Water Resource Management:
Geography/Environmental Studies 4411

Instructor: Graham Saunders (RC 2001)
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Graham Saunders

- Australian Weather Bureau
- Environment Canada
- Ministry of Natural Resources
- M.Sc. in Forestry and Climatology
- Teaching at LU since 1995
  - **Proposed, designed, teach Lake Superior course**
  - Climate Change Research – boreal forest
  - Severe Weather prediction and adaptation
  - Thunder Bay's vulnerability to flood and other severe weather
- Decades of writing about weather, climate, Lake Superior, agriculture, pricing carbon and related policy issues

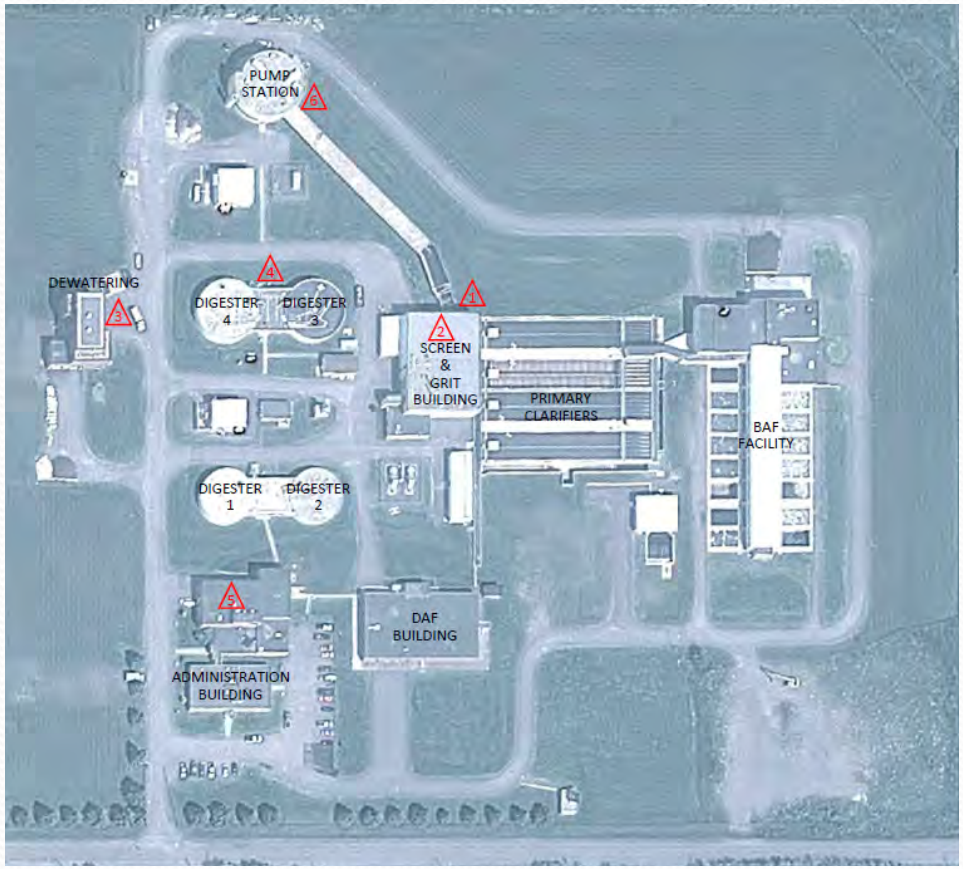
Topics for discussion

- Goals/expectations of the course
- Assigned Reading (no text purchase)
- Evaluation
  - Assignments/Briefings
  - In-class workshops
  - Midterm Final?
- Independent Research Project
- Proposal Report Seminar
- Field trips

Field Trip: January 26

Atlantic Avenue Water Pollution Control Plant (WPCP) on January 26, 2017

- Leave LU at 11:20 am
- Return approx. 1315



Assignment 1
Public lecture by David Schindler

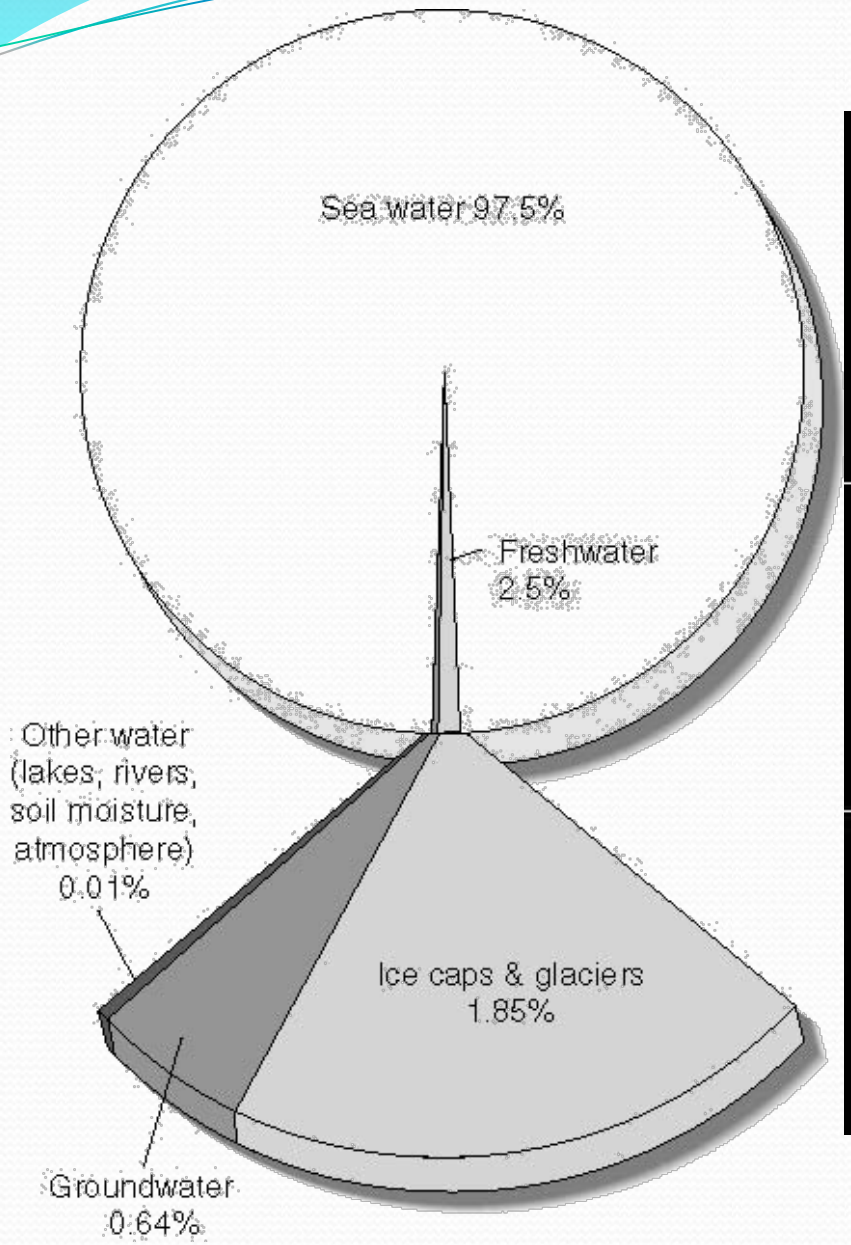
Bio of David Schindler: research and expertise in fish, mercury, various aquatic issues

Public lecture by David Schindler (recorded on June 18,2014) in Waterloo, Ontario. The lecture was titled *Canada's Freshwater in the 21st Century* and is about 61 minutes in duration.

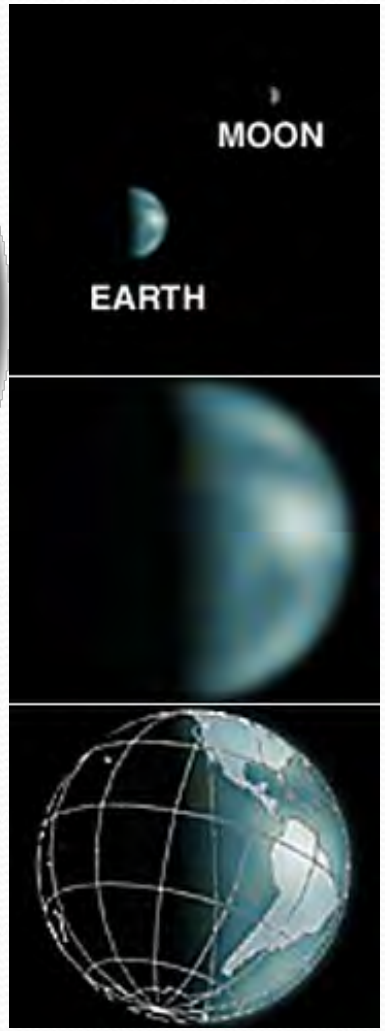
Word count: 400 to 500

Lecture 1:
A Global Water Crisis?

- Water resources
- Security
- Freshwater Supply
- Modification
- Future Stressors
- Resource Management



View of Earth from Mars



Groundwater – an integral part of the hydrological cycle

- Est. 4.2 million km^3 of groundwater
- Within 1 km of Earth's surface

Compared to:

- 125,000 km^3 freshwater lakes
- 1250 km^3 in streams

TABLE 4.4 Estimated Residence Time of the World's Water Supply

Water Type	Residence Time
Oceans and seas	4000 years (approx.)
Lakes and reservoirs	10 years (approx.)
Swamps	1–10 years (approx.)
Rivers	2 weeks
Soil moisture	2 weeks–1 year
Groundwater	2 weeks–10,000 years
Icecaps and glaciers	10–1000 years
Atmospheric water	10 days

Source: Adapted from R. Allen Freeze and John A. Cherry, *Groundwater* (Englewood Cliffs, NJ: Prentice-Hall, 1979), 5.

