Interactions and Adaptations of Natural and Constructed Elements of Water Resources Systems

20 May 2014

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U.S. Army Corps of Engineers,
Institute for Water Resources

US Army Corps of Engineers
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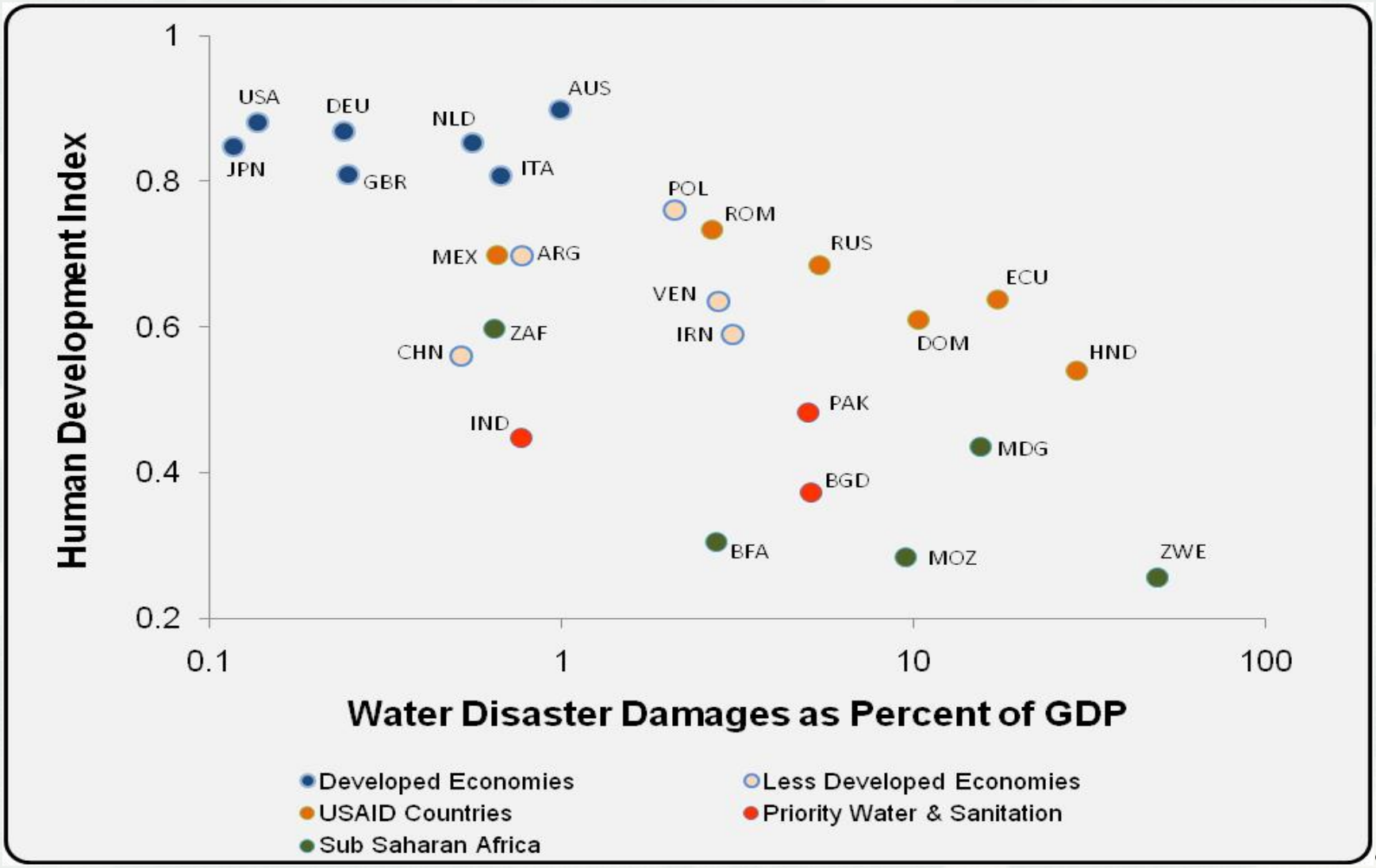
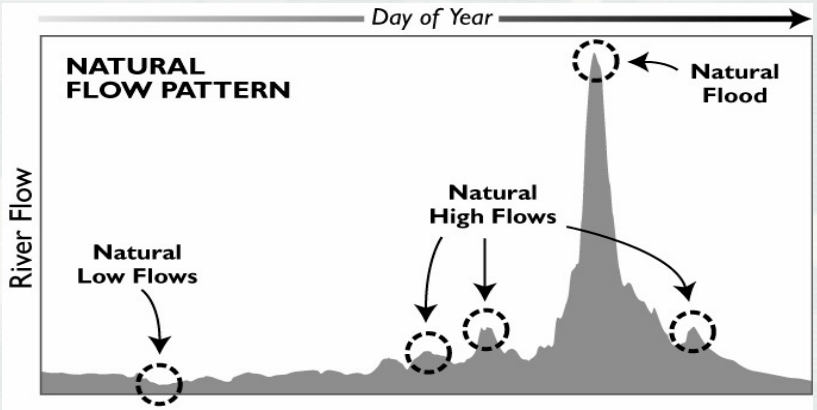
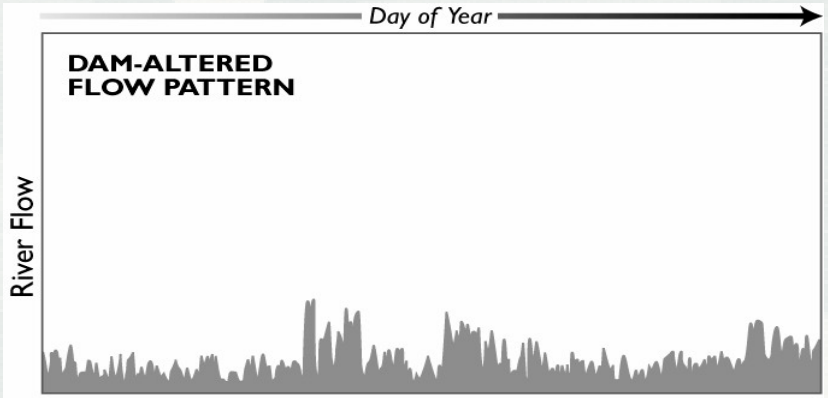
What is the goal of water management?



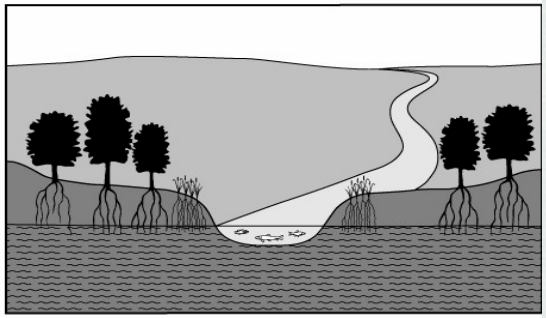
Connections between Water Management and Ecosystems





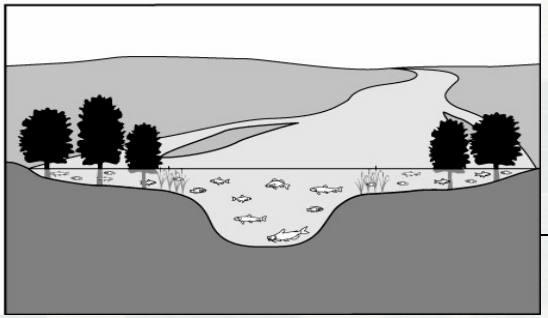
Natural Low Flow

- Fish have adequate oxygen and can move up- or downstream to feed
- Riparian vegetation sustained by shallow ground water table
- Insects feed on organic material carried downstream
- Birds supported by healthy riparian vegetation and aquatic prey



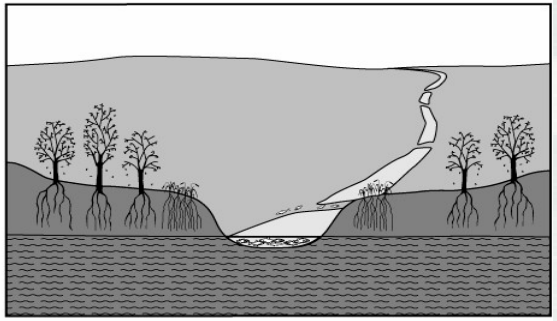
Natural Flood

- Fish are able to feed and spawn in floodplain areas
- Riparian plant seeds germinate on flood-deposited sediments
- Insects emerge from water to complete their lifecycle
- Wading birds and waterfowl feed on fish and plants in shallow flooded areas



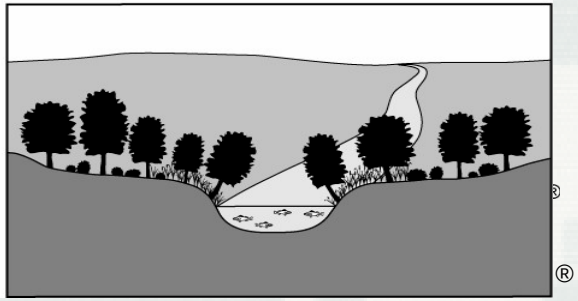
Inadequate Low Flow

- Fish are overcrowded in poor-quality water, cannot move to other feeding areas
- Riparian plants wilt when ground water table drops too low
- Insects suffer when water levels rise and fall erratically
- Birds unable to feed, rest, or breed in tree canopy



