Environmental Flows

Brij Gopal
brij44@gmail.com

Consultative Workshop on E-Flows
Bangalore, 3-4 January 2009

Why do we need FLOW in our rivers?

Upstream vs Downstream Communities

Specific Reaches vs Entire River vs Coastal Areas
OR
River Basin

Bathing, swimming, rafting?
Fishing? Sediments (Gravel, Sand)?
Waste assimilation?
Groundwater recharge?
Birds? Wildlife? Floodplain Grazing?

What does the community value more?
Off-stream benefits OR In-Stream benefits

Where does the FLOW come from?

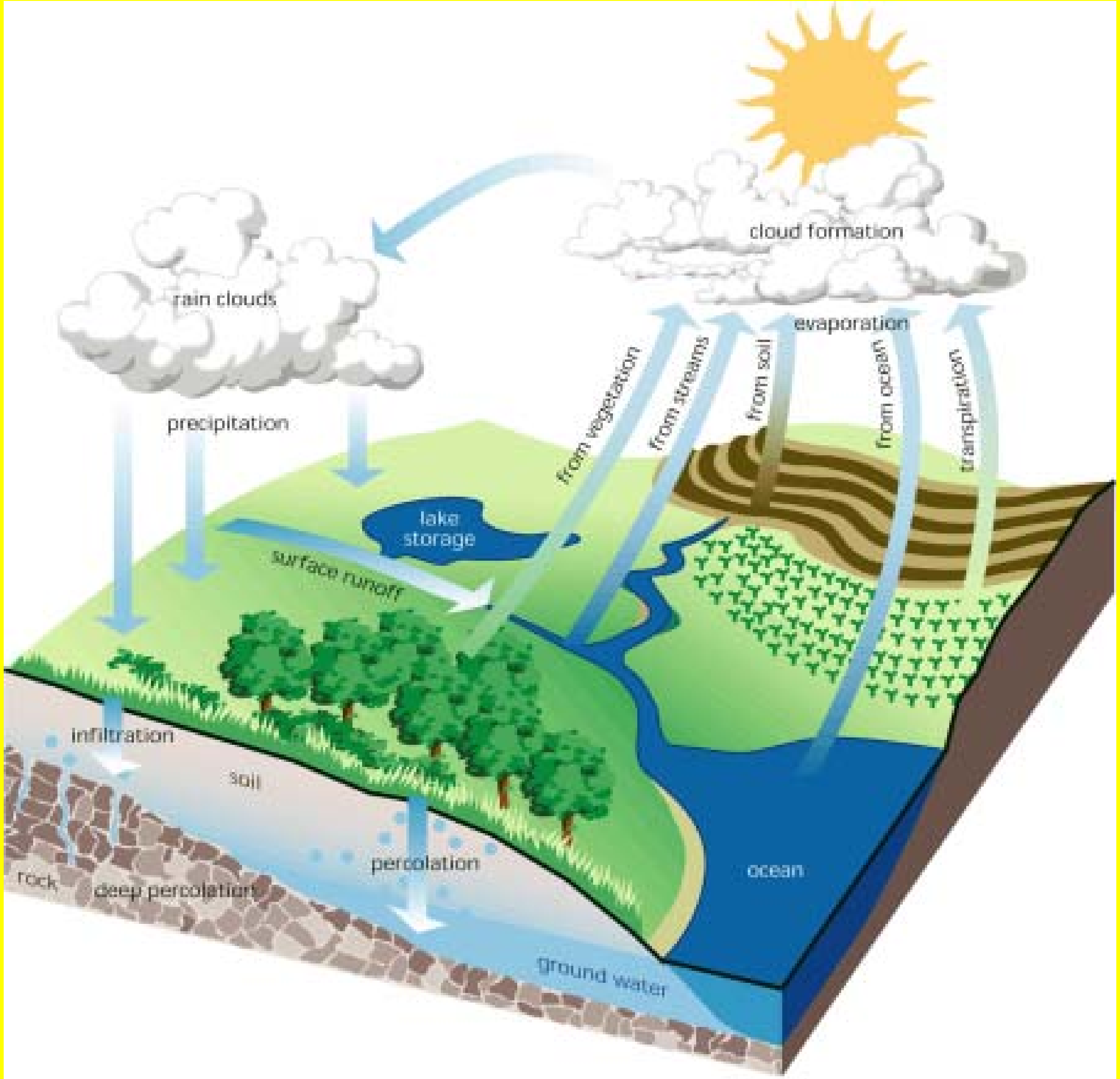
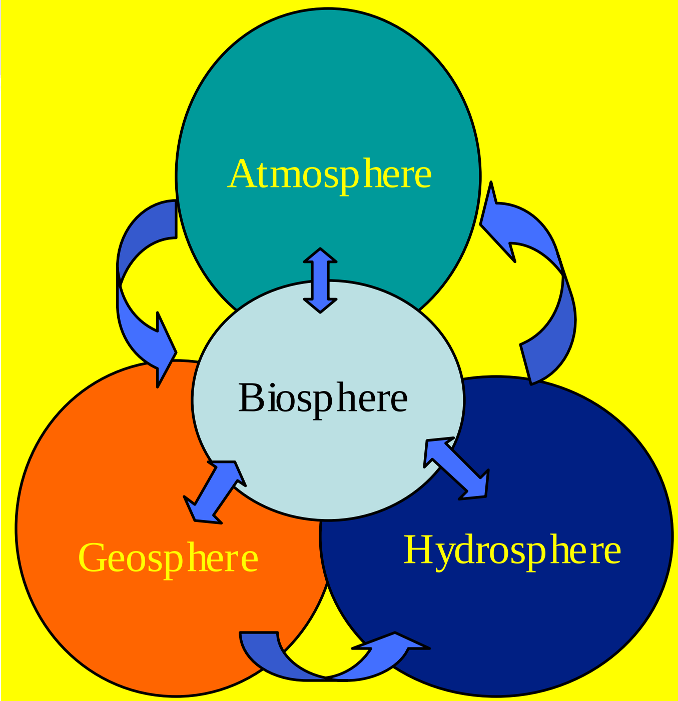


Fig. 2.2 – The hydrologic cycle. The transfer of water from precipitation to surface water and ground water, to storage and runoff, and eventually back to the atmosphere is an ongoing cycle.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Which Flow?

Surface flow and Subsurface flow

Hydrological Cycle



Human Use of Flows in India

Annual water requirement for different uses (in km3)

			2010			2050	
	1997–98	Low	High	%	Low	High	%
Surface water							
Irrigation	318	330	339	48	375	463	39
Domestic	17	23	24	3	48	65	6
Industries	21	26	26	4	57	57	5
Power	7	14	15	2	50	56	5
Inland navigation	7	7	1	15	15	1	
Environment–Ecology	5	5	1	20	20	2	
Evaporation losses	36	42	42	6	76	76	6
Total	399	447	458	65	641	752	64
Groundwater							
Irrigation	206	213	218	31	253	344	29
Domestic	13	19	19	2	42	46	4
Industries	9	11	11	1	24	24	2
Power	2	4	4	1	13	14	1
Total	230	247	252	35	332	428	36
Grand total	629	694	710	100	973	1180	100

Annual Precipitation 4000 km3 Total river flow 1953 km3
Total utilizable surface water (river flow) 690 km3
Total replenishable groundwater resource 432 km3
Total utilizable groundwater resource 396 km3

from National Commission for Integrated Water Resources Development, 1999

Why do we need FLOW in our rivers?

