

# **Environmental Flows: A call to action for hydrogeologists as well**

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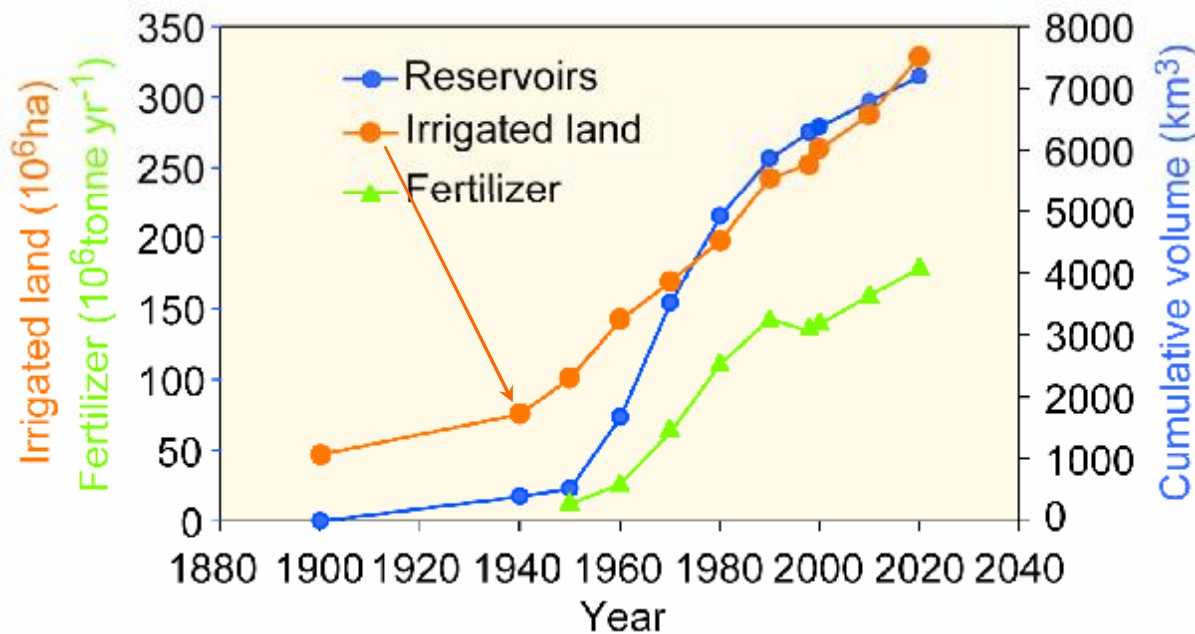
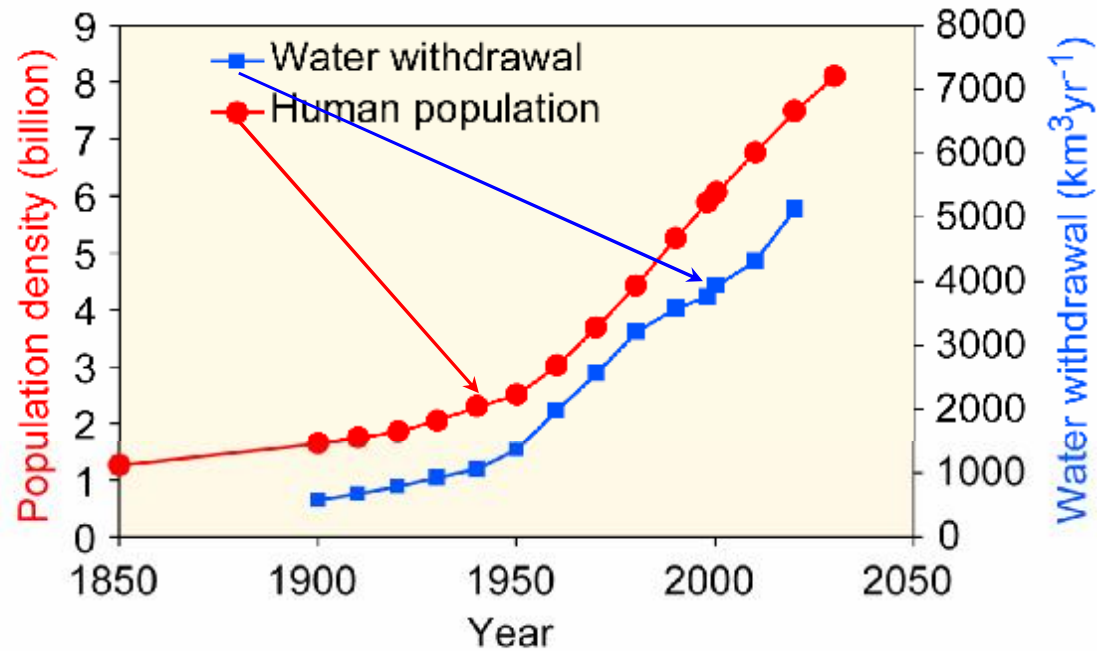
