Environmental Flows for Rivers: Rationale, Theory, Progress, and Applications

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Environmental Flows (EFs)

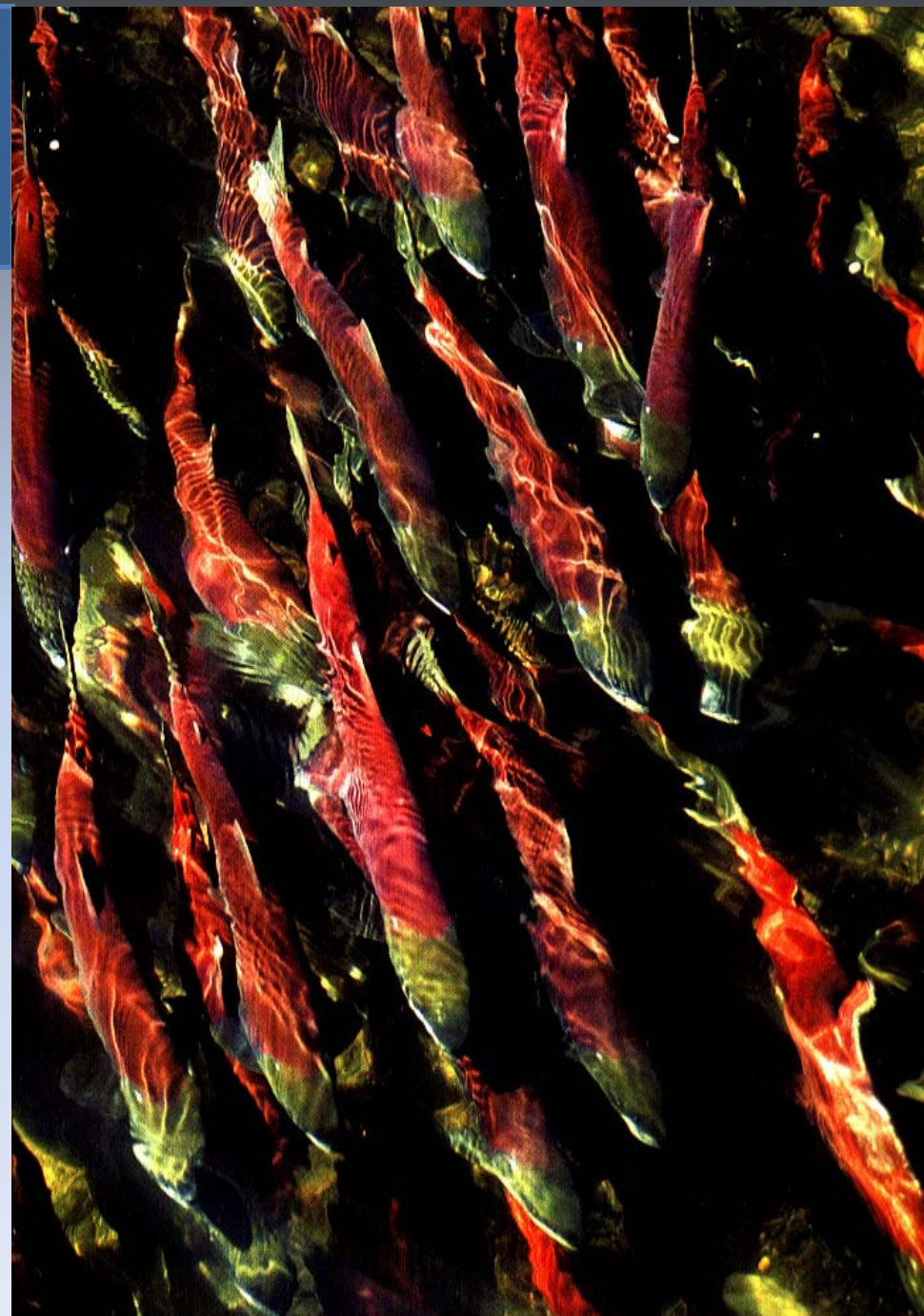
Also known as 'Ecological Flows' or 'Environmental Water Allocations', EFs are

The water regimes of a river, wetland or coastal zone necessary to maintain the biophysical components, ecological processes and health of aquatic ecosystems, as well as the associated ecological goods and services