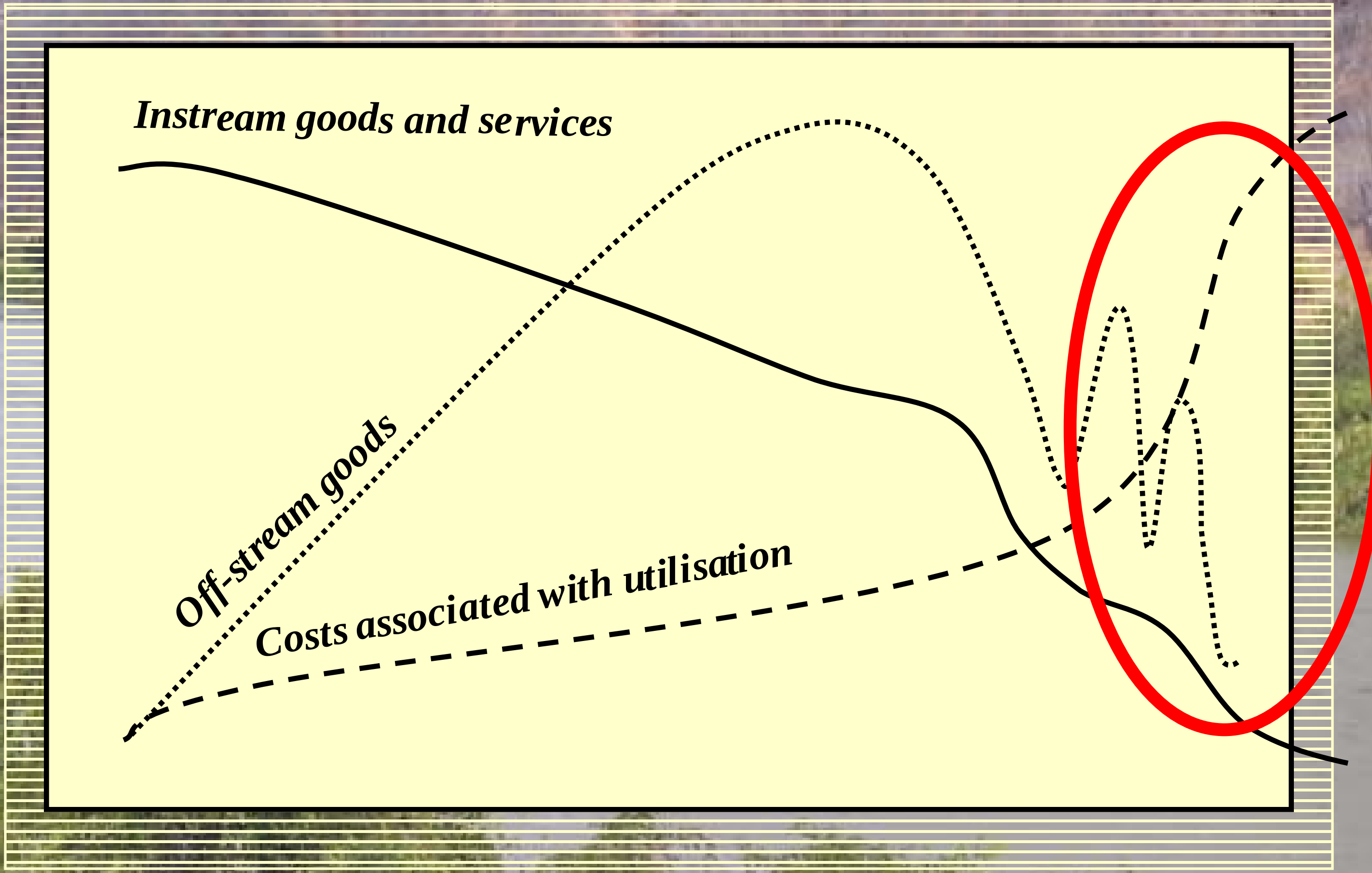
Upstream vs Downstream Communities

Specific Reaches vs Entire River vs Coastal Areas
OR
River Basin

Bathing, swimming, rafting?
Fishing? Sediments (Gravel, Sand)?
Waste assimilation?
Groundwater recharge?
Birds? Wildlife? Floodplain Grazing?

What does the community value more?
Off-stream benefits OR In-Stream benefits

Instream and offstream goods and services



From Cate Brown)

Goods and Services of River Ecosystems Need Proper Evaluation

Flow variability
Promotes diversity and resilience to disturbance

Low flows: Define whether the river flows all year. Create varying conditions during seasons dictating which (and how many) biotic species occur at any time of the year

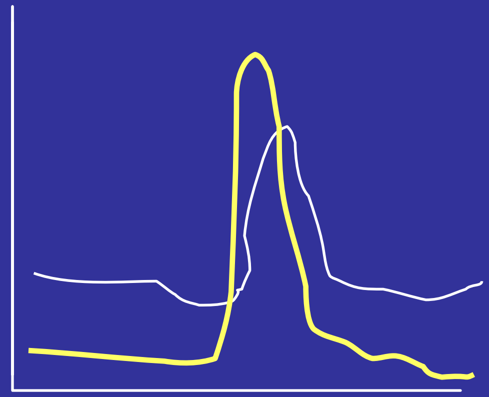
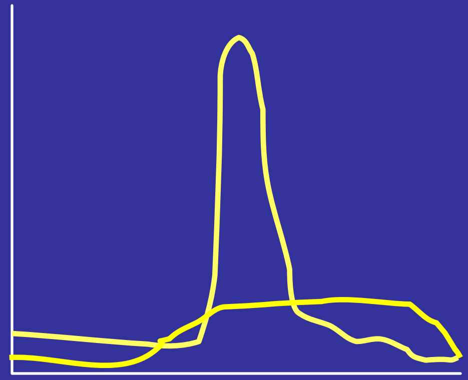
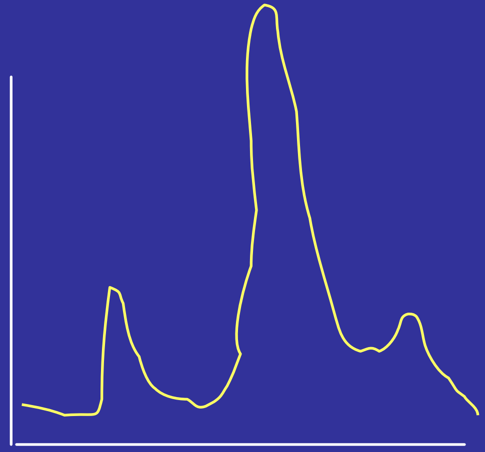
Small (relatively frequent) floods: Stimulate spawning in fish, flush out poor quality water, cleanse the river bed, sort the river stones by size, creating different kinds of habitat. Trigger and synchronize activities as varied as upstream migrations of fish and germination of seedlings on river banks

Large Floods (infrequent) floods: Provide scouring flows that shape the channel. Move and cleanse cobbles and boulders on the river bed, recharge soil moisture on banks, inundate backwaters and secondary channels, and floodplains

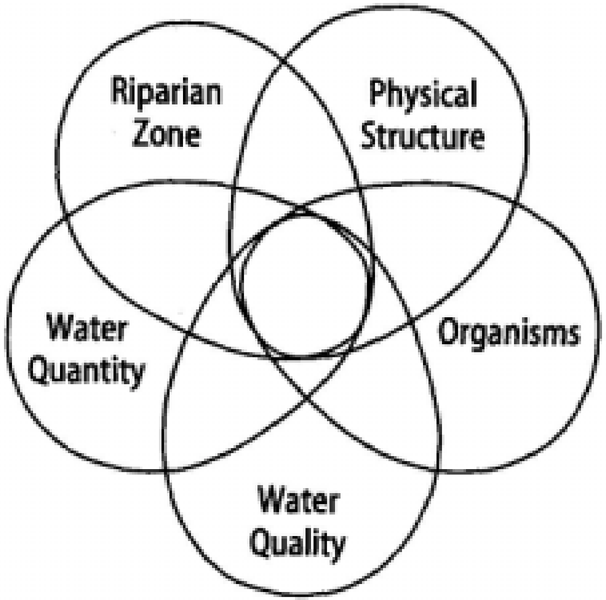
COMPONENTS OF RIVER FLOW

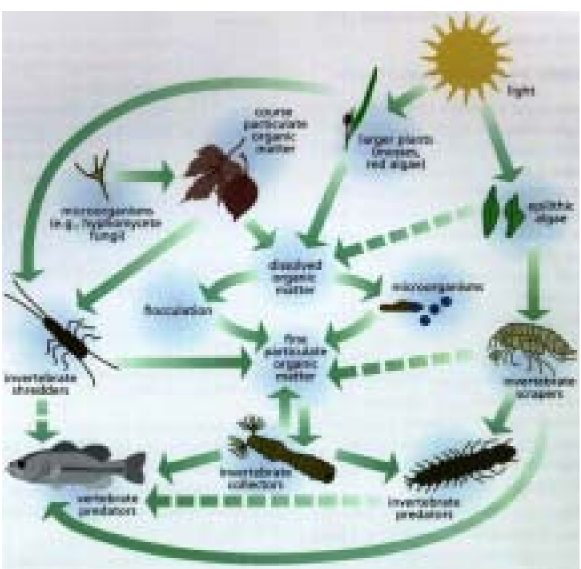
Volume: depth, area, velocity
Duration: each year
Amplitude of variation
Frequency of variation
Timing of the year

