Macroinvertebrates

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Outline of the Presentation

- River Ecosystem and River Health
- Macroinvertebrates
- Biological Indicators
- Habitat Assessment
- Macroinvertebrates sampling-Multi-habitat sampling
- Identification of Macroinvertebrates
- Quality Control and Safety
- Data Presentation

River Ecosystem

The ecosystem of a river is the river viewed as a system operating in its natural environment, and includes biotic (living) interactions amongst plants, animals and micro-organisms, as well as abiotic (nonliving) physical and chemical interactions.

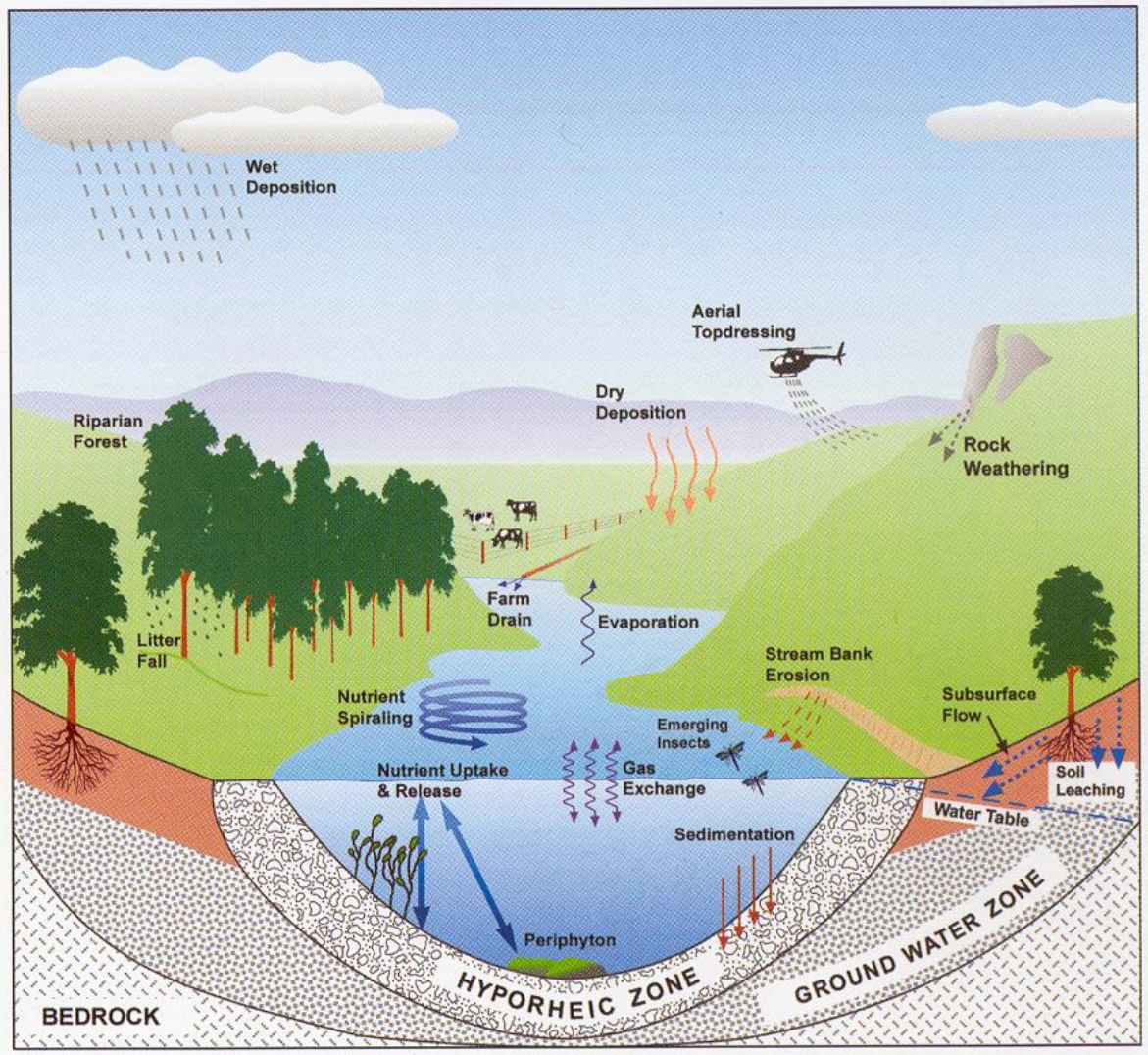


Figure 1 A stream in cross-section, showing some of the pathways that connect streams with their catchments and the atmosphere. Most pathways carry water and material to streams, but there are some that move from streams to the land (emerging insects) and from streams to the atmosphere (evaporation and gas exchange). Greg Kelly, NIWA.

What is river health ?

- Webster's dictionaries define *health* as a flourishing condition, well-being, vitality, or prosperity.
- An organism is healthy when it performs all its vital functions **normally** and **properly**, when it is able to recover from normal stresses.
- An environment is healthy when the supply of goods and services required by both *human* and *nonhuman* residents is sustained. **Healthy** is a short-hand for **good condition**.
- **Health** as a word and concept in ecology is useful precisely because it is a concept all people are familiar with.






Macroinvertebrates

- Diverse groups of small invertebrates that are retained on a 0.5 mm mesh net and can be seen with unaided eye.
- Comprised chiefly of insects, annelids, arachnids, crustaceans, clams and gastropods.
- Inhabit diverse habitats from flowing to still water.
- Adopt wide ranges of foods depending upon their habitat preferences.

Macroinvertebrates -Examples







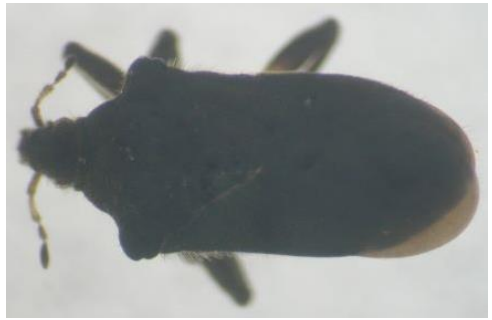





Macroinvertebrates -Examples









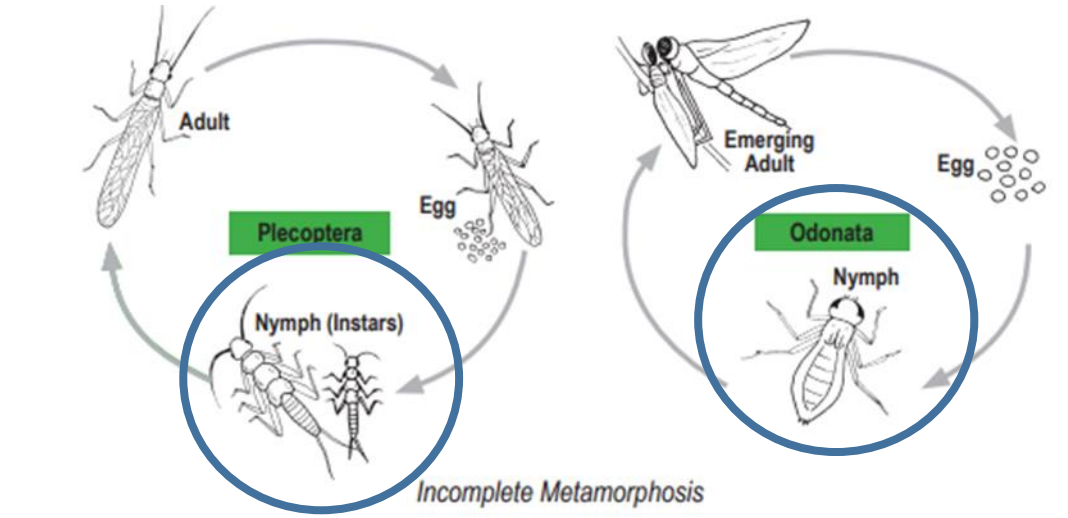


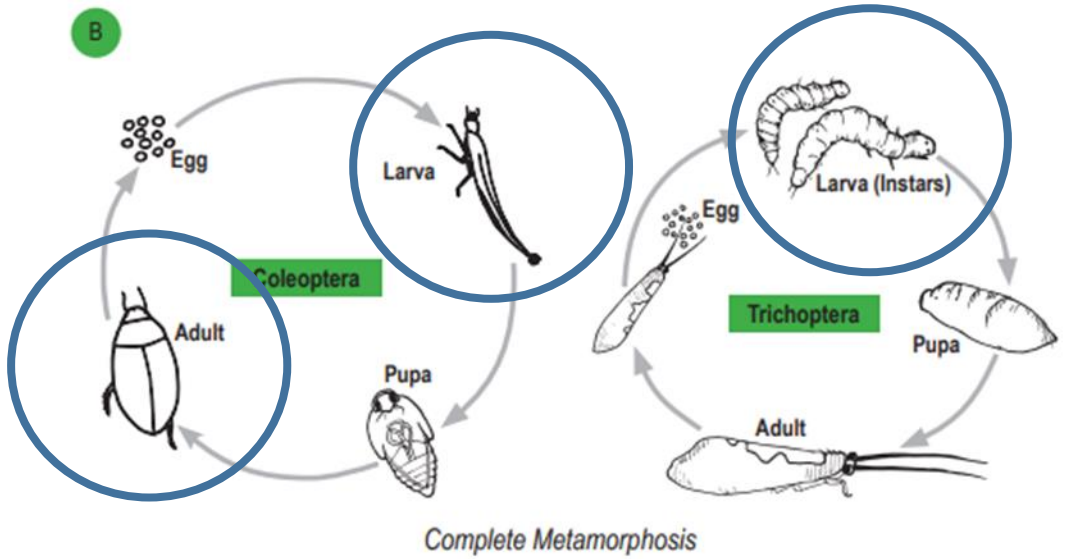


Life cycle of Macroinvertebrates

- Aquatic insects spend most of their life in water.

- Which stage of insect's life is considered for the assessment of river ecosystems?

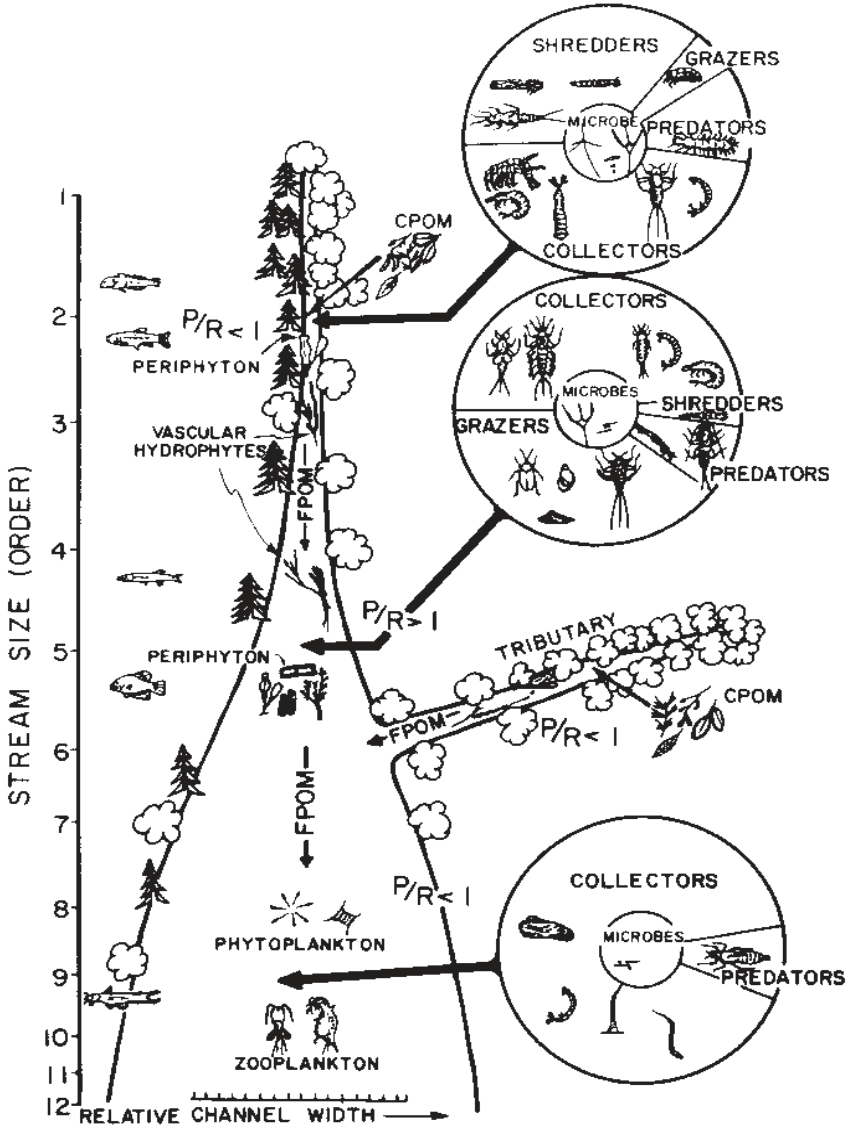




Macroinvertebrates along a river course

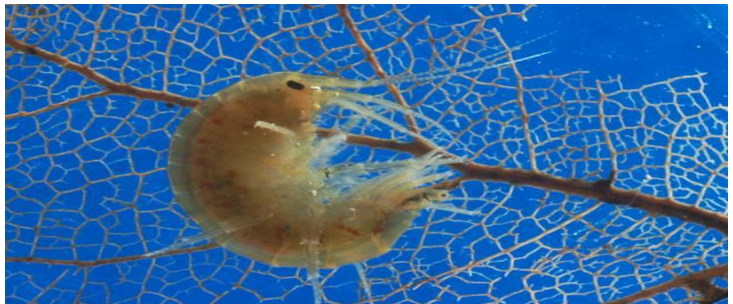
- Assembly of instream biotic community in a river's downstream reaches is linked to those in the upstream.

