



# CORRELATION BETWEEN BIOTIC FACTORS AND ABIOTIC FACTORS - FOCUSED ON THE CASE STREAMS IN GYEONGGI DISTRICT, KOREA-

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# Contents

1. Introduction
2. Research Procedure
3. Results
4. Conclusion

## 1. INTRODUCTION



- ◆ Correlation between biotic and abiotic factors
  - ✓ Classification of stream typology
  - ✓ Evaluation of ecological stream status
- ◆ LfU (Landesanstalt für Umweltschutz) Baden-Württemberg (1998) (State Institute for Environment Protection)
  - ✓ Classification of 'silicates stream' and 'carbonate stream'
- ◆ LfU Baden-Württemberg (2000)
  - ✓ Classification of stream type
- ◆ AQEM (2001) - European Water Project (The Development and Testing of an Integrated Assessment System for the Ecological Quality of Streams and Rivers throughout Europe using Benthic Macroinvertebrates)
  - ✓ Determination of representative benthic macro-invertebrates by stream types
  - ✓ Development of integrated method for assessing streams using benthic macro-invertebrates

## 2. RESEARCH PROCEDURE



- ◆ Survey of River Structure
  - ✓ Survey sheet
  - ✓ Stream typology
  - ✓ Structural quality classes
  - ✓ Nine elements dependent on stream typology
  
- ◆ Survey for Biotic Factors and Water Quality Items
  - ✓ Vegetation
  - ✓ Benthic macro-invertebrates
  - ✓ Water quality items
  
- ◆ Correlation Analysis
  - ✓ RDA (Redundancy Analysis)
  - ✓ CCA (Canonical Correspondence Analysis)

# Survey Sheet for Physical River Structure

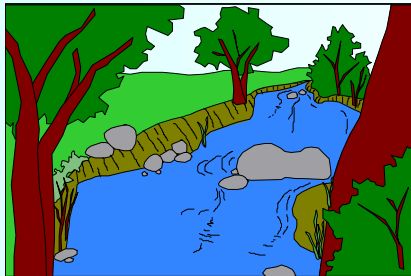
[illegible]

6  
Items  
25  
Elements

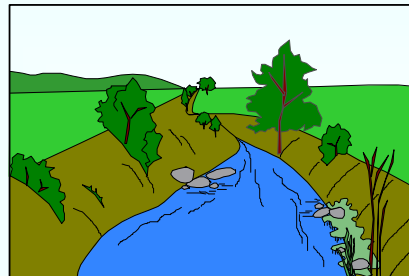
## 2. RESEARCH PROCEDURE



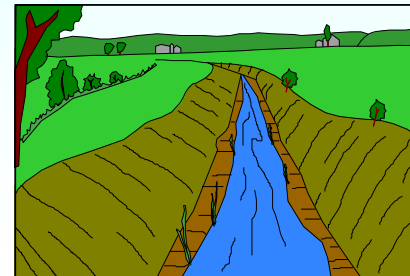
# Structural Quality Classes (LAWA, 2000)



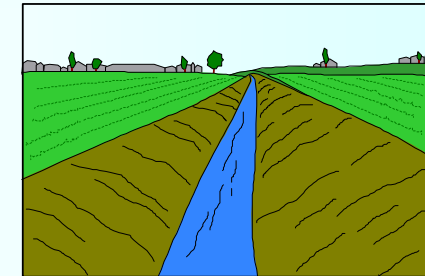
Natural State-1, 2



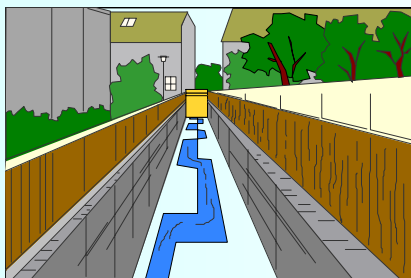
Natural State-3



Natural State-4



Natural State-5



Natural State-6, 7

Class	State	Range	EU-WFG Ecological Condition
1	Unchanged	1.0-1.7	Very Good
2	Slightly Changed	1.8-2.6	
3	Moderately Changed	2.7-3.5	Good
4	Distinctly Changed	3.6-4.4	Fair
5	Obviously Changed	4.5-5.3	Poor
6	Strongly Changed	5.4-6.2	Very Poor
7	Completely Changed	6.3-7.0	

## 2. RESEARCH PROCEDURE

## Nine Elements Dependent on Stream Typology

**중 및 소규모 하천 구조 평가서**

하천번호:  하천구분:

조사구:

이 수:

하천 규모:

유로 현황(현재):

하천 유형:

1. 종단 특성

1.1 하천 곡률:

1.2 하천 침식:

1.3 종단사주:

2. 횡단면

2.1 하천 폭:

2.2 하천 깊이:

2.3 하천 폭 변화:

3. 횡단면

3.1 하천 폭:

3.2 하천 깊이:

3.3 하천 폭 변화:

3.4 하천 폭 변화:

3.5 하천 폭 변화:

4. 하천 구조

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1. Curvature

2. Erosion due to curvature

3. Lateral patches

4. Flow diversity

5. Depth variation

6. Lateral erosion

7. Width variation

**9. Special bed structures**

**8. Substrate diversity**

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6. 하천면(토지이용)

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7.99 토지이용:

7.100 토지이용:



## 2. RESEARCH PROCEDURE



### ◆ 0. Stream Typology (LAWA, 2000)



K (Gorge)



K (V-shaped)



S (U-shaped)



M (Meandering)



A (Trough)



A (Alluvial)



F (Silt)



F (Sand)



F (Gravel)



F (Organism)



F (Lowland)



F (Lowland, Artificial)



