An integrated approach for the conservation of Aquatic insect diversity in montane streams and rivers of the Western Ghats – a clarion call

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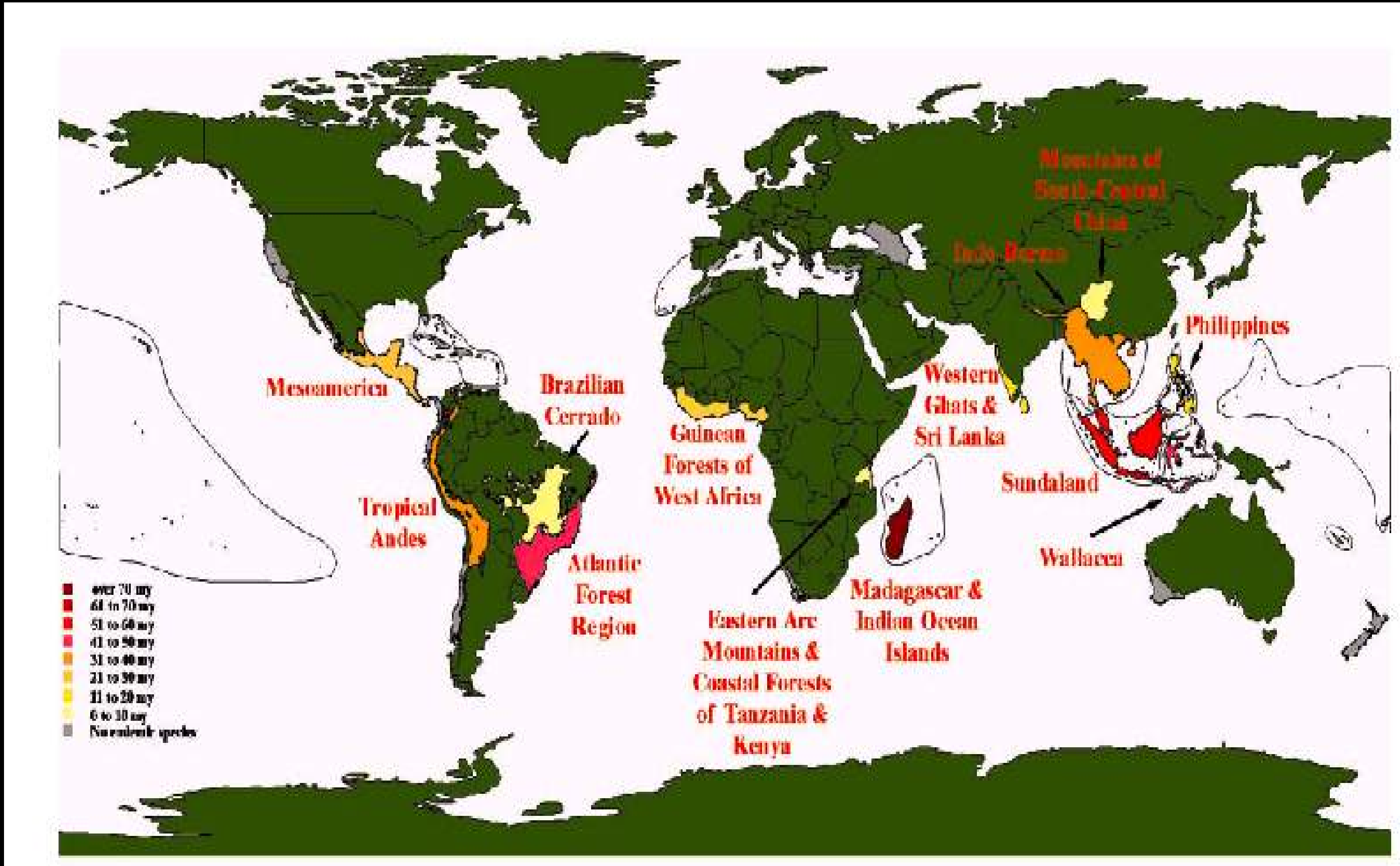
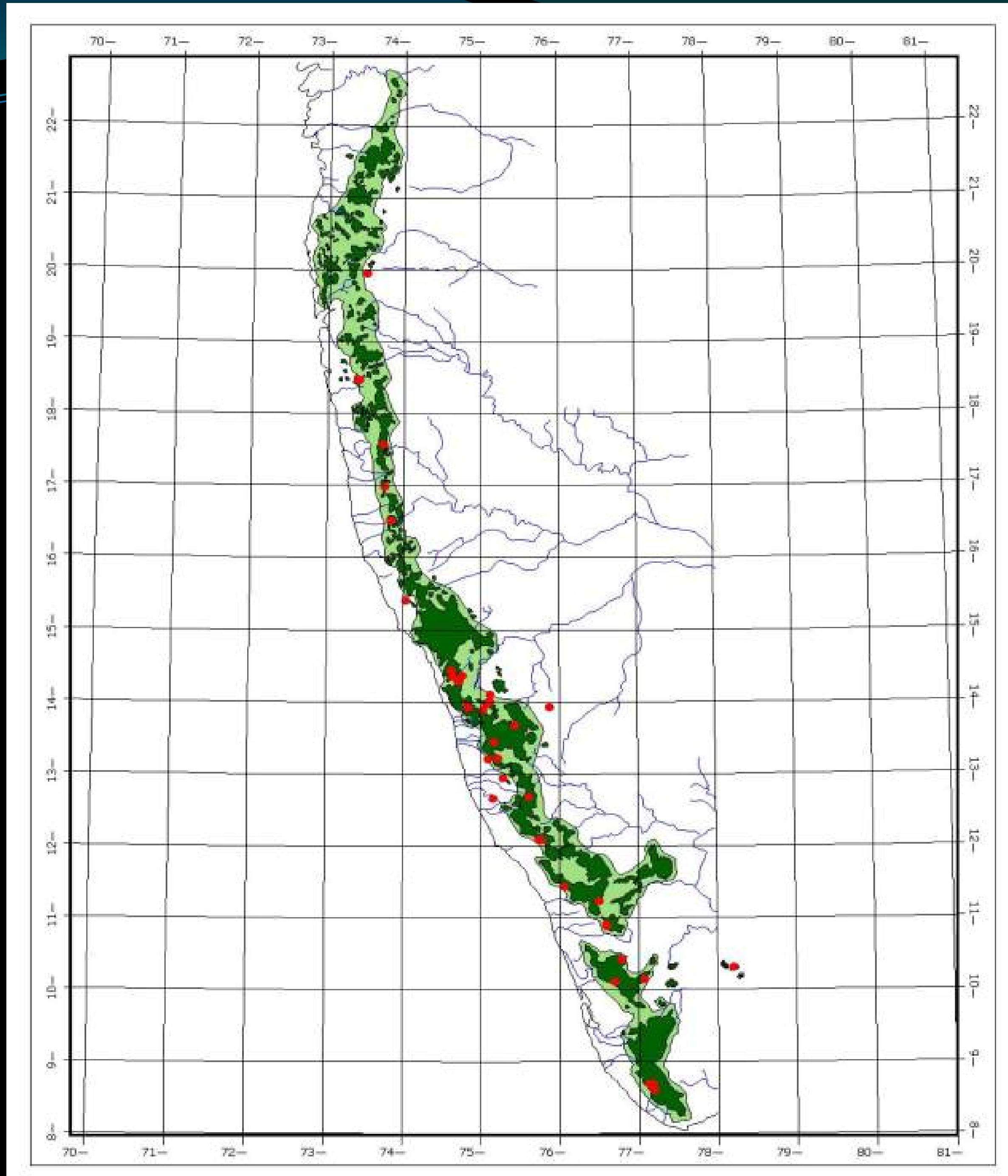
A SPECIAL CONTRIBUTION TO NATIONAL BIODIVERSITY AUTHORITY, GOVERNMENT OF INDIA ON THE OCCASION OF **INTERNATIONAL DAY FOR BIOLOGICAL DIVERSITY - 2013**

Biodiversity hotspots

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Freshwater Biodiversity – the overriding conservation priority – International Decade for action – **'Water for life'** – 2005 - 2015

Freshwater

- Only 0.1% of the World's water, occupying 0.8 % of the earth's surface.
- However, this tiny fraction of global water supports 1,00,000 species out of 1. 8 million species – 6 % of all described species.
- A fragile ecosystem with a major component of endemic and imperiled taxa.
- Experiencing declines in biodiversity for greater than those in terrestrial systems.

Values of diverse freshwater biota

Characteristic assemblages of benthic macroinvertebrates (aquatic insects being the dominant components) vital to maintain the **BIOTIC INTEGRITY** of lentic and lotic waters.

- **essential links in fish food chain**
- **sensitive biomonitoring tools**
- **several keystone and other taxa rendering important 'Ecosystem services' (for eg. Breakdown of particulate organic matter – CPOM – FPOM- UFPOM- Spiraling of nutrients- downstream transport of organic matter etc.,)**
- **several charismatic taxa**
- **Ideal objects for phylogenetic and biogeographical analyses**

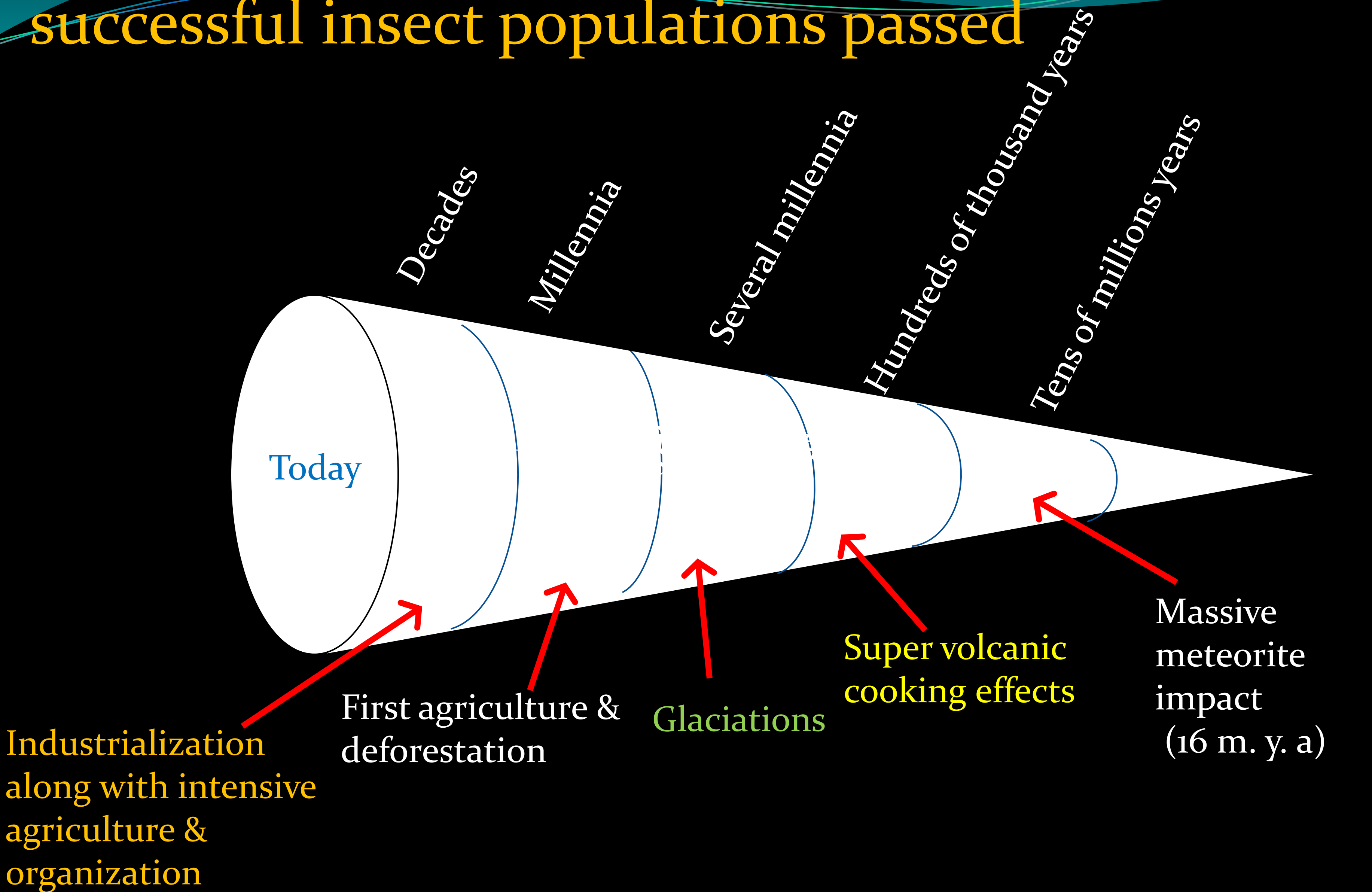
What is Biological Integrity?