Arthington et al. 2006

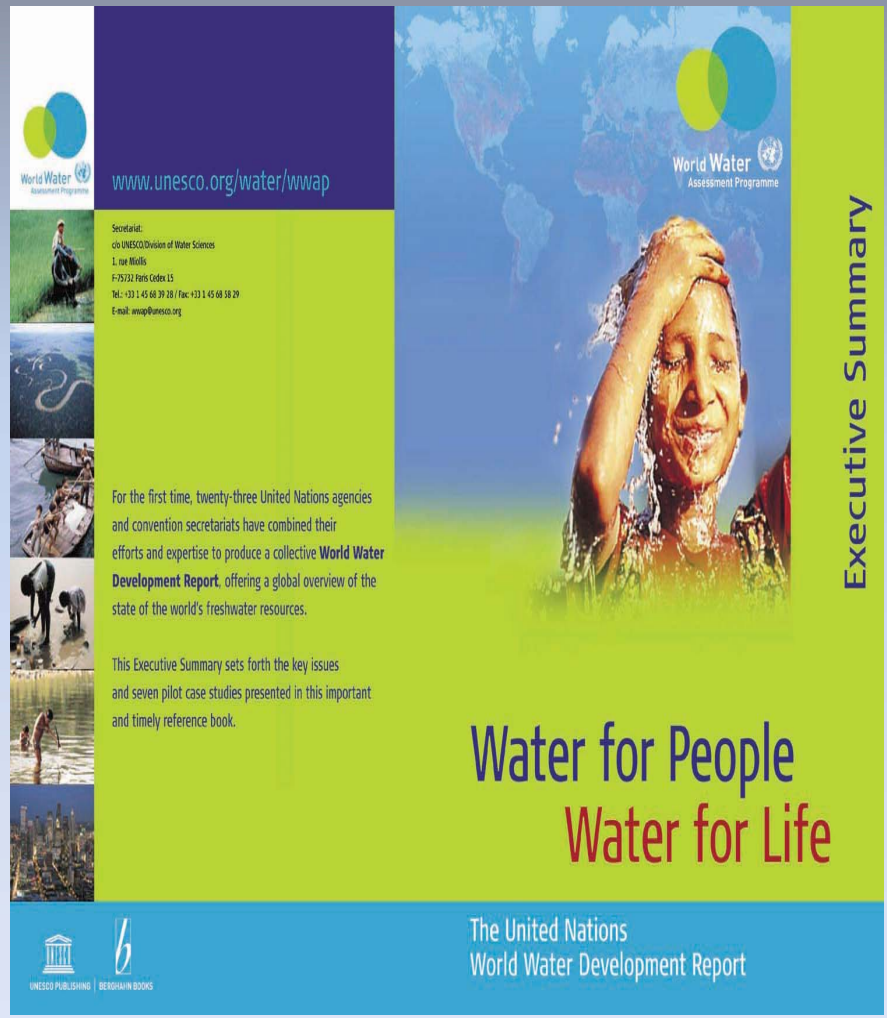
Objectives

- **Rationale – Ecological needs for flow variability**
- **Scientific advances & challenges in determining environmental flows for Nature**



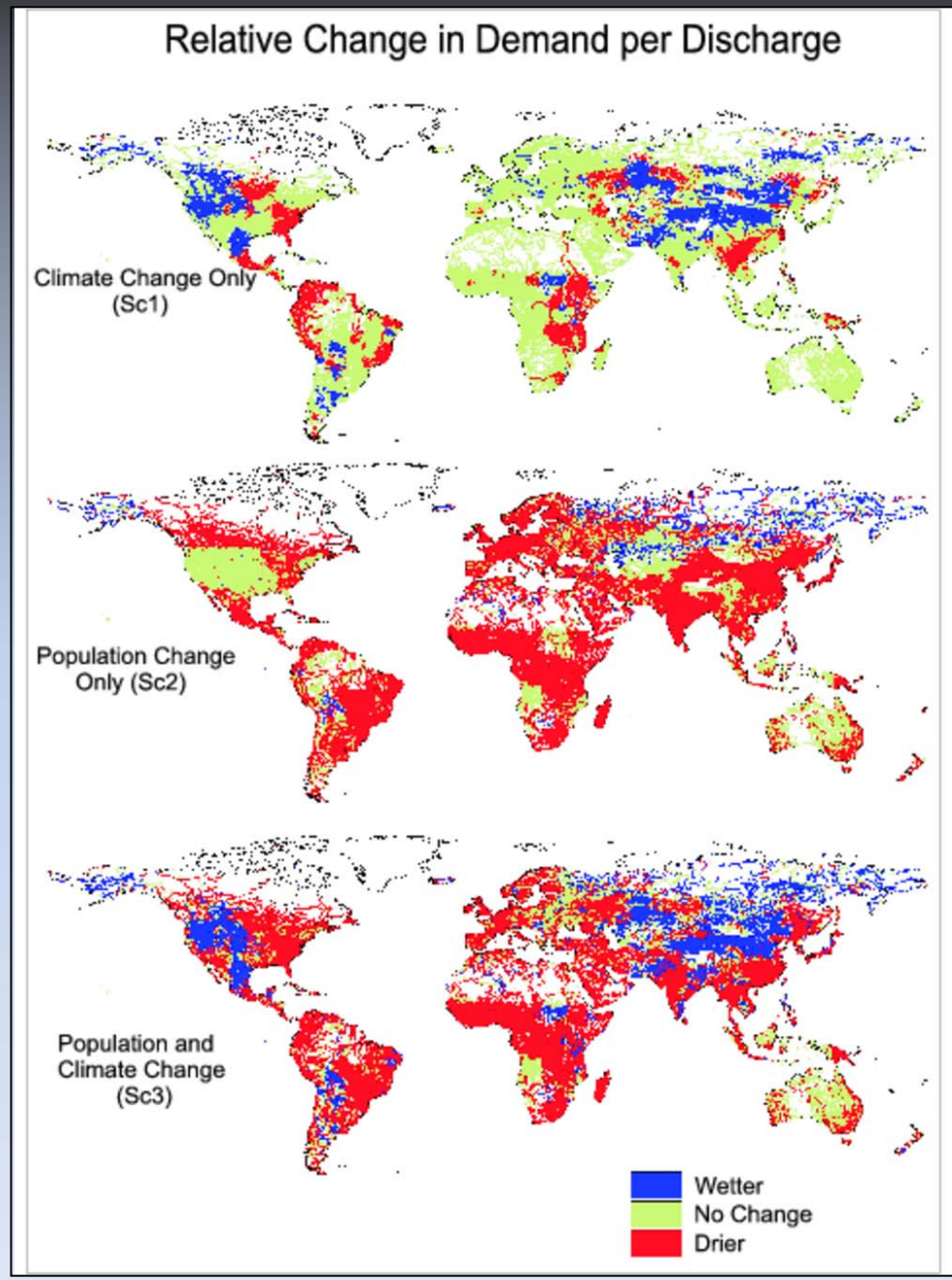
What is 'Special' About Freshwaters?

