

Aquatic Invertebrate Ecology

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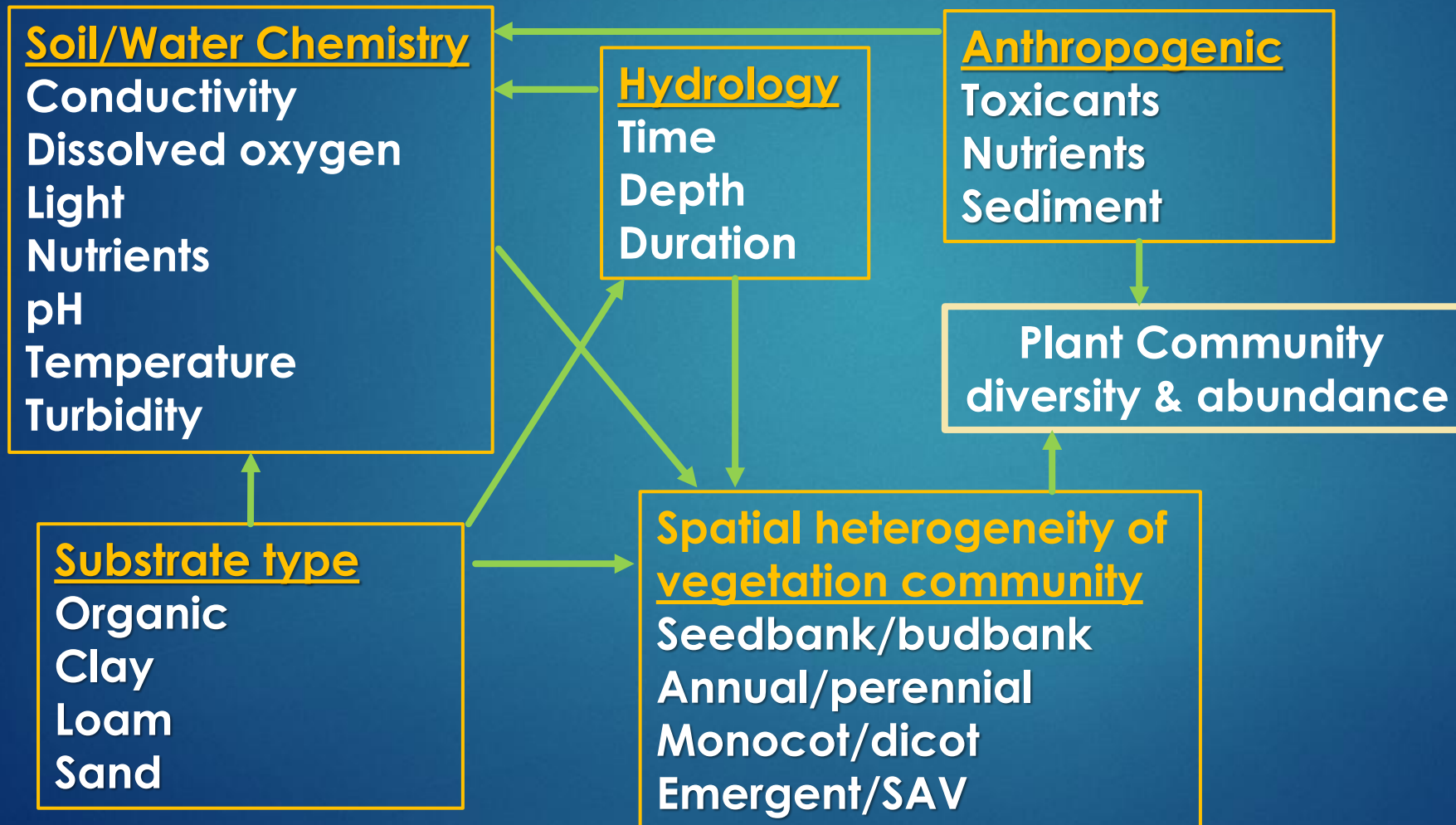
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Aquatic Macroinvertebrates (diversity)