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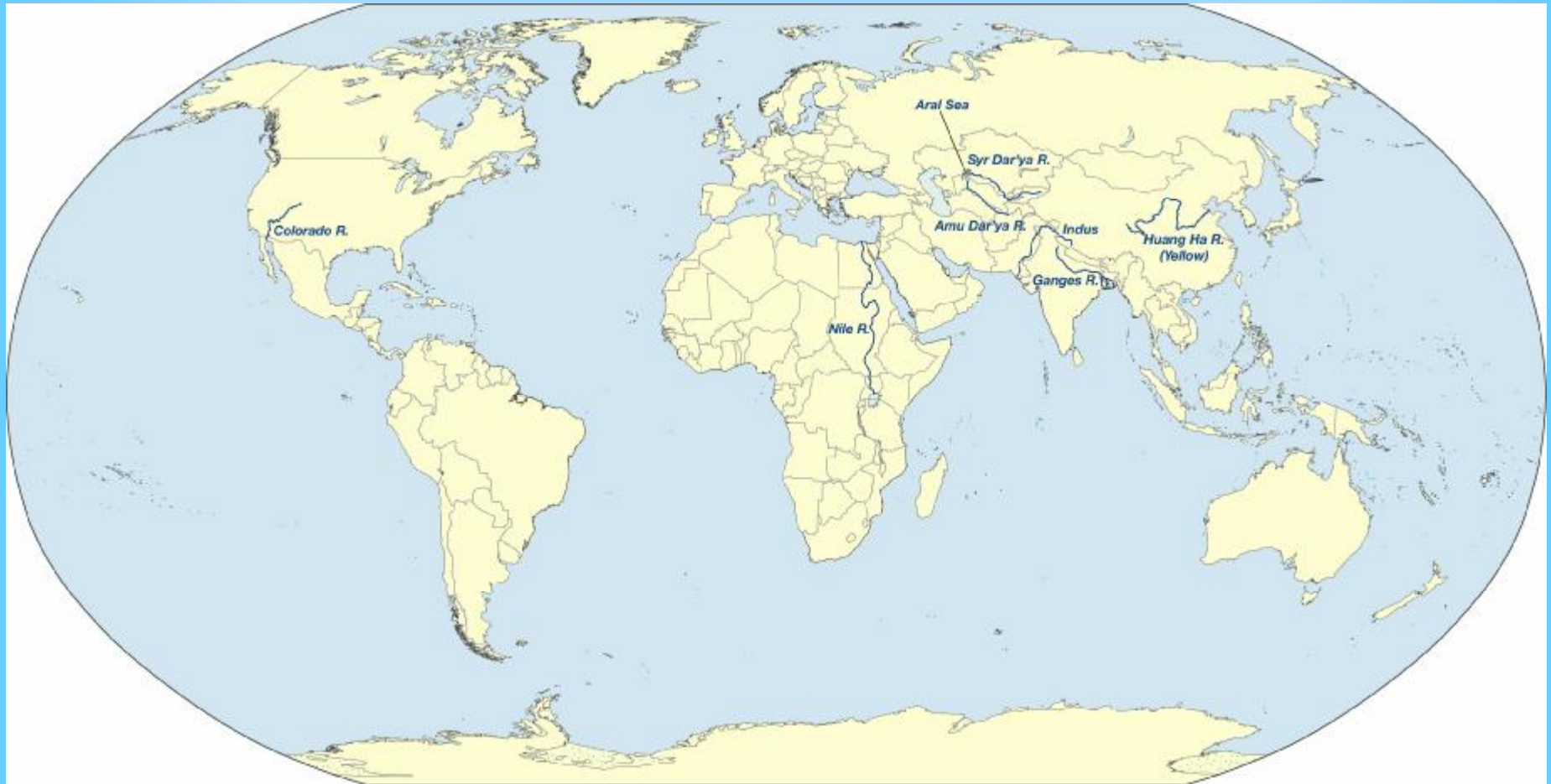
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## **Presentation outline:**