- **Topographic low points on the landscape**
- **Expand and contact rapidly**
- **Highly sensitive to climate variability**
- **Exceptional range of physiochemical conditions**
- **Hotspots of local productivity & biodiversity**
- **Strong surface-subsurface connections**



Water Stress Changes to 2025

- 80% of future stress from **population & development**, **not climate change**
- Future distortions of the water cycle are inevitable
- Consequences for FWs ….. substantial



UNH

Modified from Vörösmarty et al. 2000

Water & Societal Interfaces

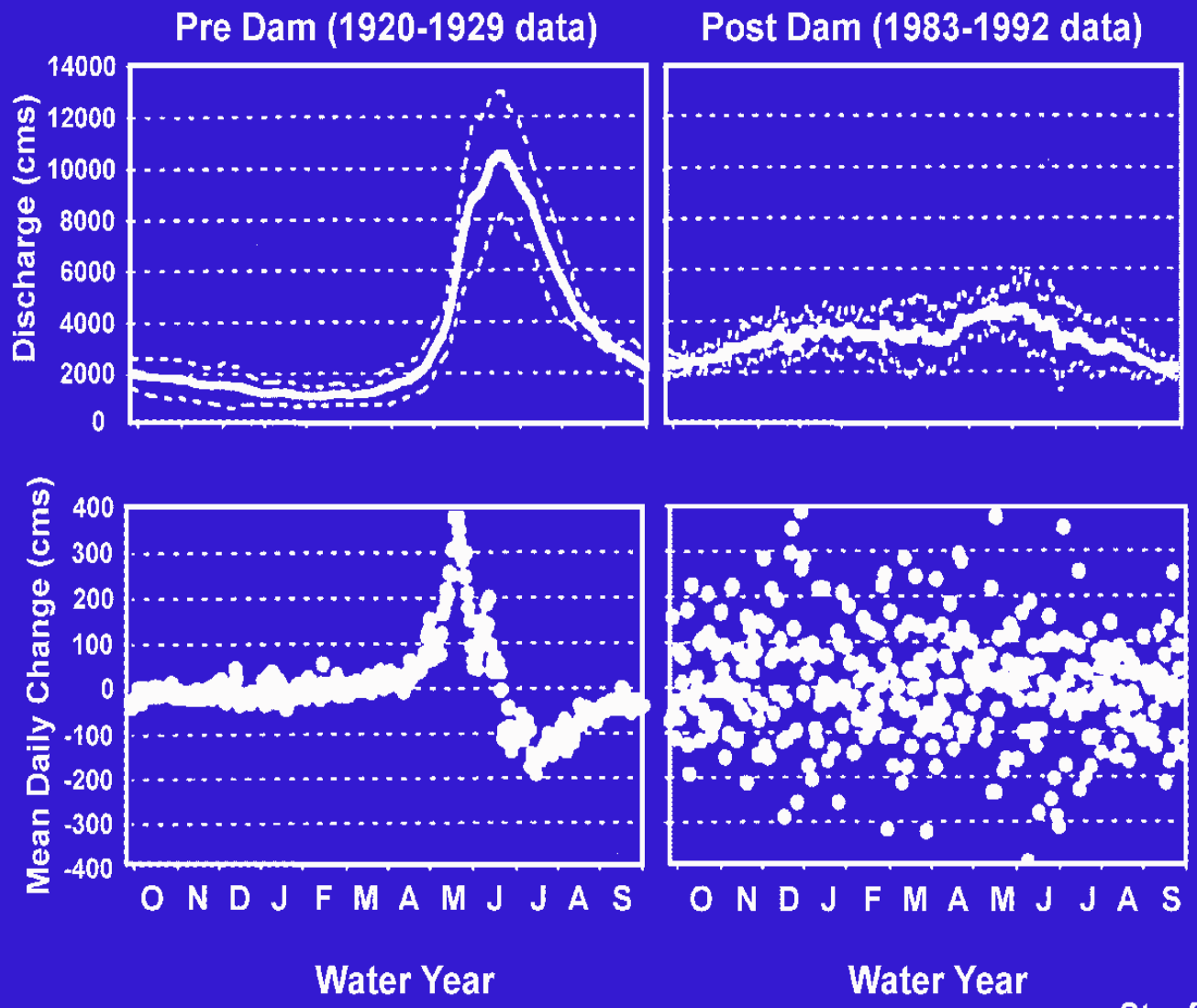
- **50% of available water (31% of total FW) already appropriated for human use**
- **Global population will increase 30-35% in 30 yrs; accessible water will increase < 10%**
- **1000 Tons of water = 1 Ton grain**
- **Human appropriation of water will be 70% of that available in 30 yrs: What about environmental requirements?**