The ability of an aquatic ecosystem to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region

Threats to biodiversity & Biodiversity erosion

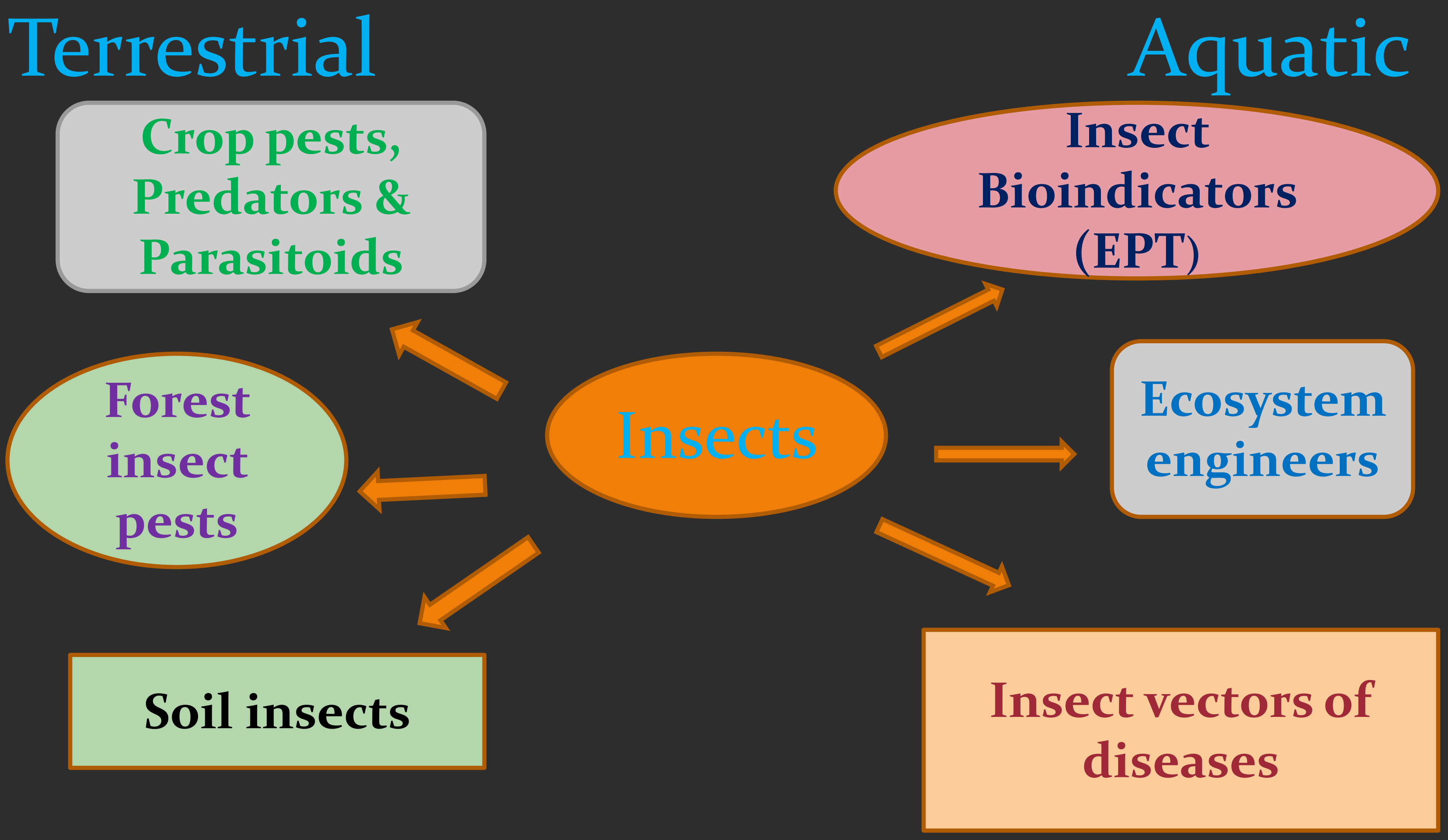
- In the geological past, 5 mega extinctions have happened due to natural calamities. The present 6th mega extinction is initiated by humans. In addition to that, several minor extinctions have occurred
- Threats
  - Habitat loss
  - Poaching of wildlife
  - Man wildlife conflicts
  - Deforestation
  - Marine pollution resulting in depletion of corals etc.
  - Loss of mangroves
  - Introduction of exotic species disrupting the existing balance

Dramatic natures events filters through which successful insect populations passed

