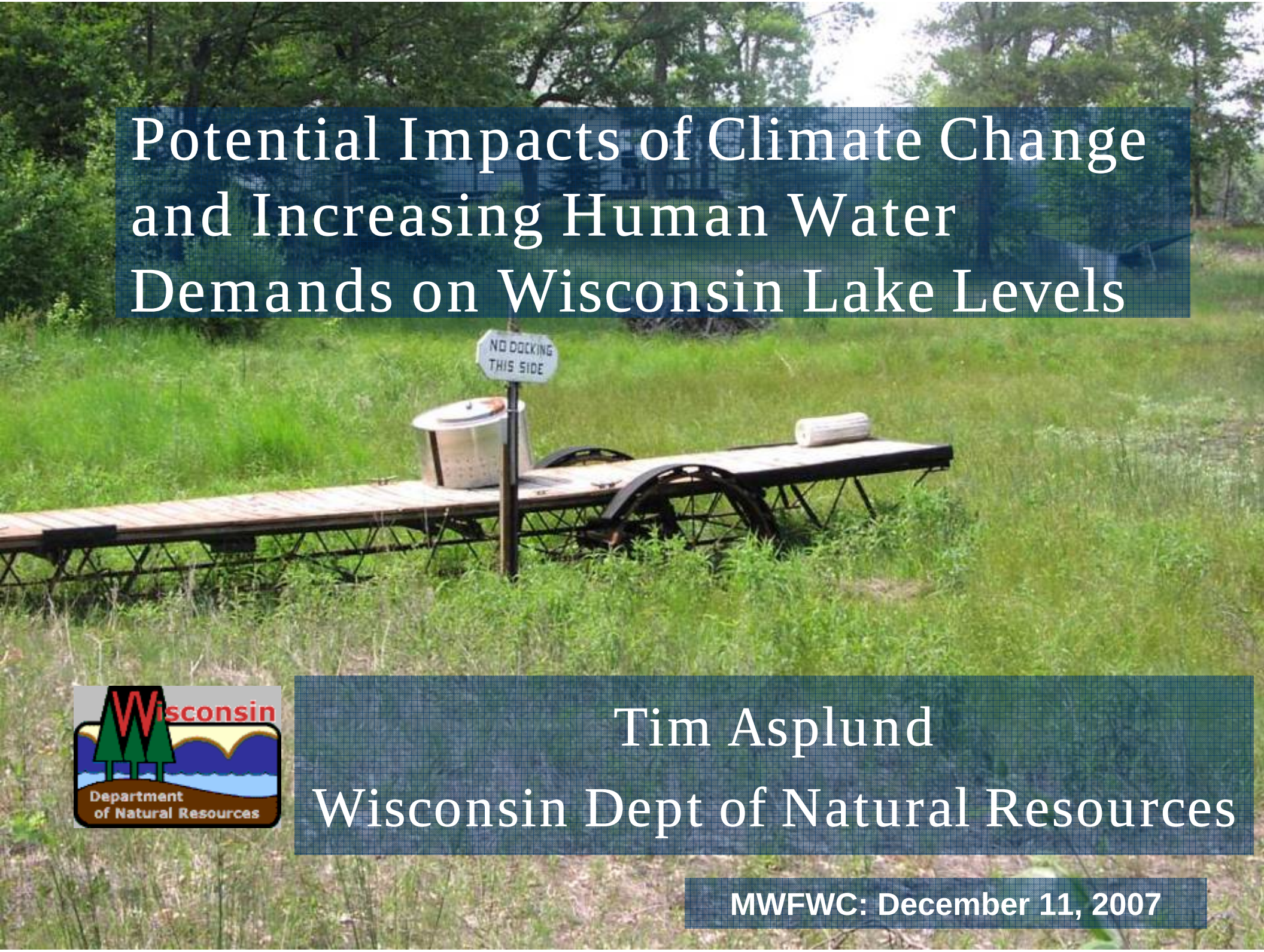
Potential Impacts of Climate Change and Increasing Human Water Demands on Wisconsin Lake Levels



Tim Asplund
Wisconsin Dept of Natural Resources

MWFWC: December 11, 2007

Huron Lake, Waushara County

Twin Lake, Marquette County

Sandbar Lake, Bayfield County

R. Lathrop

Fallison Lake, Vilas County

Shell Lake (WI) June 2002

Krohelski 2003

Lake Monona, Dane Co, August 31, 2007

Which one is the future?

Maybe both!

Many factors affect water levels

- Lake morphology and hydrology
- Landscape position
- Natural variability (weather)
- Short term drought (and wet) cycles
- Human water use (i.e. water withdrawals)
- Climate change

Lake Hydrology

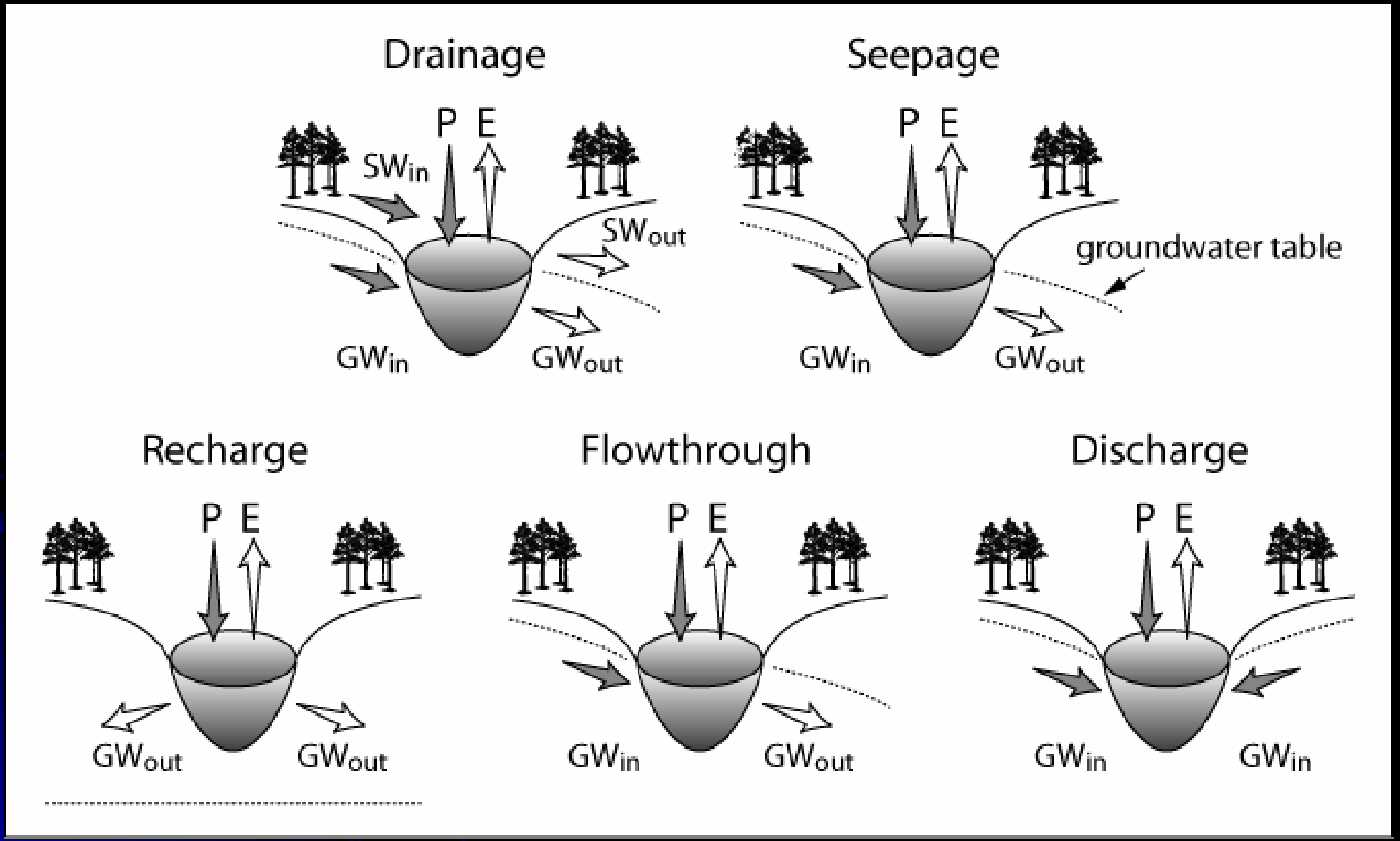
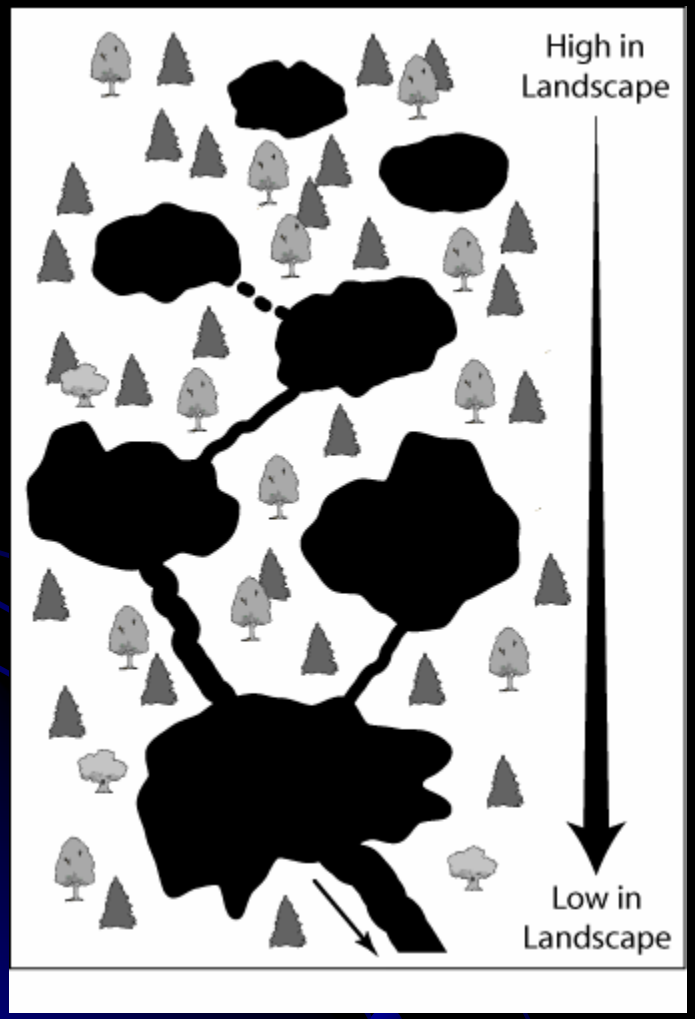
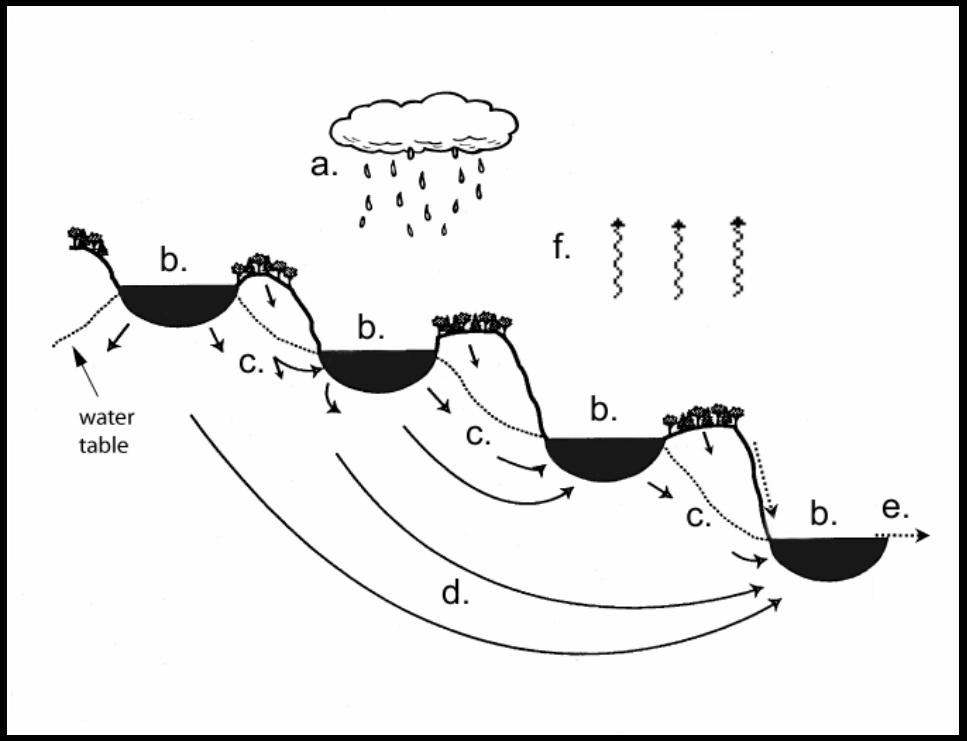