Water & Societal Interfaces - 2

- **Year 2025: Global population needs the equivalent of an additional 24 Nile Rivers or 110 Colorado Rivers for irrigated crops**
- **~250 rivers flow through two or more countries**
- **Populations in water stressed countries (<1700 m^3/person/yr) increases 6-fold (0.5 to 3.0 B). Most are food importers**

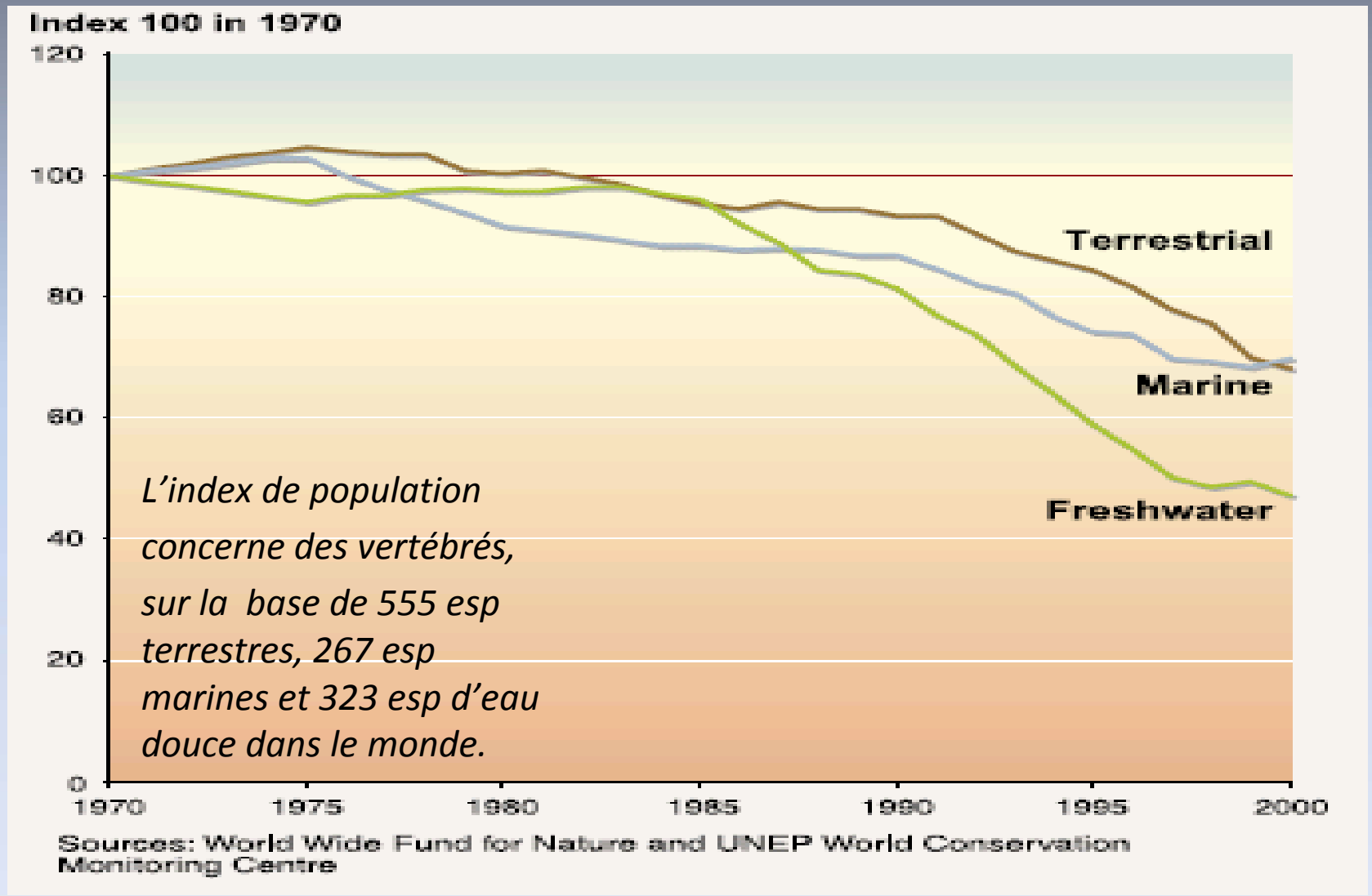
One consequence of the ubiquitous ‘use and control’ of Freshwaters is an increase in water conveyance and retention structures

Effect of Upstream Dams on Discharge of the Hanford Reach of the Columbia River



Stanford et al. 1996

Trends in Terrestrial, Marine, and Freshwater Species, 1970-2000



Millennium Ecosystem Assessment 2005

Freshwaters: Priority Foci

- **Sustained leadership in assessment and monitoring**
- **Quantifying flow requirements of FW species & ecosystems**

Environmental Flow: Quantifying the Hydrologic Requirements of FW Species & Ecosystems

Why is the Determination of Environmental Flows so Important?