- Introduction: state of freshwater ecosystems and their importance to society
- Importance of ground water in EFs
- Environmental decision making: promising international and U.S. management approaches
- Emerging science and research needs of EFs
- Concluding comments: science, society, and progress in EFs

# **The state of freshwater ecosystems**





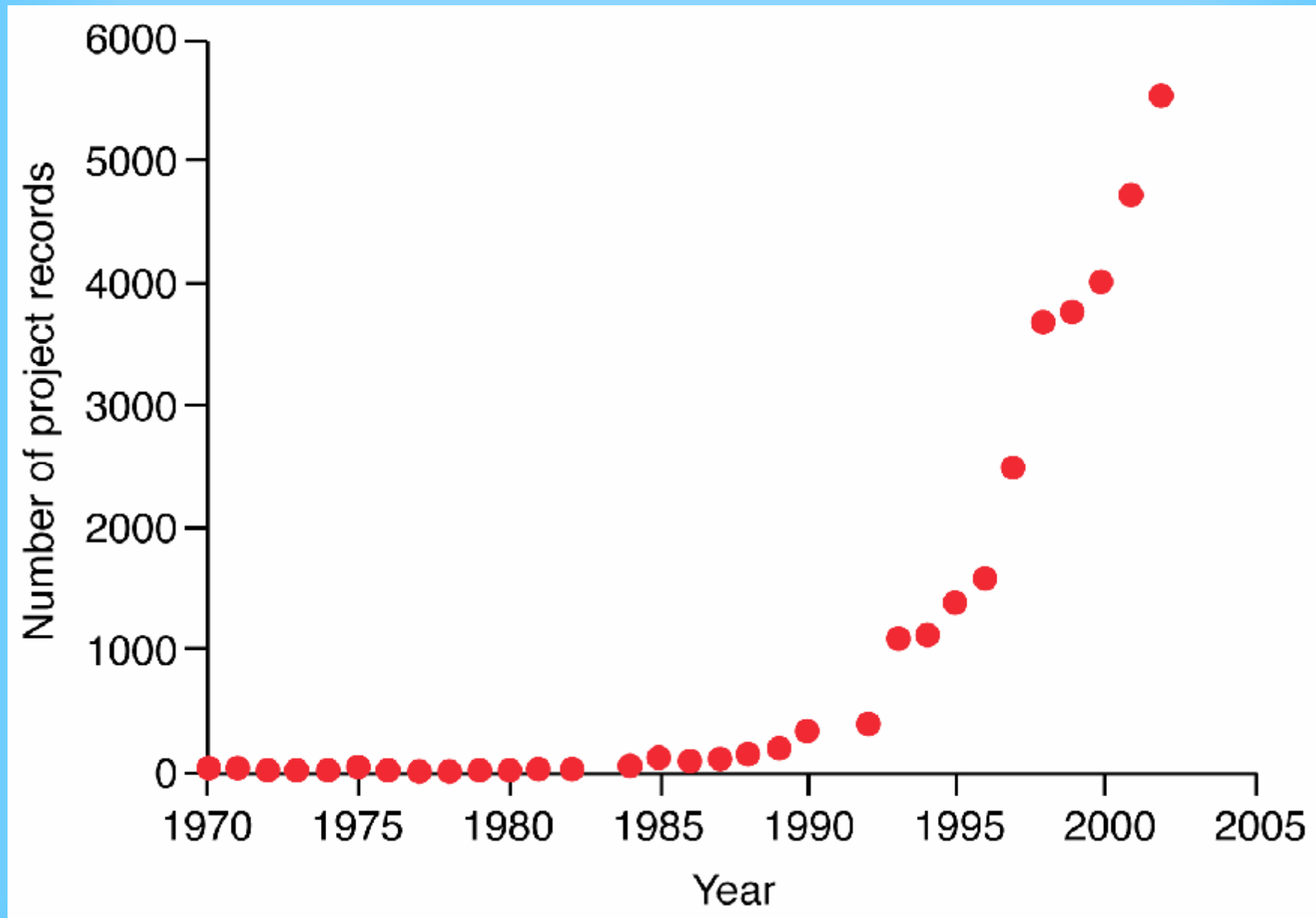
## Some vital functions of freshwater ecosystems

- Drinking water
- Seafood, game animals, fodder, fuelwood, timber, pharmaceutical products
- Flood control
- Purification of air and water
- Purification of human and industrial wastes
- Regulation of climate
- Nutrient cycling and regeneration of soil fertility
- Production and maintenance of biodiversity
- Habitat for plants and animals
- Recreation

**Freshwater ecosystems**

**as legitimate “users” of freshwater**

# River restoration projects in the U.S.



Instream Flows,

Environmental allocations,

Ecological flow requirements,

Environmental flows ...

**... The quantity and quality of water needed for river systems to maintain themselves and their functions**

# Methodologies for achieving Environmental Flows

- A huge amount of literature exists. See for example:
  - Tharme, R.E., 2003. A global perspective on environmental flow assessment: Emerging trends in the development and application of environmental flow methodologies for rivers. *Rivers Research and Applications*, vol. 19, nos. 5-6, p. 397-441.