- **Incredibly diverse with more than 140,000 species in the US**
 - ❑ Account for 70% of all known species and 96% of all known animals
- **Freshwater invertebrates in North America include**
 - ❑ Insects 8,600 species
 - ❑ Crustaceans 1,500 species
 - ❑ Oligochaete worms 213 species
 - ❑ Crayfish worms 107 species

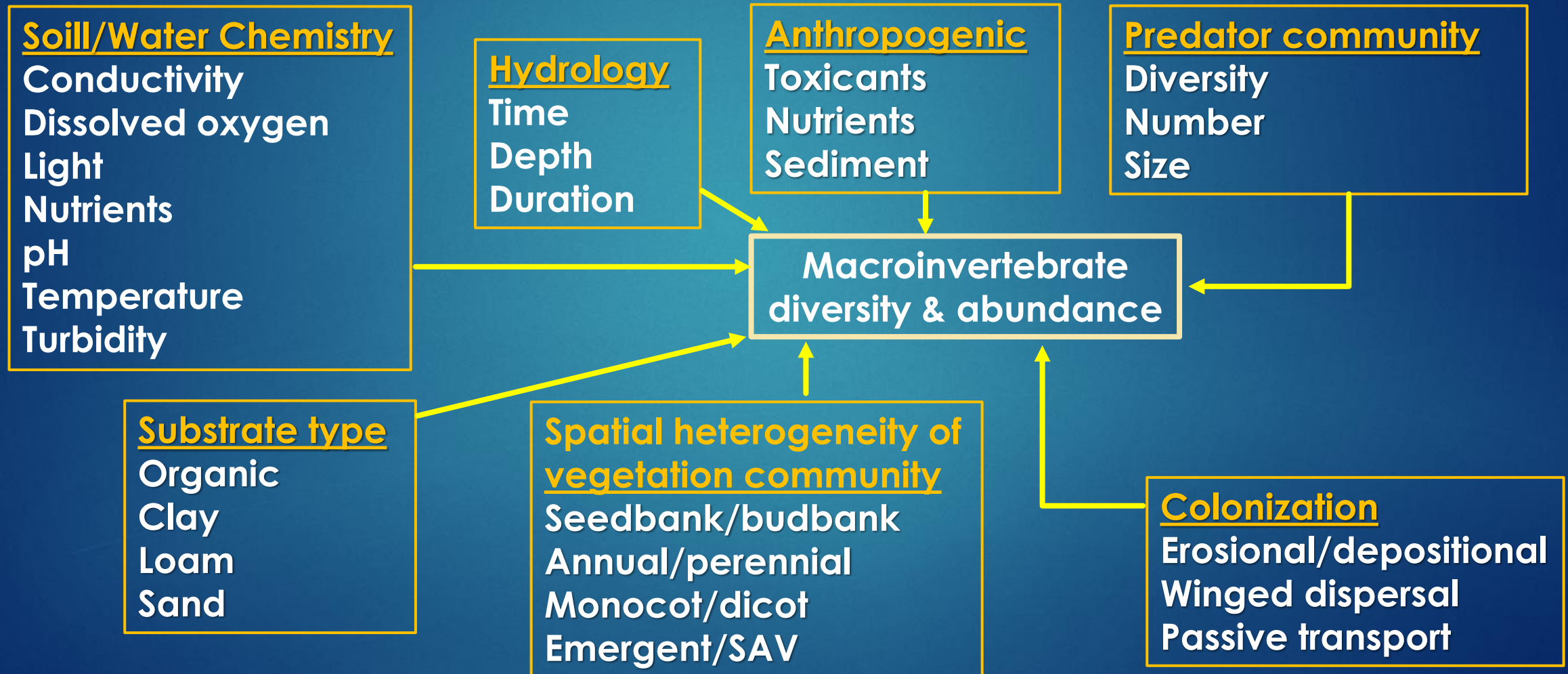
Aquatic Macroinvertebrates

(factors affecting diversity & abundance)



