Importance of Ecological Flows for Healthy Rivers

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River Network

Overview

* Flows and aquatic ecosystems
* Threats to hydrology
* Defining environmental flows
* Environmental flows in planning and management

Key factors for aquatic ecosystems

Hydrologic Regime

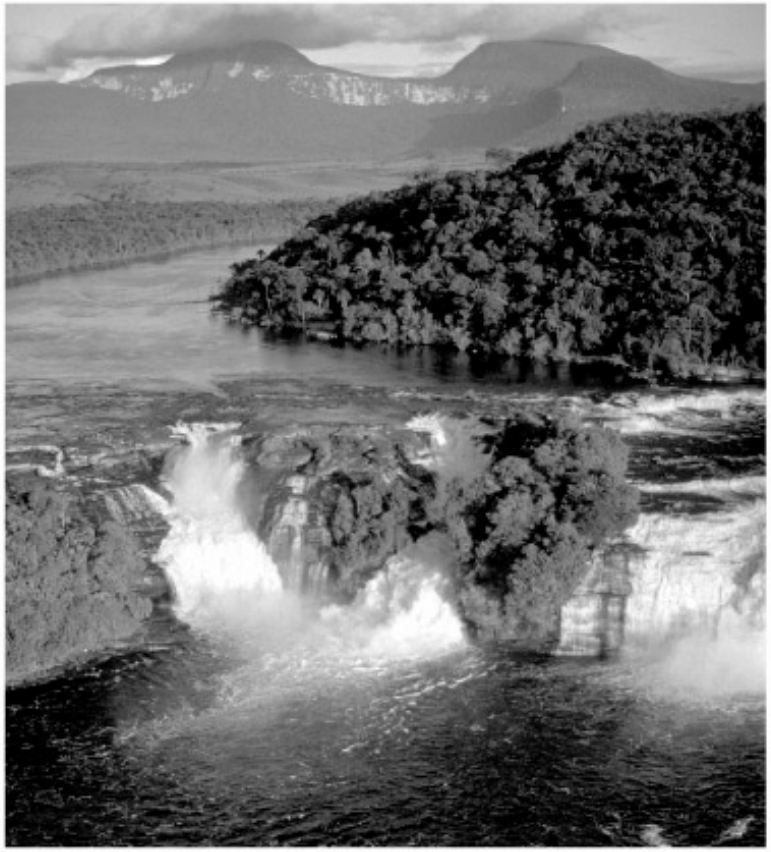
(surface flow, groundwater, surface inundation, and soil moisture regimes)

Physical Habitat Conditions →

(woody debris, riparian canopy, geomorphology, sediment/soil regime)

Biological Composition & Interactions →

(energy regime, feeding, 1· & 2· production, target structure & composition, competition & predation, reproduction, disease & parasitism, mutualism)



← **Connectivity**

(up-down gradient continuity, water-wetland-land connectivity)

← **Water Chemistry Regime**

(salinity, alkalinity, hardness, temperature, dissolved minerals, dissolved gases, turbidity, pH, ORP, radioactivity, organic compounds)

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Adaptations to flow

Current and body shape

- **Sunfish and bullheads with broad body forms are adapted to slow current.**


www.uga.edu/srel/Coal_Ash/sunfish.jpg

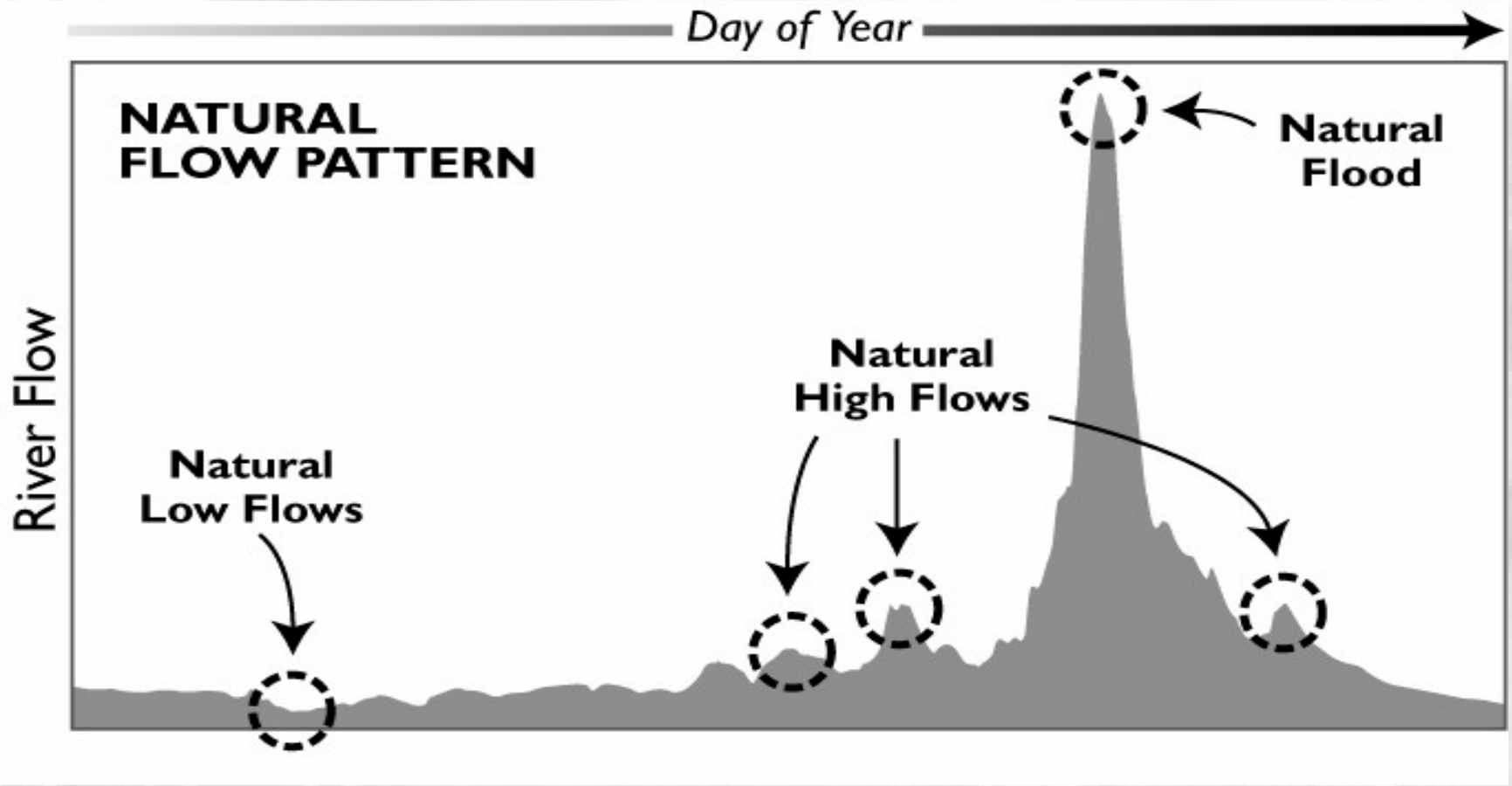

www.cnr.vt.edu/efish/families/ictaluridae.html

- **Stonecats and trout with streamlined body forms are adapted to fast current.**


www.lambs-inn.com/new-images/ trout-sm.jpg


www.cnr.vt.edu/efish/families/ictaluridae.html

Flow Events (lows, highs, floods)