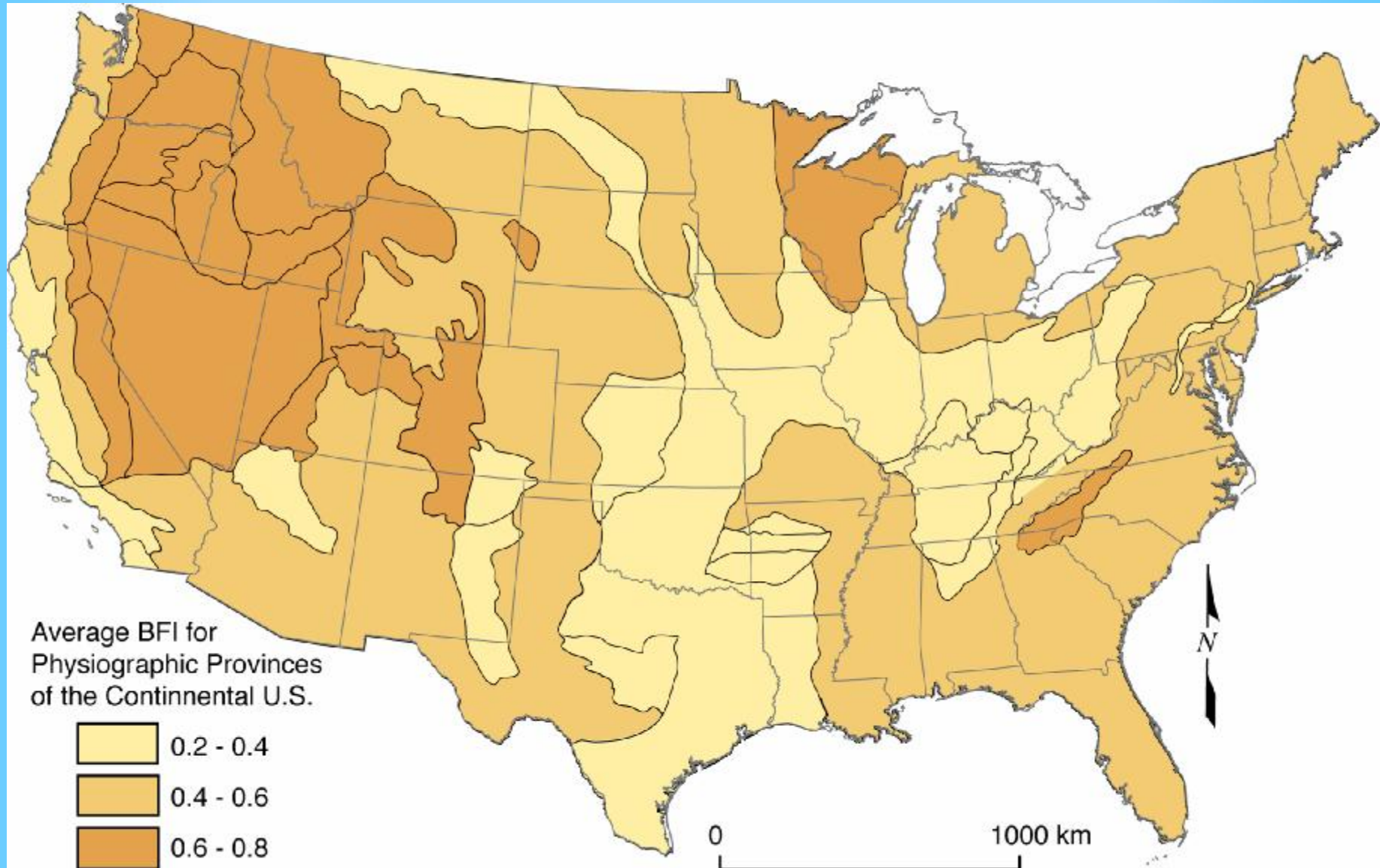
## **Instream or Environmental-Flow Science**

- a relatively new and evolving field that brings together scientists from a variety of disciplines to answer the politically charged question of how much water should be left in the river to meet ecosystem needs and not developed to meet agricultural, industrial, and municipal demands