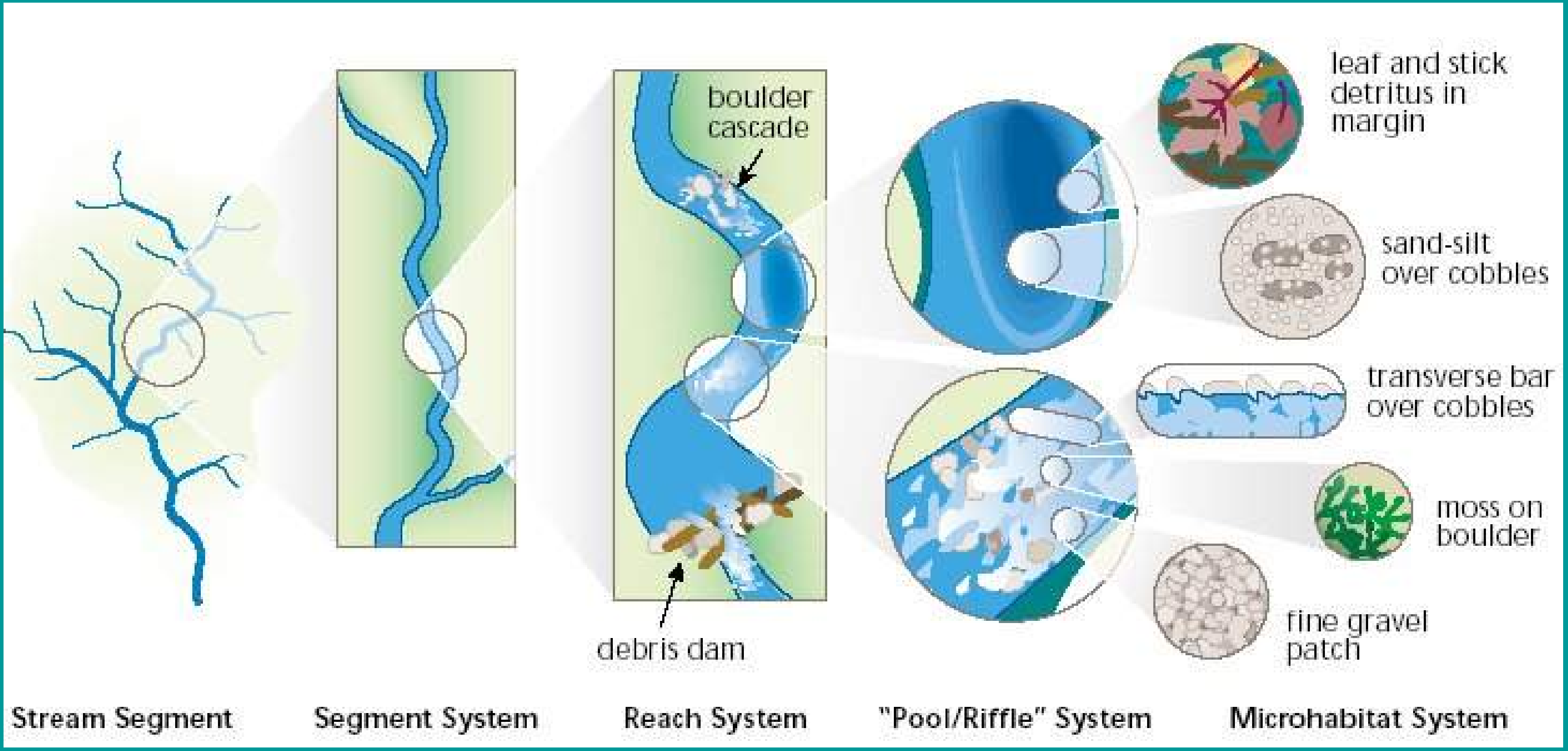


Janzen *et al.* 2005

INSECT DIVERSITY SPECTRUM

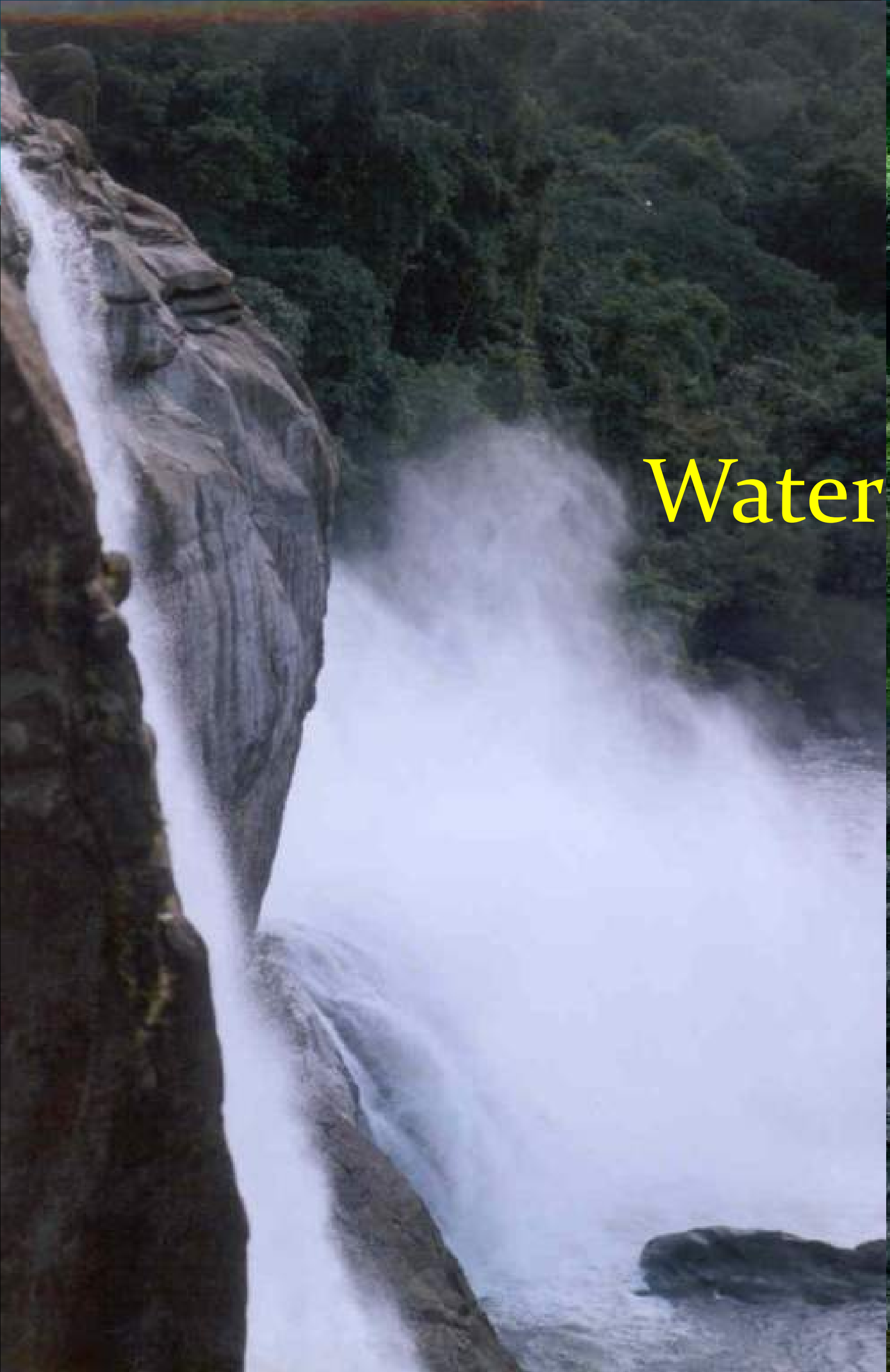


Stream system and habitat subsystem

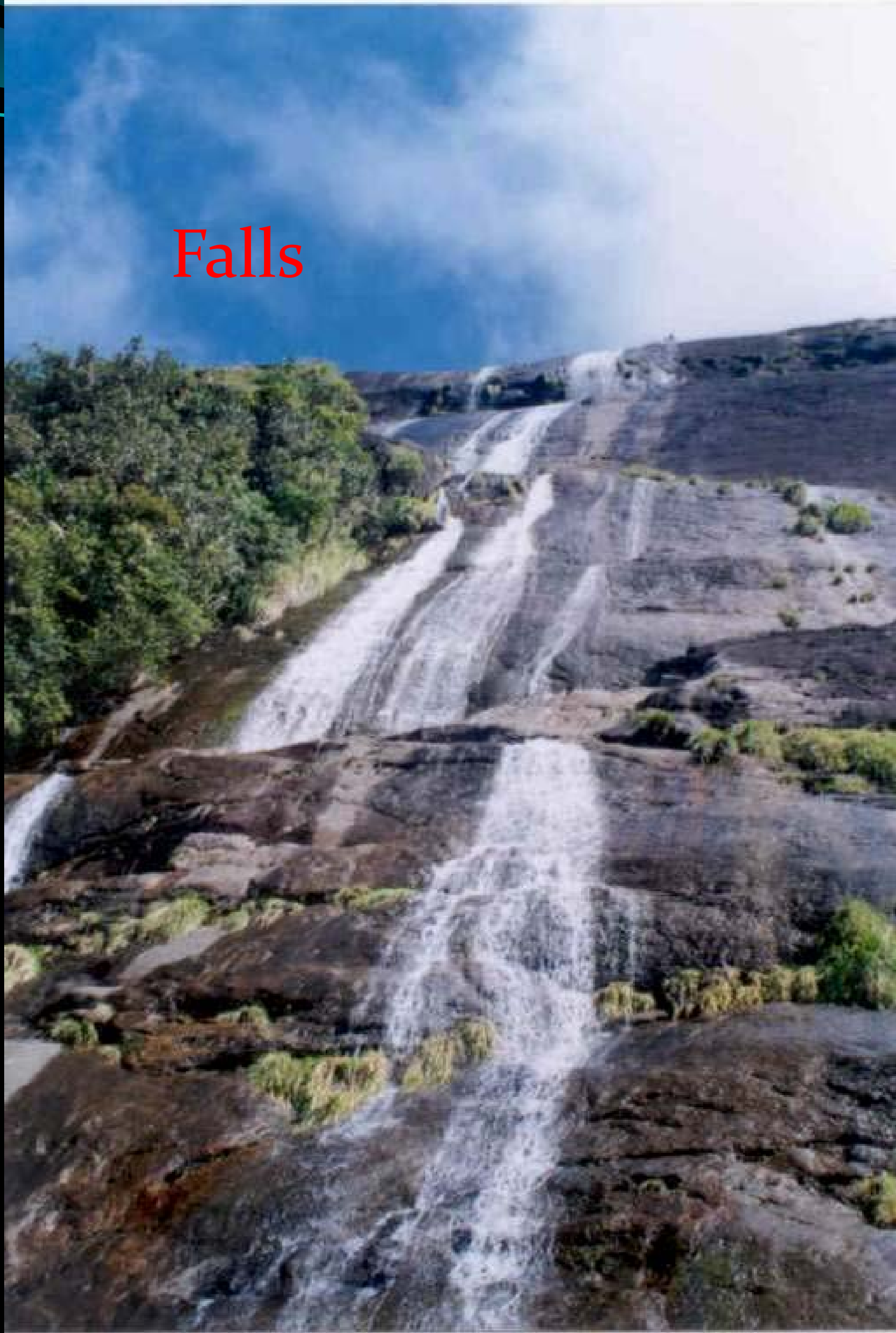


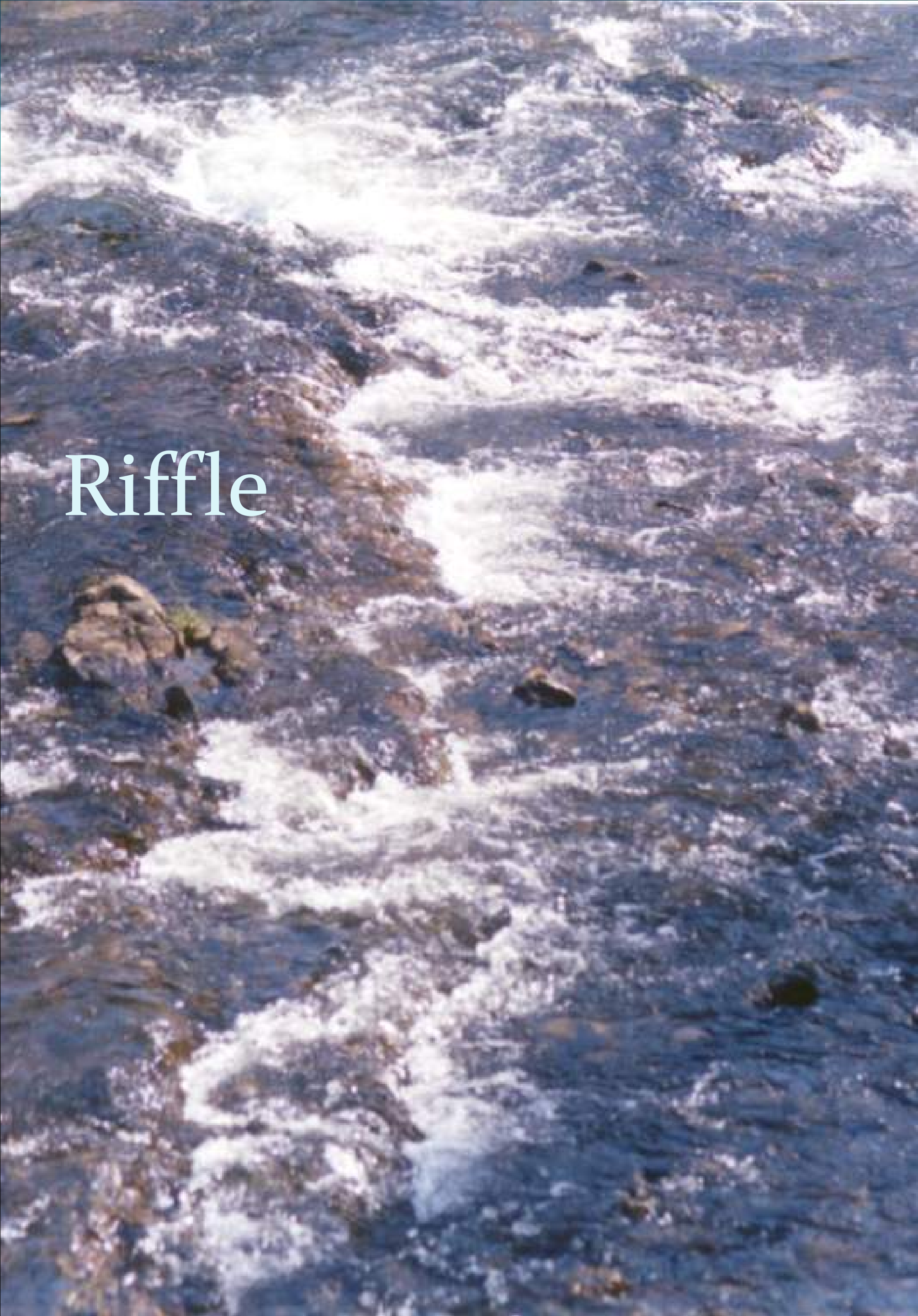
Riparian Landuse and Aquatic Insects

Water Falls




Cascade


Falls

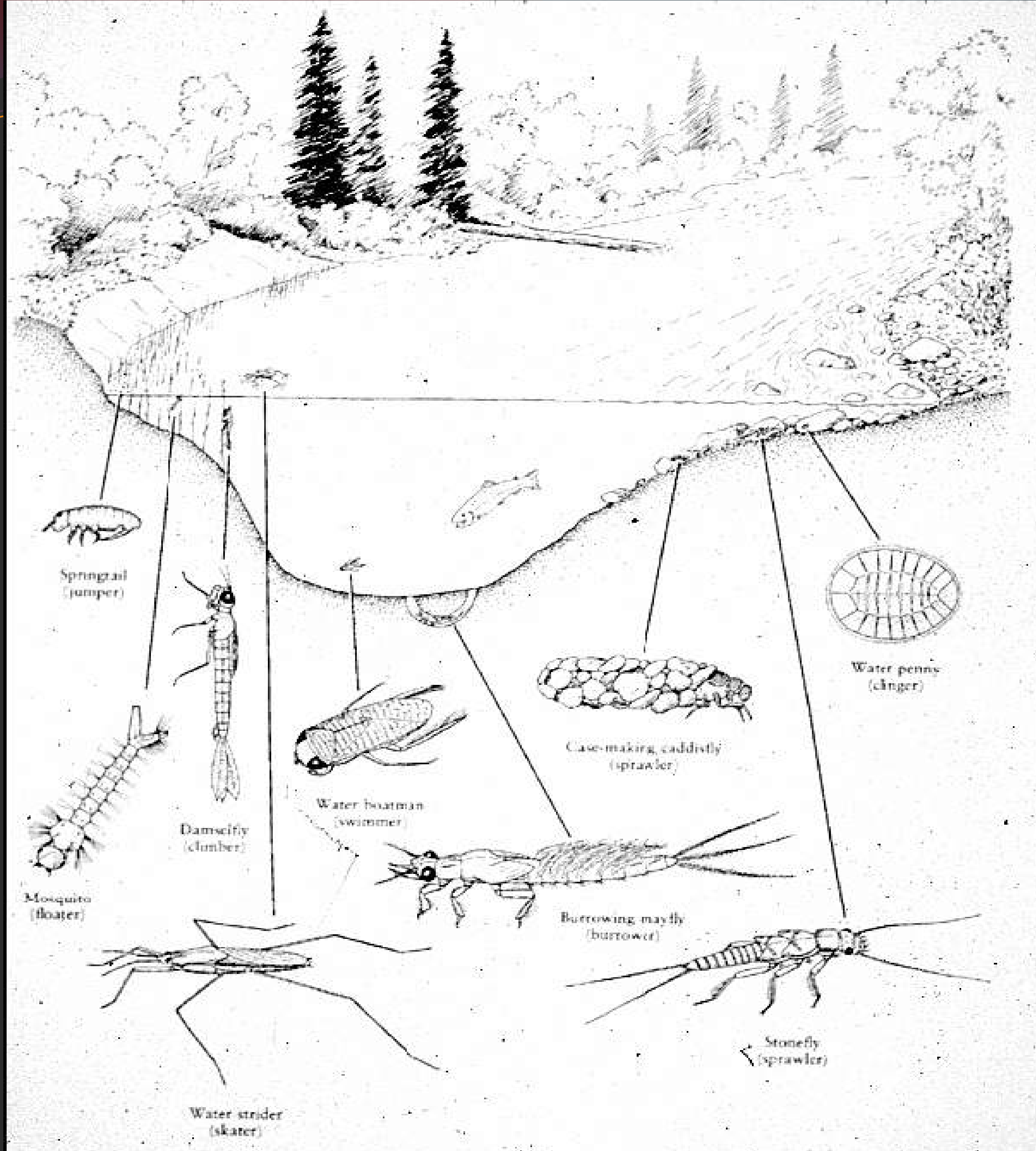

Riffle


Pool

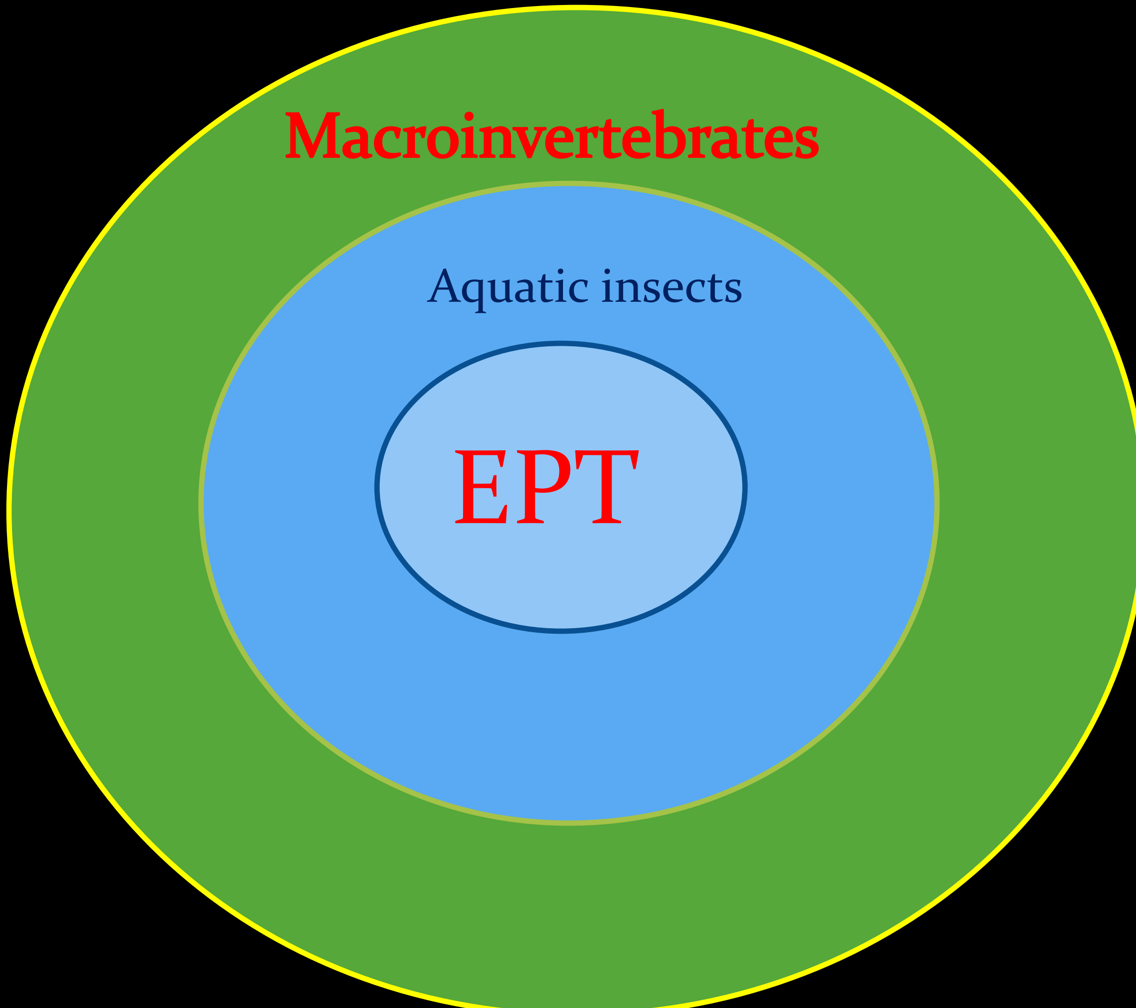






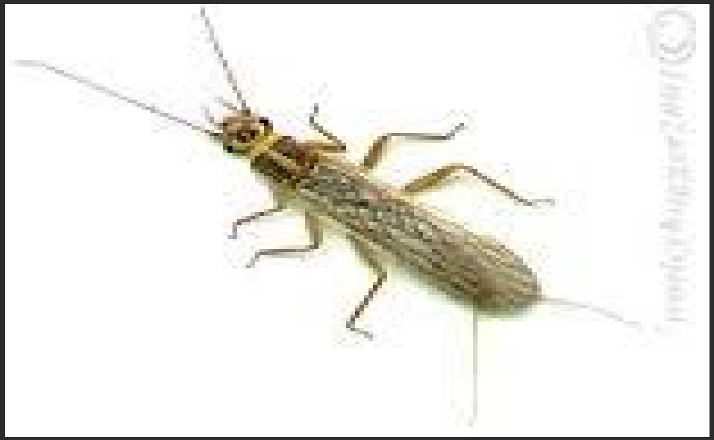


Springtail
(jumper)
Water penny
(clinger)
Case-making caddisfly
(sprawler)
Water boatman
(swimmer)
Damselfly
(climber)
Mosquito
(floater)
Burrowing mayfly
(burrower)
Water strider
(skater)
Stonefly
(sprawler)


Macroinvertebrates
Aquatic insects
EPT

Aquatic Insects

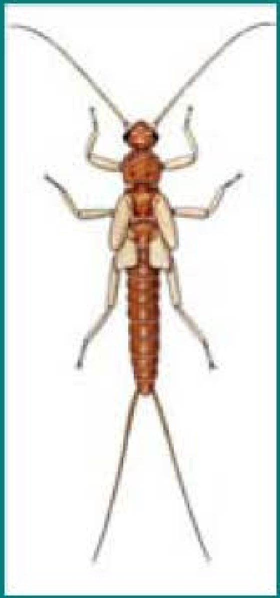

Epeorus sp.nov
Thraulus gopalani