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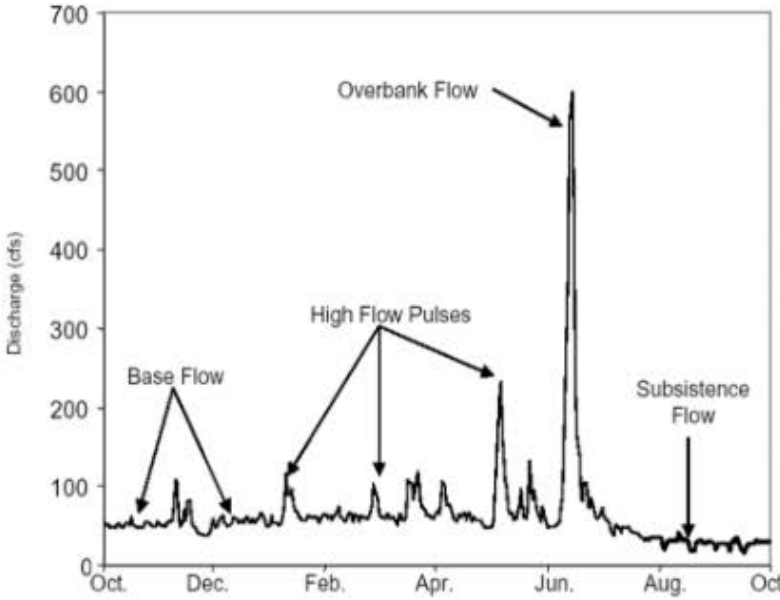
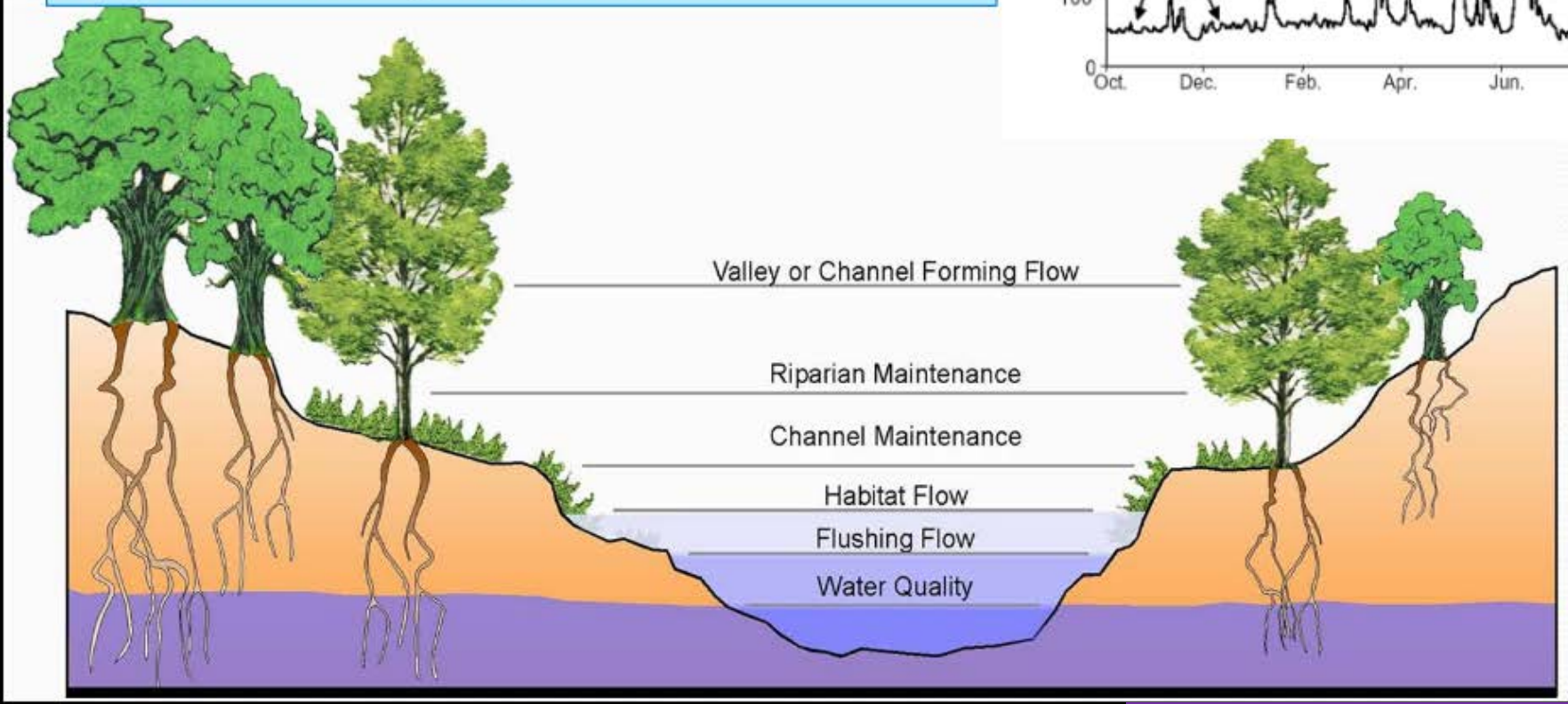
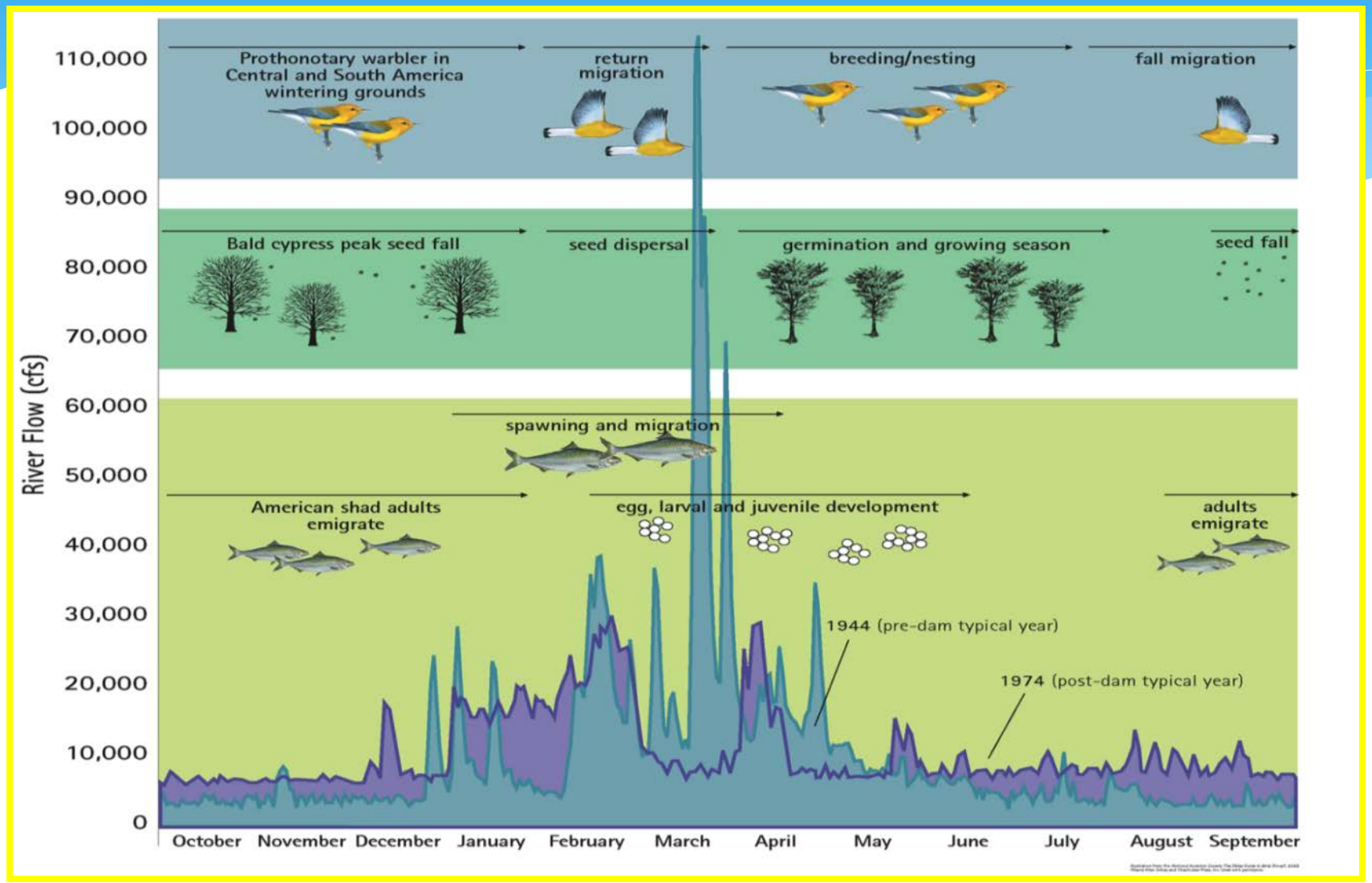
Flow Components