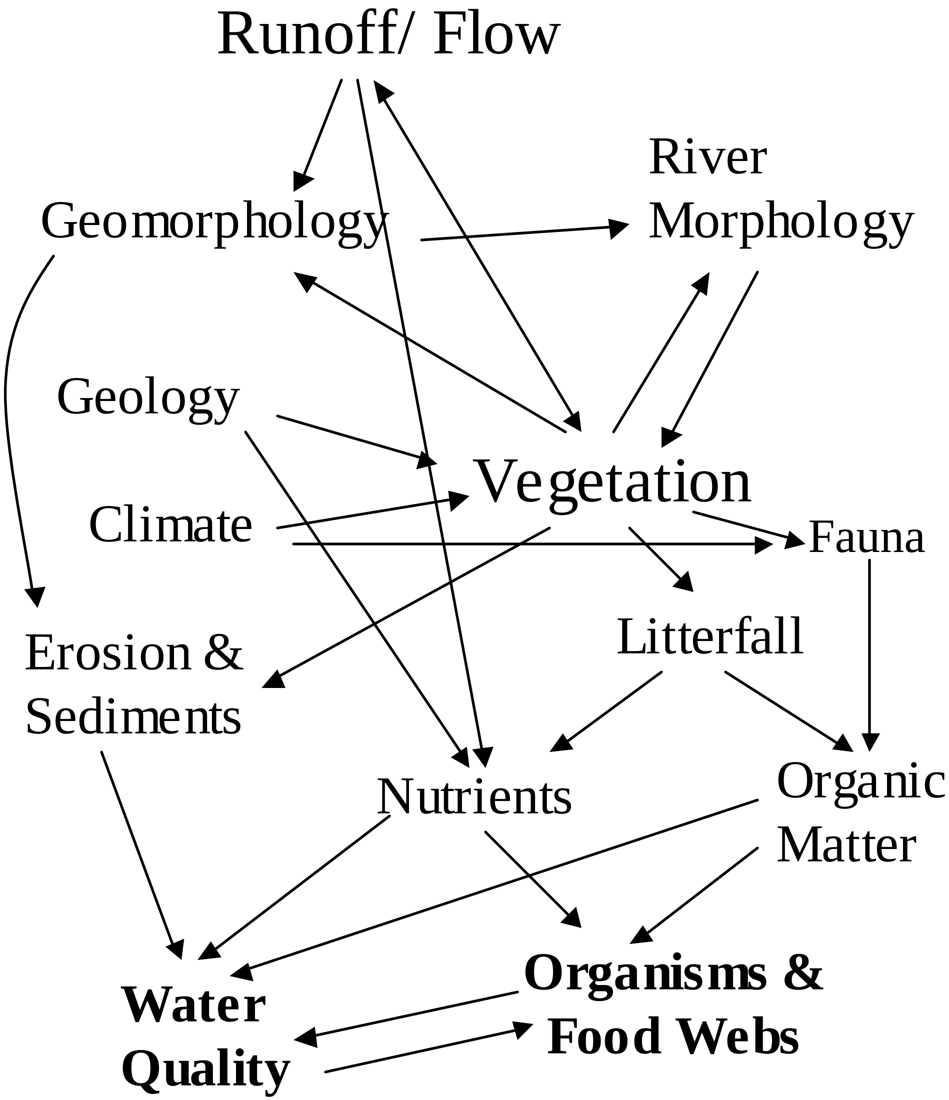
All flow components and their interactions influence the habitat and biota differently.

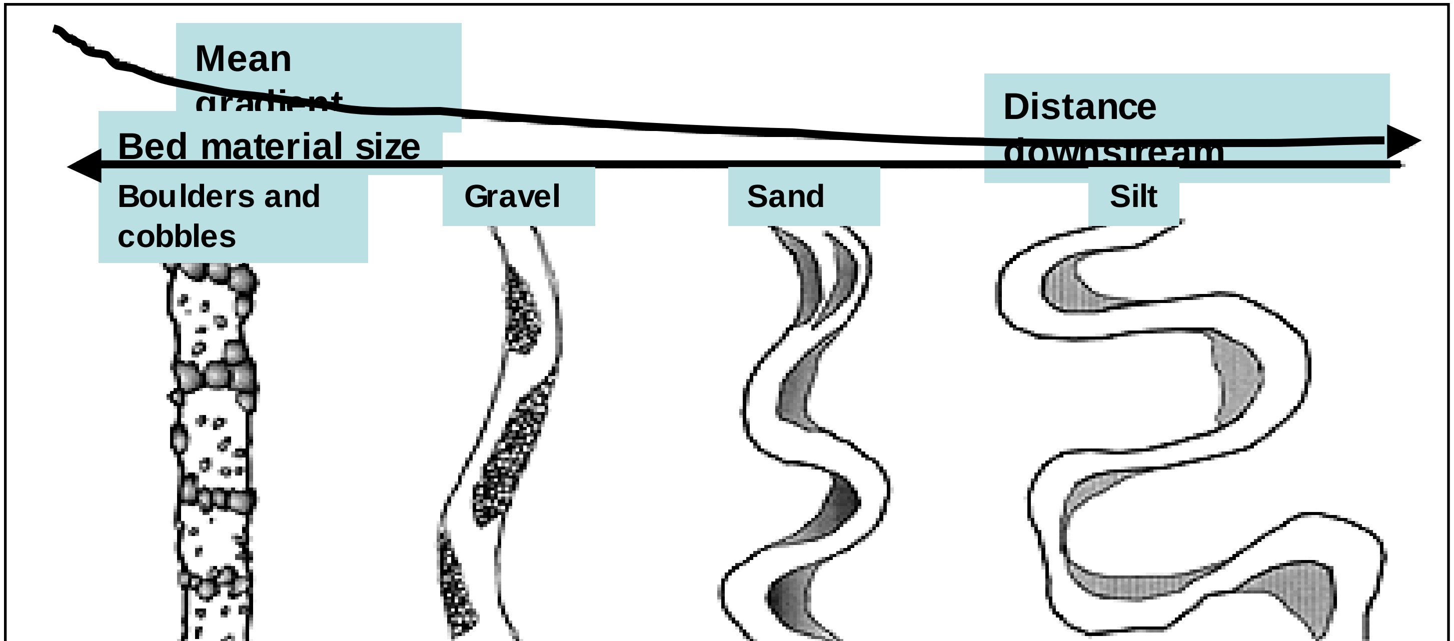
Flow affects all Components of a River System