Absence of Flood

- Fish unable to access floodplain for spawning and feeding
- Riparian vegetation encroaches into river channel
- Insect habitats smothered by silt and sand
- Many birds cannot use riparian areas when plant species change



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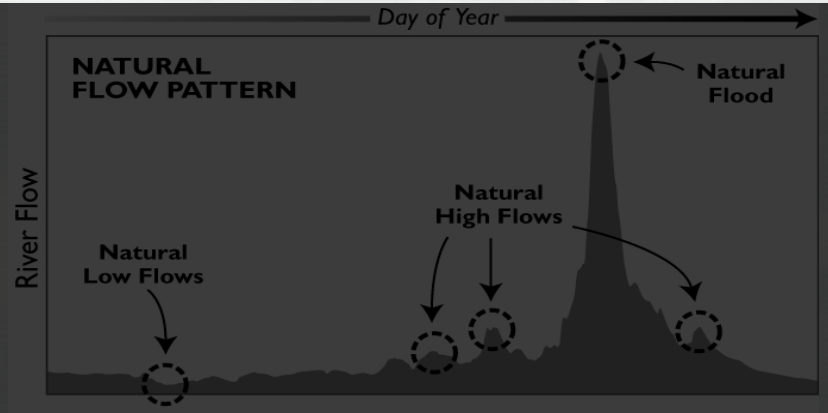

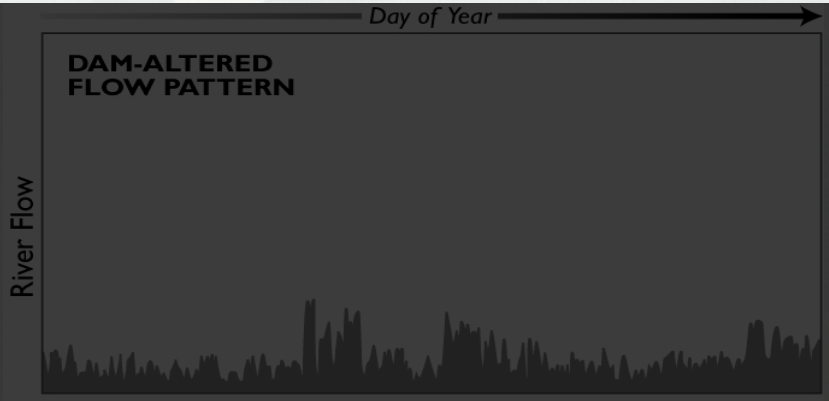

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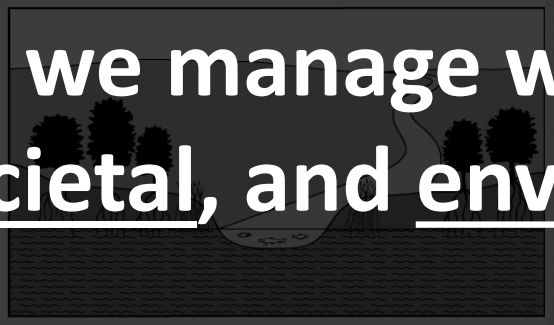

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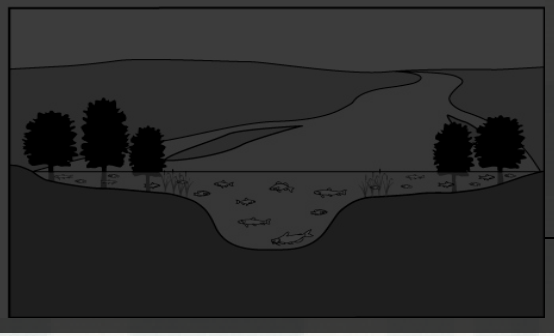

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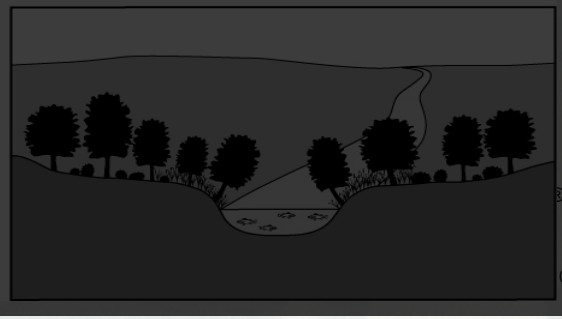
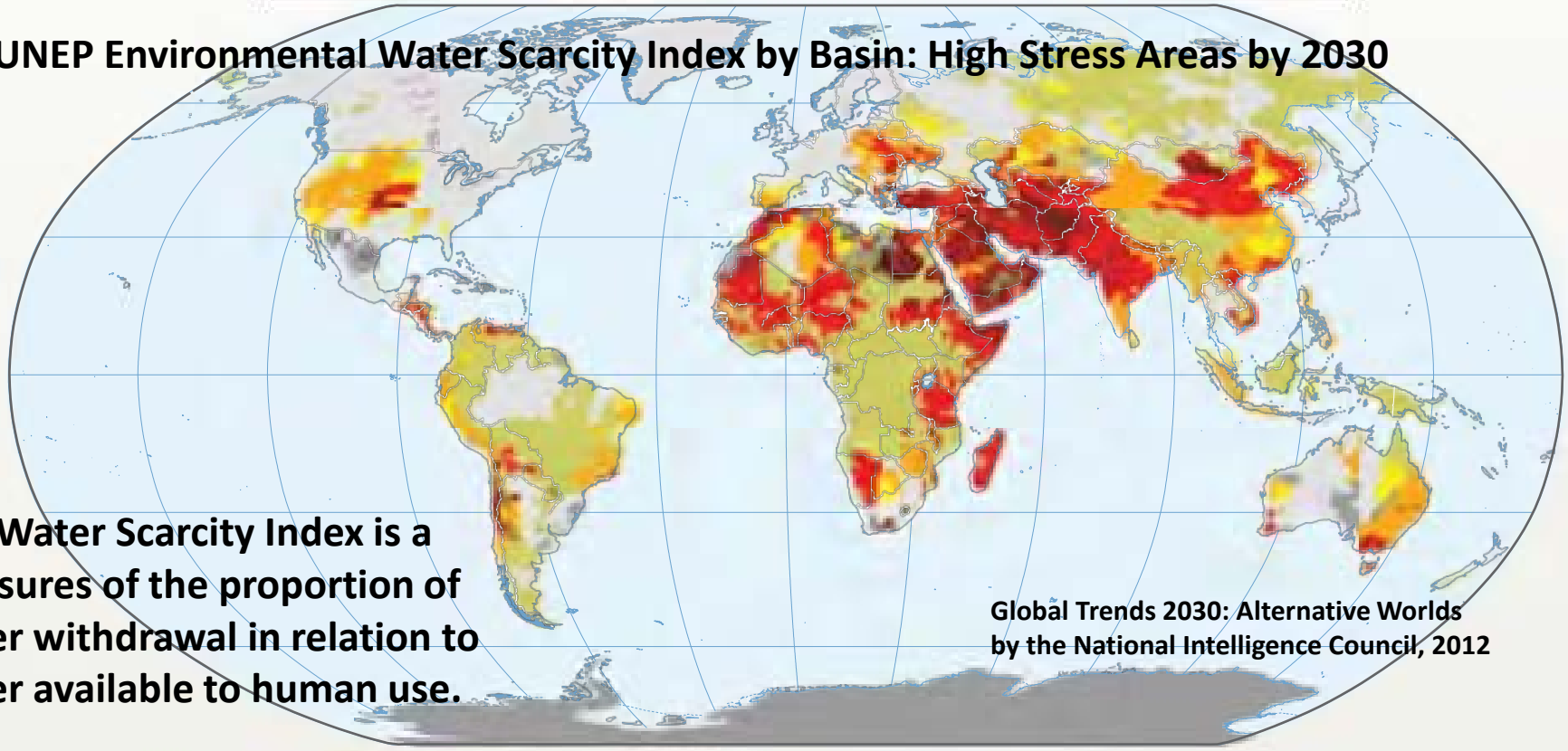


How do we manage water to meet <u>economic</u>, <u>societal</u>, and <u>environmental</u> needs?

