Nagoya Hydraulic Research Institute for River Basin Management

Development of Ecohydraulics and Ecosystem Management in River

JST-NSERC Workshop on Sustainable Water Use

Fujisoft Akiba Plaza, Tokyo, Japan, 21-22 October 2013

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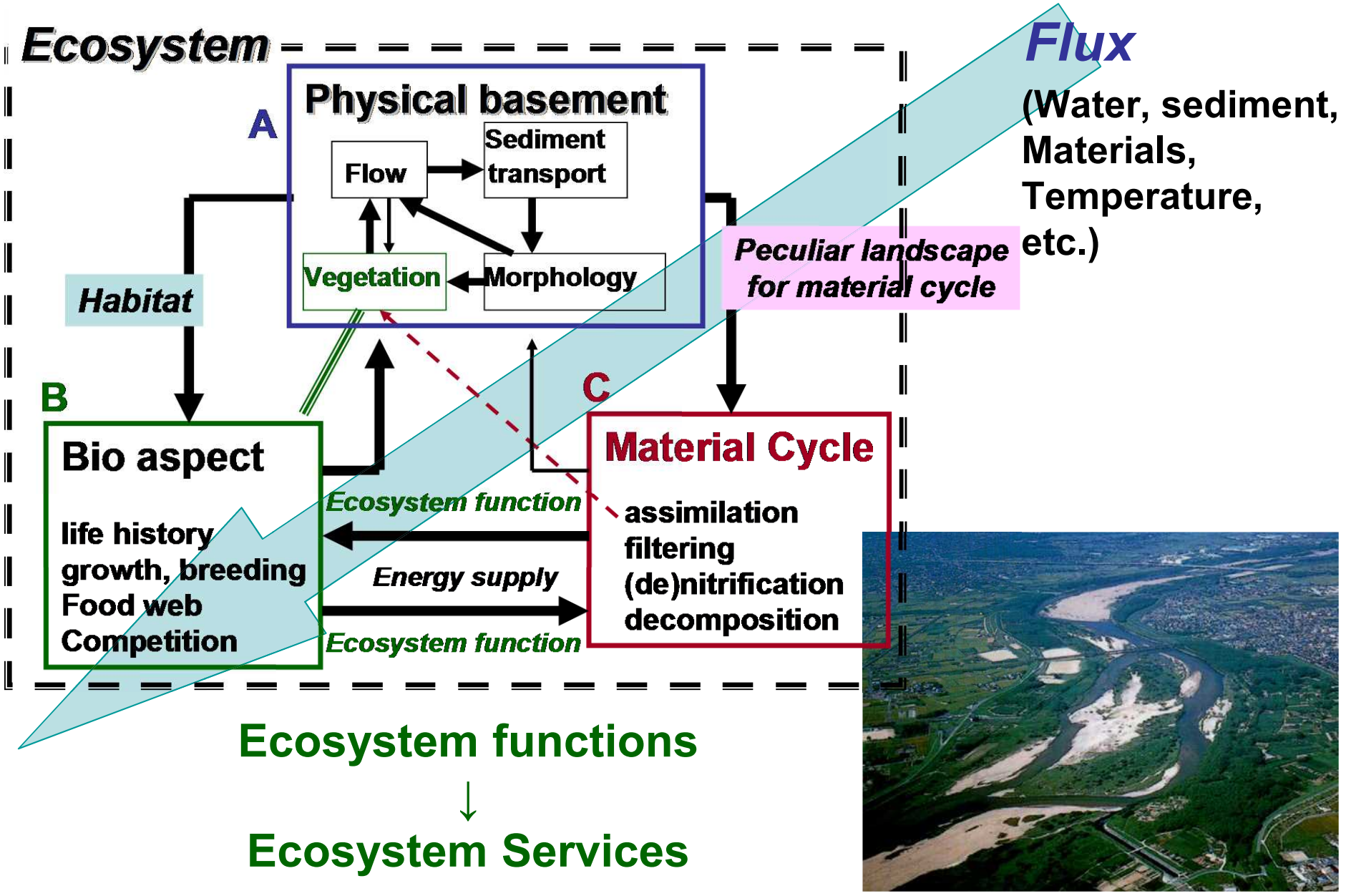
Nagoya University, Japan