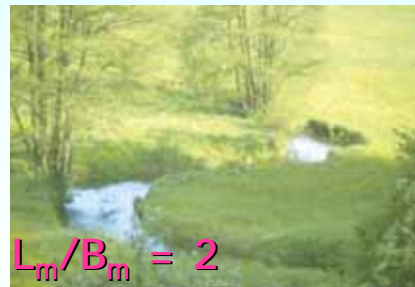
## 2. RESEARCH PROCEDURE



### ◆ 1. Curvature of channel



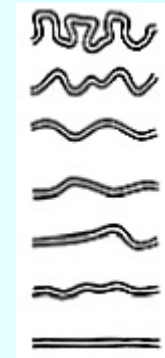
Severe, 60-90 °



Very Strong, 30-60 °



Strong, 10-40 °



Moderate, 20 °



Weak, 30-60 °



Stretched



Straight (Artificial)

Standard for estimation	Index by stream typology		
	A, F	S	M, K
Curvature			
Severe	1	1	×
Very Strong	2	1	
Strong	3	2	
Non-curvature			
Moderate	4	3	×
Weak	5	4	
Stretched	6	5	
Straight	7	7	

## 2. RESEARCH PROCEDURE



### ◆ 2. Erosion due to curvature



Cur. / Strong



Cur. / Strong



Cur. / Weak



Cur. / Weak



Non-Cur. / Strong



Non-Cur. / Strong



Non-Cur. / Strong



Non-Cur. / Weak

Standard for estimation	Index by stream typology		K, M
	S, A, F		
	Curva- -ture	Non- curva- -ture	
Frequently strong	2	2	x
Rarely strong	2	3	
Frequently weak	1	4	
Rarely weak	1	5	
None	1	7	



## 2. RESEARCH PROCEDURE



### ◆ 3. Lateral Patches



Riffle-pool/Distinct



Steps/Distinct



Bar/Distinct



Artificial Pool



Riffle-pool/Rudiment



Steps/Rudiment



Bar/Rudiment



Bar/Rudiment

Standard for estimation	Index by stream typology		
	M, A, F, S		K
	Narrow (B<5 m)	Wide (5 m<B)	
Abundant	1	1	x
Several	2	1	
Two	3	2	
One	4	2	
Half (Rudiment)	5	5	
None	7	7	7

## 2. RESEARCH PROCEDURE



### ◆ 4. Flow diversity



Smooth



Walking



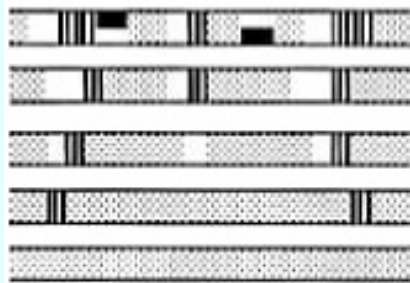
Wavy



Crest-forming



Rushing



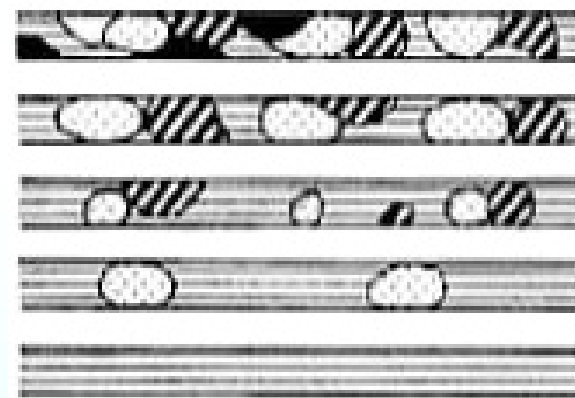
Standard for estimation	Index by stream typology	
	M, A, K	F
Very High (Crest-forming, Rushing)	1	1
High (Wavy)	2	1
Moderate (Walking)	4	3
Low (Smooth)	5	5
None	7	7

## 2. RESEARCH PROCEDURE



### ◆ 5. Depth variation

Standard for estimation	Index by stream typology	
	M, A, K	F
Very High	1	1
High	2	1
Moderate	4	3
Low	5	5
None	7	7





## 2. RESEARCH PROCEDURE



### ◆ 6. Lateral erosion



**Moderate/Strong**



**Deep/Strong**



**Very Deep/Strong**



**Very Deep/Strong**



**Moderate/Weak**



**Moderate/Weak**



**Very Deep/Weak**



**Very Deep/Weak**

Standard for estimation	Index by stream typology		
	M, A, F, S		
Depth of cross-Section	Very Deep-Deep (B/H<4)	Moderate -Very shallow (B/H>4)	K
Strong	3	3	x
Weak	5	1	
None	7	1	

## 2. RESEARCH PROCEDURE



### ◆ 7. Width variation



None



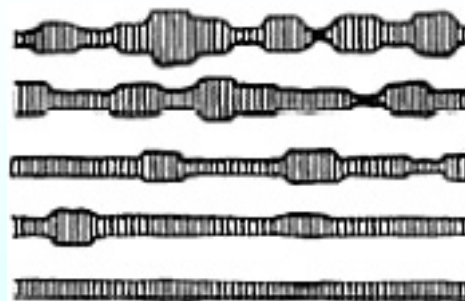
Moderate



High



Very High



Standard for estimation	Index by stream typology	
	M, A, K, S	F
Very High	1	1
High	2	1
Moderate	4	2
Low	6	4
None	7	7