# **The importance of groundwater in EFs**

# Base Flow Index (*BFI*):

the fraction of streamflow attributed to ground water



# Groundwater Dependent Ecosystems (*GDEs*)

## Habitats dependent on Groundwater



# **Environmental decision-making (1)**

# Dead salmon in the Klamath River



Courtesy of Tim McKay, Northcoast Environmental Center

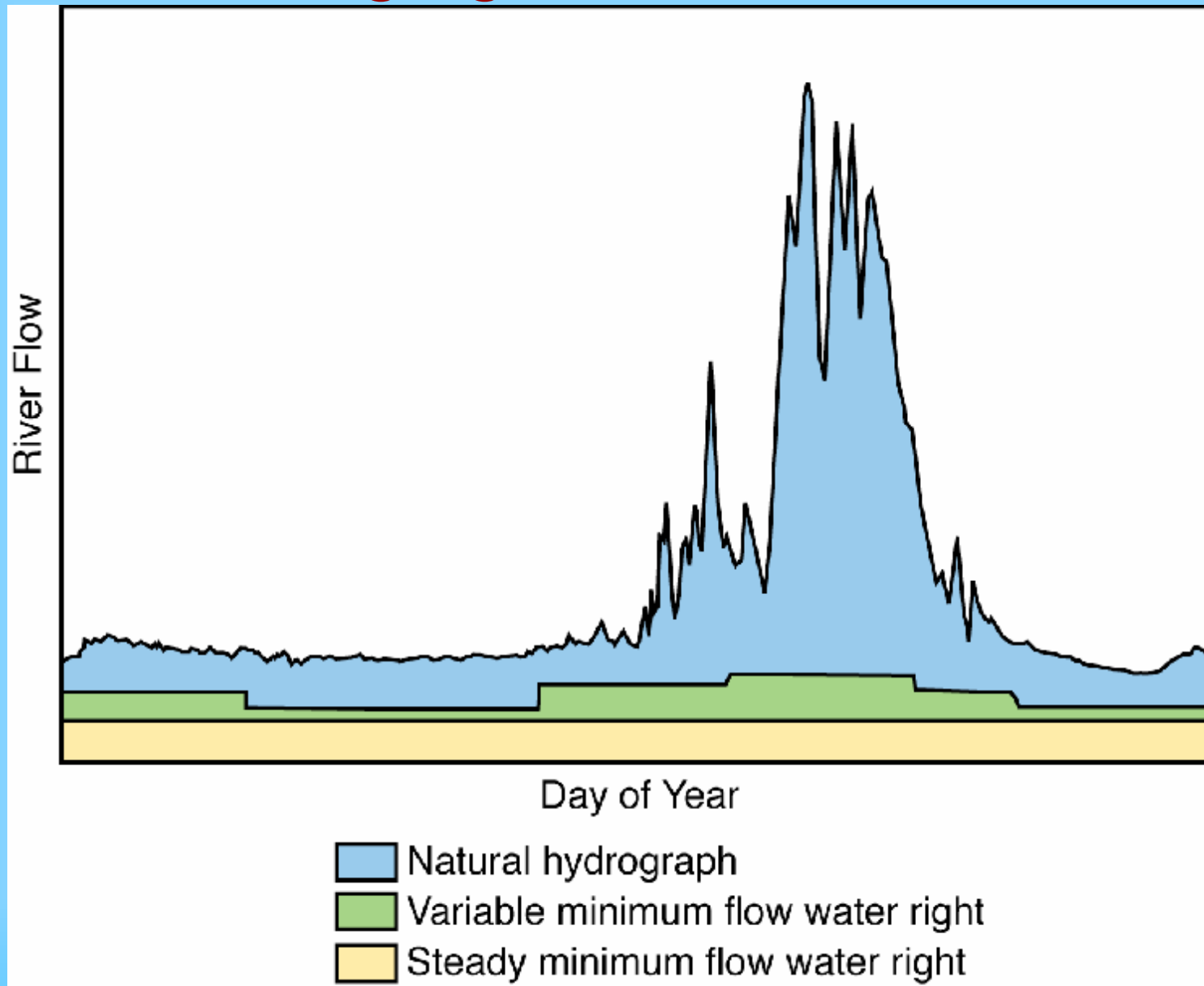
# Algal blooms



## Environmental decision making

- Instream flows within the context of **integrated water-resource** or **conjunctive SW-GW** management in river basins
- Prior appropriation doctrine: “**First in time, first in right**”
- Water rights for ecosystem protection: same status as irrigation water rights but commonly of **low priority date**