Structure and Functions of River Ecosystem



Ecosystem functions

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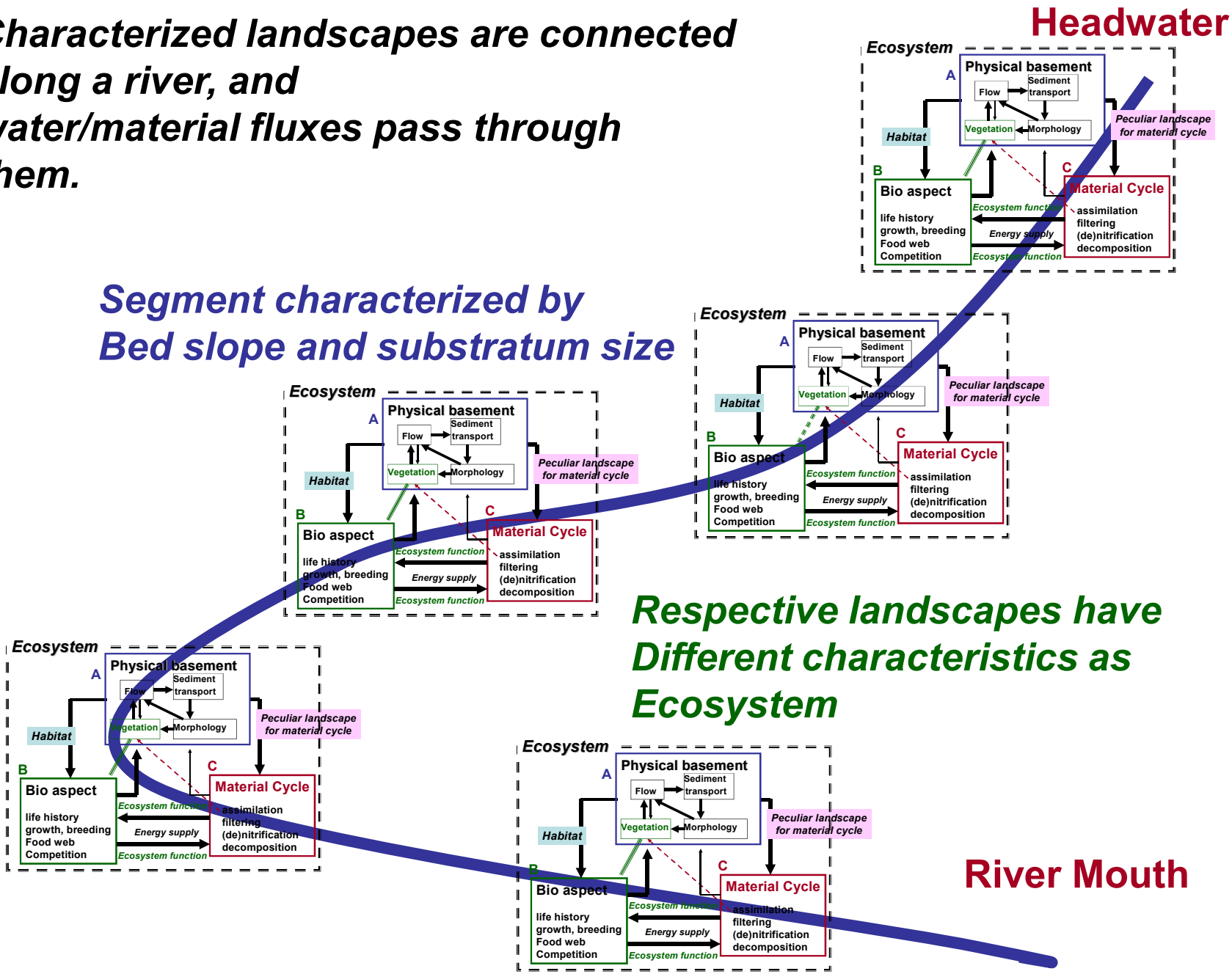
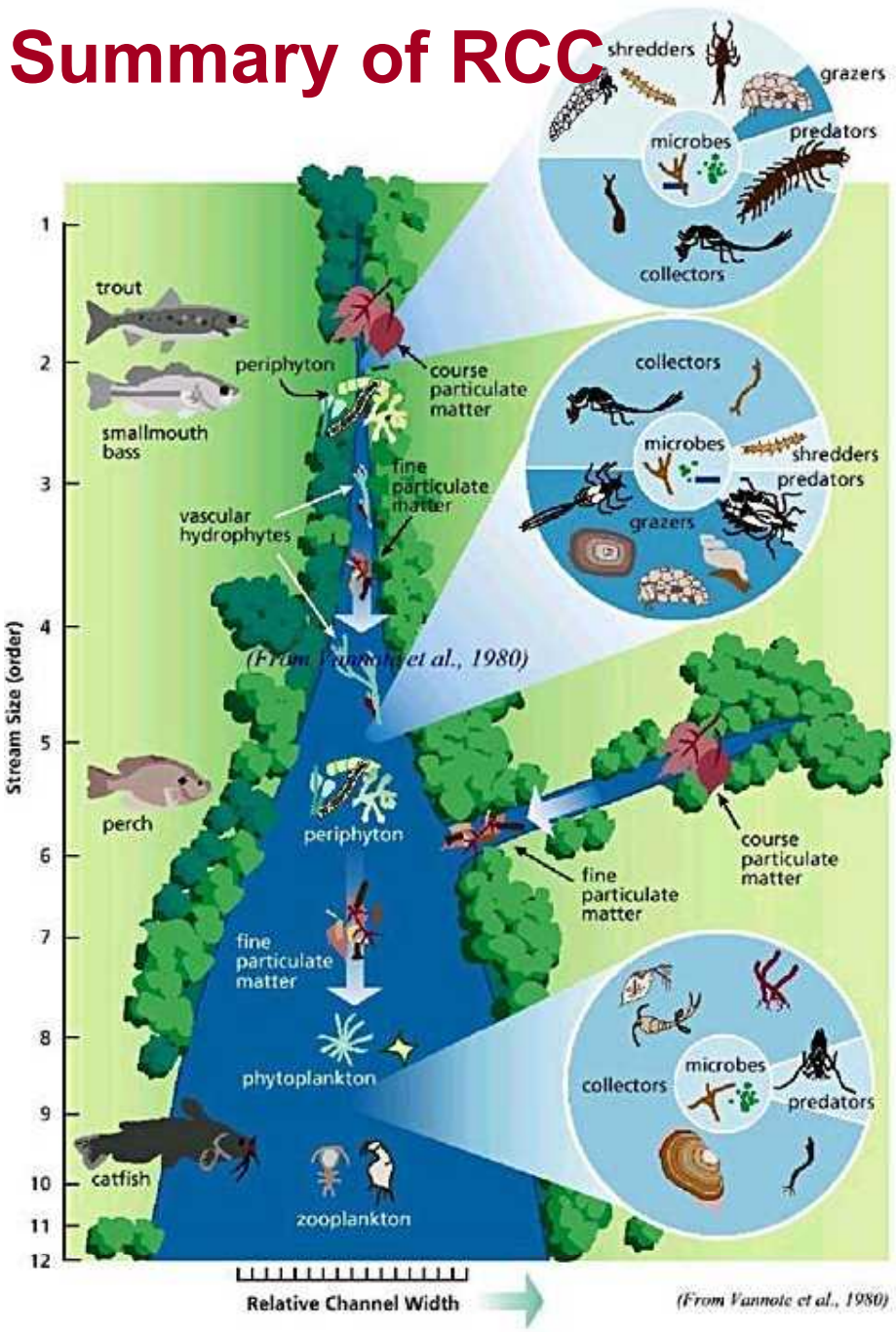
Ecosystem Services