## 2. RESEARCH PROCEDURE



### ◆ 8. Substrate diversity



Clay/Silt/Loam



Silt & Mud



Sand



Gravel



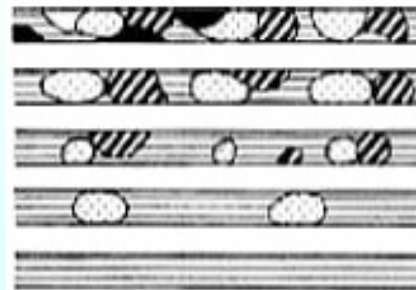
Gravel and Stone



Block, Gravel & Stone



Bedrock



Standard for estimation	Index by stream typology	
	S, A, K	F
Very High	1	1
High	2	1
Moderate	4	2
Low	6	4
None	7	7



## 2. RESEARCH PROCEDURE



### ◆ 9. Special bed structures



Scour Hole



Deep Run



Hissing Spot



Darting Spot



Stream-pool



Still Side-pool



Reverse Side-pool



Macro-hydrophyte



Root Spot



Cascade

Standard for estimation	Index by stream typology	
	M, A, K	F
Abundant	1	1
Several	2	1
Two	3	2
One	4	3
Half (1/2)	5	5
None	7	7

## 2. RESEARCH PROCEDURE



# Survey for Biotic Factors and Water Quality

- ◆ Location
  - ✓ length of 1 km showing best natural state at each stream
- ◆ Vegetation
  - ✓ Braun-Blanquet (1964) method      Phytosociology
  - ✓ Belt-transect      Emergent species along cross-section
- ◆ Benthic macro-invertebrate
  - ✓ Quantitative sampling : Surber (1937) net
  - ✓ Qualitative sampling : Hand-grab and collector
  - ✓ Dominance, Diversity, Evenness, Richness indices
- ◆ Water quality
  - ✓ Data of Water Quality Monitoring Network (Ministry of Environment, Korea)
  - ✓ pH, COD, BOD, DO, SS, T-N, T-P, NH<sub>3</sub>-N, PO<sub>4</sub>-P, water temperature, conductivity, and number of coliform



## 2. RESEARCH PROCEDURE



### Correlation Analysis Method

#### ◆ Ordination

Multi-variate Analysis	Indirect Method	Principal Component Analysis
		Correspondence Analysis
		Detrended Correspondence Analysis
	Direct Method	ReDundancy Analysis
		Canonical Correspondence Analysis
		Detrended Canonical Correspondence Analysis

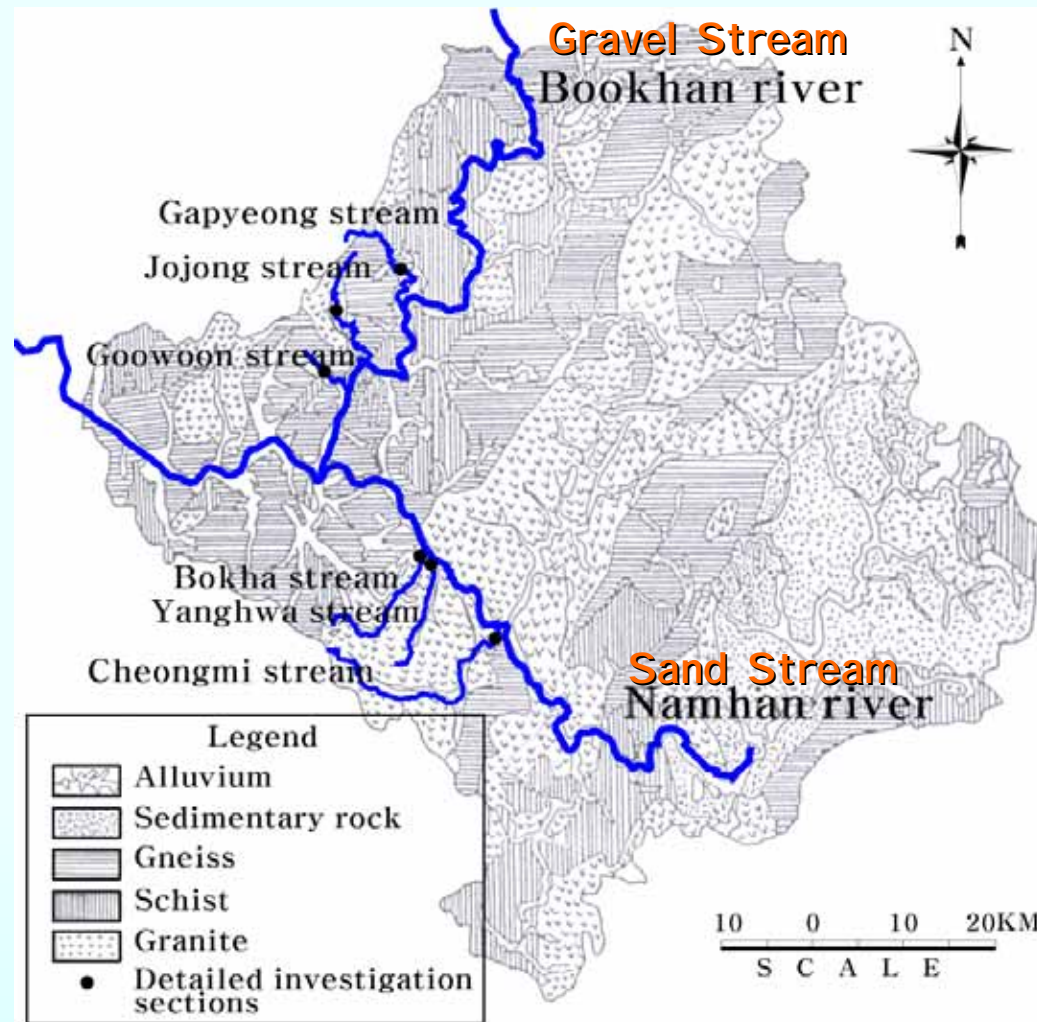
#### ◆ Programs

- ✓ CANOCO 4.5 (ter Braak, C.J.F. and Šmilauer, P.; 2002): RDA, CCA
- ✓ SPSS 13 (Statistical Package for the Social Science): Pearson Correlation, PCA