Fig 2.3

Magnuson et al. 2006

Landscape Position





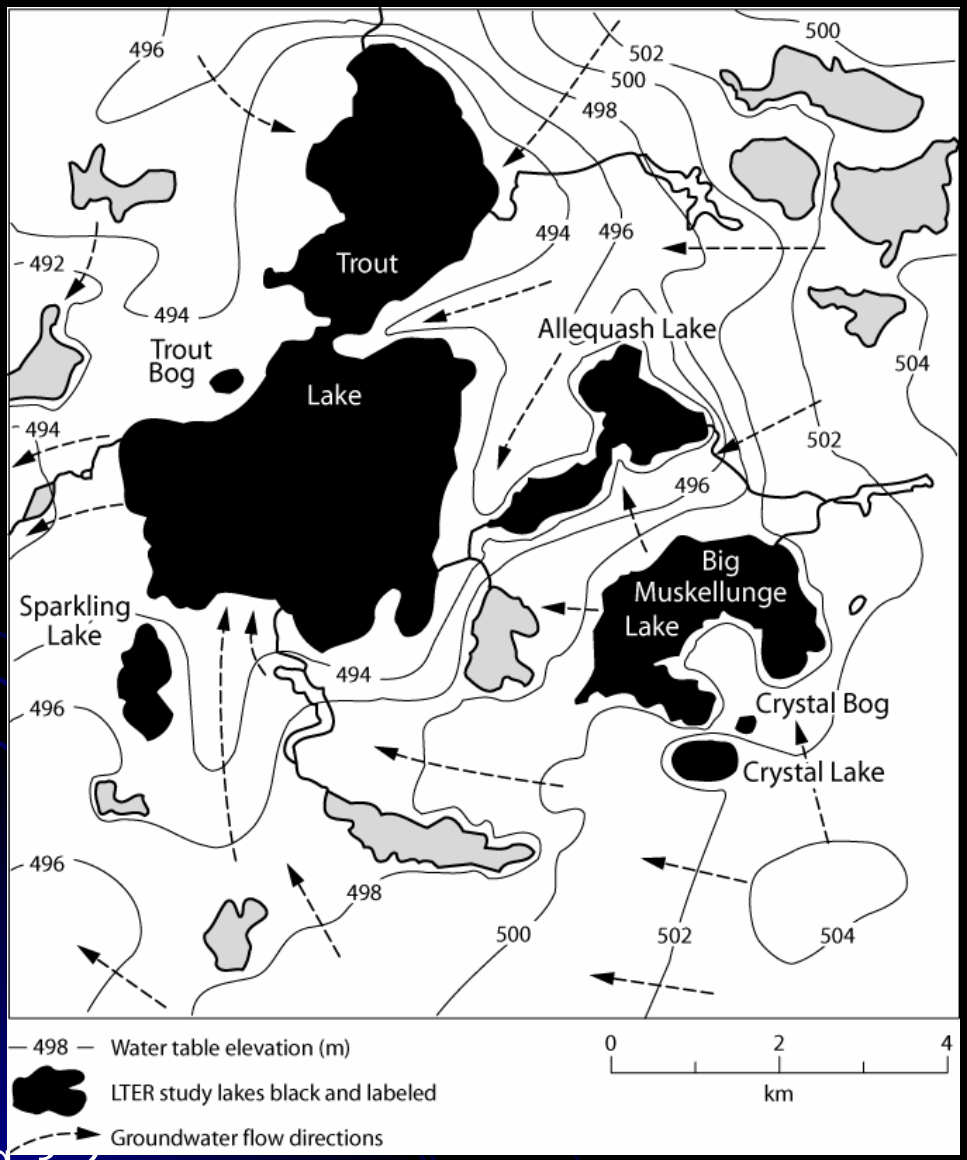
Magnuson et al. 2006

Natural variability

	Period of record (ft)	Average annual (ft)	Maximum annual (ft)	Minimum annual (ft)
Ground-water flow-through	2.5-10.5	0.8-2.7	1.2-5.5	0.3-1.4
Surface-water flow-through	2.6-7.8	1.0-2.6	2.1-4.7	0.5-1.2
Ground-water discharge	1.4-3.8	0.6-1.4	0.9-2.9	0.2-0.6

"A statistical analysis of data in table 1 indicates that ***9*** out of 10 natural lakes in the State will fluctuate within the following approximate ranges during periods of **20** years or longer."

Response of Lakes to Drought



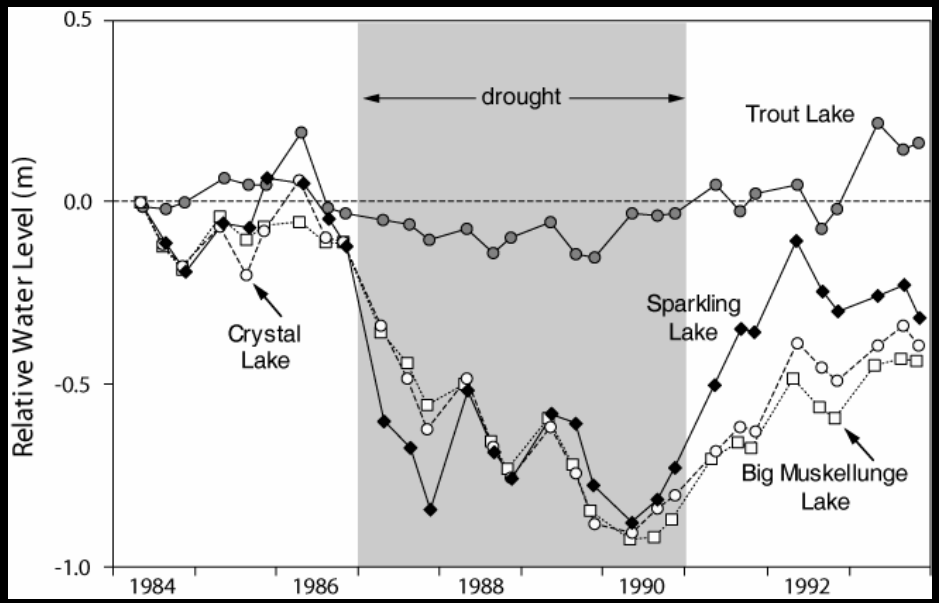
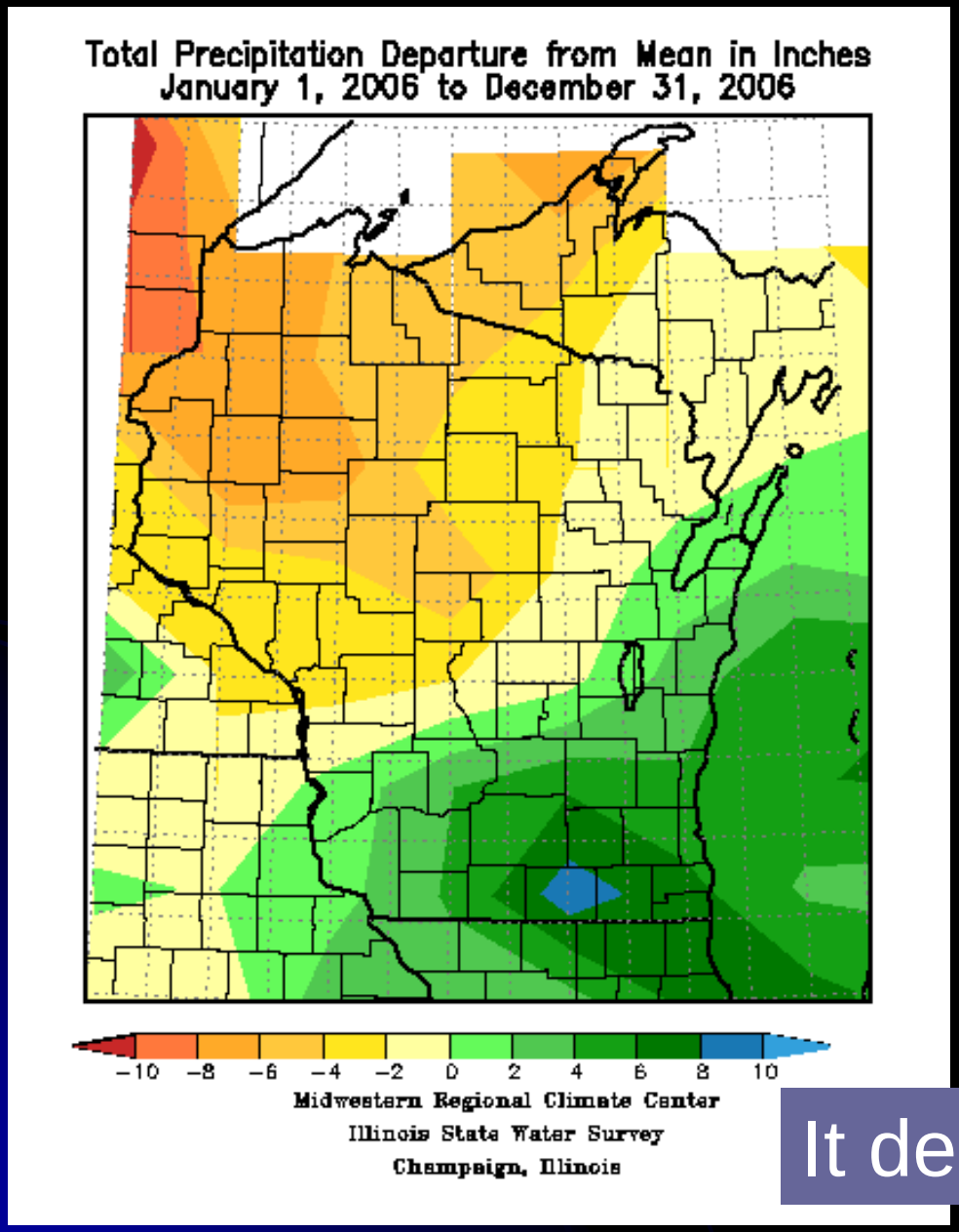
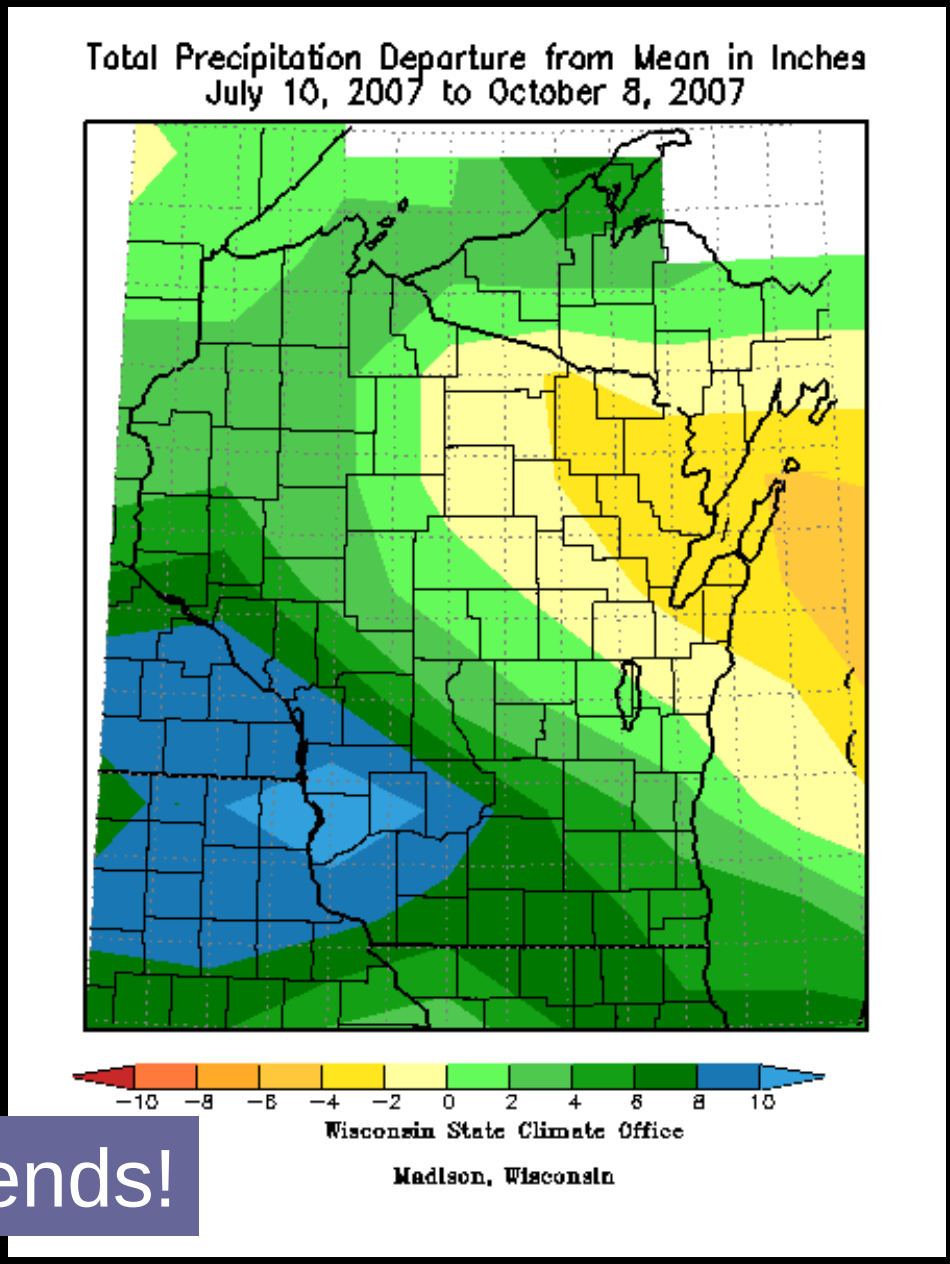