- Headwater streams harbor organisms known as "***shredders***" that break coarse organic particulate matters, the mid-rivers contain algae and diatoms consumers called "***Grazers***" while the lower reaches have "***Collectors***" that consume fine organic particulate matters.

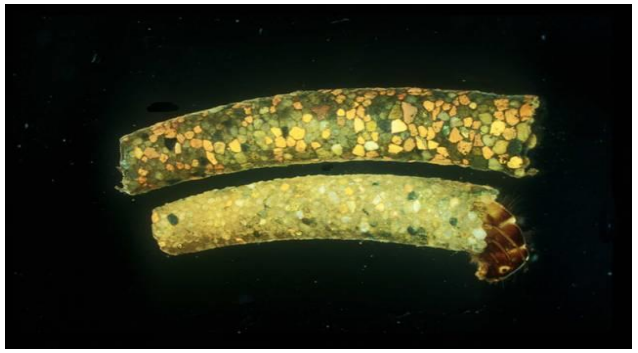


Macroinvertebrates- Functional Feeding Groups

Shredders



Scrapers



Collector-gatherers

Collector-filterers

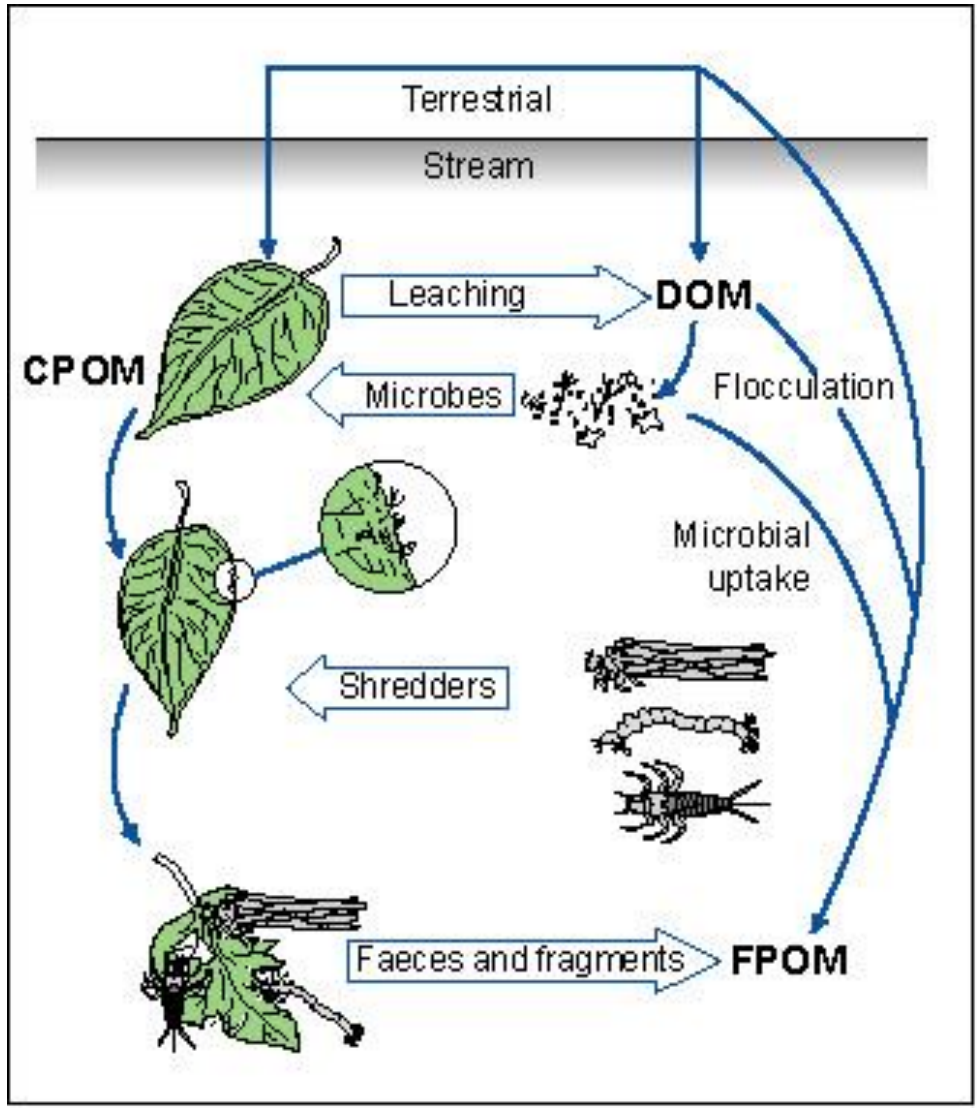
Macroinvertebrates- Functional Feeding Groups

Shredders

Collector-gatherers

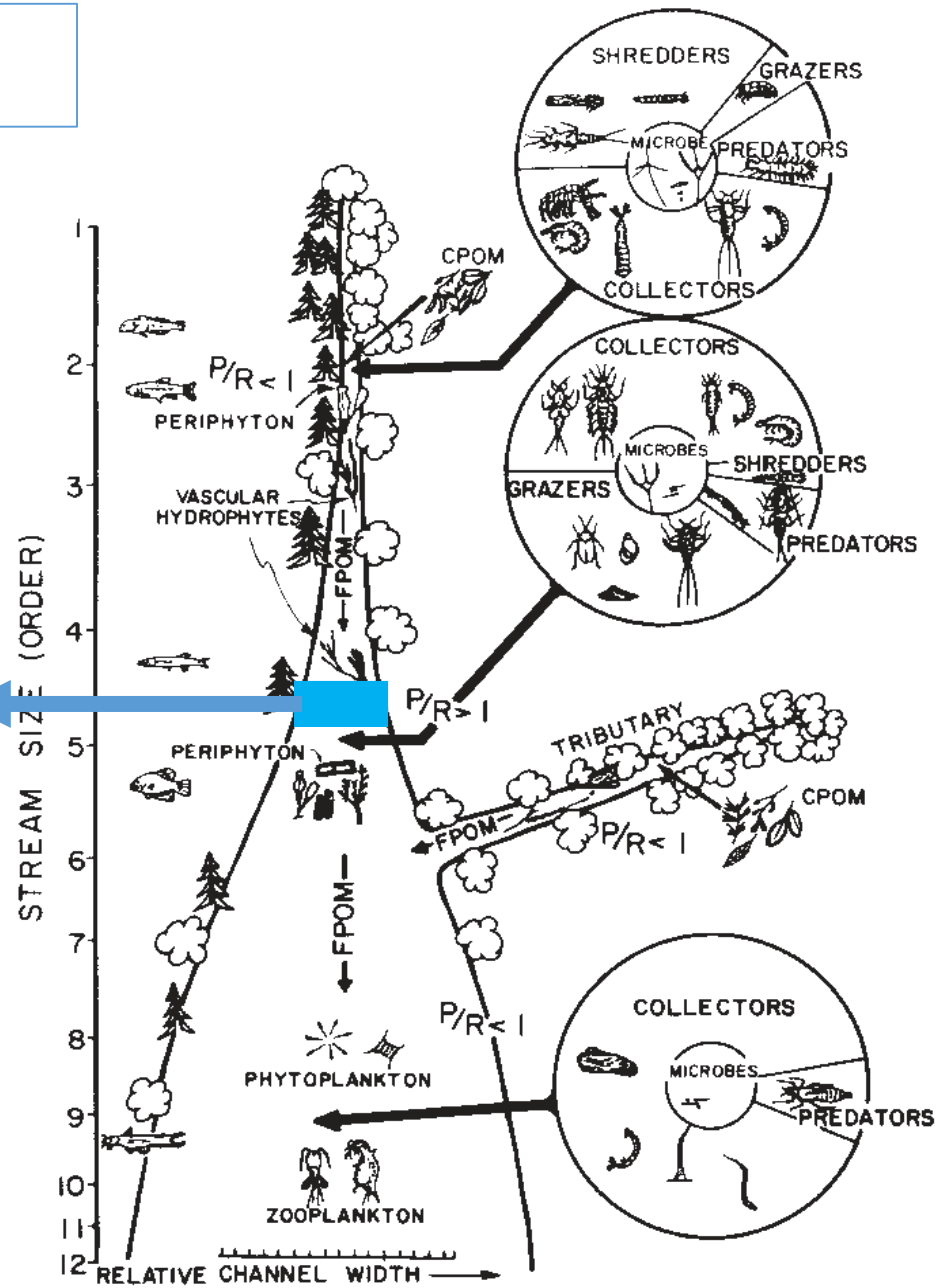
Scrapers

Collector-filterers



Stream Ecology-Limnology

Macroinvertebrates along a river course



- Disruption in sediment transports, flow regimes, habitats that influence composition and structure of biotic community.

Bio-assessment

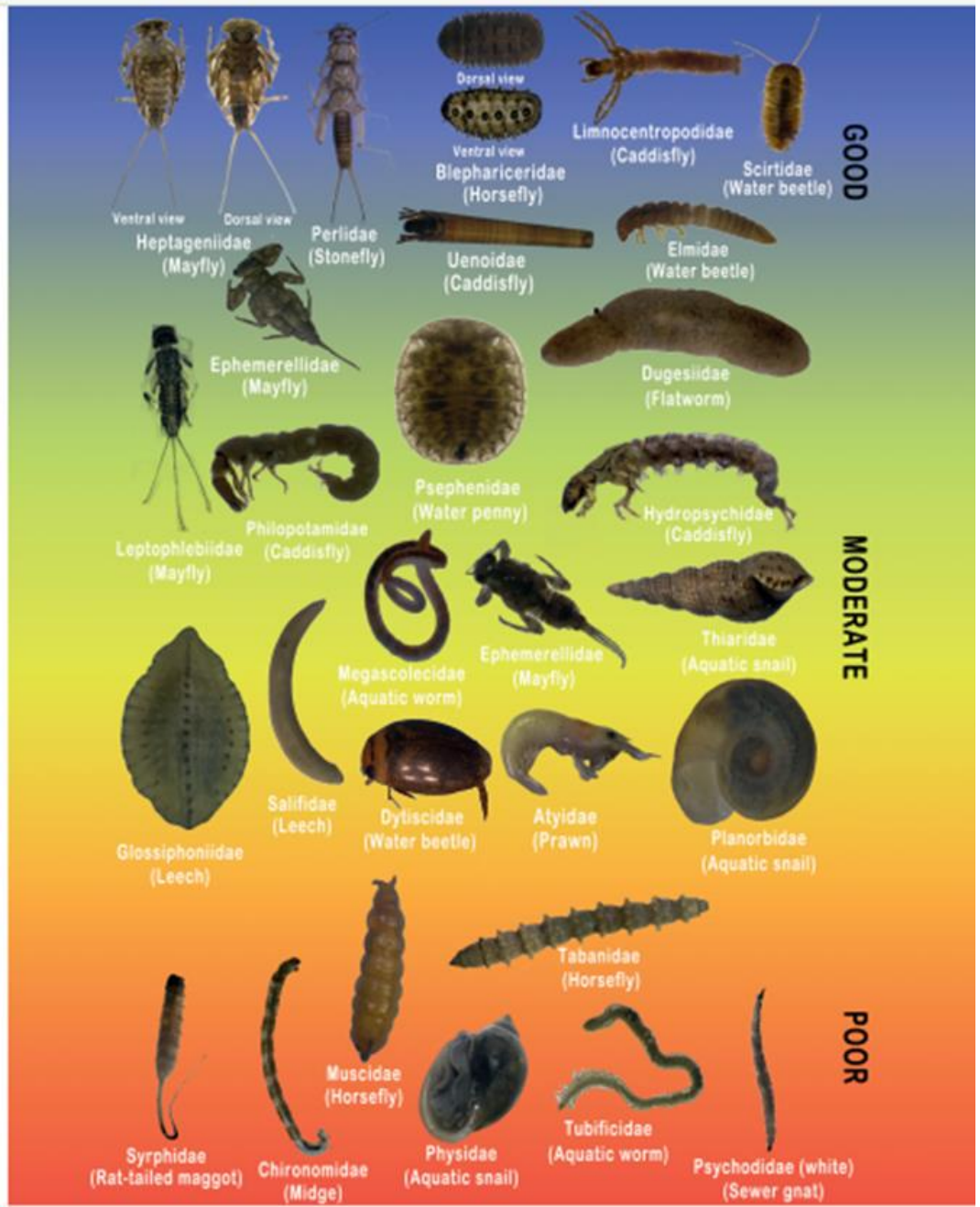
- Biological monitoring and biological endpoints provide the most integrative view of river condition, or river health.

- In many parts of the world, bio-assessment is in its infancy, but is increasing rapidly as a scientific foundation to support decisions regarding the protection of aquatic resources.

What is a biological indicator?

- Biological or animal species which, because of their ecological characteristics, react to a stressor/habitat degradation by a clear and specific modification of their vital functions.

- Why benthic macroinvertebrates?
  - Cosmopolitan in nature and highly diverse.
  - Abundantly found in river systems.
  - Due to relatively larger body size, easy to identify up to family level.
  - Less mobile



A prerequisite for the use of bio-indicators and particularly for the comparability of results is a high degree of **standardisation** of the methods and assessment and evaluation of effects.

