River Training and Ecological Restoration

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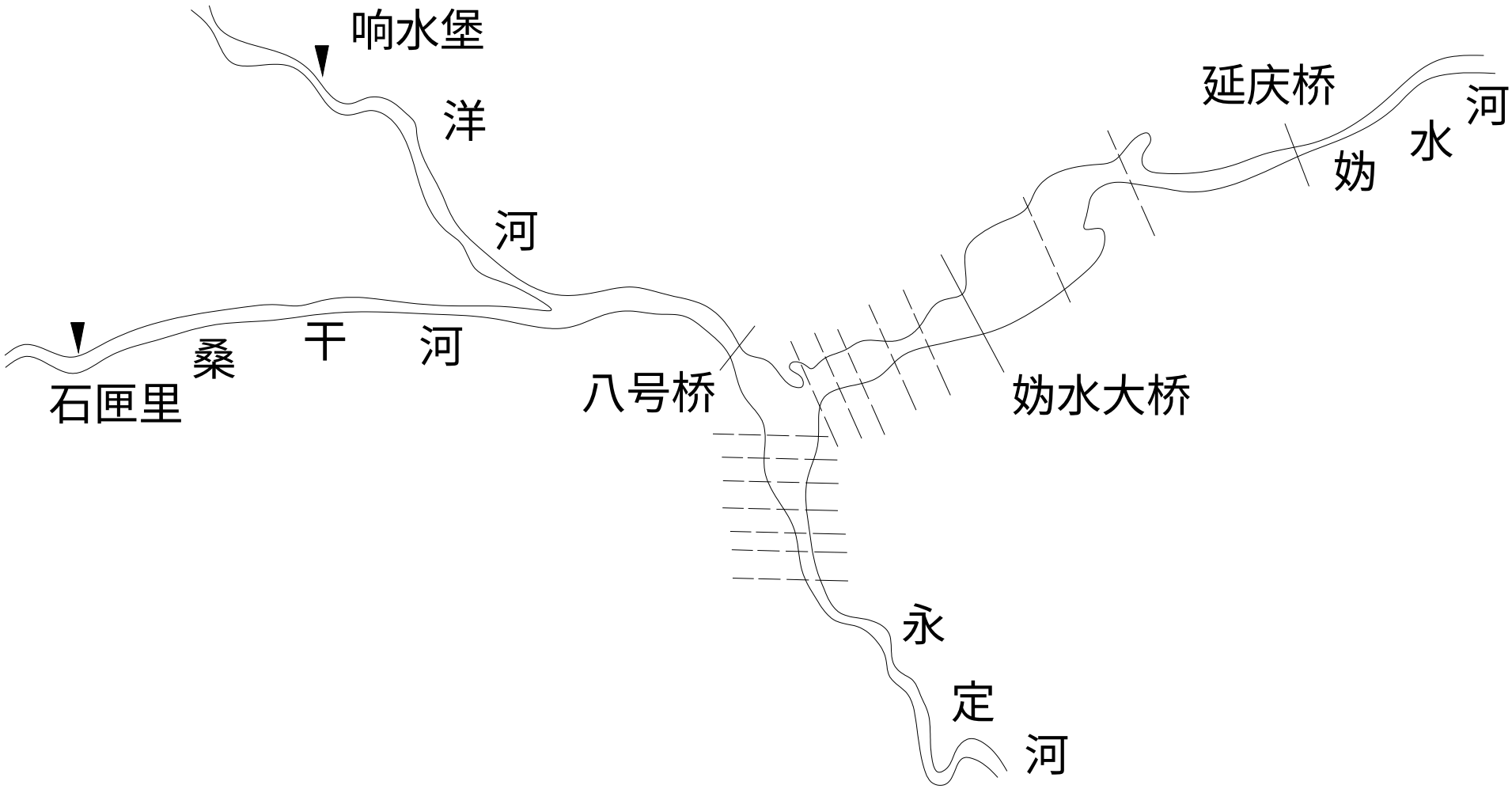
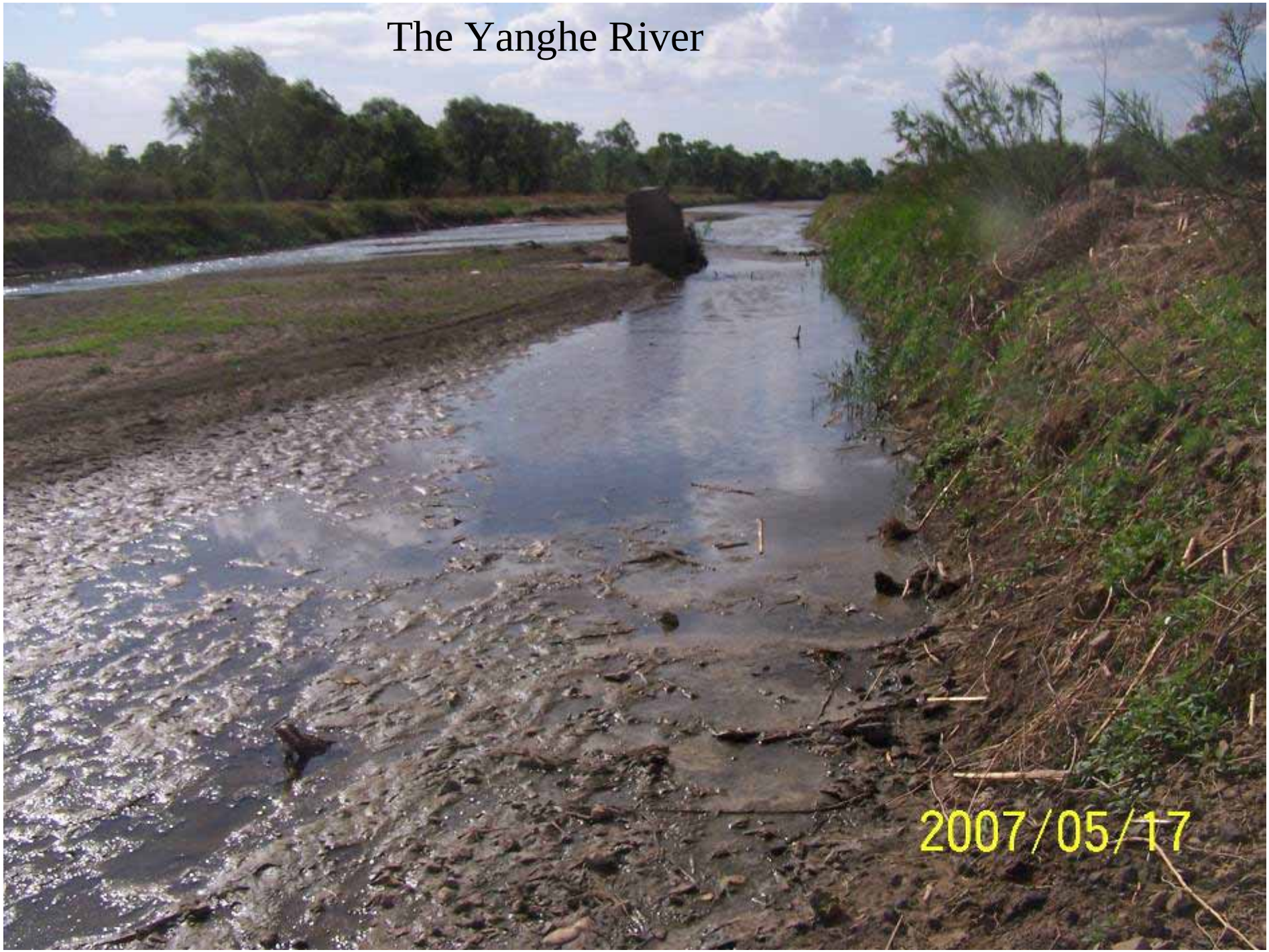
Contents

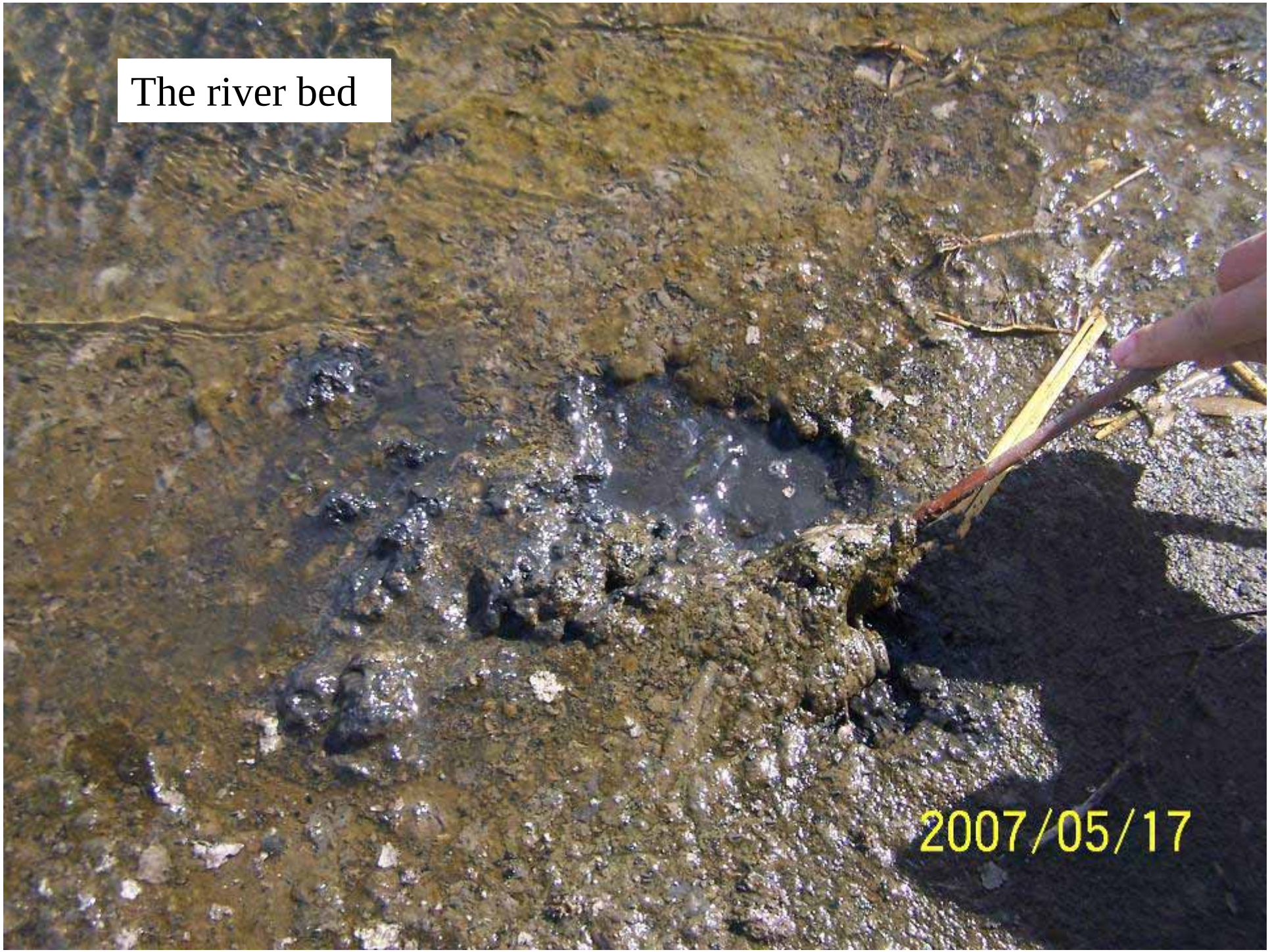
1、Impacts of River Training and River Use on Ecology

Impoundment of the Guanting Reservoir and numerous dams on the Yongding River have caused 90% runoff reduction. The water qulity has been reduced below 5-grade of national standard



The Yanghe River




The river bed
2007/05/17

Water Quality

1、Confluence of the Sanggan and the Yanghe Rivers: TN 6.74 （below grade-5）;TP 0.17 (grade-3); NH_4^+ 0.11 (gerade-1); COD_{Mn}3.49 (grade-2); F^- 0.64 (grade-1);

2、No.8 Bridge: TN 10.37 (below grade-5）;TP 0.84 (grade-5); NH_4^+ 3.34 (below grade-5); COD_{Mn} 5.42 (grade-3); F^- 0.50 (grade-1);

3、Below the dam: TN 1.38 （grade-4）;TP 0.0082 (grade-1); NH_4^+ 0.05 (grade-1); COD_{Mn} 2.04 (grade-2); F^- 0.90 (grade-1);

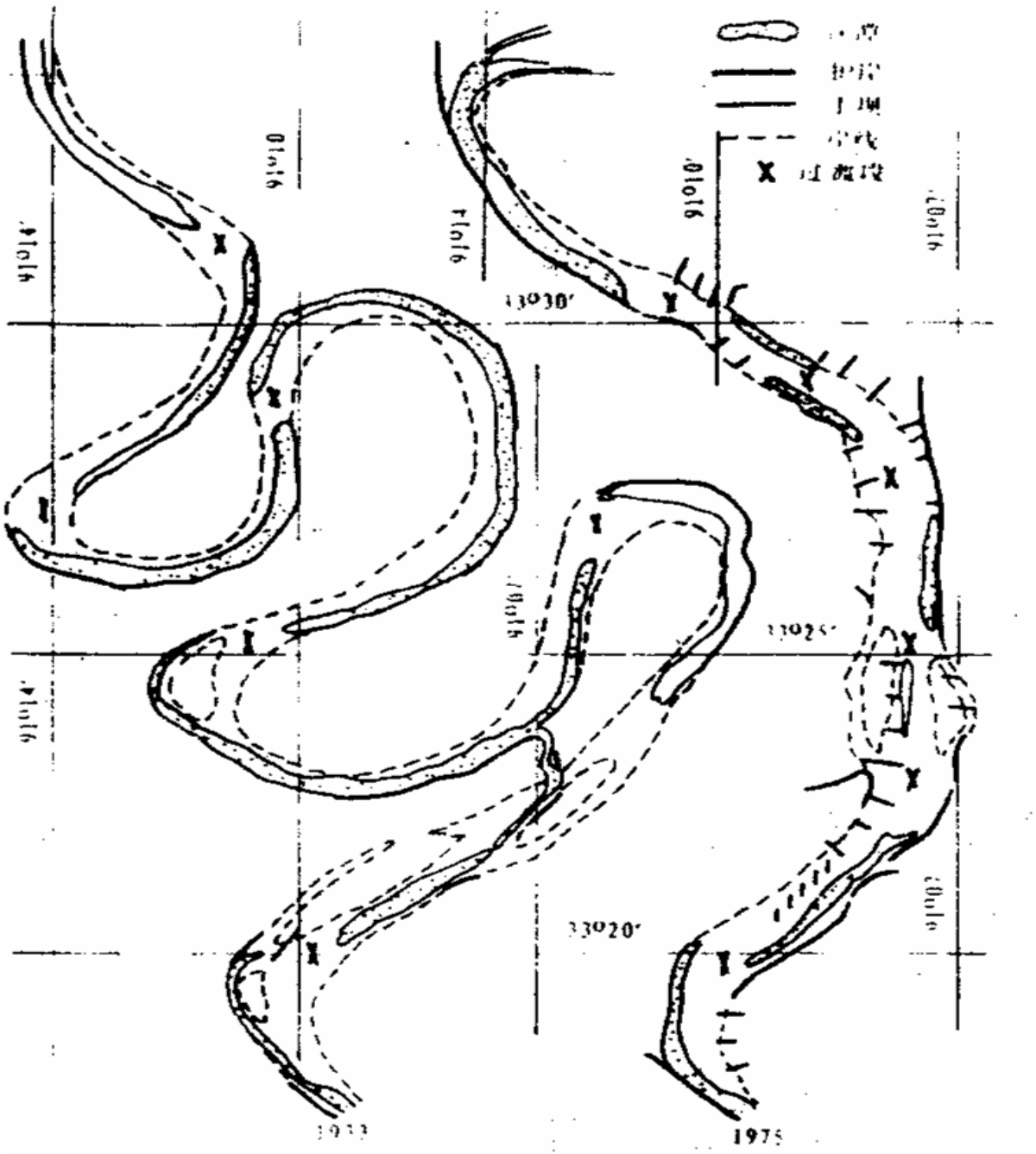
•

Only three species of macto-invertebrate are found in the River bed at No.8 bridge

