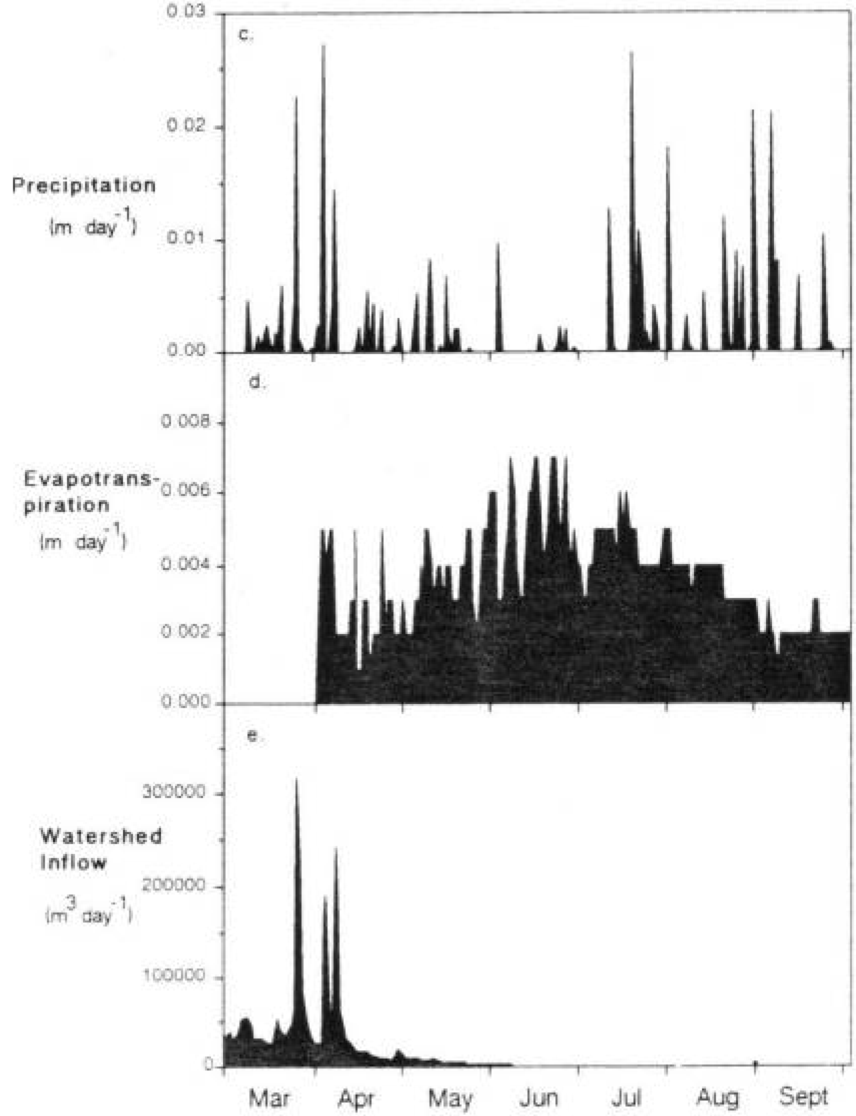
From Morrice et al. 2011 Wetlands 31:1199-1213.



From Trebitz et al. 2006. J. Great Lakes Res. 28:212-227.

WATER BUDGET example from Great Lakes coastal wetland





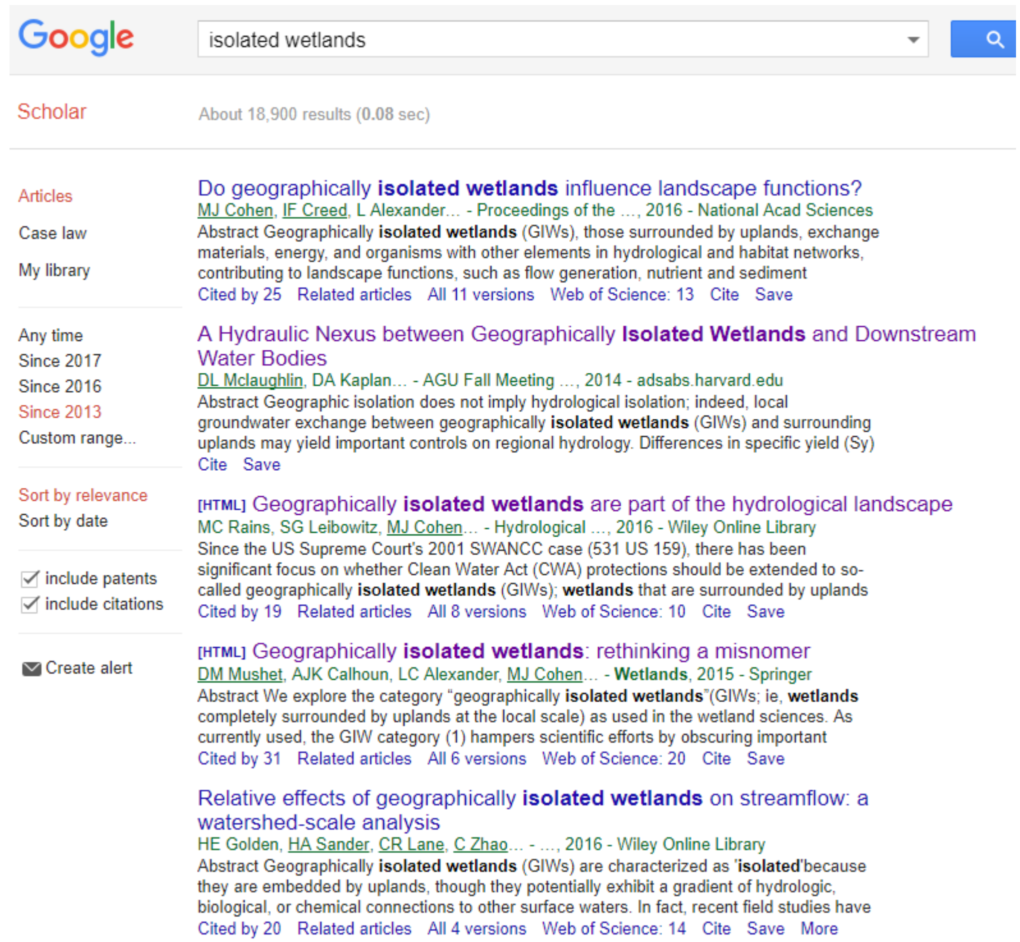
From Mitsch & Reeder. 1992. Nutrient and hydrologic budgets of a Great Lakes coastal freshwater wetland during a drought year. Wetlands Ecol. Manage. 1:211-222.