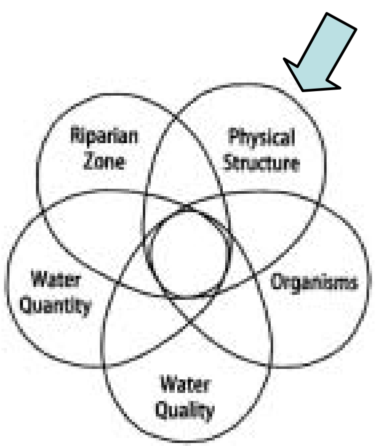


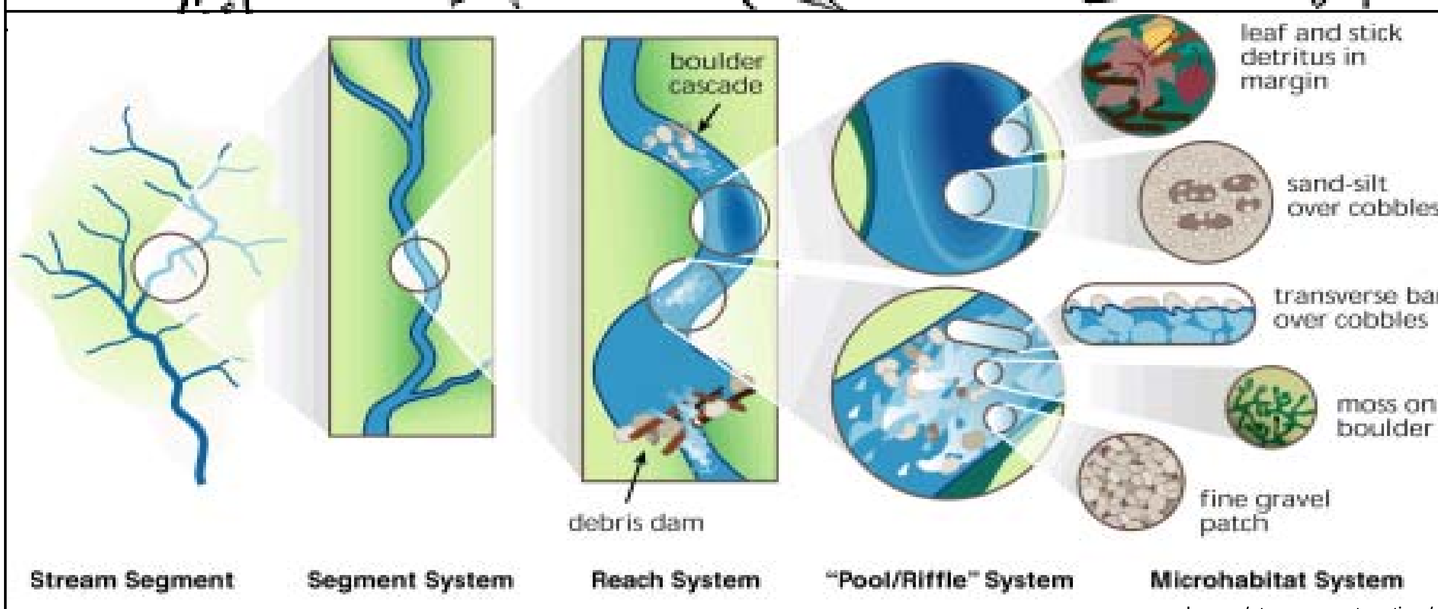


Effect of Flow on Habitat Characteristics



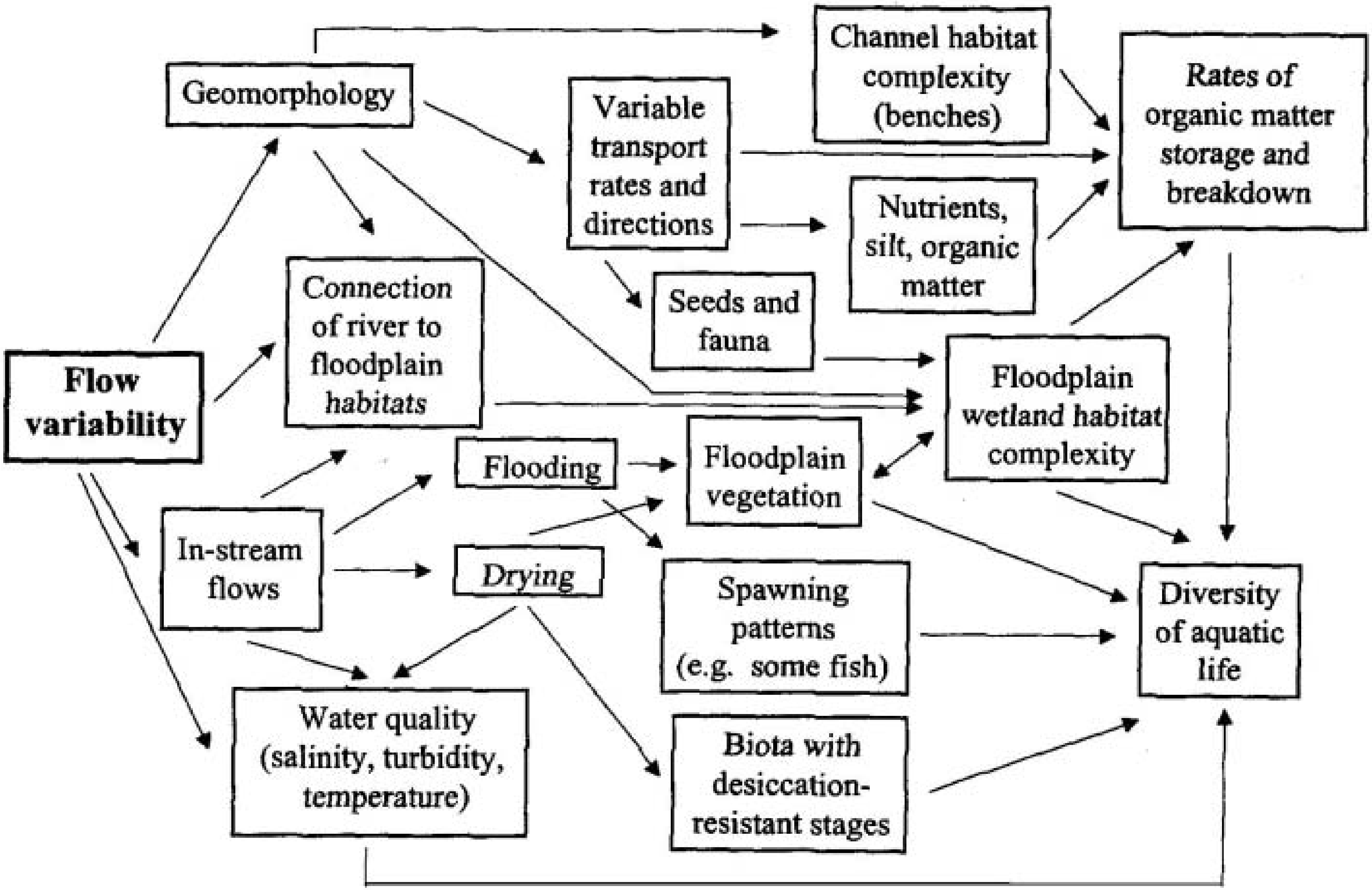
The predominant substrate size decreases downstream