Neoperla sp.
Stenopsyche kodaikanalensis
Anisocentropus kempi
Macrostemum sp.
Goera paropadecha



Ephemeroptera (mayflies)

larvae

adult



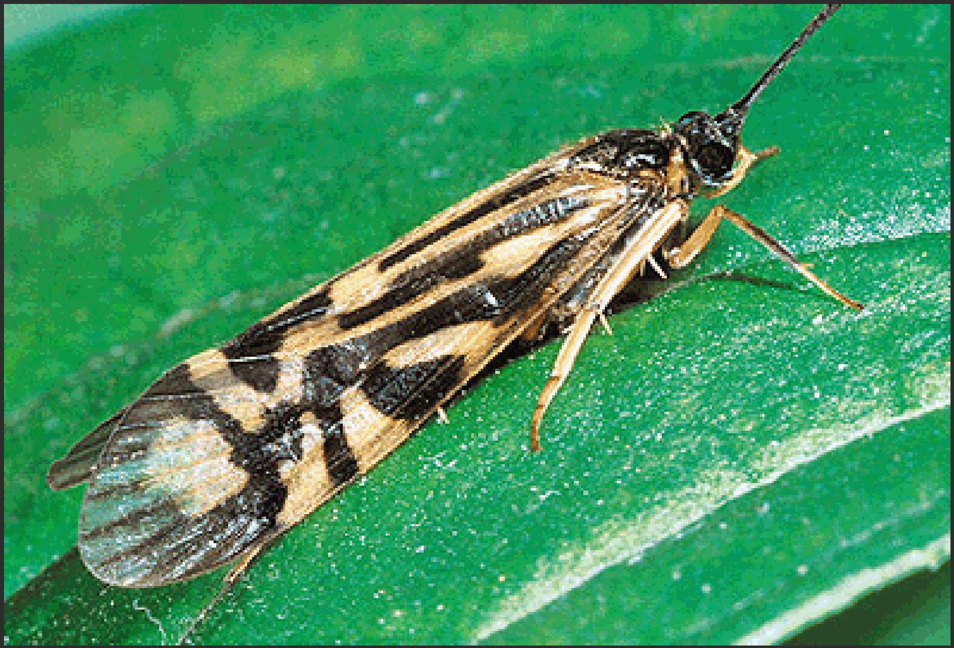
Group 1 - pollution sensitive

Stoneflies

Trichoptera (caddisflies)

larvae

adult



Vector species

Anopheles

Aedes albopictus

Culex quinquefasciatus

Aedes aegypti

Culex vishnui

MOSQUITO LARVIVORES

Mosquito Associations

Temporary water body

Phytotelma

Rice field

Mayflies (Ephemeroptera)

Dragonflies & Damselflies (Odonata)

Stoneflies(Plecoptera)

Aquatic Bugs(Hemiptera)

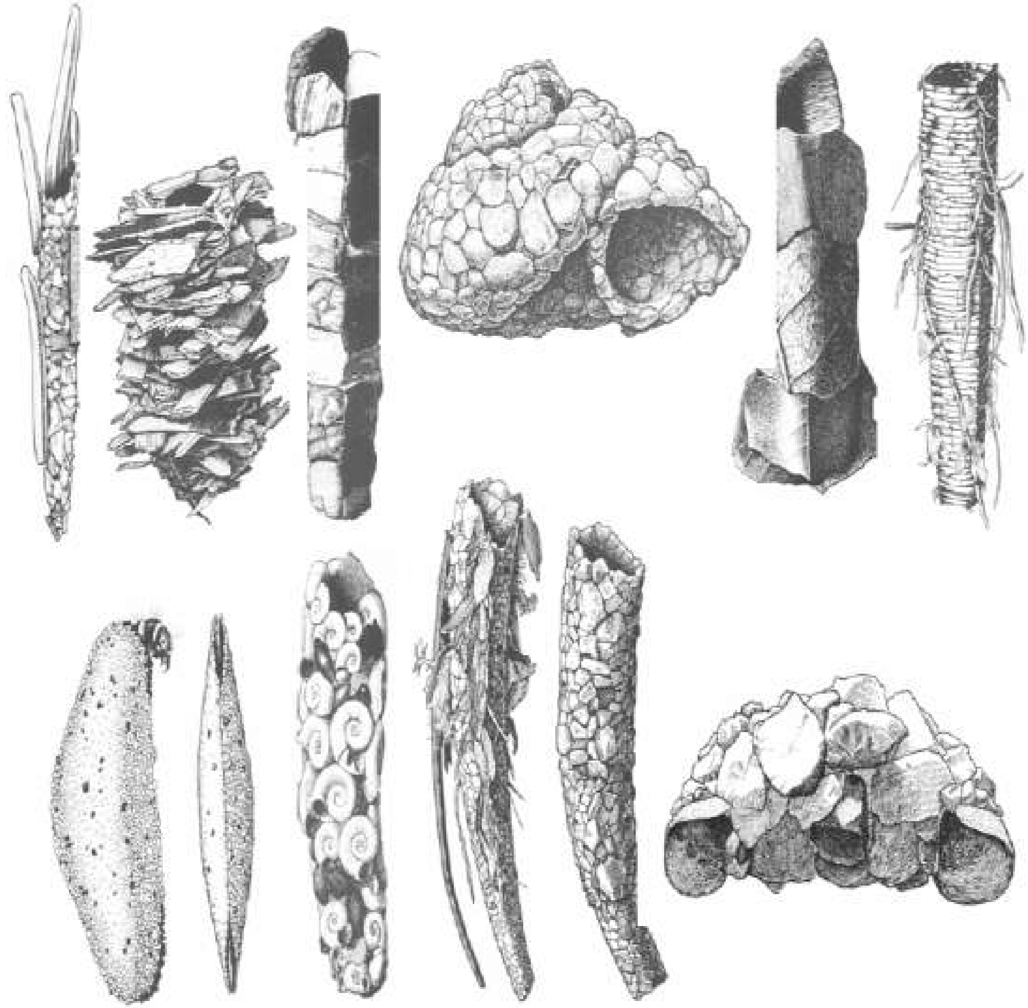
Aquatic Beetles (Coleoptera)



Flies(Diptera)

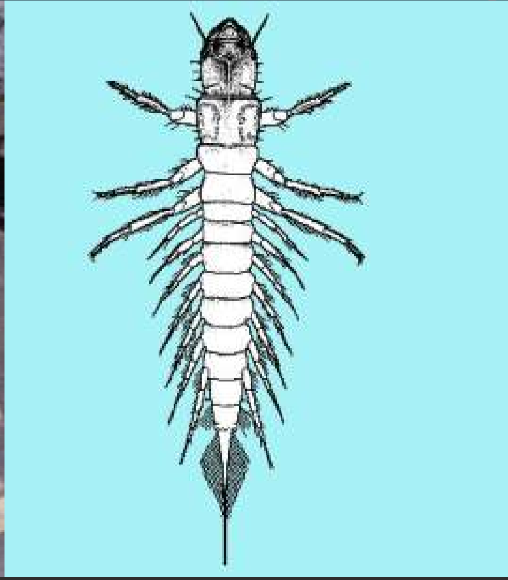


Caddisflies(Trichoptera)




Calamoceratidae
Glossosomatidae
Leptoceridae
Limnephilidae
Limnephilidae
Why so much diversity?