Many studies have shown that altering one or more flow regime components can significantly impact biota





Savannah River Ecological Model



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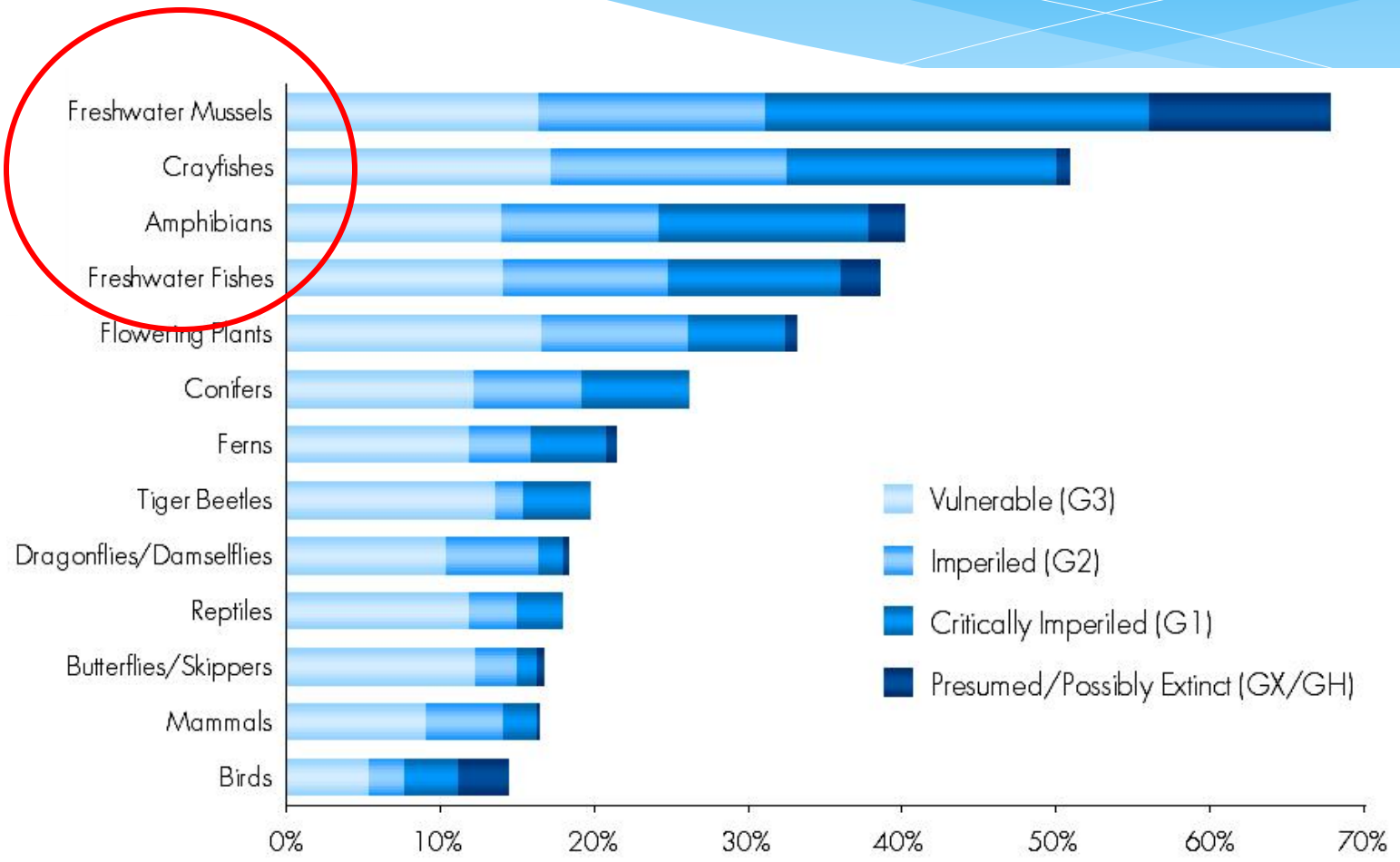
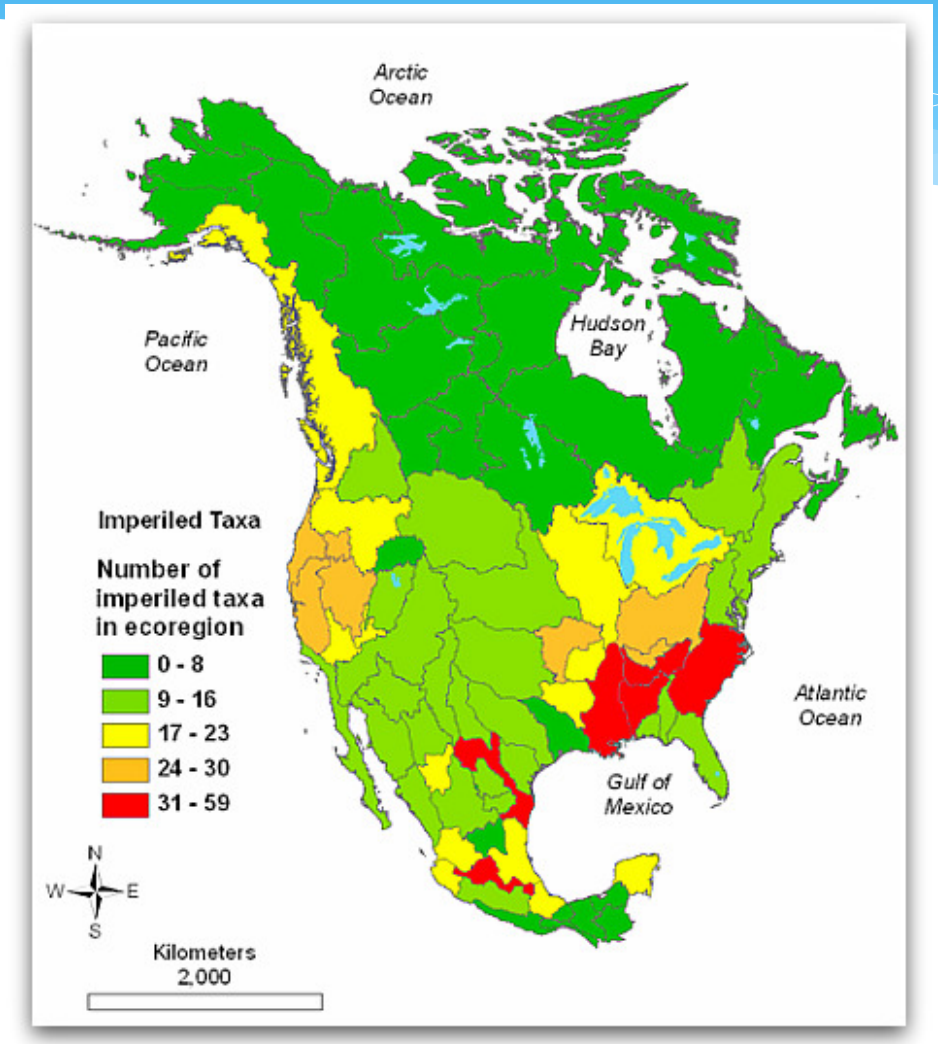
Proportion of U.S. Species at Risk