Future Global Water Scarcity

- Significantly less stressed
- Moderately less stressed
- Near status-quo conditions
- Drier but still low stress
- Moderately more stressed
- Severely more stressed
- Extremely more stressed
- Exceptionally more stressed
- Uncertainty in magnitude
- Uncertainty in direction
- No data/or out of area

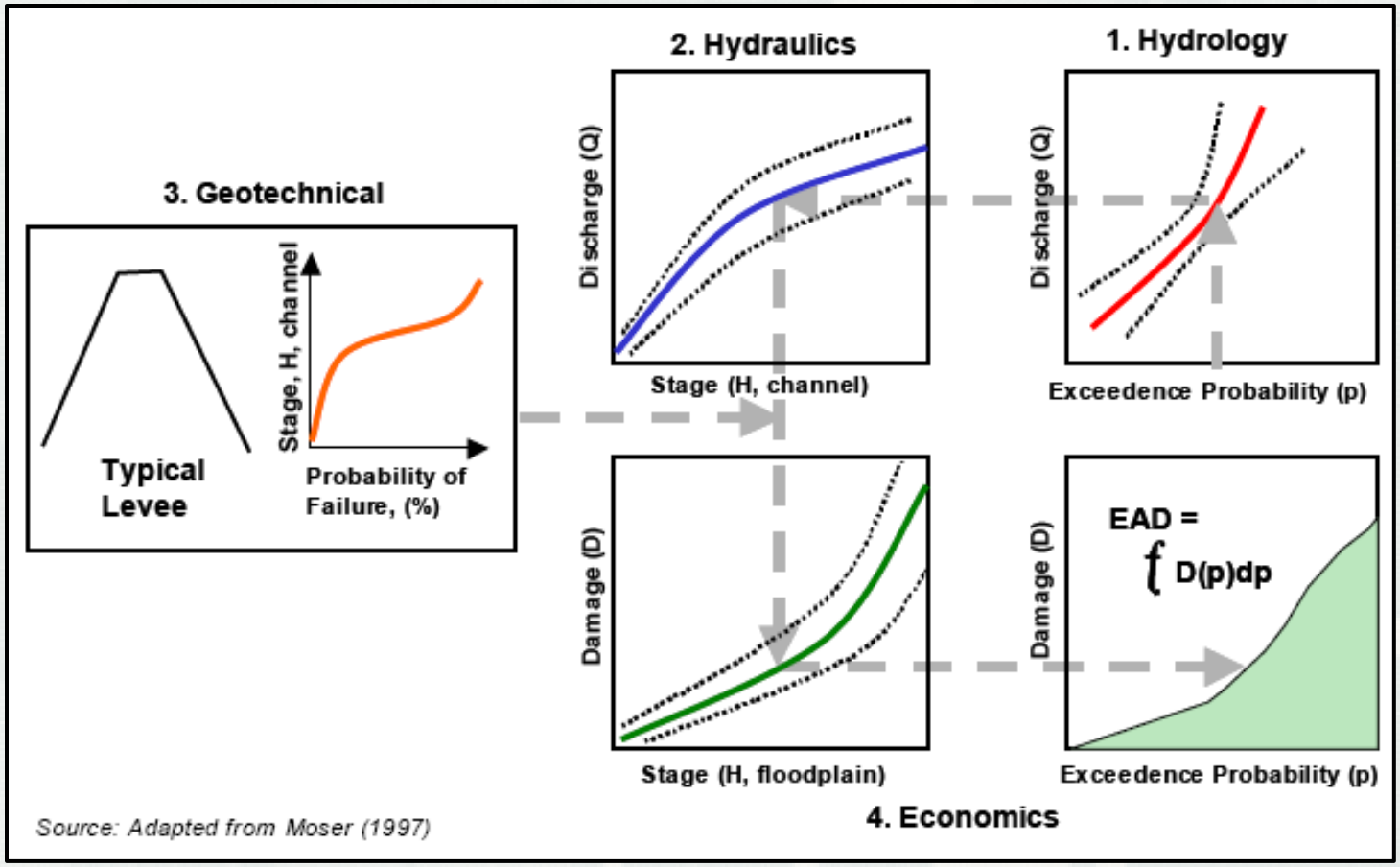
UNEP Environmental Water Scarcity Index by Basin: High Stress Areas by 2030



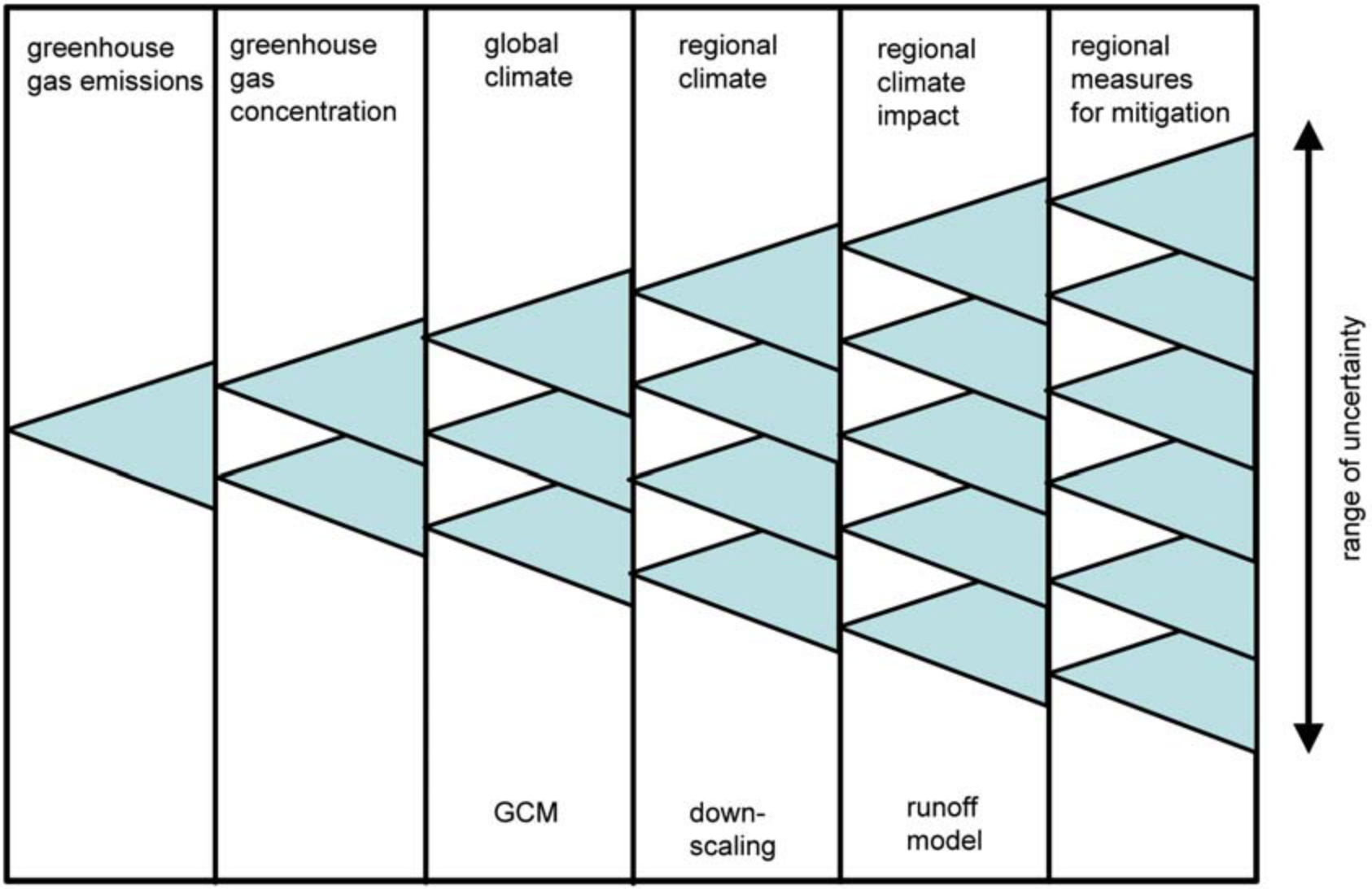
The Water Scarcity Index is a measures of the proportion of water withdrawal in relation to water available to human use.

Global Trends 2030: Alternative Worlds by the National Intelligence Council, 2012