Macroinvertebrate Sampling

Non consumables	Consumables
Rivers Handbook	99.9% Ethanol (For preservation)
GPS Device	Site information sheet, data sheets
Camera	Field note book, Pre-printed labels
Magnifying glasses	Topographic map
Kick-Net (Square shaped metallic frame) [Mesh size: 0.5 mm (500 µm); Frame- 25 cm width by 25 cm length] attached to 1 m long wooded handle	Pencil, Eraser, Sharpener, Cardboard, permanent marker, Cello Tape, Ziplock bags- small and large
Hand Net (Circular shaped metallic frame) [Mesh size:0.5 mm (500 µm);Frame-15 cm circumference] attached to 30 cm long handle	Vials
Measuring tape (50m, 1 number)	1 Sample box for 1 site
1 set of chest waders	1 Bucket
1 pair of half boots	1 Tray
1 pair of rubber gloves	Petri dishes (Minimum of 2 pieces)
Stereo-microscope	1 sharp pointed forceps
Digital weighing machine	

Site Information Sheet

Sheet 1: Site information

1. Site Description

1.1 River/Stream
1.2 River System
1.3 Place, District, Province:
1.4 Site/Station Code :
1.5 Coordinates, Elevation
N :
E :
Altitude :

1.6 Date : .....
1.7 Time : .....
1.8 Surveyor :
1.9 Investigator:

2. Weather Conditions

2.1 During Sampling
2.1.1 Precipitation
Storm (Heavy Rain) ☐ Steady Rain ☐
Showers (intermittent) ☐ None ☐
2.1.2 Wind :
2.1.3 Cloud cover
Overcast ☐ Partly Cloudy ☐
Scattered Clouds ☐ Clear ☐
2.1.4 Other (Specify)
.....
.....

2.2 Has it rained heavily in the last 24 hours?
Yes ☐ No ☐
2.3 Has it rained heavily in >24 hours ago?
Yes ☐ No ☐

3. Stream Characterization

3.1 Stream Subsystem
Perennial ☐ Intermittent ☐
3.2 Stream Type
Coldwater ☐ Warmwater ☐

3.3 Stream Origin
Glacial ☐ Swamp and bog ☐
Snow-fed ☐ Mixture of Origins ☐
Spring-fed ☐ Other(Specify).....
3.4 Stream Order:

4. Catchment Characteristics

4.1 Predominant surrounding land-use: Indicate at 10% intervals for 1 km river stretch (taken upstream of site)
☐ Forest .....%
☐ Field/Pasture .....%
☐ Agricultural .....%
☐ Residential .....%
☐ Commercial .....%
☐ Industrial .....%
☐ Other (Specify) .....%

4.2 Riparian Vegetation (within 18 m buffer in sampling)
4.2.1 Dominant Vegetation Type
Trees ☐ Shrubs ☐
Grasses ☐ Herbaceous ☐
4.2.2 Dominant species present:
4.3 Canopy Cover at Zenith
Open ☐ Partly open ☐
Partly shaded ☐ Shaded ☐
4.4 Local Watershed Erosion
None ☐ Moderate ☐ Heavy ☐

5. Stressor

Stressors Group	Stressors	Stressors Intesity				
		1	2	3	4	5
5.1 Solid waste	Waste dumping					
5.2 Effluents	Cremation					
	Sewage					
	Agricultural effluent					
	Industrial effluent					
	Landfill leachate					
5.3 Activities and Facilities	Squatter settlements					
	Picnic spots close to river					
5.4 Hydro-morphological Degradation and Ecological Degradation	Vehicle crossing the river					
	Littering by picnic goers					
	Channel, embankment and weir					
	Bank cutting					
	Reservoir, dam and impoundment					
	Irrigation					
	Fishing and boating					
	Stone quarry and crushing					
	Sand quarry					
5.5 Personal Hygiene and Sanitation	Bathing and washing					
	Open defecation					
5.6 Others						

6. Hydro-morphological Parameters (Instream Features)

6.1 Stream Depth
Min.: .....
Max.: .....
Avg.: .....

6.2 Wetted Stream Width (Avg. of 4 measurements within 100 m stretch)
I) ..... II) .....
III) ..... iv) .....
Avg.: .....

6.3 Proportion of flow type (with respect to sampling river stretch)
Rapid .....% Riffle .....%
Run .....% Glide .....%
Pool .....%

6.4 Discharge Measurement

Distance from Bank																					
Depth																					
Velocity																					

7. Water Quality Parameters (Instream Features)

7.1 Temperature .....°C
7.2 pH .....
7.3 Turbidity ..... NTU
7.4 DO, DO Saturation ..... mg/L, ...%
7.5 Electrical Conductivity ..... µS/cm
7.6 TDS .....(mg/L)
7.7 Total Alkalinity .....(mg/L)
7.8 Total Hardness .....(mg/L)
7.9 Chloride .....(mg/L)
7.10 Nitrate .....(mg/L)
7.11 Ortho-phosphate .....(mg/L)
7.12 Ammonia .....(mg/L)
7.13 Water Odor
None ☐ Muddy ☐ Sewage ☐
Chemical ☐ Fishy ☐ Other (Specify).....
7.14 Water Colour
Clear Opaque Slightly Turbid
Stained Turbid Other (Specify).....

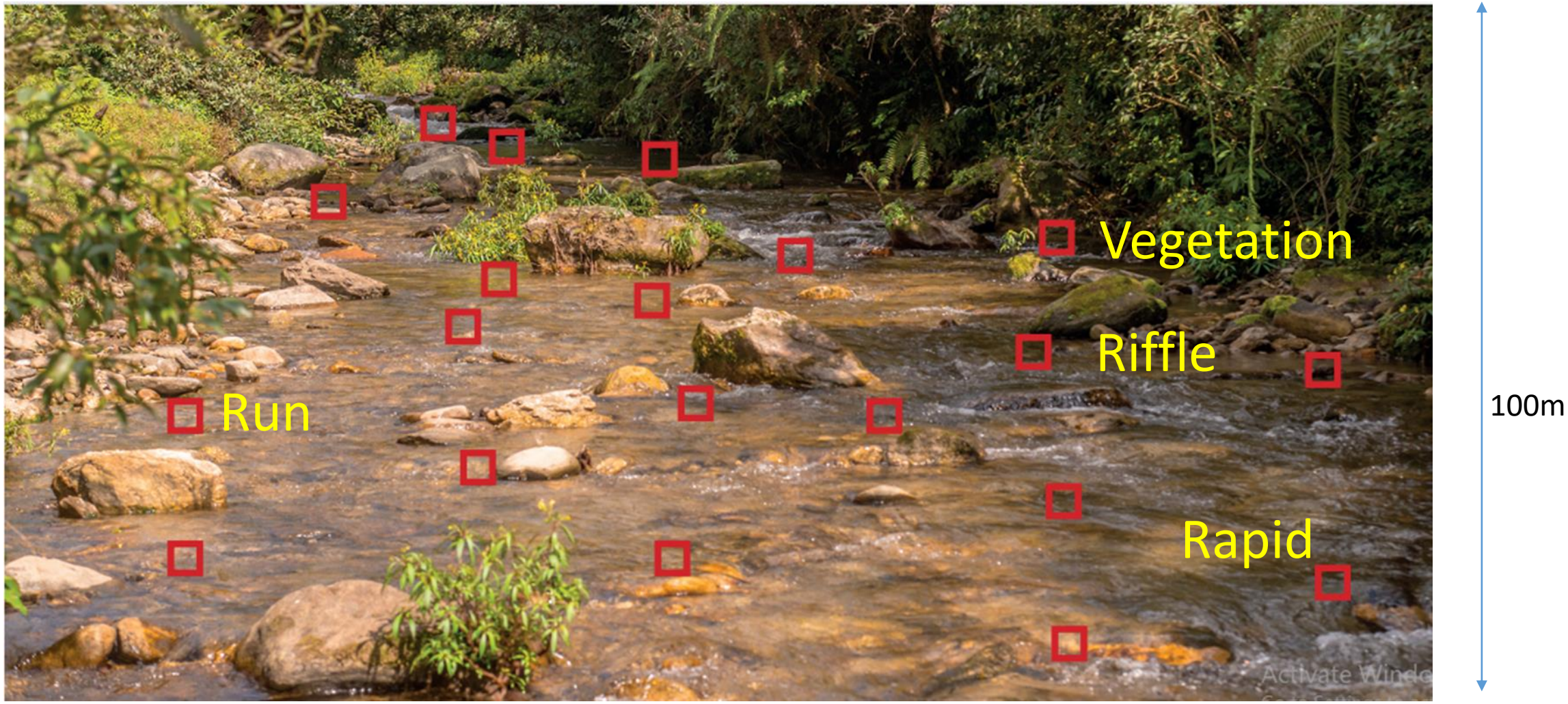
Sketch of the river stretch sampled with sample points

Macroinvertebrate Sampling

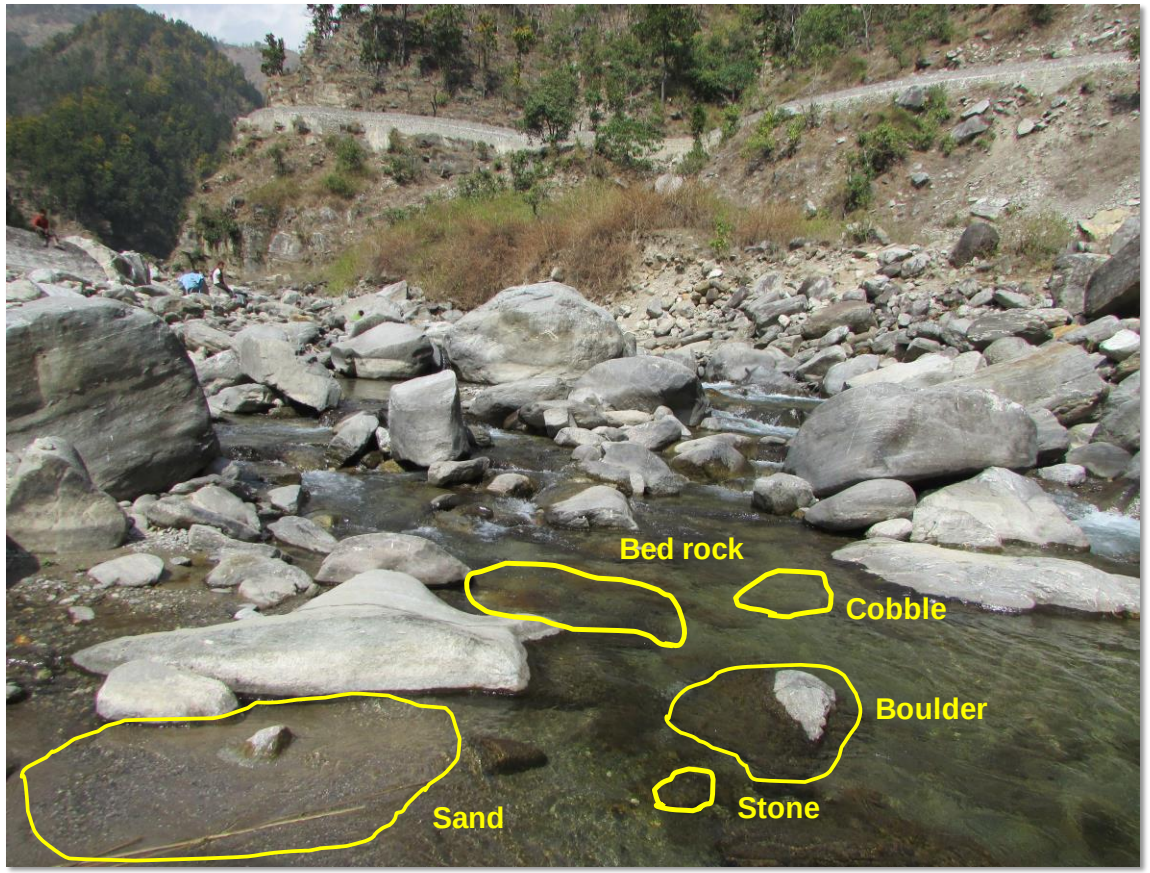
- Site selection strategy
  - Spatial and temporal scale
  - The selected site must be an appropriate river stretch that sufficiently represents the river.
  - Number of samples
  - Frequency of samples over a year: during baseflow, pre-monsoon and post-monsoon of the year

Macroinvertebrate Sampling

Identify substrate types and coverage



Habitat Assessment

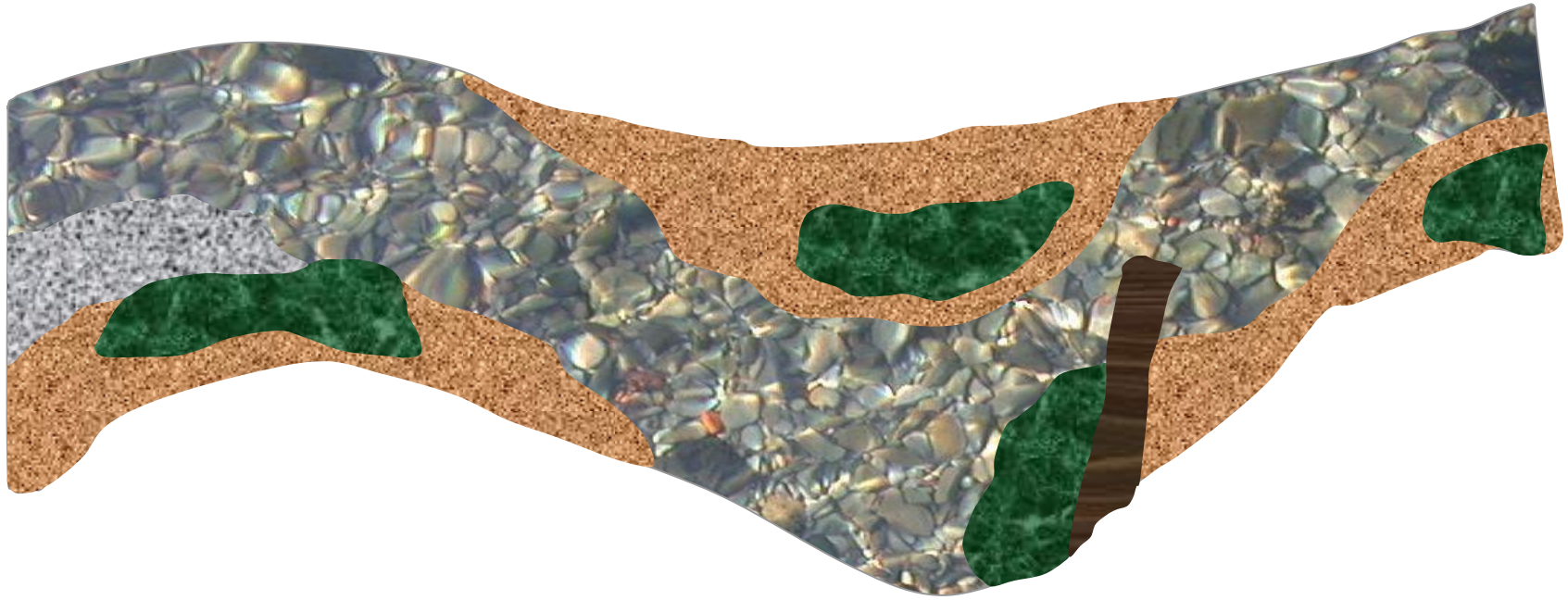


Habitat Assessment Sheet

Number of sampling units (in total 20 units at 5% interval) with respect to micro-habitats coverage in defined sampling river reach.