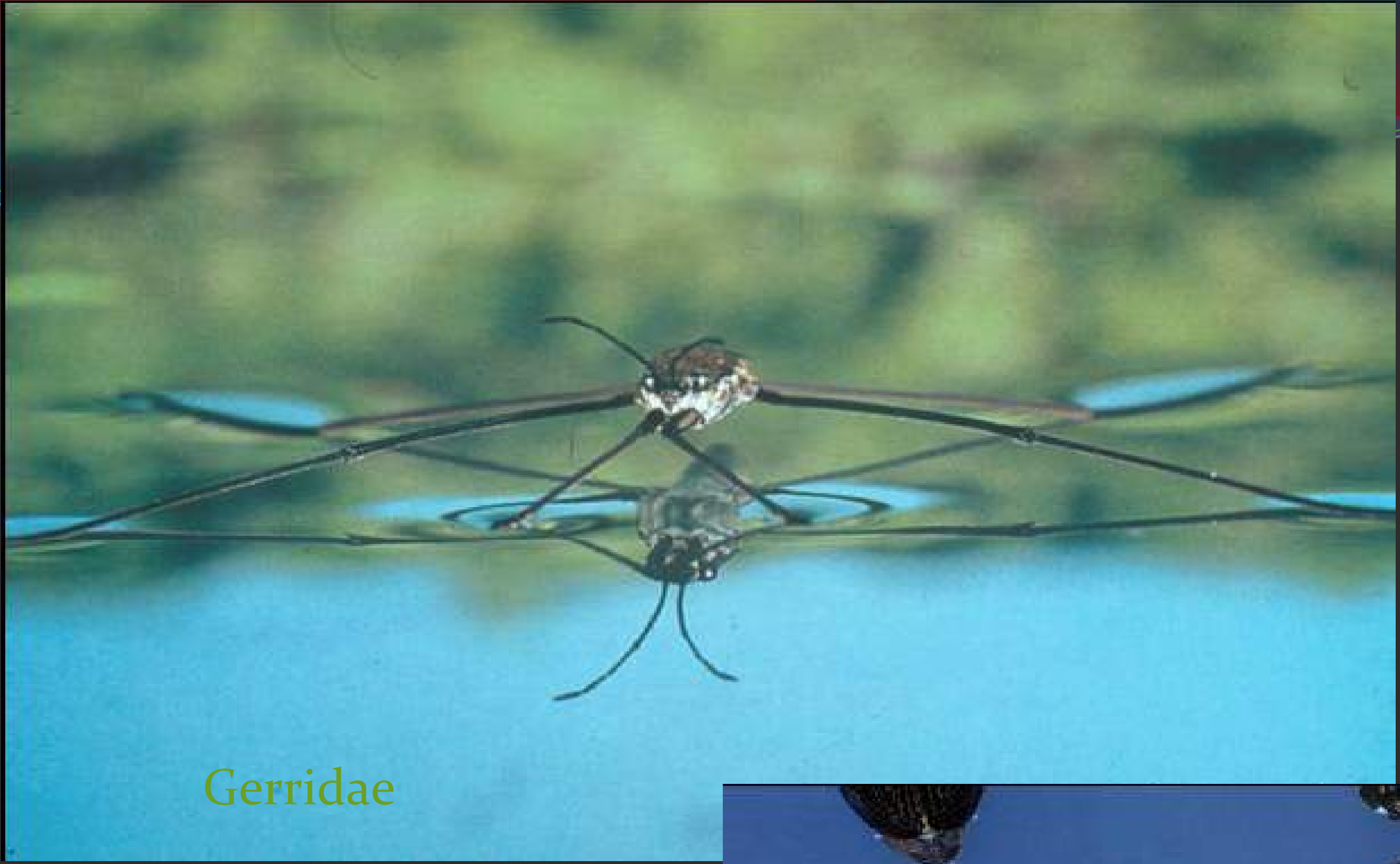
Aquatic Moths(Lepidoptera)



Dobsonflies&Alderflies(Megaloptera)

Nemobines and
Pigmy Grasshoppers
(Orthoptera)

Skater



Planktonic

Swimmer

Climber

Burrower

Gomphidae: *Progomphus obscurus*

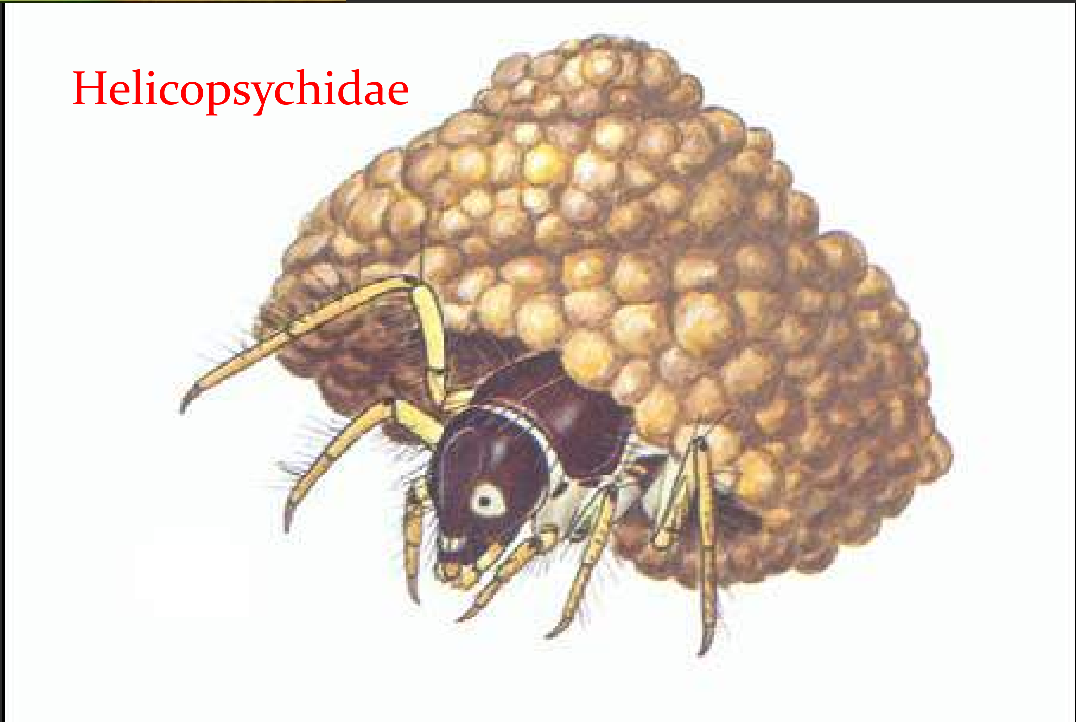
Shredder

Capniidae

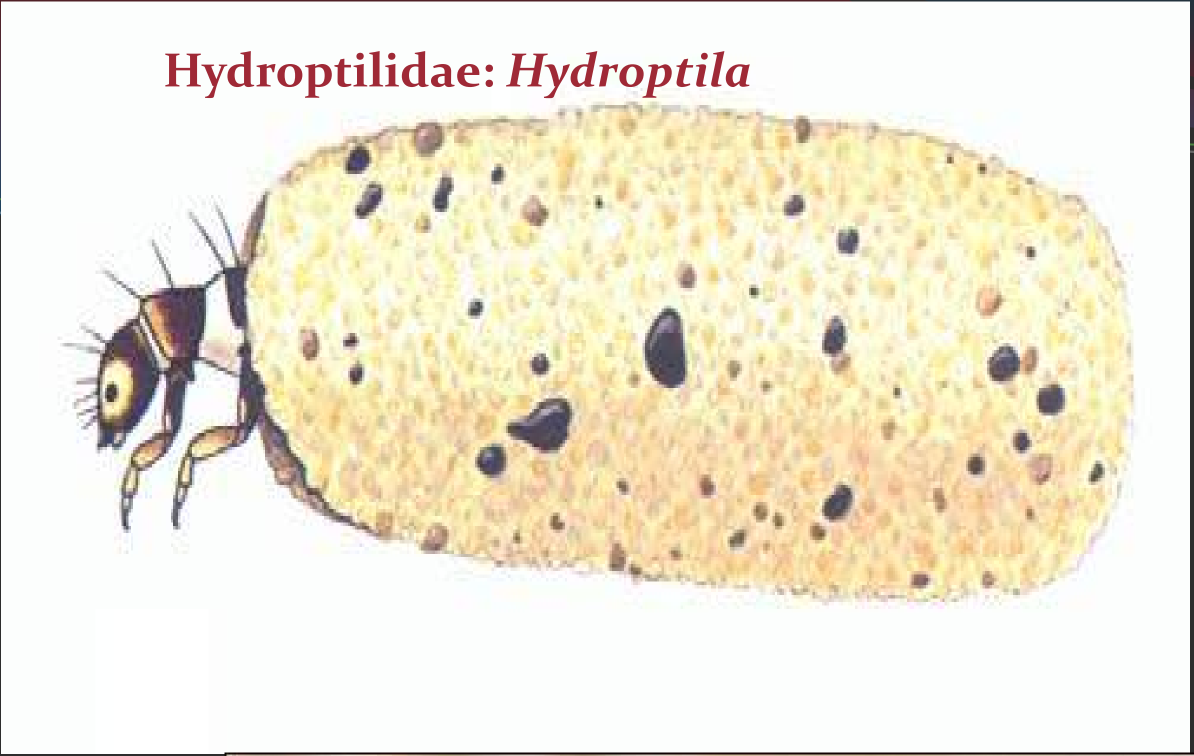
Simuliidae

Collector

Scraper



Piercer



Predator

Lotic habitats

Climate change is a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years.

Global warming is the increase in the average temperature of Earth's near-surface air and oceans since the mid-20th century and its projected continuation.

Global Warming/Climate change - long term and short term scenarios

Global Warming – an immediate threat (next only to habitat fragmentation and destruction) especially in tropics.