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Aquatic Macroinvertebrates (factors affecting diversity & abundance)

- Due to diversity of species, the relationship between abiotic factors and invertebrate community structure is complex & varied

The seemingly intractable ecological responses of
invertebrates in North American Wetlands

A review by D. P. Batzer (2013) in Wetlands 33:1-15

Lotic (running water) Habitat and Inverts

➤ Stream/river Habitats

- ❑ Erosional – water velocity carries small particles in suspension
- ❑ Depositional – slower water causing particles to fall out of suspension

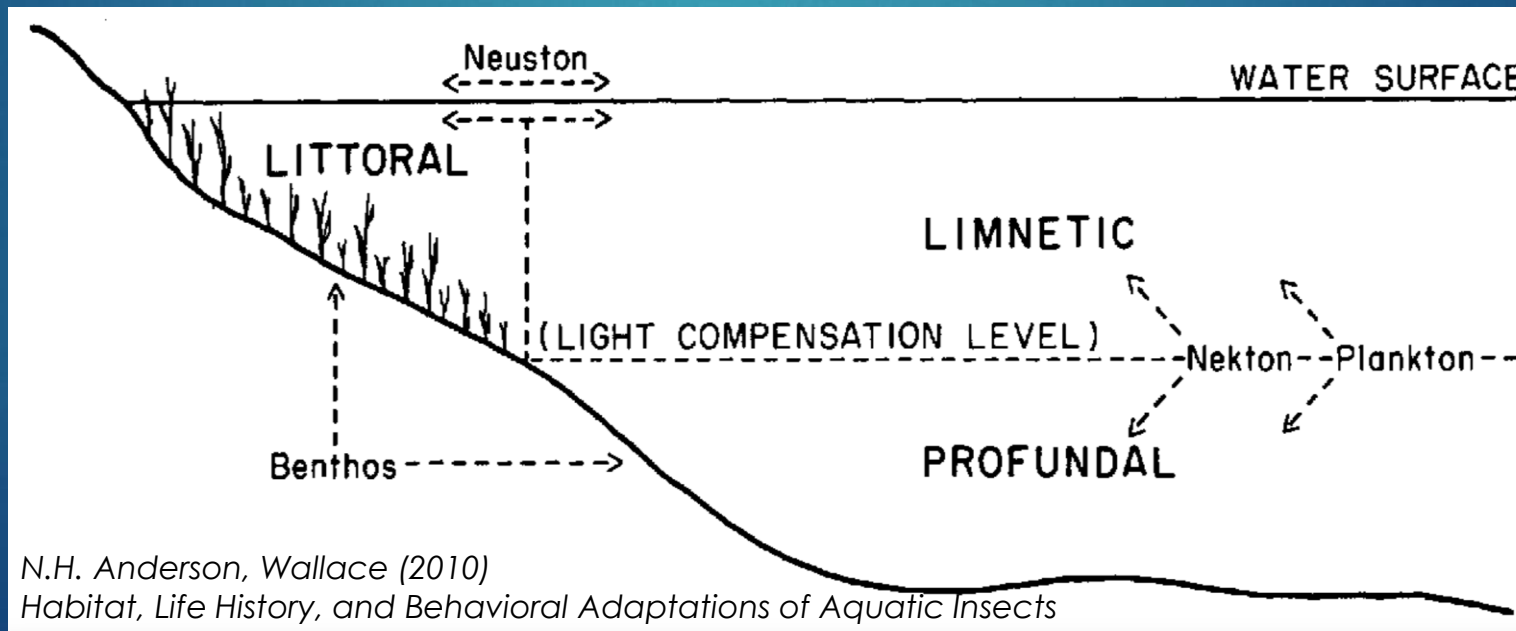
➤ Highest invert diversity in erosional zones with loose cobbles, pebbles, and few boulders