Site code:	Date/time:	Investigator:	
Mineral Substrate		**Coverage (5% steps)**	**No. of Sampling Units**
Boulders, bedrock (> 40 cm)			
Cobbles (> 20 cm – 40 cm)			
Stones (> 6 cm – 20 cm)			
Pebbles (> 2 cm – 6 cm)			
Gravel (>0.2 cm – 2 cm)			
Sand and mud (>6µm – 2 mm)			
Silt loam, clay (inorganic) (< 6 µm)			
Artificial substrates			
Sum		**100**	**20**
Biotic Substrate			
Algae			
Macrophytes- Emergent			
Macrophytes- Submerged			
Macrophytes- Floating			
Living parts of terrestrial plants			
Wood – Tree trunks, branches, roots			
Coarse particulate organic matter (CPOM) deposits			
Fine particulate organic matter (FPOM) deposits			
Sewage fungi and bacteria			
Debris – Organic and inorganic matter deposits			

Distribution of Sampling Units



step 1: recording of microhabitats (mineral & organic)

step 1

mesolithal

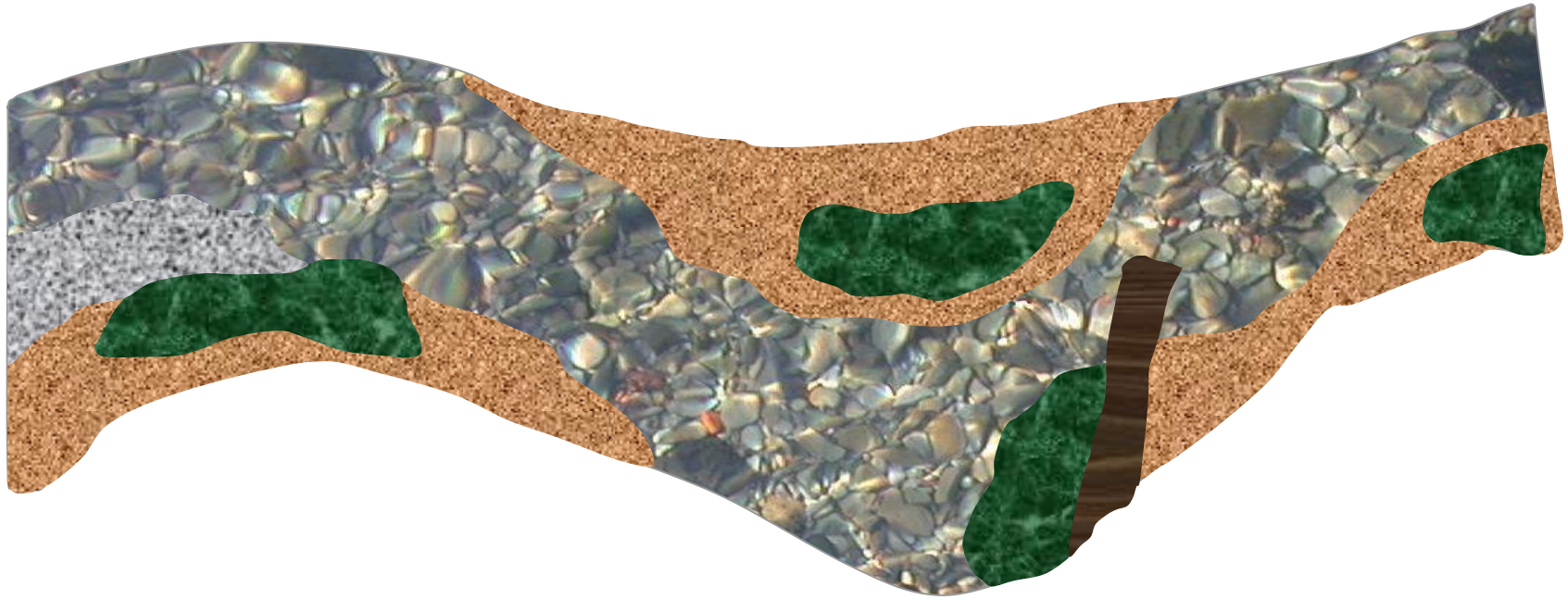
akal

psammal

Stone/algae

xylal

Distribution of Sampling Units



step 1: registration of microhabitats
(mineral & organic)

step 2: estimation of microhabitats
(in intervals of 5 % steps)

step 1 / step 2

mesolithal: 55 %

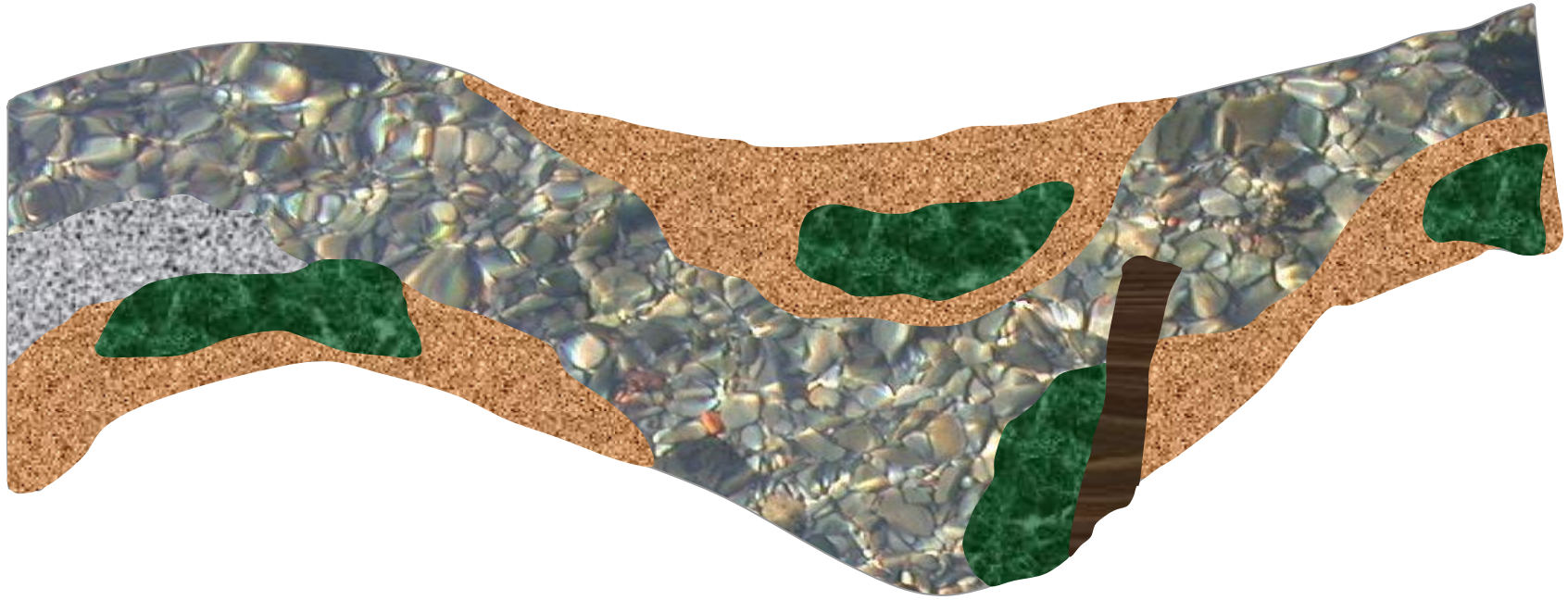
akal: 5 %

psammal: 25 %

Stone/algae: 15 %

xylal : < 5 %

Distribution of Sampling Units



step 1: registration of microhabitats
(mineral & organic)

step 2: estimation of microhabitats
(in intervals of 5 % steps)

step 3: assignment of sampling units
(1 sampling unit per 5 % step)

step 1 / step 2 / step 3

mesolithal: 55 % = 11 sampling units

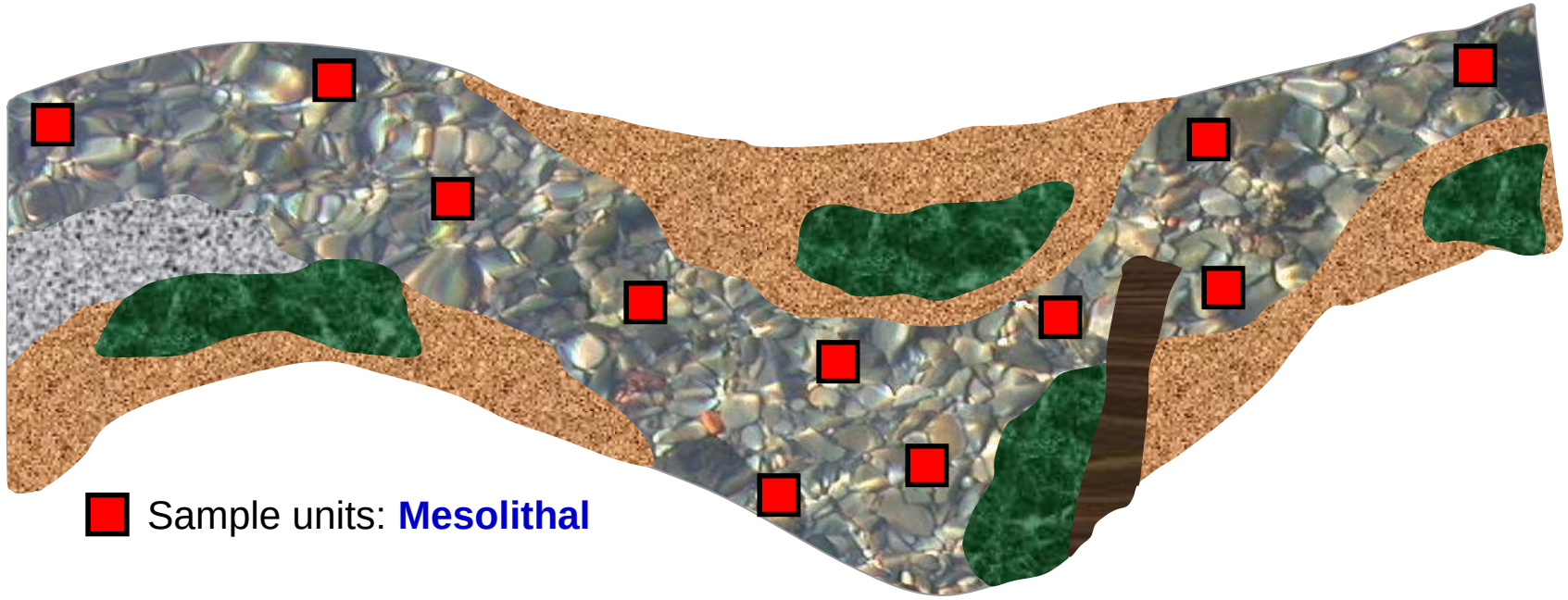
akal: 5 % = 1 sampling units

psammal: 25 % = 5 sampling units

Stone/algae: 15 % = 3 sampling units

xylal : < 5 % = **no** sampling units

Distribution of Sampling Units



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(see examples above)

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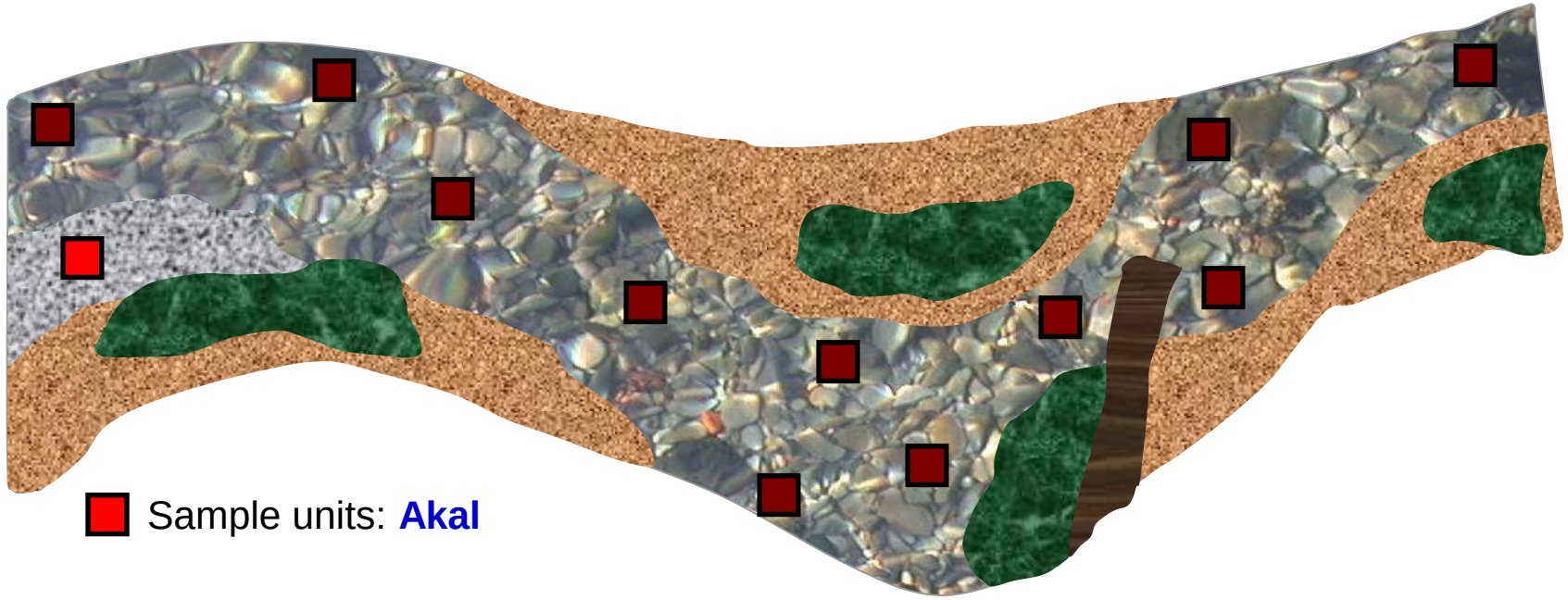