Fish at Risk by Ecoregion



Walsh et. al, 2009

Threats to Hydrology

* Dams
* Water withdrawals
* Land use change
* Climate change

Dams

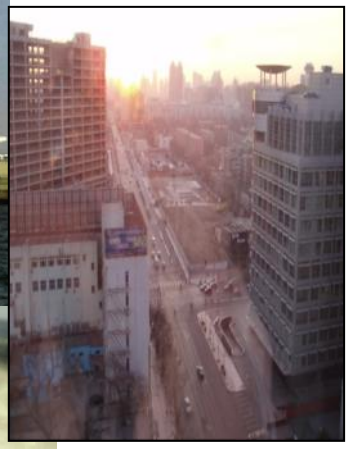
* Barrier to movement
* Trap sediment
* Change temperature
* Change flow regime

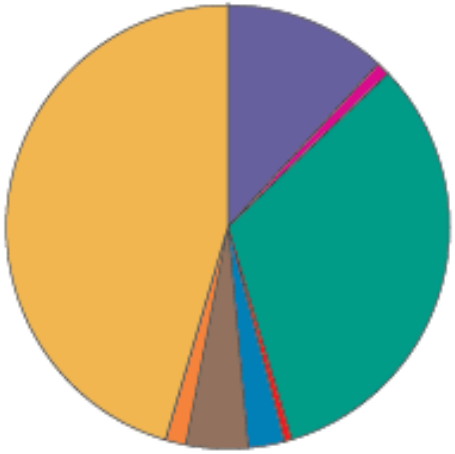
Carbonton Dam removal

Snail Darter – 1970s

Knoxville News Sentinel

Water withdrawals





2010 withdrawals by category, in million gallons per day

Public supply	42,000
Self-supplied domestic	3,600
Irrigation	115,000
Livestock	2,000
Aquaculture	9,420
Self-supplied industrial	15,900
Mining	5,320
Thermoelectric power	161,000