- ❑ Irregular composition provides array of hiding places and attachment sites
- ❑ Provides surfaces for algae growth and edges to catch coarse debris
- ❑ Inverts also live in hyporheic zone below stream bottom erosional zones



Lentic (standing water) Habitat and Inverts

- Neuston – Water surface
- Littoral – edge to limit of rooted aquatic plants
 - Greatest diversity of invertebrates in lentic habitat occur in this zone
- Limnetic – water surface to depth light penetrates
- Profundal – deep water (no light penetration)
- Benthos – bottom substrate



Vegetation

➤ Structure

- ❑ Provide sites for egg attachment
- ❑ Finely-divided leaves generally support larger invertebrate assemblages
- ❑ Greater surface area generally support more invertebrates
- ❑ Greater plant abundance/density improves invertebrate protection from predators

➤ Nutrients

- ❑ Most important source in palustrine wetlands



Vegetation

➤ Composition

- ❑ Species with large lignin content (e.g., cattail) or other protective adaptations (e.g., waxy cuticle of lotus) decompose more slowly

➤ Mix of types (annual/perennial, monocot/dicot) can be beneficial

- ❑ Decomposition rates variable
- ❑ Nutrient releases over longer time
- ❑ Contributes to greater surface area



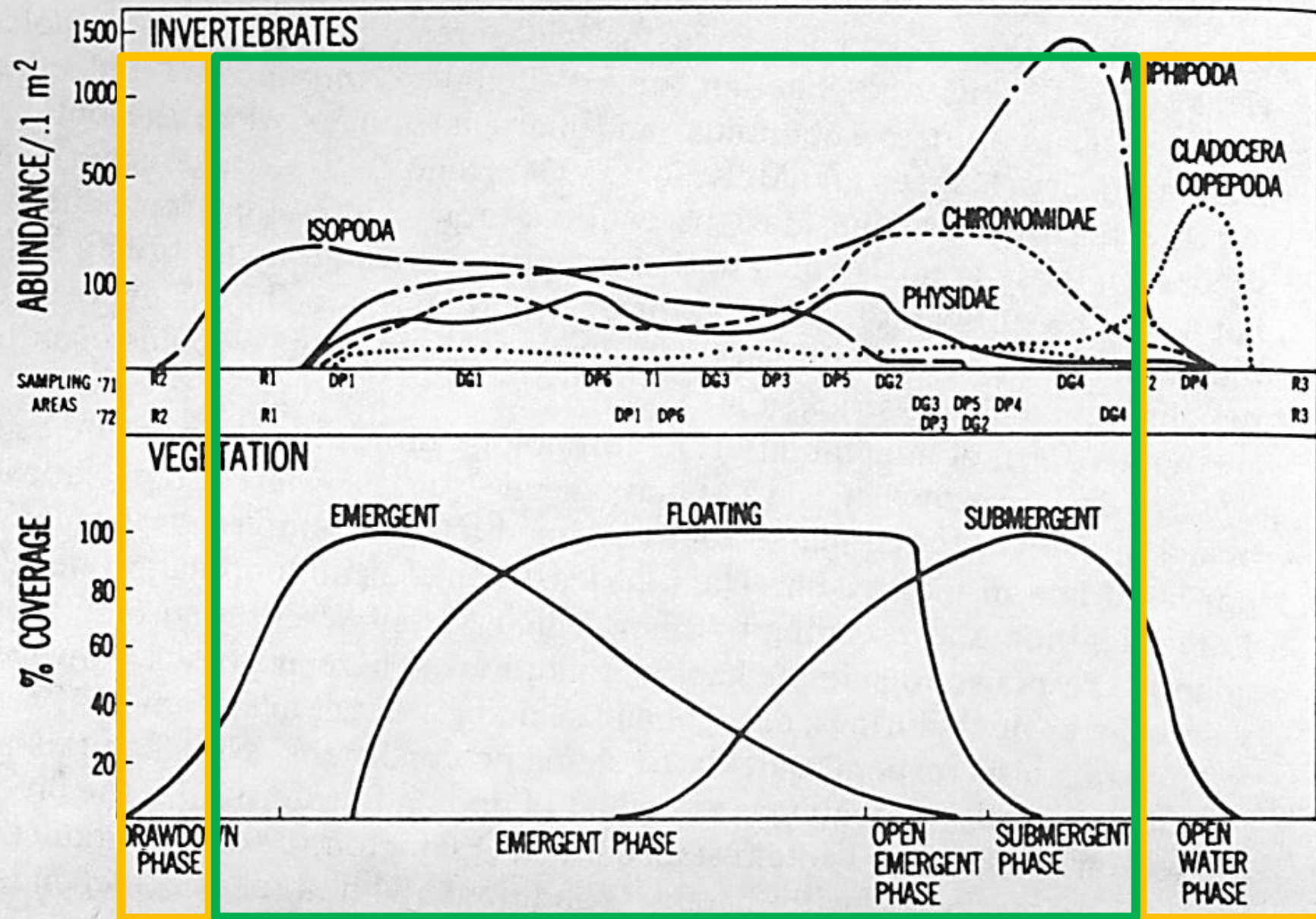


Fig. 4. Generalized vegetation macrofauna associations along a gradient of natural vegetation change in freshwater marshes (from Voigts, 1976).

Vegetation	Inverts/100 g of plant	
	Number	Biomass (g)
Duckweed (<i>Lemna trisulca</i>)	152	2.06
Coontail (<i>Ceratophyllum demersum</i>)	161	1.51
Water stargrass (<i>Heteranthera dubia</i>)	103	1.53
American waterweed (<i>Elodea canadensis</i>)	58	1.12
Spiny naiad (<i>Najas marina</i>)	85	0.91
Sago pondweed (<i>Stuckenia pectinata</i>)	101	0.79
Leafy pondweed (<i>Potamogeton foliosus</i>)	66	0.53
Filamentous green algae (<i>Rhizoclonium hieroglyphicum</i>)	60	0.31
Stonewort (<i>Chara vulgaris</i>)	44	0.60
Eurasian water-milfoil (<i>Myriophyllum spicatum</i>)	36	0.07

Temperature (soil & water)

➤ Invertebrates

- ❑ Defines geographic range
- ➔ ❑ Affects metabolism and growth (positive relationship)
- ❑ Affects timing and duration of emergence
 - Earlier as temperature warms (lower elevations & latitudes)
 - Duration longer with sustained temperatures