Sample units: **Akal**

step 1: registration of microhabitats
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(in intervals of 5 % steps)

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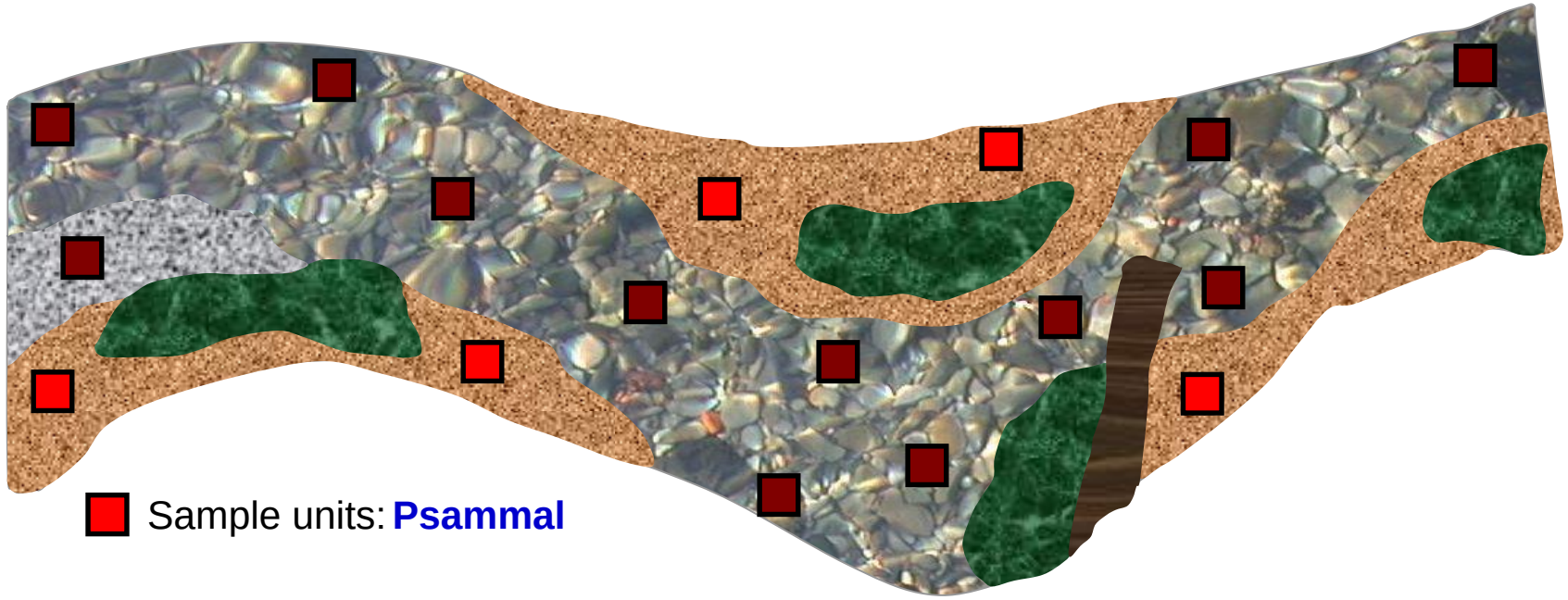

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(see examples above)

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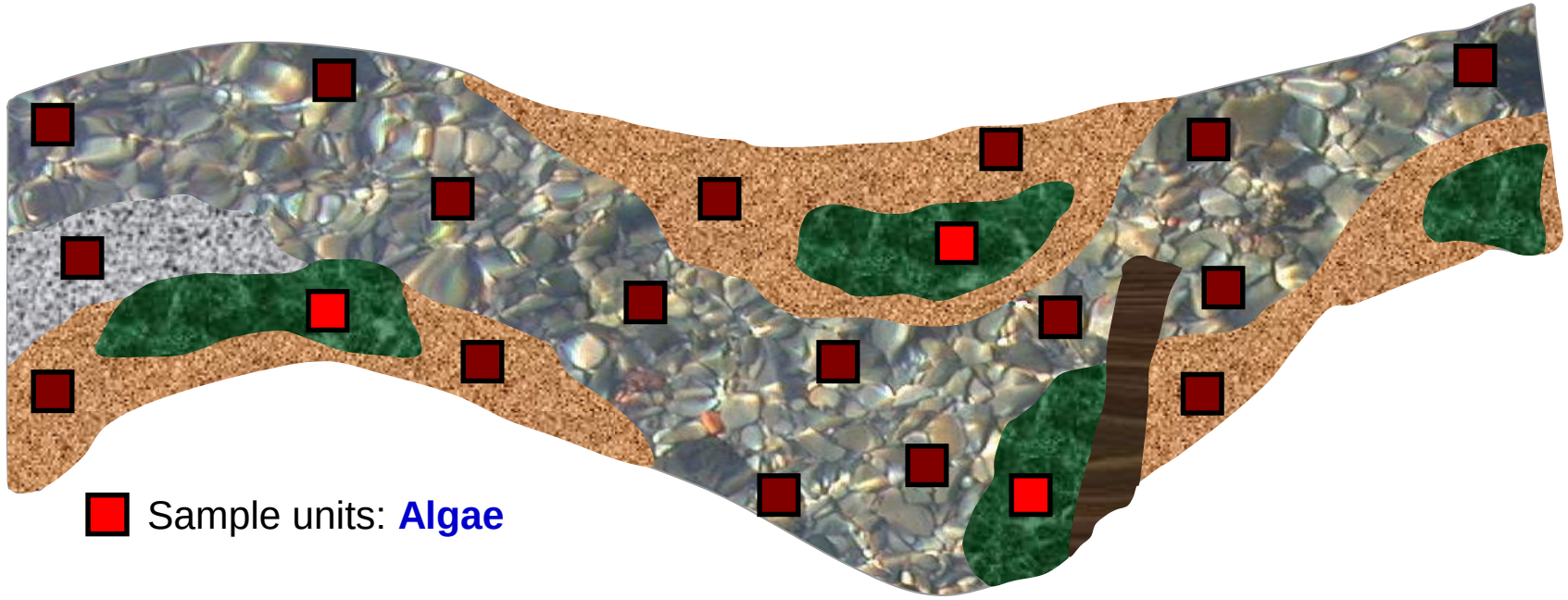

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Multi-habitat Sampling (MHS)

- Multi-habitat sampling = representative sampling of all major habitats (mineral and organic)

- ✓ Sampling is directed <u>against</u> the current
- ✓ Each sampling unit covers an area of 25 cm x 25 cm
- whirl up the substrate by foot or hand
- maximum depth: 5 cm
- wash off cobbles or large wood by hand (soft bush)
- empty the hand net into a bucket or tray in time (e. g., after sampling 2–4 units) to avoid clogging of net

Sampling in non-wadeable rivers

Artificial substrate

River bank

Macroinvertebrate Sample Processing

Labelling and preservation

- All sample containers, vials, bottles, buckets, etc. must be properly labelled with at least:
  - Sampling code
  - Site name
  - Date
  - Total no. of containers (if more than one used)

- Only properly labelled samples are then fixed and preserved with standard preservative

Preservation

- Standard preservatives are:
  - Ethyl alcohol
  - Formalin (4 % Formaldehyde)

Samples preserved with Formalin must at least be stored for two weeks before being treated further.

After the storage in Formalin, samples should be transferred from fixative (e.g. formalin) to preservative (ethanol) if they are kept for more than a few weeks before sorting.

Laboratory processing of samples

Taxonomic Identification

JoTT Communication 3(9): 2045–2060

Key to the larval stages of common Odonata of Hindu Kush Himalaya, with short notes on habitats and ecology

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[2] Hindu Kush Himalayan Benthological Society, Kausaltar, Nepal. P.O. Box: 20791, Sundhara, Kathmandu, Nepal
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Date of publication (online): 26 September 2011
Date of publication (print): 26 September 2011
ISSN 0974-7907 (online) | 0974-7893 (print)

Editor: K.A. Subramanian

Manuscript details:
Ms # o2759
Received 11 April 2011
Final received 22 July 2011
Finally accepted 11 August 2011

Citation: Nesemann, H., R.D.T. Shah & D.N. Shah (2011). Key to the larval stages of common Odonata of Hindu Kush Himalaya, with short notes on habitats and ecology. *Journal of Threatened Taxa* 3(9): 2045–2060.

Author Details: Hasko Nesemann, Ram Devi Tachamo Shah & Deep Narayan Shah are aquatic ecologists. They are specialized in aquatic macroinvertebrates diversity with a keen interest in freshwater ecology, biogeography, conservation, and ecological water quality monitoring.

Author Contribution: HN, RDTS and DNS conducted fieldworks and equally contributed in manuscript preparation. HN illustrated the specimens.

Acknowledgements: We want to thank Subodh Sharma (Aquatic Ecology Centre, Kathmandu University, Dhulikhel, Kavre, Nepal), Gopal Sharma (Zoological Survey of India, Gangetic Plains Regional Station, Patna, India), and R.K. Sinha (Centre for Environmental Science, Central University of Bihar, Patna, India) for their help in fieldwork.

Abstract: The order Odonata is one of the most widely studied groups among insects from the oriental region. They colonize in both stagnant and running water bodies of wide water quality. Hitherto, the existing literature on the Odonata contained numerous publications with coloured figures of adults, helpful for identification. Identification key with figures on larval stages, using their coloration as distinguishing characters are largely missing. The current work attempts to provide an identification key to aquatic larvae of the most common families of Zygoptera, Anisoptera and Anisozygoptera with colour illustrations. The specimens were collected from Nepal and India (northern part). Each family is represented by several examples to demonstrate the range of morphological variability. This key helps determination of aquatic larvae Odonata up to family level without enormous efforts in field and laboratory.

Keywords: Aquatic insect, damselfly, dragonfly, ecology, identification key, India, Nepal.

INTRODUCTION

The modern order Odonata is highly diversified with 5,680–5,747 (accepted) extant species, 864 (accepted) extant subspecies and approximately 600 fossil species (Xylander & Günther 2003; Kalman et al. 2008; van Tol 2008). The highest species number is known from the Oriental region which has more than 1,000 species. From India, exactly 499 species were recorded until 2005 by Mitra and 463 species confirmed by Subramanian (2009). Among all the species and subspecies within this geographical limit, the figure or description is known only for 78 taxa (Mitra 2005). For Nepal the number of species and subspecies was previously 172 published by Vick (1989). Later Sharma (1998) listed 202 taxa and Kemp & Butler (2001) added a new species for the country. In Bhutan, Mitra (2006) has published an actualized Odonata list with 31 taxa, to which the occurrence of *Epiophlebia laidlawi* around Thimpu can be added (Brockhaus & Hartmann 2009).

The taxonomy and knowledge of odonates in the Indian subcontinent and in many other parts of the world is largely based on terrestrial adults. There has been an old tradition in publication of very high quality colour figures for each species since the 18th century (Malz & Schröder 1979). In recent years all known Odonata species from the Japanese Archipelago were published by Okudaira et al. (2005) giving colour figures of both the larvae and the adults.

Mitra (2003) has provided an updated list of the regional species

JoTT Communication 2(1): 648-652

First records of *Rhicnoda natatrix* and *Rhicnoda rugosa* (Blattodea: Blaberidae) from Nepal and India (Maharashtra) with notes on habitat quality

Hasko Nesemann [1], Ram Devi T. Shah [2], Deep Narayan Shah [2] & Subodh Sharma [3]

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Date of publication (online): 26 January 2010
Date of publication (print): 26 January 2010
ISSN 0974-7907 (online) | 0974-7893 (print)

Editor: Prem Budha

Manuscript details:
Ms # o2281
Received 03 August 2009
Final received 09 November 2009
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Citation: Nesemann, H., R.D.T. Shah, D.N. Shah & S. Sharma (2010). First records of *Rhicnoda natatrix* and *Rhicnoda rugosa* (Blattodea: Blaberidae) from Nepal and India (Maharashtra) with notes on habitat quality. *Journal of Threatened Taxa* 2(1): 648-652.

Author Details: All the authors specialize in aquatic Macro-Invertebrate diversity and biological water quality monitoring in different ecoregions of the Central Himalayas with special emphasis on applicable keys for detailed identification of the regional fauna.

Author Contribution: HN conducted the field study and wrote up the paper as well as illustrated the species. The other authors contributed by writing the paper as well as conducted field and lab study.

Acknowledgements: Thanks are due to Andreas Dorsch (Lorsbach, Germany) for kindly helping in the literature search and especially for the original description of Shelford (1907).

Abstract: Two species of cockroaches were collected from aquatic habitats of undisturbed natural forest streams in Nepal and India (Maharashtra): *Rhicnoda natatrix* and *Rhicnoda rugosa*. Nymphs and adults are depicted and field observations of microhabitat and behavior described. Taxa lists of accompanying macroinvertebrate fauna are given, and water quality class is calculated using three biotic scoring systems. *R. natatrix* is a true aquatic species with amphibious lifestyle in the eulittoral of springs (Crenon) and streams (Rhithron) of excellent and good water quality classes I and II. *R. rugosa* is a predominantly terrestrial species that also colonizes the banks of water bodies and appears in between aquatic fauna. These species cannot be classified using the traditional habitat system.