Characterized landscapes are connected along a river, and water/material fluxes pass through them.



Summary of RCC



Vannote et al., 1980
Canadian Journal of Fisheries & Aquatic Sciences

Litters provided by terrestrial zone form CPOM, and shredders use them as food source.

FPOM downsized by shredding by them and abrasion is used by collectors who use traps or filters to catch them.

Grazers feed off periphyton produced through photosynthesis on stable cobbles in shallow stream.

In deep segment of downstream of a river, light cannot reach the bed while flow is tranquil then phytoplankton becomes dominant food source.

Image of Coupling various Landscapes with Flux Networks

ES: Ecosystem Service
Δϕ: Flux change
PM: Policy Menu

Ex.1) Forested Area

Modeling the quantity of CO_2 extraction by the trees

ES: CO_2 extraction

***Δϕ:* water (Q), T-N,SS**

***PM:* Change of the tree class, Forest thinning (Forest Management)**

Ex.2) Sand River

-Middle Reach-

Modeling the effect of water purification by attached algae

ES: water purification

***Δϕ:* water (Q), T-N**

***PM:* Control of water discharge by dam operation change**

Ex.3) Tidal Area

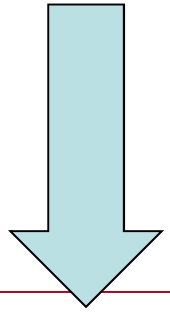
Modeling the quantity of ecological production due to the conditions of physical basement