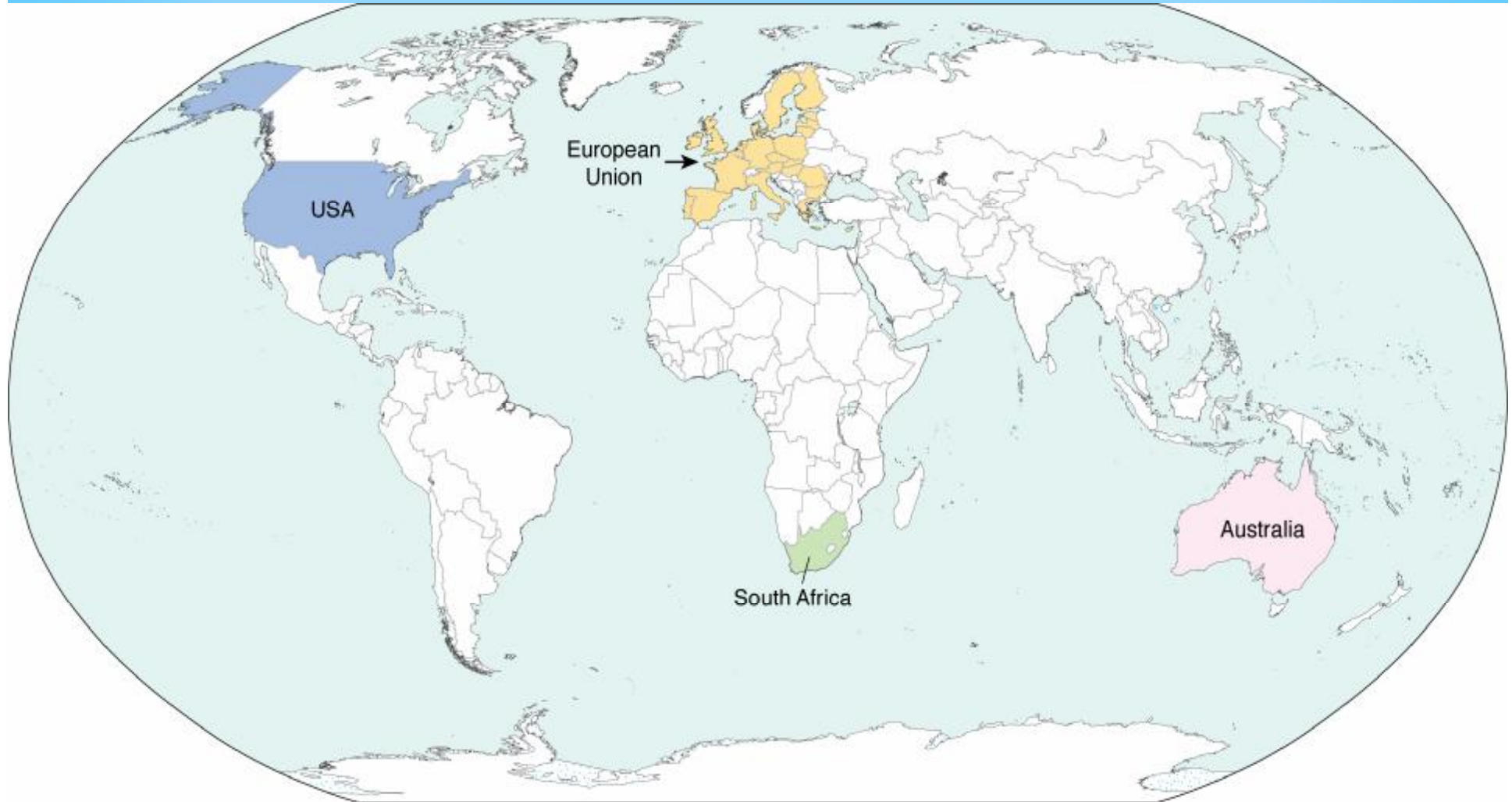
# Managing minimum flows



## Dead cottonwood trees along the Arkansas River near Larned, south-central Kansas



# **Environmental decision-making (2): Promising international management approaches**



# European Union's **Water Framework Directive**

Main goal: Reach “**good status**” (= “**good chemical status**” plus “**good ecological status**”) of all EU waters by 2015

# South Africa's National Water Act

Integrates:

- Public trust principles
- Ecosystem service values
- The natural flow paradigm

(i.e., the full range of natural intra- and inter-annual variation of river flows and associated characteristics of timing, duration, frequency, and rate of change are critical in sustaining the full native biodiversity and integrity of freshwater ecosystems)

# South Africa's National Water Act

Establishes the “**Reserve**” consisting of:

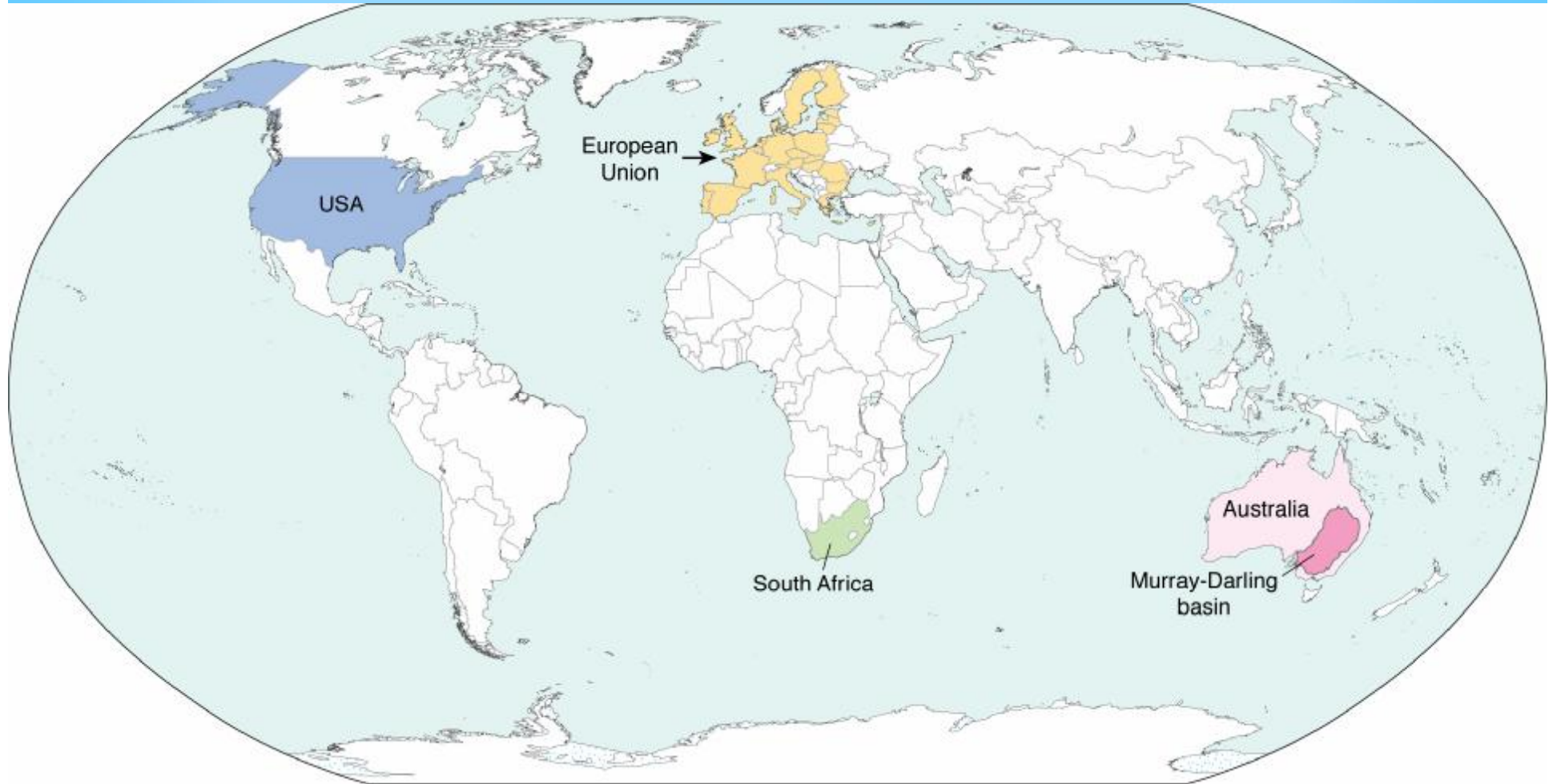
- a non-negotiable allocation to meet the basic needs of all South Africans for drinking, cooking, sanitation, and other essential purposes
- an allocation of water to support ecosystem functions in order to conserve biodiversity and secure the valuable ecosystem services they provide to society