Cost-Benefit Analysis for Flood Risk Management Design



Uncertainty in Climate Change Impact Analysis



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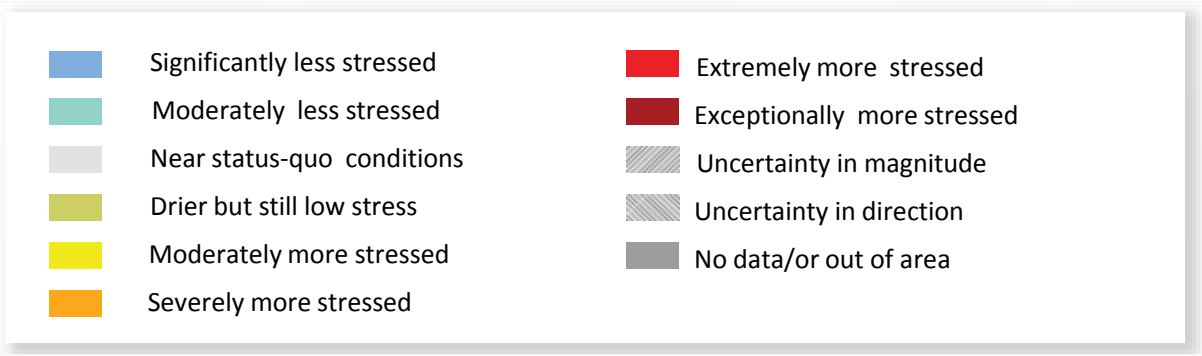
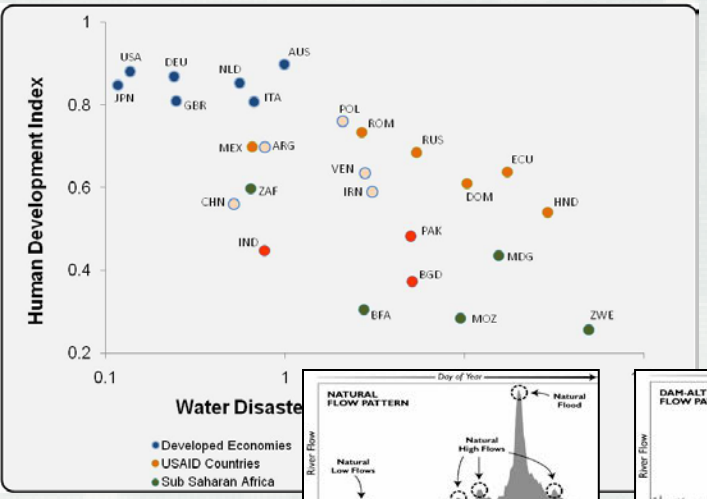
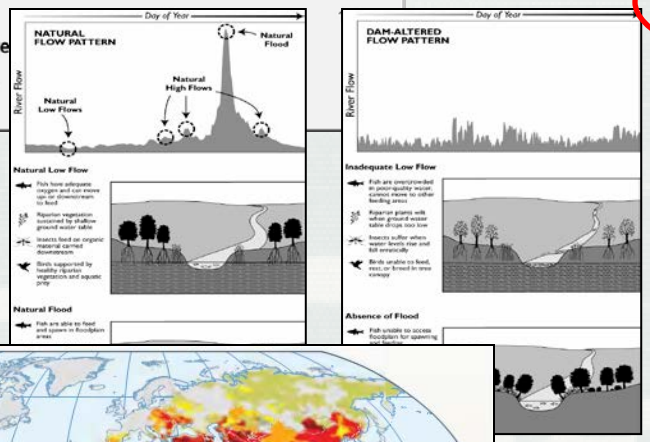


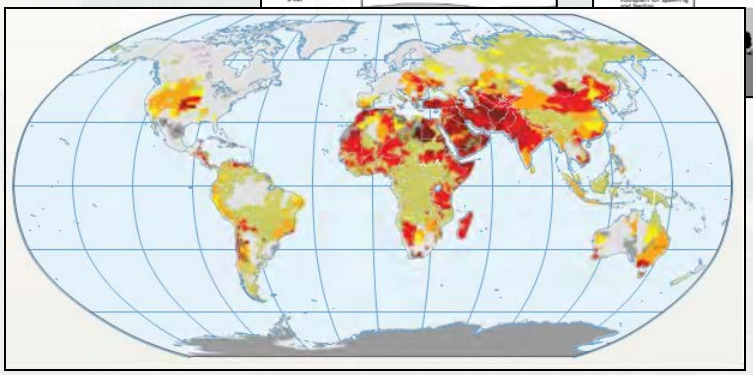
How do we manage water to meet economic, societal, and environmental needs?

...with added uncertainty of climate change?

Presentation Goals





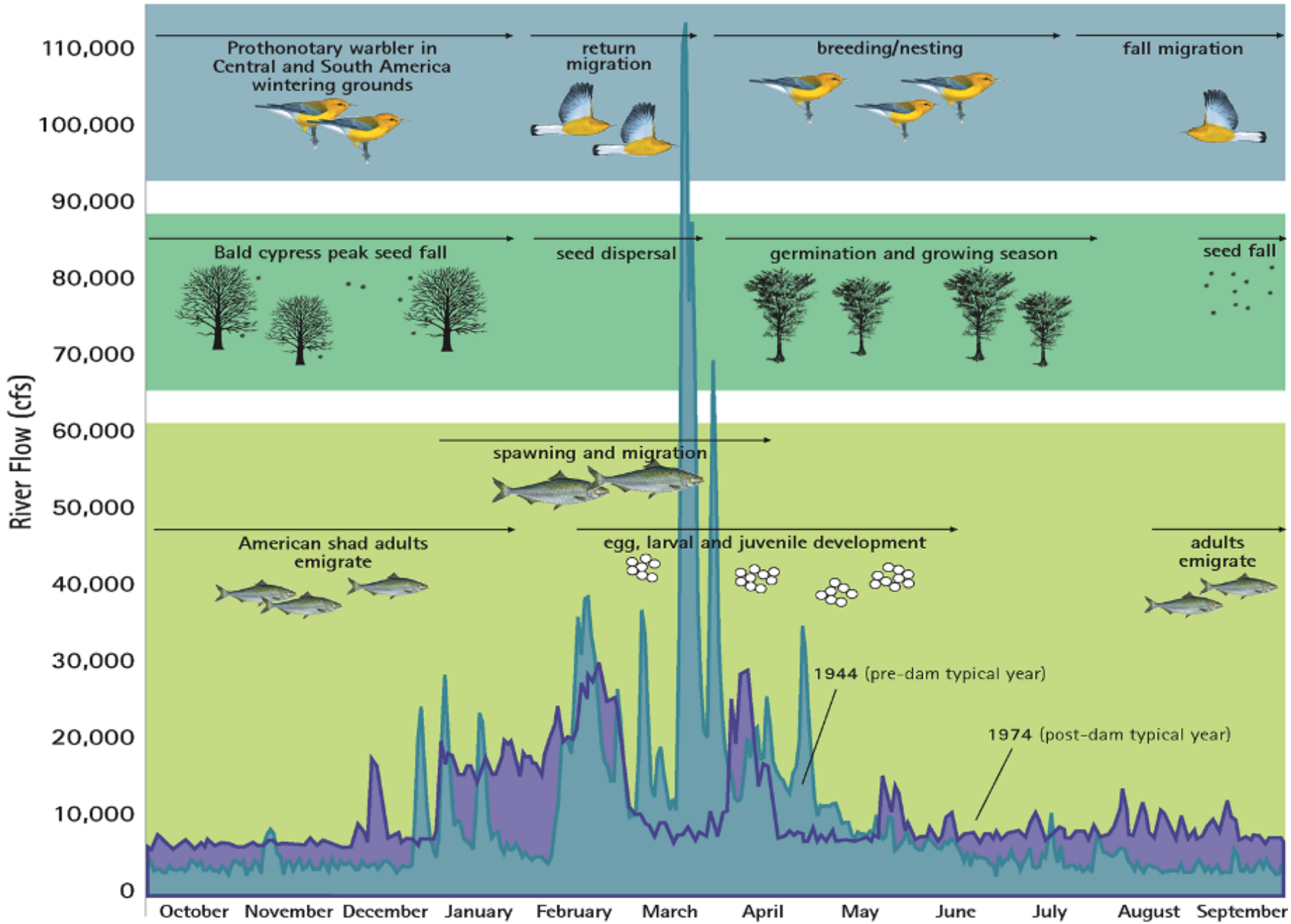


- Incorporating environment into water management
  - Using water infrastructure to restore ecosystems
  - Using natural systems to support engineering objectives
- Addressing climate change adaptation

Sustainable Rivers Program

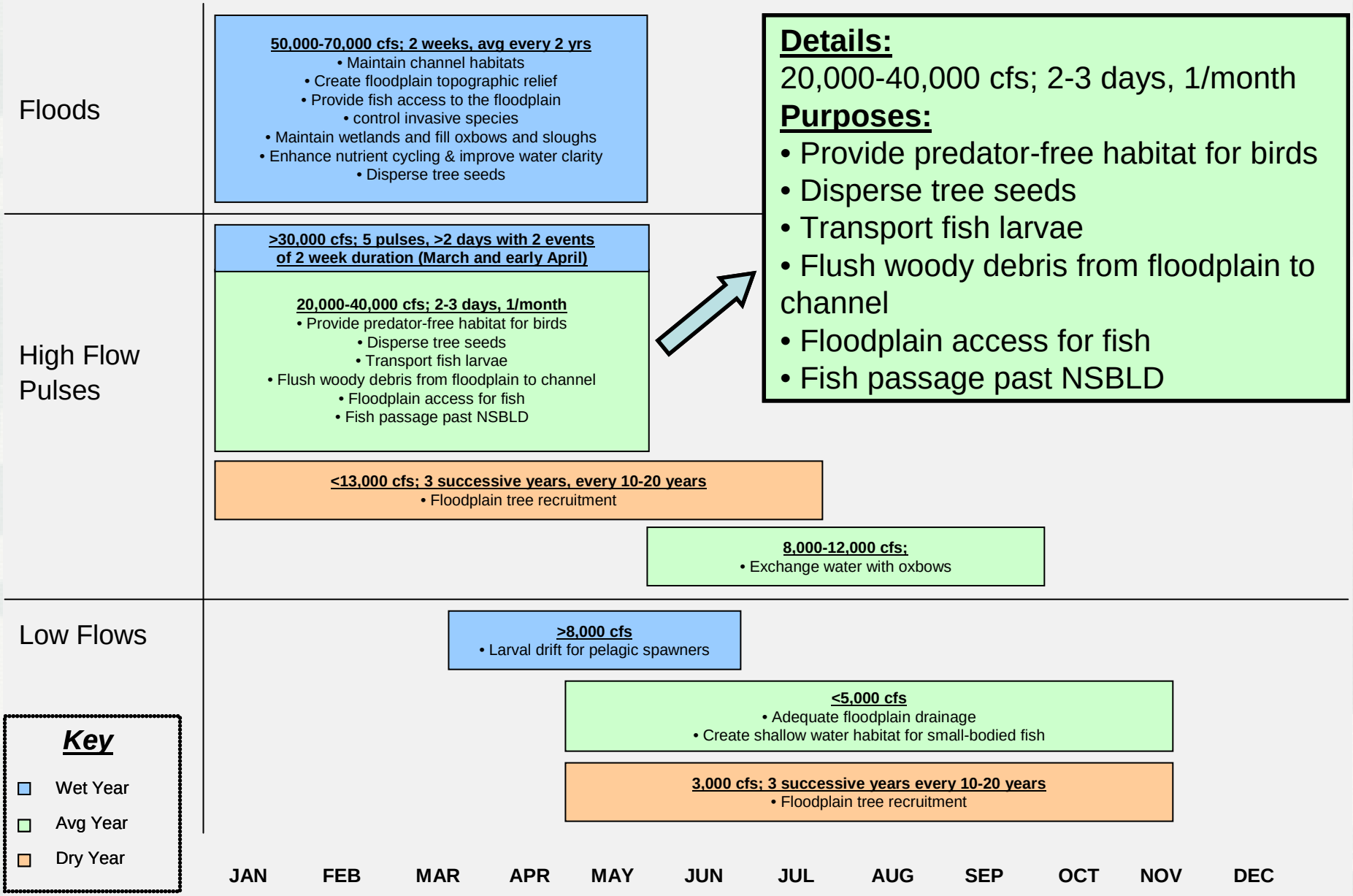
Environmental Flows -- the flows of water in a river that sustain healthy ecosystems and the goods and services that humans derive from them (SRP)