Canada

- ***0.5% of world's population***
- ***20% of global freshwater***
- ***Lake Superior: 10%***
- ***25% of wetlands (recharge)***
- ***7% flow of renewable water***

Economic value of …

$7.5-$23 billion annual contribution to Canada's economy

Discuss this estimate

Global Water Security

Control of Water Resources : where water supplies or access to water is at the root of tensions.

Military Tool : where water resources, or water systems themselves, are used by a nation or state as a weapon during a military action.

Political Tool: where water resources, or water systems themselves, are used by a nation, state, or non-state actor for a political goal.

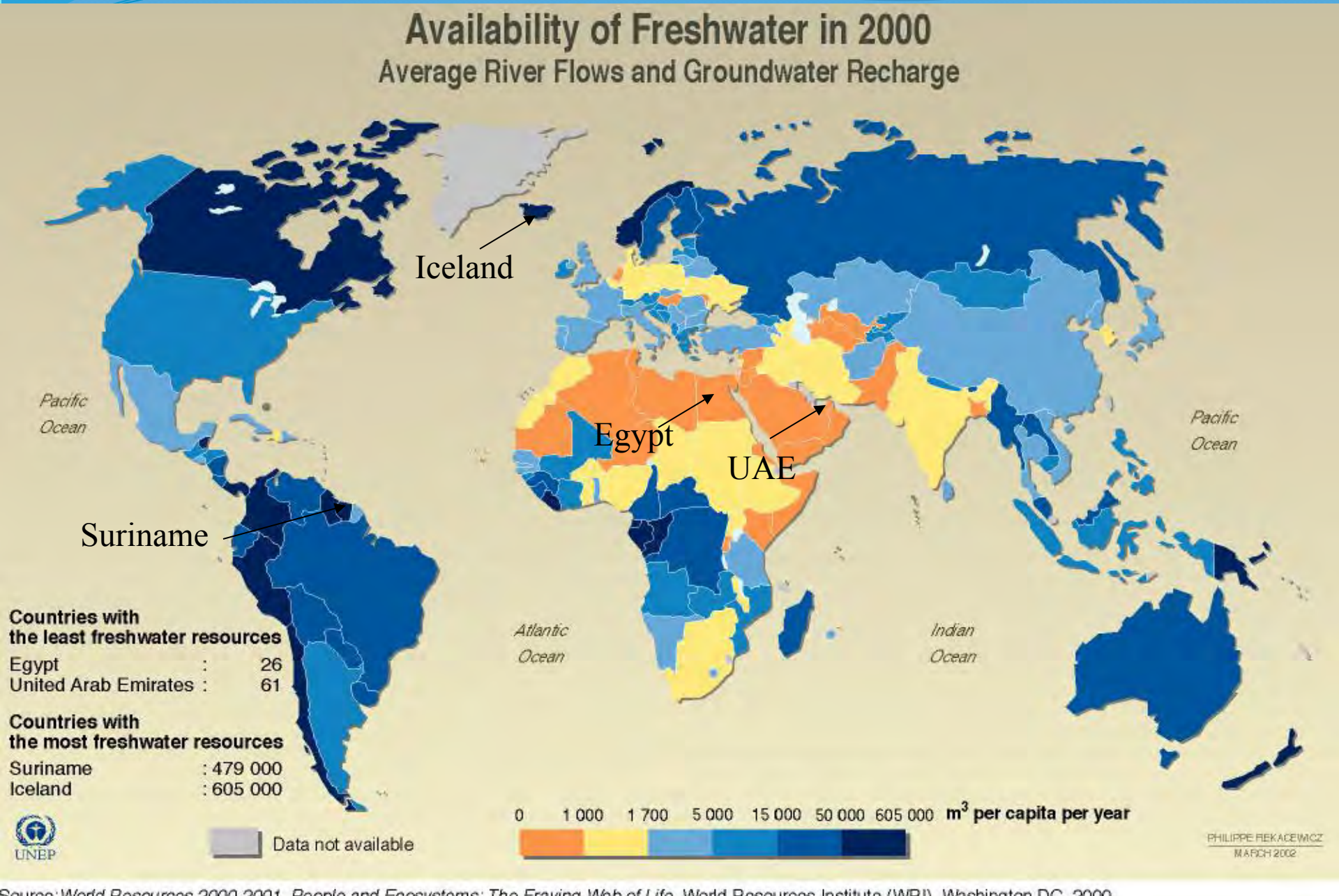
Terrorism (non-state actors): where water resources, or water systems, are either targets or tools of violence or coercion by non-state actors.

Military Target: where water resource systems are targets of military actions by nations or states.

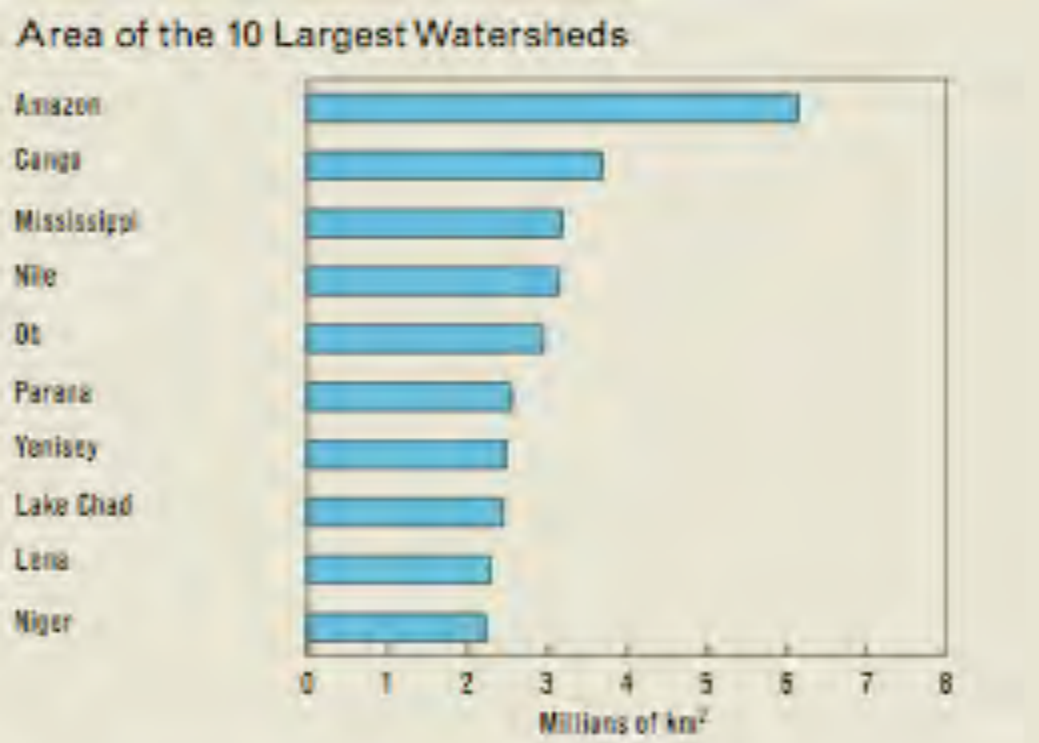
Development Disputes (state and non-state actors): where water resources or water systems are a major source of contention and dispute in the context of economic and social development.

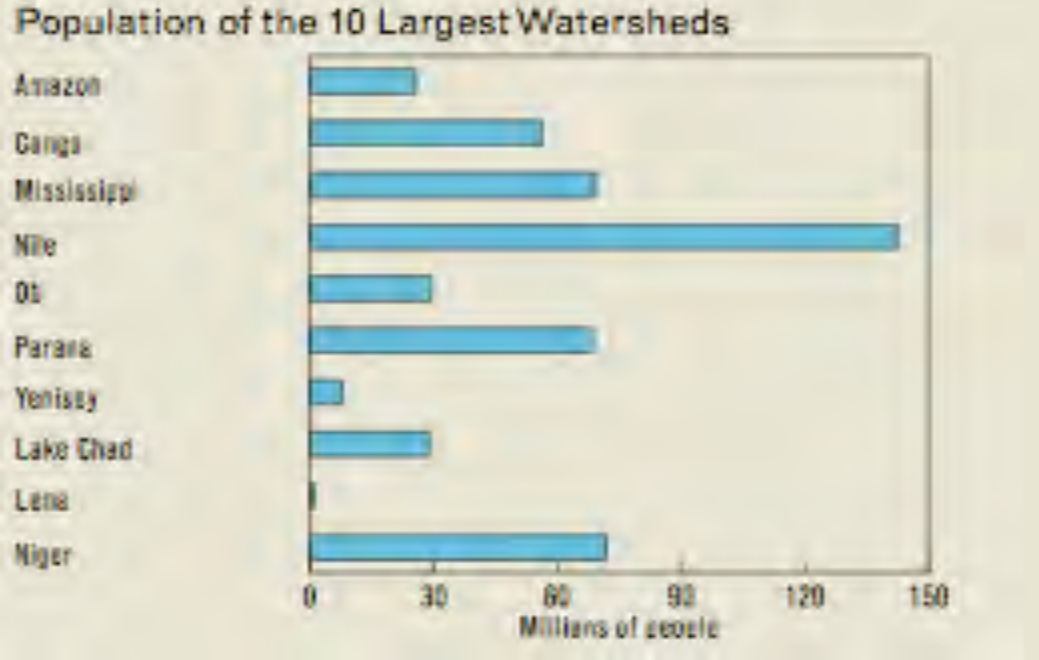
http://www.worldwater.org/conflictchronoglogy.html

Global Water Issues



Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000





Sufficient quantity/quality of water adequate for human use:

- 1.4 billion people globally without access to safe water supplies
- 2/5 without adequate sanitation
- Humans become thirsty after losing 1% of bodily fluids
- Danger of death at 10%

- 41%, or 2.9 billion people, under water stress, per capita water availability is less than 1,700 m3/year
- Of these, 2.1 billion people in highly stressed river basins where annual water availability is less than 1,000 m3/ person.
- Assuming current consumption patterns continue, by 2025, at least 4 billion people, will live in water-stressed river basins.