ES: Food provision, Water purification

***Δϕ:* water (Q), T-N**

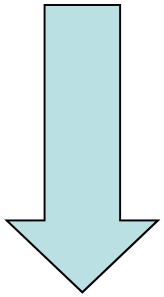
***PM:* Creation of tideland, Settled of Nori-net**

River Ecosystem
= Landscape (Mosaics, Segment)
connected by
Water/Material/Energy Flux Network



Human activities as Impacts
direct damages in landscape
alternation of flux network

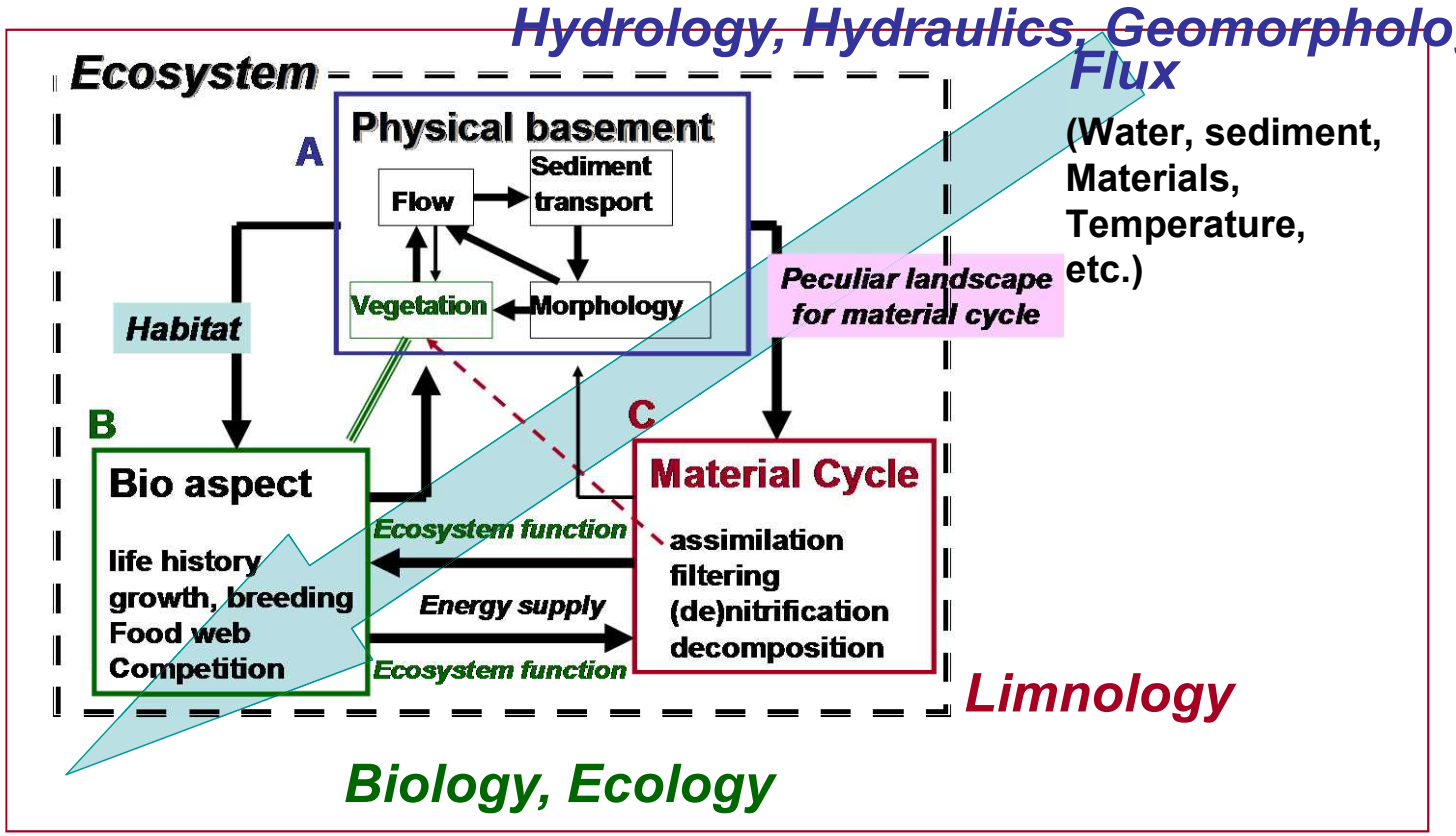
Degradation of Ecosystem



Restoration of landscape (mosaic)