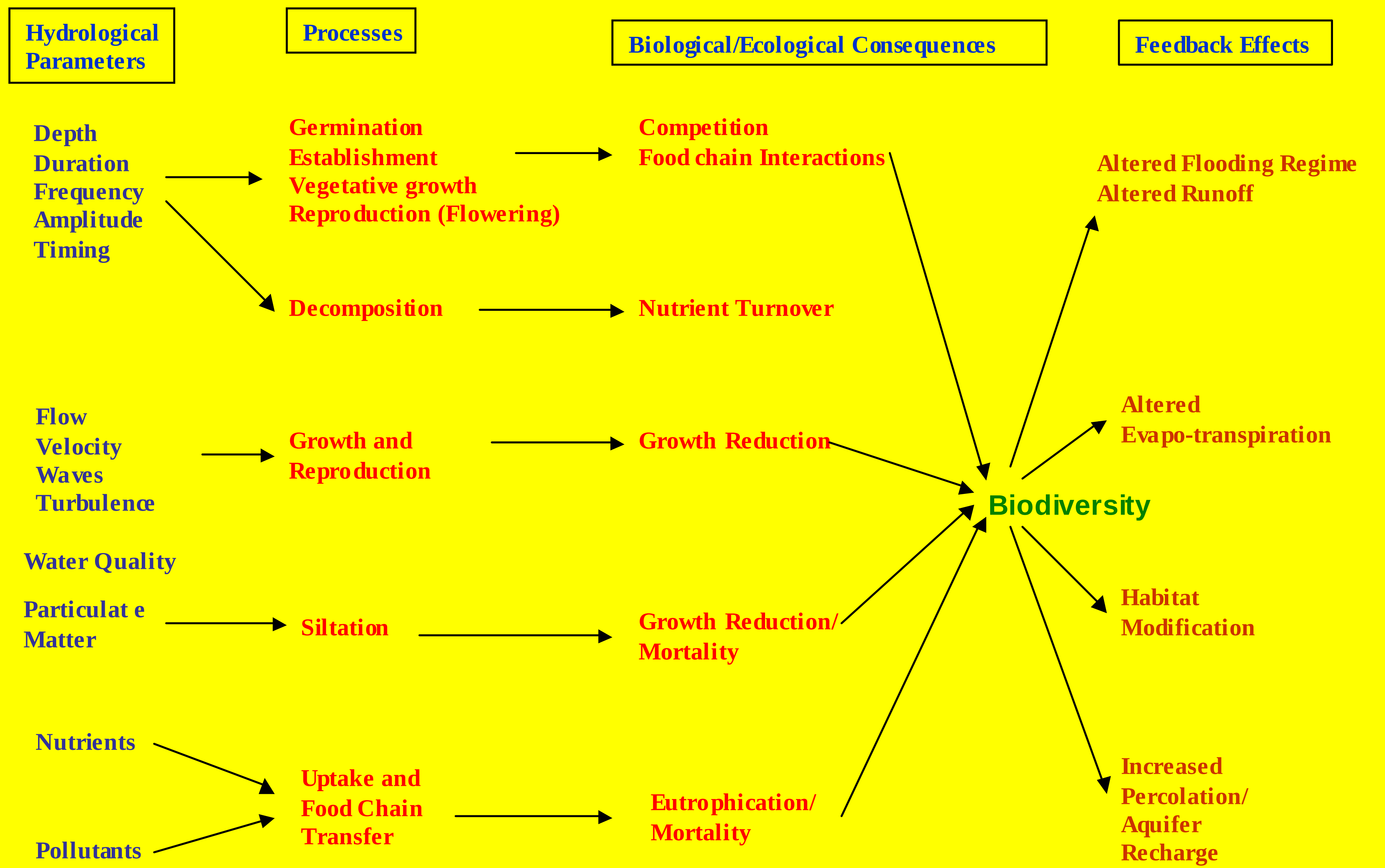


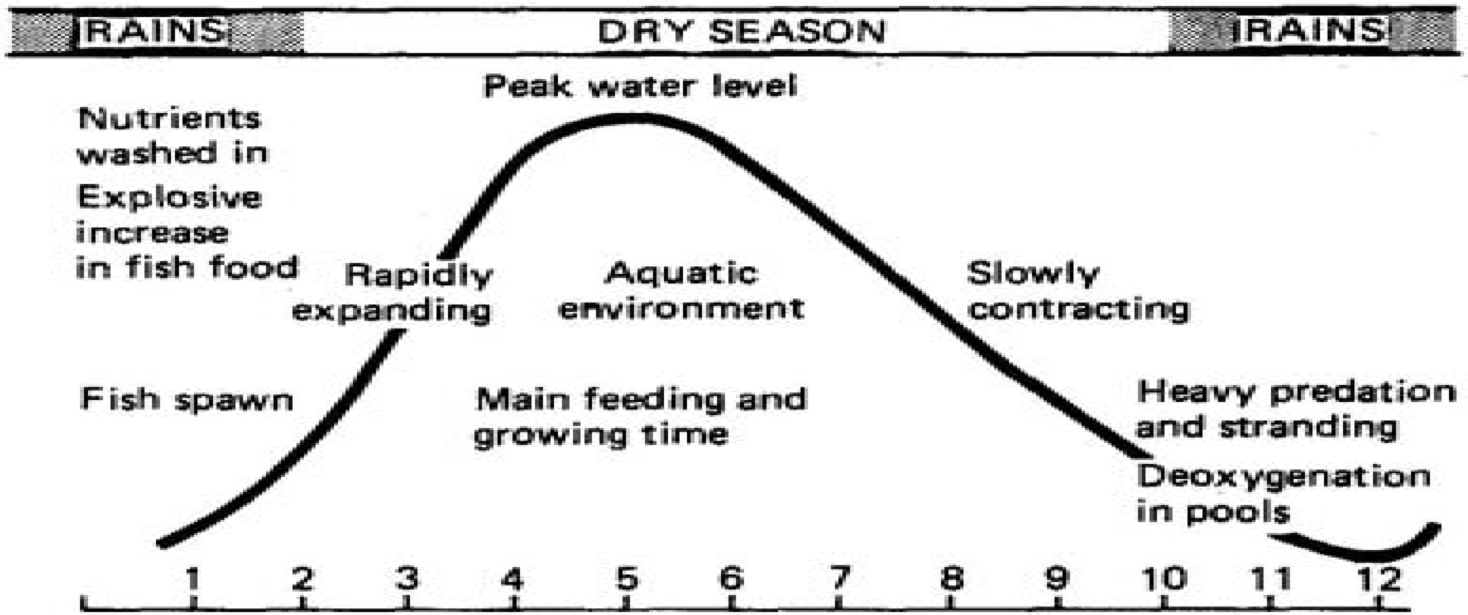
ml
www.usda.gov/stream_restoration/chap

Effect of Flow Variability on Aquatic Biota



Influence of flow variables on biological/ecological processes

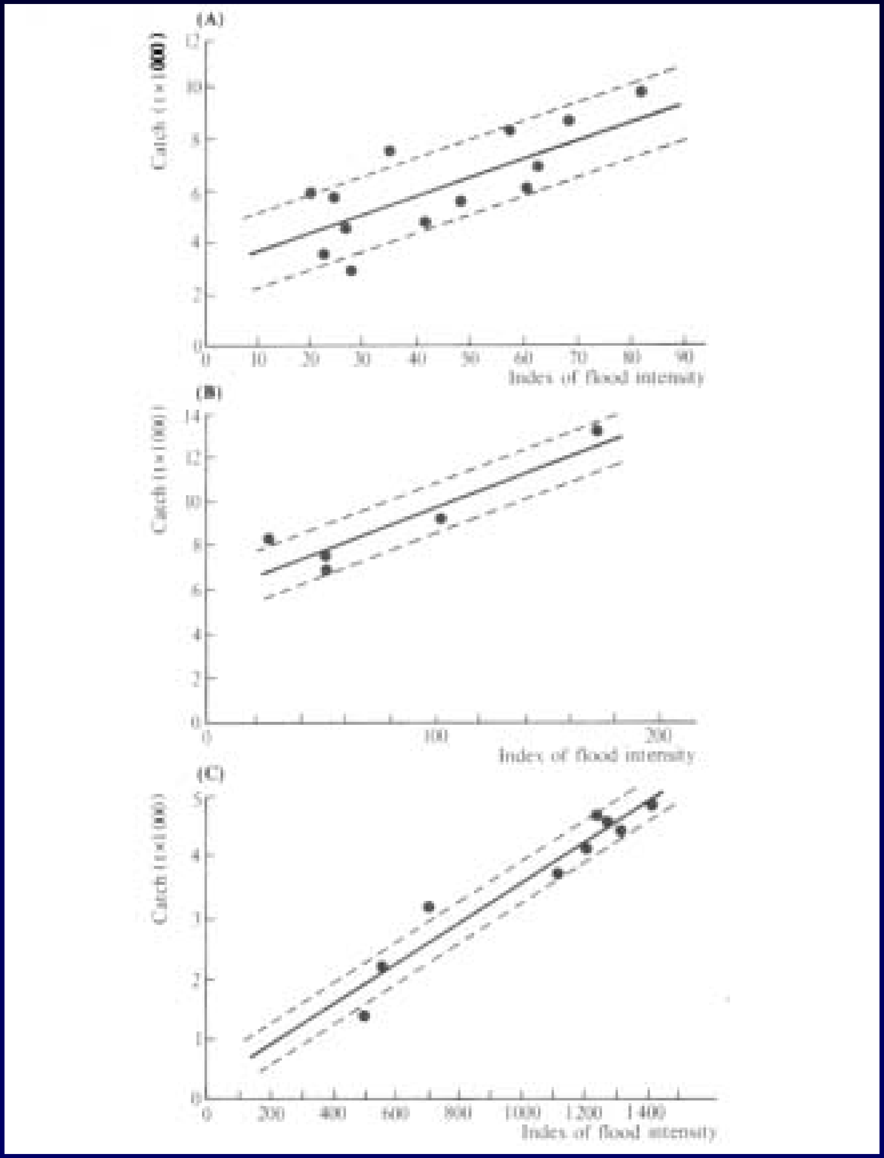




Month (actual month depends on time of rains and time taken for water to travel down river to floodplain)

Fish movements	up river	disperse on floodplain	back to river	confined to pools
Fish biomass	production of young	very rapid growth	heavy losses	much reduced
Fishing	of upstream migrants (destructive)	difficult: fish dispersed, much cover	intensive as fish move back to river	in pools (dry season refugees)