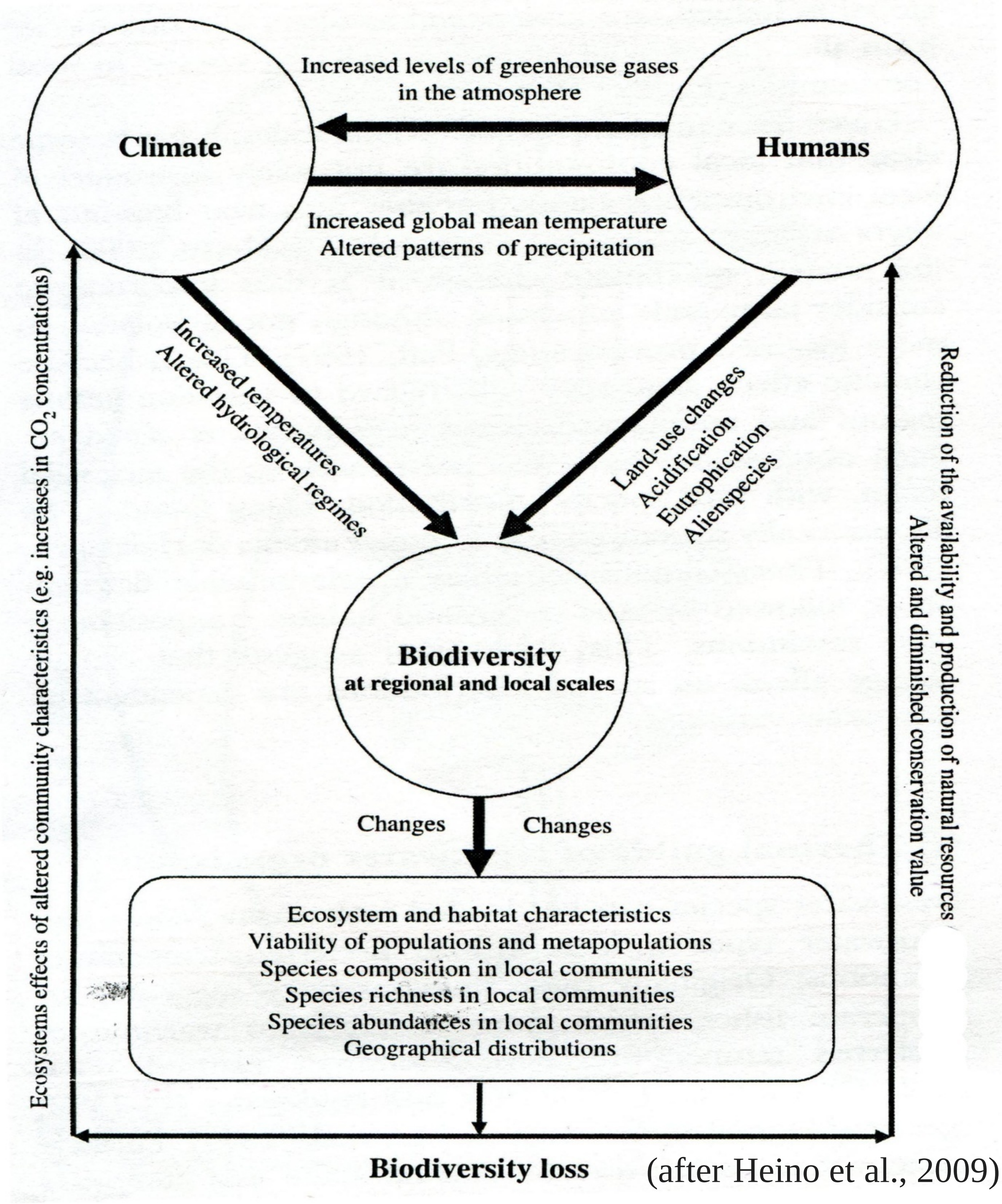
- ❑ For the past 2 million years – numerous Ice Ages
- ❑ Present millennium – warm interglacial period
- ❑ 1550 – 1850 – little Ice Age
- ❑ 1850 – 1940 – warming over 0.5° C.
- ❑ 1940 - 1965 - subsequent cooling
- ❑ 1965 – till date – unprecedented warming

Increase of annual mean air temperature - 8° C.

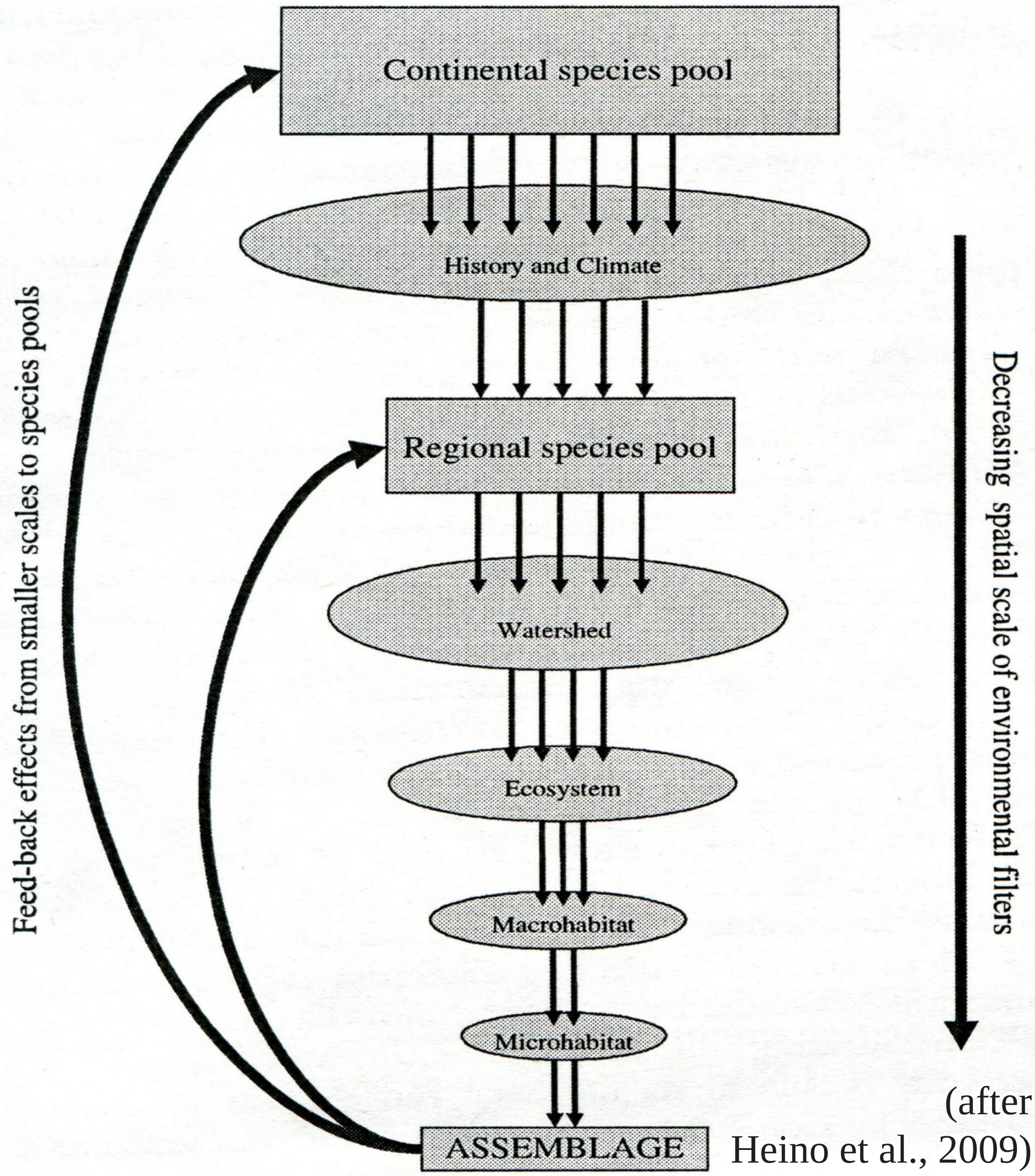
'Era of anthropogenic climate change' due to

- **land use change**
  direct effects of increased atmospheric CO_2 on plant and insect ecophysiology

(IPCC, 2001)



(after Heino et al., 2009)



(after
Heino et al., 2009)

In a nutshell, climate change

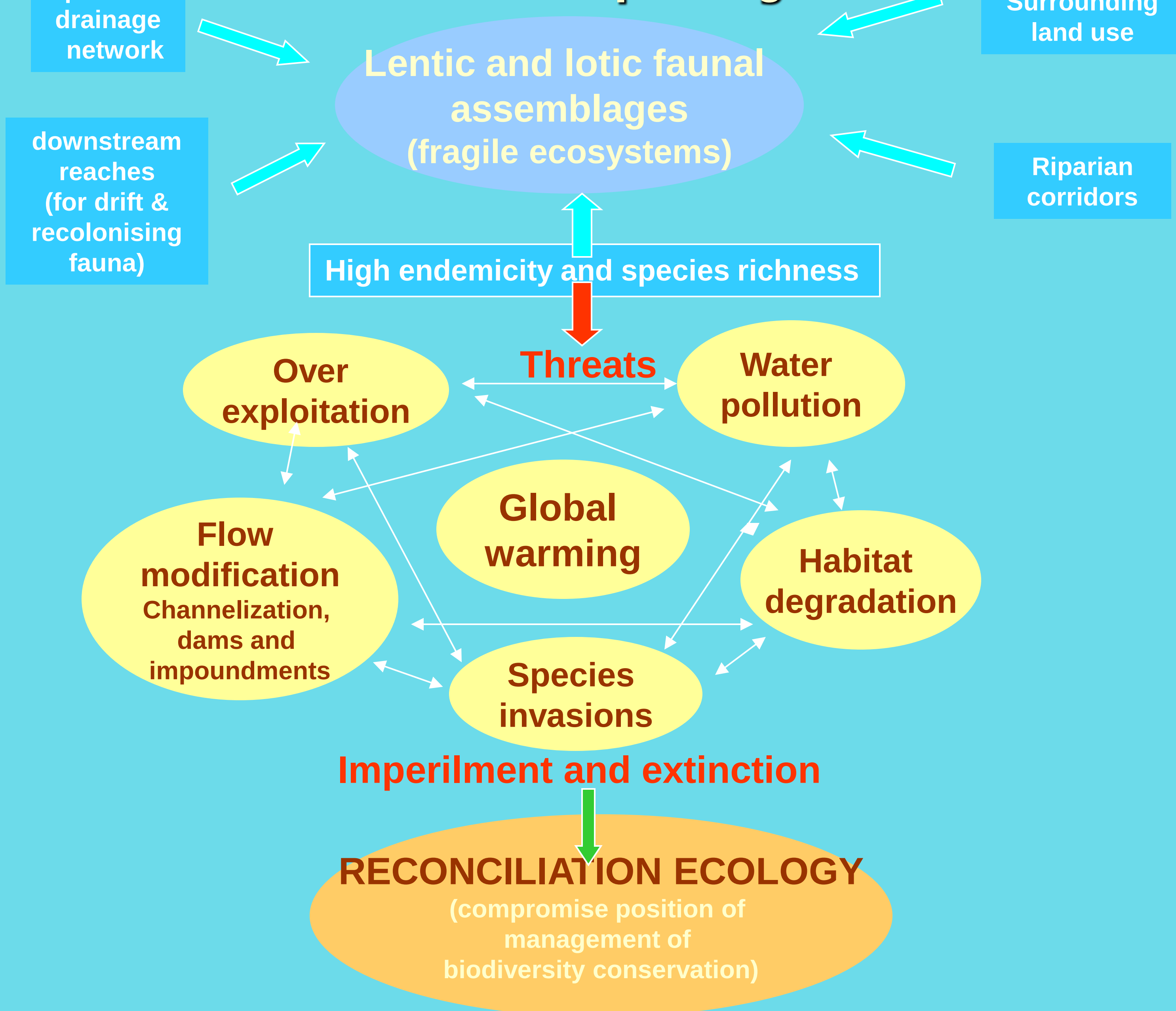
- Large-scale biome, ecosystem, and species shifts
- A breakdown and re-sorting of current plant communities and ecosystems
- A general expansion of species ranges northwards and upslope
- Loss of ecosystems, including some wetland and alpine areas
- Changes in habitat quality and availability
- Increases in growing degree days
- Changes in synchronony between speceis – for example, the timing of predator/prey or flower/polinator interaction
- Differential range shifting – for example, when a polinator insect experiences a range expansion but its host plant does not