Rehabilitation of flux network

Conservation of Ecosystem

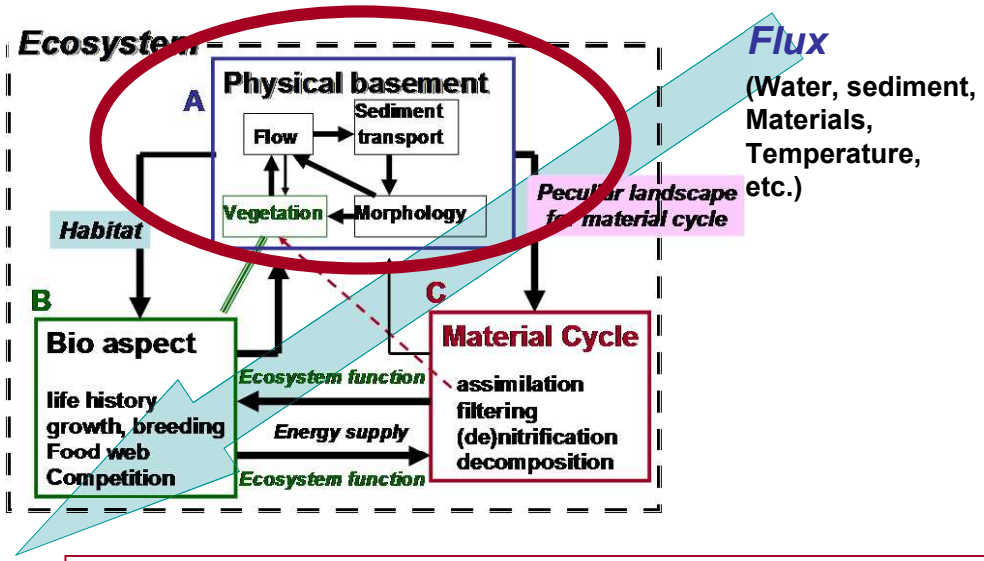
Interdisciplinary research



Cooperation of Science and Policy

New academic society in Japan (1997～)

“Ecology and Civil Engineering Society”



Fluvial Hydraulics

Mechanics of Sediment Transport

Geomorpholgy

Flow with Vegetation

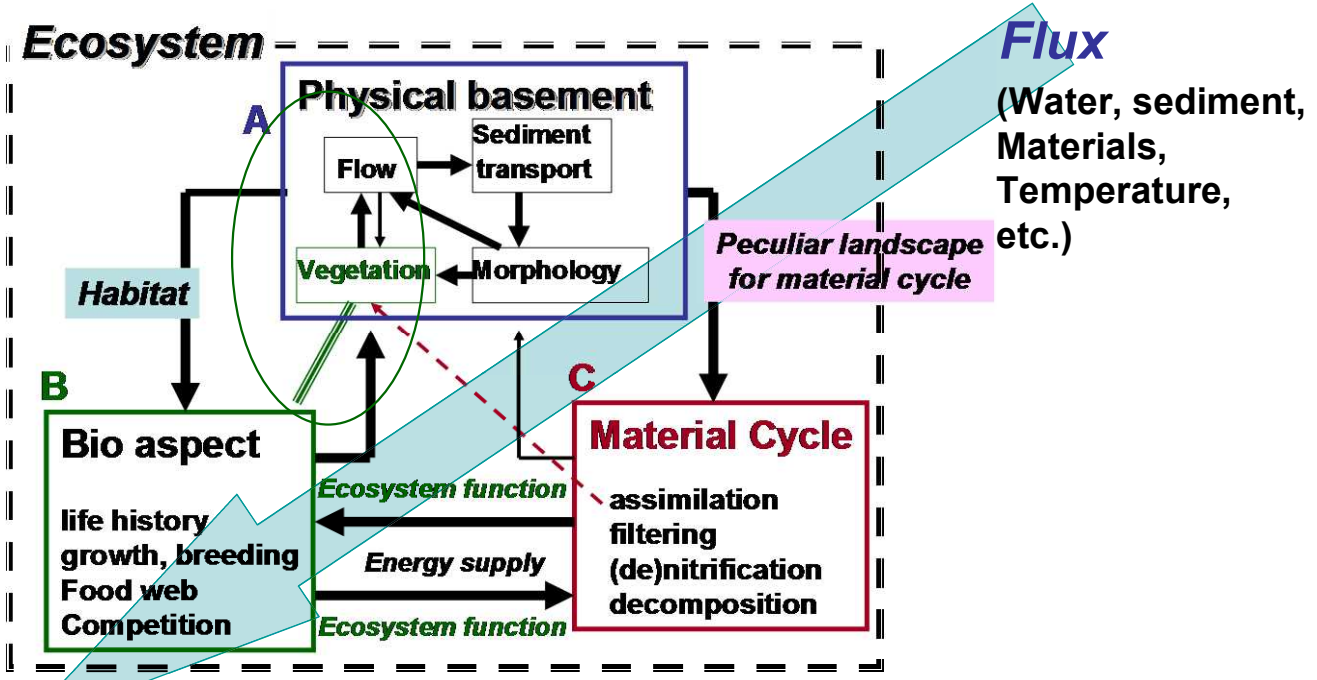
IAHR （International Association for Hydraulic Research)