Ecological Model of the Savannah River



Environmental Flow Recommendations

Savannah River, USA (below Thurmond Dam)



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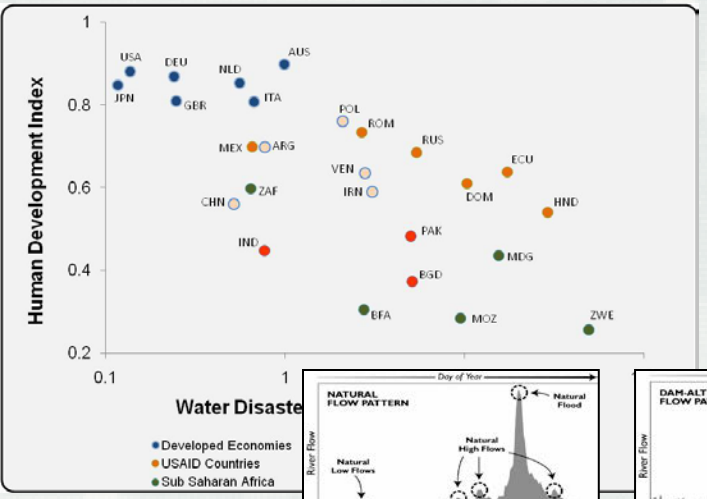

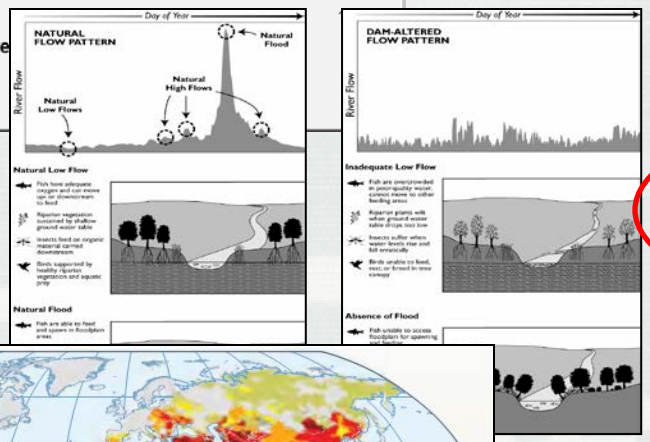

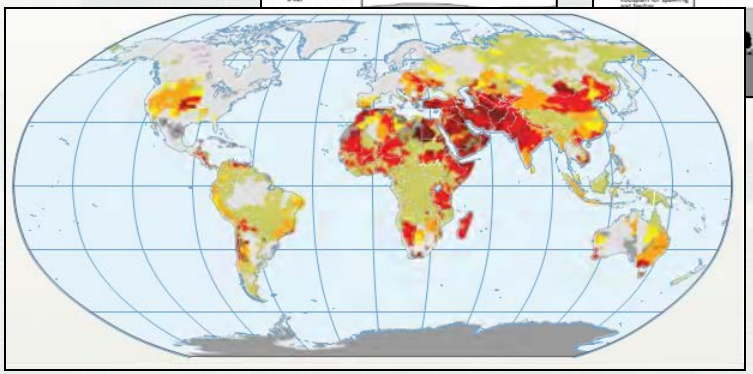

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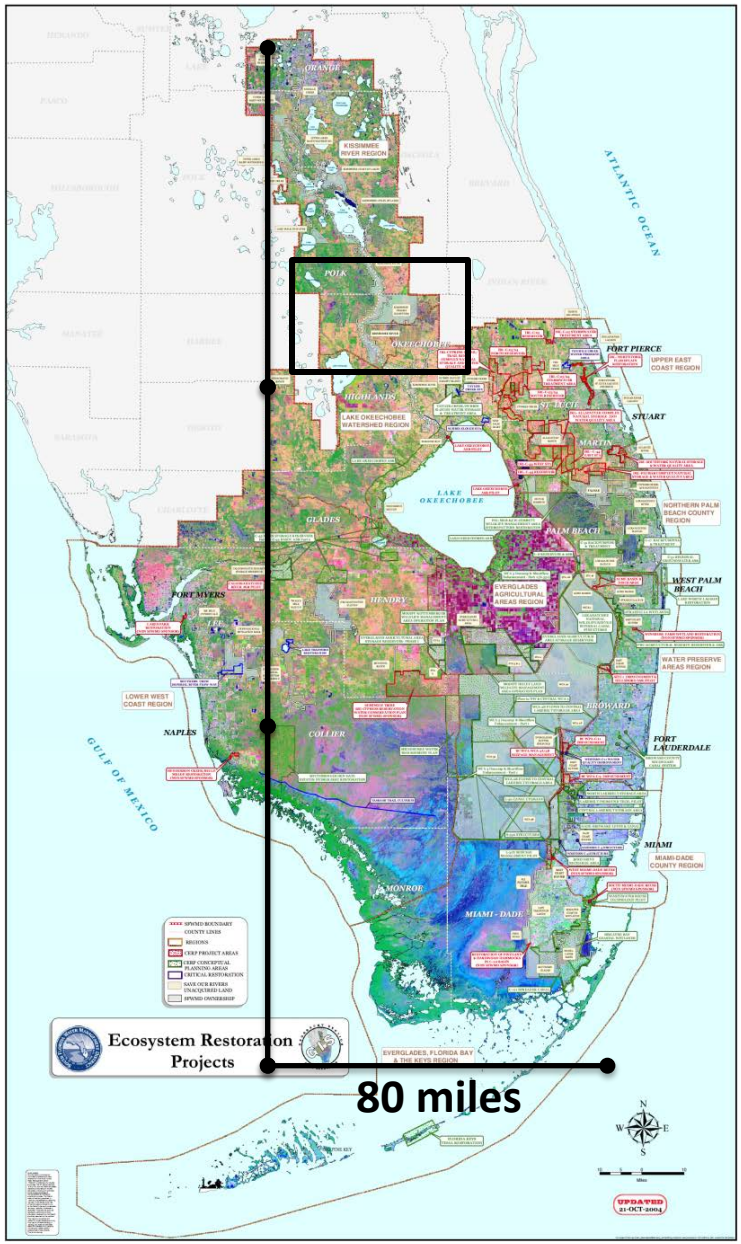
The Everglades



Late 1800's: Everglades Drainage District

- Climate and topography make region prone to **flooding**
- First **canal system constructed to drain Lake Okeechobee and NE Everglades**

1920s-1940s: Natural Disasters

- **Hurricanes** kill 2400 people and ruin property/agriculture
- Devastating **droughts**

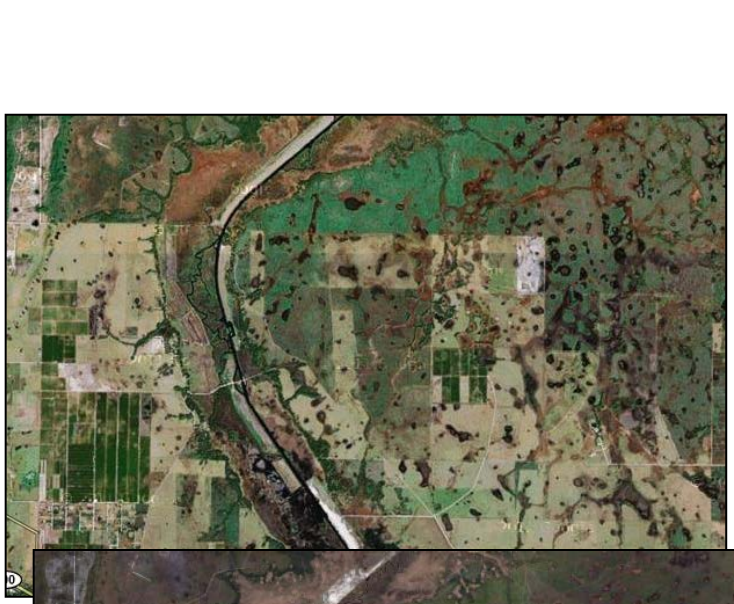
1950: Central & South Florida Project

- USACE constructed 1,000 miles of **levees**, 720 miles of **canals**, 200 **water control structures**
- Negatively effected **timing**, **quantity**, and **quality** of freshwater flows