Modification of Water Resources

Global demand in the 20th and 21st century

- Population growth
- Industrialization
- Expansion of irrigated agriculture

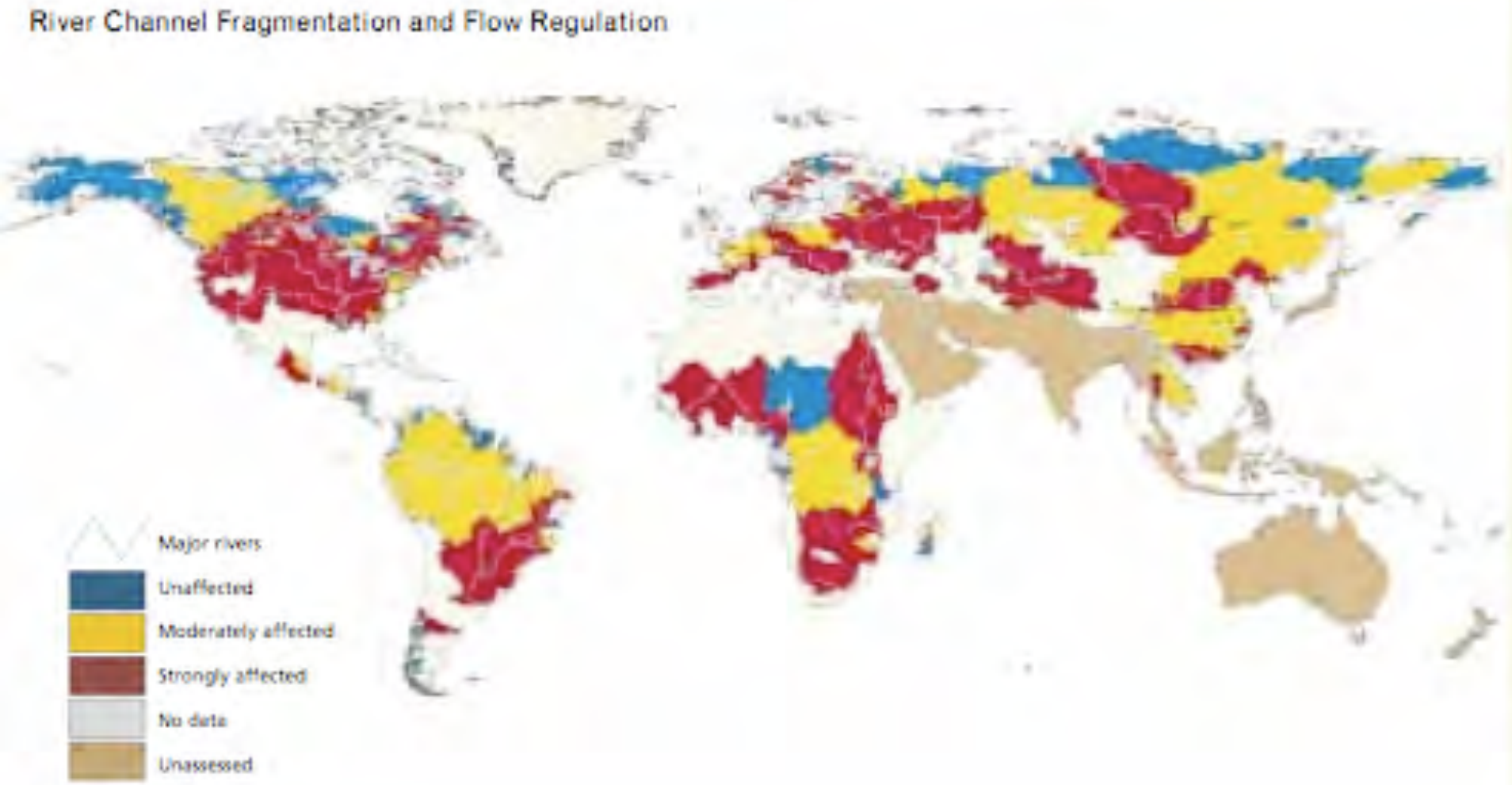
Change in rivers, lakes, reservoirs

- Altering waterways

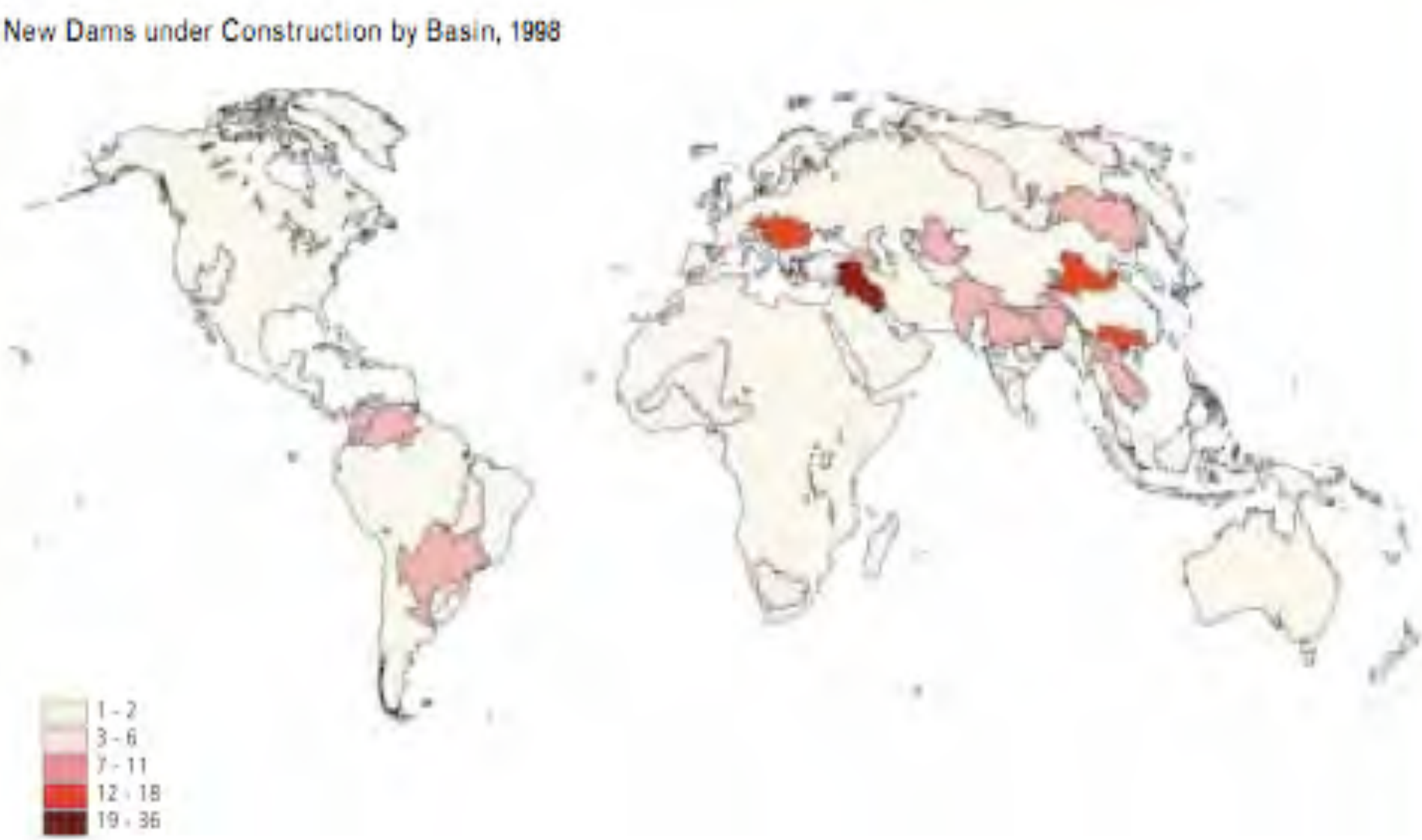
  - draining wetlands

  - constructing dams and irrigation channels

  - Connecting water basins with canals, pipelines, water transfer)