Fig 3.2

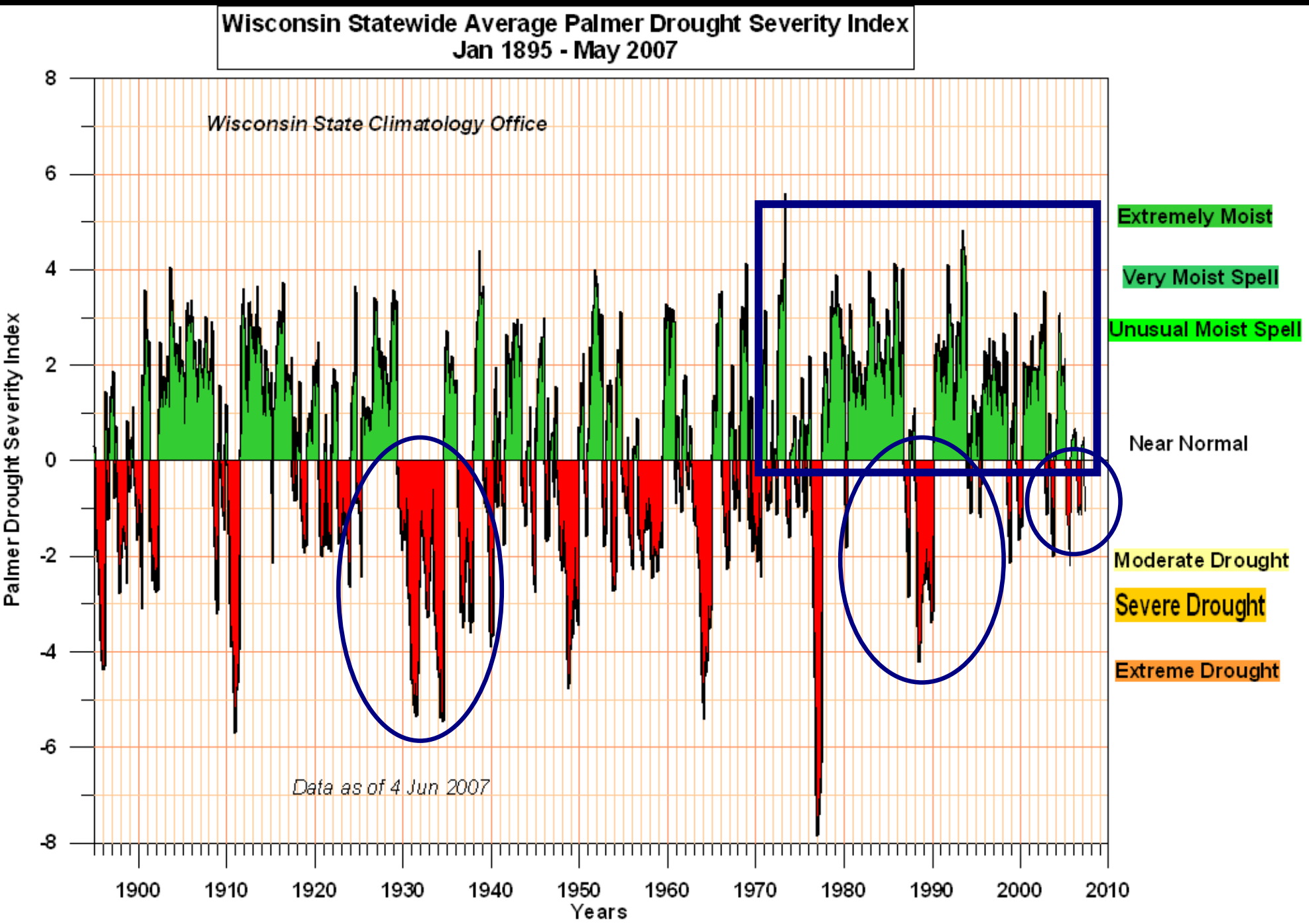
Magnuson et al. 2006

Is WI in a drought?

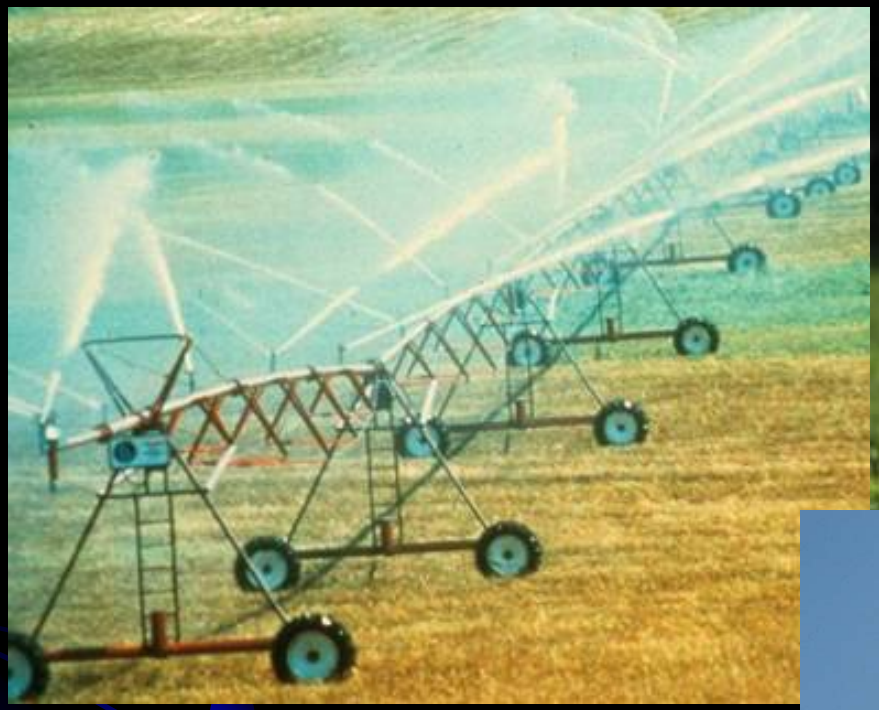




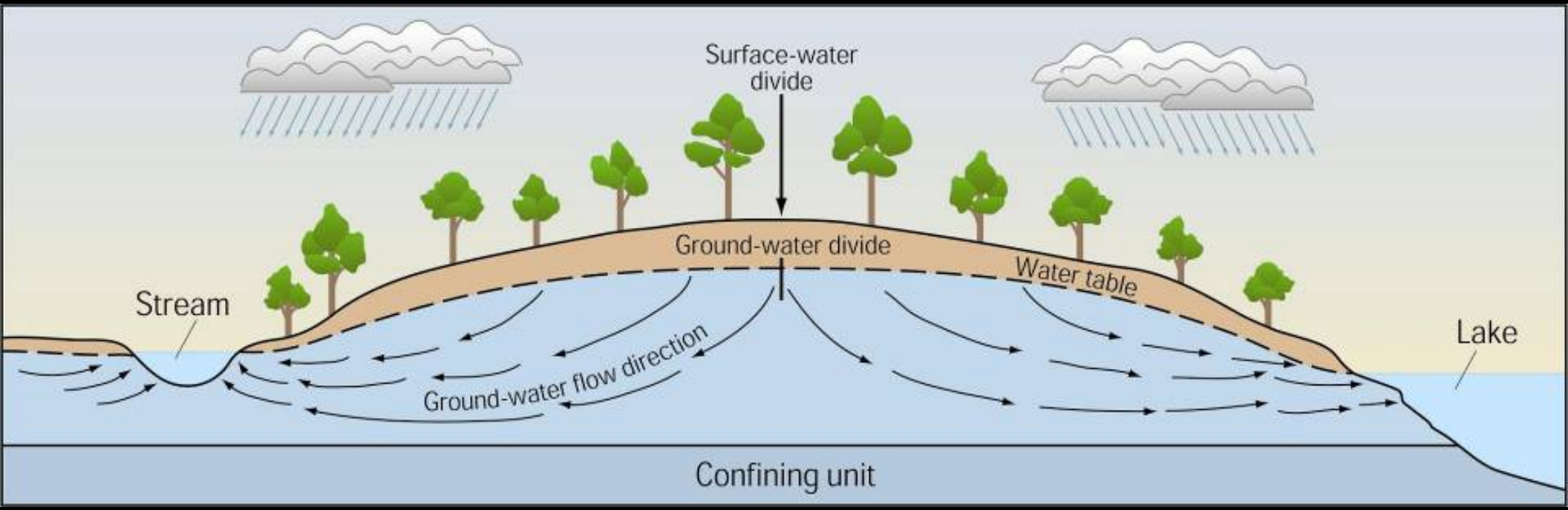
It depends!


Wisconsin Statewide Average Palmer Drought Severity Index
Jan 1895 - May 2007
Wisconsin State Climatology Office
Palmer Drought Severity Index
8
6
4
2
0
-2
-4
-6
-8
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Years
Data as of 4 Jun 2007
Extremely Moist
Very Moist Spell
Unusual Moist Spell
Near Normal
Moderate Drought
Severe Drought
Extreme Drought

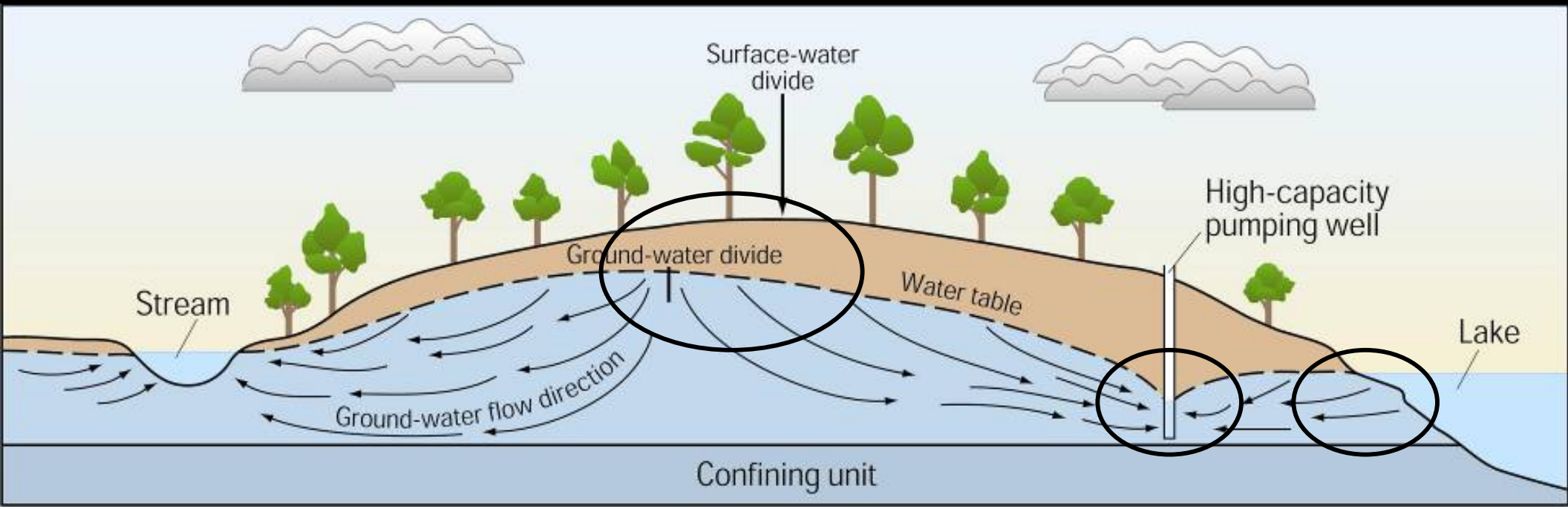
Human water use



Natural



Affected By Pumping



Evidence of Climate Change in the Great Lakes Region*

- Temperatures are rising, especially in winter.
- Extreme rainfall events (24-hr and 7-day) are becoming more frequent.
- Winters have become shorter.
- Spring is coming earlier.
- Duration of ice cover is shorter, especially on smaller lakes.