Values do not sum to 355,000 Mgal/d because of independent rounding

Source: USGS

Consumptive Loss

Water import or desalinization

Consumptive loss

Water use

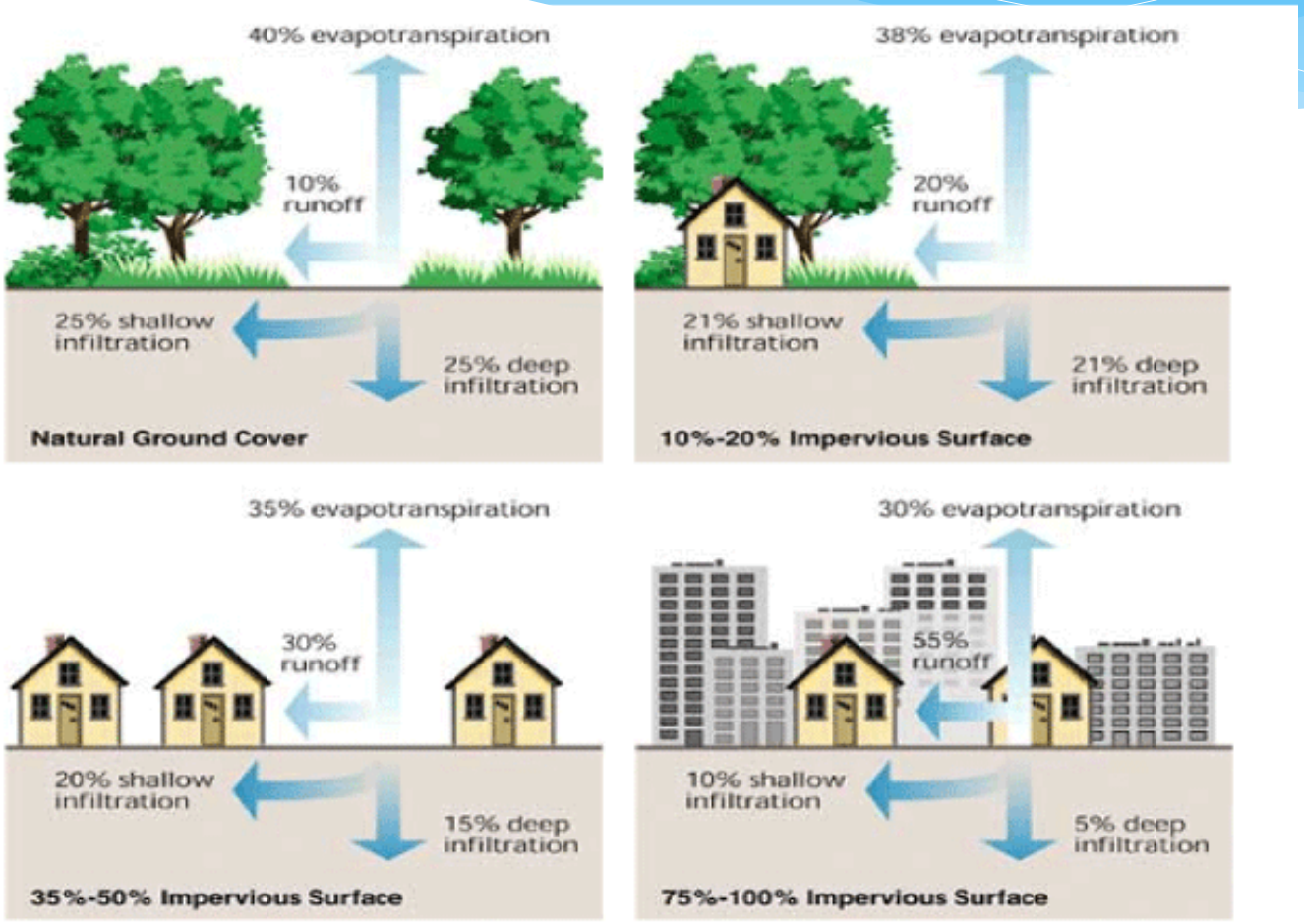
Natural water supply (Rain/snow)

Water withdrawal

Return flow

Adapted from: Chasing Water, Brian Richter (2014)

Land use change



Climate Change

- Changing baselines
- More extreme weather at both ends – droughts and floods
- Impacts on infrastructure, availability, quality

Aerial view of the Missouri River flooding on July 30, 1993, at U.S. Highway 54 just north of Jefferson City, Missouri, looking south (photograph from the Missouri Highway and Transportation Department).

Delta Smelt - today

AP / August 4, 2015, 2:36 PM

Tiny endangered fish highlights California drought conflicts

In this Wednesday, July 15, 2015 photo, a Delta smelt is seen at the University of California Davis Fish Conservation and Culture Lab in Byron,Calif. The tiny, endangered fish, found in the Sacramento-San Joaquin River Delta is at the the center of the state's water battle between farmers and biologists. / RICH PEDRONCELLI/AP

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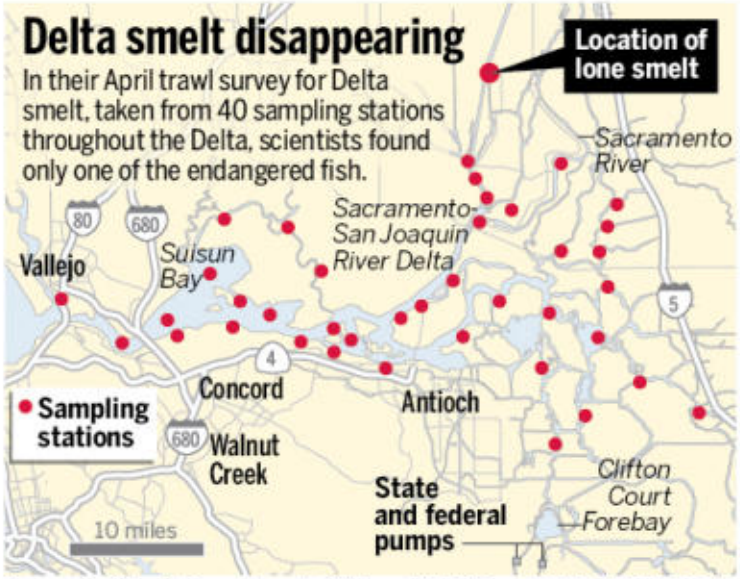


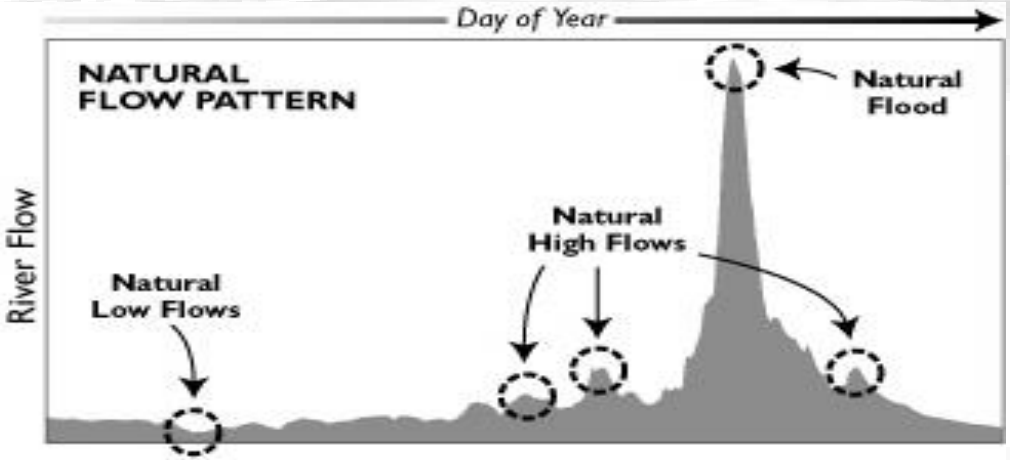
Source: California Department of Fish and Wildlife BAY AREA NEWS GROUP