The “**Reserve**” has priority over all other uses and only this water is guaranteed as a right

## The Council of Australian Governments (CoAG) Water Reform Framework...

- recognized the need to move forward toward sustainable use of water and greater protection of freshwater ecosystems
- developed a set of “**National Principles for the Provision of Water for Ecosystems.**” Among its 20 principles, is one stating that:

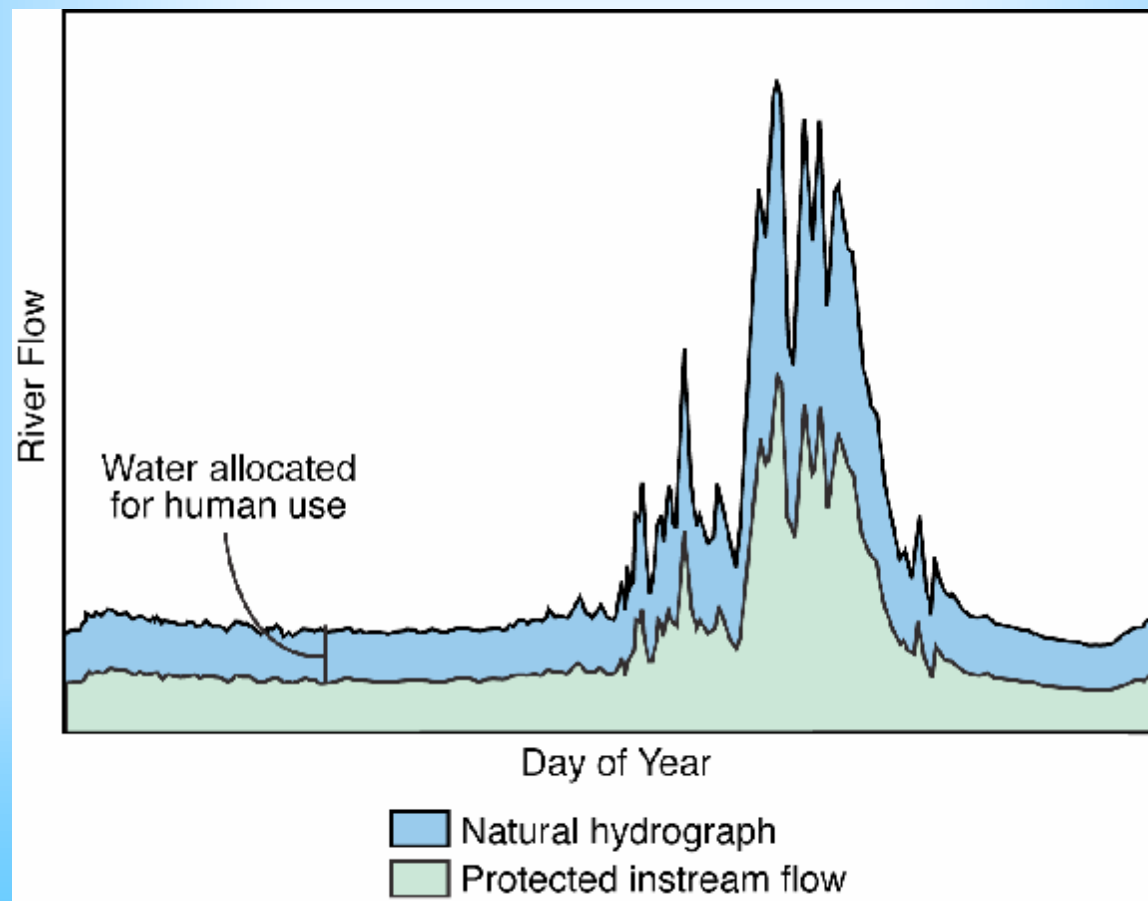
when environmental water allocations are not sufficient to prevent significant ecological harm, extractions of water from the river basin “should be capped.”