Source; Edge of the Wilderness Scenic Byways

*http://www.ucsusa.org/greatlakes

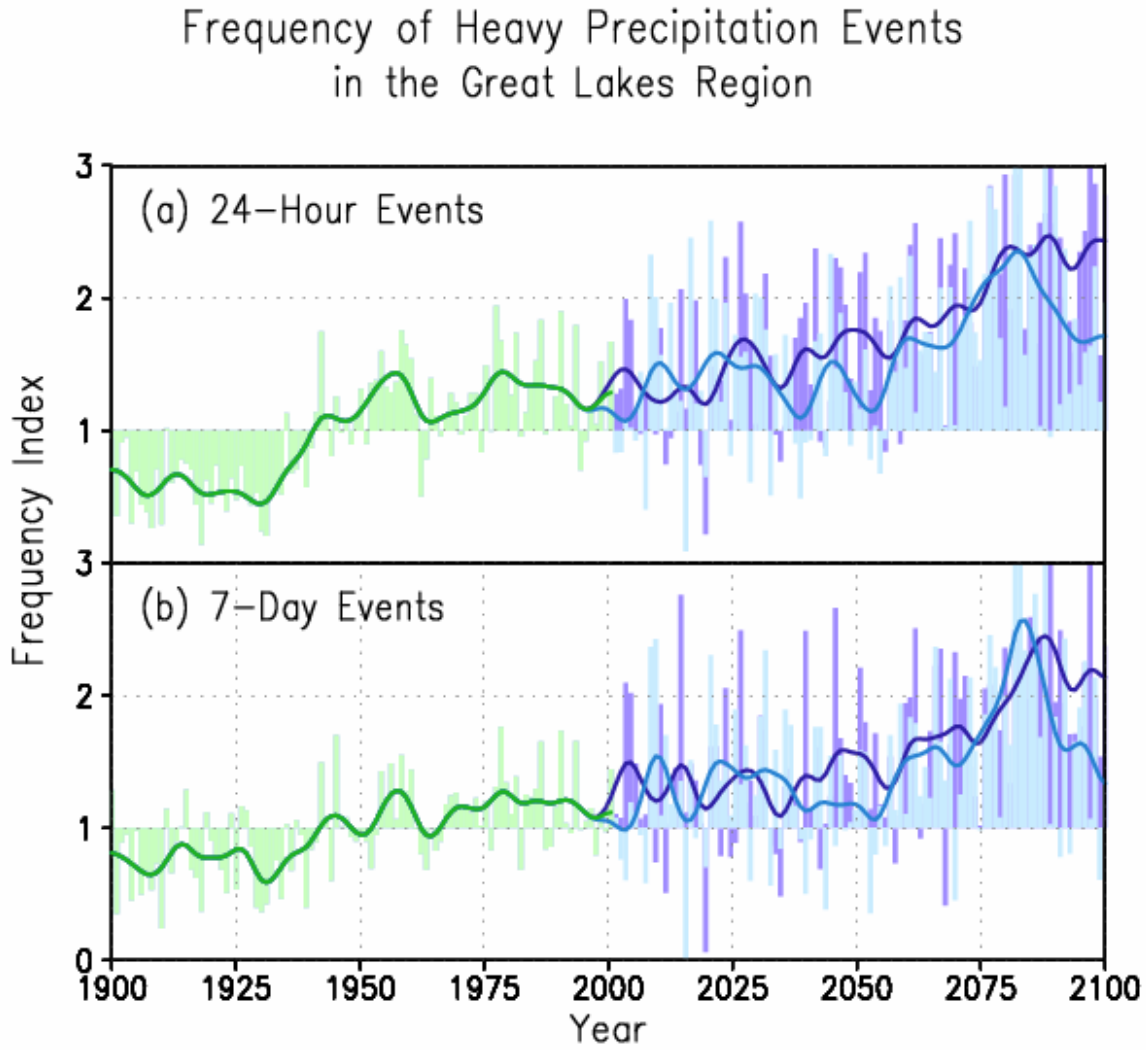
Projected Climate Changes in the Great Lakes Region by 2100

*http://www.ucsusa.org/greatlakes

- **Temperature**
  - Winter 5-12 °F (3-7 °C)
  - Summer 5-20 °F (3-11 °C)
  - Extreme heat more common
  - Growing season several weeks longer
- **Precipitation**
  - Winter, spring increasing
  - Summer, fall decreasing
  - Drier soils, more droughts
- **More extreme events** – storms, floods
  - Could be 50-100% more frequent than now
- **Ice cover decline** will continue

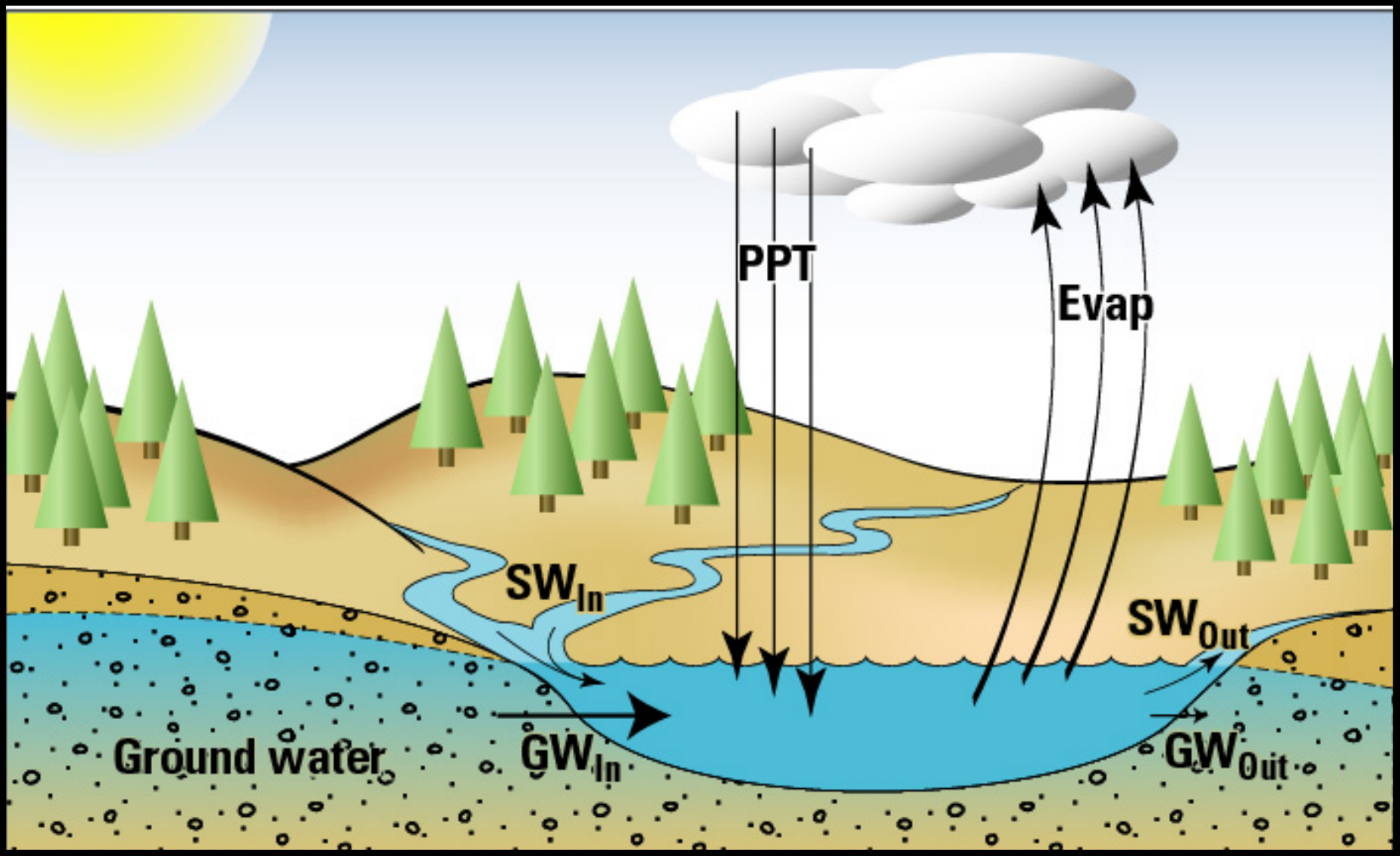
Source: Bob Allan, NREL

Projected Precipitation Changes in the Great Lakes Region (by 2070-99)

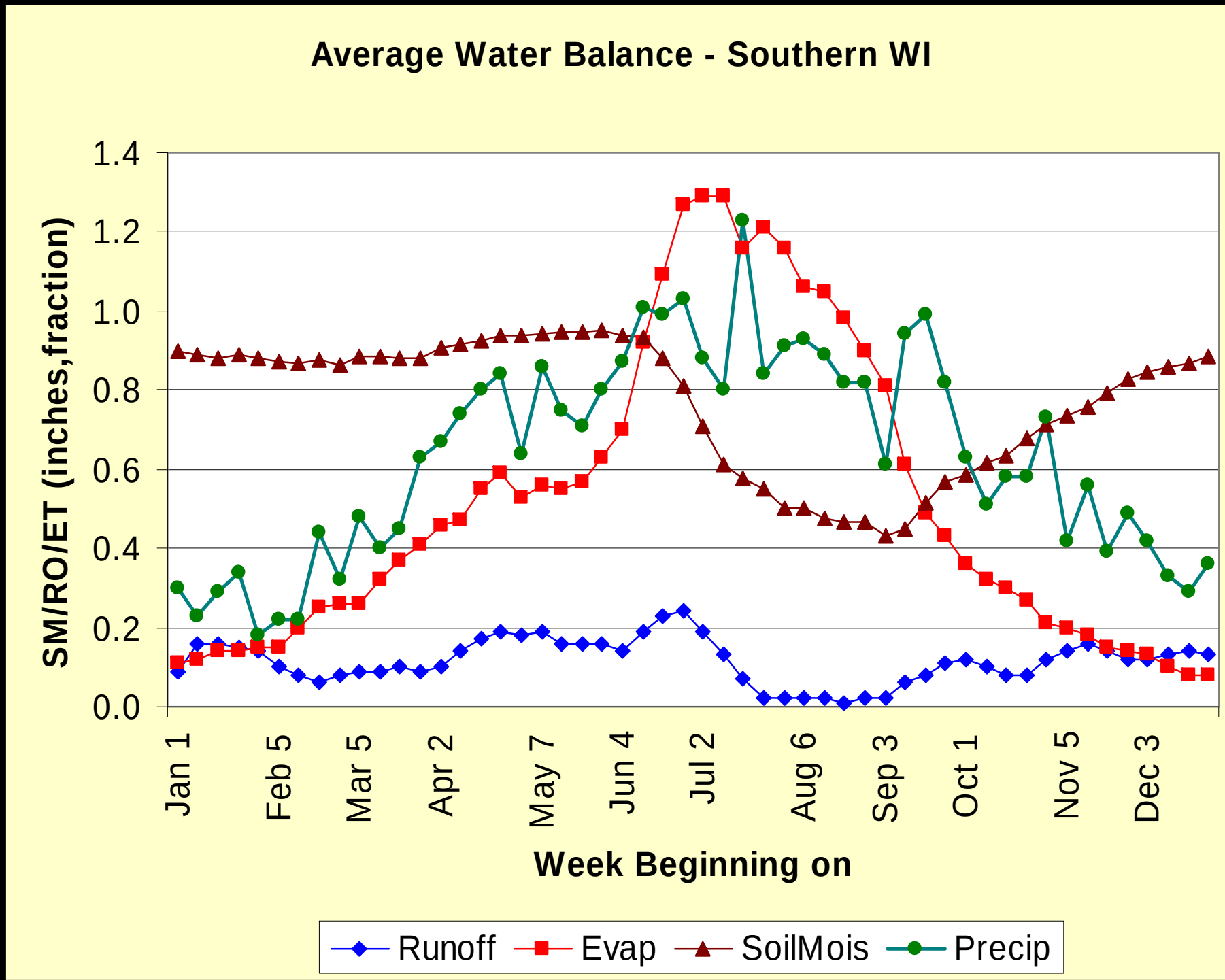


- Doubling of heavy precipitation events
- Seasonal shifts in precipitation --
  * More rain in winter and spring (planting season)
  * Less rain during the summer and fall growing seasons