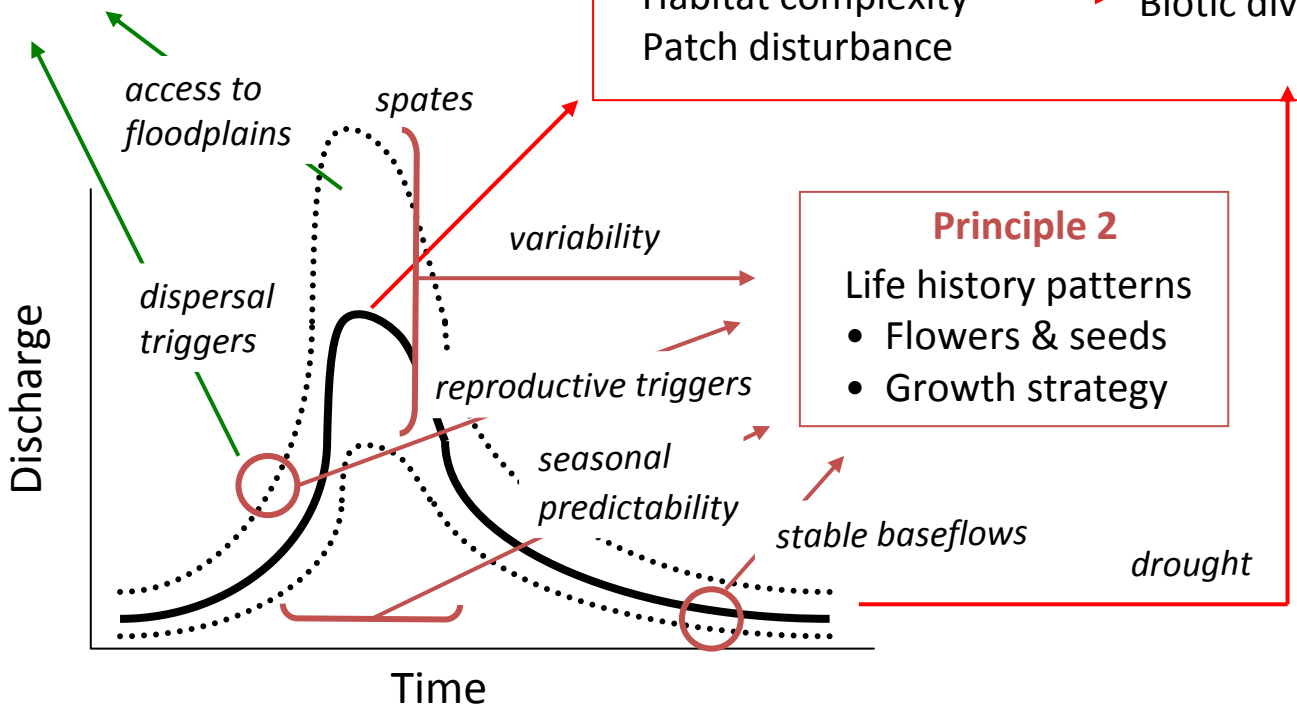
The life histories, distributions and relative abundances of freshwater & riparian organisms are intimately linked to flow regimes, as are system-scale processes,