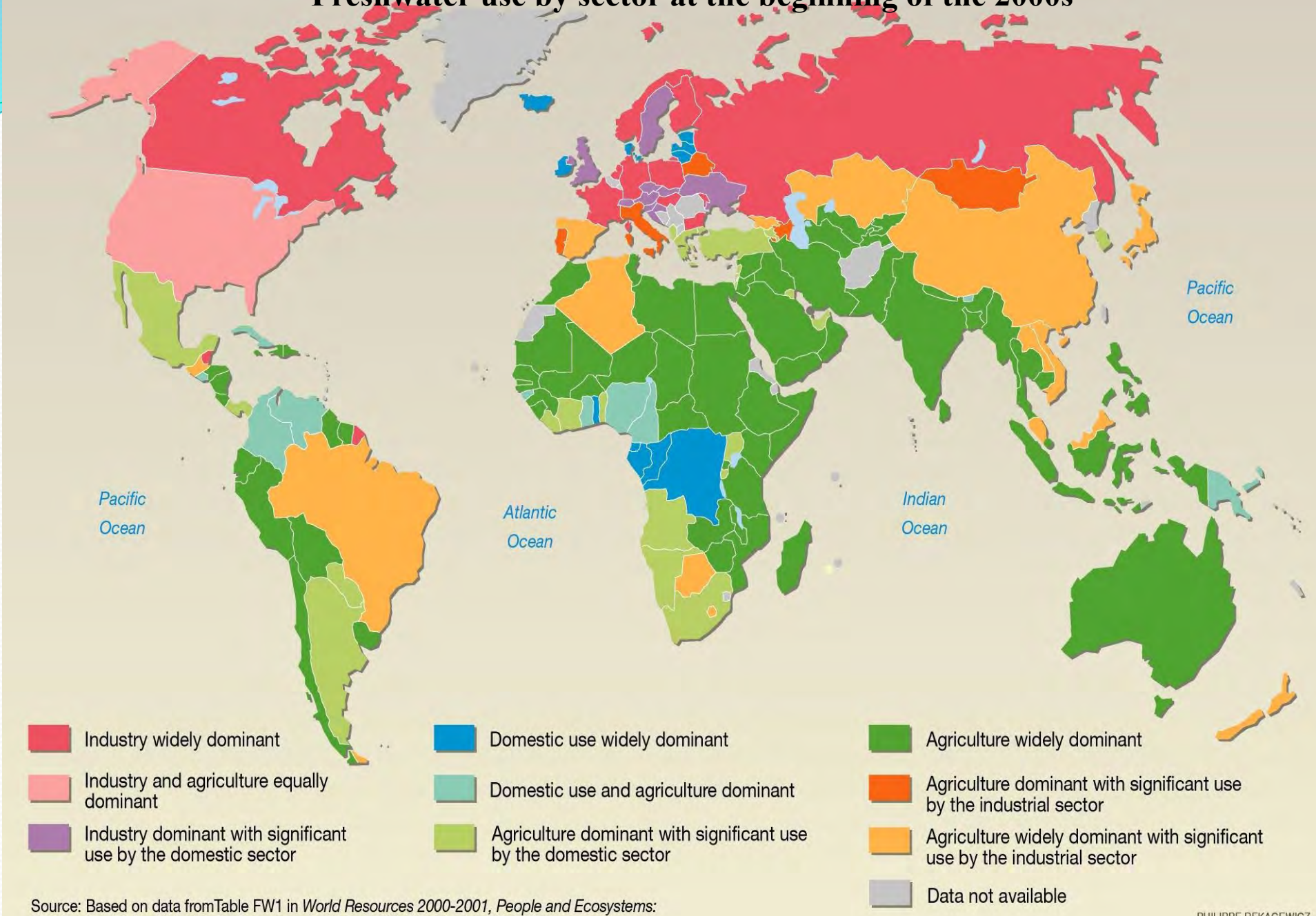


The map shows the extent of fragmentation, or interruption of natural flow, caused by human intervention in 227 large river systems



Dams slow the rate of natural flow, thereby increasing sedimentation and lowering levels of dissolved oxygen.

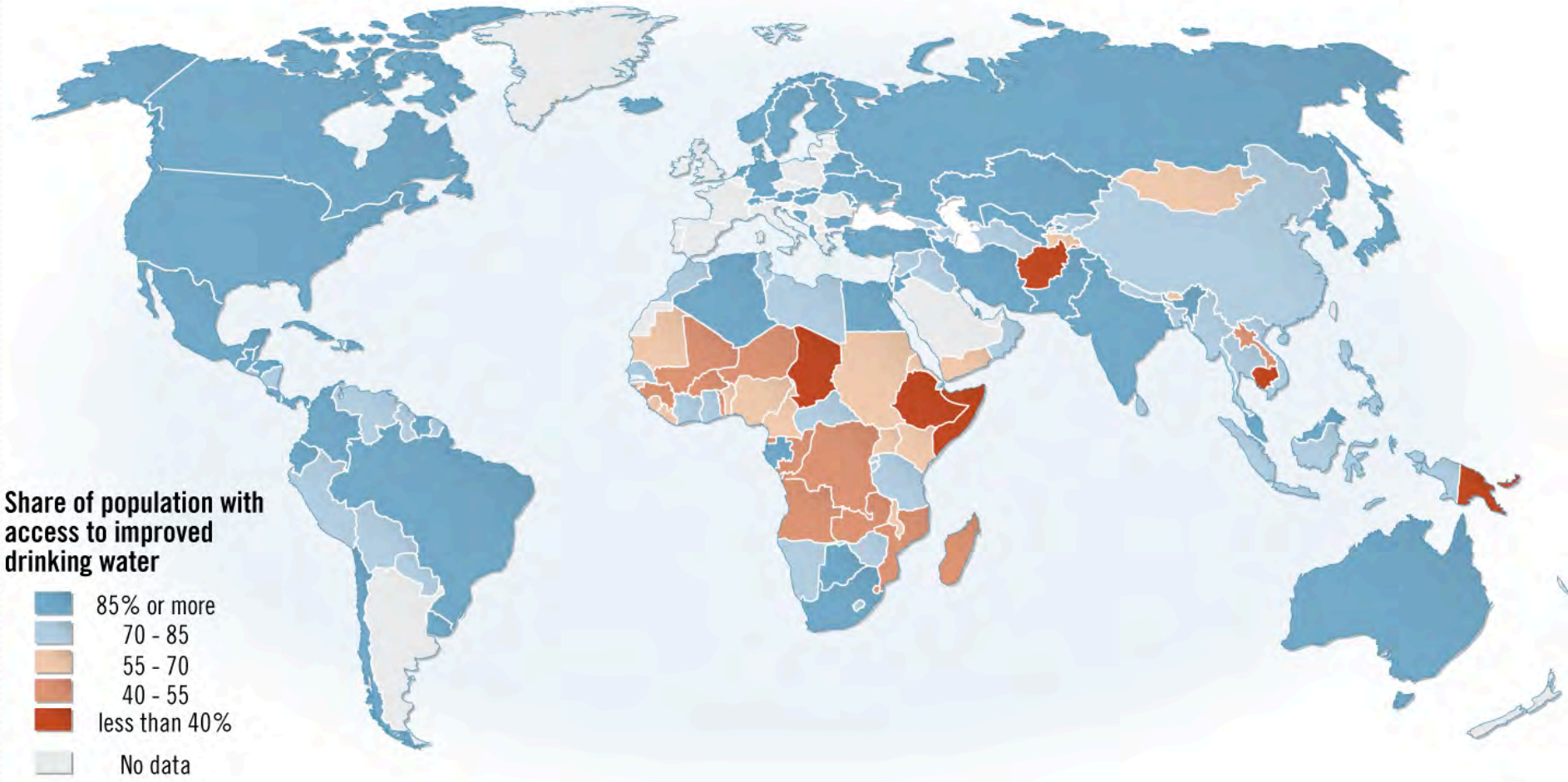
Freshwater use by sector at the beginning of the 2000s



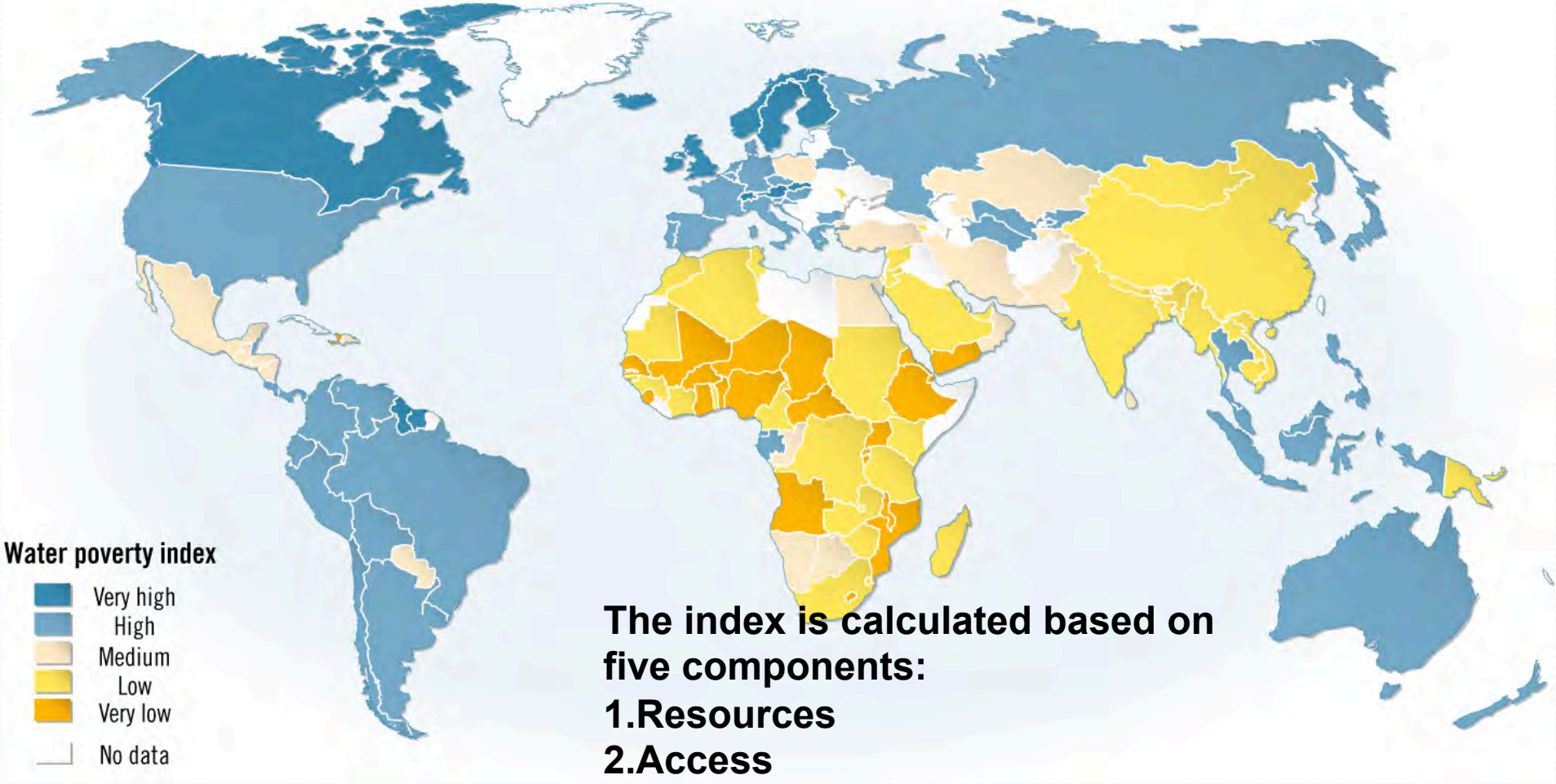
Source: Based on data fromTable FW1 in *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.