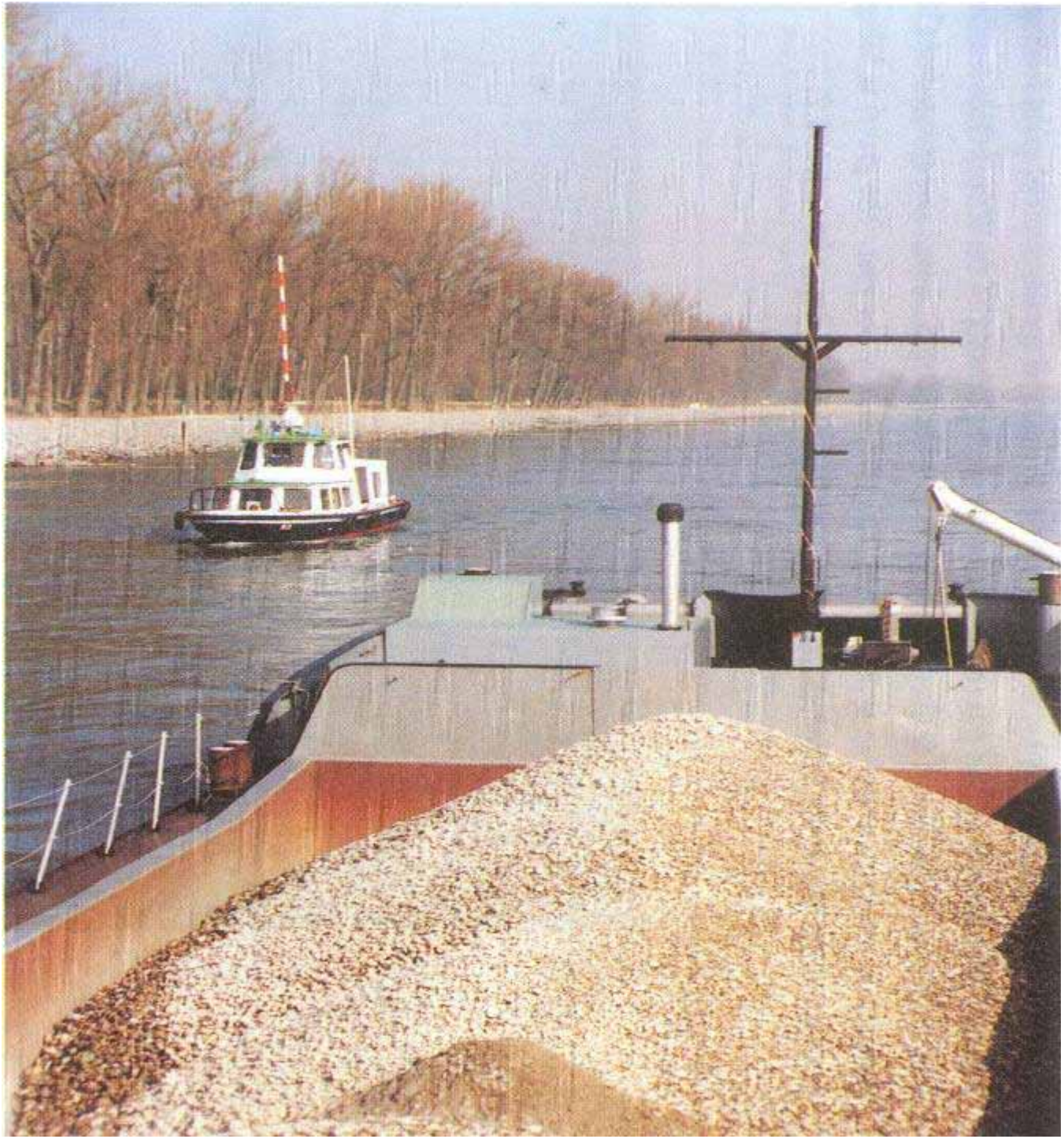
寡毛纲Oligochaeta

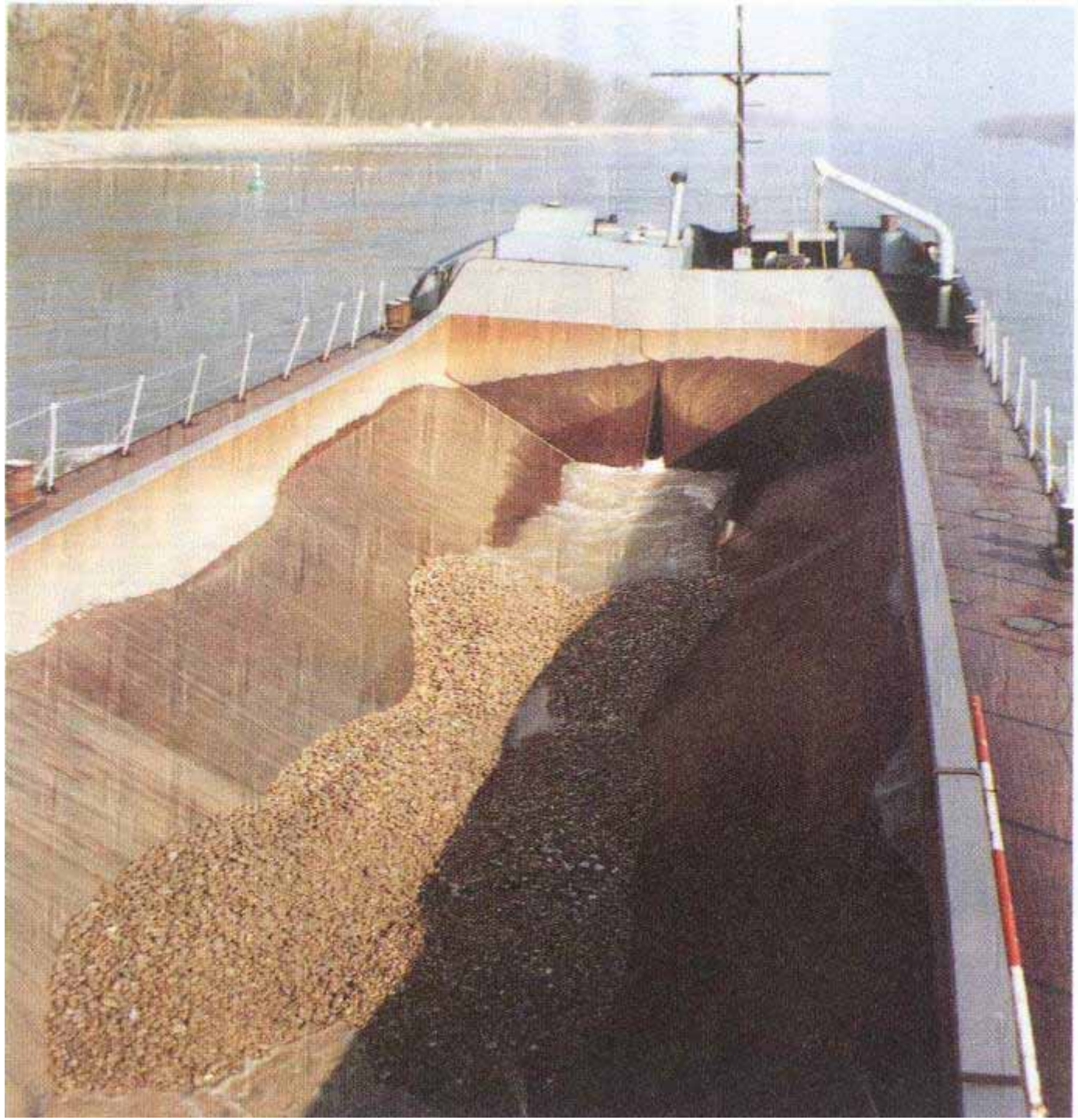
摇蚊科Chironomidae

Artificial cut-off of meanders have been performed in many river training projects, which often results in new fluvial process and loss of habitats.

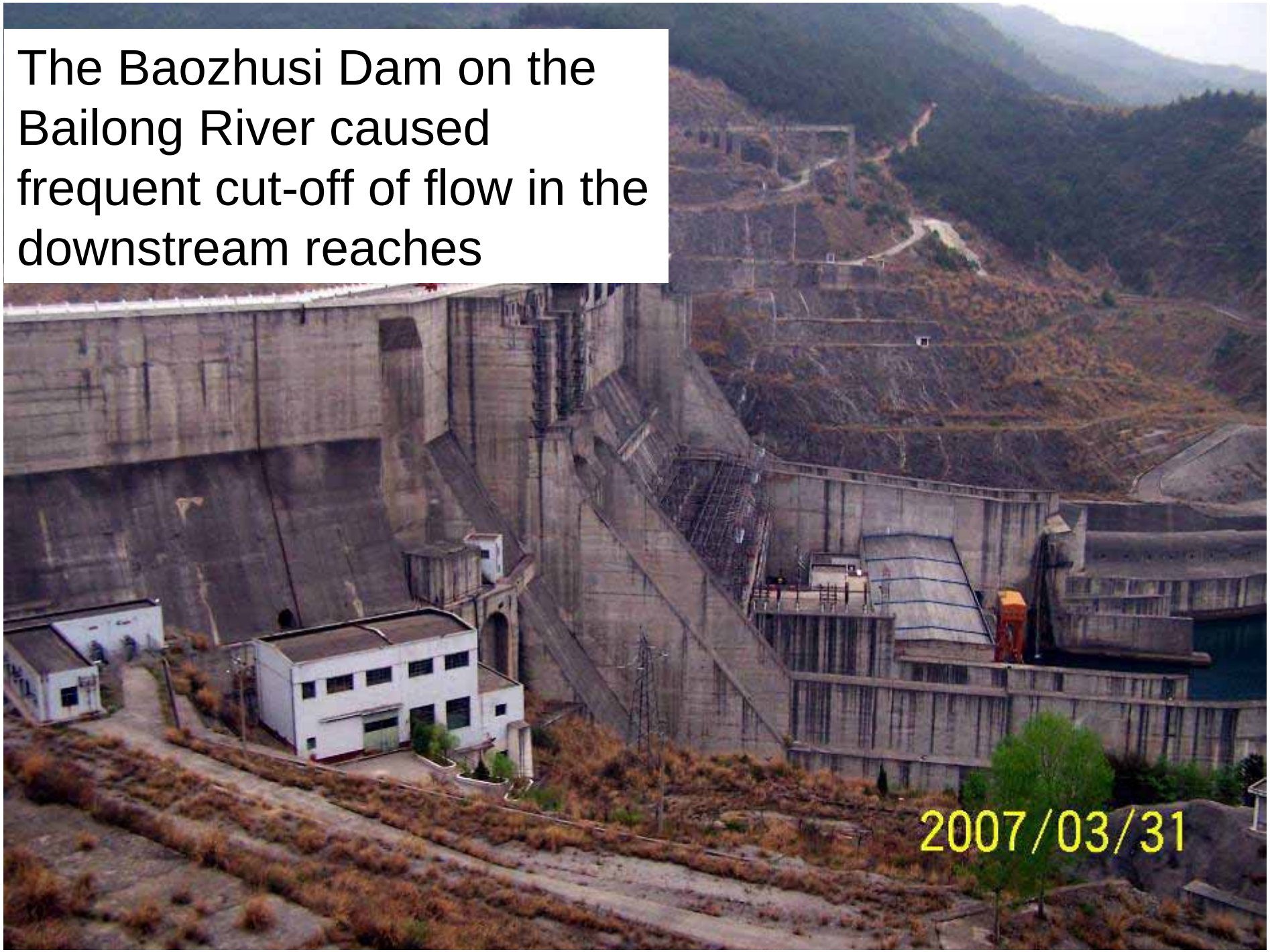


The cut-off of meanders and hardened banks in the Rhein River have caused channel incision and ecological problems. Humans have to feed bed load into the river to mitigate the impacts.