### 3. RESULTS



## Location and Geology of Survey Streams



### 3. RESULTS



## Field Survey for River Structure



Curvature of channel  
(Very Strong)



Erosion due to curvature  
(Frequently Strong)



Lateral patches  
(One)



Flow diversity  
(Rushing Very High)



### 3. RESULTS



**Depth variation  
(Very High)**



**Lateral erosion  
(Very Deep/Strong)**



**Width variation  
(Moderate)**



**Substrate diversity  
(Moderate)**

### 3. RESULTS



**Special bed Structures  
(Darting Spot)**



**Special bed Structures  
(Still Side-pool)**



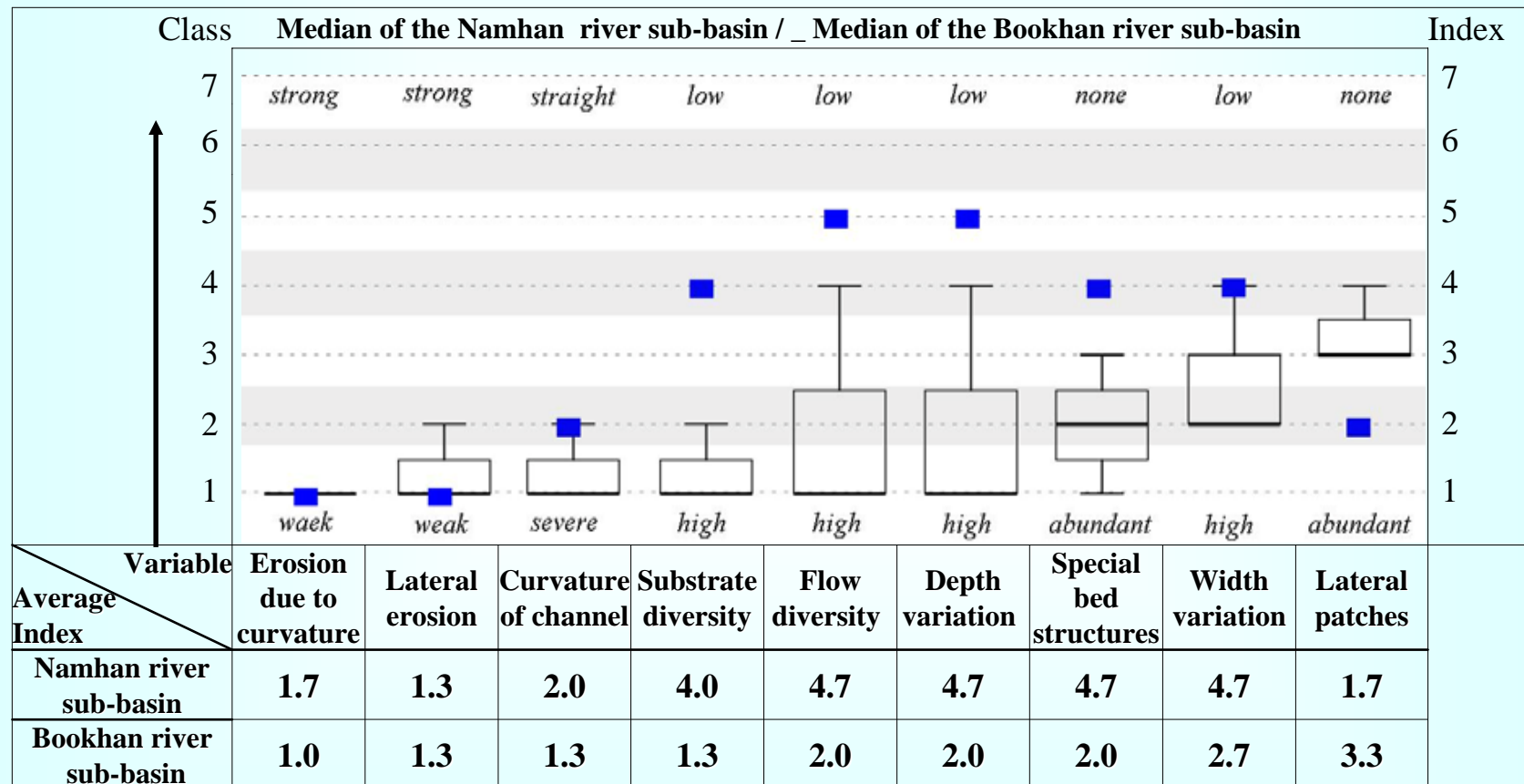
**Special bed Structures  
(Root Spot)**