PHILIPPE REKACEWICZ
MARCH 2002

Access to Safe Drinking Water

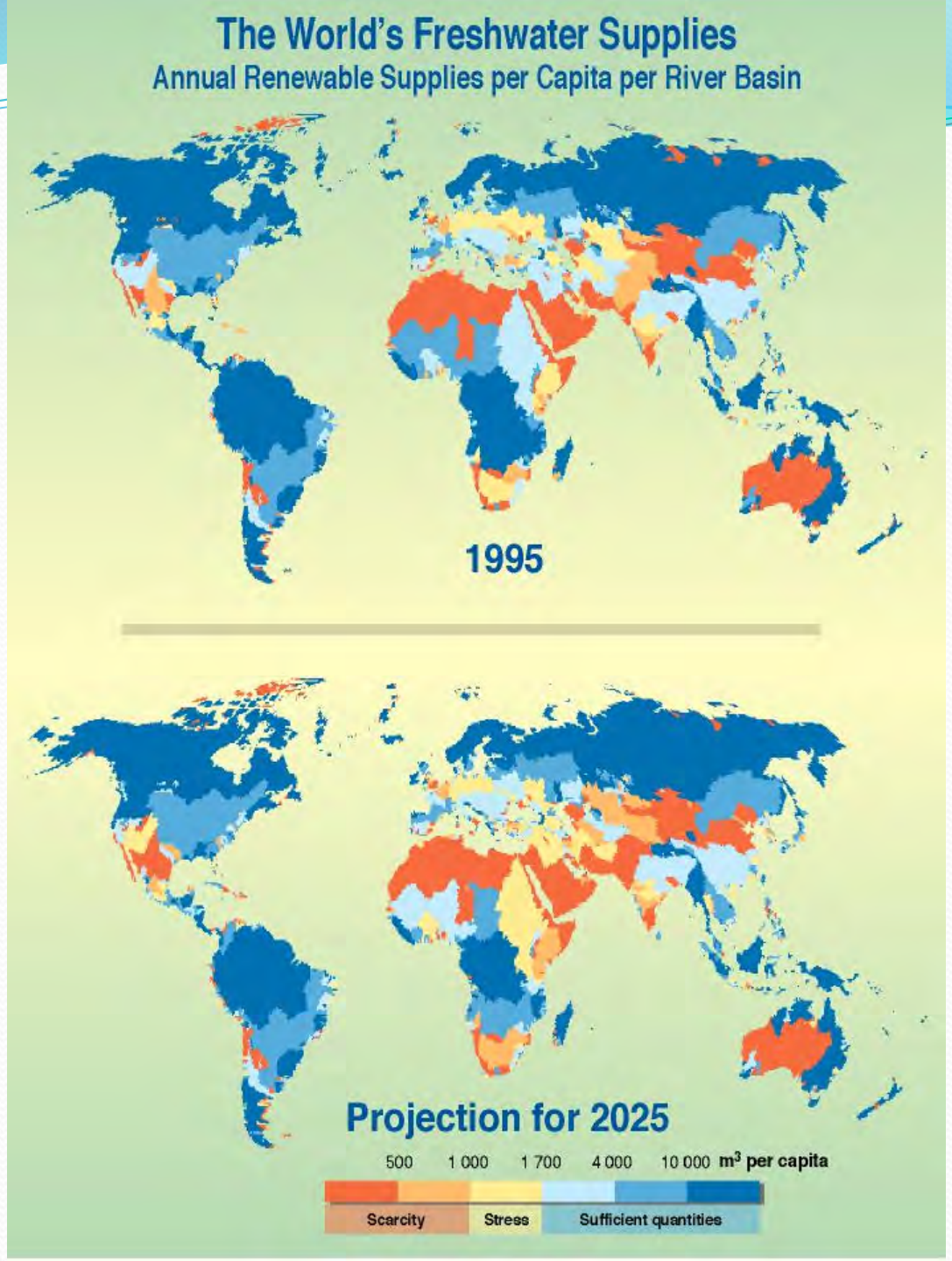


Water Poverty Index



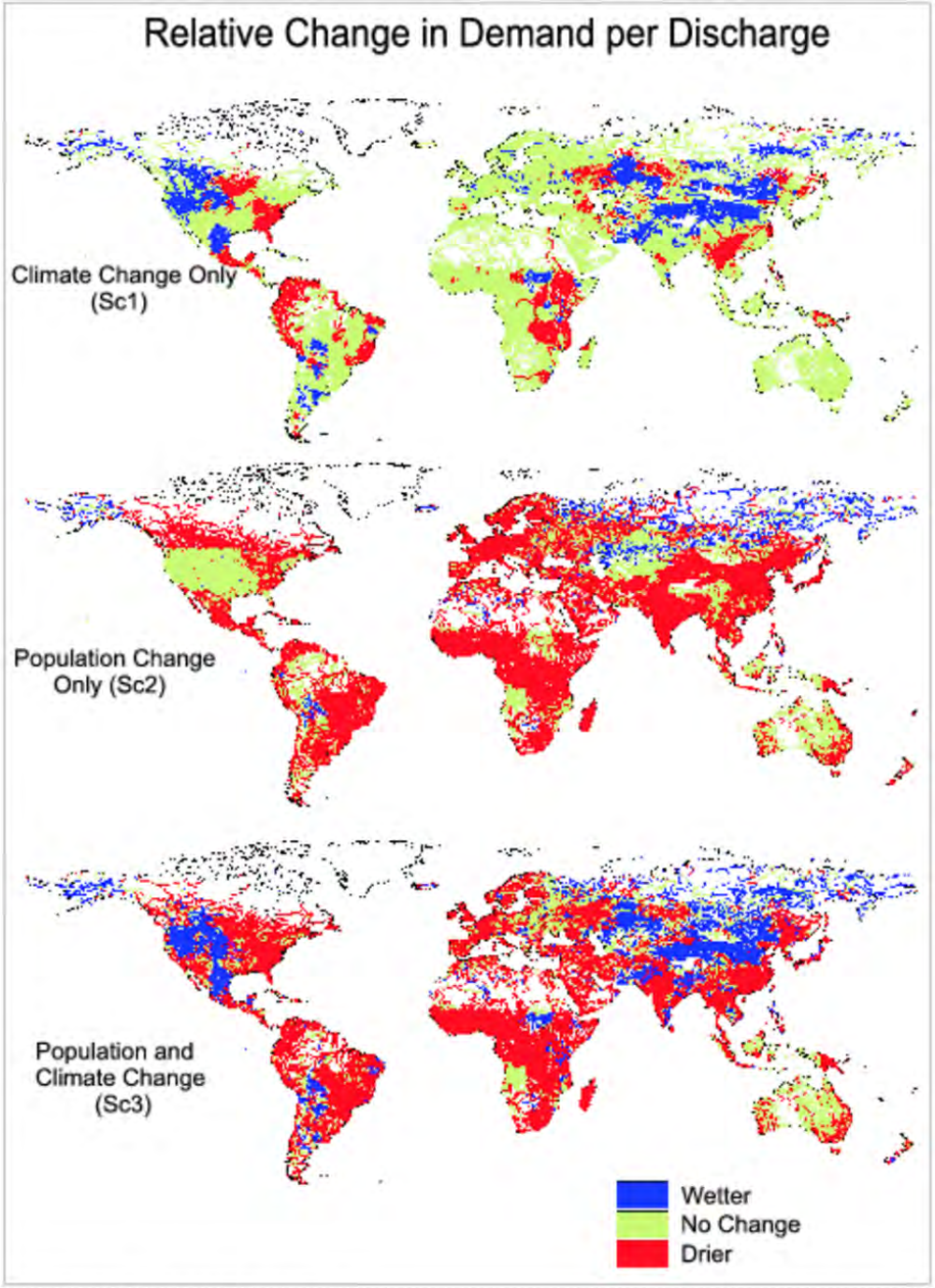
The index is calculated based on five components:

1.Resources
2.Access
3.Capacity, use
4.Environment


The World's Freshwater Supplies
Annual Renewable Supplies per Capita per River Basin
1995
Projection for 2025
500
1 000
1 700
4 000
10 000
m³ per capita
Scarcity
Stress
Sufficient quantities