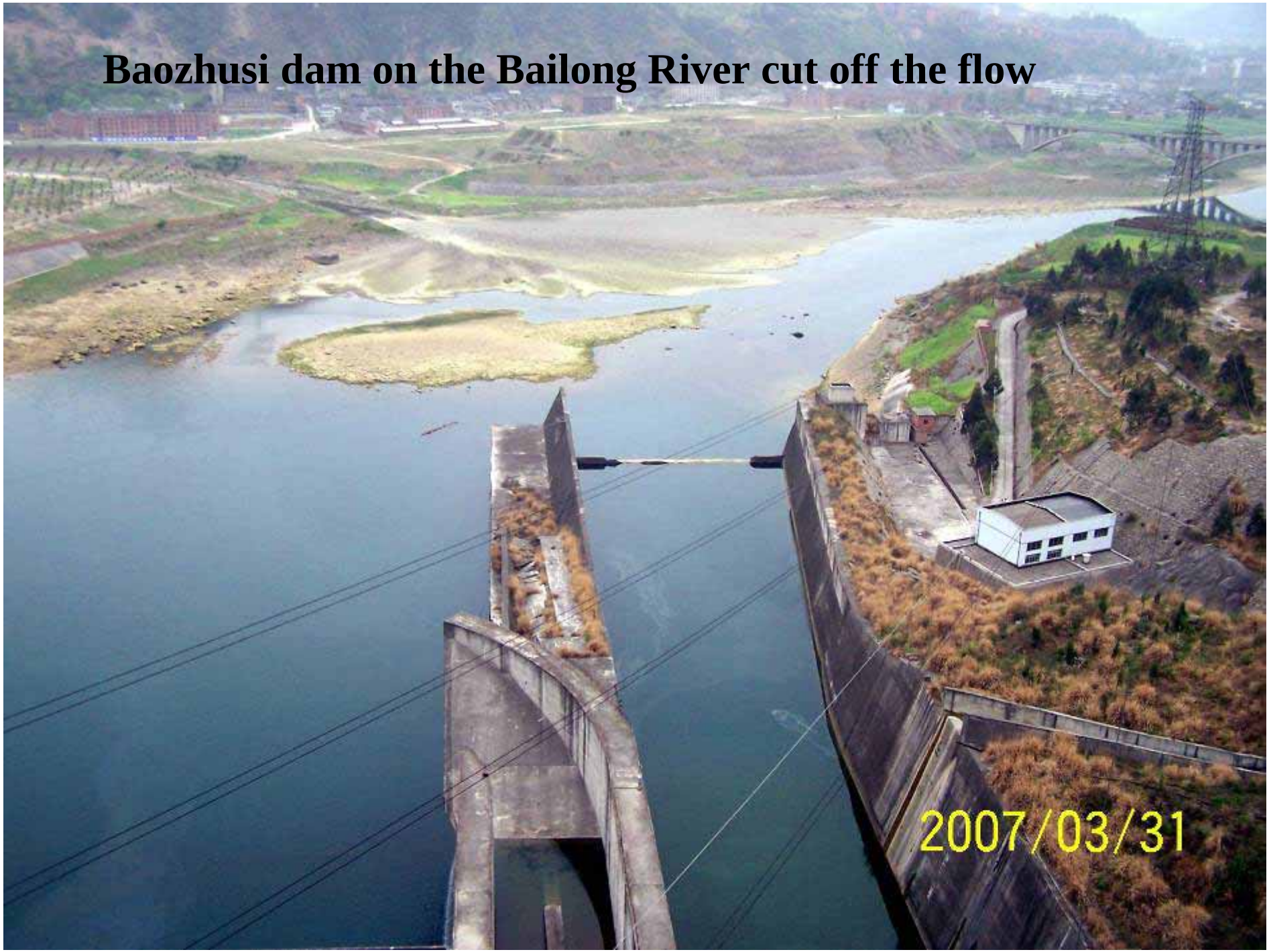




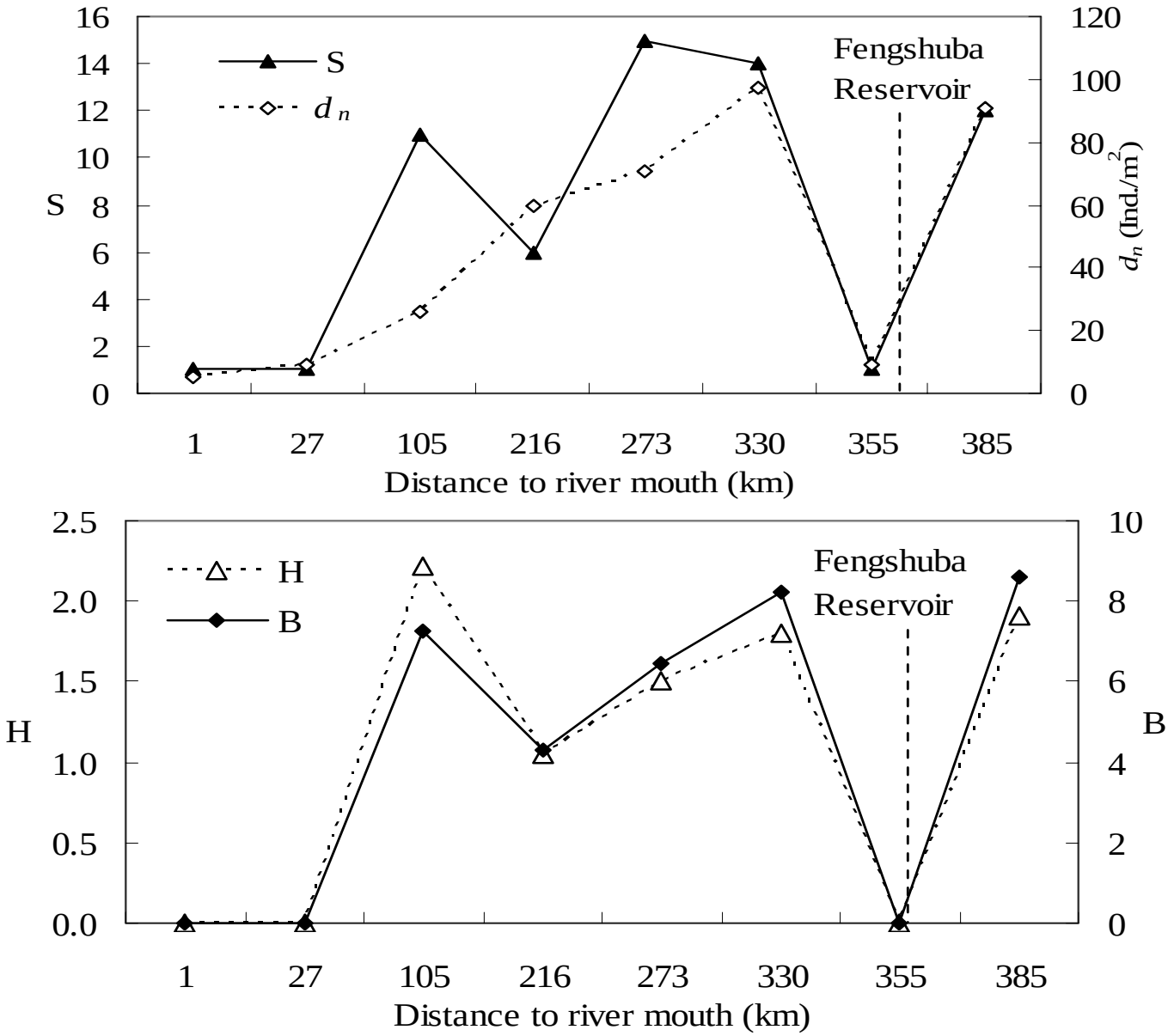
The Baozhusi Dam on the Bailong River caused frequent cut-off of flow in the downstream reaches



Baozhusi dam on the Bailong River cut off the flow

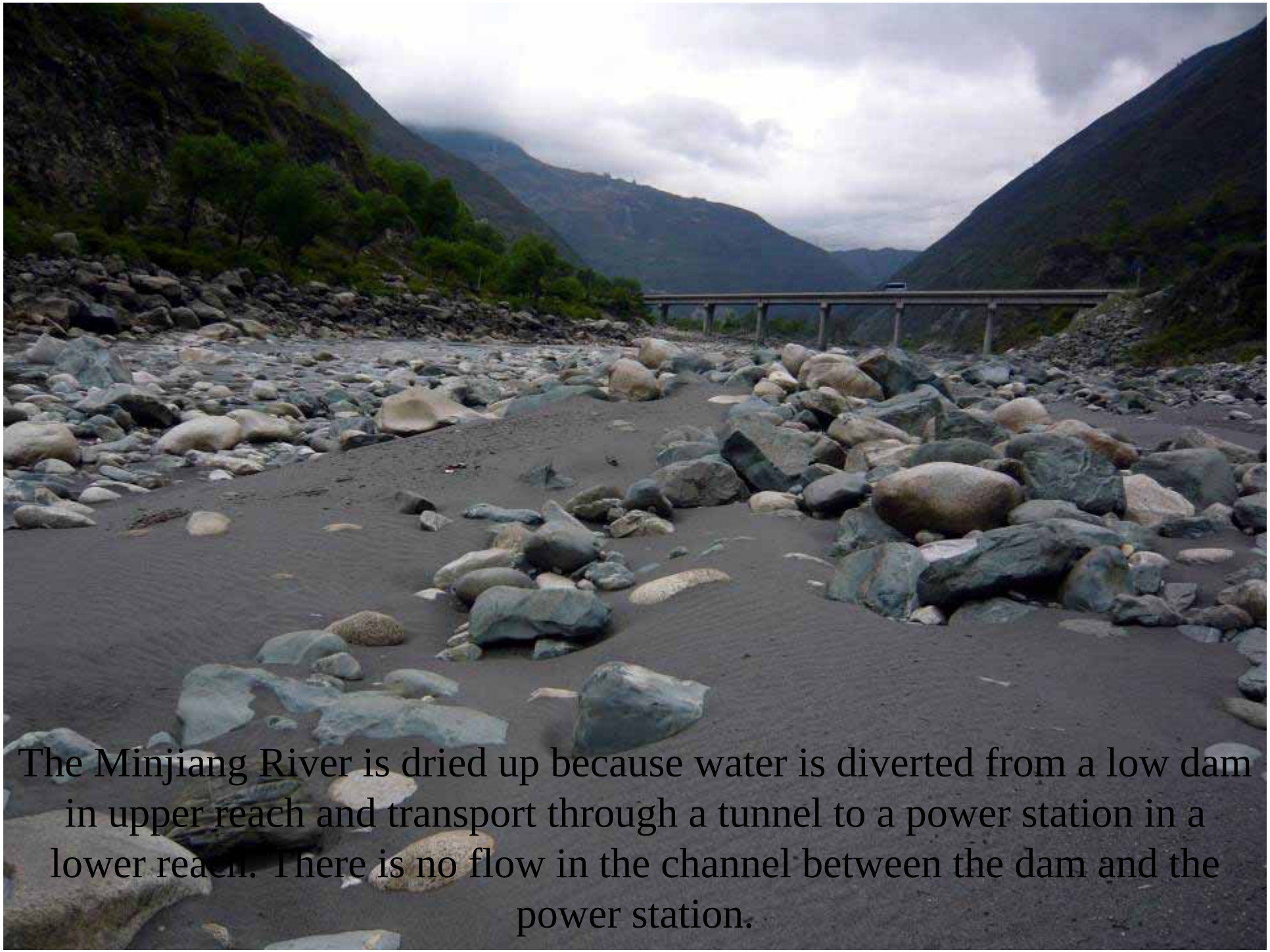


Fengshuba dam on the East River causes artificial fluctuation of discharge which impact the ecosystem in the downstream reaches.



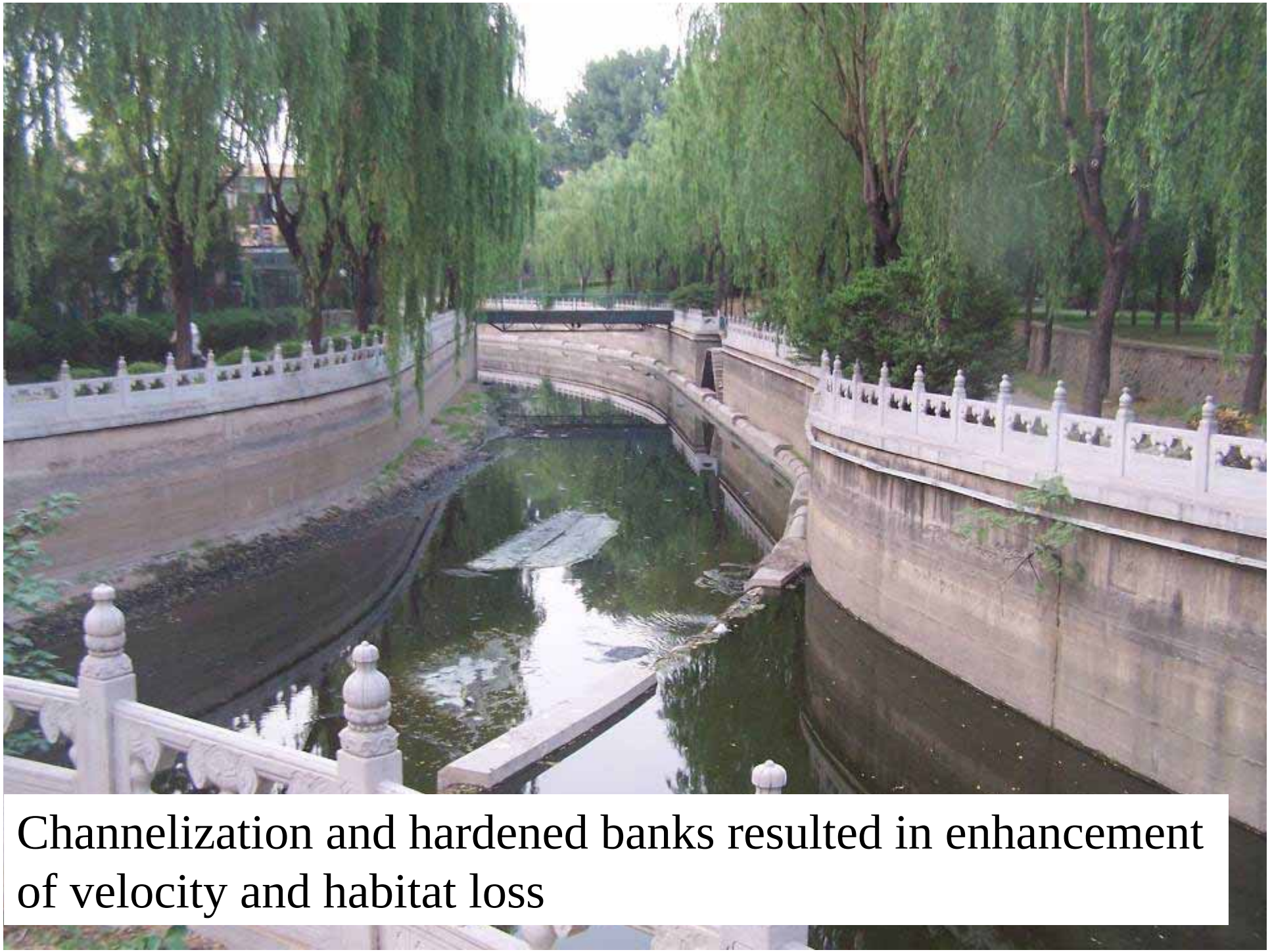
Richeness S and abundance dn, Shannon-Wiener Index, *H*, and the bio-community index, *B*, as functions of distance to the river mouth

Many mountain streams in south-west China are dried up due to water diversion for power generation.(Baoxing River –Tributay of the Xiaojinchuan)

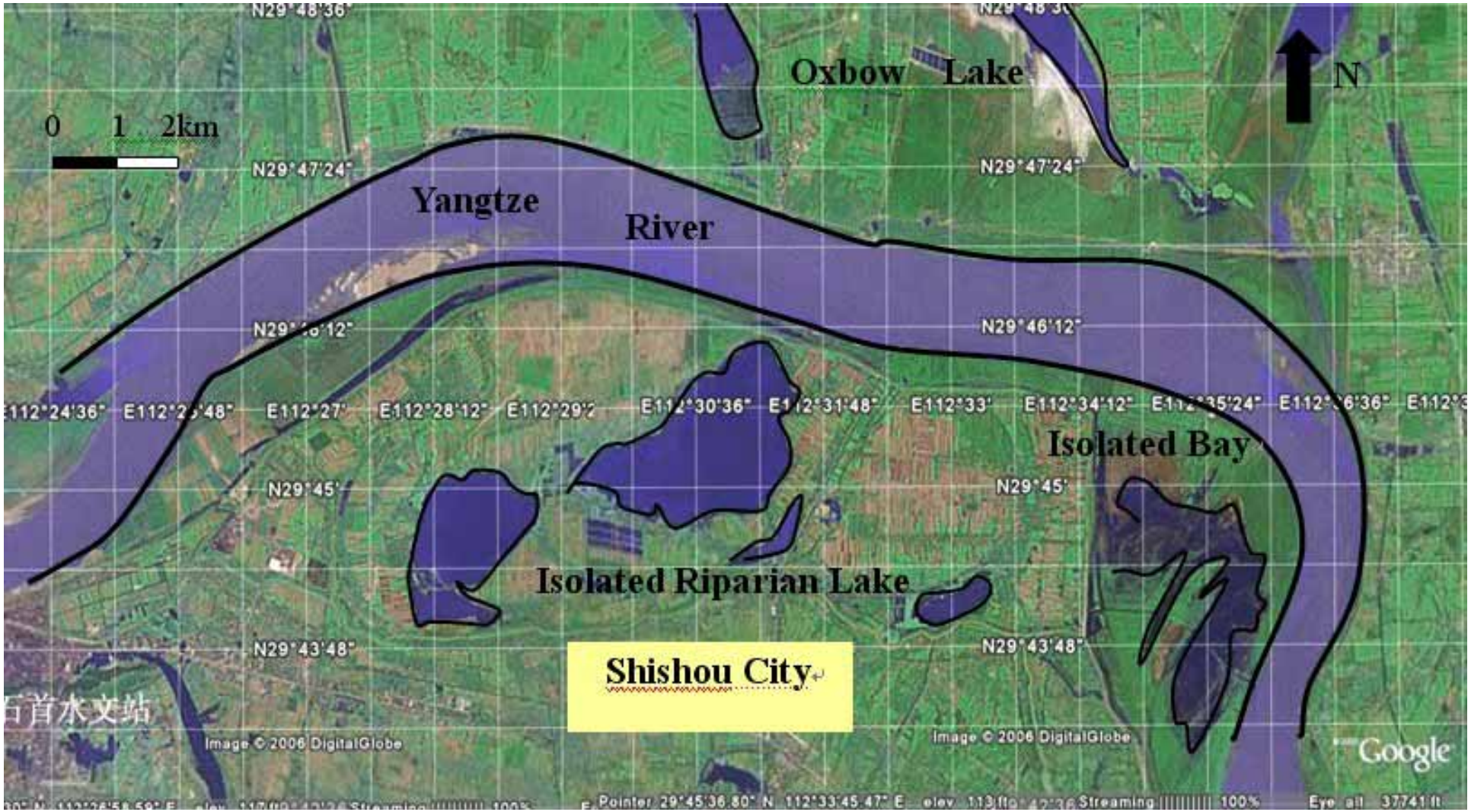


The Minjiang River is dried up because water is diverted from a low dam in upper reach and transport through a tunnel to a power station in a lower reach. There is no flow in the channel between the dam and the power station.