Defines upper limit
of temperature

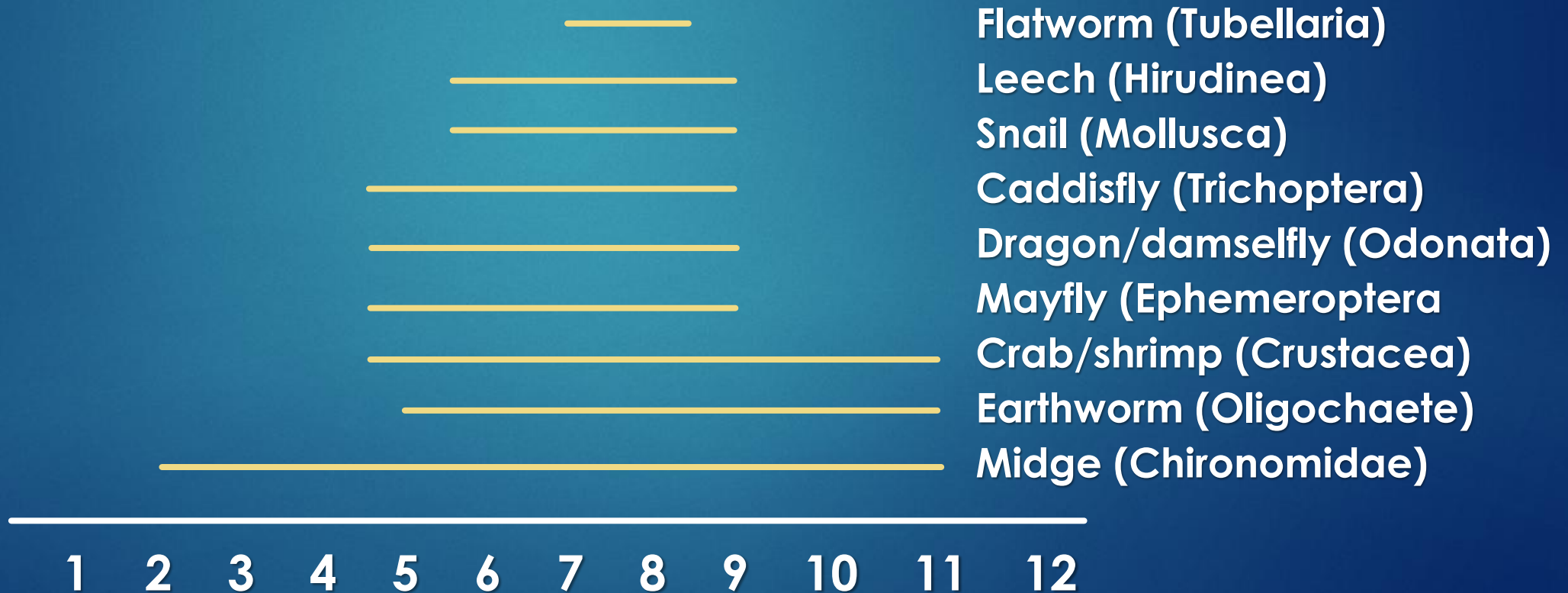
➤ Abiotic

- ❑ Dissolved oxygen concentration (inverse relationship)