Keywords: Aquatic fauna, ecological habitat, water quality

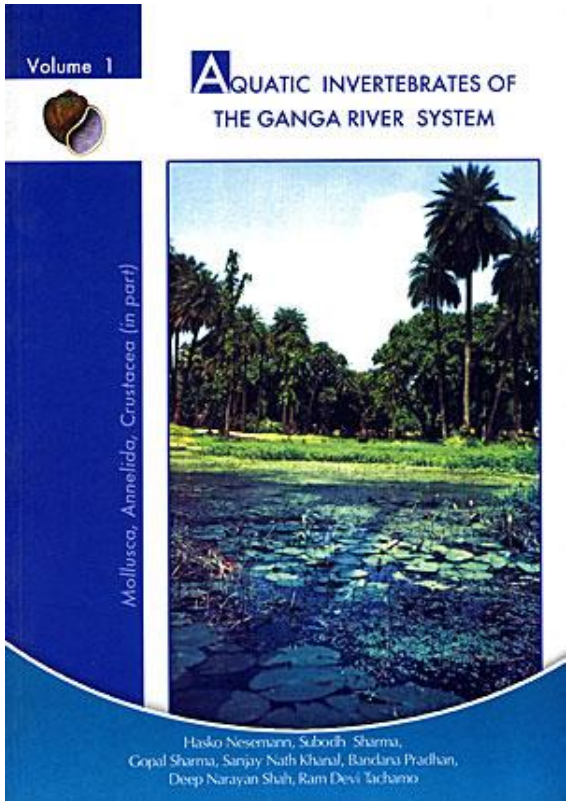
Introduction

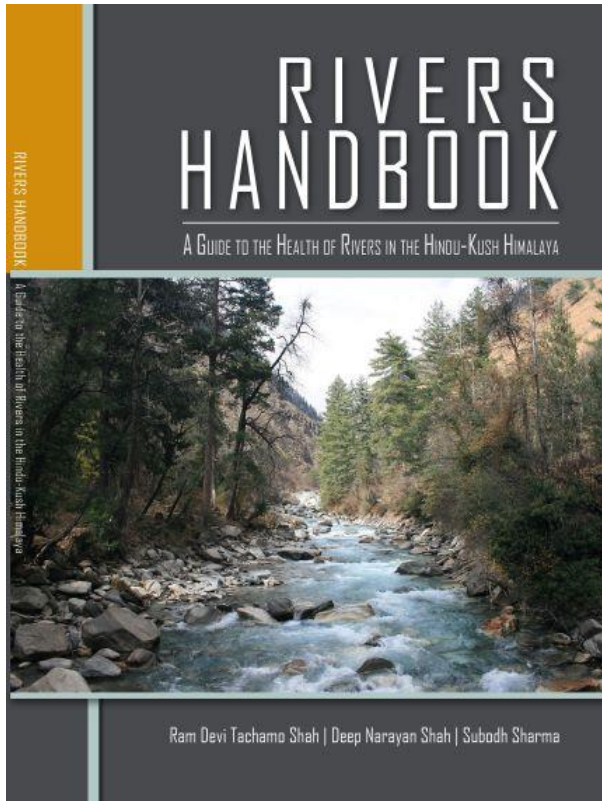
Fossil ancestors show the order Blattodea to be among the oldest extant groups of insects. "Blattoid" insects were already highly diversified in the Paleozoic and cockroaches (Eublattoidea) were dominant terrestrial insects in the Carboniferous and Permian (Beier 1967 - more recently true modern cockroach origins have been dated to the Triassic/Jurassic; Wichard et al. 1995). At present 4560 living species are known, but only a few enter aquatic zones. Fossil aquatic cockroaches are found from the Mesozoic, while extant aquatic cockroaches are known only from South Asia, South-East Asia and Japan. They share some characters with "living fossils" in belonging to geologically ancient taxa having Mesozoic characteristics and formerly wide distribution ranges, like the relict dragonflies (Anisozygoptera: Epiophlebiidae, Tab. 3, 4). Information in the literature is sparse. Only a few papers were published in the years 1900 to 1921 when the present taxa were still regarded as members of the order Orthoptera (Annandale 1900, 1906; Green 1902; Shelford 1907, 1909; Takahashi 1921). Findings of aquatic Epilamprinae in a Malaysian stream were published by Bishop (1973) who identified three genera. In the more recent taxonomical literature of aquatic macro-invertebrates Blattodea are briefly mentioned only by Ward (1992: 28), Hutchinson (1993: 569) and Dudegon (1999: 511-512).

From the Indian subcontinent the first published record (Annandale 1906: 105) described unidentified aquatic cockroaches in Jharkhand. Annandale collected a female nymph on 04 March 1905 "while turning over stones in a small jungle stream on a hill near Chakardharpur in Chota Nagpur". This and few other specimens prior to the description *Rhicnoda natatrix* are undoubtedly lost (Shelford 1907: 225). During the present study aquatic cockroaches were found in Maharashtra and Nepal. In both states no lists of cockroaches exists. Thus our records appear to be new for the country and the Himalayan region. Mandal (2003, 2006) did not mention the presence of *Rhicnoda* species for the fauna of Sikkim and Arunachal Pradesh. Most of the scattered published literature includes only terrestrial samples without specific habitat information. Aquatic forms might have been simply overlooked, because no particular research was done.

Materials and Methods

During different stream surveys in Nepal and India undertaken by the first three authors, Blattodea were discovered in qualitative samples and considered to be accidentally terrestrial forms. After recognizing them as true semi-aquatic and aquatic fauna in the field, thorough research was done to obtain more knowledge on these virtually unknown animals. Field collection of aquatic macroinvertebrates was done by the hand pickup method and with hand nets (mesh size 0.5mm) on various occasions. The relative abundance of each taxon was estimated in field observations and [after





Advantages of multi-habitat sampling

- It is a quantitative method, therefore, the number of species recorded for a site can be directly employed to statistical techniques.

- It is a representative copy for a site.

- It provides abundance of each group in addition to composition which can later be analysed in different ways and for purposes. E.g., FFGs.

Cons of multi-habitat sampling

- Does not cover an under represented habitat (< 5% habitat coverage in selected river stretch)
- Does not represent all available species for the site.

Qualitative sampling approach

- to provide complete taxa lists!
- to sample particular species or species groups!

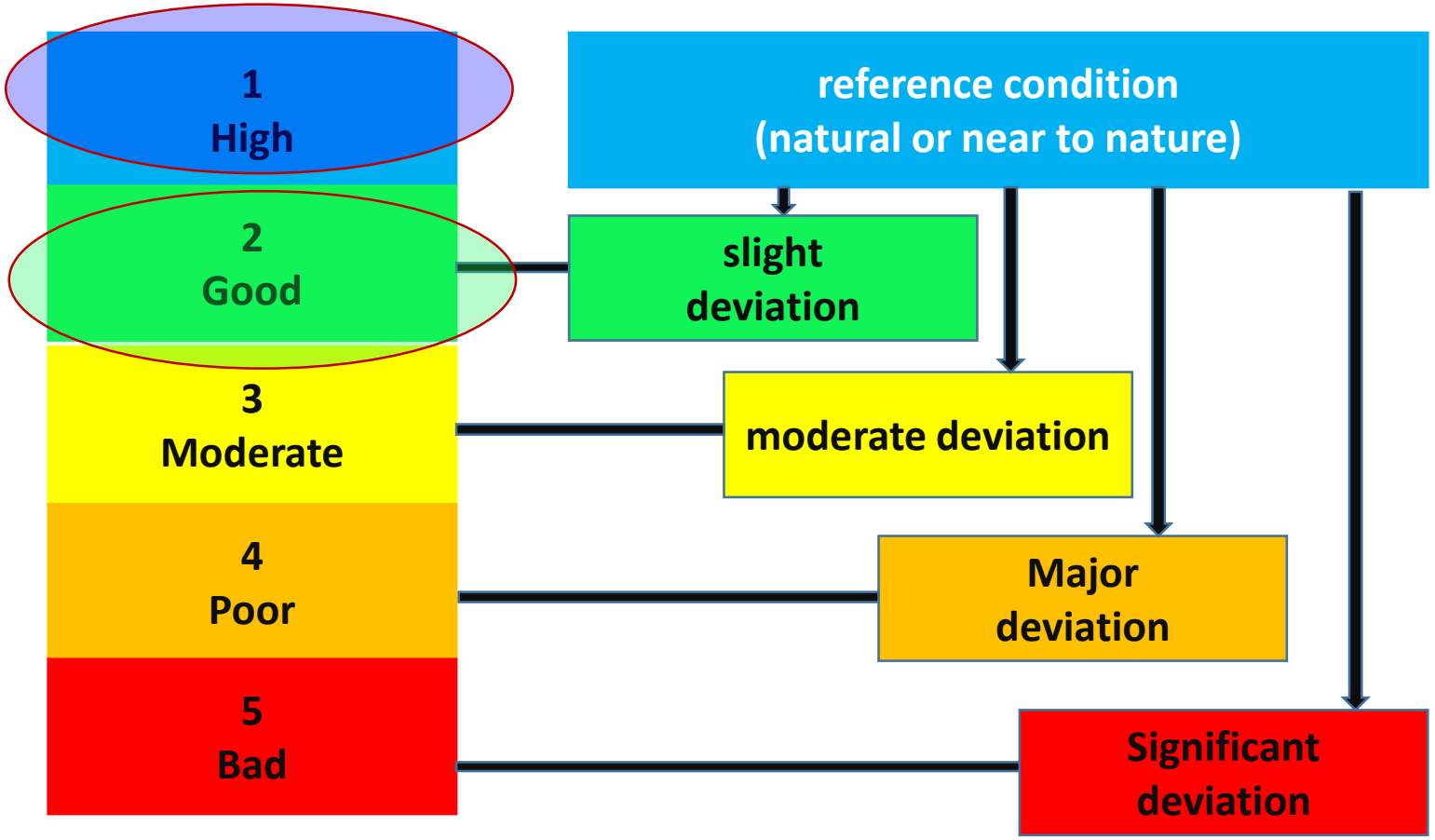
Quality Control

- Sample labels must be properly placed into the sample container. The outside of the container should also be labeled with the same information.
- After sampling has been completed at a given site, nets and other gear that have come in contact with the sample should be rinsed thoroughly, examined carefully, and made free of organisms or debris. Any additional organisms found should be placed into the sample containers. The equipment should be examined again prior to use at the next sampling site.

Safety

- Before going to the river, put on wading trousers on body.
- Precautions should be taken while getting into the river as the river bed might be slippery due to algal growth.
- While preserving samples, hand gloves should be worn to protect skin as they may dry skins.
- A first-aid kit should be in the field.

River status classification



EPT Index

- EPT Index = Total number of E, P and T taxa in a site

Table: EPT index and respective water quality class(NCDEHNR. 1997)

Water Quality ratings	Excellent	Good	Good-Fair	Fair	Poor
EPT	>27	21-27	14-20	7-13	0-6

Biotic metrics

Table 13 : List of commonly applied candidate biotic metrics to assess the impact of perturbation in a site under investigation.

Metric type	Candidate metrics	Calculation
Richness Measures	Total taxa richness	Total number of present taxa
	EPT richness	Number of present Ephemeroptera, Plecoptera and Trichoptera taxa
	Ephemeroptera richness	Number of present Ephemeroptera taxa
	Trichoptera richness	Number of present Trichoptera taxa
	COH richness	Number of present Coleoptera, Odonata and Hemiptera taxa
	Diptera richness	Number of present Diptera taxa
	Worm and Leech richness	Number of present Worm and Leech taxa
	Shannon-Wiener diversity index (H')	$-\Sigma p_i \ln p_i$ (Shannon and Weaver, 1949) where, p_i=Relative abundance of i^{th} taxon
	Pielous evenness (E)	$\frac{H'}{\ln (S)}$ where, H'= Shannon-Wiener diversity index, S= species richness
	Simpson's index of diversity	1-D, Simpson index (D)= $\Sigma n(n-1)/N(N-1)$

Biotic metrics

Composition Measures	% EPT richness	Percentage of Ephemeroptera, Plecoptera and Trichoptera taxa
	% Ephemertoptera richness	Percentage of Ephemeroptera taxa
	% Trichoptera richness	Percentage of Trichoptera taxa
	% COH richness	Percentage of Coleoptera, Odonata and Hemiptera taxa
	% Three dominant taxa	Percentage of three highly abundant taxa
	% Diptera individuals	Percentage of Diptera individuals
	% Chironimdae individuals	Percentage of Chironomidae individuals
	% Non insecta individuals	Percentage of non insecta individuals
	% Worm and Leech individuals	Percentage of Worm and Leech individuals
	% of Mollusca individuals	Percentages of Mollusca individuals