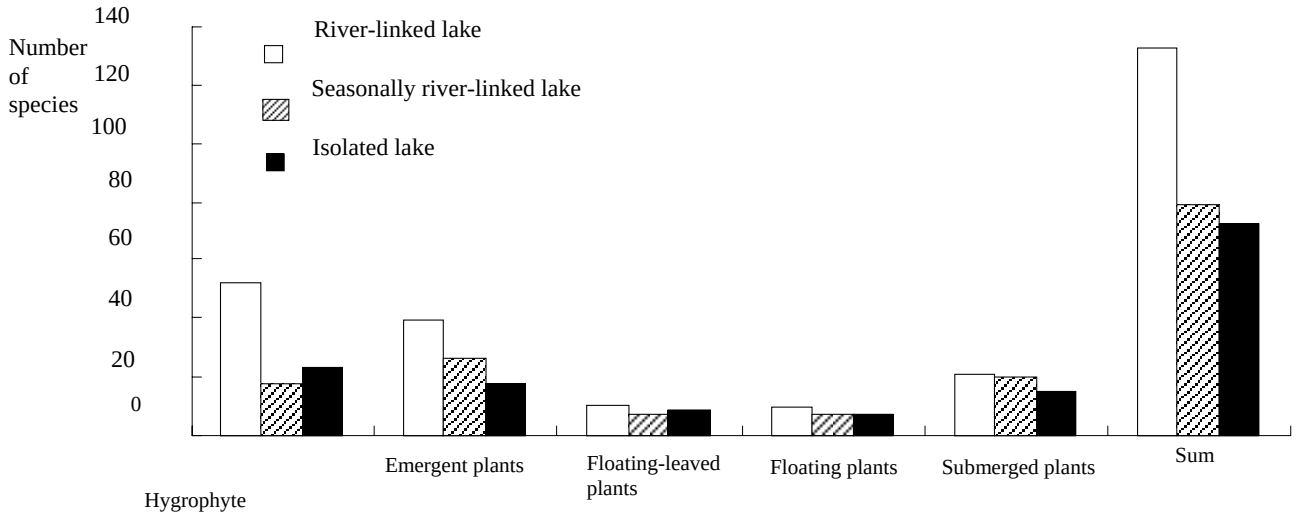
Grand levees and channelization have resulted in separation of habitats and reduction of bio-diversity



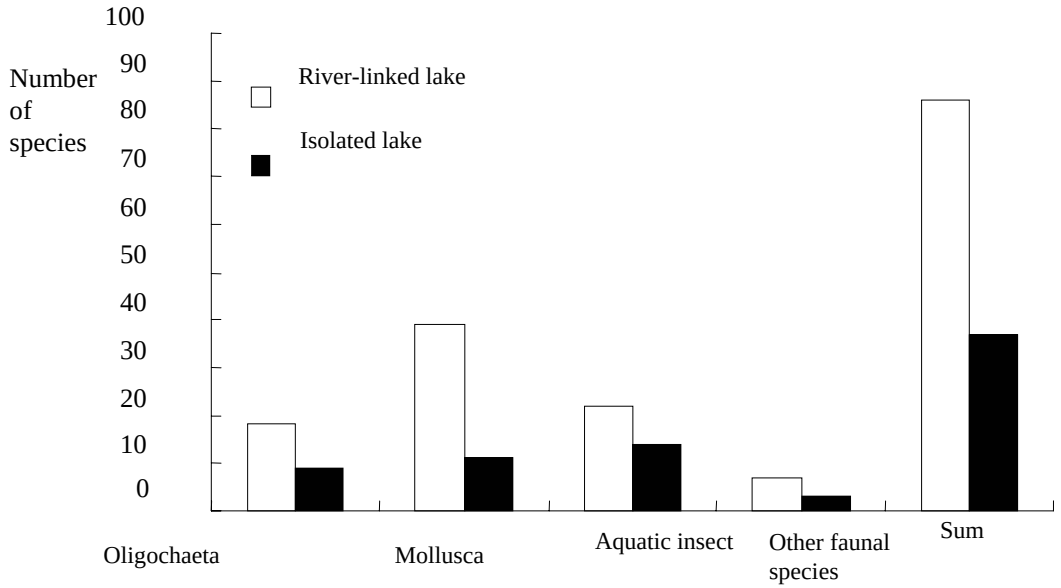
Channelization and hardened banks resulted in enhancement of velocity and habitat loss



The complex Yangtze River-lakes habitat has been fragmented



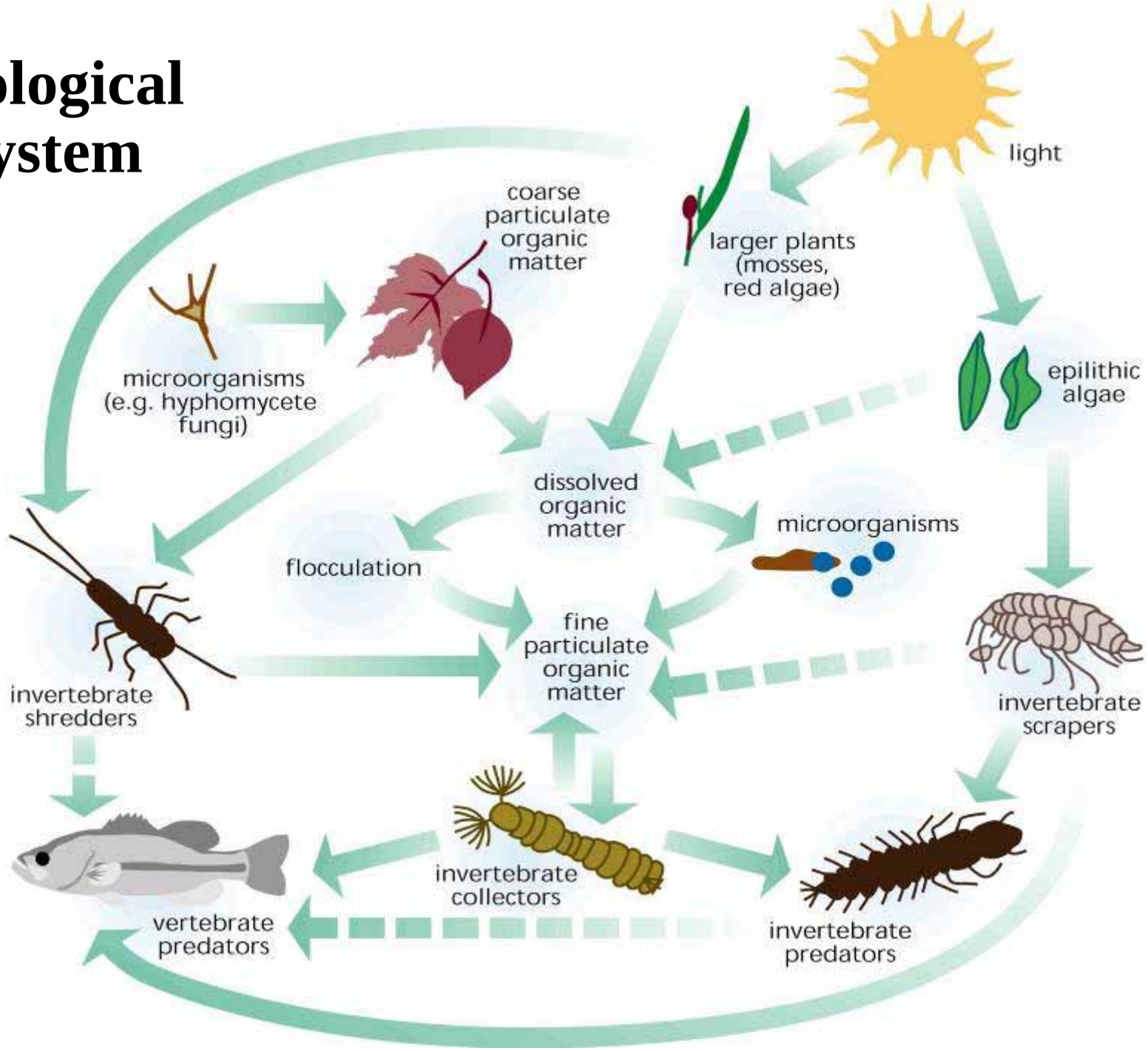
Comparison of biodiversity between river-linked and isolated lakes in the Yangtze River basin



2、Restoration Strategies for stream ecology

1. Indicator species
2. Stability of habitat
3. Habitat diversity
4. Enhance the stability and diversity of habitat
5. Improving substrate and providing cover
6. Increase the area and connectivity of habitat
7. Control pollution below the purification capacity of stream

Ecological system



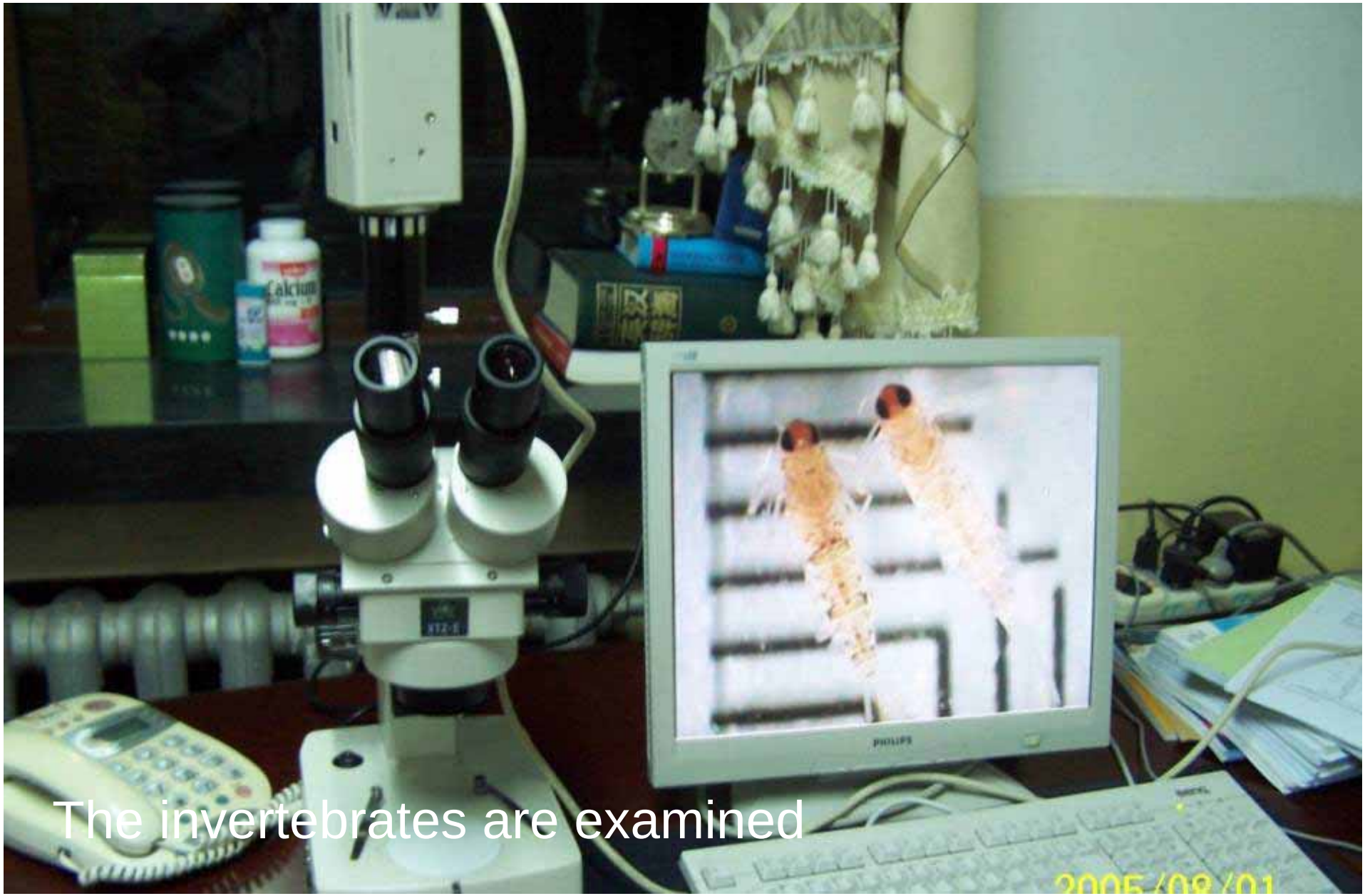
Criteria for Selecting Indicators

1) Sensitivity of the species to the environmental attribute being evaluated.
2) Indicator accurately and precisely responds to the measured effect.
3) Size of the species home range. If possible, the home range should be larger than that of other species in the evaluation area. Threatened and endangered species, are poor indicators because they are difficult to sample adequately, often due to budget constraints.
4) Response uniformity in different geographic locations. Response of an indicator species to an environmental stress cannot be expected to be consistent across varying geographic locations. If possible, the response to a stress should be more uniform than that of other species in different geographic locations.

Benthic Macroinvertebrates

Using benthic macroinvertebrates is advantageous for the following reasons: 1) They are good indicators of localized conditions. 2) They integrate the effects of short-term environmental variables. 3) Degraded conditions are easily detected. 4) Sampling is relatively easy. 5) They provide food for many fish of commercial or recreational importance. 6) Macroinvertebrates are generally abundant. 7) Many states already have background data.

Identification of species of invertebrates:



The invertebrates are examined

（a） **predator-dragonfly**; (b) **scraper-snails**; (c) collector-filter - cadisfly; (d) 蚬 (**filter and collector**); (e) **shredder**-沼梭)

Fish

The advantages of using fish as bioindicators are as follows: 1) They are good indicators of long-term effects and broad habitat conditions.2) Fish communities represent a variety of trophic (nutrient) levels. 3) Fish are at the top of the aquatic food chain and are consumed by humans. 4) Fish are relatively easy to identify. 5)Water quality standards are often characterized in terms of fisheries. 6) Nearly one-third of the endangered vertebrate species and subspecies in the United States are fish.