Fluvial Hydraulics Committee

Prof. Selim Yalin (Queen's University)

JHR Special Issue, 1997

"Fluvial processes in streams with vegetation"

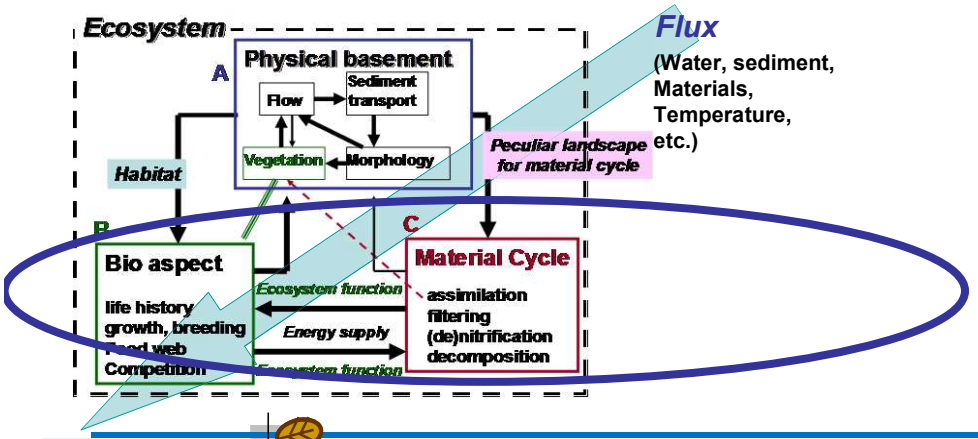


IAHR started International Symposia for "Habitat Hydraulics" in 1994 (Tronheim, Norway).
The 2nd was held in Ottawa, Canada.

Habitat Suitability Evaluation

- Habitat suitability Indecies
- Preference curves – Physical parameters

Afterwards, the name of symposia and committee in IAHR changed to "Ecohydraulics"