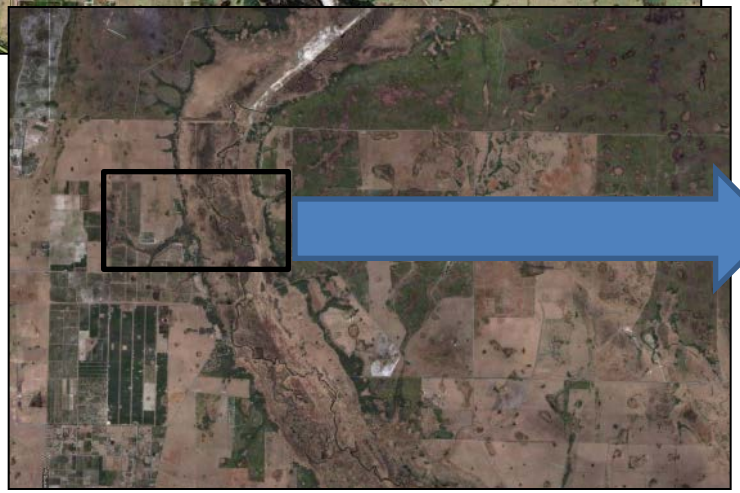
1996+: Multiple Restoration Plans

- Comprehensive Everglades Restoration Plan: World's largest **Ecosystem Restoration** project
- Restoring natural timing and quantity of freshwater flows and improving water quality

The Everglades:
Kissimmee River Restoration Project



Before



After

New York City Water Supply System

- One of the largest unfiltered surface water supply systems in the world
  - 1.3 billion gallons per day
  - 9 million consumers
  - 2,000 square miles of watershed
  - 578 billion gallon storage capacity
- In 1989, **EPA's Surface Water Treatment Rule (SWTR),** issued under the federal Safe Drinking Water Act, **required filtration of surface water** to mitigate microbial contamination of drinking water
- New York City estimated construction costs for Catskill/Delaware filtration facilities to be as much as **$6 billion** with annual operating expenses estimated to be more than **$300 million**

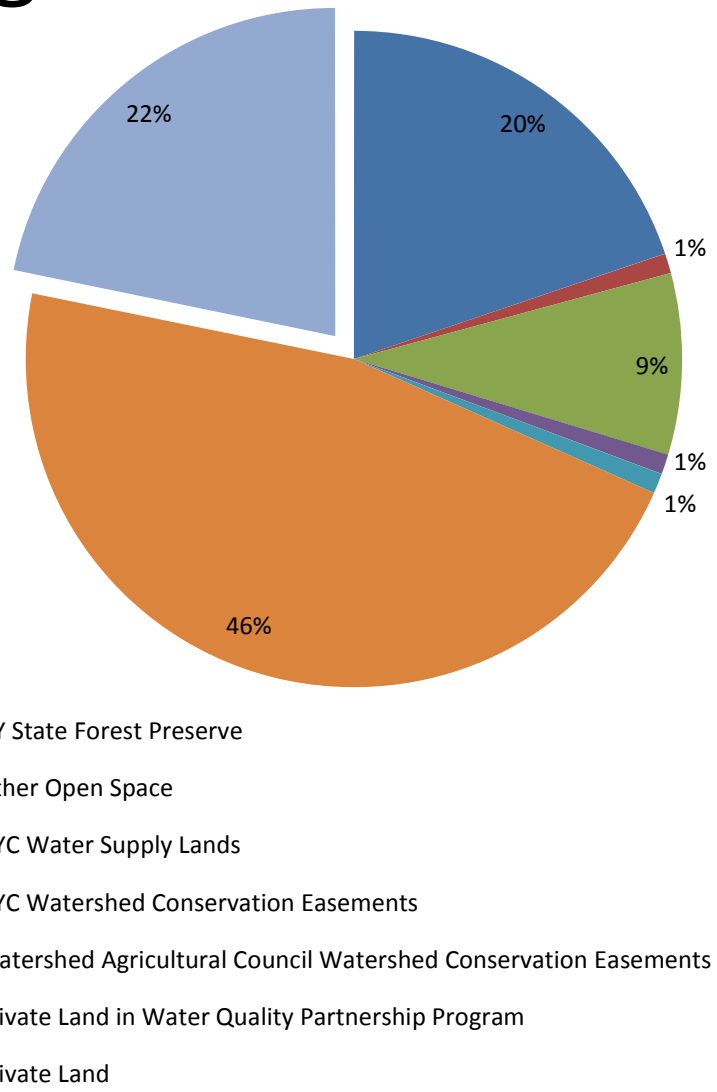
http://www.awra.org/committees/techcom/watershed/pdfs/0203WU.pdf

http://www.nap.edu/openbook.php?record_id=9677&page=25

New York's Comprehensive Watershed Protection Program

- Protection and Remediation Programs
  - Land management
  - Watershed agricultural program
  - Riparian buffer protection program
  - Non-point source pollution control program

- Comprehensive watershed monitoring network
  - Scientific basis for assessing changes in watershed conditions and water quality
  - Contributes to the ongoing refinement of watershed protection program.

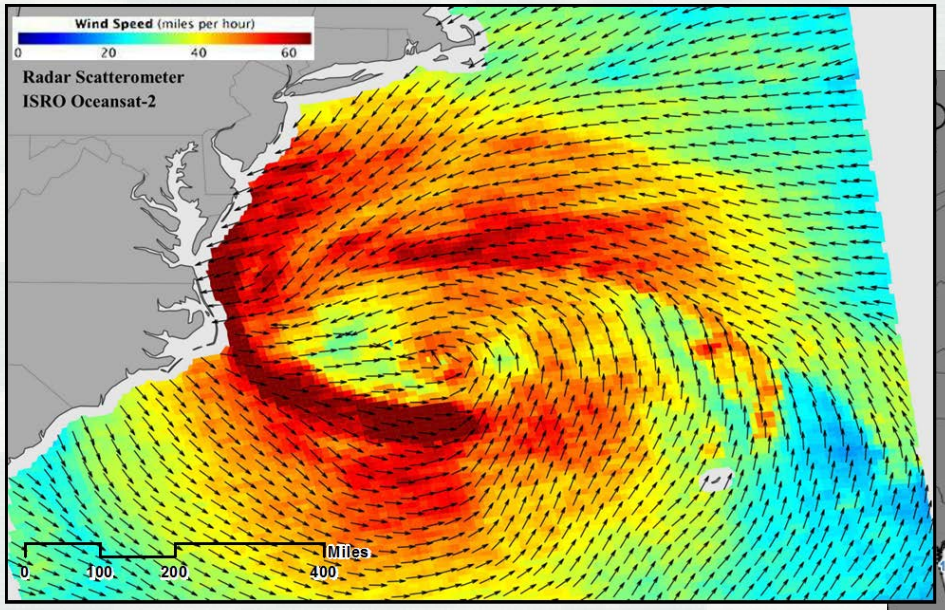


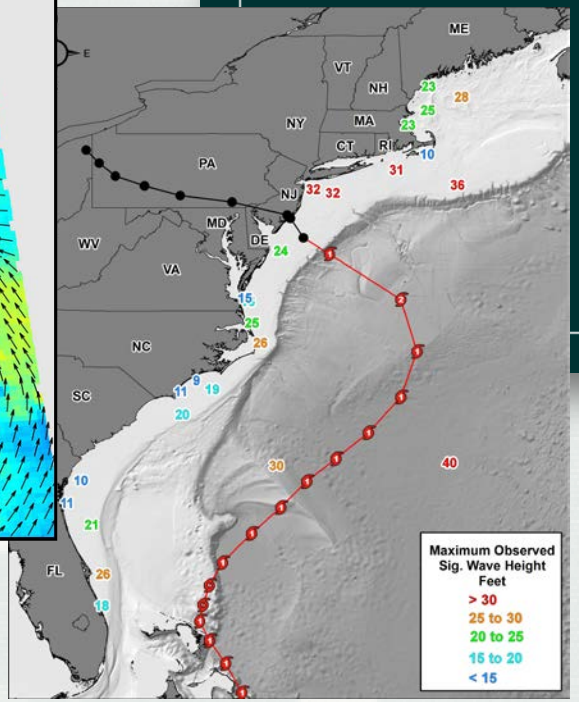
http://www.nyc.gov/html/dep/html/drinking_water/history.shtml