Water levels and fish catch



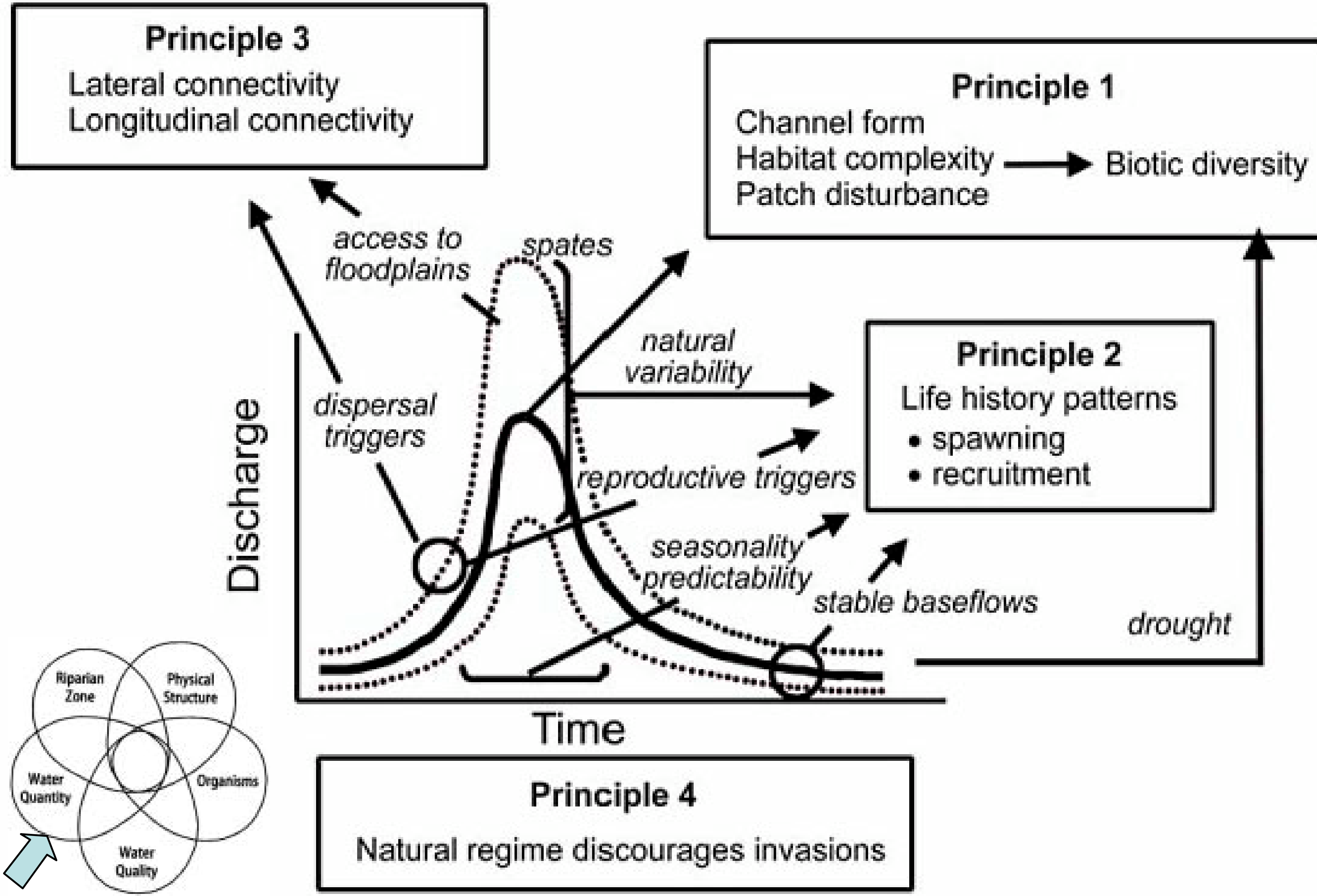
Kafue floodplain

Shire floodplain

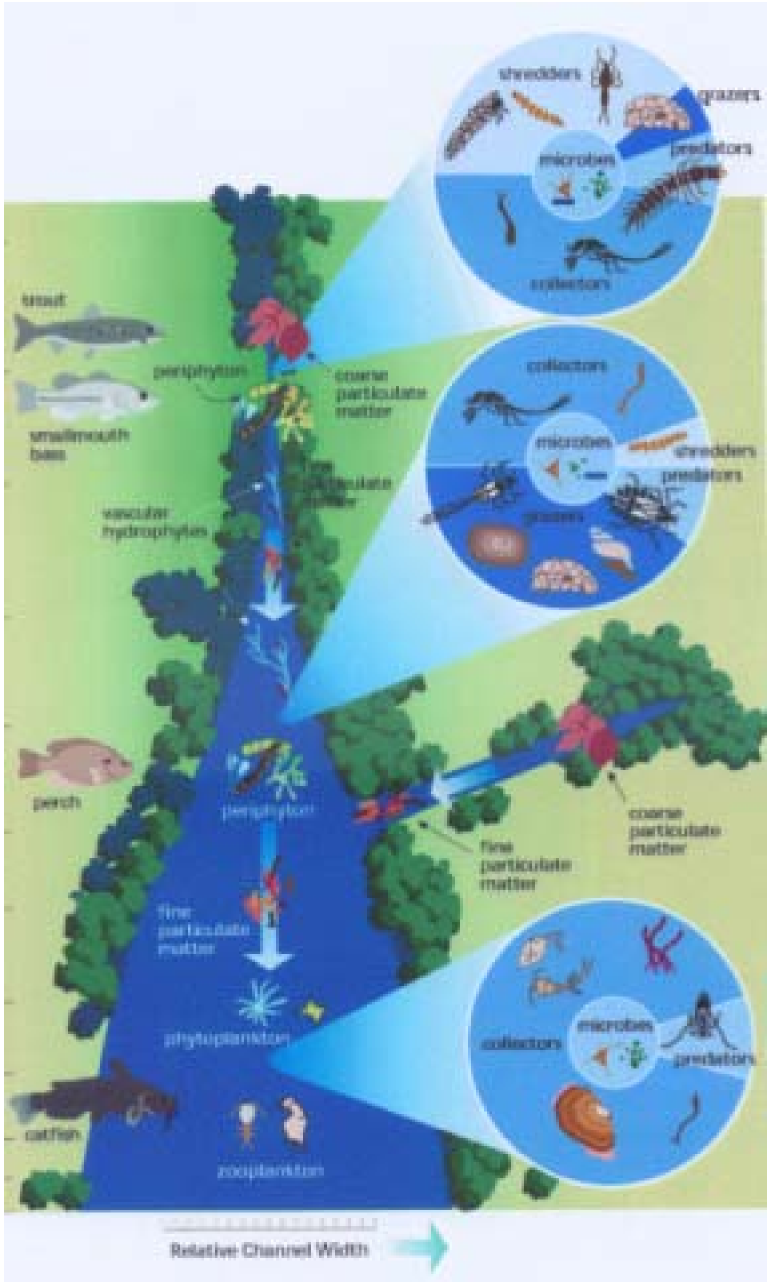
Niger Central Delta

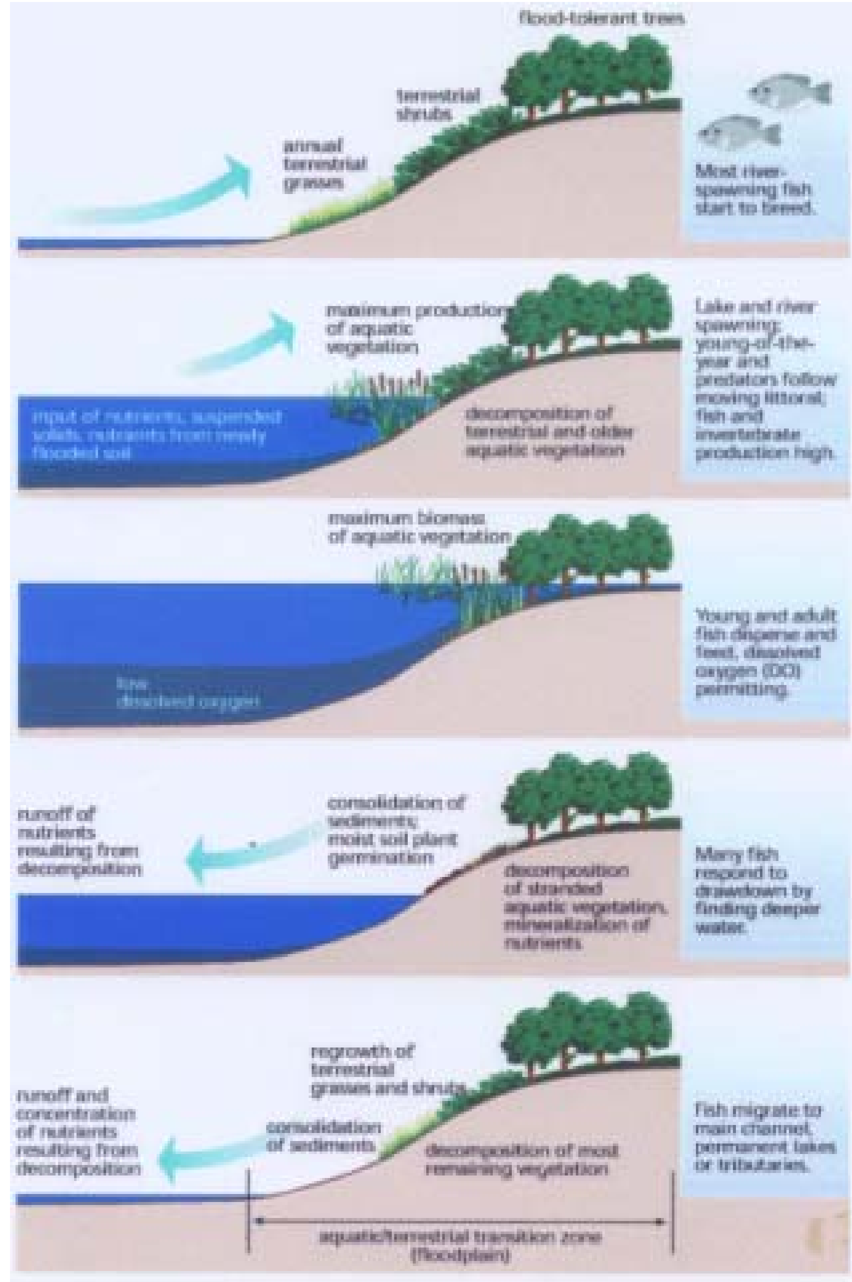
Courtesy: Robin Welcomme