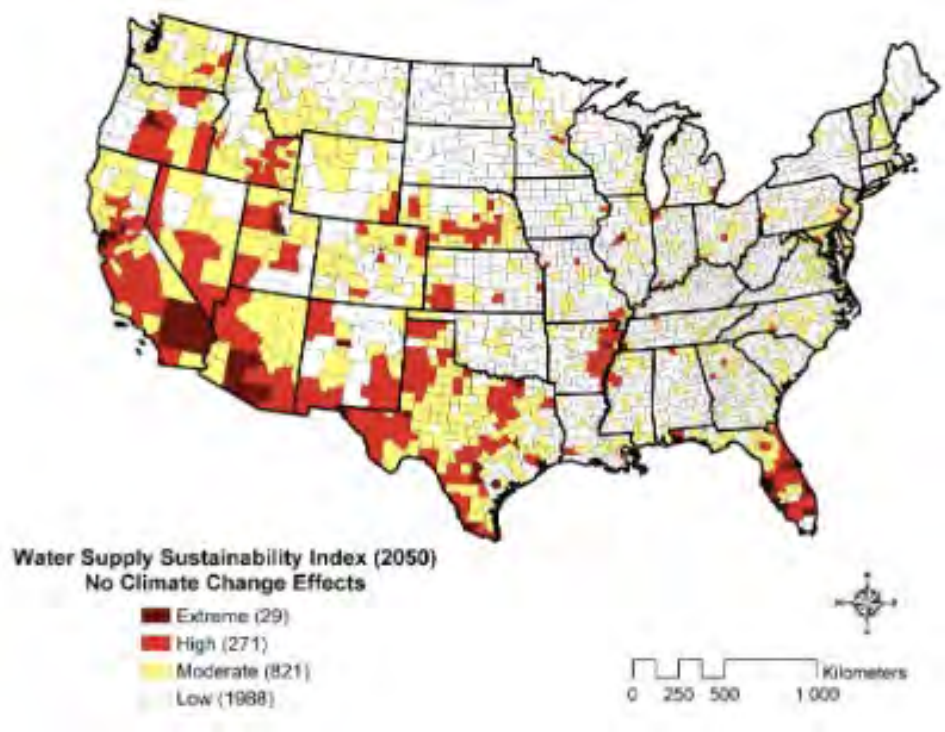
Water Stress Changes to 2025

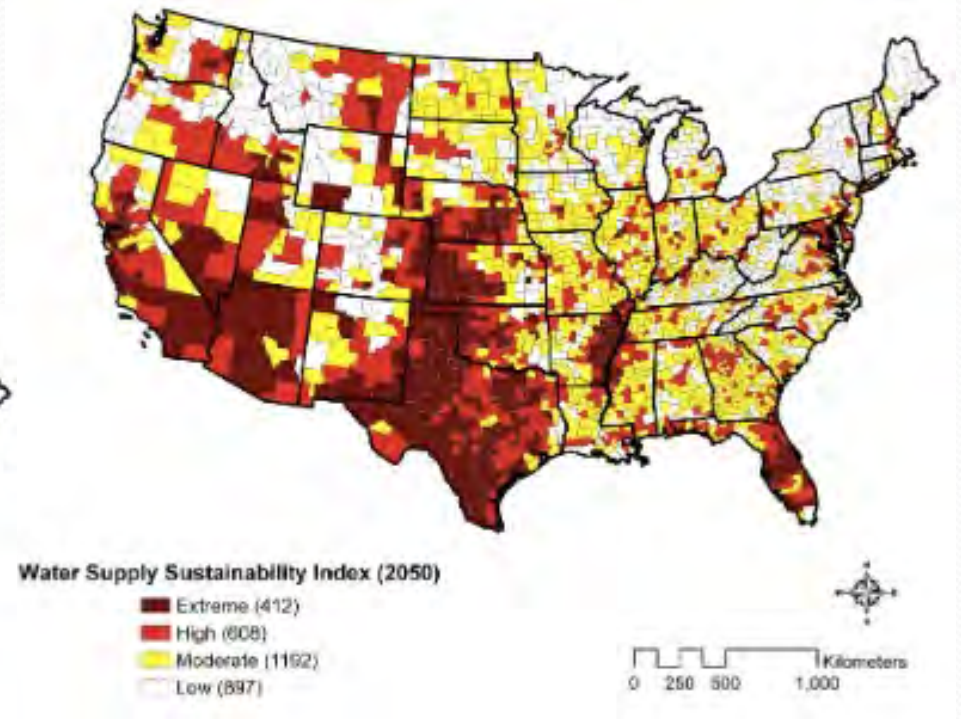
- 80% of future stress from **population development**, **climate change**!
- Future distortions of the water cycle are inevitable
- High resolution operational mapping of water stress important to food, health, international security



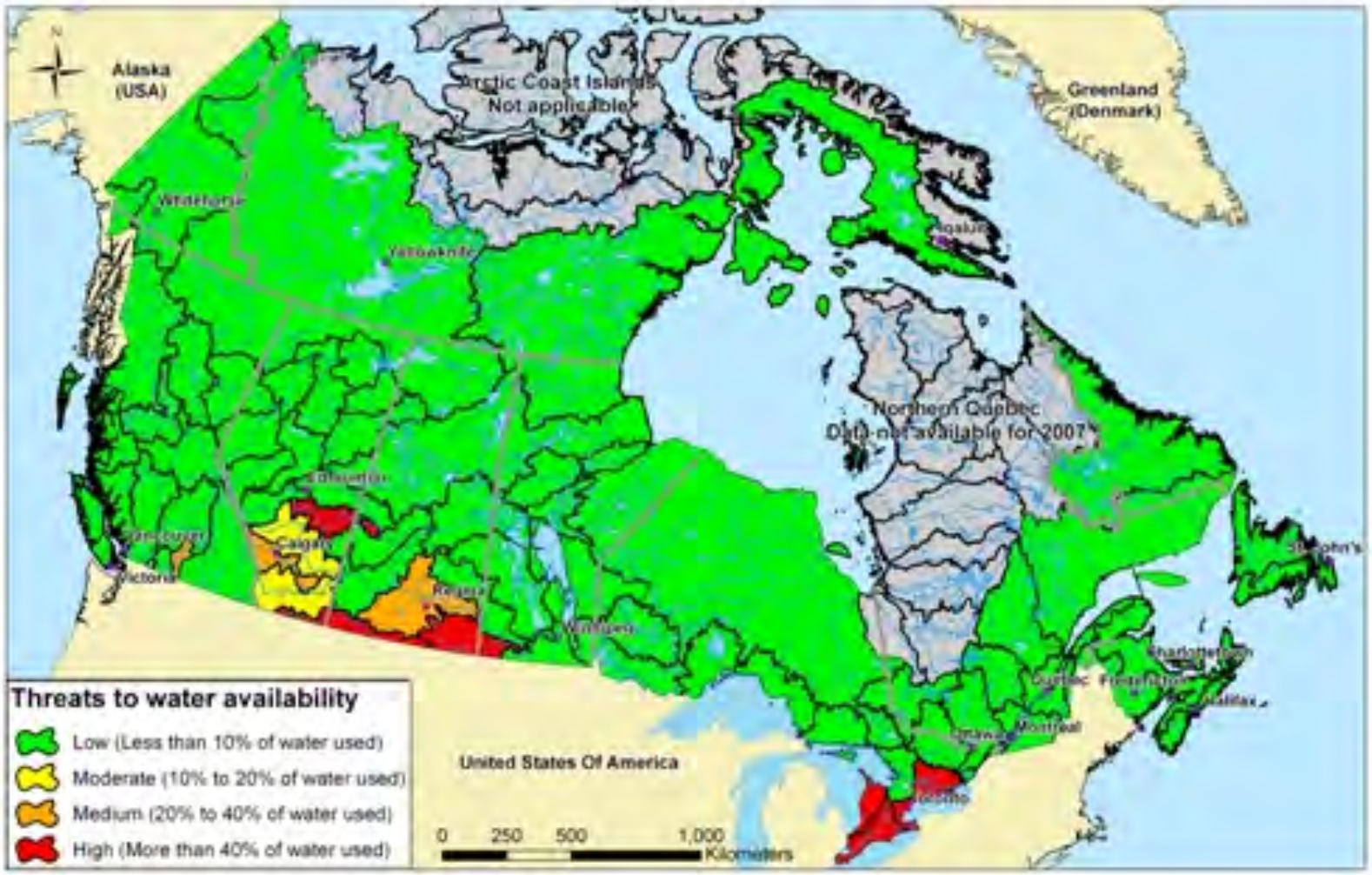
Vörösmarty et al. 2000

Water Stress Changes in the US 2050





And in Canada?


Alaska
(USA)
Arctic Coast Islands
Not applicable
Greenland
(Denmark)
Northern Quebec
Data not available for 2007
United States Of America
Threats to water availability
Low (Less than 10% of water used)
Moderate (10% to 20% of water used)
Medium (20% to 40% of water used)
High (More than 40% of water used)
0 250 500 1,000
Kilometers

Other related global Issues…

Water Resource Management

• **World Bank:** Water Resources Management is the integrating concept for a number of water sub-sectors such as hydropower, water supply and sanitation, irrigation and drainage, and environment.

•An integrated water resources perspective ensures that social, economic, environmental and technical dimensions are taken into account in the management and development of water resources.

• The decision-making, manipulative and nonmanipulative processes by which water is protected, allocated or developed

• **Principles of Water Resources:** Historical, development, management and policy arenas surrounding water resources

The Great Lakes Basin

- A shared resource between Canada and the U.S.
- 20% of the world's surface fresh water
- Drinking water - more than 45M people
- Rich biodiversity
- Vital role in supporting central Canada's economics

Political Stakeholders

History of Great Lakes Environmental Programs

- 1909 - Boundary Waters Treaty established the International Joint Commission (IJC)
- 1970 - National environmental agencies:
  - Environment Canada (EC)
  - U.S. Environmental Protection Agency (U.S. EPA)
- 1972 – Ontario Ministry of the Environment
- 1972 - The Great Lakes Water Quality Agreement (GLWQA)

History of Great Lakes

Past historical disputes and agreements of water flowing along or across the boundary, notably for navigation:

- Europe
- Mexico and United States
- Canada – US Disputes included:
  - St. Mary and Milk Rivers in the west
  - Rainy River
  - the Chicago Diversion of Lake Michigan (which lowered lake levels by 15 cm)
  - St. Mary's River at Sault Ste. Marie and the Niagara River

Signing of the 1972 Canada-U.S. Great Lakes Water Quality Agreement

Goals of the Great Lakes Water Quality Agreement

- The Great Lakes Water Quality Agreement is an Executive Agreement between Canada and the United States. It is not a Treaty.