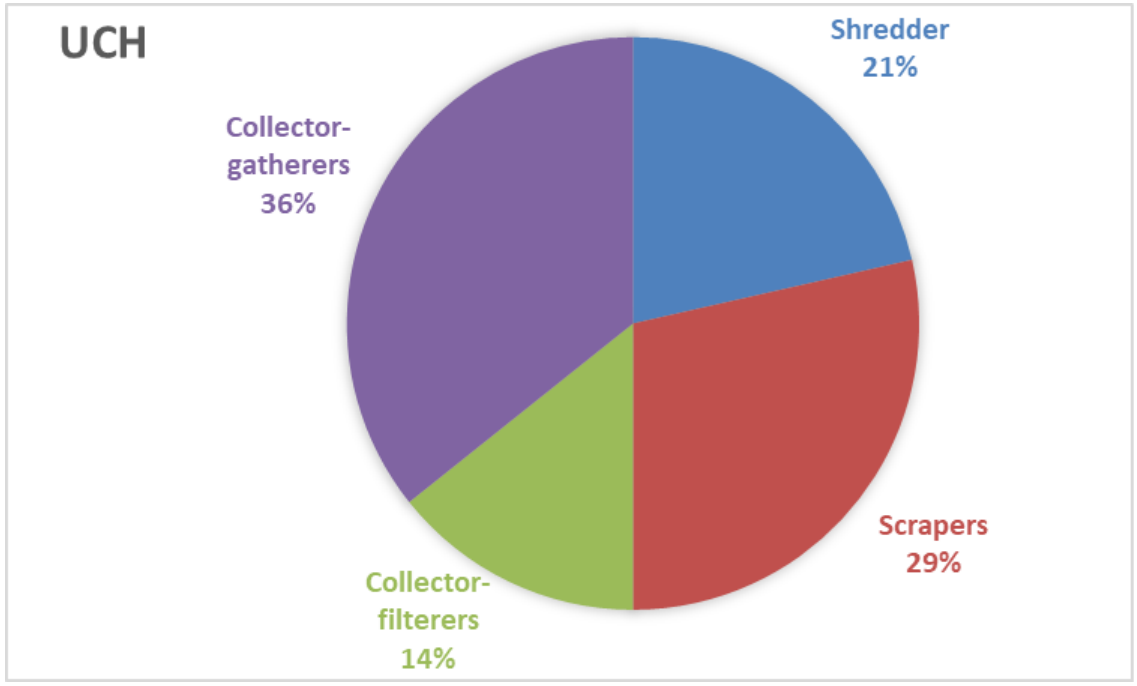
Biotic metrics

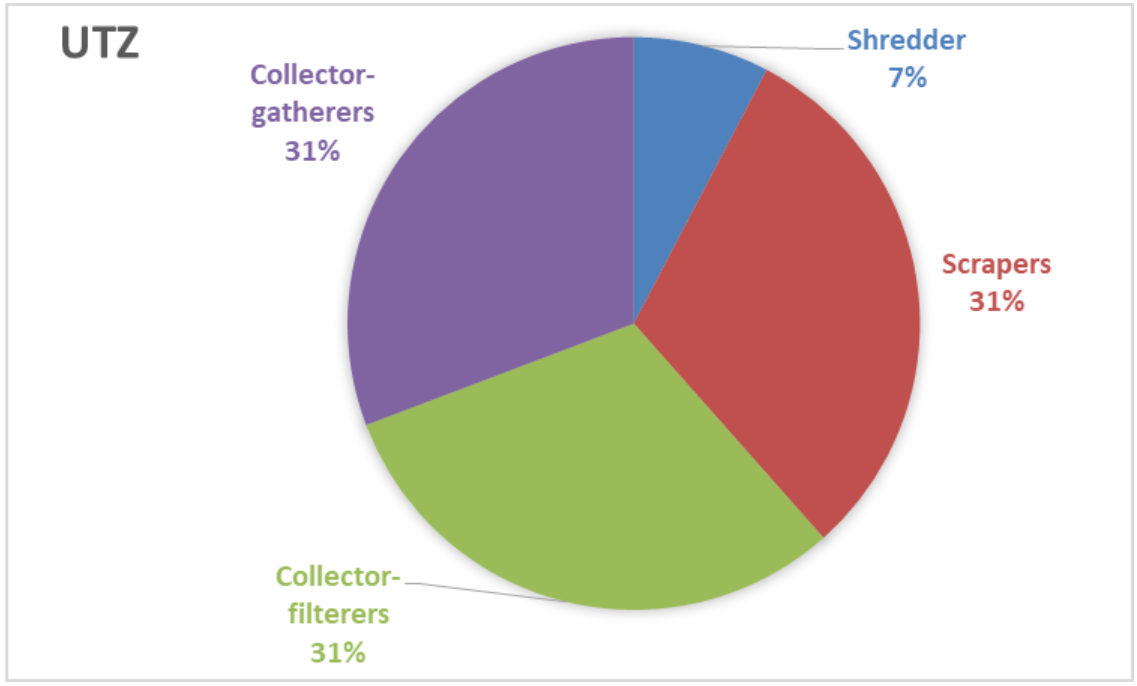
Metric type	Candidate metrics	Calculation
Sensitive Measures	Sensitive taxa richness	Number of taxa with tolerance score ≥7
	Facultative taxa richness	Number of taxa with tolerance score 4 to 6
	Tolerant taxa richnss	Number of taxa with tolerance score 1 to 3
	% Sensitive individuals	Percentage of present taxa individuals with tolerance score ≥7
	% Facultative individuals	Percentage of present taxa individuals with tolerance score 4 to 6
	% Tolerant individuals	Percentage of present taxa individuals with tolerance score 1 to 3
	Biotic Index	$Biotic\ Index = \frac{\sum_{i=1}^{n} TSS_i}{n}$ where, TSS_i is the Taxa Sensitive Score of taxon i and n is the total number of scored taxa*

Biotic metrics

Functional Feeding Groups	Shredder richness	Number of Shredder taxa
	Scraper richness	Number of Scraper taxa
	Collector-gatherer richness	Number of Collector-gatherer taxa
	Collector-filterer richness	Number of Collector-filterers taxa
	Predator richness	Number of Predator taxa
	% Shredder individuals	Percentage of Shredder individuals
	% Scraper individuals	Percentage of Scraper individuals
	% Collecter-gatherer individuals	Percentage of Collecter-gatherer individuals
	% Collector-filterer individuals	Percentage of Collector-filterer individuals
	% Predator individuals	Percentage of Predator individuals
Others	Density	Number of individuals per square meter
	Biomass	Dry biomass of all individuals in a site

Functional Feeding Groups-Example





Trishuli River System

EPT Index- Example

Sites	Code	EPT	Rating
Upper Chilime	UCH	15	Good-Fair
Lower Chilime	**LCH**	**13**	**Fair**
Sankhu	SAK	18	Good-Fair
Langtang Khola	LAN	18	Good-Fair
MailungKhola	MAI	24	Good
Tadi Khola	TAD	21	Good
Upper Budi Koshi	UBK	18	Good-Fair
Below Trushuli Dam	**BTD**	**8**	**Fair**
Upper Trishuli River	UTR	14	Good-Fair
Trishuli Dewatered Zone (UDZ)	**UTZ**	**12**	**Fair**
Lower Trishuli River	**LTR**	**11**	**Fair**

Determination of RQC

Box 2 Determination of biotic index value and river quality class of a study site.

S.No.	Taxa	TSS
1	Baetidae	4
2	Baetidae- *Baetiella spp.*	7
3	Perlidae	8
4	Calamoceratidae	8
5	Rhyacophilidae- *Hypo-rhyacophila spp.*	8
6	Stenopsychidae	8
7	Psephenidae- Psephenoidinae	7
8	Scirtidae	10
9	Synlestidae	NA
10	Dixidae	7
11	Hydracarina	7
12	Pomatiopsidae	10
	Sum	**84**