Fish samples

Cyprininae ~90% of Chinese fish are cyprinids

"includes common carp 鯉科

and goldfish"

2) Stabiltiy of habitat

- Analyzing 300 samples from about 60 rivers concluded that
- Stability of aquatic habitat is the most important for stream ecology

Streams with stable bed have the best aquatic ecology

- 襀翅目

Plecoptera

- 蜉蝣目

Ephemeridae

- 毛翅目

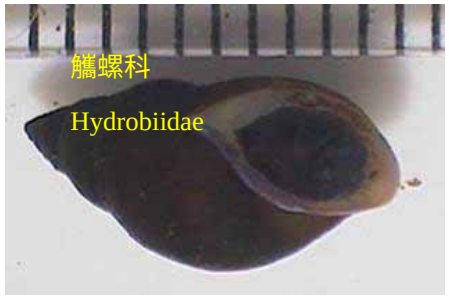
Trichoptera

- 鞘翅目

Plecoptera

- 腹足纲

Gastropoda

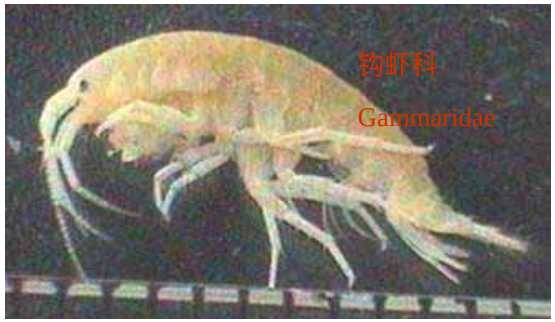


- 双翅目

Diptera

- 端足目

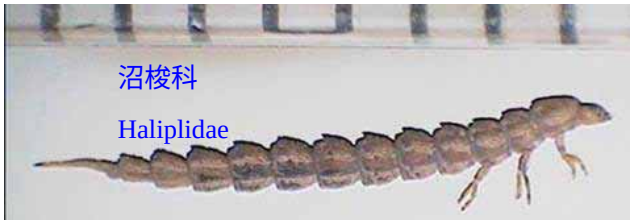
Amphipoda



Incised streams have less species

- 鞘翅目

Plecoptera

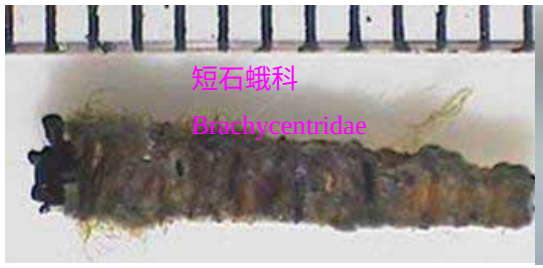


- 蜉蝣目

Ephemeridae

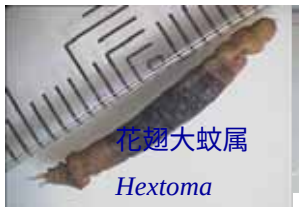
- 毛翅目

Trichoptera



- 双翅目

Diptera



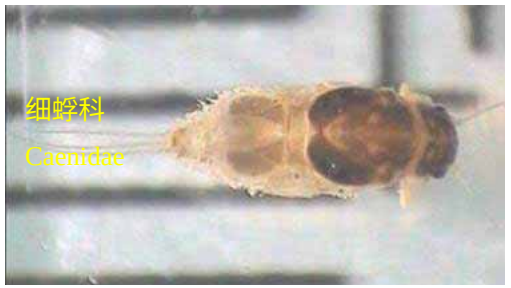
Aggradating streams have only few species

- 蜻蜓目

Odonata

- 蜉蝣目

Ephemeridae



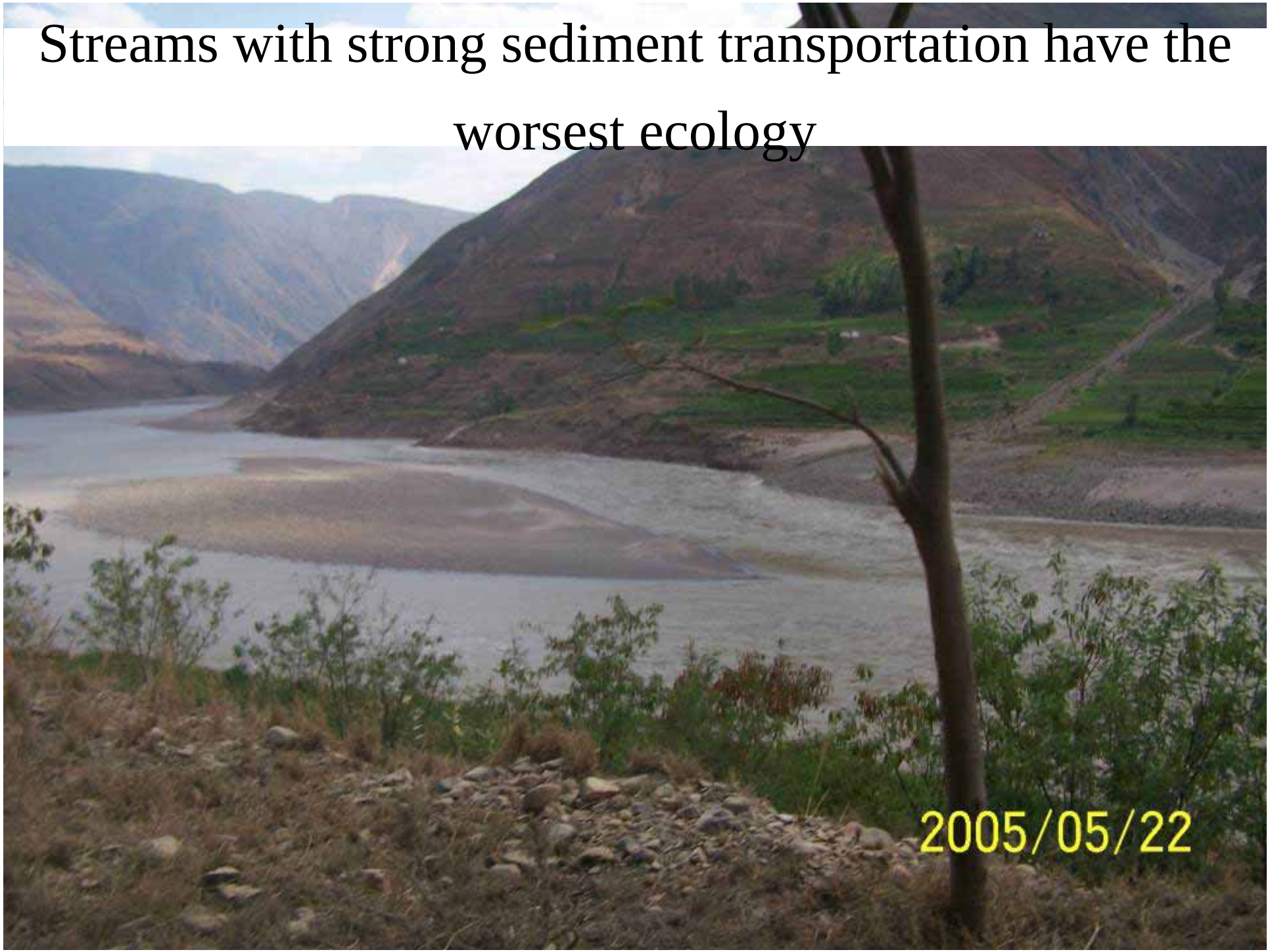
- 双翅目

Diptera

- 鞘翅目

Plecoptera

Streams with strong sediment transportation have the worsest ecology



3). Habitat Diversity

Habitat has a definable carrying capacity, or suitability, to support or produce wildlife populations. The capacity depends on the habitat diversity.

The physical conditions of stream habitat are mainly 1) the substrate; 2) water depth; and 3) flow velocity.

A habitat diversity index, *HD*, is proposed as follows

$$H_D = N_h N_v \sum_i \alpha_i$$

Table 10.3 Substrate diversity, α , values for different substrates (Wang et al., 2008)

Substrate	Boulders and cobbles (D＞200 mm)	Aquatic grass	Gravel (2-200 mm)	Fluid clay mud (D<0.02m m)	Silt (0.02 ~0.2 mm)	Sand (0.2~2 mm)	Unstable sand, gravel, and silt bed (0.02~20 mm)
α	6	5	4	3	2	1	0

If a streambed has three parts with different substrates: boulders and cobbles, aquatic grasses, and fluid clay mud, and each of the three parts is larger than 1/10 of the total stream area, the sum of the -values for the stream is

$$\sum_i \alpha_i = 6+5+3 = 14$$

If the streambed is covered by moving sand and gravel or the bed is very unstable, the substrate diversity is zero.

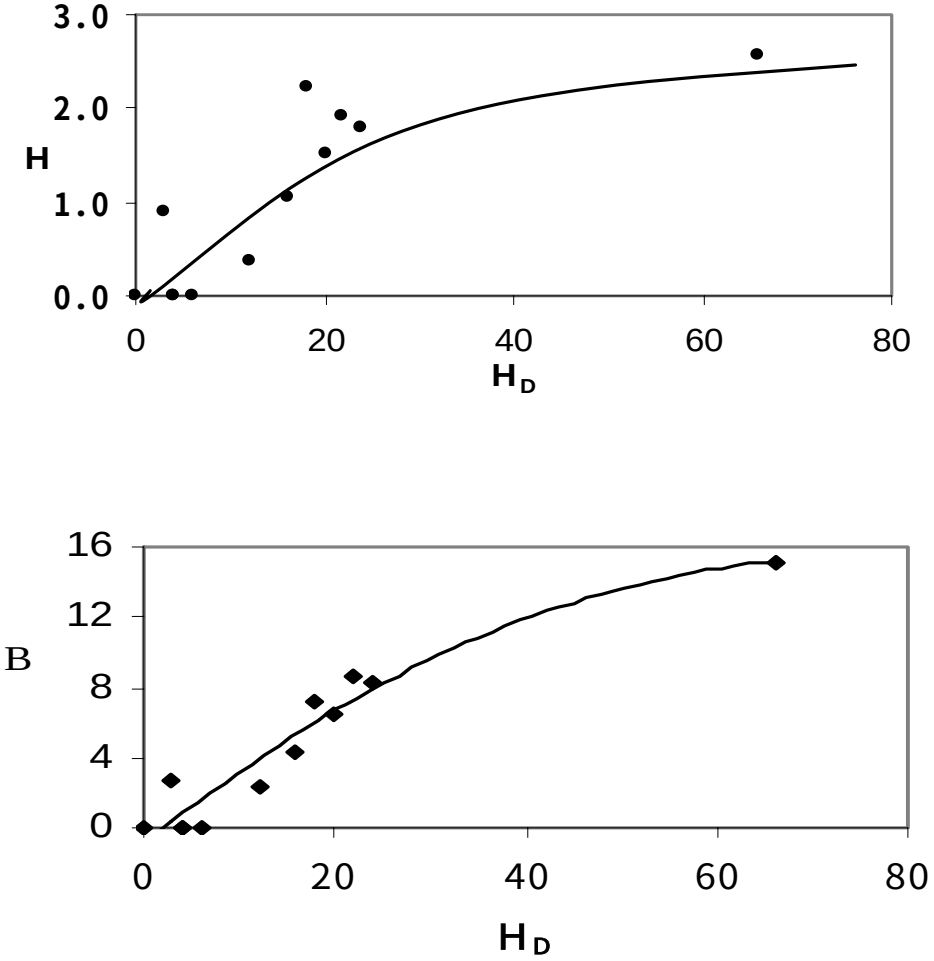


Fig. 10.36 Relation between habitat diversity, H_D, and Shannon-Weaver index, H (upper); and the relation between habitat diversity, H_D, and bio-community index, B (lower)

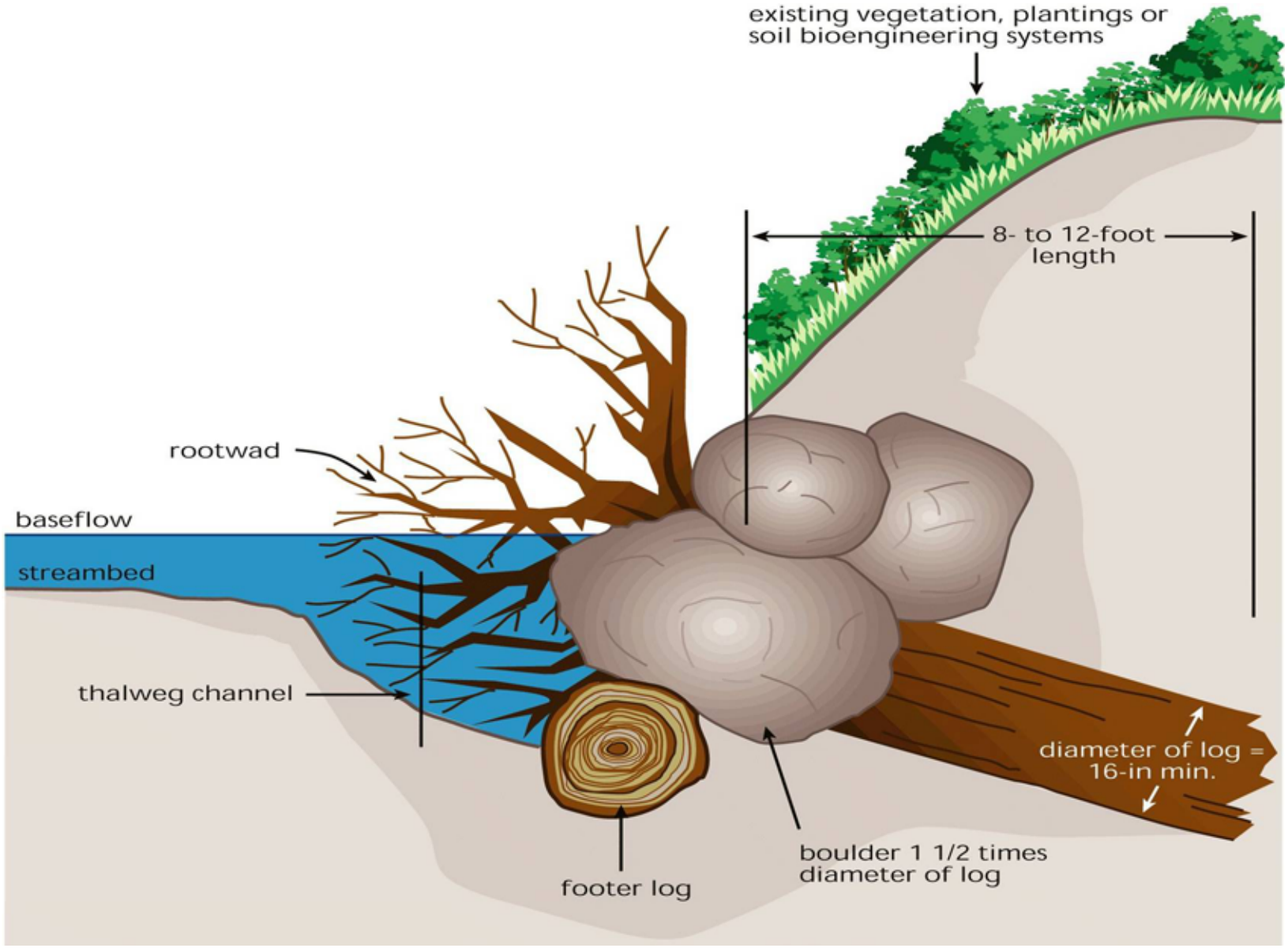
4)、Enhancing habitat diversity

Riprap weirs

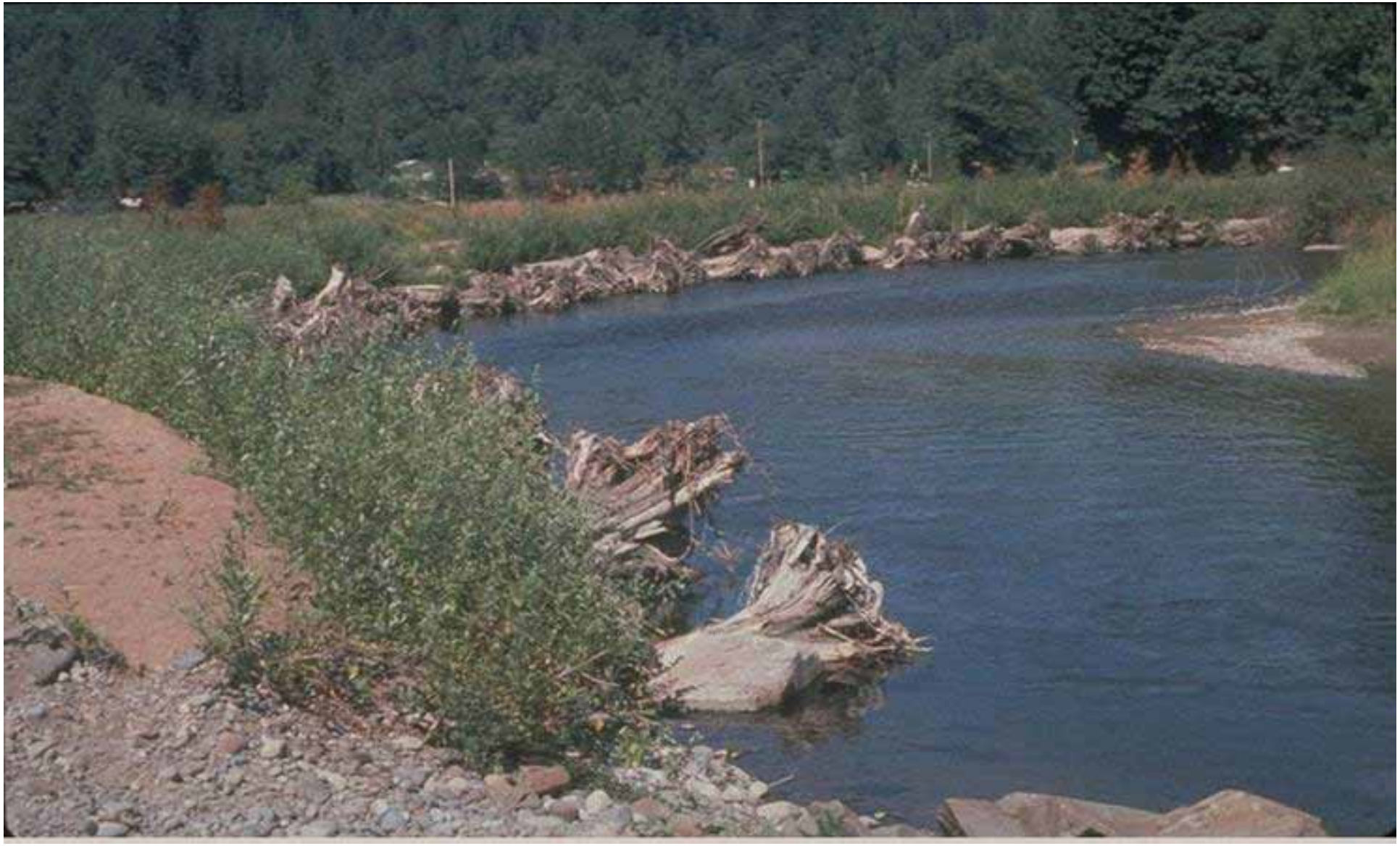
Robber weirs on a mountain stream create stable habitat for fishes

Deflectors – increase habitat diversity

Deposition induced both upstream and downstream from limestone deflectors in a channel in England. One year after the implementation vegetation has become established on the deposit (Brookes).