PART 3: IMPORTANCE OF HYDROLOGY TO ECOLOGY

HYDROLOGY has legal importance

- Supreme Court decision in 2001 removed Clean Water Act protection from wetlands having "*isolated, intra-state, non-navigable waters*" unless there was a "*significant nexus*" with navigable waters.

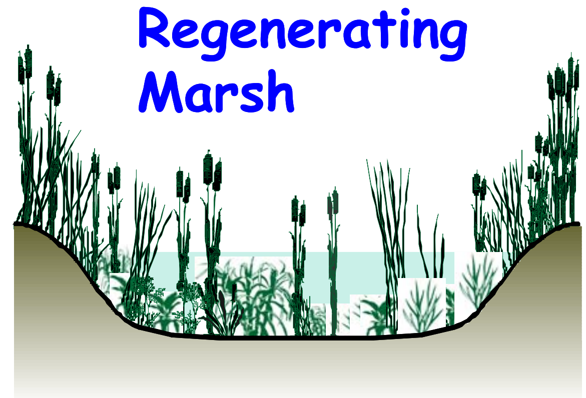
- Has catalyzed significant research on hydrological and ecological connectivity of such wetlands.



LONG-TERM PATTERNS:	inundated area depth time connectivity	→	plant succession seed banks resident species ecosystem connectivity invasive plant establishment
SEASONAL CYCLES:	evaporation snowmelt runoff water table lake level	→	ice scour primary production migratory species. resident species water chemistry oxic/anoxic sediments
DAILY CYCLES:	tide seiche	→	temperature salinity dissolved O_2 species movements plant zonation

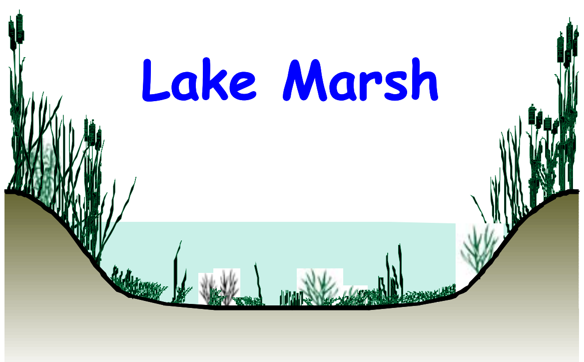
PRAIRIE POTHOLES: seasonal & interannual water level effects on biota

<u>rainfall & re-flooding</u>
- die-off of terrestrial veg
- aquatic veg establishes
- epiphytic algae increase
- dormant & flying inverts return
- increased epiphitic inverts



<u>drought drawdown</u>
- death of remaining submerged veg
- algae establish on mudflats
- terrestrial & emerg veg germinates
- aquatic inverts leave/go dormant
- colonization by terrestrial species
- shorebirds abundant on mudflats

<u>succession</u>
- emergent veg & epiphytes degenerate
- increased algal mats
- highest abundance of epiphytic inverts
- increased benthic inverts
- highest abundance of waterfowl



<u>more succession</u>
- deeper veg disappears
- phytoplankton replaces algal mats
- decreased epiphytic inverts
- increased benthic inverts
- highest abundance of diving birds