### 3. RESULTS



## Hydromorphological Structure



### 3. RESULTS



## Benthic Macro-invertebrate

- ◆ **62 species** : 1: *Tipulide* sp.1, 2: *Tipulide* sp.2, 3: *Nothopsyche* KUa, 4: *Kamimuria* KUa, 5: *Baetis fuscatus*, 6: *Calopteryx atrata*, 7: *Ranatra chinensis*, 8: *Glossosoma* KUa, 9: *Chironomidae* sp. 1, 10: *Laccophilus difficilis*, 11: *Micronecta sedula*, 12: *Hydaticus grammicus*, 13: *Baitis thermicus*, 14: *Goerodes* KUa, 15: *Ecdyonurus levis*, 16: *Macromia daimoji*, 17: *Whitmania edentula*, 18: *Semisulcospira libertina*, 19: *Erpobdella lineata*, 20: *Ephemera orientalis*, 21: *Paraleptophlebia chocolata*, 22: *Sympetrum eroticum*, 23: *Ecdyonurus kibunensis*, 24: *Cercion calamorum*, 25: *Whitmania pigra*, 26: *Unio douglasiae*, 27: *Anax nigrofasciatus*, 28: *Ephemera strigata*, 29: *Rhyacophila* KUa, 30: *Lymnaea auricularia*, 31: *Muljarus japonicus*, 32: *Cincticostella levanidovae*, 33: *Orthetrum albistylum speciosum*, 34: *Platycnemis phillopoda*, 35: *Epeorus pellucidus*, 36: *Drunella aculea*, 37: *Aquaris paludum*, 38: *Davidius lunatus*, 39: *Hippeutis cantori*, 40: *Limnodrilus gotoi*, 41: *I schnura asiatica*, 42: *Rhantus pulverosus*, 43: *Baetiella tuberculata*, 44: *Sieboldius albardae*, 45: *Stenopsyche bergeri*, 46: *Gabbia misella*, 47: *Hesperocorixa kolthoffi*, 48: *Physa acuta*, 49: *Wormaldia* KUa, 50: *Laccotrephes japonensis*, 51: *Rhoenanthus coreanus*, 52: *Corbicula fluminea*, 53: *Semisulcospira tegulata*, 54: *Hydropsyche* KUa, 55: *I ron aesculus*, 56: *Macrobrachium nipponense*, 57: *Anodonta woodiana*, 58: *Semisulcospira coreana*, 59: *Stylurus annulata*, 60: *Potamonectes hostilis*, 61: *Dytiscidae* sp. 1, 62: *Dytiscidae* sp. 2

### ◆ Common species

Gravel stream	Sand stream	Gravel and sand stream
15	9	5

### 3. RESULTS



#### ◆ Result of RDA for hydromorphological structure

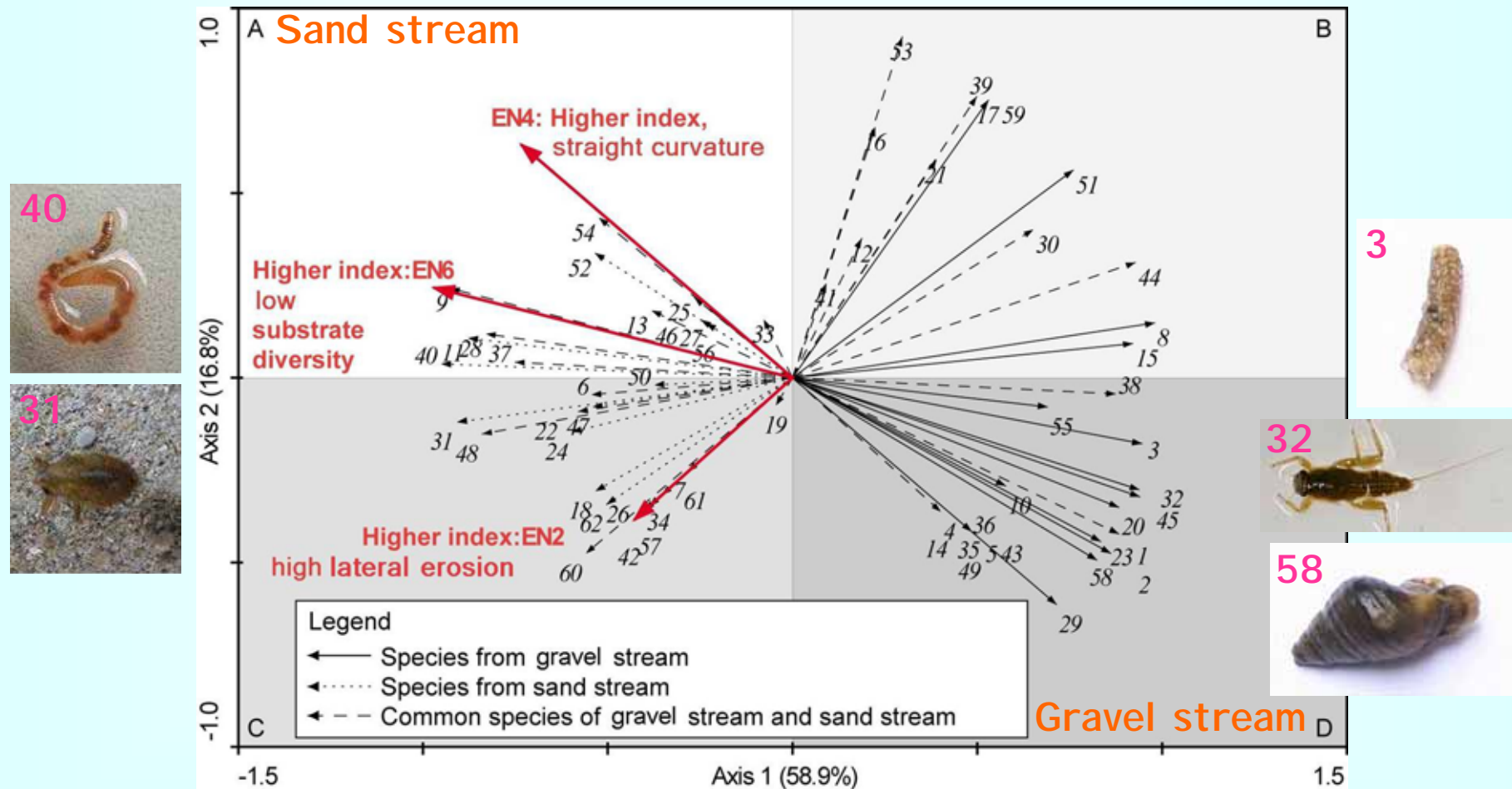
Result	Axis		Axis		Total variable
	Axis 1		Axis 2		
Sum of all eigenvalues					1
Sum of all canonical eigenvalues					0.821
Eigenvalues ( )	0.589		0.168		1
Cumulative percentage variance					
of species data	58.9		75.7		
of species-environment relation	71.7		92.2		
Species-environment correlations (R)	0.989		0.977		
Canonical coefficients ( <i>c</i> ) and intra-set correlations ( <i>r</i> )	<i>c</i>	<i>r</i>	<i>c</i>	<i>r</i>	
of environmental variable EN2 (Lateral erosion)	-0.0575	-0.4265	-0.4708	-0.3829	
of environmental variable EN4 (Curvature)	0.5015	-0.7316	1.7271	0.6294	
of environmental variable EN6 (Substrate diversity)	-1.3867	-0.968	-1.0978	0.2435	