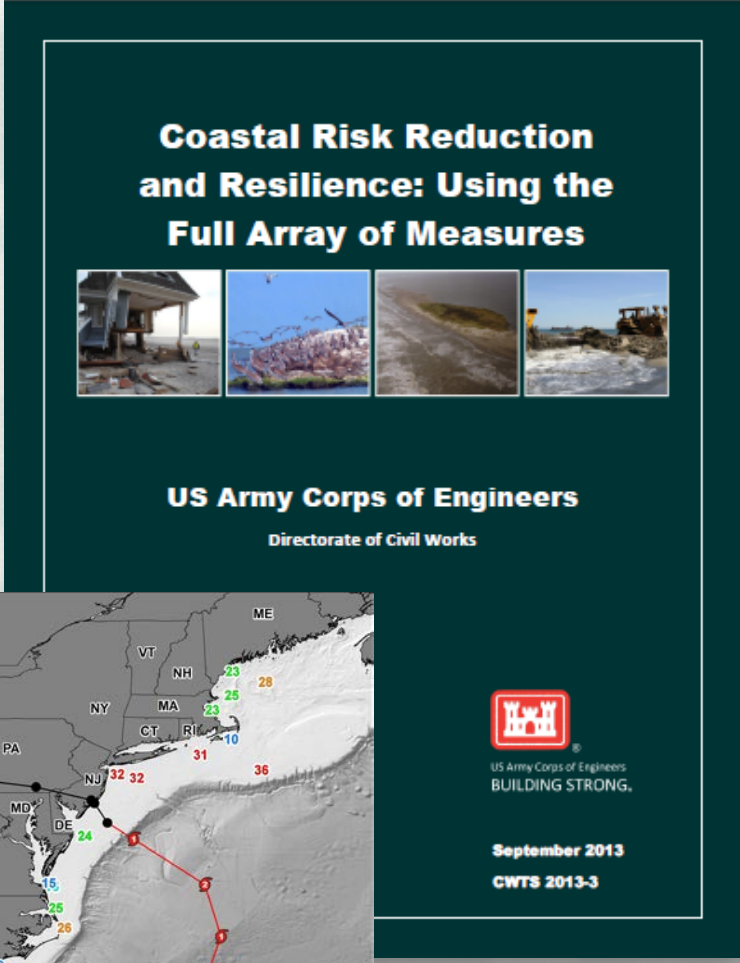
http://www.awra.org/committees/techcom/watershed/pdfs/0203WU.pdf

Hurricane Sandy Recovery

"Natural and nature-based measures are capable of improving the quality and resilience of economic, ecologic, and social systems"







$68 billion in damages
286 fatalities

IWR

BUILDING STRONG®

Natural and Nature-Based Features for Coastal Risk Reduction and Resilience

Dunes and Beaches

Benefits/Processes

Breaking of offshore waves

Attenuation of wave energy

Slow inland water transfer

Performance Factors

Berm height and width

Beach slope

Sediment grain size and supply

Dune height, crest, and width

Presence of vegetation

Vegetated Features

Benefits/Processes

Breaking of offshore waves

Attenuation of wave energy

Slow inland water transfer

Increased infiltration

Performance Factors

Marsh, wetland, or SAV elevation and continuity

Vegetation type and density

Oyster and Coral Reefs

Benefits/Processes

Breaking of offshore waves

Attenuation of wave energy

Slow inland water transfer

Performance Factors

Reef width, elevation, and roughness

Barrier Islands

Benefits/Processes

Wave attenuation and/or dissipation

Sediment stabilization

Performance Factors

Island elevation, length, and width

Land cover

Breach susceptibility

Proximity to mainland shore

Maritime Forests/Shrub Communities

Benefits/Processes

Wave attenuation and/or dissipation

Shoreline erosion stabilization

Soil retention

Performance Factors

Vegetation height and density

Forest dimension

Sediment composition

Platform elevation

IWR

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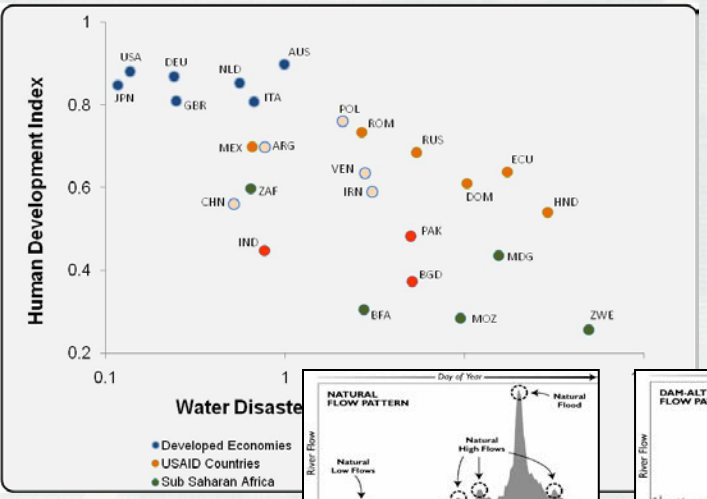
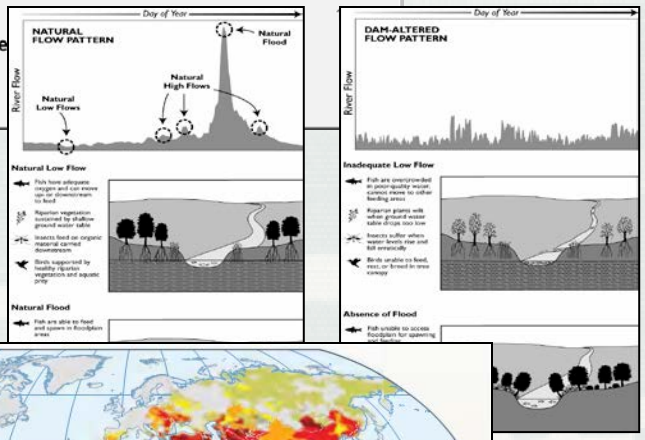
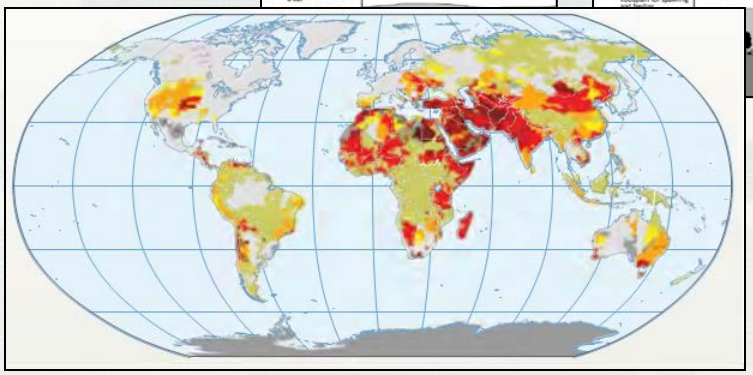
Presentation Goals