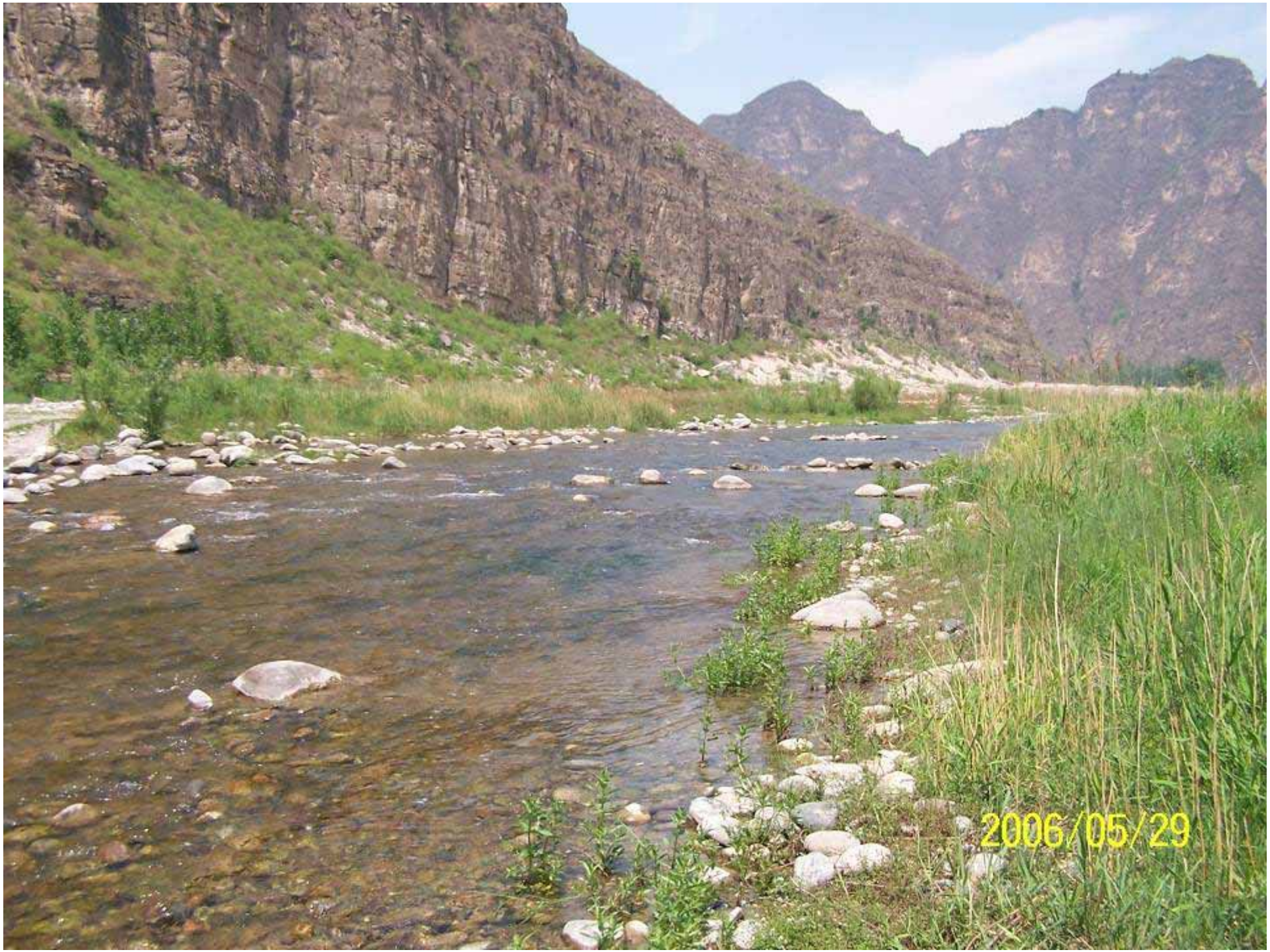
Stabilize the banks with rootwad log



The protruding rootwads effectively reduce flow velocities at the toe and increase habitat diversity.

5)、Improving substrate and providing cover

1. **Cobbles and high aquatic plant are the best substrate for faunal community；Mud layer is also good.**
2. **Sand bed does not suitable for animals to live**
3. **Cover**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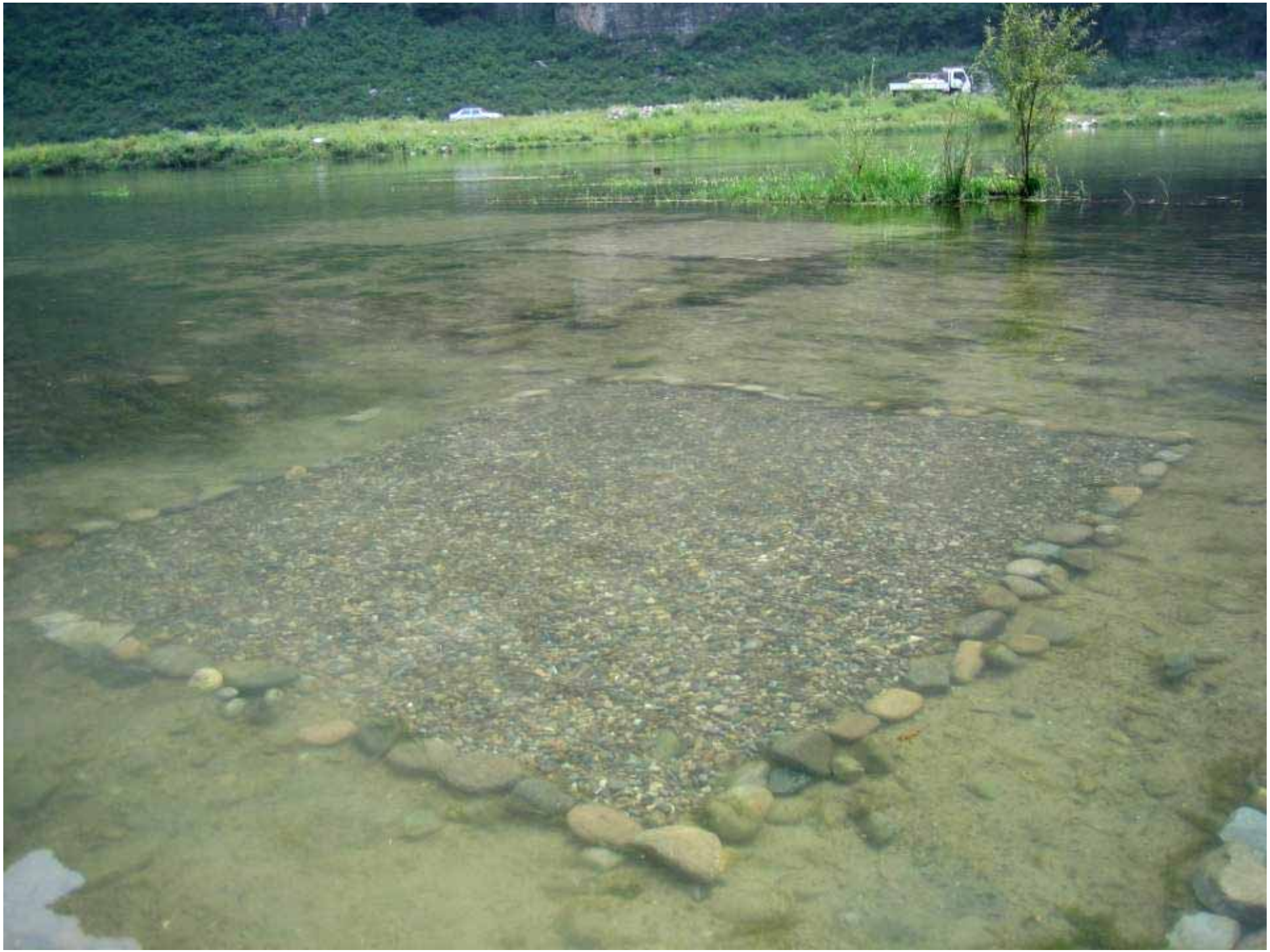
Replacing the substrate with cobbles and gravel increased biodiversity


Field experiments by replacing the substrate with gravel and stones



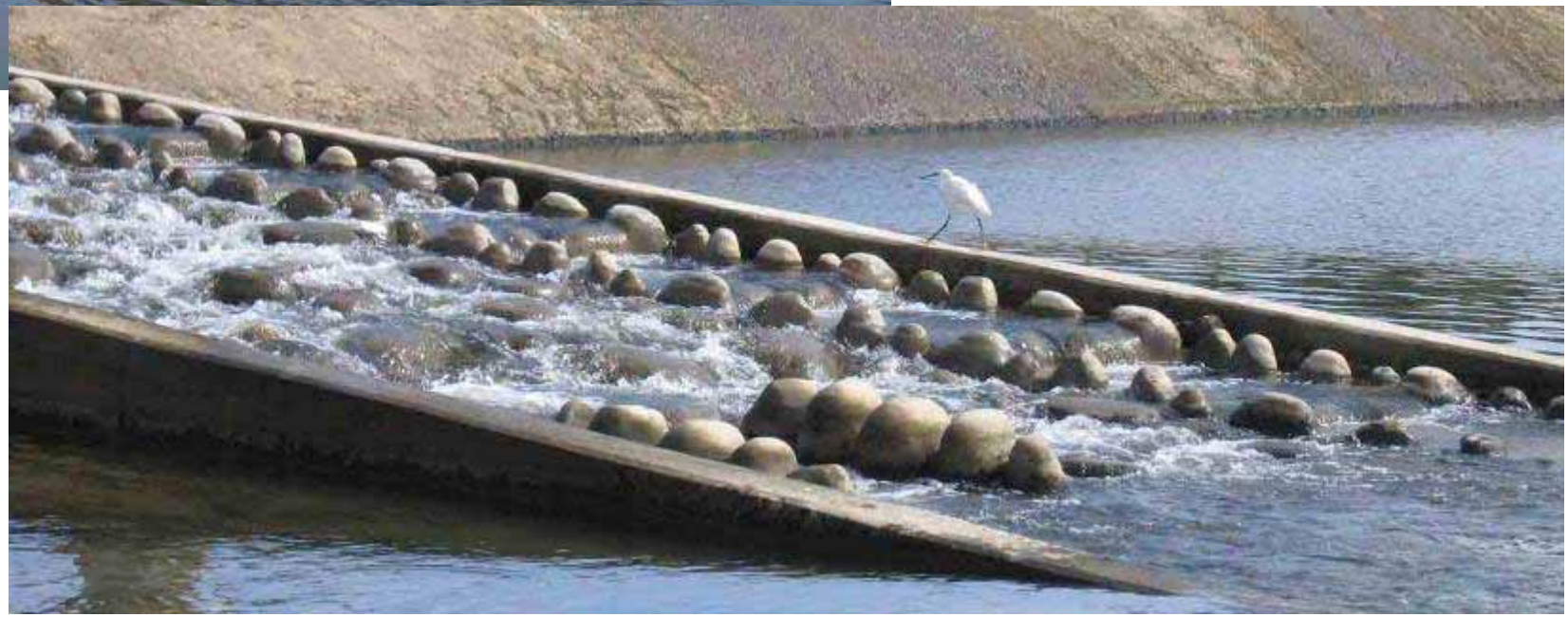
Provide cover (increase habitat diversity)

Engineered logjams can restore riverine habitat and in some situations provide effective bank protection

Artificial wetland (South Korea)

- Fish ladder

Fish ladder



7)、Control pollution below the stream purification capacity for pollutants and enhance the purification capacity

Aquatic plant species and macro-invertebrate species in the Juma River

Plant：Potamogeton perfoliatus (穿叶眼子菜)、Chara fragilis Desv (轮藻)、Myriophylum verticillatumLinn (狐尾藻)、 Potamogeton malaianus (竹叶眼子菜)、团藻

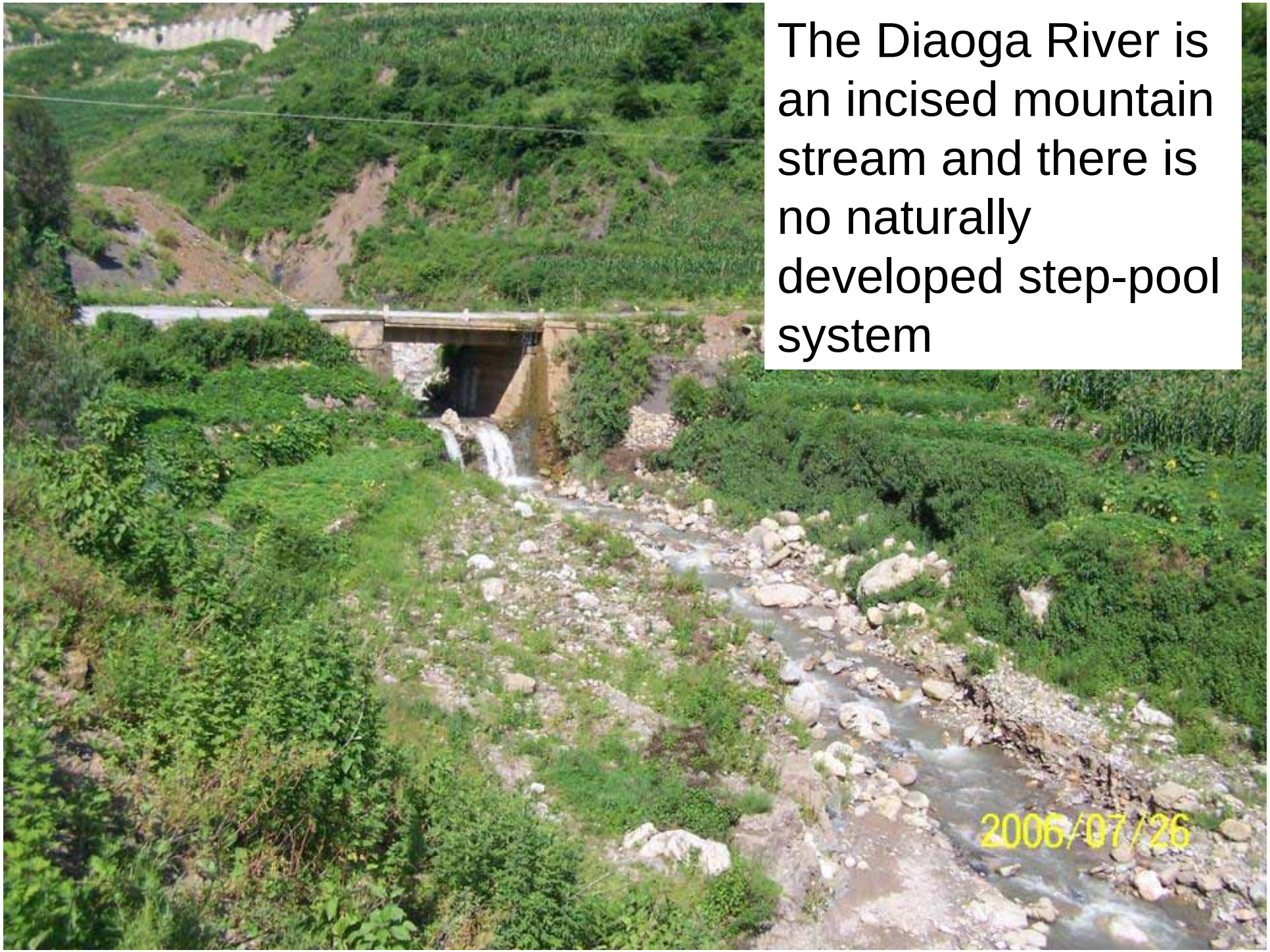
Benthic macro-invertebrates（ind/m2 for each species)