- ✓ Three environmental variables by forward selection.
- ✓ 'Axis 1-EN6' and 'Axis 2-EN4' have strong influence.
- ✓ Axis 1 explains 58.9 % of variance of species and 71.7 % of species-environment correlation.
- ✓ Axis 2 explains 16.8 % of variance of species and 20.5 % of species-environment correlation.

### 3. RESULTS



#### ◆ RDA ordination graph for hydromorphological structure



### 3. RESULTS



#### ◆ Result of RDA for COD

Result	Axis		Axis		Total variable
	Axis 1		Axis 2		
Sum of all eigenvalues					1
Sum of all canonical eigenvalues					0.447
Eigenvalues ( )	0.447		0.224		1
Cumulative percentage variance of species data	44.7		67		
of species-environment relation	100		0		
Species-environment correlations (R)	0.868		0		
Canonical coefficients ( <i>c</i> ) and intra-set correlations ( <i>r</i> ) of environmental variable COD	<i>c</i>	<i>r</i>	<i>c</i>	<i>r</i>	
	-1	-1	0	0	

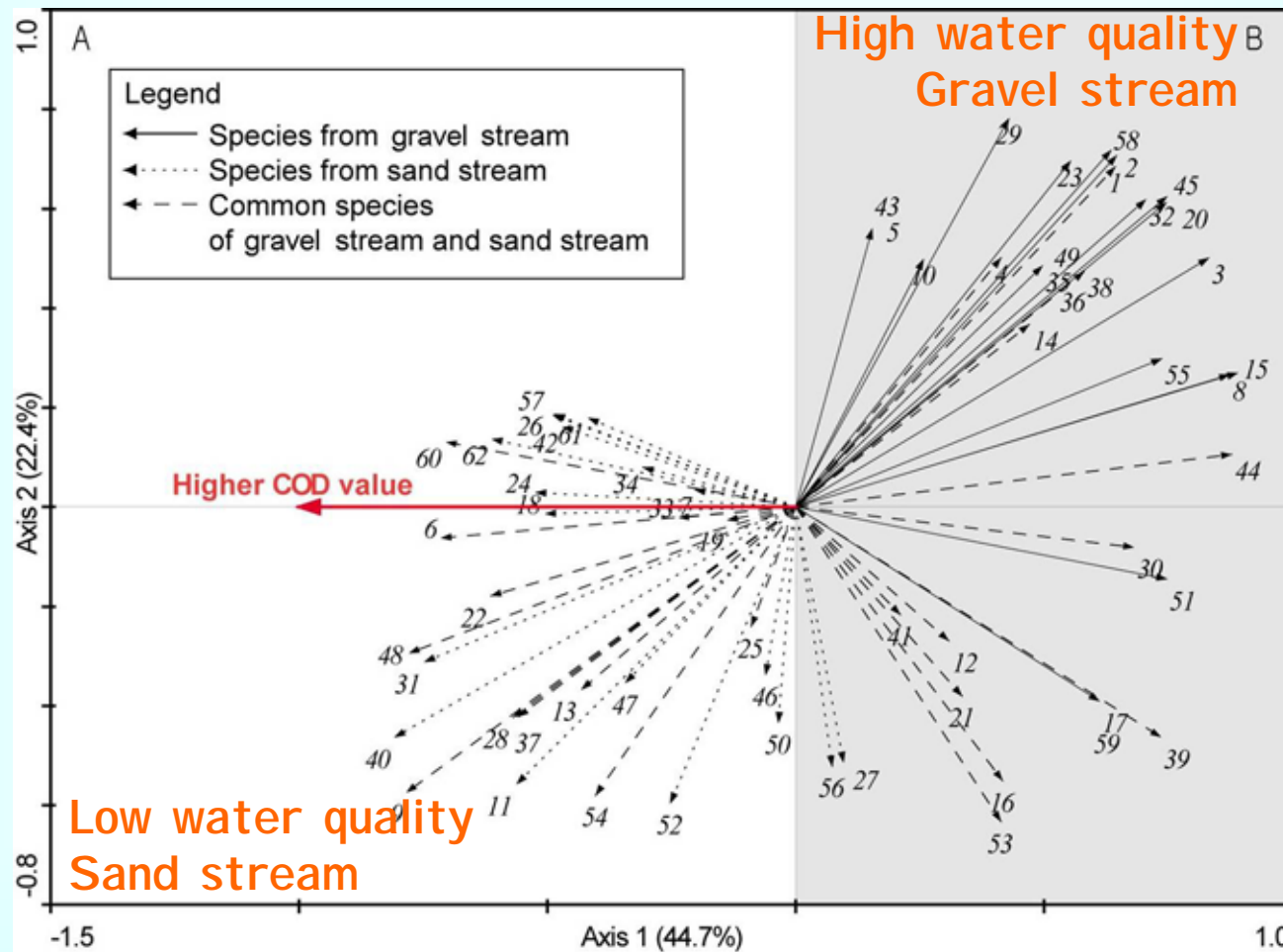
- ✓ One environmental variables by Pearson correlation and forward selection of PCA.
- ✓ Axis 1 explains 44.7 % of variance of species and 100 % of species-environment correlation.
- ✓ Axis 2 explains 22.4 % of variance of species though it is not attributed by environmental variables.