Aquatic biodiversity and natural flow regimes

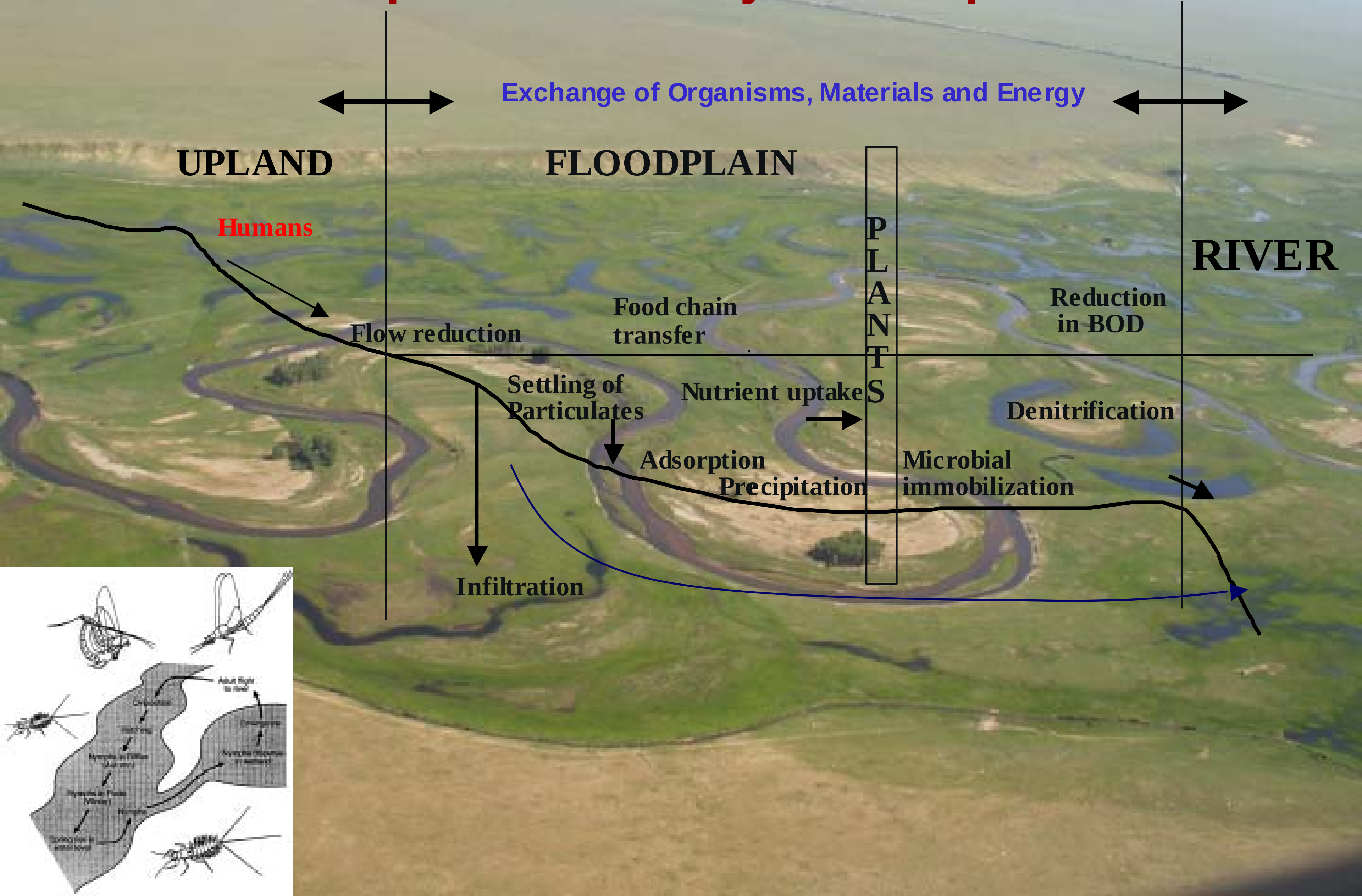


FLOW AND CONNECTIVITY

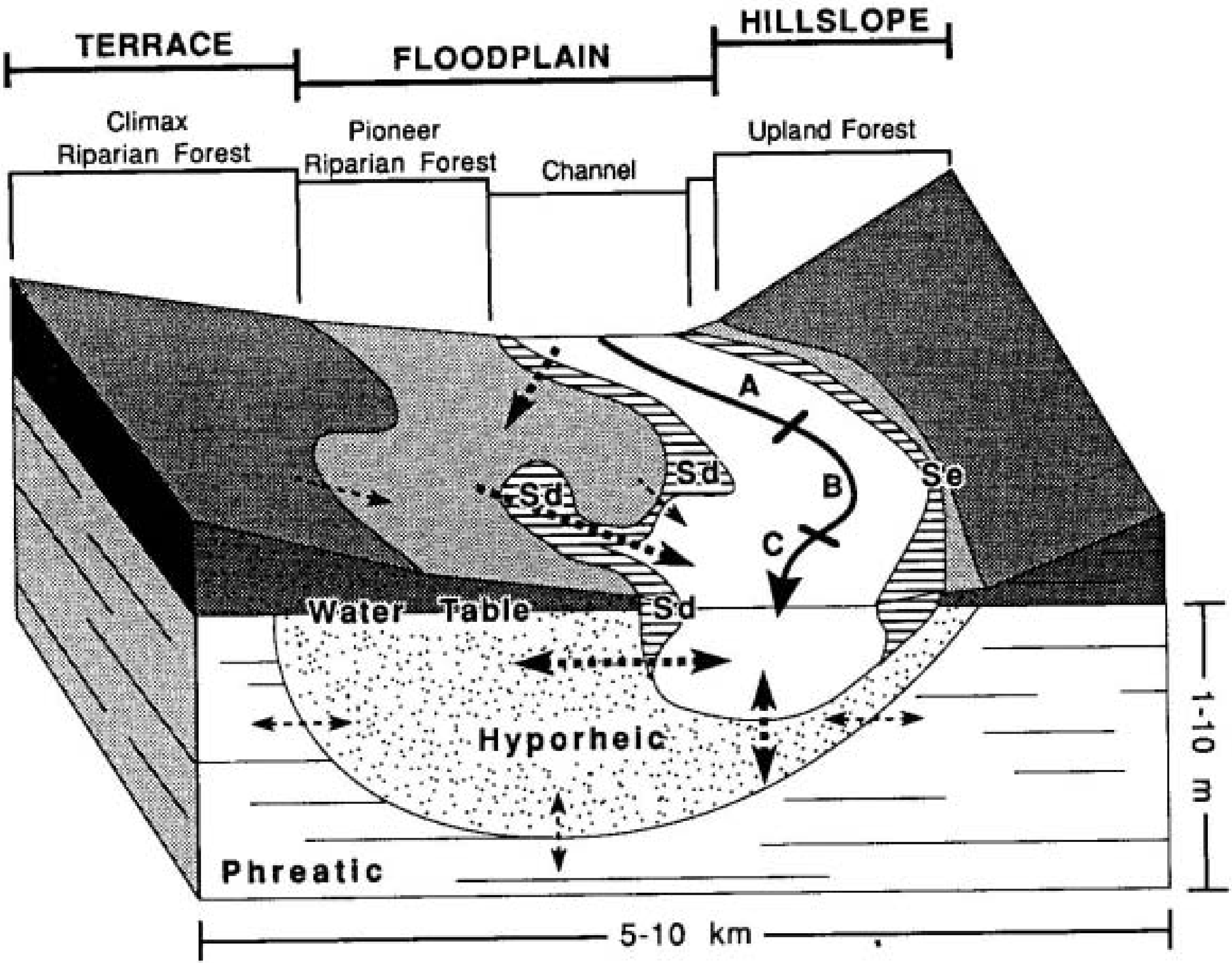




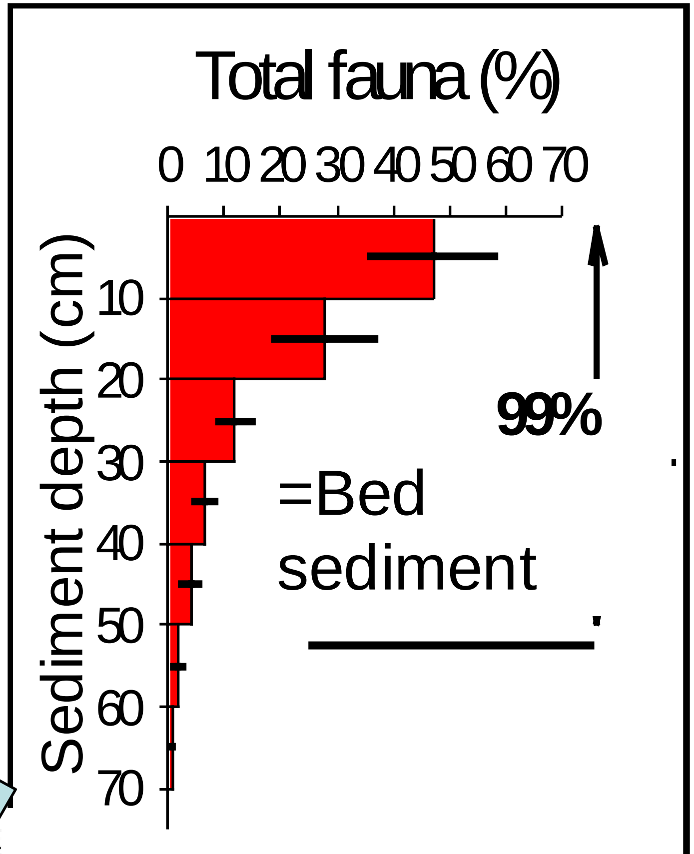
Interactions Between Rivers, Floodplains and Adjacent Uplands