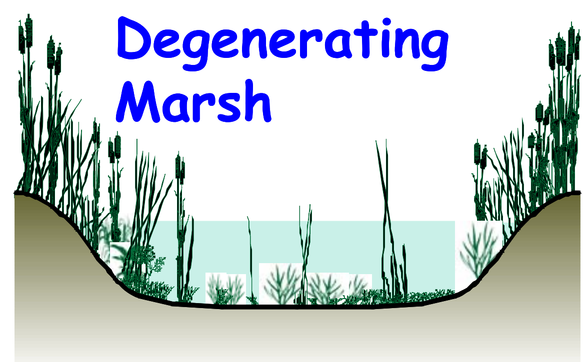
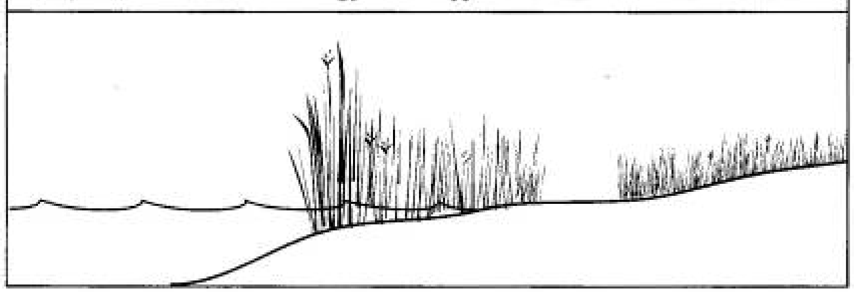


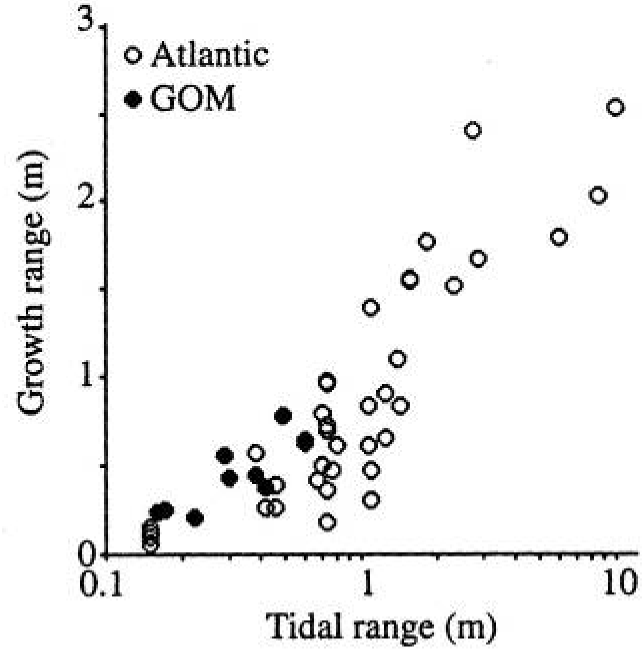
Figure from Dale Wrubleski, drawn after A.G. van der Valk, and C.B. Davis. 1978. The role of seed banks in the vegetation dynamics of prairie glacial marshes. Ecology 59:322-335.

ESTUARIES: tide effects on vegetation

Vegetation zones	Tidal creek	*Spartina alterniflora*		Salt flats	*Salicornia, Batis*	*Juncus*
		Tall	Short			
Frequency of flooding, %	100	80-100	40-80	5-10	4-8	2-5
Interstitial salinity, ppt	20	23	33	127	41	24.5

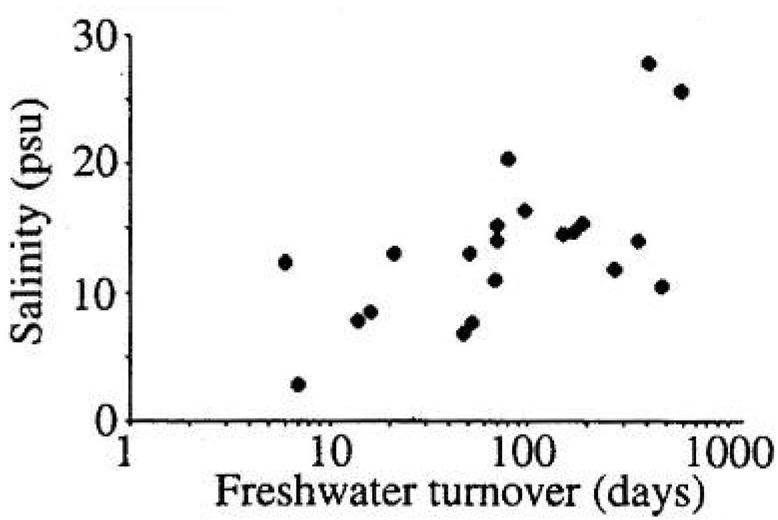


From W.J. Mitsch & J.G. Gosselink. 2000. *Wetlands*. John Wiley & Sons



from R.E. Turner. 2001. Of manatees, mangroves, and the Mississippi River: is there an estuarine signature for the Gulf of Mexico? Estuaries 24:139-150.