### 3. RESULTS



#### ◆ RDA ordination graph for COD



### 3. RESULTS



## Plants from Belt-transect

### ◆ 116 species : 1:*Ailanthus altissima*, 2:*Galium spurium*, 3:*Setaria vidis*, 4:*Rorippa indica*, 5:*Ampelopsis*

*brevipedunculata* V. *heterophylla*, 6:*Salix gracilistyla*, 7:*Youngia sonchifolia*, 8:*Pteridium aquilinum* V. *latiusculum*, 9:*Staphylea bumalda*, 10:*Securinega suffruticosa*, 11:*Oxalis corniculata*, 12:*Stephanandra incisa*, 13:*Carex lanceolata*, 14:*Festuca ovina*, 15:*Trigonotis peduncularis*, 16:*Vicia unijuga*, 17:*Impatiens noli-langere*, 18:*Corydalis ochotensis*, 19:*Actinidia arguta*, 20:*Maackia amurensis*, 21:*Acer palmatum*, 22:*Commelina communis*, 23:*Bilderdykia dumetora*, 24:*Parthenocissus tricuspidata*, 25:*Carex siderosticta*, 26:*Aceriphyllum ossii*, 27:*Ambrosia artemisiifolia* V. *elatior*, 28:*Alopecurus aequalis* V. *amurensis*, 29:*Woodsia manchuriensis*, 30:*Kummerowia striata*, 31:*Berberis koreana*, 32:*Hypericum ascyron*, 33:*Impatiens textori*, 34:*Bidens frondosa*, 35:*Aster pilosus*, 36:*Cardamine leucantha*, 37:*Angelica decursiva*, 38:*Duchesnea chrysantha*, 39:*Stellaria alsine* V. *undulata*, 40:*Weigela subsessilis*, 41:*Rhus chinensis*, 42:*Hosta longipes*, 43:*Torilis japonica*, 44:*Rubus crataegifolius*, 45:*Morus bombycis*, 46:*Crataegus pinnatifida*, 47:*Rhododendron yedoense* V. *poukhanense*, 48:*Vicia angustifolia* V. *segetilis*, 49:*arex dispalata*, 50:*Menispermum dauricum*, 51:*Amphicarpea edgeworthii* V. *trisperma*, 52:*Lycopus ramosissimus* V. *japonicus*, 53:*Acer ginnala*, 54:*Lespedeza bicolor*, 55:*Aster yomena*, 56:*Malus sieboldii*, 57:*Chelidonium majus* V. *asiaticum*, 58:*Onoclea sensibilis* V. *interrupta*, 59:*Potentilla fragarioides* var. *major*, 60:*Persicaria hydropiper*, 61:*Hemerocallis fulva*, 62:*Lactuca indica* var. *laciniata*, 63:*Youngia denticulata*, 64:*Callicarpa japonica*, 65:*Trisetum bifidum*, 66:*Viola mandshurica*, 67:*Artemisia japonica*, 68:*Arthraxon hispidus*, 69:*Lespedeza maximowiczii*, 70:*Spiraea prunifolia* for. *simpliciflora*, 71:*Viola acuminata*, 72:*Quercus serrata*, 73:*Boehmeria spicata*, 74:*Lysimachia vulgaris* V. *davurica*, 75:*Gleditsia japonica* V. *koreiensis*, 76:*Aristolochia contorta*, 77:*Hemistepta lyrata*, 78:*Plantago asiatica*, 79:*Rosa multiflora*, 80:*Lilium tigrinum*, 81:*Aster scaber*, 82:*Pueraria thunbergiana*, 83:*Viola verecunda*, 84:*Euonymus alatus* for. *ciliato-dentatus*, 85:*Oenanthe javanica*, 86:*Metaplexis japonica*, 87:*Pinus densiflora*, 88:*Quercus mongolica*, 89:*Rubia cordifolia* V. *pratensis*, 90:*Salix koreensis*, 91:*Persicaria perfoliata*, 92:*Robinia pseudo-acacia*, 93:*Rosa multiflora*, 94:*Artemisia selengensis*, 95:*Phragmites communis*, 96:*Bromus japonicus*, 97:*Quercus aliena*, 98:*Morus alba*, 99:*Miscanthus sinensis* V. *purpurascens*, 100:*Beckmannia syzigachne*, 101:*Dioscorea batatas*, 102:*Agropyron tsukushiense* V. *transiens*, 103:*Stellaria aquatica*, 104:*Oenothera odorata*, 105:*Rumex crispus*, 106:*Fraxinus rhynchophylla*, 107:*Persicaria thunbergii*, 108:*Erigeron canadensis*, 109:*Clematis apiifolia*, 110:*Carex dispalata*, 111:*Phalaris arundinacea*, 112:*Erigeron annuus*, 113:*Humulus japonicus*, 114:*Equisetum arvense*, 115:*Artemisia princeps* V. *orientalis*, 116:*Phragmites japonica*