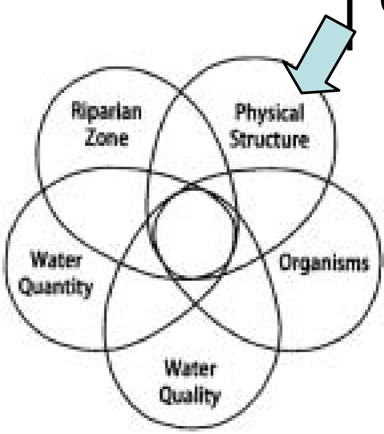


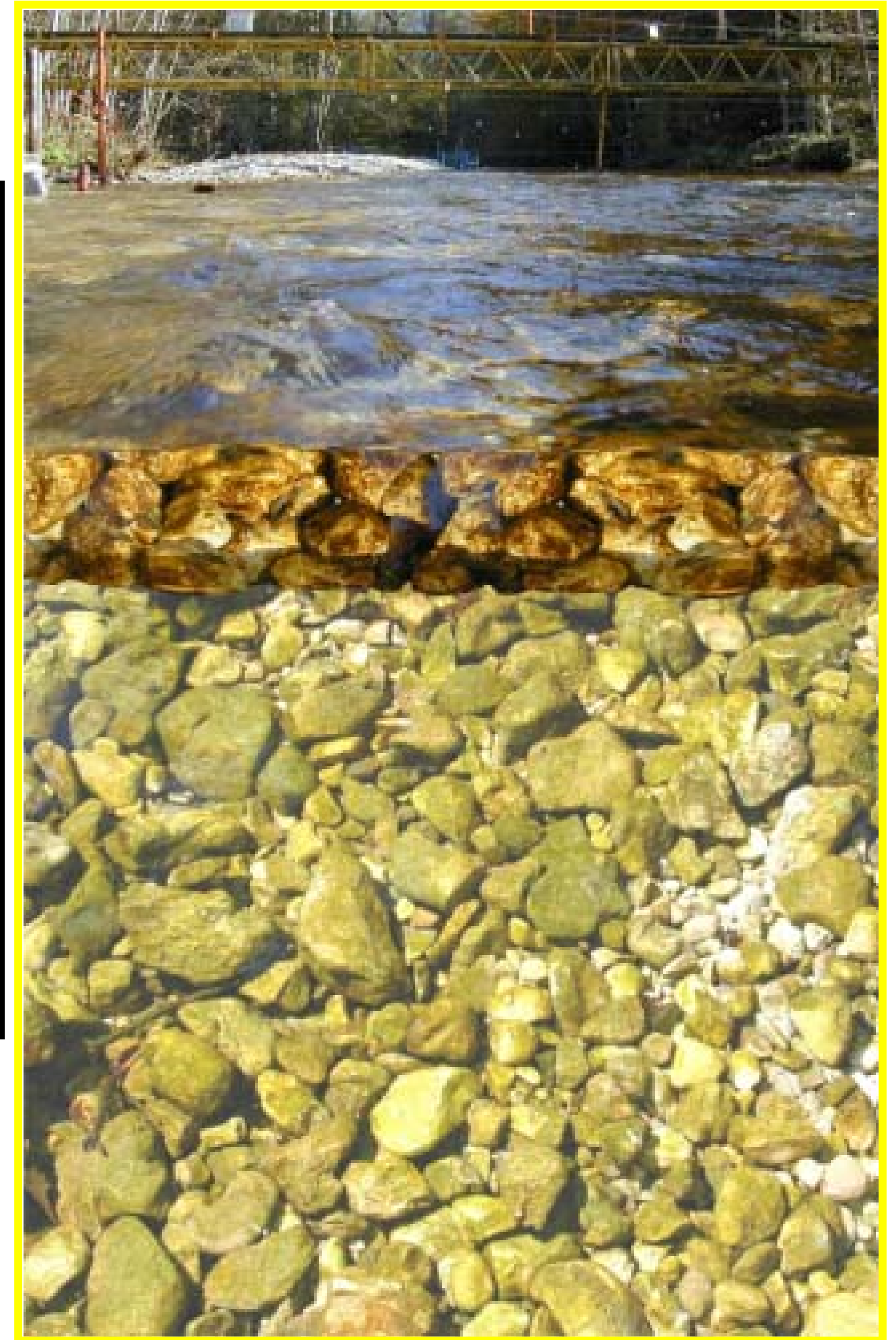
longitudinal, lateral and vertical transfers
of Water, energy, nutrients, organisms

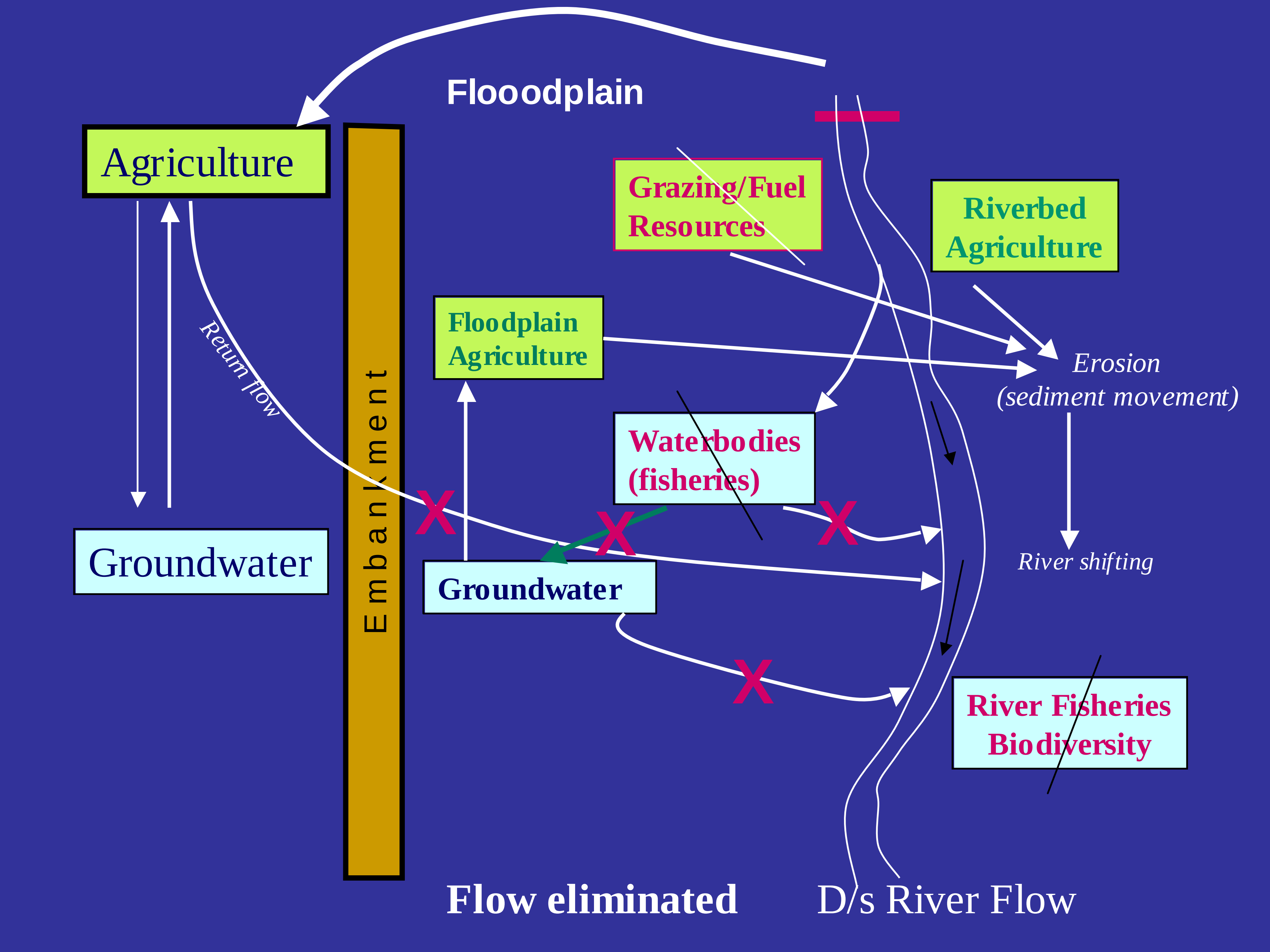


Stream Bed Sediments








Flooodplain
Agriculture
Grazing/Fuel Resources
Riverbed Agriculture
Floodplain Agriculture
Erosion (sediment movement)
Return flow
Embankment
Waterbodies (fisheries)
Groundwater
Groundwater
River shifting
River Fisheries Biodiversity
X
X
X
X
Flow eliminated
D/s River Flow

Ecosystem Services Dependent upon Flow

- Transport and deposition of sediments along river course
- Watering Floodplain wetlands
- Recharging groundwater
- Moderation of salinity

Role of Floodplains

Supply of good quality water
Resources: fish, reeds and forage
Purification of wastes
Flood protection
Agriculture and fisheries
Recreation, aesthetics, social-cultural activity
Eco-tourism
Support estuarine and marine species
Support terrestrial species

livelihoods, food, income, quality of life for communities

Methods for Environmental Flows

	Method	Data and Time requirements	Appr. duration of assessment	Confi-dence output	Levels of experience
Prescriptive	Tennant method	Moderate to low	Two weeks	Low	USA/extensive
	Wetted perimeter method	Moderate	2-4 months	Low	USA/Extensive
	Expert panels	Moderate to low	1-2 months	Mediu m	Australia/very limited
	Holistic Method	Moderate to high	6- 18 months	Mediu m	Australia/Very limited
Interactive	IFIM Instream Flow Incremental Methodolgy	Very high	2 – 5 Years	High	USA, UK, Extensive
	DRIFT Downstream Response to Imposed Flow Tranformation	High to very High	1-3 Years	High	Lesotho, South Africa/very limited

Methods for Environmental Flows

Hydrological: Complexity- Low. Data needs: Mainly desktop; Some virgin naturalistic historic flow records Expertise: hydrological, ecological

Hydraulic rating: Complexity: Low- Medium. Data needs: Discharge linked to hydraulic variables - typically single river cross-section Expertise: Hydrological, hydraulic modelling, ecological

Habitat Simulation: Complexity: Medium – High. Data needs: desktop and field, Historical flow records, many hydraulic variables – multiple cross-sections, Physical habitat suitability data for target species. Expertise: Advanced hydrological modelling, advanced computer-based hydraulic and habitat modelling, specialist ecological expertise on physical habitat-flow needs of target species

Holistic: Complexity Medium – High. Data needs: + many hydraulic variables – multiple cross-sections, biological data on flow- and habitat-related requirements of all biota and ecological components. Expertise: As above

No agreement on methods or any common method

All available methods developed for the specific conditions of small, headwater streams

Not suitable for large, lowland, monsoon-fed rivers

Ecosystem services and livelihoods need to be considered


River Yamuna near Asan Barrage
Thank You