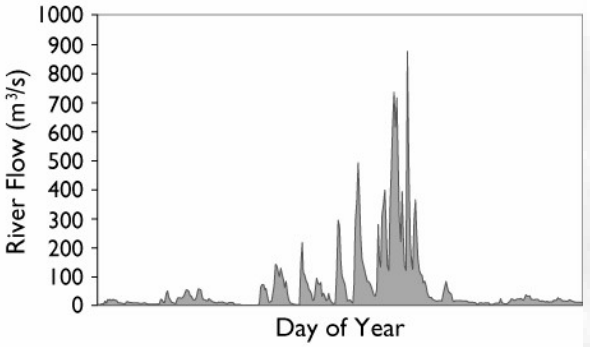
Defining Environmental Flows

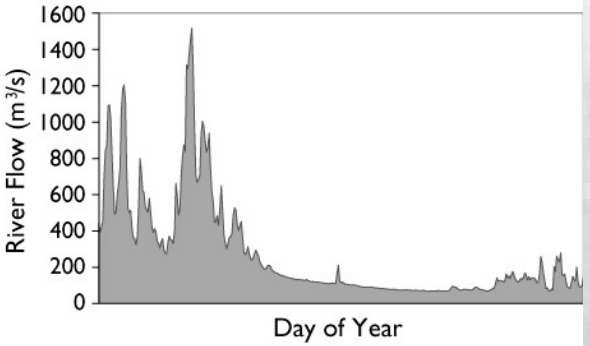
Natural Flow Regime

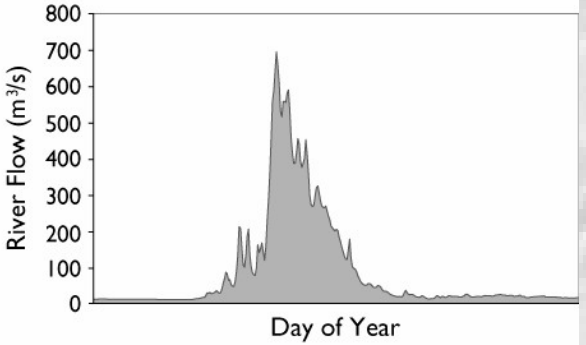
"The full range of natural intra- and inter-annual variation in hydrologic regimes, and associated characteristics of timing, duration, frequency, and rate of change, are critical in sustaining the full native biodiversity and integrity of aquatic ecosystems."

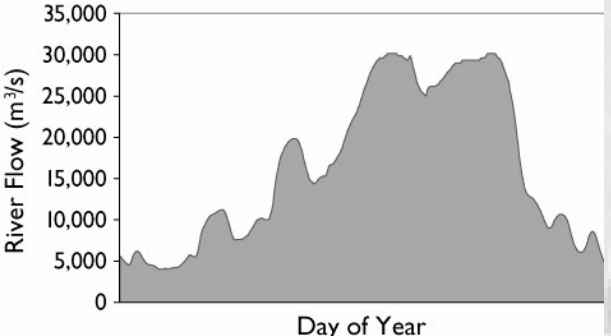
(Poff et al. 1997)


Day of Year
NATURAL
FLOW PATTERN
Natural
Flood
Natural
High Flows
Natural
Low Flows
River Flow


River Flow (m3/s)
1000
900
800
700
600
500
400
300
200
100
0
Day of Year


River Flow (m3/s)
1600
1400
1200
1000
800
600
400
200
0
Day of Year


River Flow (m3/s)
800
700
600
500
400
300
200
100
0
Day of Year

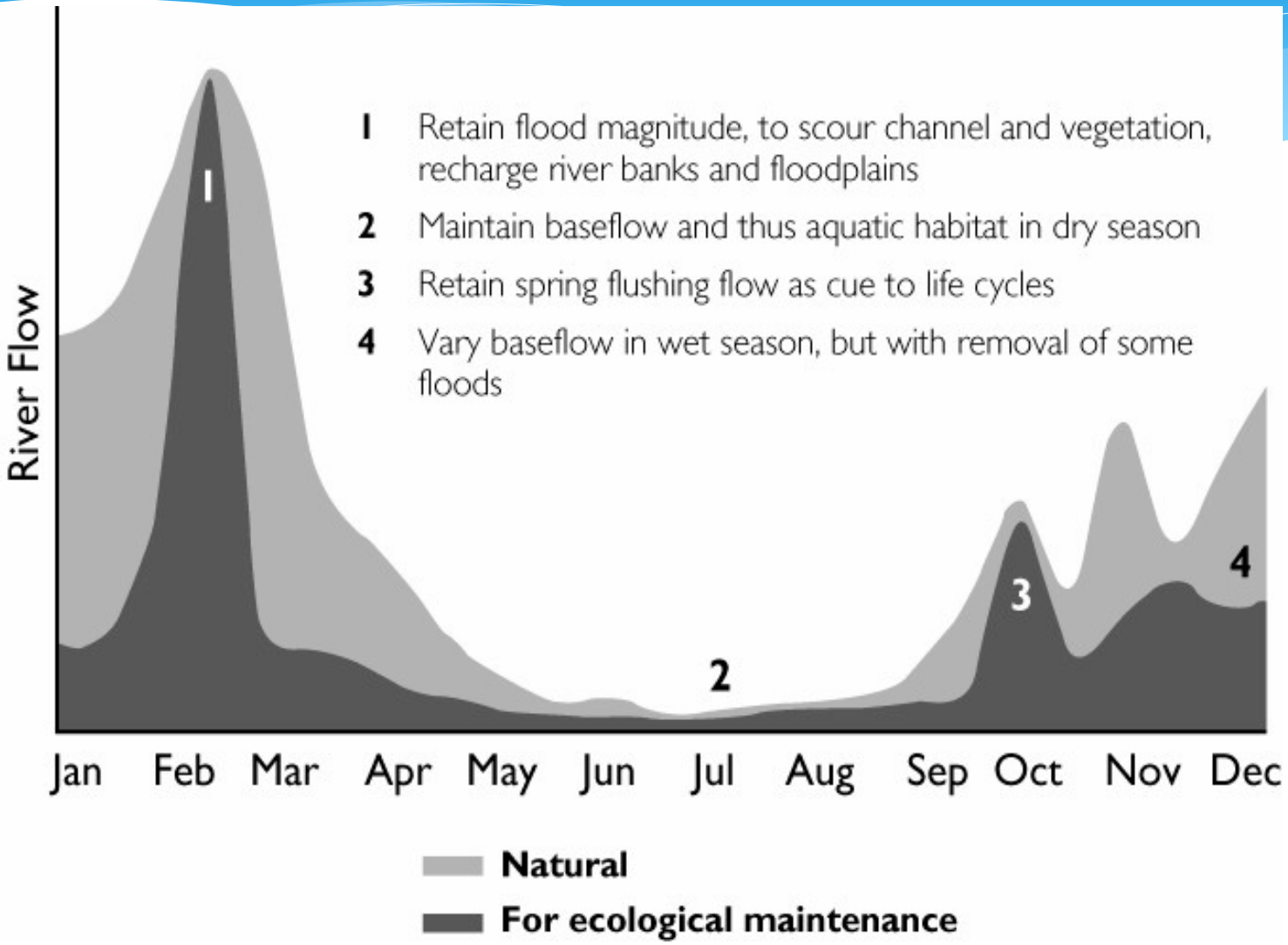

River Flow (m3/s)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Day of Year

Environmental Flows

* ***Environmental flows*** **describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems**

* **Environmental flow *management* provides the water flows needed to sustain freshwater and estuarine ecosystems *in coexistence with* agriculture, industry, and cities**