四节蜉科 Baetidae 191
蜉蝣科 Ephemeridae 90
寡毛纲 Oligochaeta 58
摇蚊科 Chironomidae 48
无齿蚌属 Anodonta 16
蚬科 Corbiculidae 15
大蚊科 Tipulidae 8
龙虱科 Dytiscidae 4
蠓科 Ceratopogonidae 4
小裳蜉Leptophlebiidae 2
纹石蛾科 Hydropsychidae 1
扁形动物 Platyhelminthes 1
萝卜螺属 Radix 111
Limnophilidae 70
扁蜉科 Heptageniidae 57
蛛形目 Acariformes 29
细蜉科 Caenidae 14
其他蜉蝣目 Ephemeroptera 13
方格短沟蜷 S.cancellata 5
双翅目Diptera 4
箭蜓科 Gomphidae 3
蛭纲 Hirudinea 2
半翅目 Hemiptera 1

Purification capacity of stream per length

Reach	TN（mg/L）	TP（mg/L）	lenth（km）	Purification capacity per length for TN (mg/L·km)	Purification capacity per lenth for TP (mg/L·km)
L_{1-2}	0.15	0.0011	2	0.075	0.00055
L_{2-3}	0.23	0.0002	3.5	0.0657	0.000057
L_{1-3}	0.38	0.0013	5.5	0.0691	0.000234

3、Integrated stream restoration with an artificial step-pool system



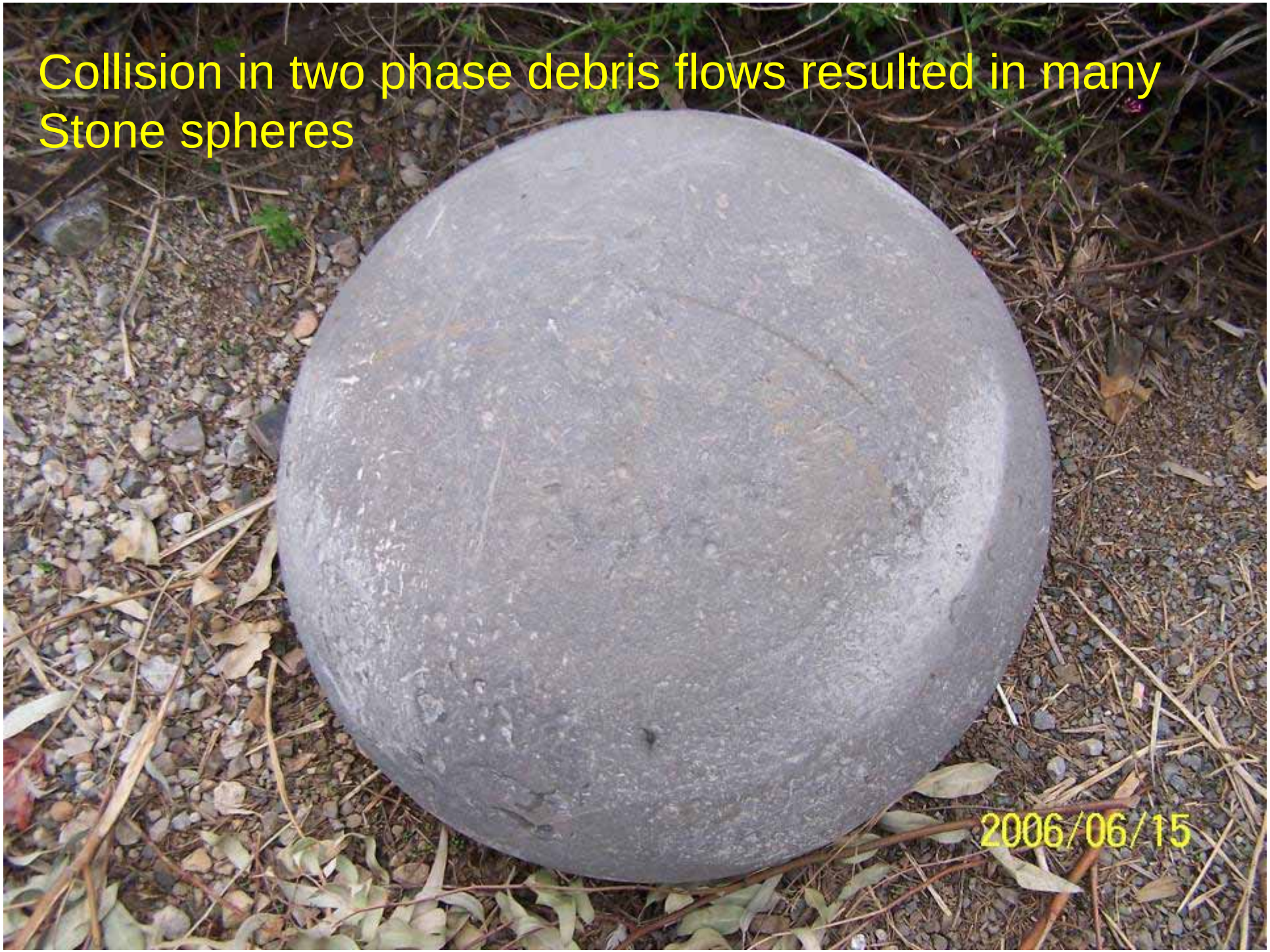
The Diaoga River is an incised mountain stream and there is no naturally developed step-pool system