Changes in the Hydrologic Cycle



Krohelski 2003


Average Water Balance - Southern WI
SM/RO/ET (inches,fraction)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 1
Feb 5
Mar 5
Apr 2
May 7
Jun 4
Jul 2
Aug 6
Sep 3
Oct 1
Nov 5
Dec 3
Week Beginning on
Runoff
Evap
SoilMois
Precip

Source: ISWS

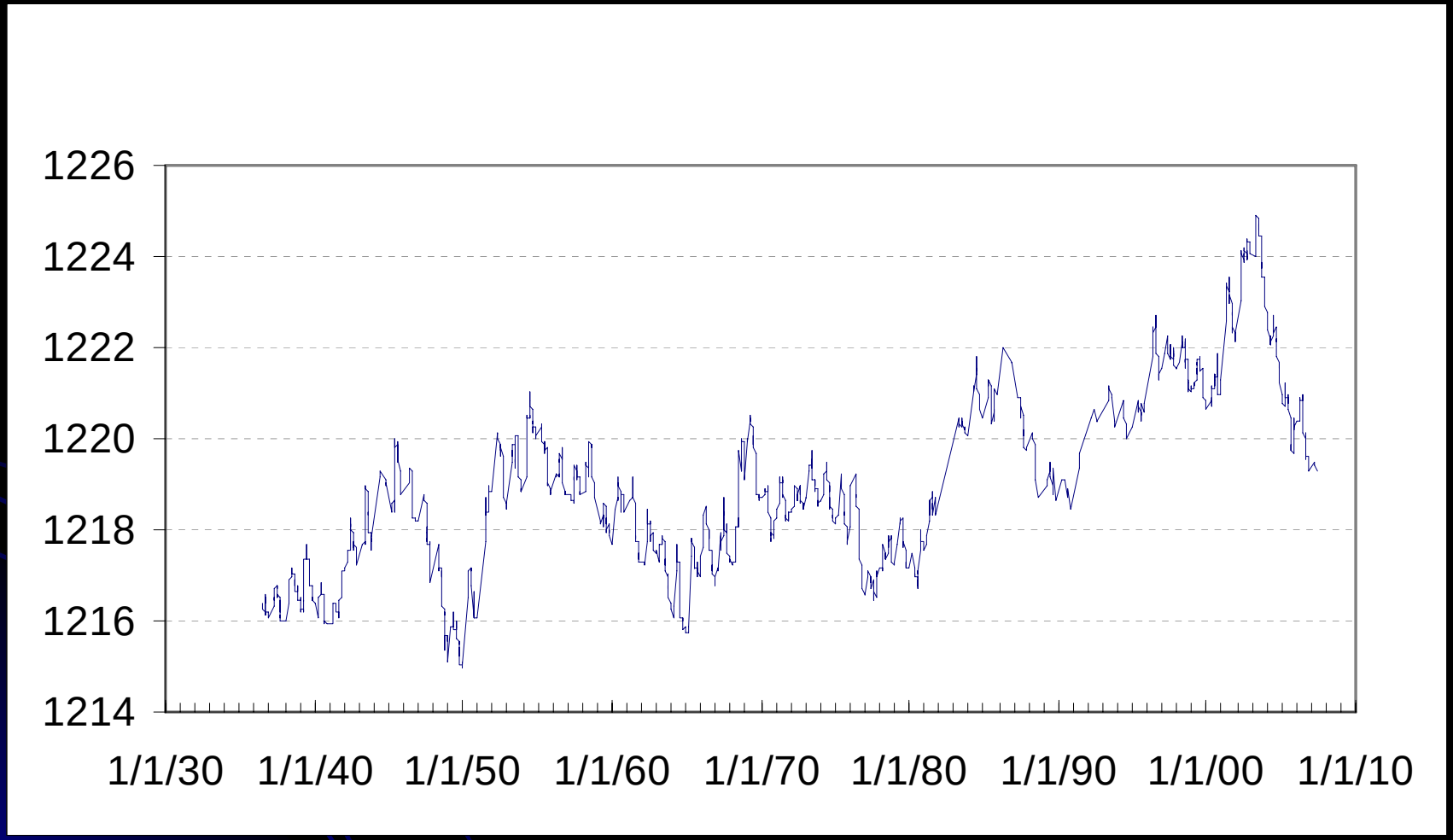
Water Levels – Scenario #1

- Warmer, wetter winters
- More CO_2 in atmosphere makes plants more water efficient
- More storms increases runoff
- More recharge increases baseflow and groundwater levels
- Lakes may go up

Source: John Magnuson, 2007

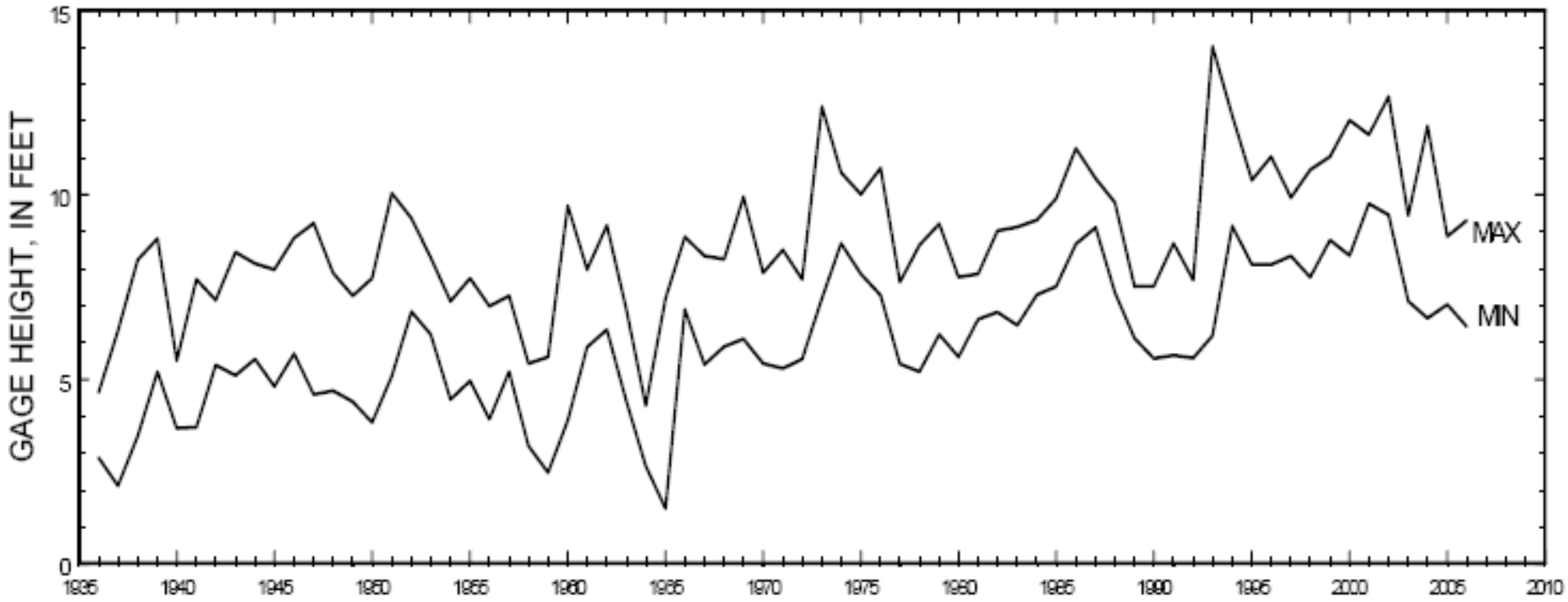
Lake Monona, Dane Co, August 2007

Shell Lake (Washburn Co) Stage (1936 – 2006)



Source: USGS

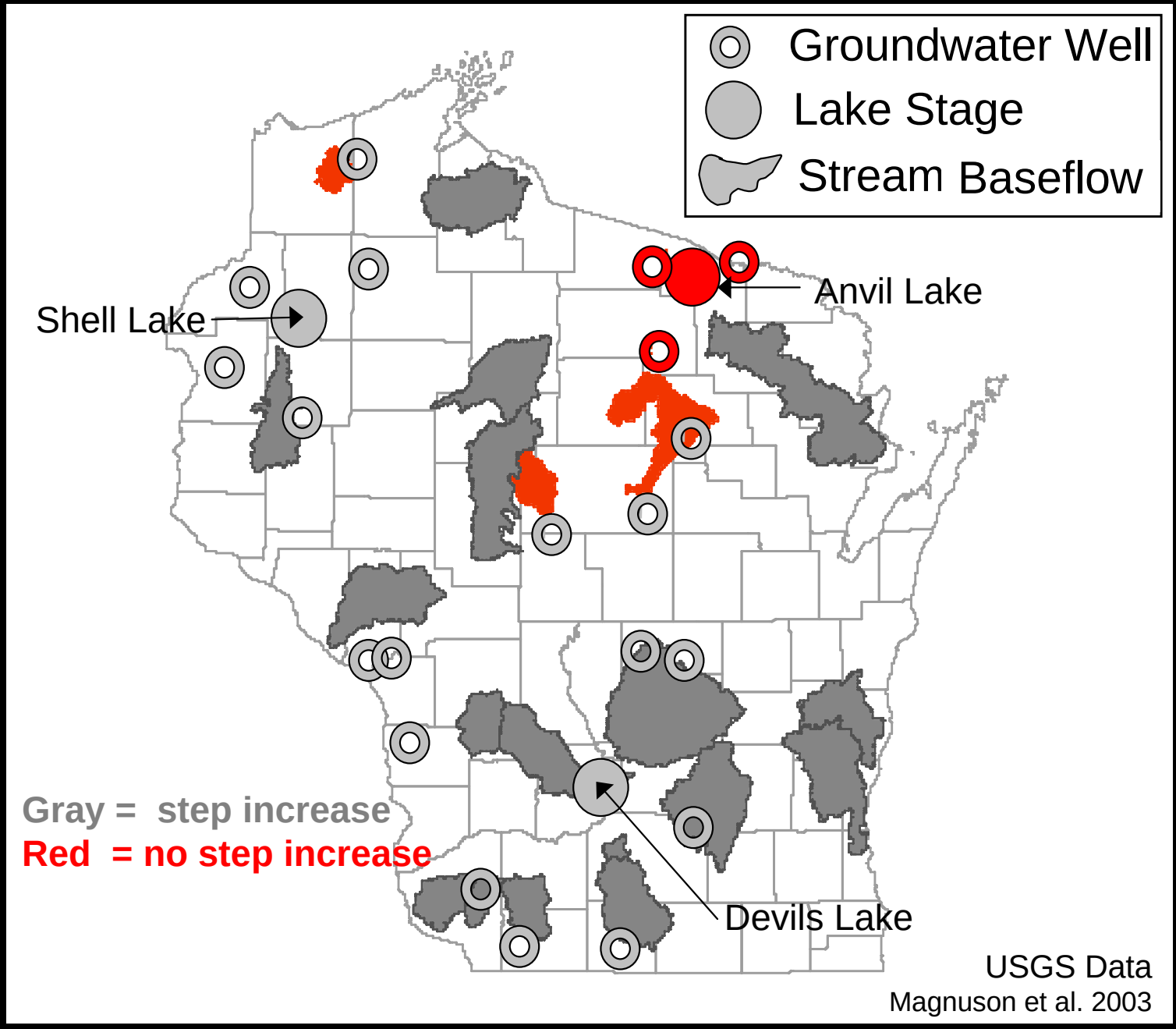
Devil's Lake (Sauk Co) Stage (1935-2006)