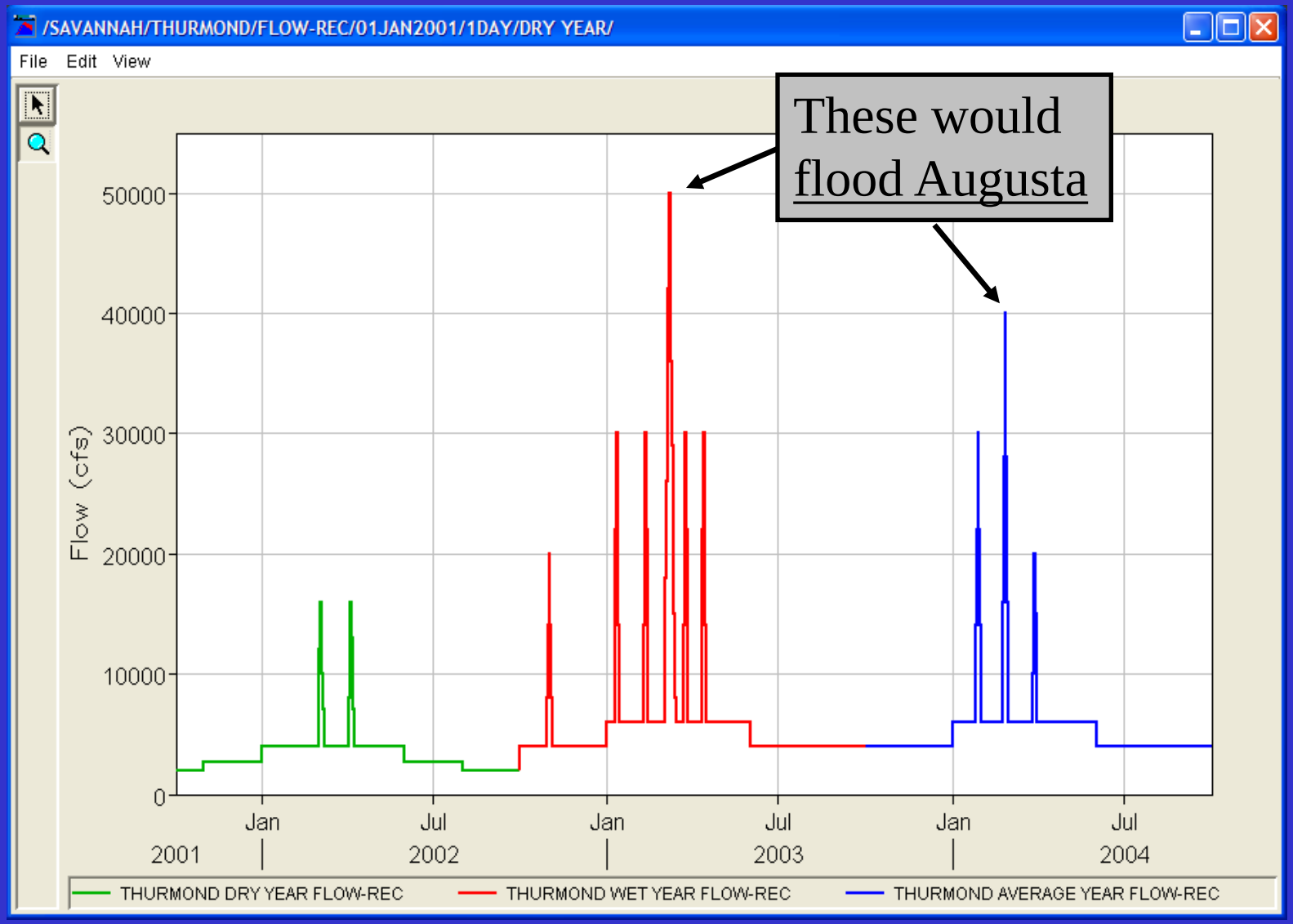
Maintaining Natural Flow Patterns



From: "Rivers for Life: Managing Water for People and Nature" by Sandra Postel and Brian Richter, Island Press