… over ecological and evolutionary time scales

Biodiversity and Natural Flow Regimes

Principle 3
Lateral connectivity
Longitudinal connectivity

Principle 1
Channel form
Habitat complexity → Biotic diversity
Patch disturbance



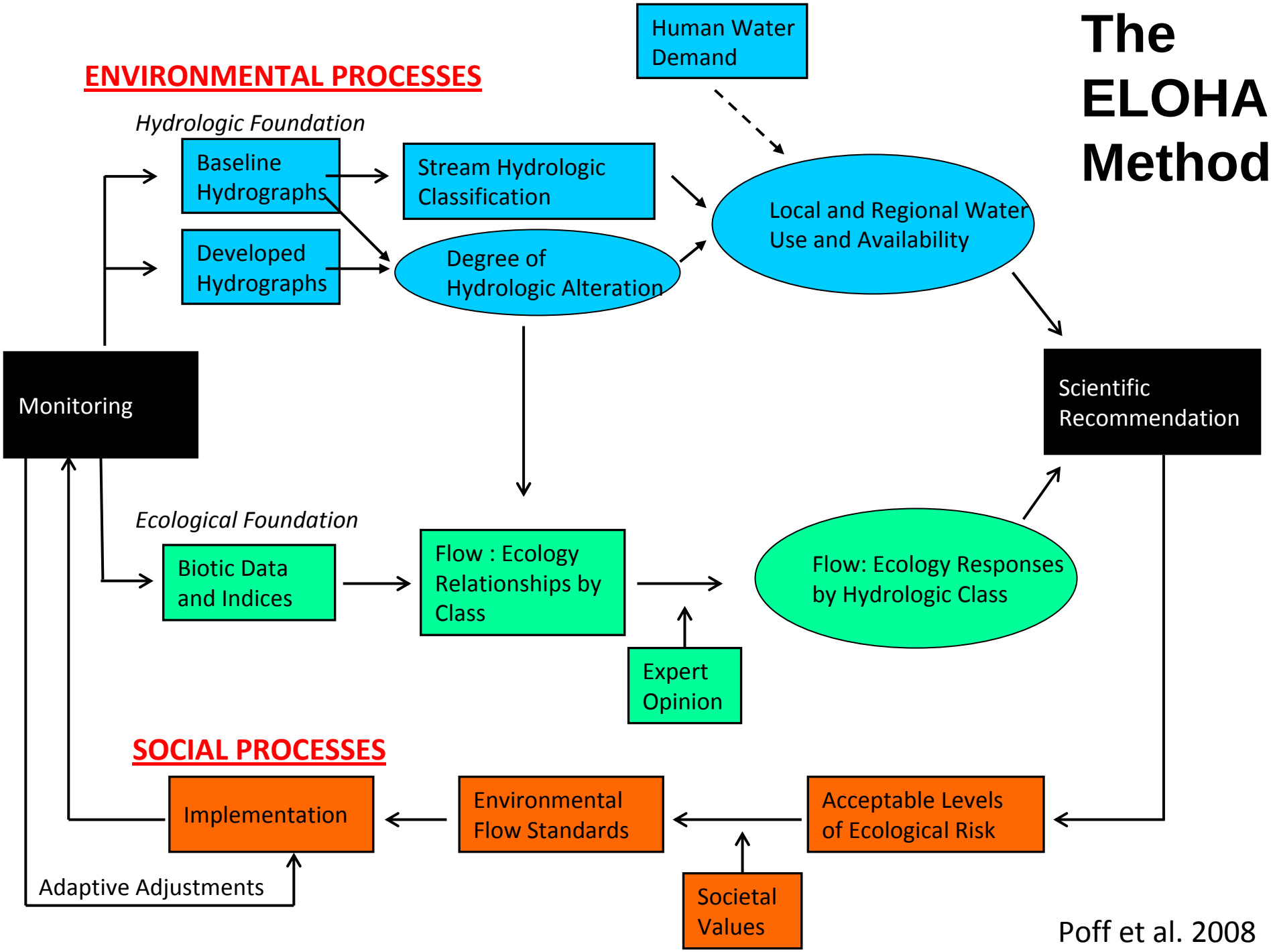
Principle 2
Life history patterns
- Flowers & seeds
- Growth strategy

Principle 4
Natural regime discourages invasions

Bunn & Arthington 2002

Progress in Environmental Flows

- Major research & environmental groups banded together, globally and locally
- International meetings on E-Flows
- The Brisbane Declaration <www.riversymposium.com>
- Website: <www.iucn.org/themes/wani/flow/main.html>
- New publications:
  - Arthington, McClain, Naiman & Nilsson, Freshwater Biology 2008
  - Poff, et al. 2008. ELOHA


The ELOHA Method
ENVIRONMENTAL PROCESSES
Human Water Demand
Hydrologic Foundation
Baseline Hydrographs
Developed Hydrographs
Stream Hydrologic Classification
Degree of Hydrologic Alteration
Local and Regional Water Use and Availability
Monitoring
Scientific Recommendation
Ecological Foundation
Biotic Data and Indices
Flow : Ecology Relationships by Class
Flow: Ecology Responses by Hydrologic Class
Expert Opinion
SOCIAL PROCESSES
Implementation
Environmental Flow Standards
Acceptable Levels of Ecological Risk
Adaptive Adjustments
Societal Values
Poff et al. 2008

The Scientific Process

In general, there are four scientific steps:

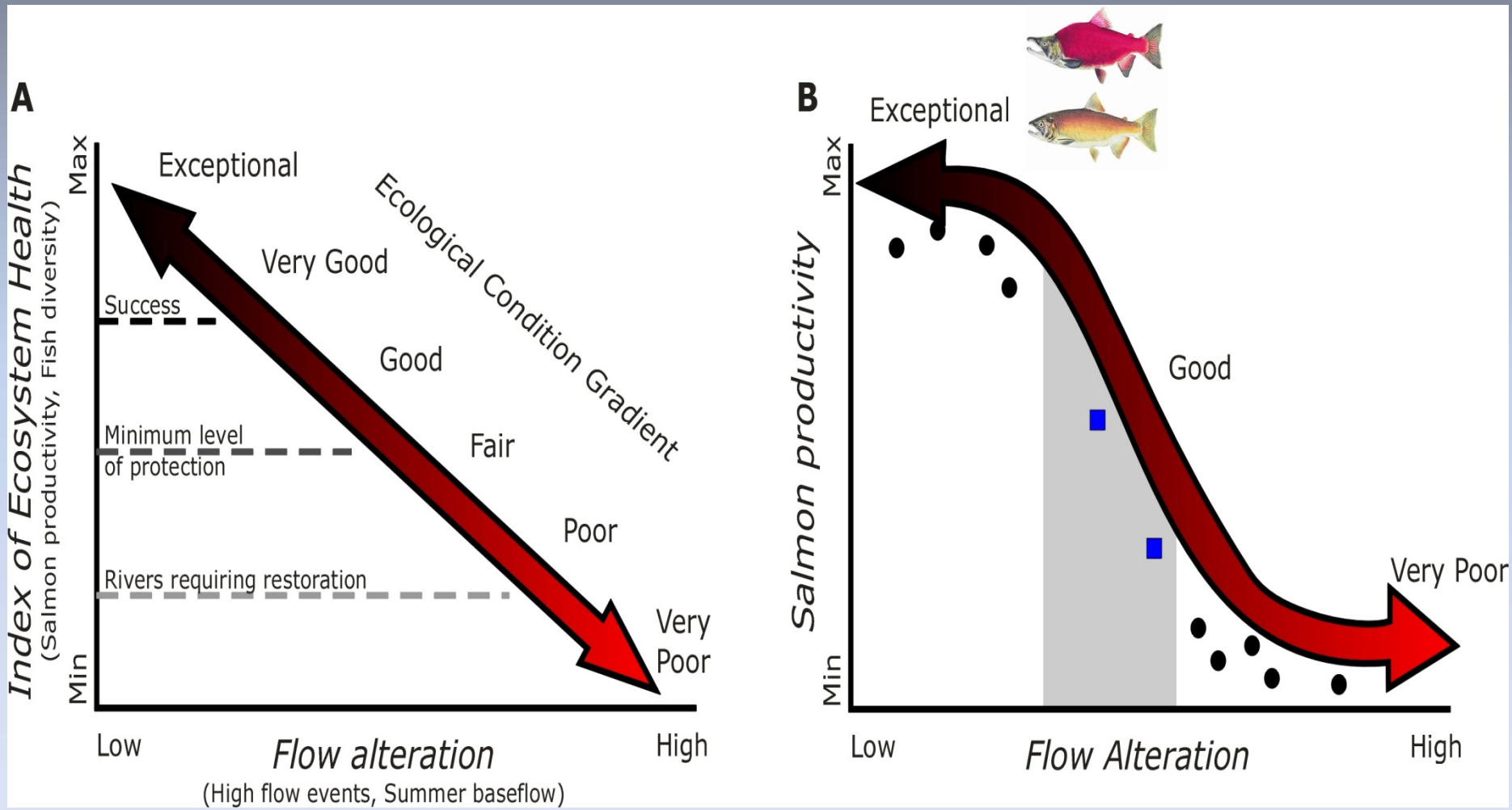
(1) Build a "hydrologic foundation" of streamflow time series for both undeveloped and developed conditions;

(2) Classify rivers into "hydrologic types" using streamflow time series that represent undeveloped conditions;

(3) Estimate the degree of hydrologic alteration, based on comparisons between undeveloped and developed conditions;

(4) Develop flow-ecology response curves for each hydrologic type by associating degrees of hydrologic alteration with changes in ecological condition

Flow-Ecology Relationships



Current Water Management

- Minimum instream flows provide perennial streams with base flows (that sometimes vary seasonally) to preserve wildlife, fish, scenic, aesthetic, and other environmental and navigational values

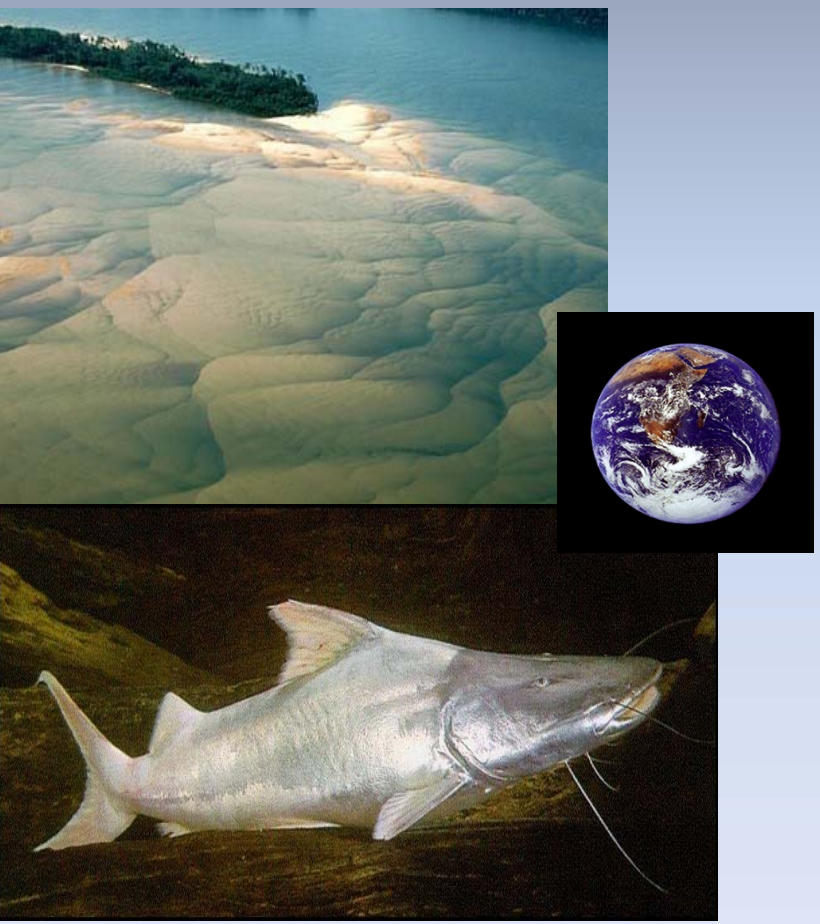
- The Instream Flow Incremental Methodology (IFIM) is considered the best available tool for setting minimum instream flows and predicting how available fish habitat changes in response to streamflow