- The Agreement commits the two countries to *restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem.*

- The Agreement is a relatively successful model of Canada-United States binational cooperation.

Great Lakes – St. Lawrence Seaway

St. Lawrence River, St. Lawrence Seaway and the Great Lakes, sometimes termed Hwy H2O, is a 3,700-kilometre (2,300 mile) marine highway that runs between Canada and the United States.

Some history

- **1895**

The first joint Commission is formed to study the feasibility of a Seaway. This is followed by the International Joint Commission in 1909, but no further action on Seaway proposal.

Seaway history (the opening)

- **1954** Completion of the Seaway navigation project links the Great Lakes to global markets.

On April 25, the icebreaker "D'Iberville" begins the first through transit of the St. Lawrence Seaway. Gross shipping weight for this first navigation season amounts to 22 million tonnes.

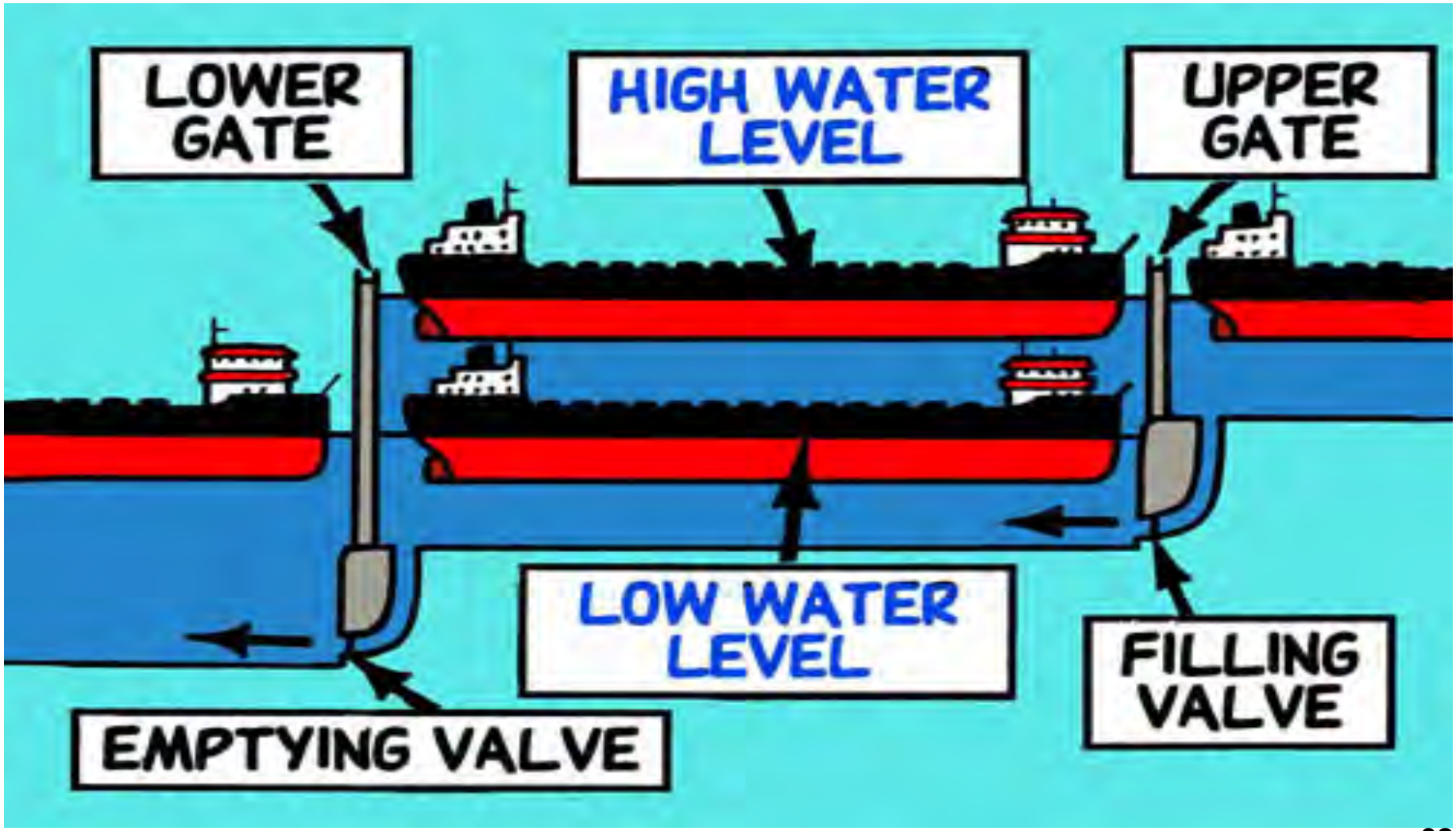
- **1979**

  The gross tonnage of ships passing through the Seaway reaches 80 million tonnes.

- **1996**

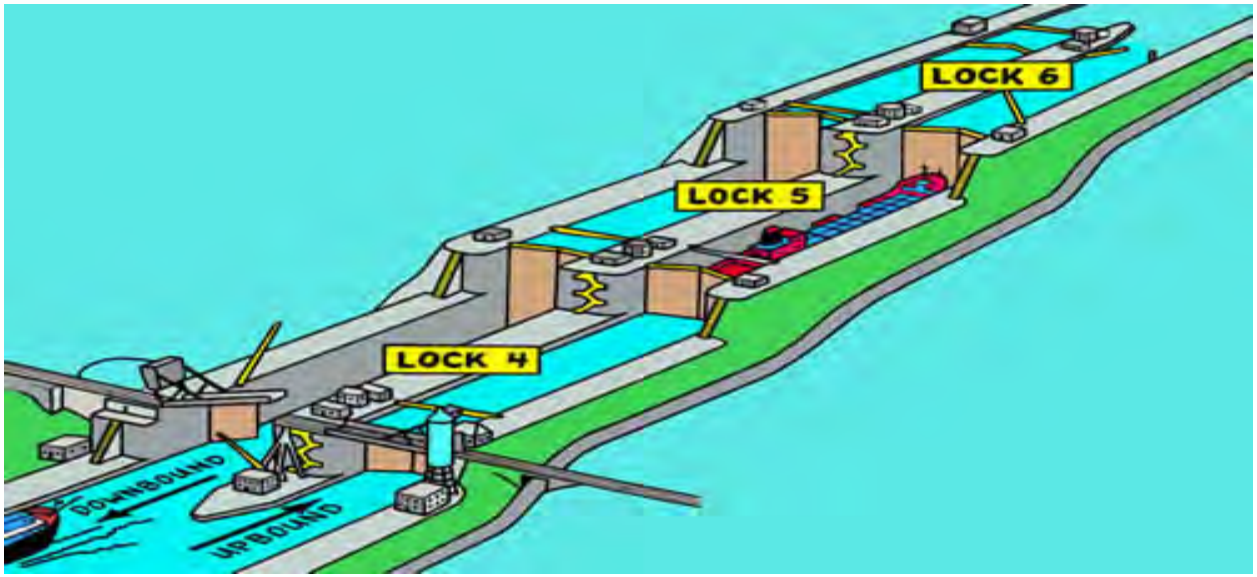
  Total of two billion tonnes of cargo, valued at more than $300 billion.

Example of a lock



Seaway Locks

This lift system and accommodate ships to 225.5 metres in length (740 feet) and 23.8 metres (78 feet) in the beam. Ships can be twice as long and half as wide as a football field and carry cargoes the equivalent of 25,000 metric tonnes. Passage through a lock takes about 45 minutes.



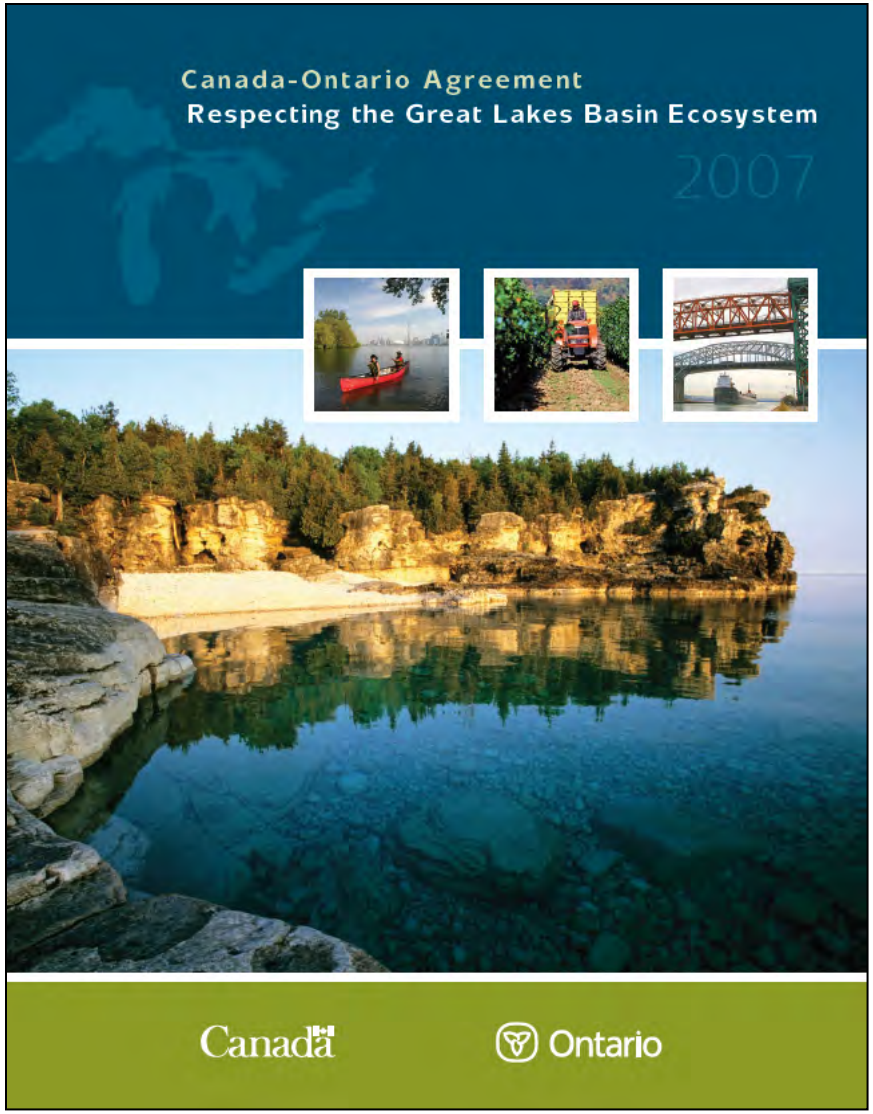
Discussion

- **1993**
  The Seaway's draft is increased from 7.87 m to 7.95, enabling ships to carry more cargo per voyage
- **2004**
  - The Seaway's draft is increased 8.03m (26.5 feet) enabling ships to carry up to 300 tonnes of additional cargo per voyage.