1935 1970 2005

Source: USGS

Step Increase in Lake Stage, Stream Flow, and Groundwater Levels after 1970



Water Levels – Scenario #2

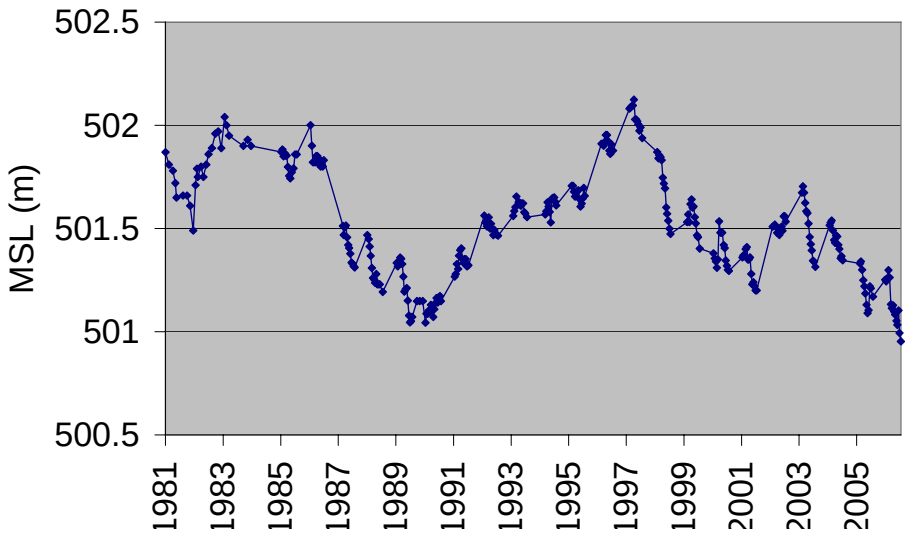
- Shorter duration of ice cover will increase evaporation in winter
- Warmer air temperatures will increase evapotranspiration
- Lower precipitation in summer will decrease soil moisture
- Lakes may go down

SOURCE: UCS/ESA 2003

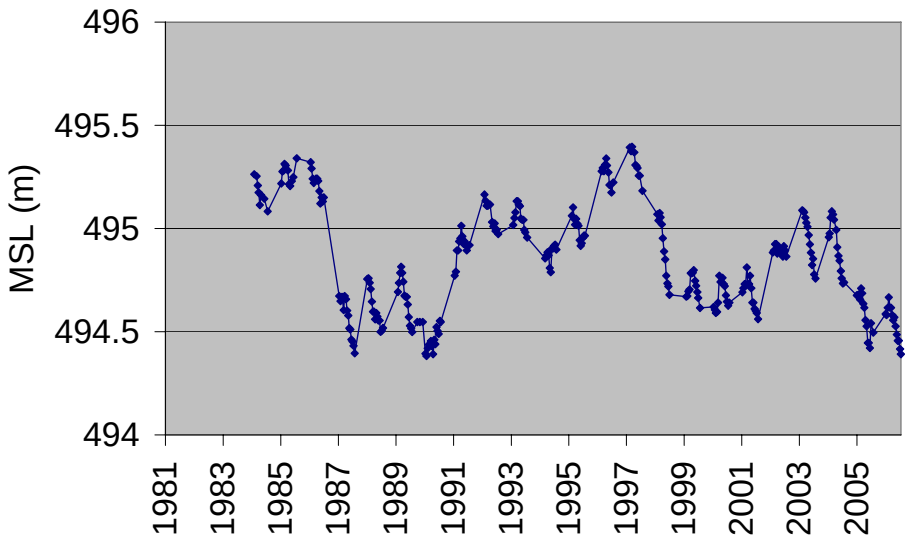
Long Lake, Waushara County

LTER Lake Levels, Vilas Co

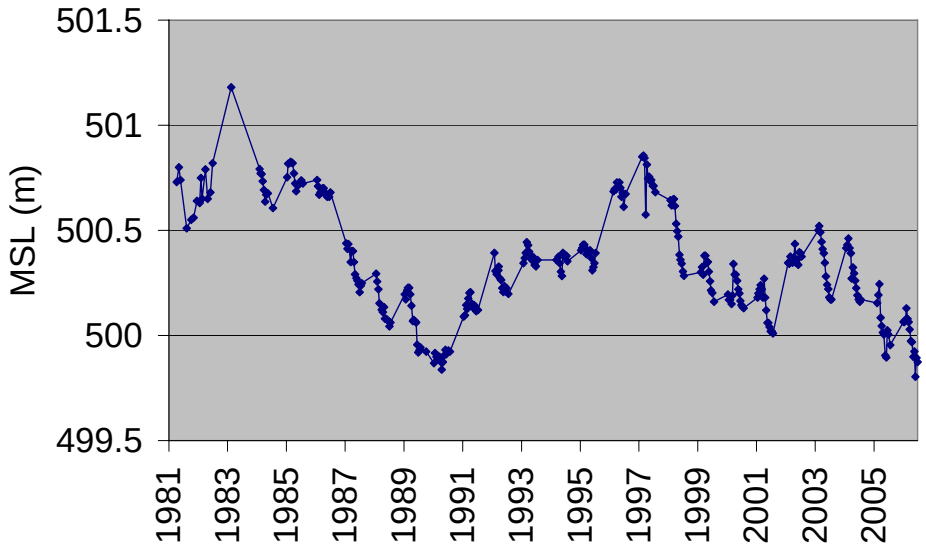
Crystal Lake, Vilas County



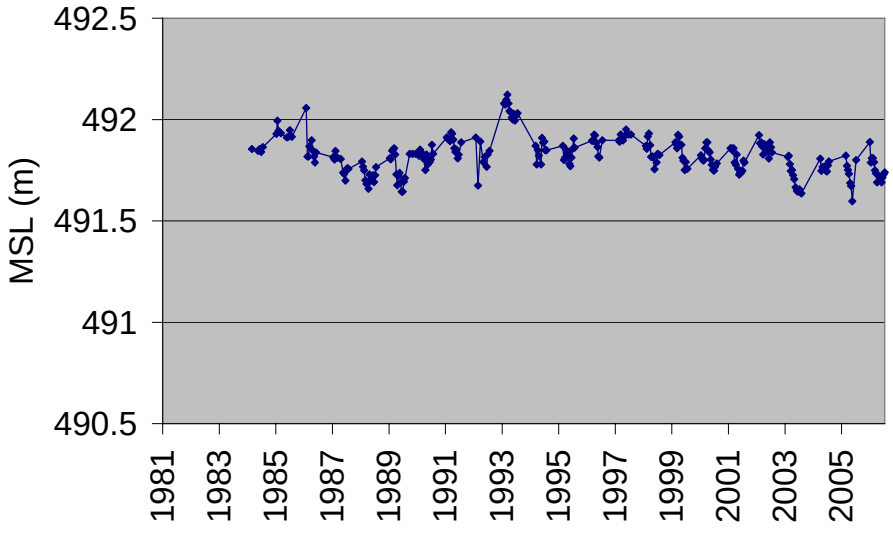
Sparkling Lake, Vilas County



Big Muskellunge Lake, Vilas County

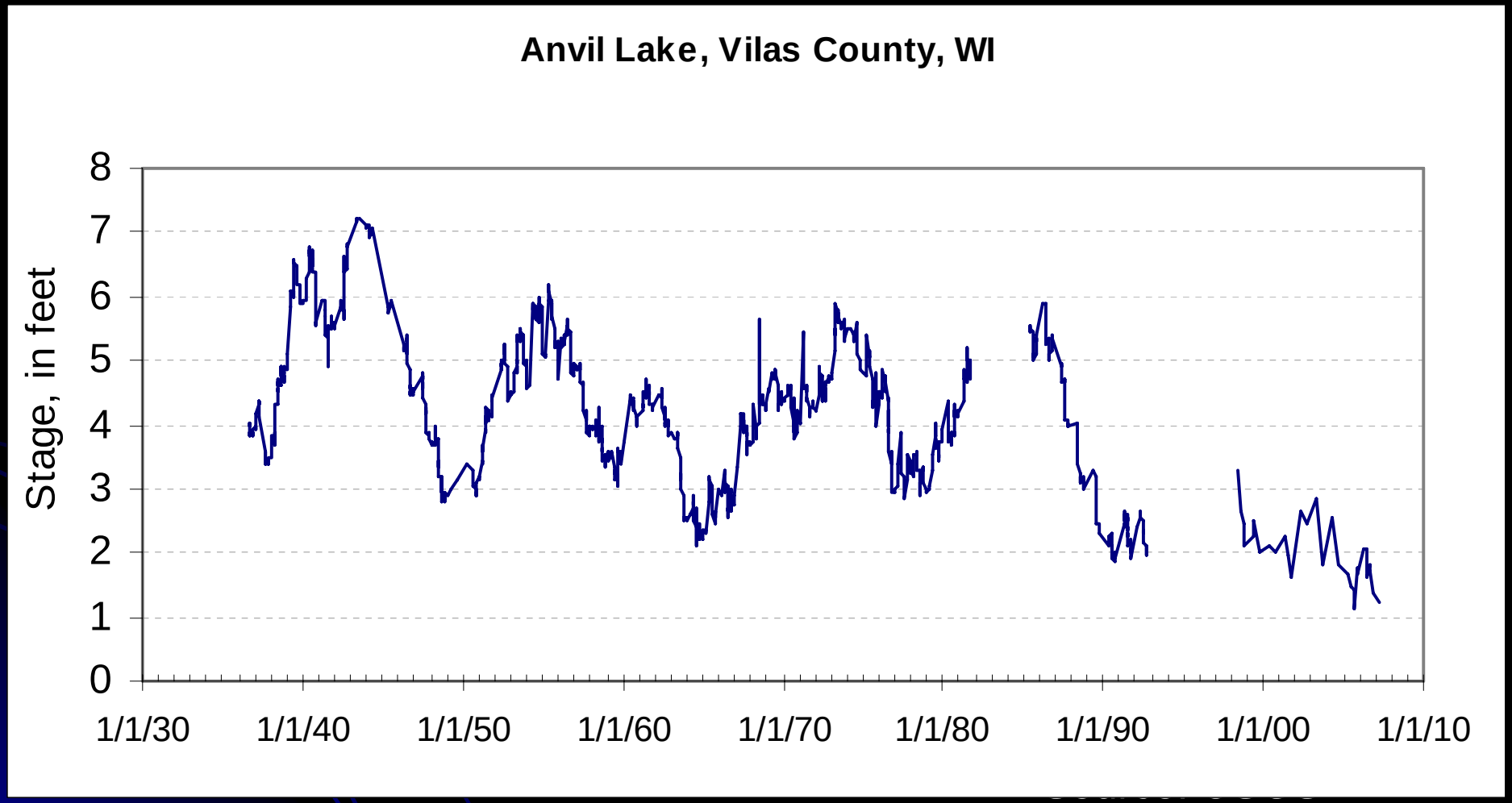


Trout Lake, Vilas County



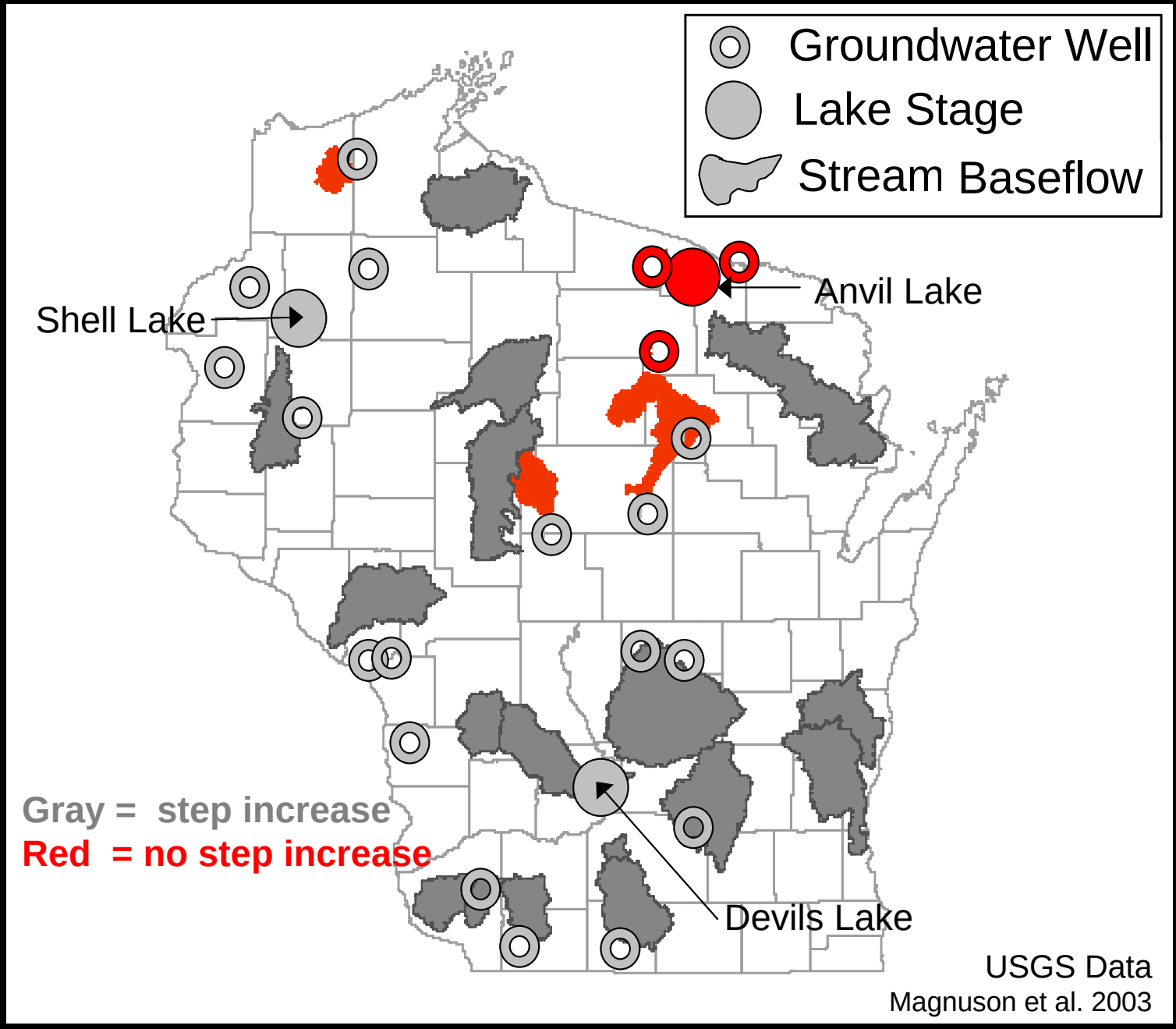
Source: NTL LTER, Center for Limnology

Anvil Lake (Vilas Co) Stage (1936 – 2006)