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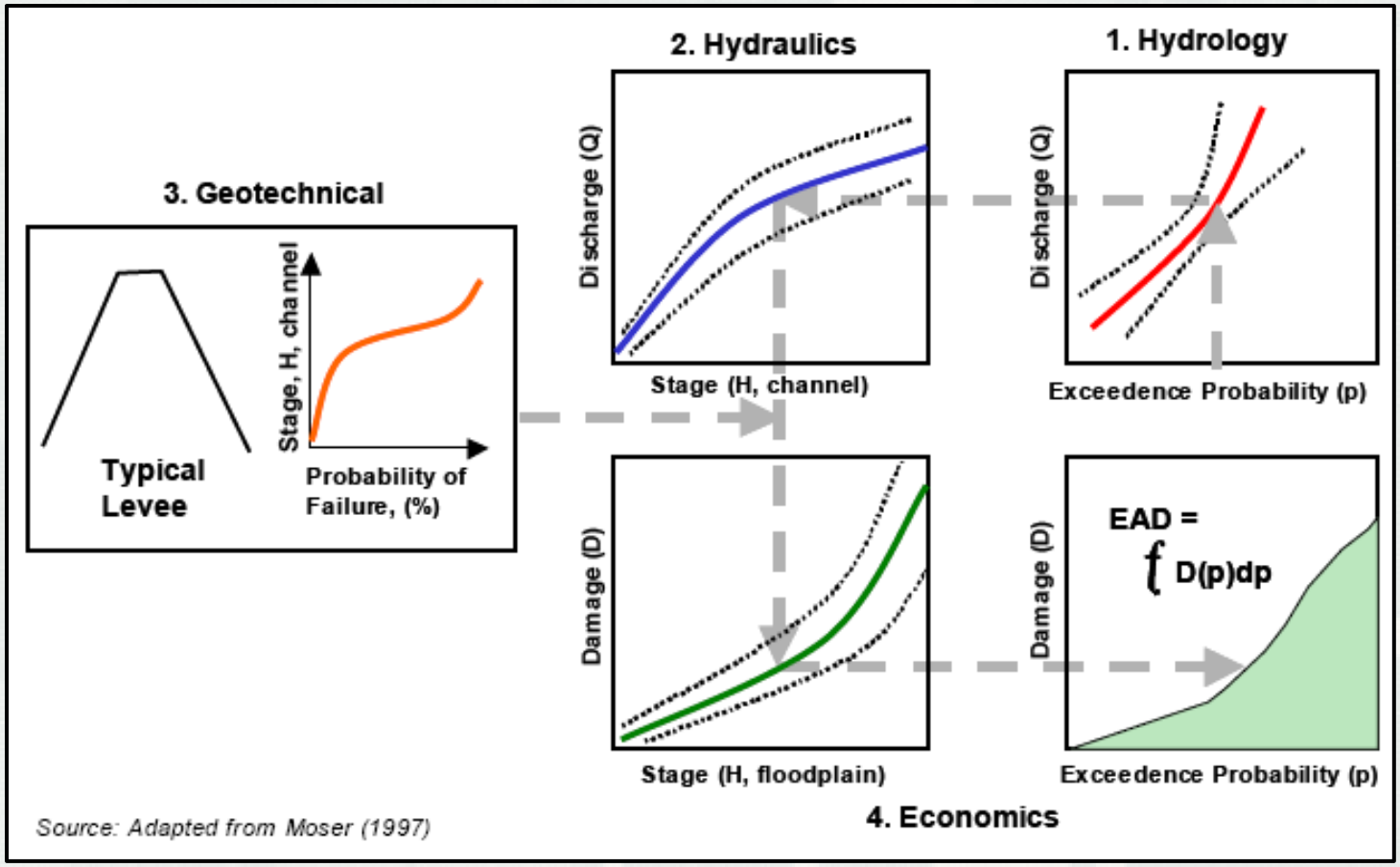
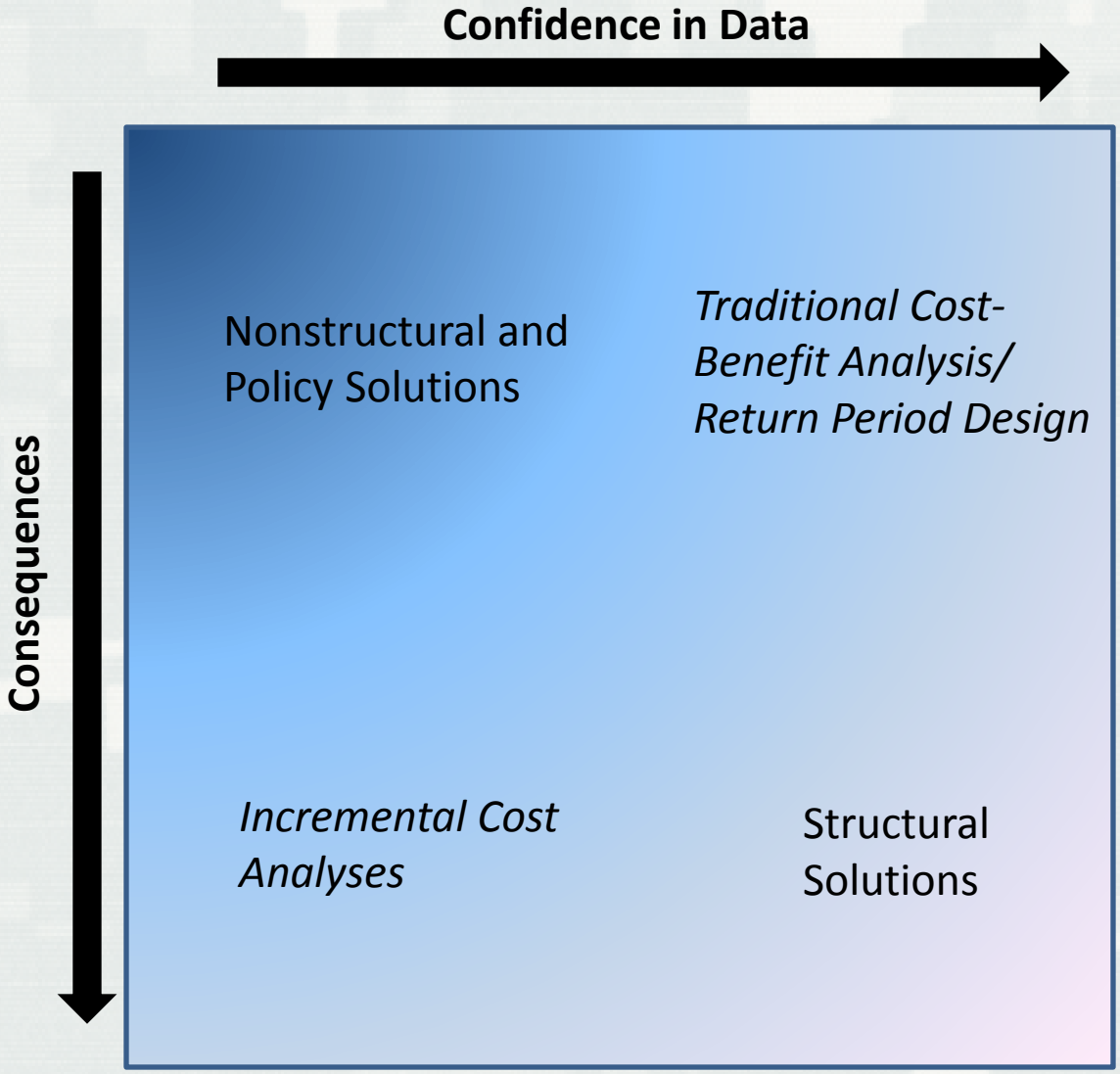
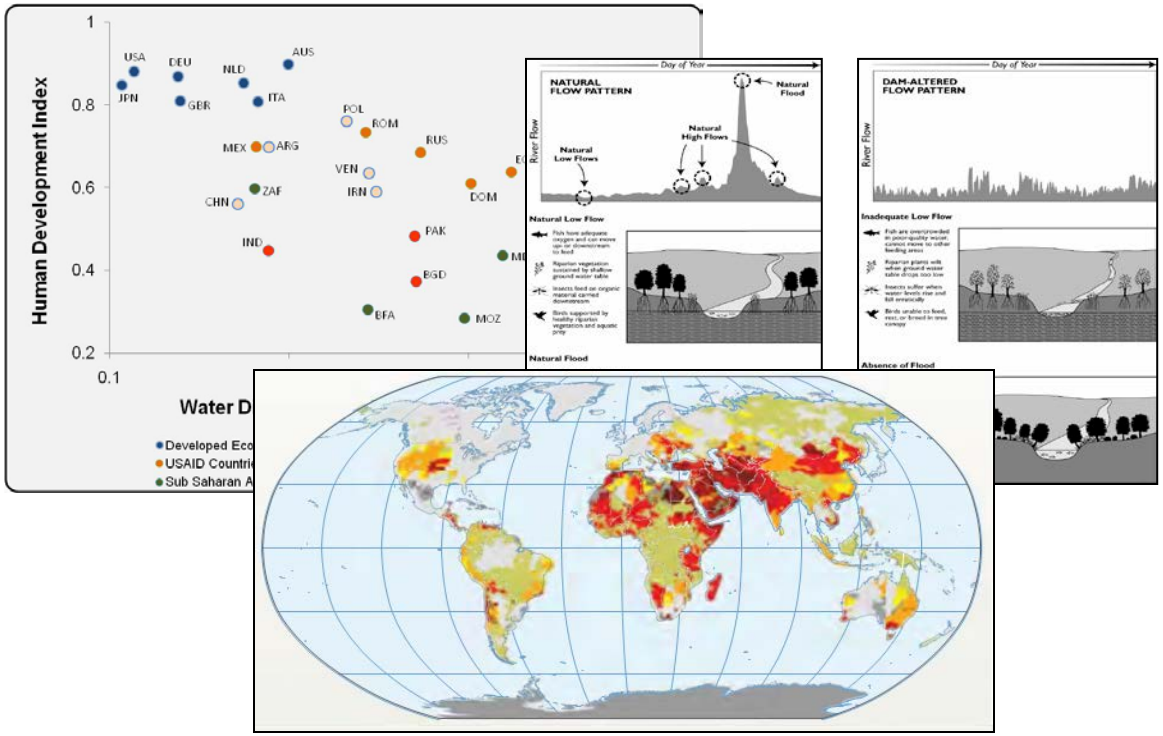


Climate Change Adaptation: Buying Down Risk

Climate Change Adaption



Conclusions



WATER RESOURCES MANAGEMENT GOALS

Support Development

↓

Balance Economic, Societal, and Environmental Needs

↓

CLIMATE CHANGE → Build Robustness into Systems →

- Eco-Engineering/ Hybrid Engineering
- Policy Development
- Structural Solutions

Future Challenges

- Balancing environmental, societal, and economic needs
  - Evaluating the trade-offs between the three sectors
  - Understanding long term environmental effects
- Defining the natural system
  - Most aquatic systems are already managed
  - Some change is natural, which change is man-made?
- Climate Change
  - Decision-making under uncertainty. How far in future do we plan for?
  - How do we determine how climate change will effect ecosystems?
- Communication
  - Between stakeholders, scientists, engineers, and policy makers
- Policy Reform
  - Authority to implement ecohydrology and eco-engineering projects

Thank you for your time!

This computer-generated pictorial shows how the wetland expansion would impact Manhattan. These wetlands will mitigate flooding and absorb storm surges (NYTimes)