$$Biotic\ Index = \frac{\sum_{i=1}^{n} TSS_i}{n}$$

= 84/11

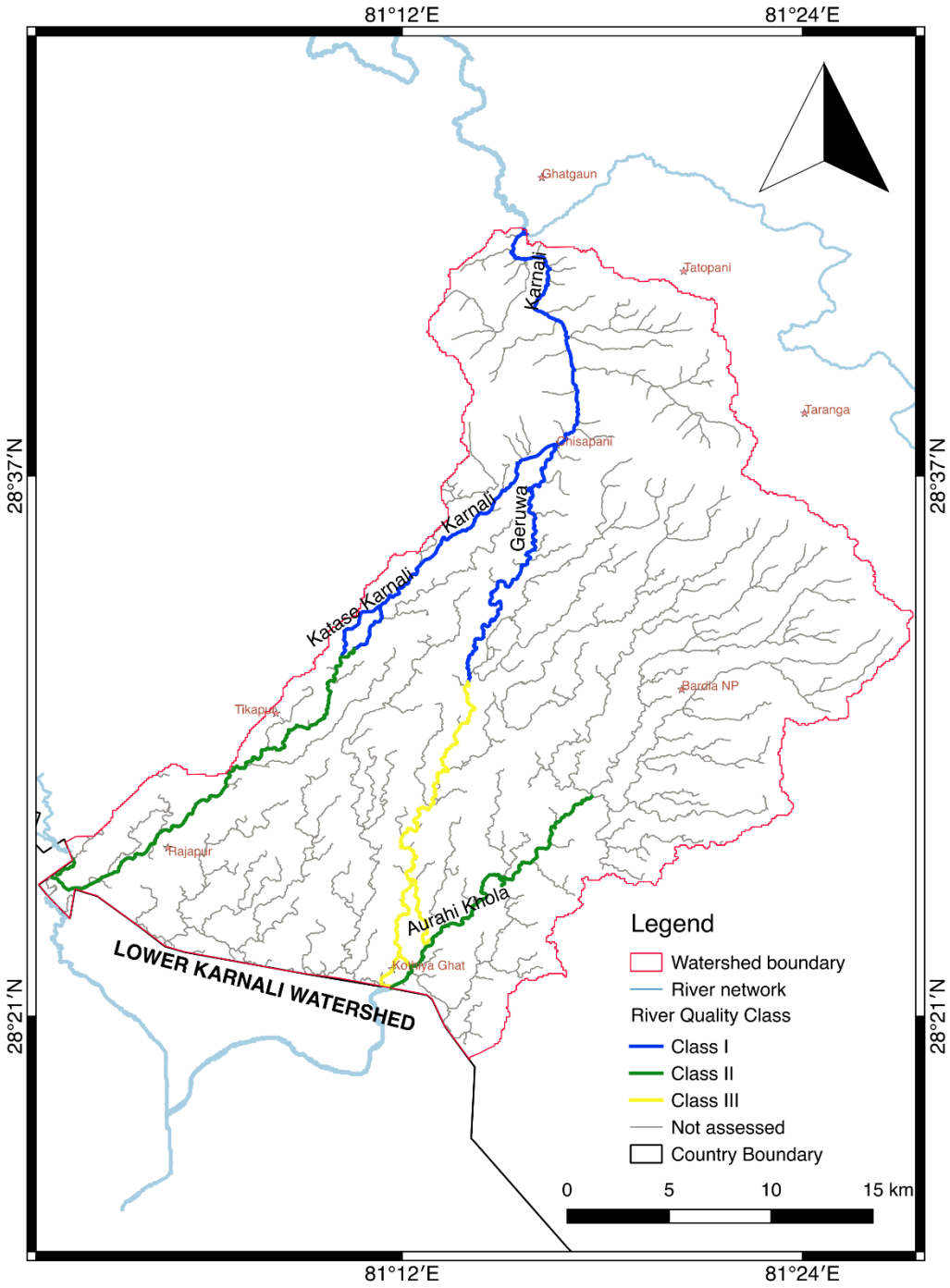
= 7.64

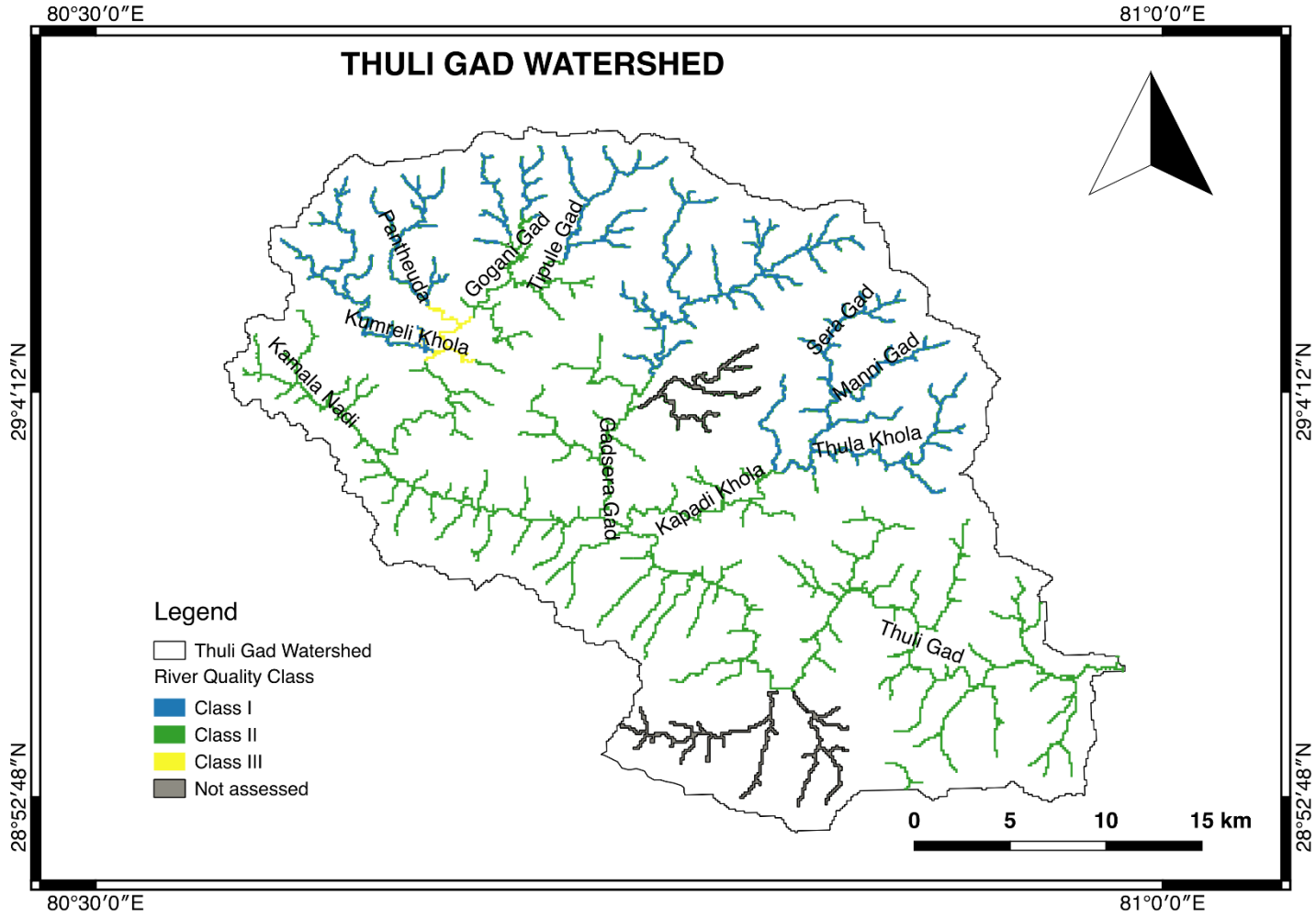
River quality class = I

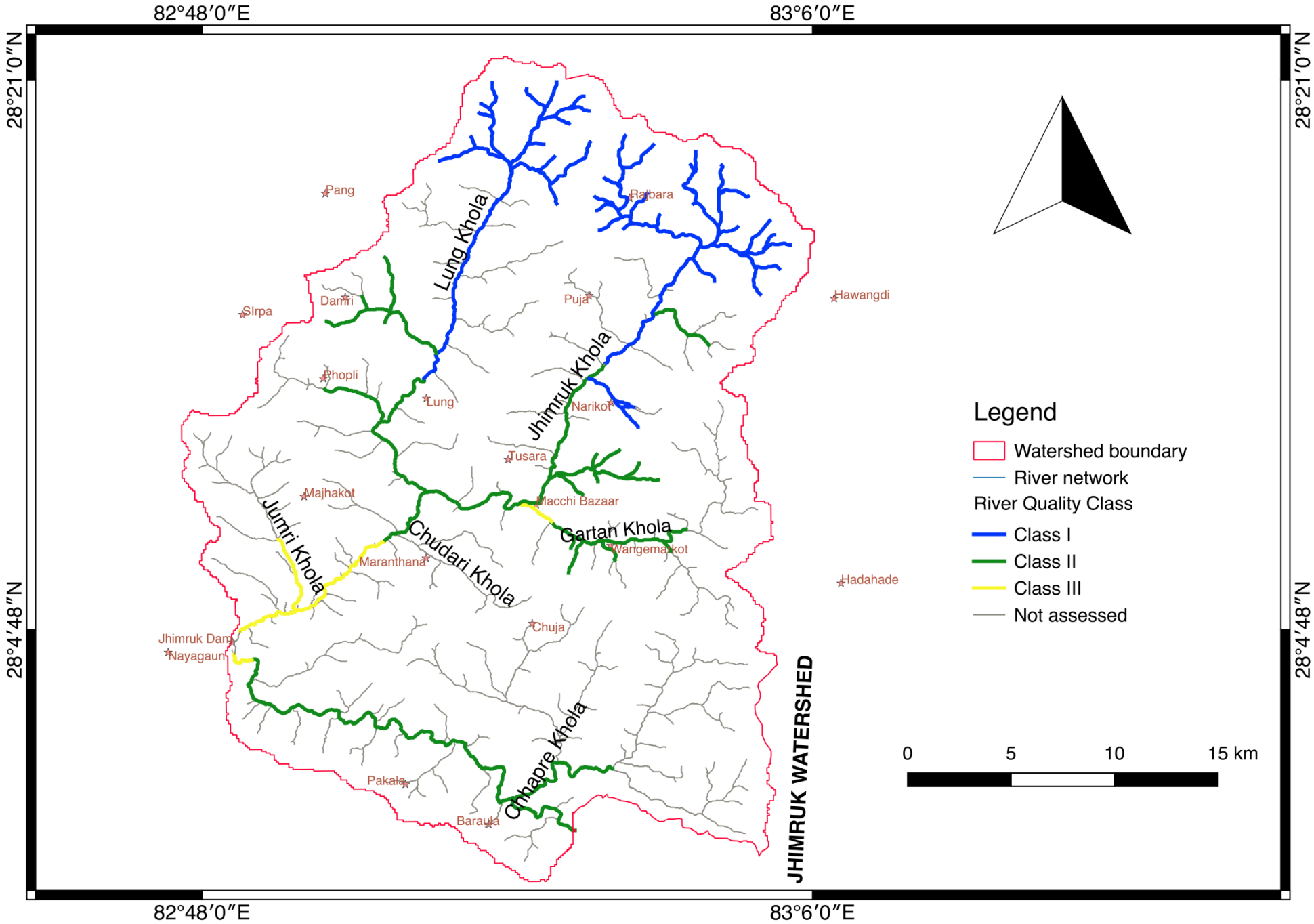
Colour banding of rivers is an easily understandable transformation of complex scientific information.

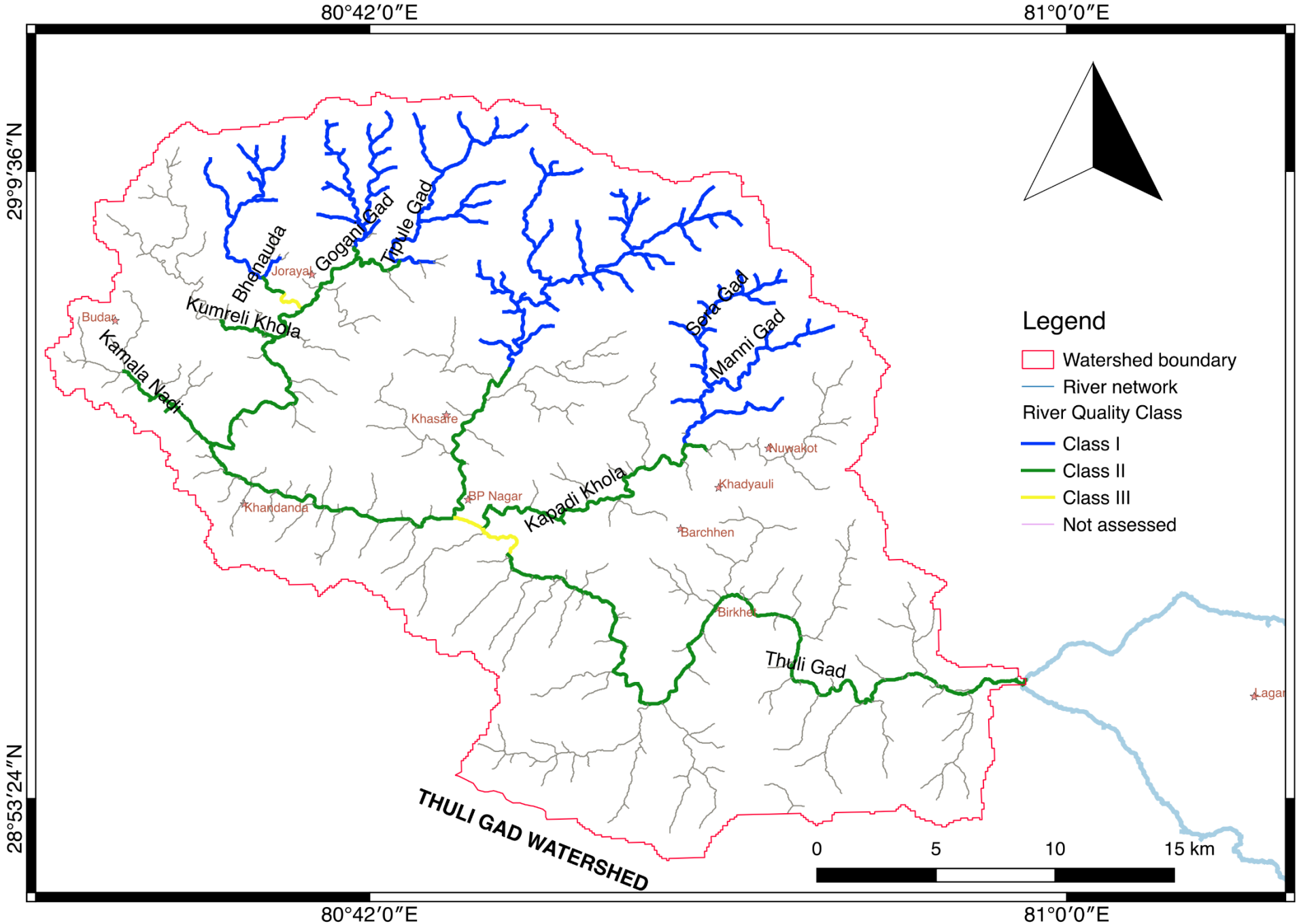
Water quality maps visualise the ecological status of rivers and thus **stimulate** politicians, decision makers, stake holders, water managers and the interested public to **start** actions.

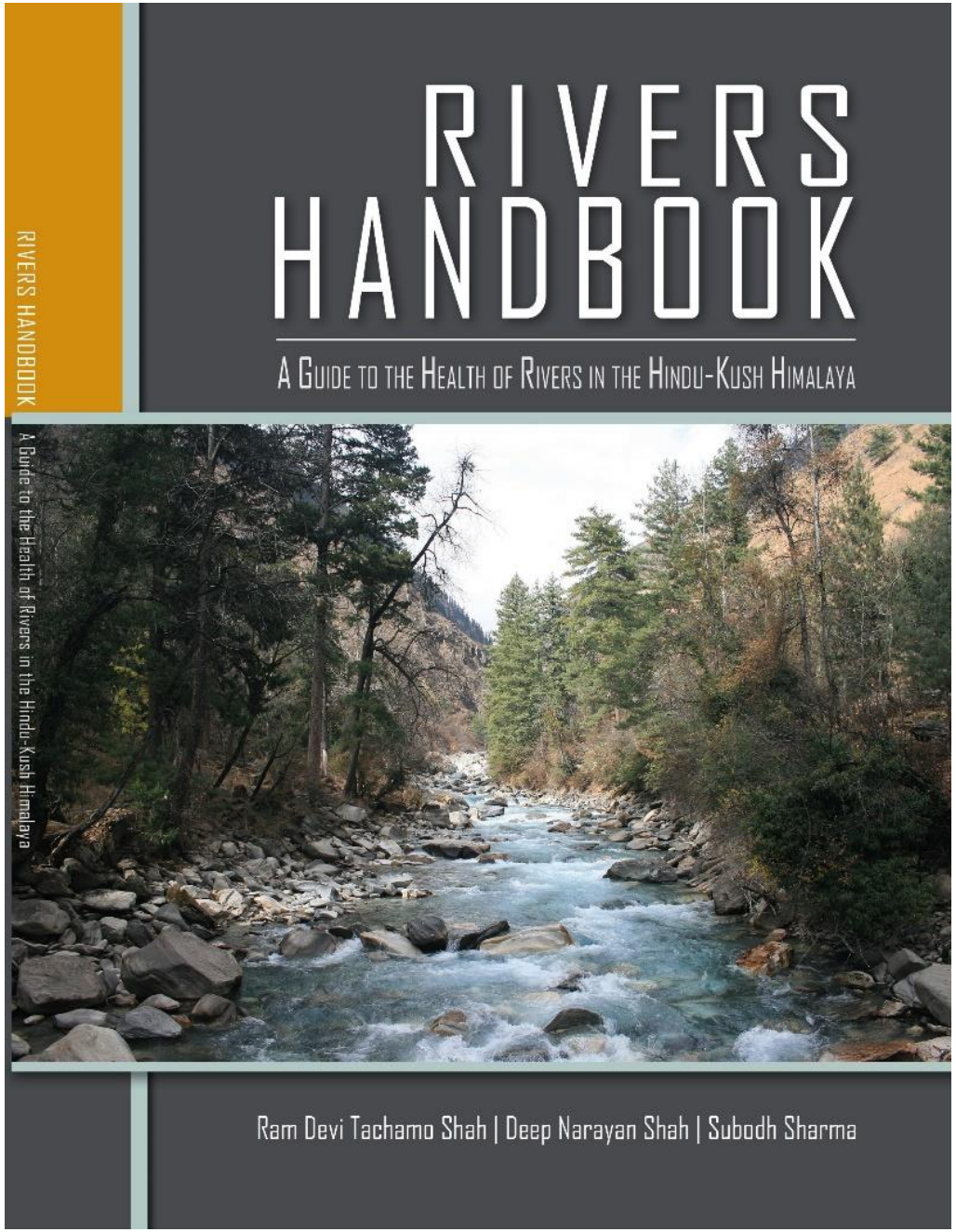
River Quality Maps






82°48′0″E
83°6′0″E
28°21′0″N
28°4′48″N
Pang
Rabara
Lung Khola
Hawangdi
Puja
Damri
Sirpa
Phopli
Lung
Jhimruk Khola
Narikot
Tusara
Majhakot
Macchi Bazaar
Jumri Khola
Chudari Khola
Gartan Khola
Wangemakot
Maranthana
Hadahade
Chuja
Jhimruk Dam
Nayagaun
Orhapre Khola
Pakala
Barauta
JHIMRUK WATERSHED
Legend
Watershed boundary
River network
River Quality Class
Class I
Class II
Class III
Not assessed
0
5
10
15 km


80°42′0″E
81°0′0″E
29°9′36″N
28°53′24″N
Bhelnauda
Gogani Gad
Tipule Gad
Kumreli Khola
Kamala Nadi
Sera Gad
Manni Gad
Kapadi Khola
Thuli Gad
Joraya
Buda
Khasare
Khandanda
BP Nagar
Nuwakot
Khadyauli
Barchhen
Birkhet
Lagar
THULI GAD WATERSHED
Legend
Watershed boundary
River network
River Quality Class
Class I
Class II
Class III
Not assessed
0
5
10
15 km



Available at:

Aquatic Ecology Centre (AEC)

Kathmandu University (KU)

Dhulikhel, Kavre, Nepal

Citizen Scientist

Thank you

Ephemeroptera