ESTUARIES: tide and tributary effects on water quality



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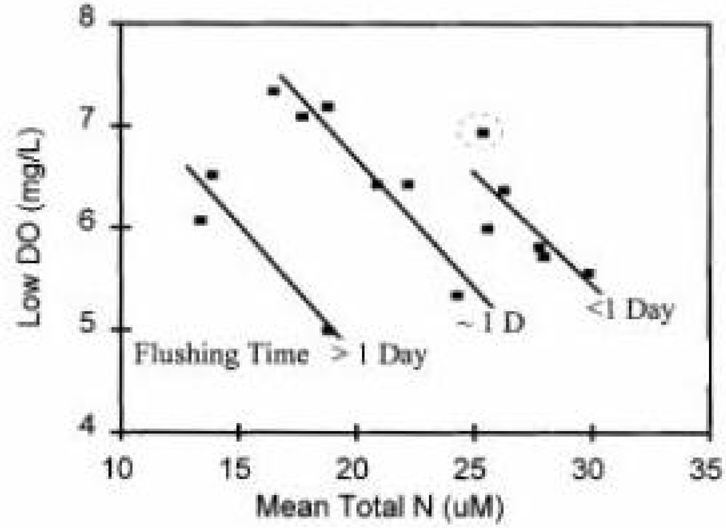
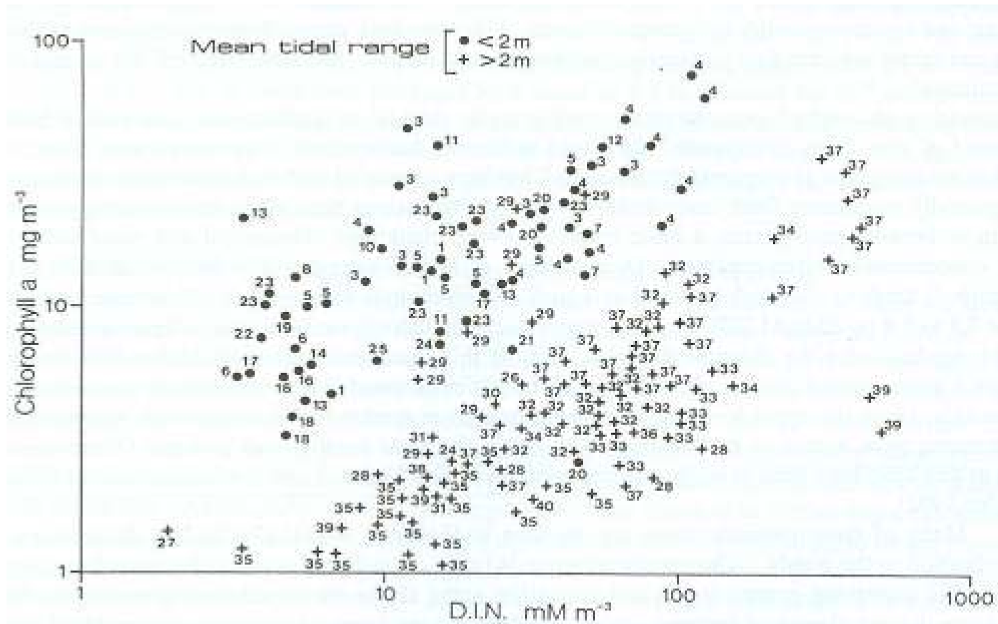
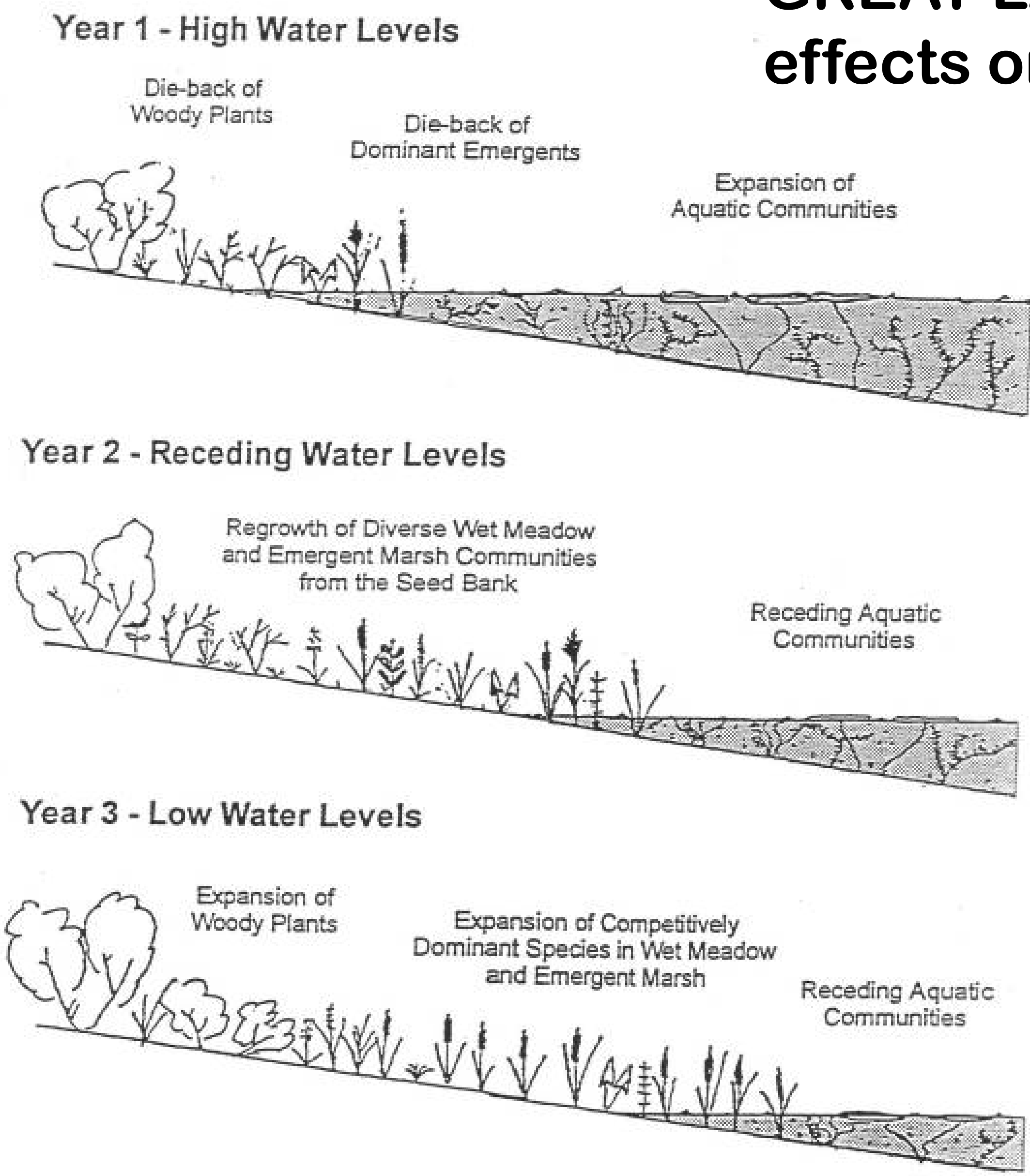