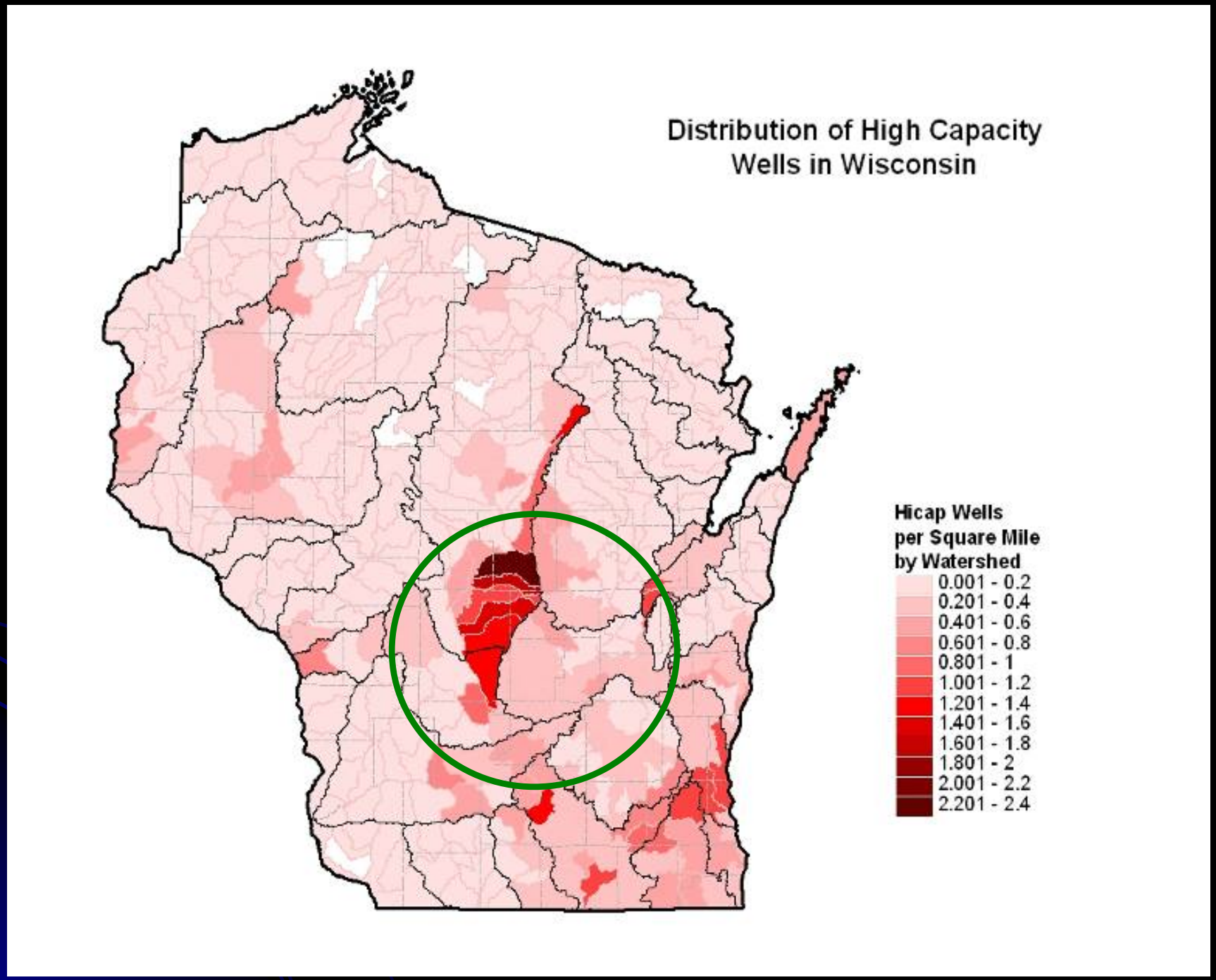


Source: USGS

Step Increase in Lake Stage, Stream Flow, and Groundwater Levels after 1970

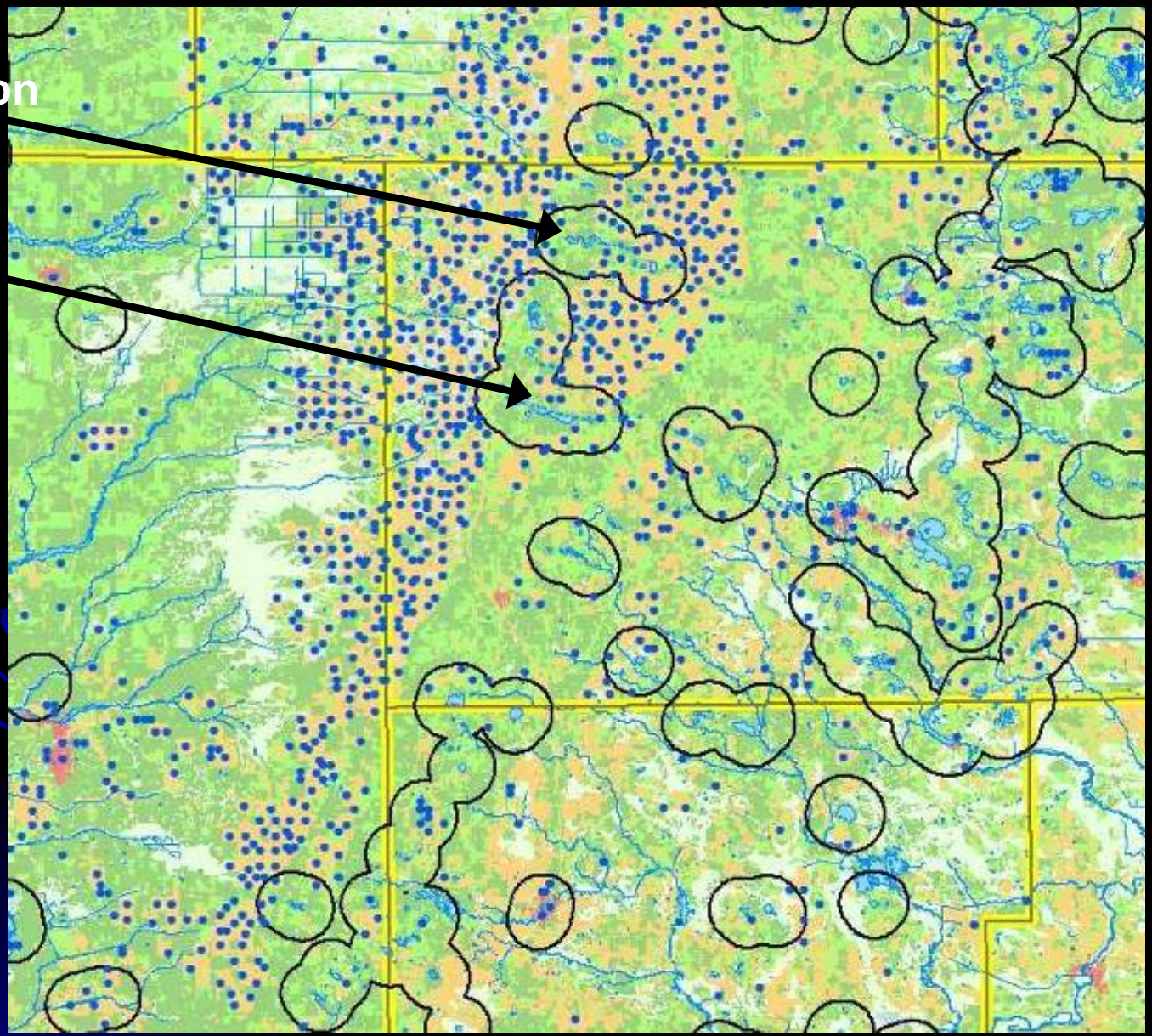


Source: WGNHS


Distribution of High Capacity Wells in Wisconsin
Hicap Wells per Square Mile by Watershed
0.001 - 0.2
0.201 - 0.4
0.401 - 0.6
0.601 - 0.8
0.801 - 1
1.001 - 1.2
1.201 - 1.4
1.401 - 1.6
1.601 - 1.8
1.801 - 2
2.001 - 2.2
2.201 - 2.4