- While IFIM provides an ecologically-based benchmark for regulatory base flows, there is a critical need – at the regional scale – to further the understanding and tools available for ecologically sustainable water management

Ecologically Sustainable Water Management

- **Critical considerations:**
  - **Grounded in mechanistically-based, science that explicitly recognizes the ecological need for hydrologic variability**
  - **Founded on long-term ecosystem health, rather than single species management**
  - **Applicable at a regional scale, i.e., to many streams and rivers simultaneously, as opposed to a case-by-case manner**
  - **Applicable across an array of types of flow alteration, from modified land use to river regulation by dams, and across a wide range of available data and scientific capacity**
  - **Useful regardless of stage of water resource development and historical status of instream flow protection**

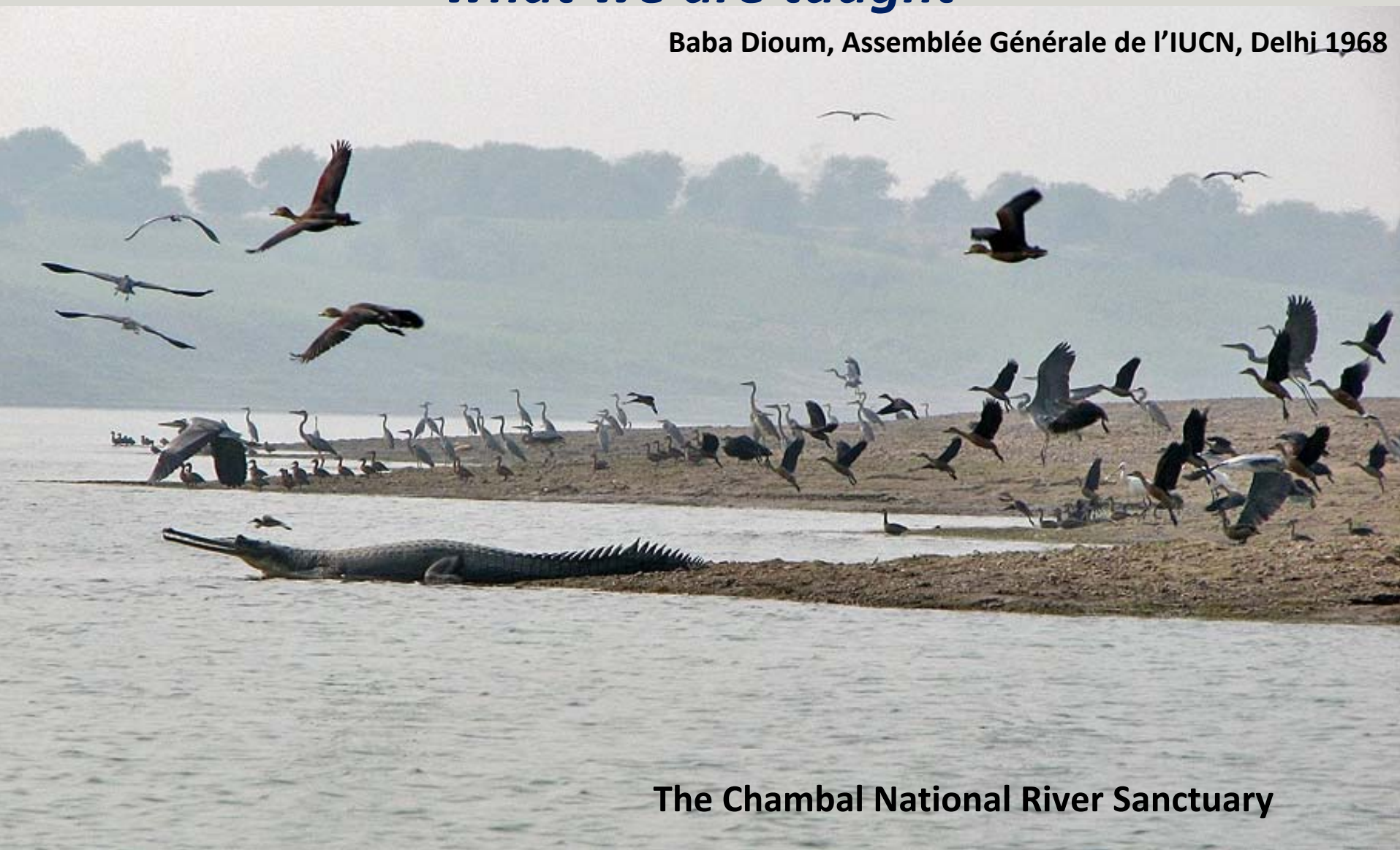
Our Challenge



Collectively, we must discover how to position FW research so that it makes a fundamental difference in the science and in the applications underpinning sustainable management of water resources.

In the end we conserve only what we love, we love only what we understand, and we understand only what we are taught

Baba Dioum, Assemblée Générale de l'IUCN, Delhi 1968



The Chambal National River Sanctuary

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