From Kelly 2001. Nitrogen effects on coastal marine ecosystems. Pp. 207-251 in *Nitrogen in the Environment: Sources, Problems, and Management*. Follett and Hatfields (eds), Elsevier.

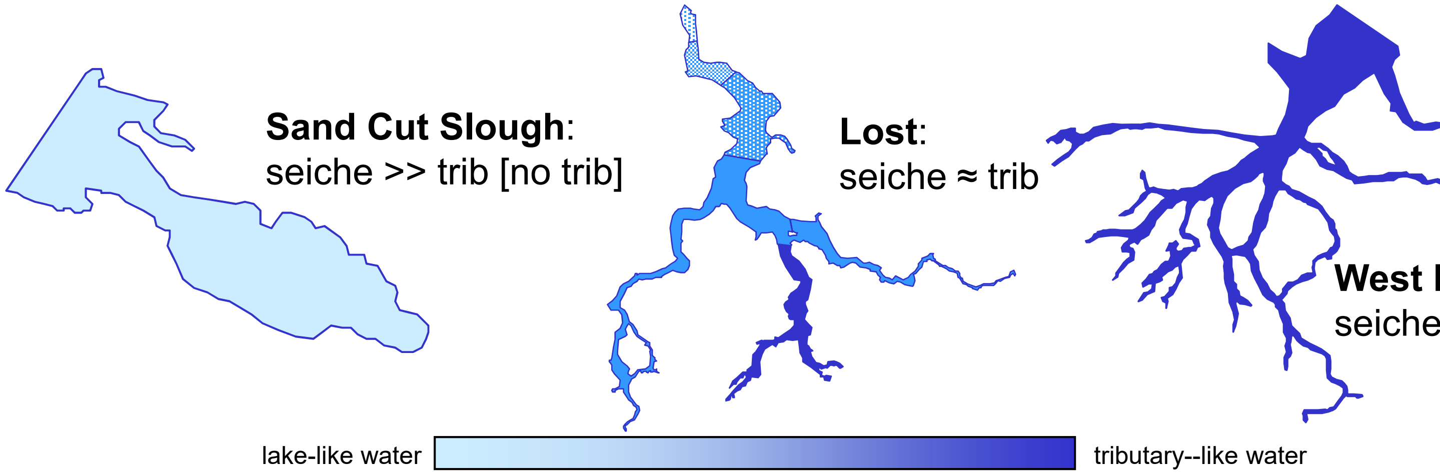


GREAT LAKES: lake-level effects on vegetation

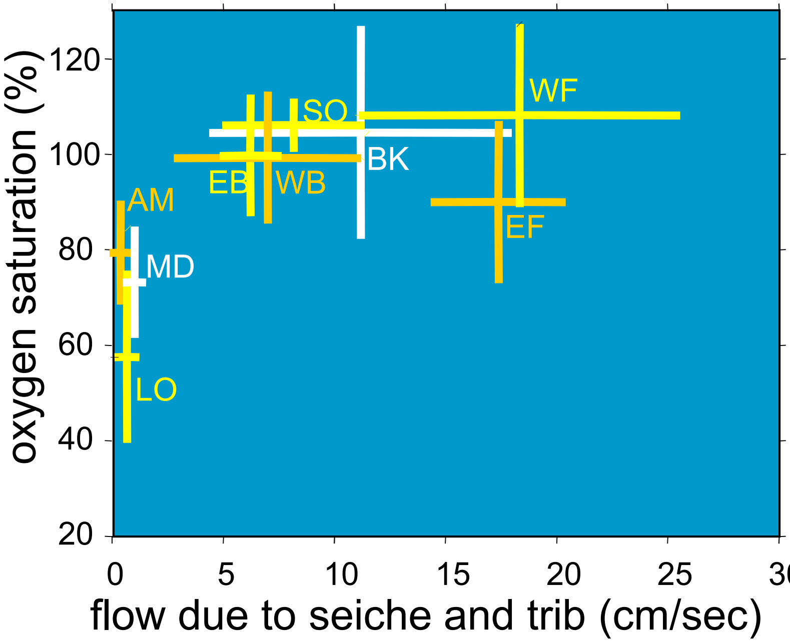


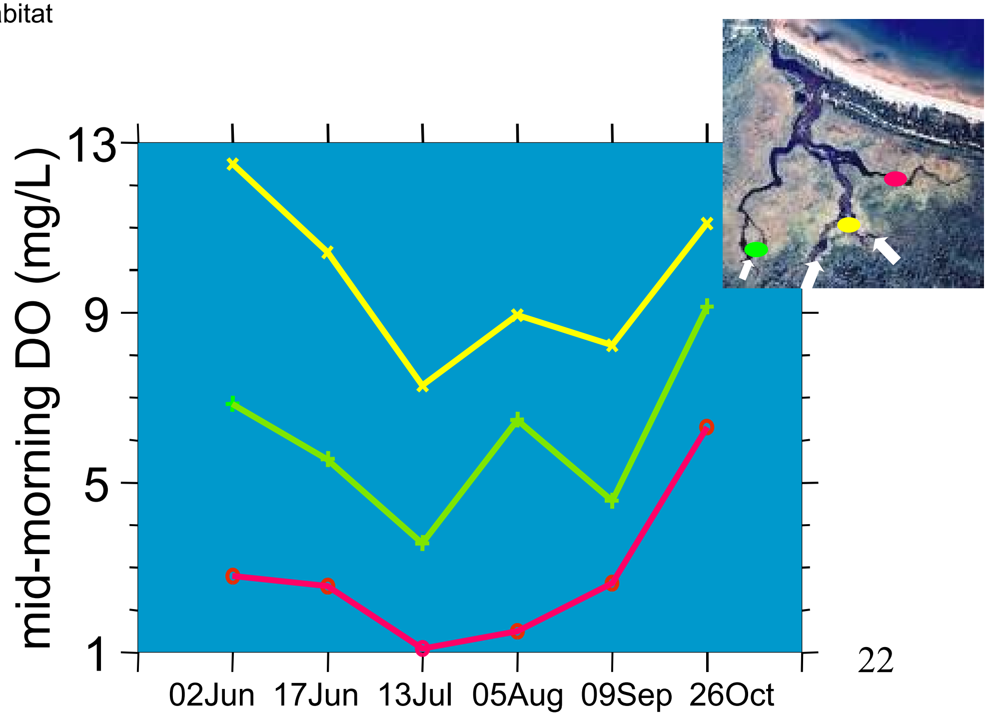
From Minc. 1997. Vegetative response in Michigan's coastal wetlands to Great Lakes water level fluctuations. Mich. Nat. Features Inventory report.