**Environmental decision-making (3):  
Promising U.S. management approaches**

# New type of policies to achieve broader goals of ecosystem functioning

- *Percent of natural flow at any given time*



## **New type of policies to achieve broader goals of ecosystem functioning**

- ***Upside-down instream-flow water rights***  
***(applied to Glacier & Yellowstone National Parks)***

Instead of reserving the minimum amount of flow necessary for ecosystem survival, and allocating the rest to development purposes, policy makers could set a specific development goal and then allow only the minimum amount of water necessary to achieve such a goal, leaving the remainder instream.

# Opportunities for achieving instream flow goals

## 1. In river basins with un-allocated water

- Direct appropriations (Colorado)
- Increased efficiency measures (Oregon)
- Reservation of un-appropriated water
- “Upside-down instream-flow water rights”

## 2. In basins with large storage or hydropower dams

## 3. In basins where water is already over-allocated:

- Water trusts (Colorado, Montana, Oregon, Washington)
- Addressing new flow protections on existing permits when changes to those permits are requested
- **Public trust**



## California's Supreme Court 1983 ruling on Mono Lake

“the public trust doctrine and the appropriative water rights system are parts of an integrated system of water law. The public trust doctrine serves the function in that integrated system of preserving the continuing sovereign power of the state to protect public trust uses, a power that precludes anyone from acquiring a vested right to harm the public trust and imposes a continuing duty on the state to take such uses into account in allocating water resources.”

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- Public trust
- Water markets
- **Federal law**

# **Emerging Science for *Environmental Flows***

# Important principles linking Hydrology and Aquatic Biodiversity

(from Bunn & Arthington, 2002)

- (1) flow is a major determinant of physical habitat in streams, which in turn is a major determinant of biotic composition;
- (2) aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes;
- (3) maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species; and
- (4) the invasion and success of exotic and introduced species in rivers is facilitated by the alteration of flow regimes.

Predicting the ecological benefits  
that are likely to result from EFs  
is a major research need

## **Evidence that both river ecology and river geomorphology are altered when river flows are changed from natural conditions...**

...is summarized by Lloyd et al. (2005) in a review of 70 studies (from an Australian perspective):

61 of the 70 studies (i.e. 87%) determined that modifications to river flow were followed by responses in ecology and/or geomorphology

## Additional knowledge gaps

- Knowledge about *GDEs* is rudimentary
- Two time lags associated with *GDE* protection: *hydraulic* and *ecological* time lags
- Characterization of *GDEs* at the catchment scale
- Providing quantitative criteria for protecting priority ecosystems
- Indicators of ecosystem stress
- Guidance on what impacts are acceptable
- Predicting and quantifying the biotic response to flow regulation
- Ecosystem valuation

## **Understanding changing land-use patterns**

The hydrological impacts of different land-use types on aquifer behavior, including the change in the volume of recharge, the change in discharge patterns, flooding, and waterlogging, are not well understood

## **What water managers need:**

- predict how far certain attributes of the flow regime can be altered from their natural state before an impact occurs.
- be convinced that providing additional environmental flows, such as reducing irrigation allocations at considerable cost, can produce demonstrable environmental benefit.

# A major constraint to achieving ecological sustainability is ...

- our limited ability to predict and quantify the biotic response to flow regulation

--water managers or stakeholders should not expect scientists to be “perfectly right” about EF needs on their first attempts

--the process of determining EF needs should be viewed as an iterative process of deliberate learning through testing, evaluation, and modifying management actions

**(adaptive management)**

# **Science and Society: Concluding comments**

## Concluding statements (1)

- Human security and well-being are closely related to maintaining ecosystems, such as forests, wetlands, and rivers, and avoiding environmental degradation. *Values placed on the different uses of water by society ultimately determine where the water is allocated.*

## Concluding statements (2)

By basing the environmental needs of hydrological systems on rigorous science (an area where *hydrogeologists* can also contribute significantly), these needs can then be legitimately recognized and addressed by water management authorities.

## Concluding statements (3)

- The objective in implementing instream flows is not to return rivers or any other water system to their pristine, natural state but to rehabilitate them as practically possible and to allow the ecological requirements of rivers to be included in the debates over sustainable water resource allocation.

## Concluding statements (4)

- By increasing the productivity of water in different sectors, the saved water can be used in other ways deemed appropriate by society, such as meeting the basic environmental needs of ecosystems.

## Concluding statements (5)

- Instream-flow needs can be legitimately recognized and addressed by following a combination of necessary steps, such as:

- (1) basing the environmental needs of hydrologic systems on solid science as much as feasible,

- (2) engaging society in understanding the benefits and costs of decisions affecting natural ecosystems,

- (3) focusing on increasing productivity of water use, and

- (4) taking advantage of various opportunities for achieving instream-flow goals (some of which are outlined previously).