2006/07/26


Aquatic ecology is bad
2006/07/26


2006/10/25


2006/10/25


Collision in two phase debris flows resulted in many Stone spheres
2006/06/15

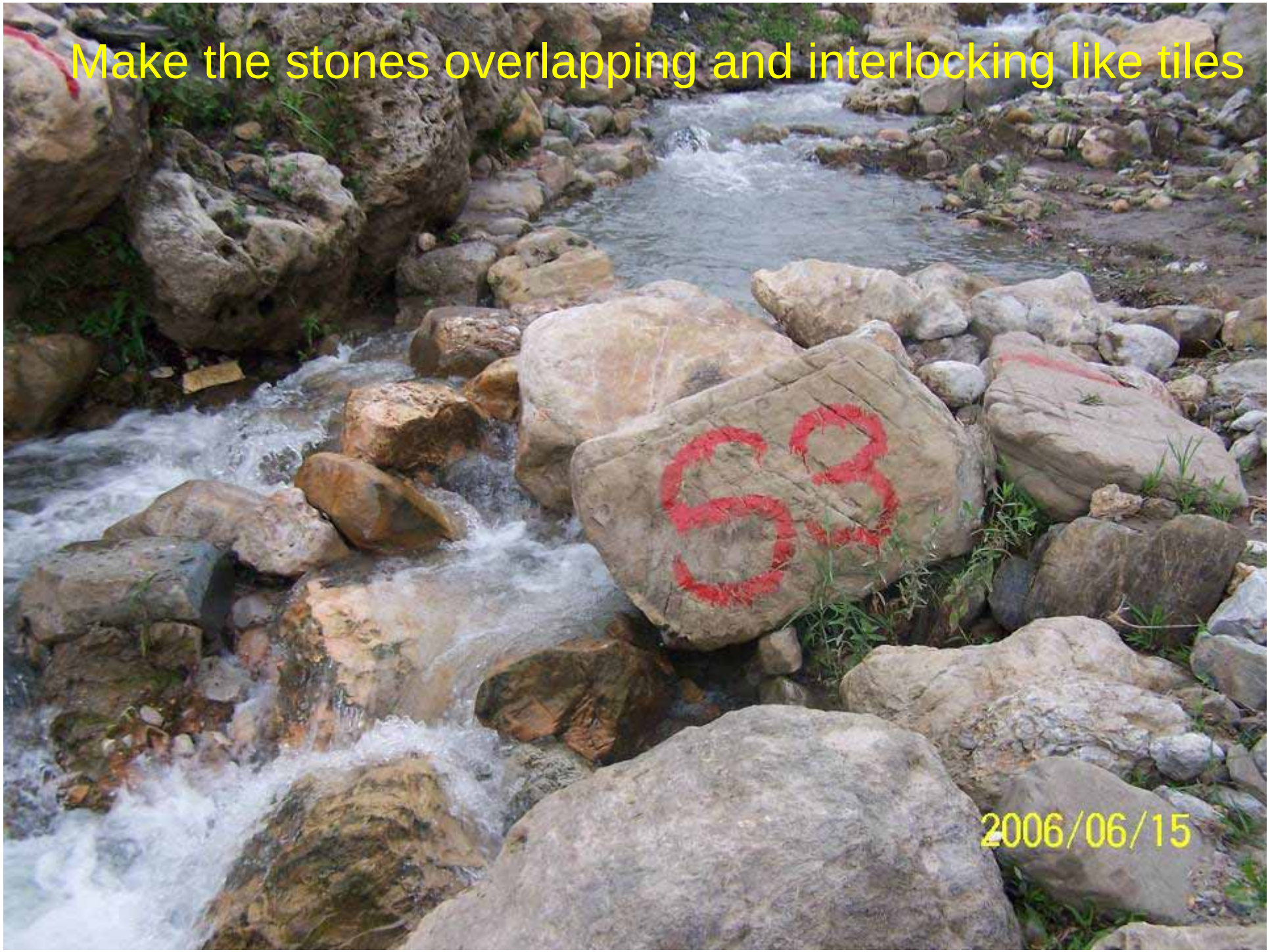

2006/10/25


Measurement of bed load transportation
2006/06/16

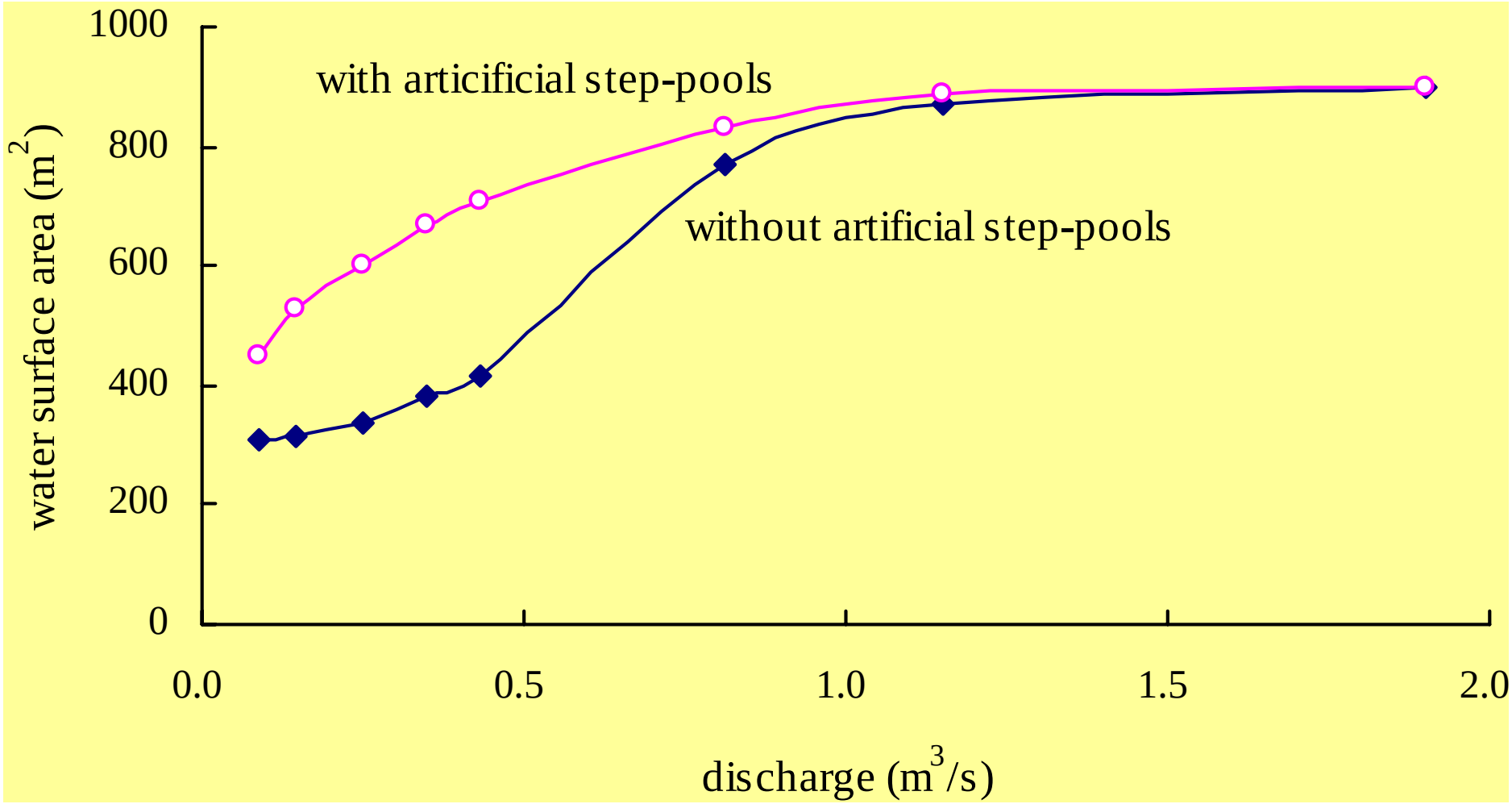

2006/07/26


Macro-benthic invertebrate
sampling in the Diaoga Ravine
2006/06/13


S4
S4
2006/06/15

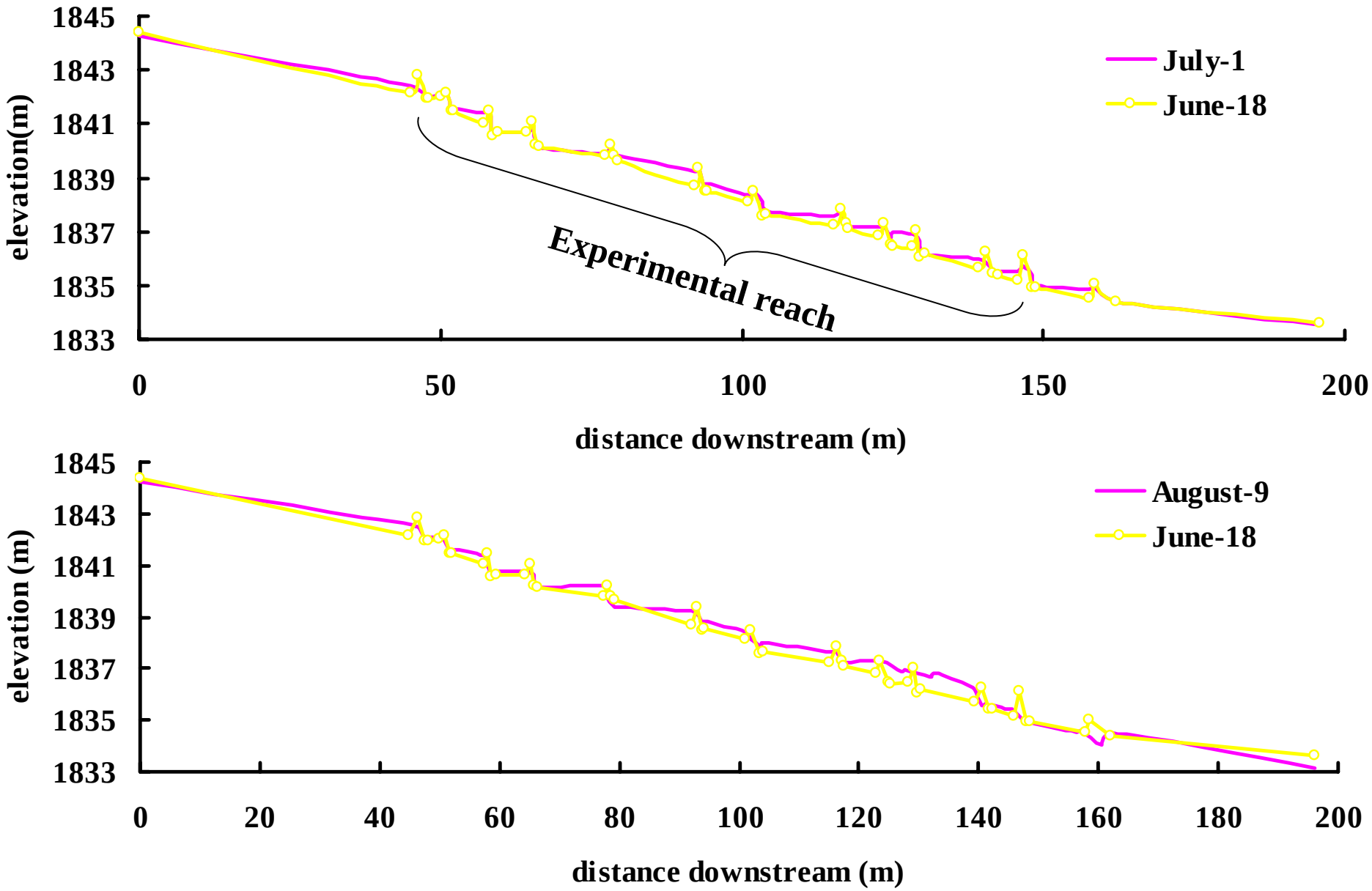

Make the stones overlapping and interlocking like tiles
68
2006/06/15


Create habitats for aquatic biocommunity
2006/06/16

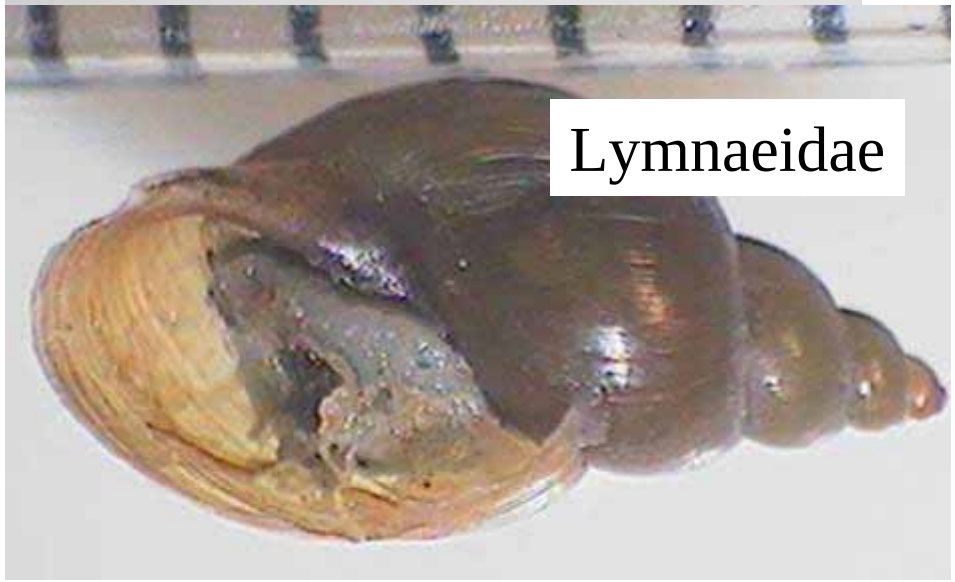


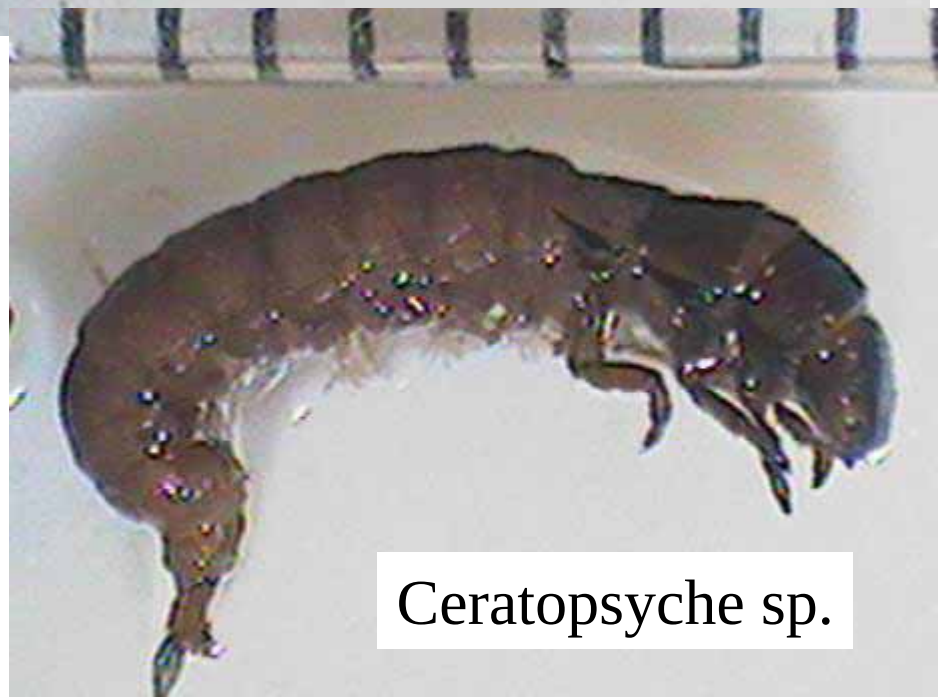
Water surface area as a function of discharge before and after the artificial step-pools

Variation of longitudinal profile of experimental reach



Main species before the artificial step-pools





Newly appeared species

With Step-Pools

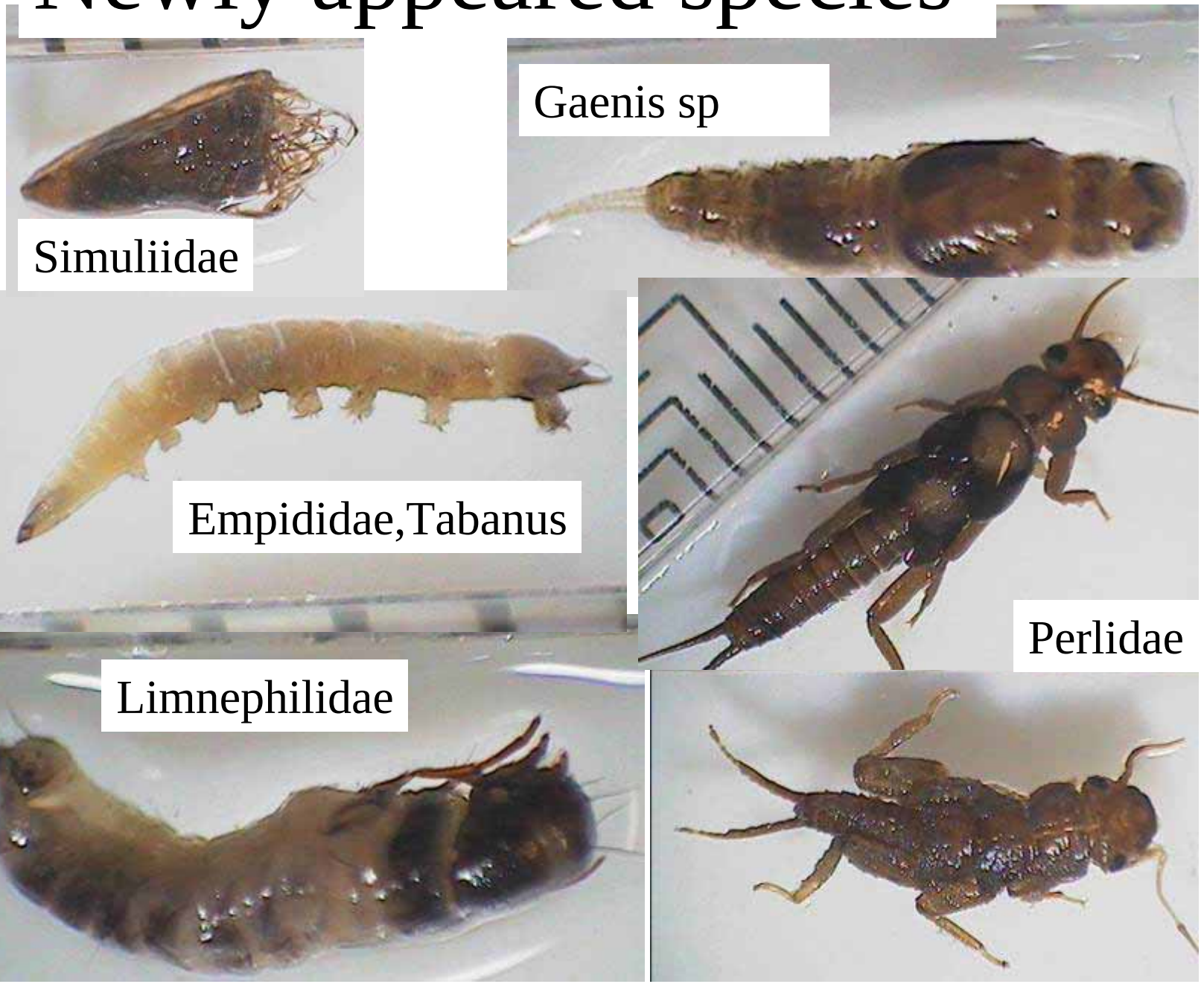
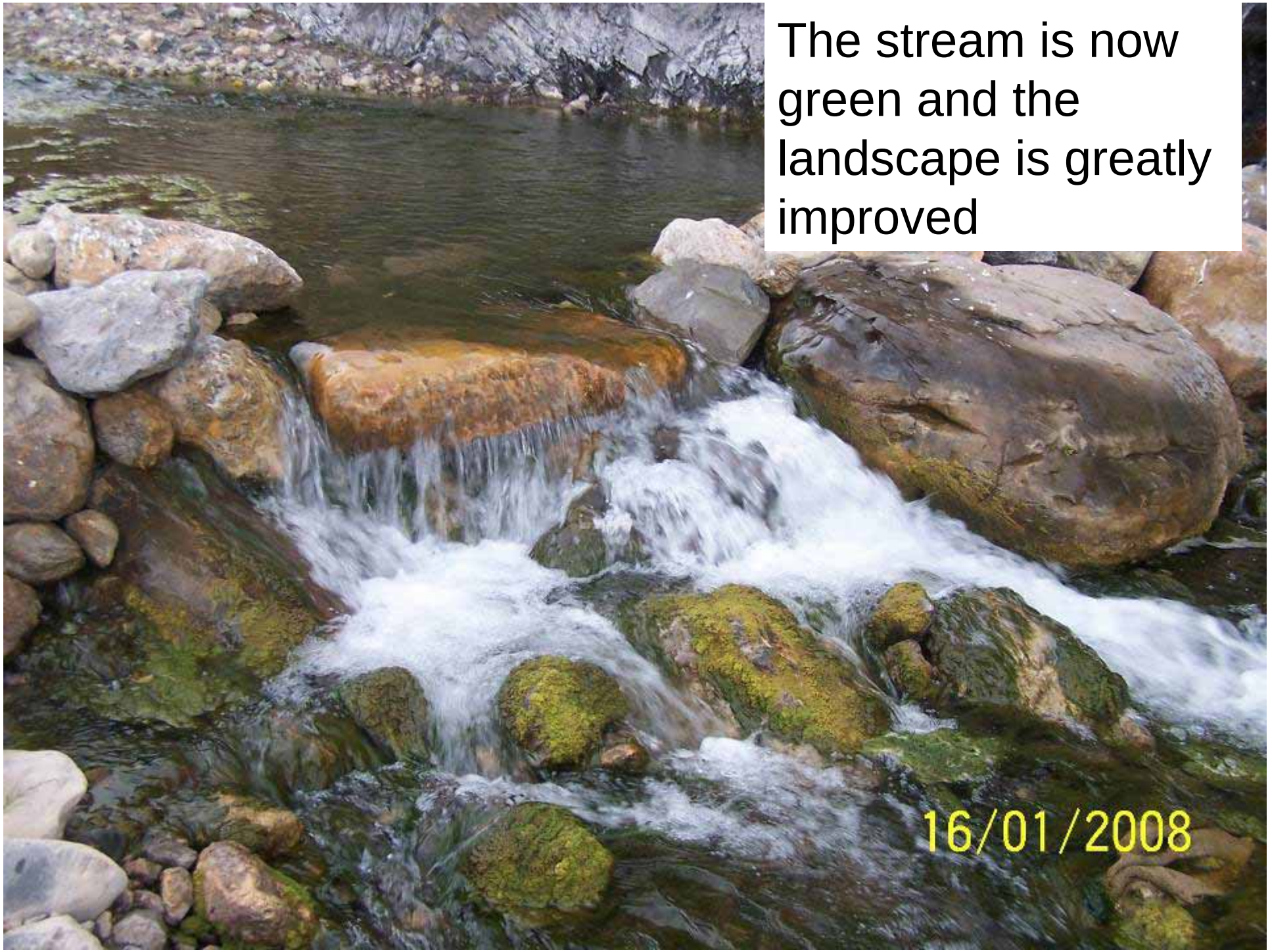


Table 2 variation of taxa richness and diversity before and after artificial step-pool system

	Sampling date	Taxa richness	Number density (ind/m^2)	Dominant species (number density of the individual invertebrate per m^2)
Natural channel	13-Jun	17	61.5	Hydropsychidae (17); Baetidae (9); Haliplidae, Haliplus sp (7)
With artificial step-pools	28-Jun	39	881.5	Baetidae (492); Simuliidae (150); Tipulidae, Antocha (65)
	11-Sep	28	612.8	Baetidae, Baetis (330); Baetidae, Baetiella sp. (70); Chironomidae sp1 (57); Chironomidae sp2 (48)



The stream is now green and the landscape is greatly improved


16/01/2008


Create beautiful landscape
16/01/2008

Conclusions

1. River training projects impact the stream ecology greatly.
2. 河流治理应从“以人为本”改为 “以河为本” The focal point of river training projects should shift from human’s demands to river’s.
3. River management should follow the principles: I – Extending the duration of river water on the continent; II –Controlling erosion and reducing sediment transportation; III – Increasing diversity and connectivity of habitats; and IV – Restoring natural landscapes
4. Biodiversity is proportional to habitat stability and diversity.
5. Artificial step-pool system is the best strategy for stream stabilization and ecology improvement

Thank you !