GREAT LAKES: seiche and tributary effects on water quality

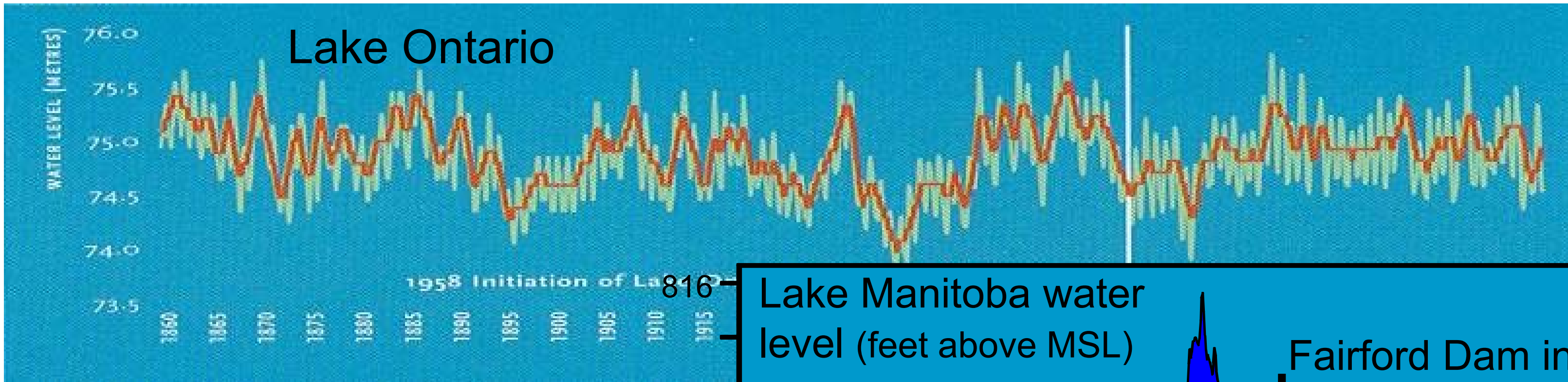


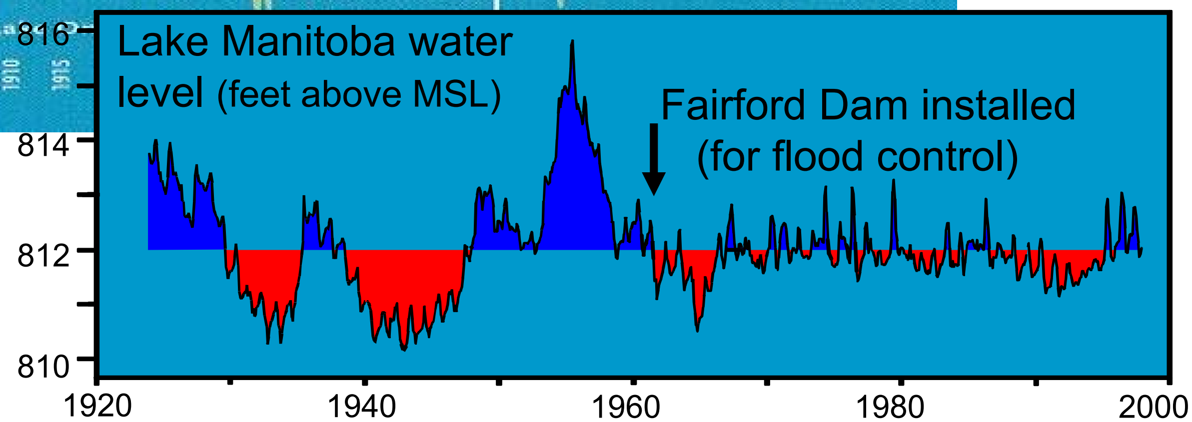
From Trebitz et al. 2006. Hydromorphic determinants of aquatic habitat variability in Lake Superior coastal wetlands. Wetlands 25:505-519.

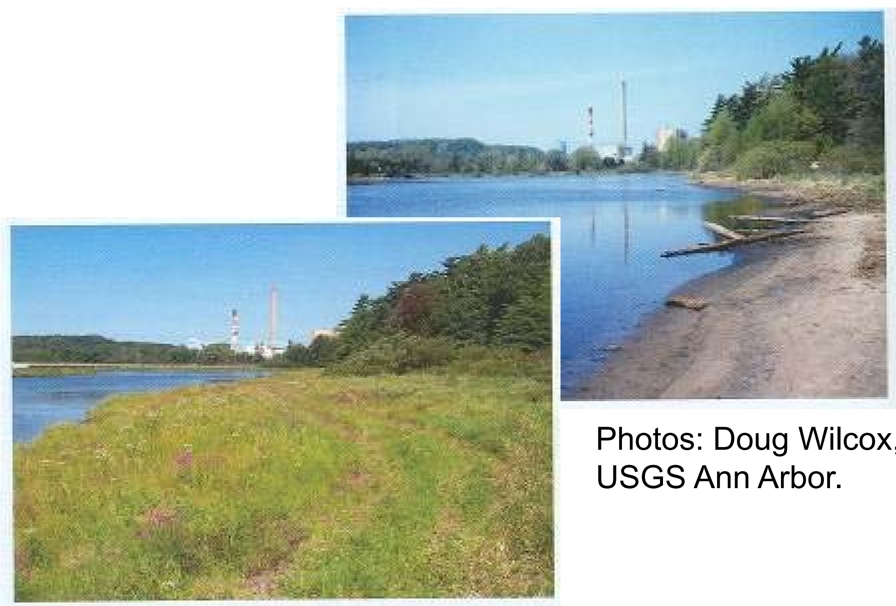




EFFECTS OF WATER LEVEL STABILIZATION







Photos: Doug Wilcox, USGS Ann Arbor.