- ❑ Rate of decomposition (positive relationship)

pH

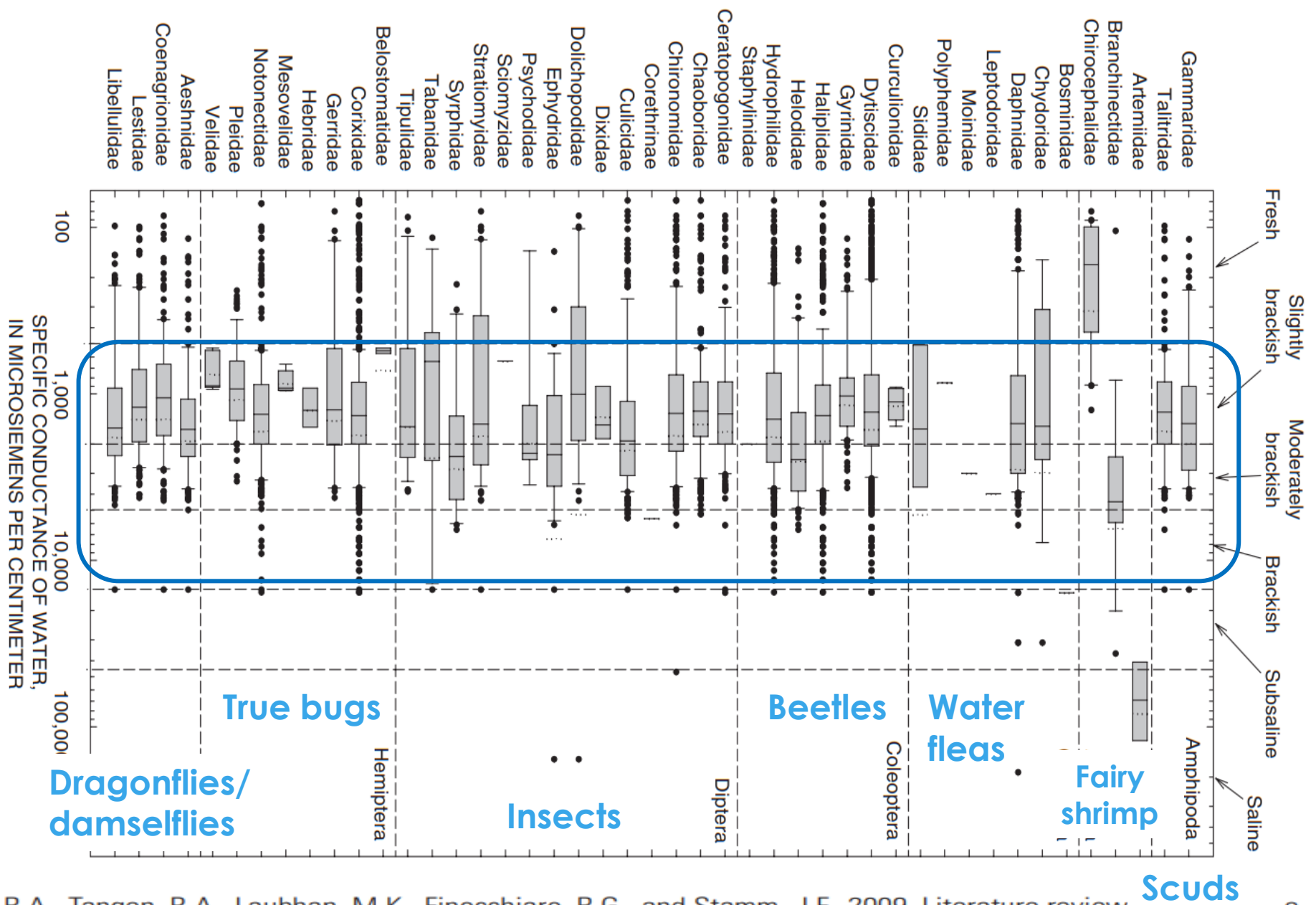
➤ Invertebrate diversity tends to decrease at pH <4 & >9