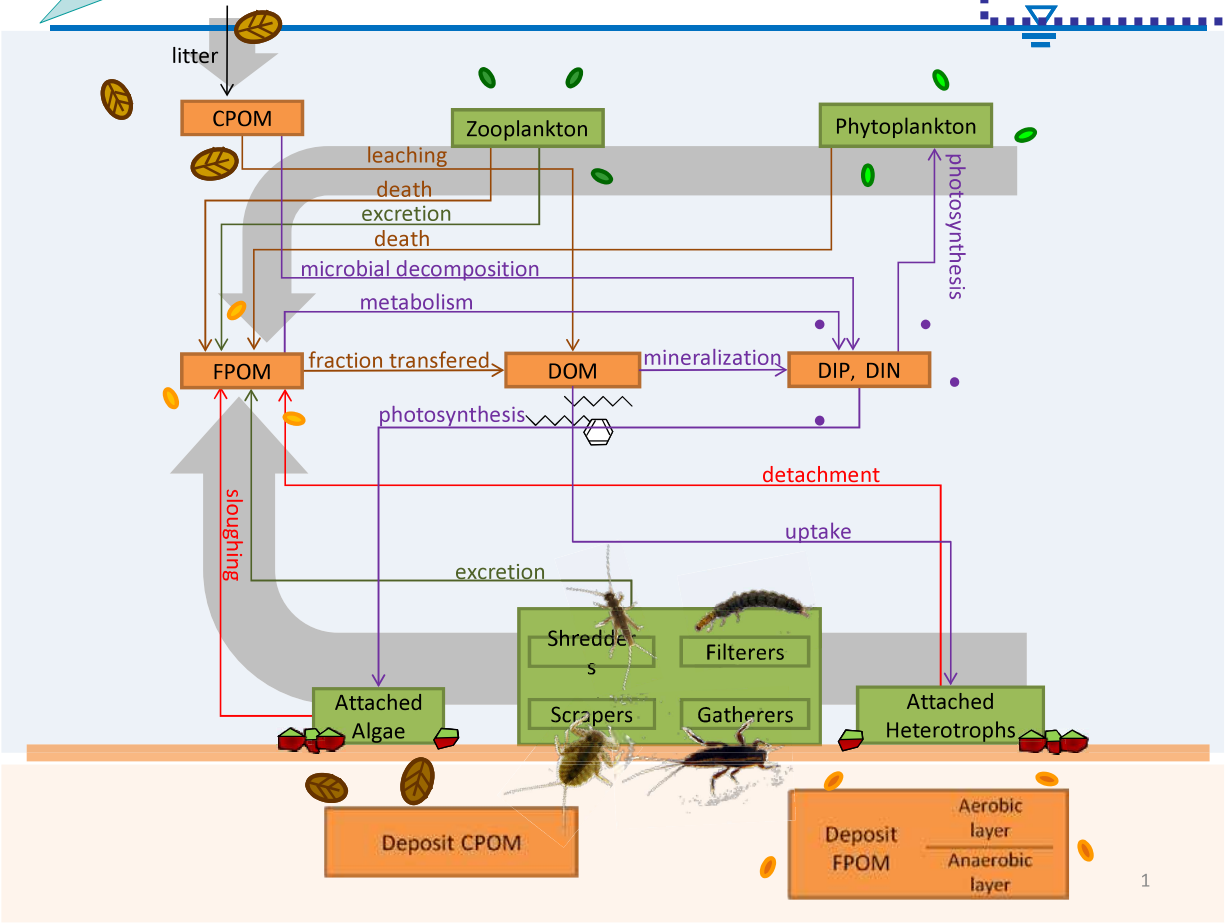
Population Dynamics

growth

species population

Biochemical action

Change of concentration of biophilic elements

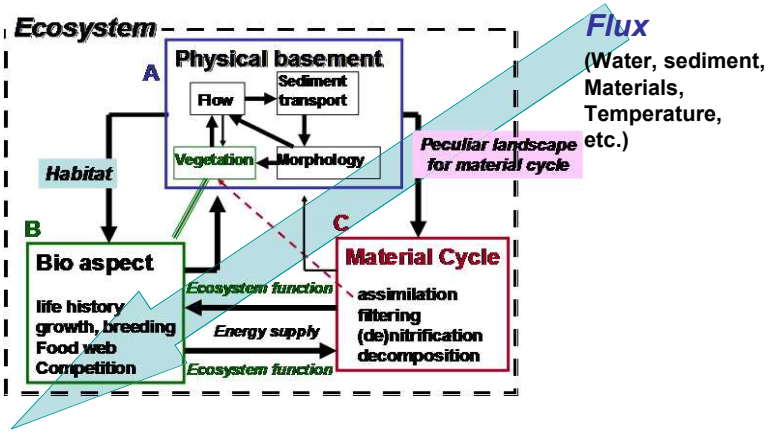


Characterized by "segment" (mosaic)

Flux

Governed by

Convection-Diffusion equation



Unsteady term + **Convection** + **diffusion**

For each material or rganism,

= **Productoin - Dissipation**

Interaction terms among various elements

for each segment or mosaic

Biological Aspect

Production

Food web

Respiration

Excretion,….

Material Cycle

Nitrification

Denitrification

Trap - Release

Examples of equations and each connection

Material cycle model

Concentration of coarse particulate organic matter CPOM(g/m³)

$$\frac{\partial(CPOM)}{\partial t}+U_M\frac{\partial(CPOM)}{\partial x}=-\frac{1}{H}(Dep_{cp}-Ero_{cp})-k_{mic}CPOM$$
$$+LF+\frac{\partial}{\partial x}\left\{Dis\frac{\partial(CPOM)}{\partial x}\right\}+\frac{q_S}{BH}(CPOM_S-CPOM)$$

K_{mic} : leaching and microbial decomposition rate [g/s], LF : litter input in Seg.M [g/m²/s]