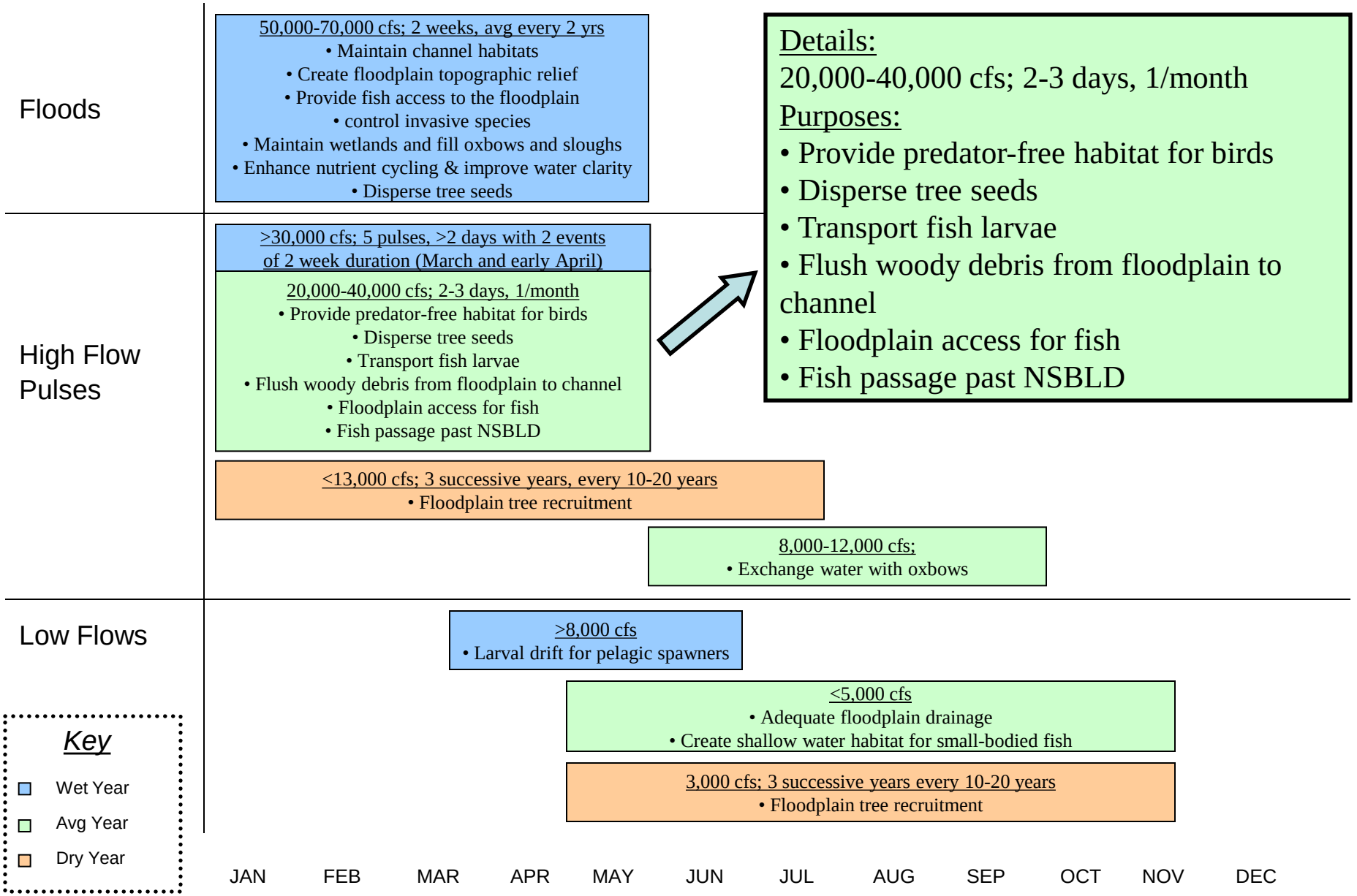
Courtesy of TNC

Savannah Flow Recommendations



Environmental Flow Recommendations

Savannah River, USA (below Thurmond Dam)



Source: TNC

Applying Environmental Flows in Planning and Management

Types of Ecological Flow Standards

Instream flow criteria vs withdrawal limits

Minimum flow standards

* **7Q10** – lowest flow for seven consecutive days every 10 years
* Minimum of mean annual flow – e.g. 30% MAF
* Variable mean annual flow by season

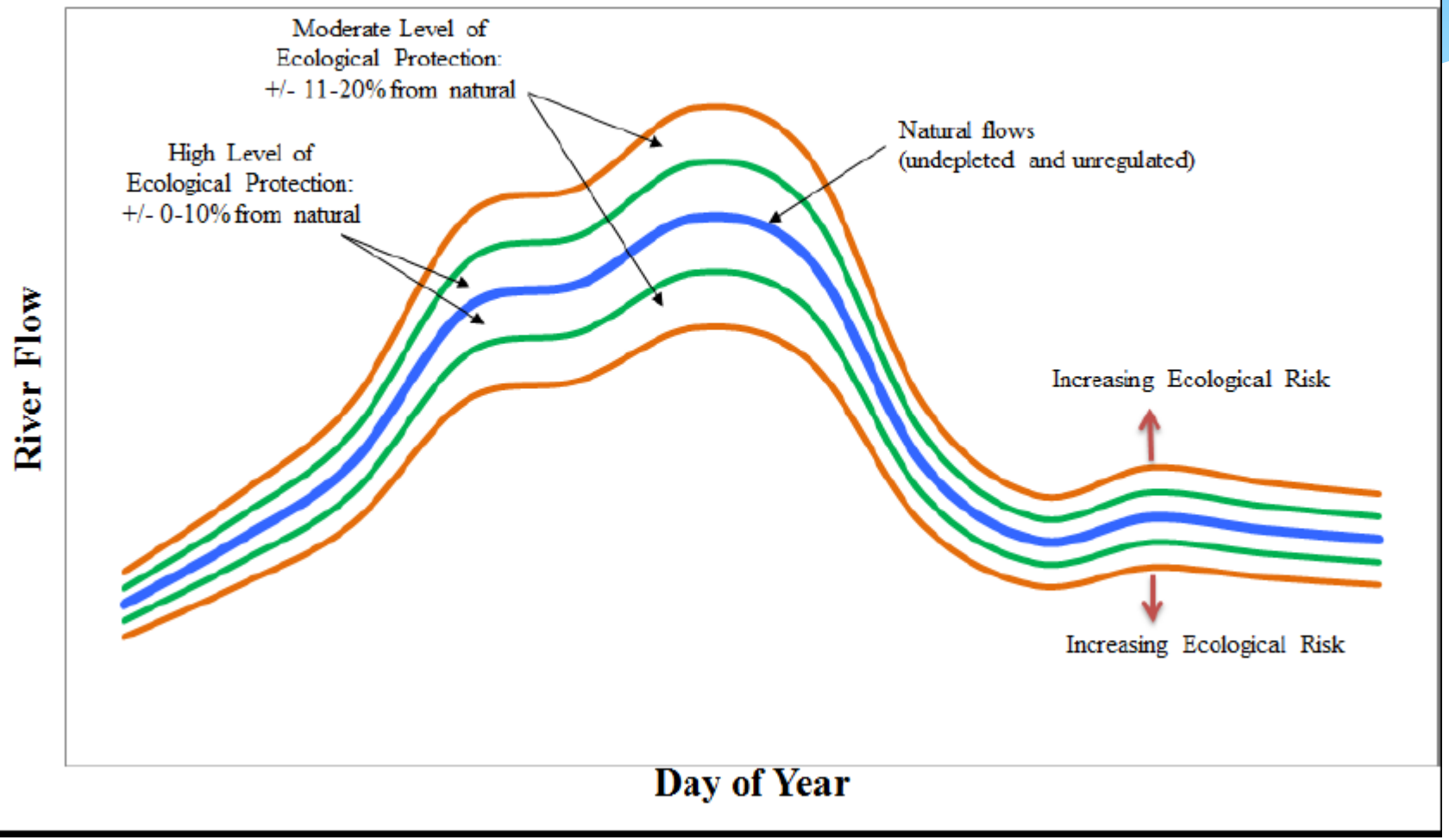
Statistically based standards

* Maintain characteristics of flow regime
  * E.g. protect certain high or low flows with certain frequency

Percent of Flow Standard

* Can only remove X% of flow going by certain point during Y period of time
  * Can vary X or Y
* “flow-by”

Presumptive Flow Standard



Richter (2011)

NC Ecological Flows Assessment

* State-driven, stakeholder process
* Adopted an "85% flow by" approach

Developing Environmental Flows

Challenges Include:

- identifying what components of flow are ecologically most critical in a particular river system
- quantifying those flow components to help guide water management
- incorporating new knowledge and understanding into water management over time
- achieving these tasks for all rivers within resource constraints

Developing Environmental Flows
A Four Level Approach

- Level I: Hydrologic Desk Top Method
- Level II: Experts Workshop
- Level III: Detailed Instream Flow Studies
- Level IV: Adaptive Refinement

Opportunities

* Hydropower relicensing
* Water withdrawal permits
* CWA standards
* Basin planning
* Voluntary processes
* Corporate replenishment

Resources

* TNC - https://www.conservationgateway.org/ConservationPractices/Freshwater/EnvironmentalFlows/Pages/environmental-flows.aspx
* Southern Instream Flow Network - http://southeastaquatics.net/sarps-programs/sifn
* USGS - https://water.usgs.gov/coop/products/availability/ecoflows.html
* River Network - http://www.rivernetwork.org/resource-library/river-voices-april-2015-water-security-sustainability

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