Describing the Biological Condition: Metrics

Benthic Macroinvertebrates

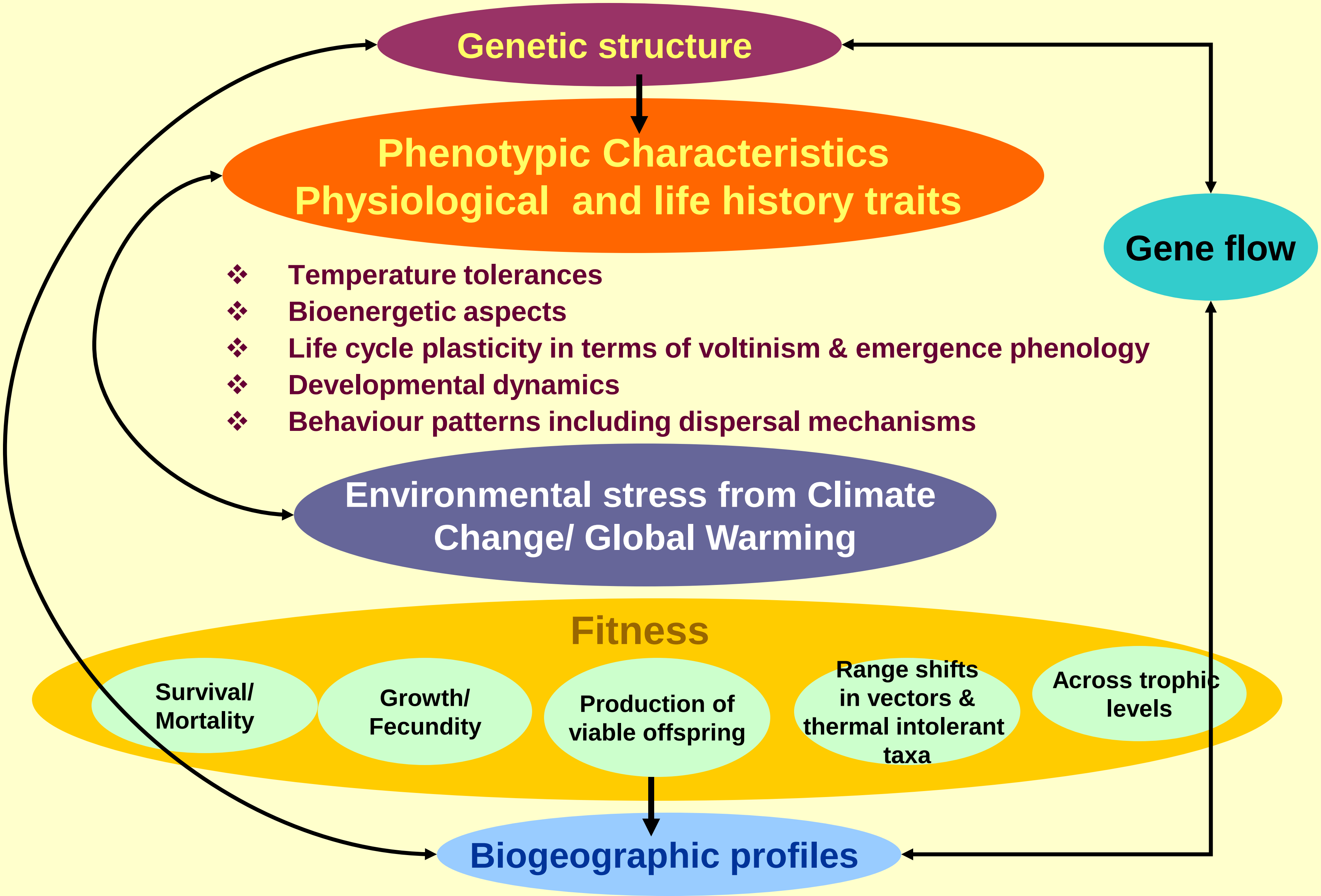
- *Abundance*
- *Taxa Richness (EPT and Total)*
- *Pollution Tolerance/Intolerance*
- *Feeding Ecology*
- *Community Composition*
- *Behavior*
- *Life Cycle*

Reconciliation Ecology – an aquatic biodiversity conservation paradigm

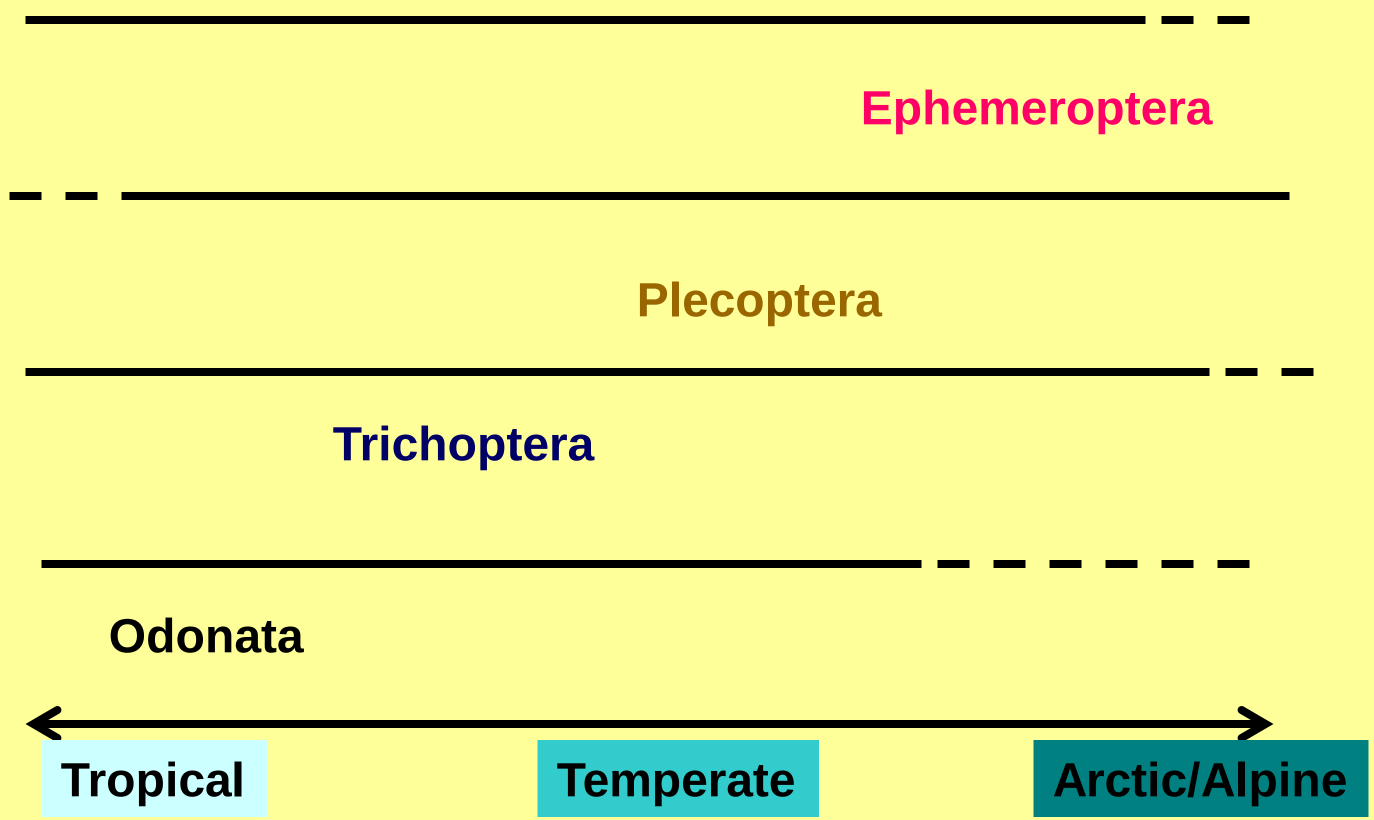


Multifaceted Impact of Climate Change/ Global Warming on Aquatic Insects

Conceptual relationships



Optimal and suboptimal geographic and climatic regions of a few orders of Aquatic insects



Response of aquatic insects to temperature changes

Consequences of climate change at the species or population level:

1) Simple adaptation – inherent plasticity in response to environmental change.

egg stage i) water temperature influencing the length of egg development.

ii) distinct temperature limits for successful development eg. Australian mayfly, *Colobyriscoides* (Successful hatch between 15- 25 °C.)

iii) Adult body size in mayflies correlated with fecundity resulting in changed mayfly distributions under global warming.

iv) Considerable life cycle plasticity eg. *Baetis rhodani,* multivoltine in warmer lowland habitats, univoltine in cooler streams, two year semi-voltine in alpine areas.

v) earlier emergence of many mayfly species in a warmer climate and changing temperature regimes advance in the phenology of Odanata (advance in the flight dates)

2) Demographic changes

3) Emigration/Immigration and extinction

Consequences of climate change at the community and ecosystem levels:

Community level – floods have a major structuring effect triggering

species replacement and succession

eg. Decreased density of *Baetis rhodani* nymphs due to unusually high spring floods and increased density soon after the flood of the summer species, *Acentralla lapponica* present in the egg stage down in the substrate.

Flow reductions favour genera of lentic habitats eg. *Cloeon*, *Paraleptoflebia* at the expense of typical lotic genera such as *Baetis* and *Epeorus.*

ecosystem levels – Secondary effects affecting decomposition and levels of secondary production.

Long term consequences of climate change on stream insects

Climate change signal study of Prof. Ormerod & Dr. Durance on stream macroinvertebrates including aquatic insects spanning 25 years in UK predicts that at the present rate the spring time abundance in streams could decline by twenty one percent for every 1°C rise in temperature. Stream species number at investigated sites might also fall by 12 – 25 % if trends continue as expected over the next 50 years

Science Daily, May 5 2007

Impact of climate change on aquatic insect adult's survival

Adult stage in life cycle - important in regulating the size of aquatic insect populations. During this stage Riparian zones (stream side vegetation can provide food, sites for mating, completion of egg development and refuge from predators.)

Stress caused by high air temperature will affect female aquatic insects to develop mature ovaries potentially reducing their population eg. Several mayfly, stonefly and caddisfly adults.

Conservation strategy:

Planting or protecting stream side vegetation to manage riparian microclimate conditions for aquatic conditions.

Species traits and climate change

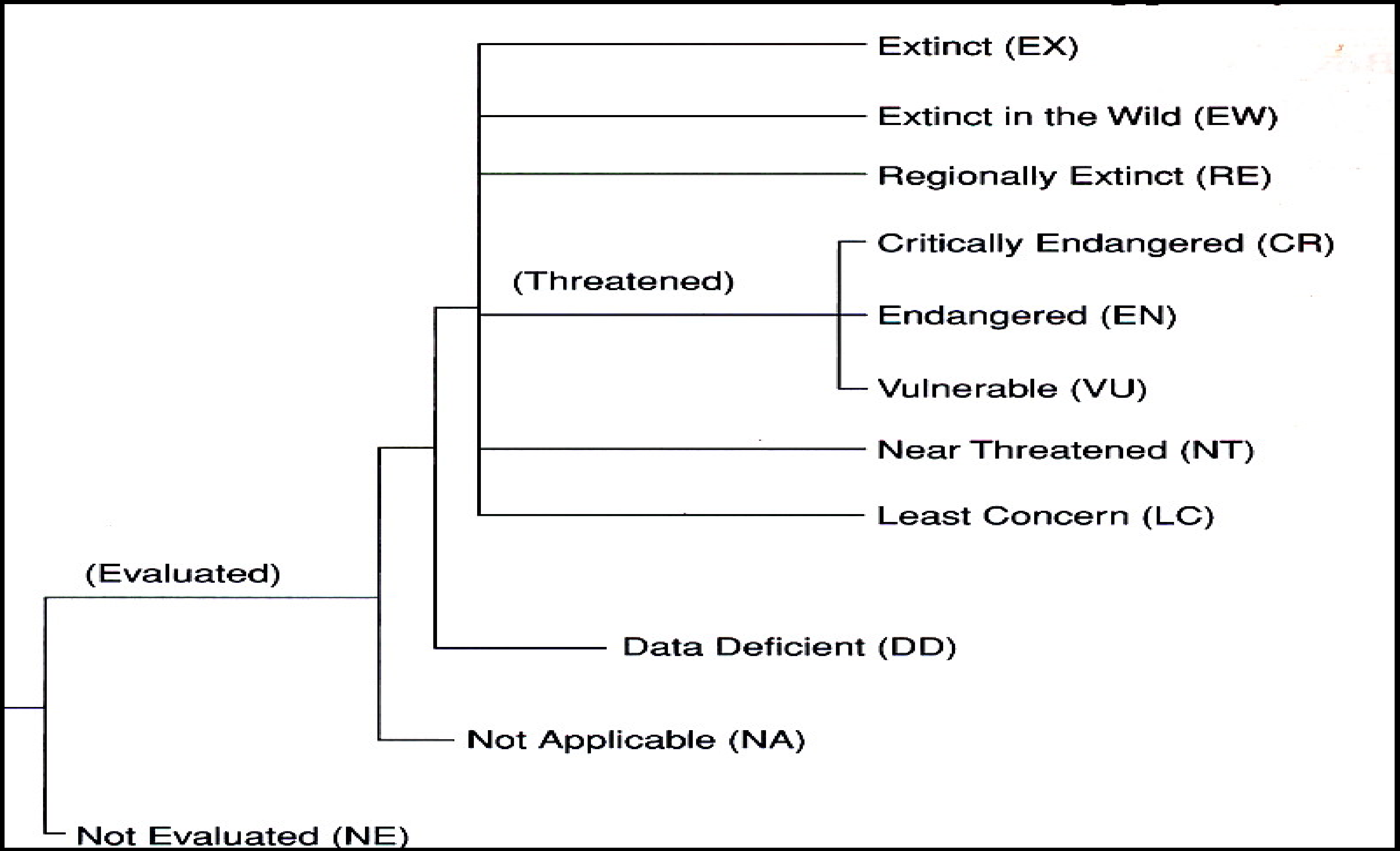
Aquatic insect species traits advantageous or disadvantageous in the context of changing environments due to climate change/global warming

Species trait	advantageous	disadvantageous
Egg development	Long	Short
Egg hatching	Asynchronous	Synchronous
Nymphal development	Asynchronous	Synchronous
Nymphal size and shape	Small and cylindrical	Large
Temperature relationships	Eurytherm: temperature independent	Stenotherm: temperature dependent
Life cycle	Flexible; multivoltine	Fixed; univoltine

after **Brittain, 2008**

A few archaic, small orders of aquatic insects (eg. mayflies) by virtue of their cosmopolitan distribution and sensitive response to environmental cues, have the potential to function as sensitive indicators of present and future climate change.