### ◆ Common species

Gravel stream	Sand stream	Gravel and sand stream
29	7	9

### 3. RESULTS



#### ◆ Result of CCA for hydromorphological structure

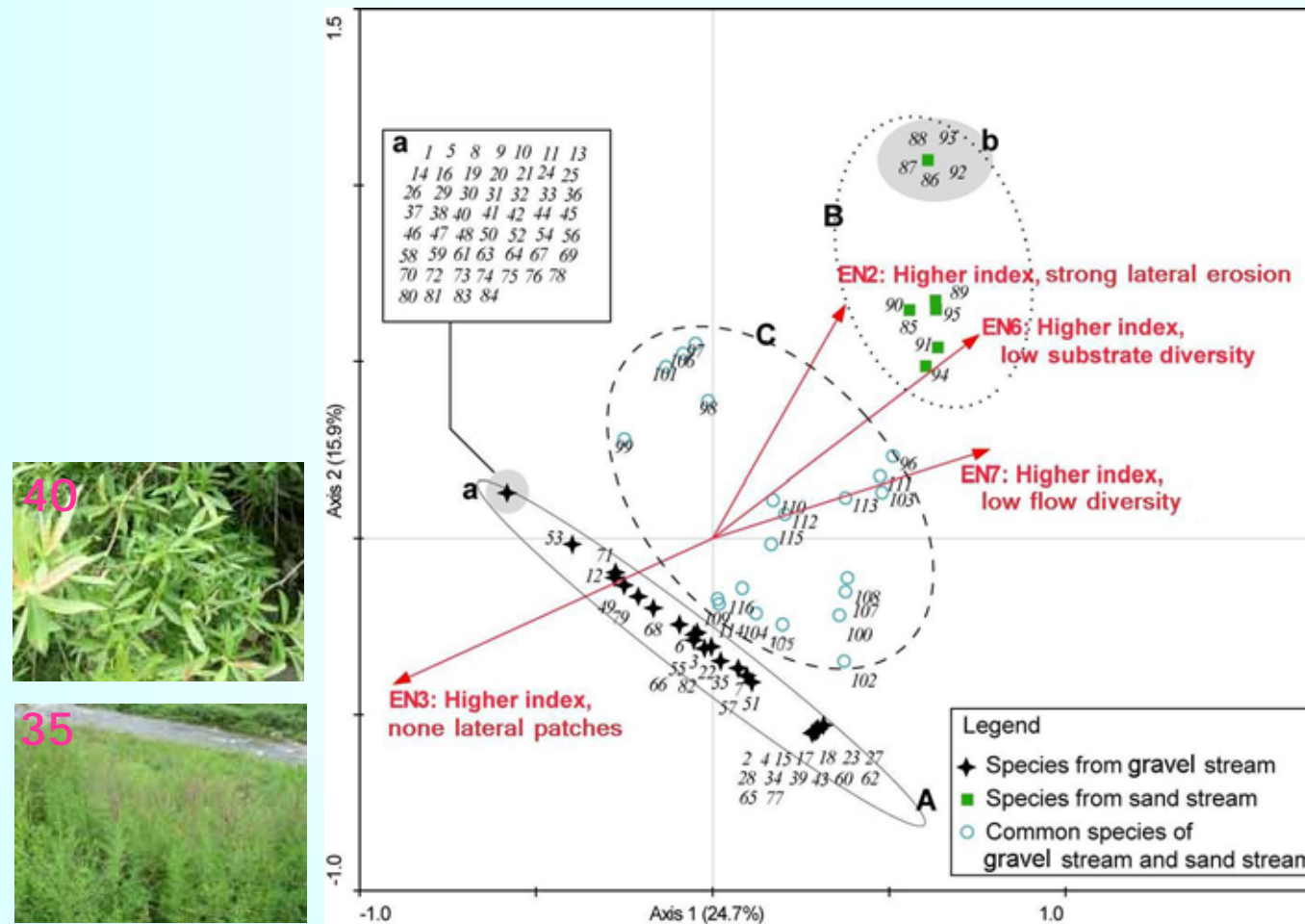
Result	Axis		Axis		Total variable
	Axis 1		Axis 2		
Sum of all eigenvalues					2.519
Sum of all canonical eigenvalues					1.495
Eigen values ( )	0.624		0.398		1
Cumulative percentage variance					
of species data	24.7		40.6		
of species-environment relation	41.7		68.4		
Species-environment correlations (R)	0.997		0.979		
Canonical coefficients ( <i>c</i> ) and intra-set correlations ( <i>r</i> )	<i>c</i>	<i>r</i>	<i>c</i>	<i>r</i>	
of environmental variable EN2 (Lateral erosion)	-0.5251	0.3741	0.7858	0.6571	
of environmental variable EN3 (Lateral patches)	-1.6684	-0.9007	1.2269	-0.4117	
of environmental variable EN6 (Substrate diversity)	-0.7324	0.7517	2.1906	0.573	
of environmental variable EN7 (Flow diversity)	0.3125	0.7816	-1.069	0.2493	

- ✓ Four environmental variables by forward selection.
- ✓ 'Axis 1-EN3' and 'Axis 2-EN6' have strong influence.
- ✓ Axis 1 explains 24.7 % of variance of species and 41.7 % of species-environment correlation.
- ✓ Axis 2 explains 15.9 % of variance of species and 26.7 % of species-environment correlation.

### 3. RESULTS



#### ◆ CCA ordination graph for hydromorphological structure





## 4. CONCLUSION



### ◆ Benthic macro-invertebrates

- ✓ They have strong correlations with substrate diversity and curvature of channel.
- ✓ They can be classified into two groups observed in a sand stream and gravel stream.
- ✓ Concentration of COD was only selected as a significant factor influencing their habitats.

### ◆ Plants

- ✓ They have strong correlations with lateral patches like bars, steps, and riffle-pools and substrate diversity.
- ✓ They can also be classified into two groups observed in a sand stream and gravel stream.

### ◆ Suggestion

- ✓ There can be significant differences in hydromorphological and ecological characteristics between a sand stream and gravel stream.



# Thank You!