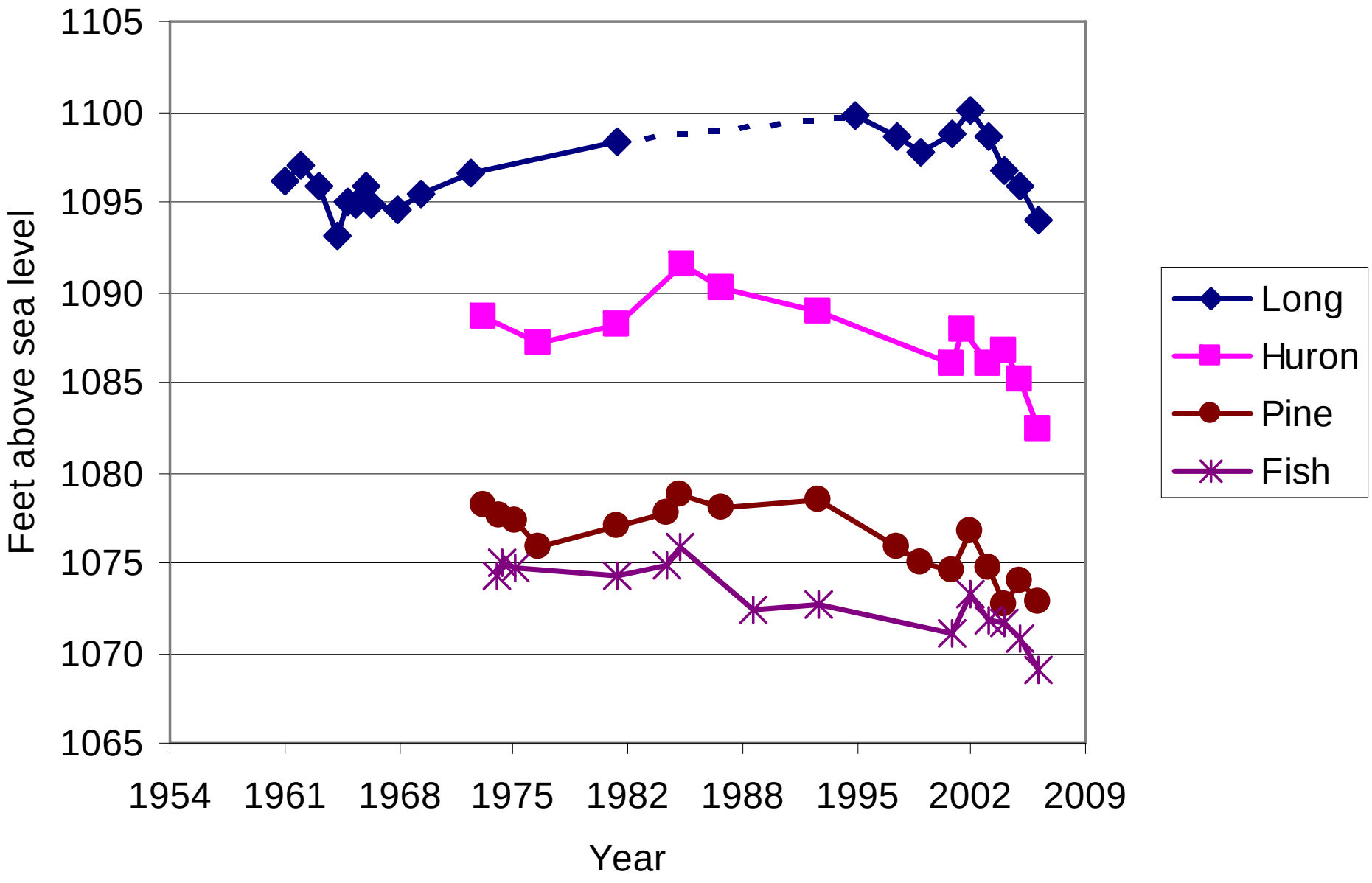
Source: UWSP

Waushara County Lakes



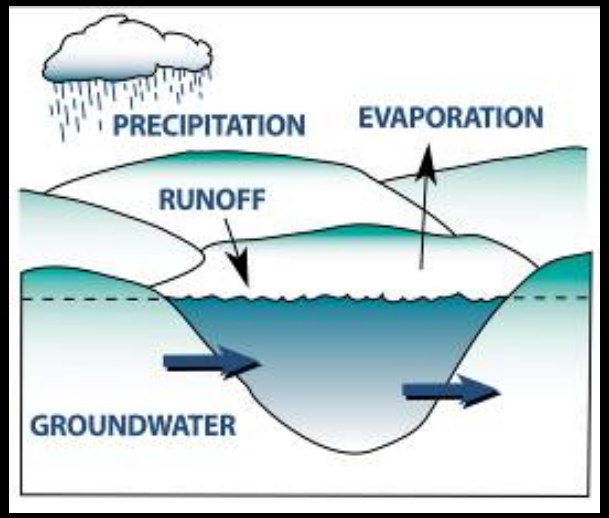
Source: UWSP

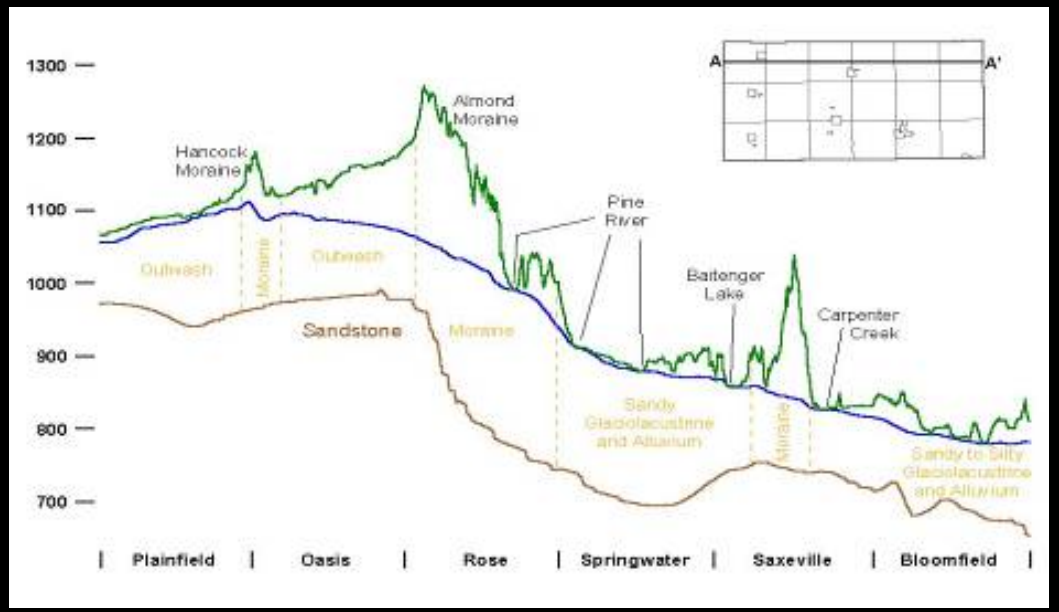
NW Waushara County Lakes



Waushara County Lakes

- Landlocked lakes, no outlet
- Vary 2.5 to 10 feet over decadal scale
- Lakes near major regional groundwater divide
- Recent declines after unusually high period in the 1990s
- Short-term drought in Central WI
- Major pumping center





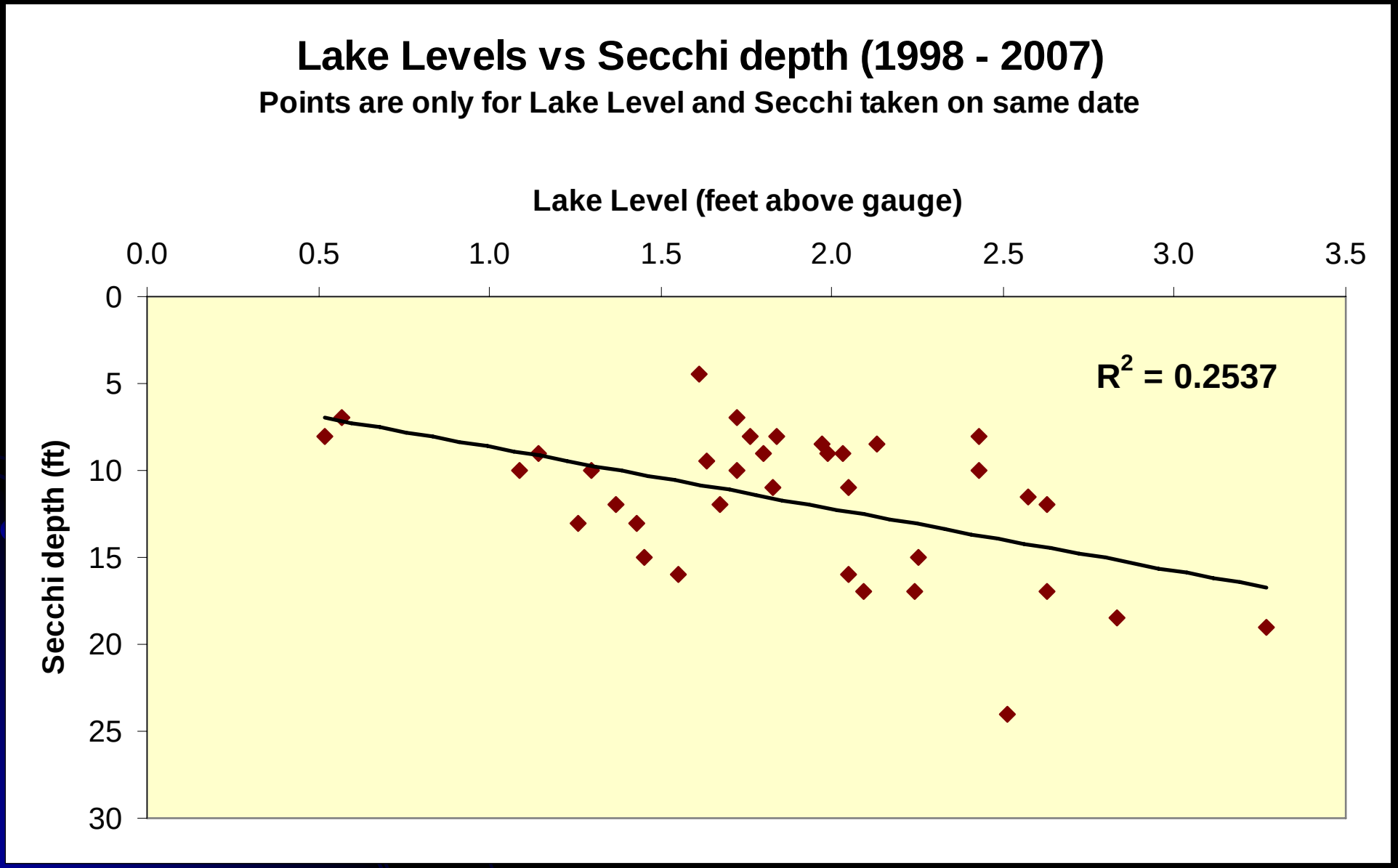
Response of lakes to changing climate

- Landscape position and lake type affects response of lake levels to changes in climate
- Lakes higher in the landscape (both seepage and headwater) may drop, because they are sensitive to changes in precipitation and evaporation
- Lakes lower in the landscape may rise, because they are buffered from short term dry periods and respond to longer term changes in groundwater recharge
- Local conditions are important, including human influences!

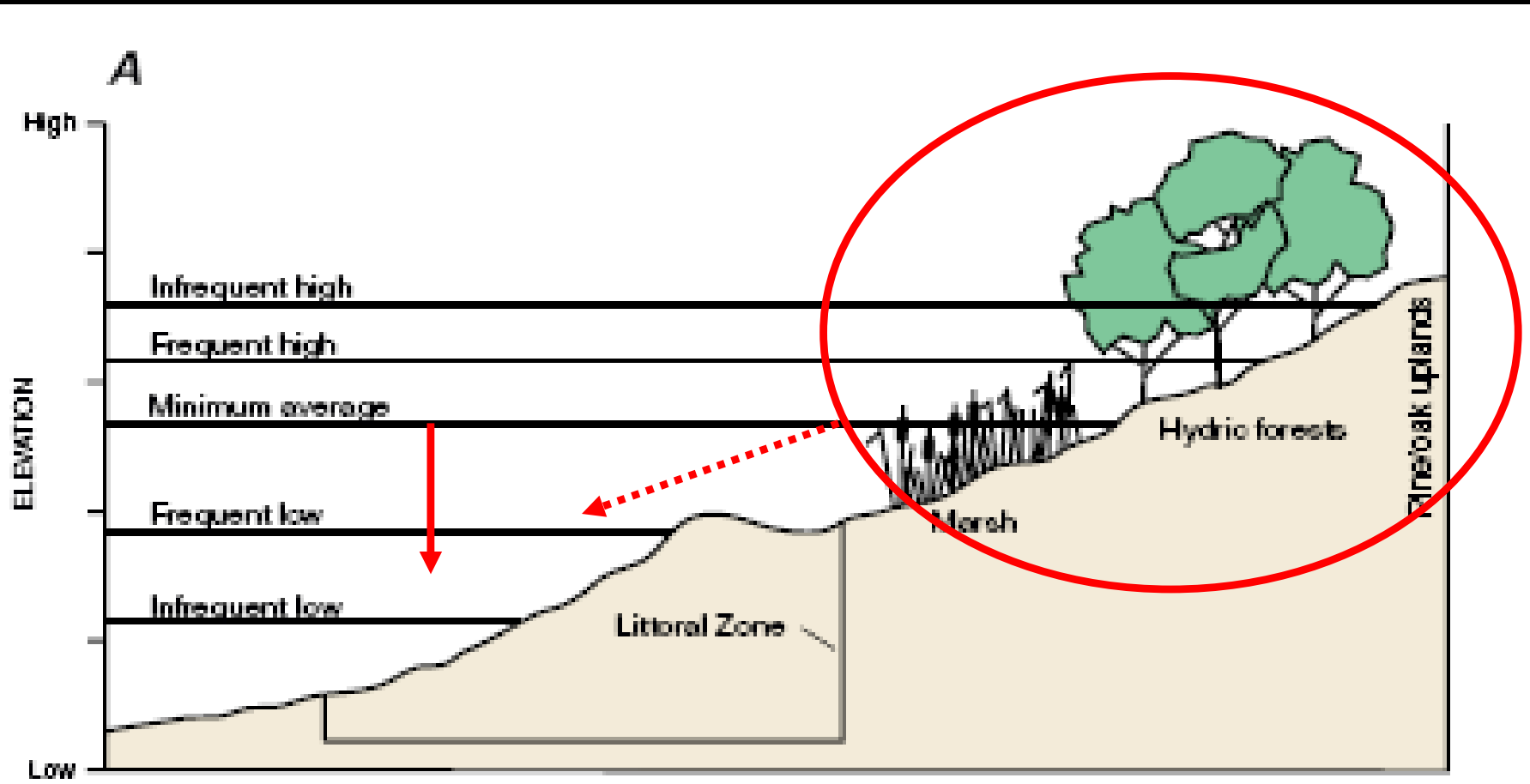
Implications of low water levels

- Water quality/clarity
- Shift in aquatic plant community
- Reduced fish cover
- Exposure of lake beds to disturbance
- Navigational issues
- Potential for spread of invasives (e.g. EWM, *Phragmites*)

Anvil Lake Water Clarity



Implications of low water levels



Source: USGS Circular 1186

R. Lathrop

Fallison Lake, Vilas County

Tomahawk Lake, Bayfield County

F. Koshere

Tomahawk Lake, Bayfield County

Acknowledgements

- Ken Bradbury, WGNHS
- George Kraft, Dave Mechenich, UW Stevens Point
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- John Magnuson, Tim Kratz, Barbara Benson, UW Madison
- Scott Provost, Ann Schachte, Pamela Toshner, Dick Lathrop, Frank Koshere, WDNR