Material cycle model

Concentration of ammonia nitrogen NH_4-N(g/m³)

$$\frac{\partial NH_4}{\partial t}+U_S\frac{\partial NH_4}{\partial x}=-\frac{\alpha_N}{H}\phi_A G_A+\frac{1-\sigma}{\sigma}\frac{\alpha_N}{H}G_H+\frac{\alpha_N}{H}k_{ae}(A+Het+FPOMH)$$
$$+\frac{\alpha_N}{H}k_{an}(Het-Het_A)+\frac{\alpha_N}{H}r_{dec}+\frac{\alpha_N\alpha_{DNP}}{H}k_{mic}(CPOMH+Se_{cp})+\alpha_N(k_{pe}-\phi_P\mu_P)P+\alpha_N k_{ze}Z$$
$$+\frac{\alpha_N}{H}(e_{Bent}-g_{Bent})G_{Bent}+\alpha_{NC}k_{DOC}DOC-k_{NH_4}NH_4+\frac{\partial}{\partial x}\left\{Dis\frac{\partial NH_4}{\partial x}\right\}+\frac{q_S}{BH}(NH_{4S}-NH_4)$$

Loss by macrobial decomposition

ϕ_A : algae uptake fraction of inorganic nitrogen [-], ϕ_P : phytoplankton uptake fraction of inorganic nitrogen [-], k_{NH4} : nitrification rate of NH_4 [/s], α_{NC} : N/C ratio [-], α_N : nitrogen content in biomass [-]

Biological model

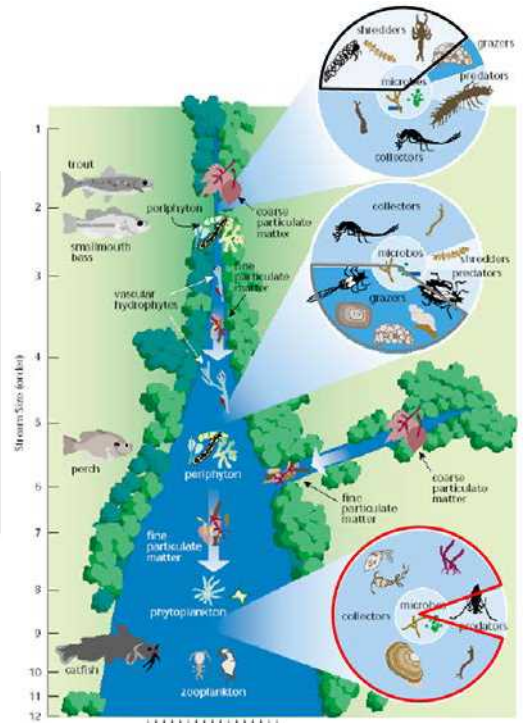
Attached algae

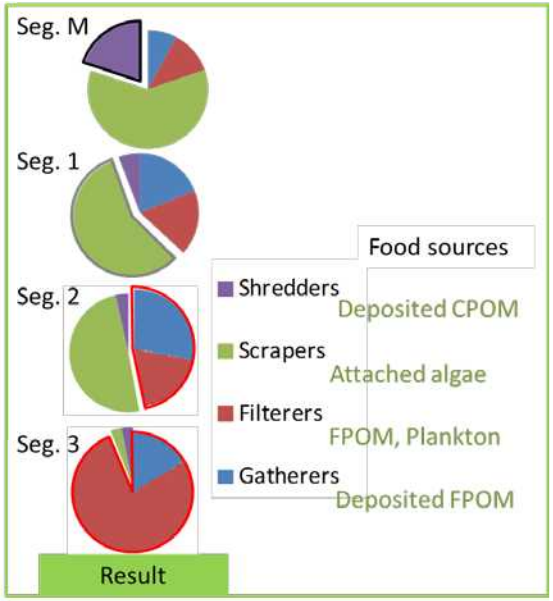
uptake

Amount of attached algae per unit area A(g/m²)

$$\frac{dA}{dt}=G_A-h_A A-k_{ae}A-G_{SC}$$

h_A : Detachment rate of attached algae [/s]





Modeling of various functions (physical, chemical and biological) for Each segment (mosaic).

Biomasses of various species are correlated one another, and furthermore other material cycle processes

Transportation from headwater to river mouth

governed by simultaneous system of "convection-diffusion" equations for biomasses of various species and concentrations for various materials

Spatio-temporal changes in species composition and concentration of various types of biophilic elements

Evaluation of ecosystem function

"Ecosystem Service" "Biodiversity"

Contribution to IPBES

(Intergovernmental policy-science Platform for Biodiversity and Ecosystem Service)