IUCN threat categories



Before launching a conservation plan find out

1. Which species do you want to protect? – that is, to set priorities among the numerous deserving candidates, not all of which can be supported individually.
2. What is causing them to decline? – that is, to determine the prime motivation for their conservation.
3. Can we manage the agents of decline?
4. What are the key sites? – again, a prioritisation exercise, with selection incorporating other values such as finding the areas that will conserve the greatest numbers of threatened species.
5. Does it constitute a priority for funding?

Also find out

1. Assessing the relative importance of habitat variables to a species.
2. Determining differences in the habitat use by a species, even on a small scale.
3. Assessing the habitat quality of surroundings of populations of focal species.
4. Predicting the effect on species occurrence of environmental changes within a habitat.
5. In conjunction with geographical data, helping in the development of conservation areas and management practices.

Restoration strategies

1. Restoration of sites, either single sites or multiple sites across a landscape.
2. Restoration of specific resources, either generally or to particular levels.
3. Restoration of populations, either by augmentation of existing populations or establishment of new ones.

APPROACHES TO CONSERVATION

1. Ecological approach
2. Biotechnological approach
3. Socio-cultural and legal approach

1. Ecological approach

- Species traits, life-cycle patterns and ecological preferences
- Global climate change & synergistic impacts
- Habitat fragmentation & disturbance impacts
- Species conservation versus ecosystem conservation
- Conservation models with a multimetric approach

1. Introducing insects conservation

2. Taxonomy & curation of insects

3. Designing sampling protocols

4. Collecting & recording insects

5. Measuring environmental variables

Population studies (Single species studies)

Assemblages & community studies (multispecies studies)

6. Estimating population size & condition

7. The population & the landscape

8. Ex situ conservation: Captive rearing & reintroduction programmes

9. Biodiversity & Assemblage studies

10. Studying insects in the changing environment

11. Key questions for insect conservation in an era of global change

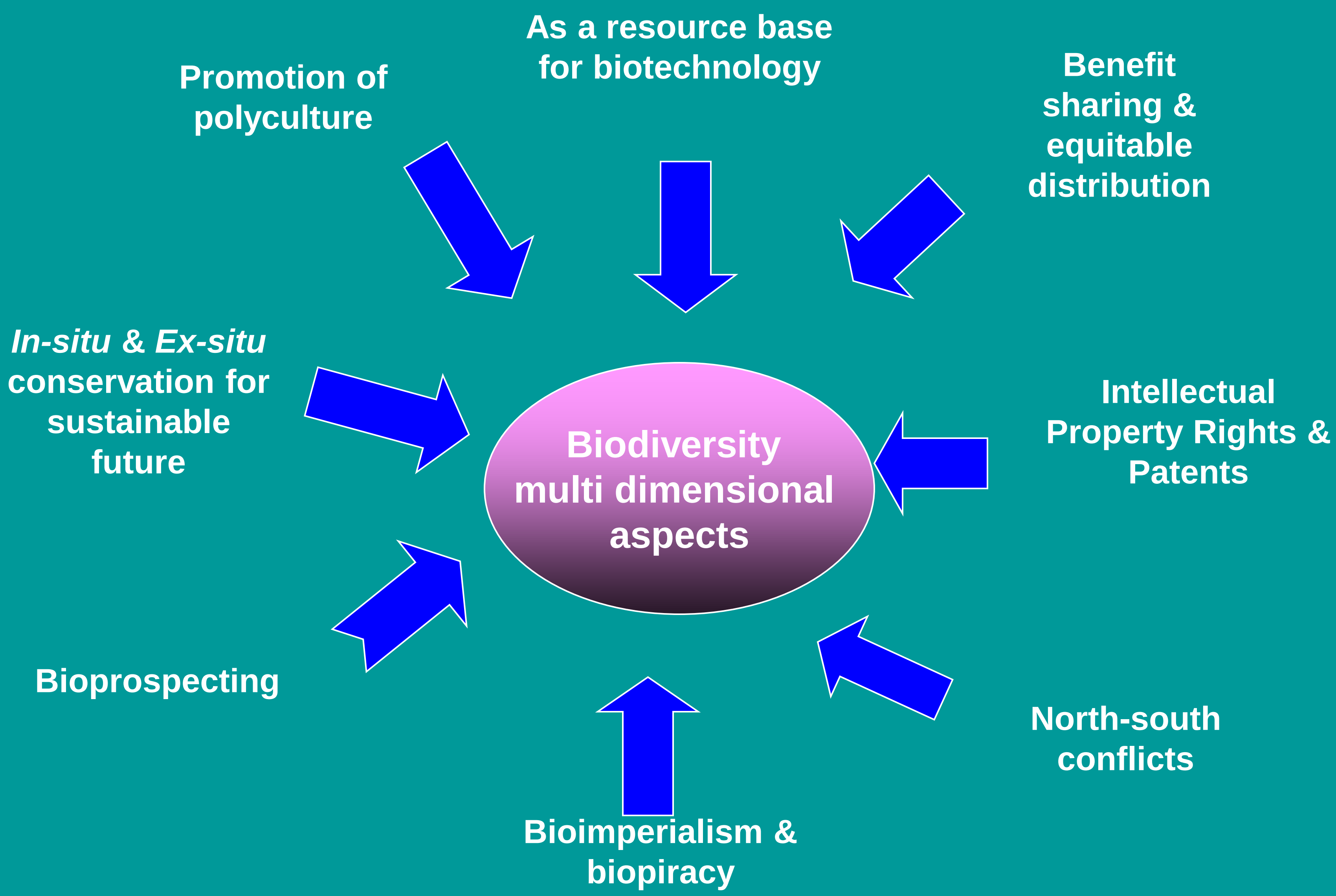
We conserve insects for the functionally important contribution that insects make to ecology & society

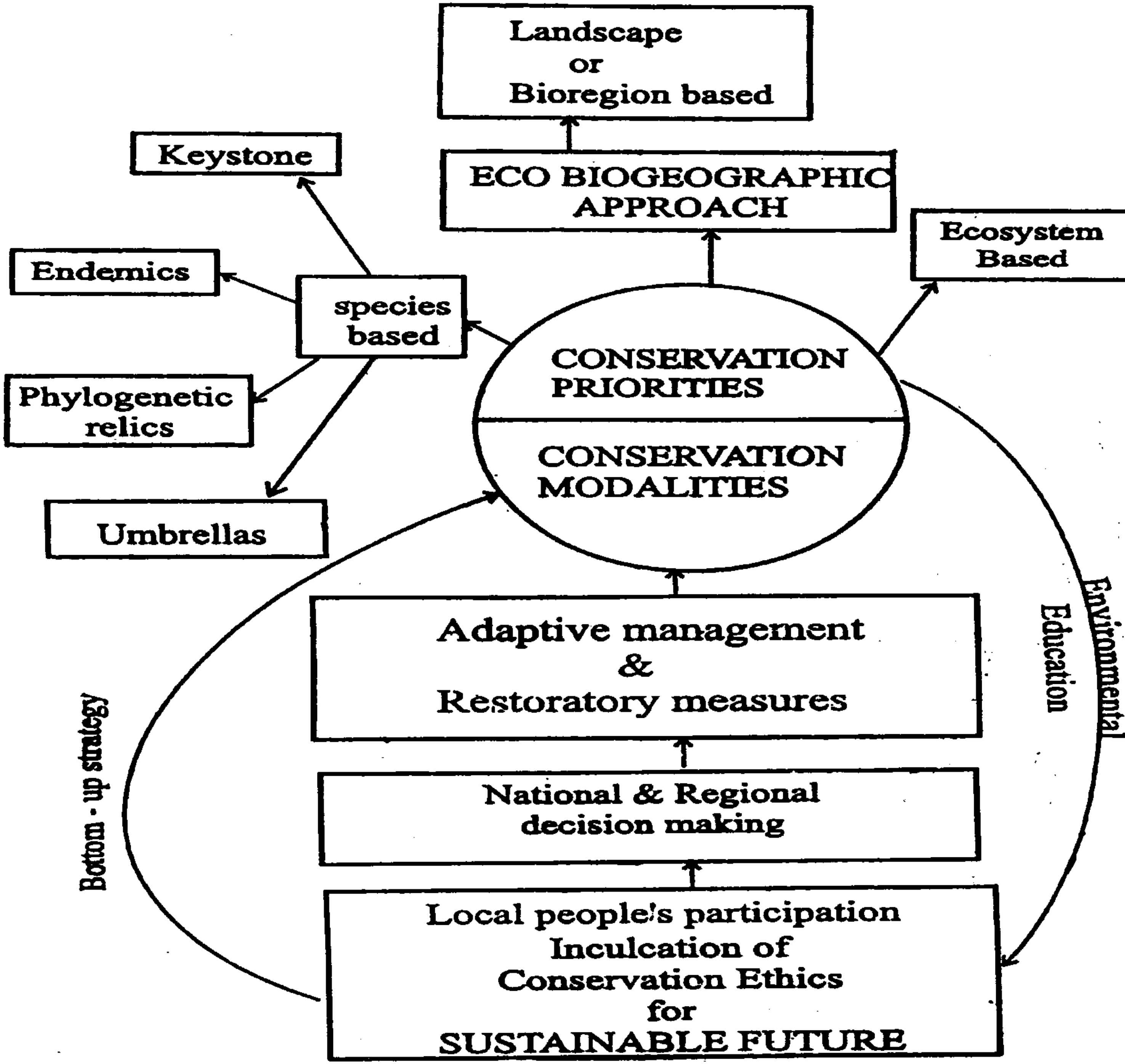
2. Biotechnological approach

- Rapid identification methods
- DNA Barcodes & life stage associations
- Molecular phylogenetic & phylogeographic studies
- Origin and diversification of evolutionary lineages and endemic taxa
- "Cryptic species" conservation to safeguard hidden subspecific diversity – role of conservation genetics

3. Socio-cultural and legal approach

- Inculcation of conservation ethics among masses and students
- Awareness promotion regarding anthropogenic impacts, climate change, habitat fragmentation and destruction and consequent "extinction crisis"
- Augmentation of inter-institutional collaborative research
- Relaxation of legal & bureaucratic hurdles to facilitate free & fair exchange of specimens and genetic material exclusively for non-profit academic research
- Aquatic insect species as assemblages for conservation
- Formulation & implementation of an integrated strategy for the conservation of aquatic insects as part of the conservation of zoo benthic diversity


As a resource base for biotechnology
Promotion of polyculture
Benefit sharing & equitable distribution
In-situ & *Ex-situ* conservation for sustainable future
Biodiversity multi dimensional aspects
Intellectual Property Rights & Patents
Bioprospecting
North-south conflicts
Bioimperialism & biopiracy


Landscape
or
Bioregion based
ECO BIOGEOGRAPHIC
APPROACH
Keystone
Endemics
species
based
Phylogenetic
relics
Umbrellas
Ecosystem
Based
CONSERVATION
PRIORITIES
CONSERVATION
MODALITIES
Environmental
Education
Bottom - up strategy
Adaptive management
&
Restoratory measures
National & Regional
decision making
Local people's participation
Inculcation of
Conservation Ethics
for
SUSTAINABLE FUTURE

Thank you