Delta Marsh Vegetation 1979

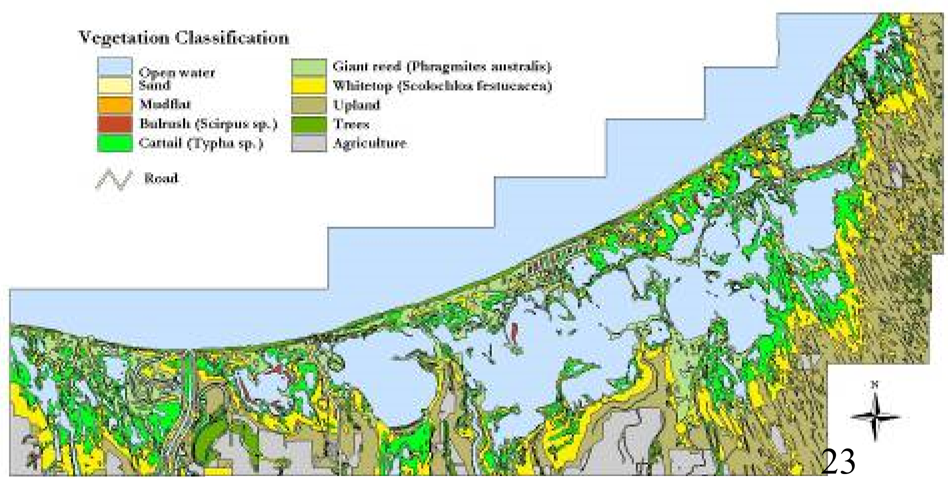
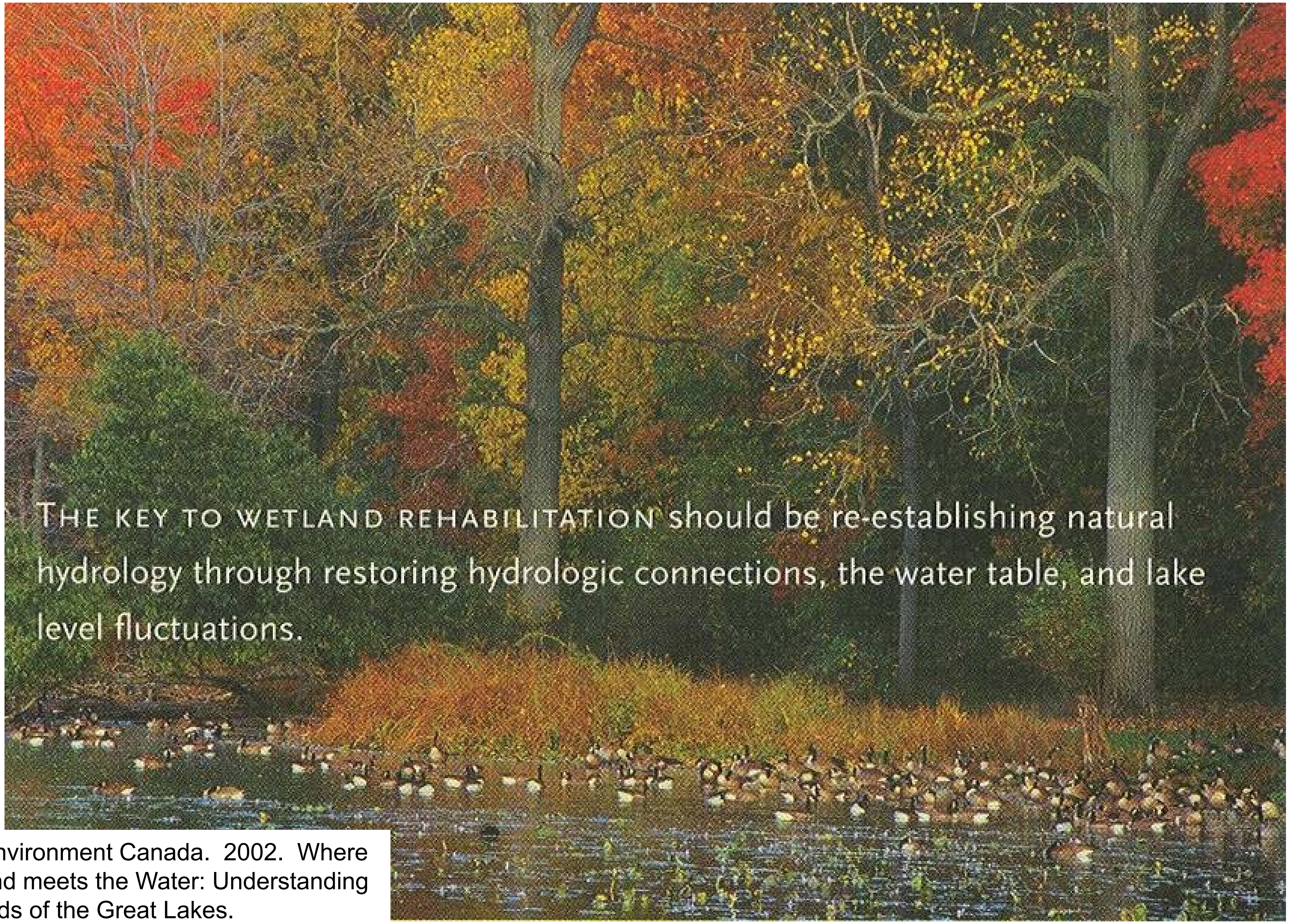


Image: Dale Wrubleski, Institute for Wetland and Waterfowl Research

Re-establishing hydrology is critical to wetland restoration



from Environment Canada. 2002. Where the Land meets the Water: Understanding Wetlands of the Great Lakes.

METZGER MARSH AERIAL VIEW

Douglas A. Wilcox

EXAMPLE: Metzger Marsh (Lake Erie)

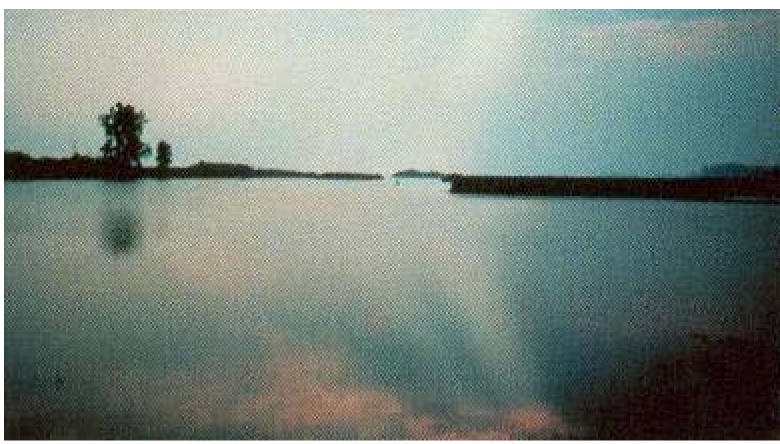
- natural barrier beach lost: combination of stream diversion, shoreline hardening, high water

- diking stopped wetland loss but didn’t restore original condition

- water control structure installed: permits drawdown and water exchanges with lake

- drawdown and flooding used to control nuisance plant species

from Environment Canada. 2002. “Where Land Meets Water: Understanding Wetlands of the Great Lakes”.



Final Photo: Delta Marsh wetland complex adjacent to Lake Manitoba