In-class discussion/consideration

Canada-Ontario Agreement

Respecting the Great Lakes Basin Ecosystem



Agreement between the Government of Canada and Ontario

- Six Federal Department Signatories

  8 Federal Agencies/Departments: Agriculture and Agri-Food; Environment; Fisheries and Oceans; Health; Parks Canada Agency; Natural Resources; Public Works and Government Services; and Transport (and Infrastructure Canada)

- Three Provincial Signatories

  3 Provincial ministries: Environment; Natural Resources and Agriculture, Food and Rural Affairs

- There have been seven COA's since 1971.

Canada-Ontario Agreement (COA)

- Coordinates the governments of Canada and Ontario's efforts to achieve the vision of a healthy, prosperous and sustainable Basin Ecosystem for present and future generations.
- Key mechanism to engage the broader Great Lakes community and collaborate with other implementers to protect the Great Lakes
- Contributes to meeting Canada's commitments under the Canada-U.S. Great Lakes Water Quality Agreement
- Present – 2014 agreement http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=46027E23-1
  - GLWQA revisions
  - Align Federal/Provincial Great Lakes funding

Water Levels (Lake Superior)

- Lake Superior regulation determined by Plan 1977
  - Plan 1977 designed to balance the levels of Lake Superior and Michigan-Huron *(Hartmann, 1990)*

- Difference: Lake Superior 183.2
  - Lake Huron 176.2

Water Levels

- Shorter duration of ice cover will increase evaporation in winter
- Warmer air temperatures will increase evapotranspiration
- Summers with decreased soil moisture

Lake Superior, the world's largest freshwater lake, has made a major recovery. The period 1998 to 2013 featured well below levels. Its lowest level in 81 years was set in 2007 at 182.98 average and records set in some months.

Decrease of 48 cm from 1998 to 2007

Recovery of about 50 cm

The present level is 183.46 m above MSL

Long Term Average: 183.32 m

Minimum: 182.83 (1926)

Maximum: 183.70 (1986)

Wetlands (Lake Superior)

- Formation of wetlands: necessity of excess precipitation, flat terrain or depression in landscape, and little permeability.

- Types of wetlands affected by climate change:
  - Confined wetlands
  - Shoreline Wetlands

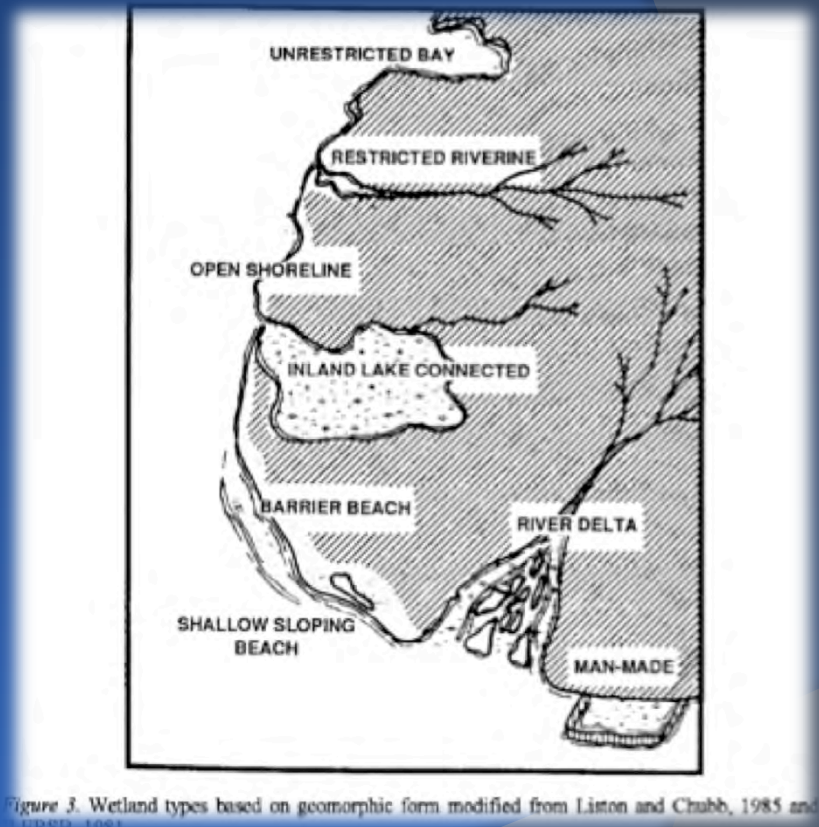
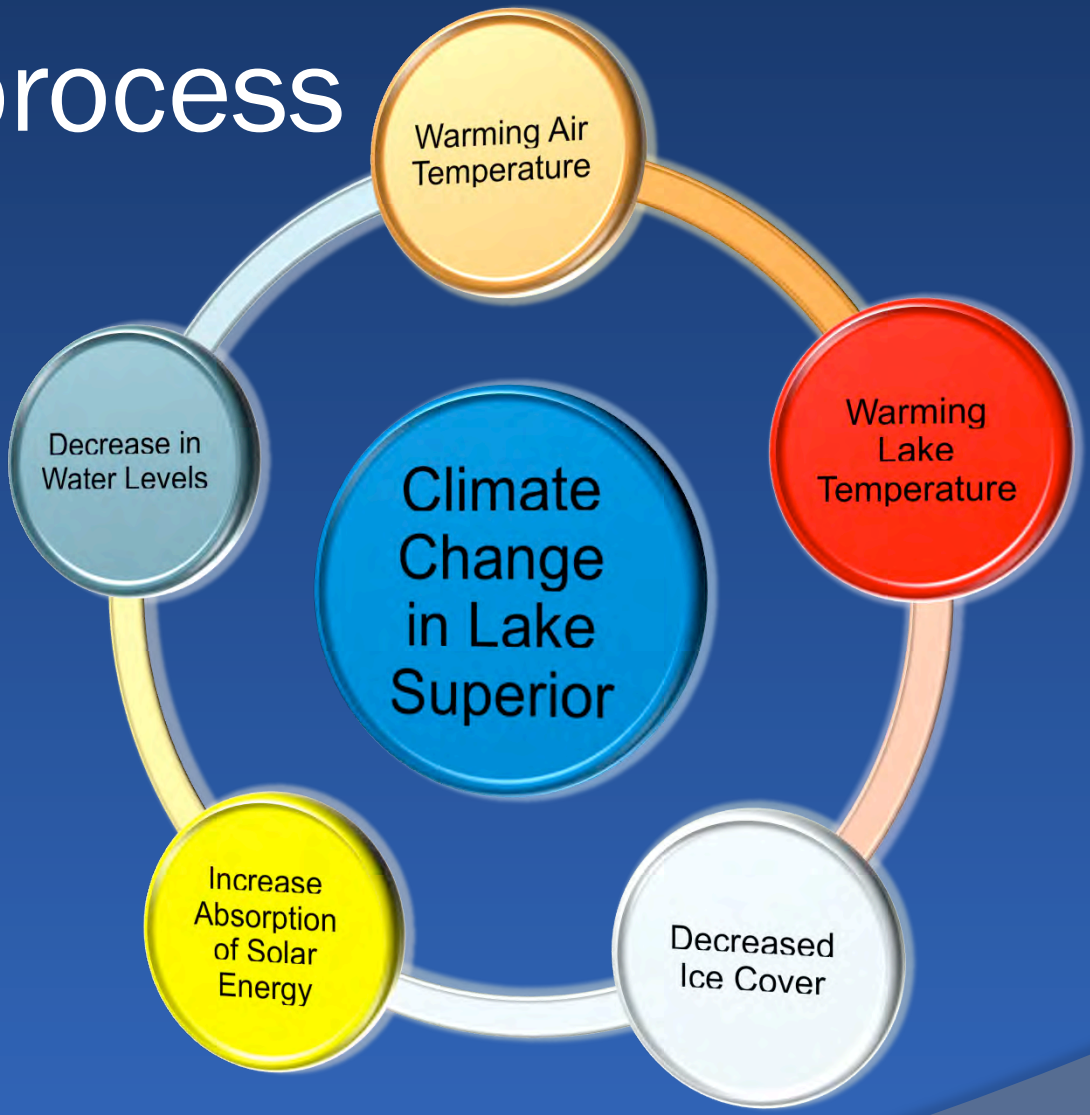


Figure 3. Wetland types based on geomorphic form modified from Linton and Chubb, 1985 and

Likely process



Concerns Issues