- ❑ At pH <5, diversity and abundance of snails & clams lower
- ❑ At pH <4, only insects
- ❑ Many species more sensitive during emergence



Salinity

Tolerance of eggs and younger stages of many species can be significantly less than adults



Gleason, R.A., Tangen, B.A., Laubhan, M.K., Finocchiaro, R.G., and Stamm, J.F., 2009, Literature review of relations between salinity and aquatic biota—applications to Bowdoin National Wildlife Refuge, Montana: U.S. Geological Survey Scientific Investigations Report 2009–5098, 76 p.

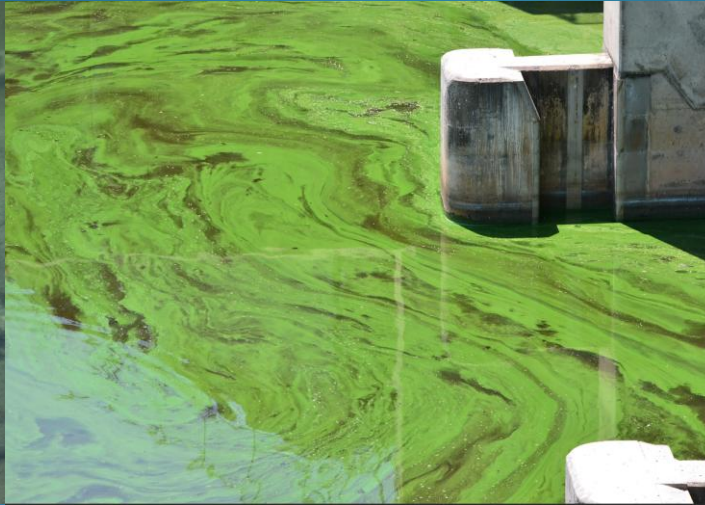
Anthropogenic



Agricultural chemicals

Neonics

Organophosphates



Nutrient loading

Fertilizer runoff

Biotoxins

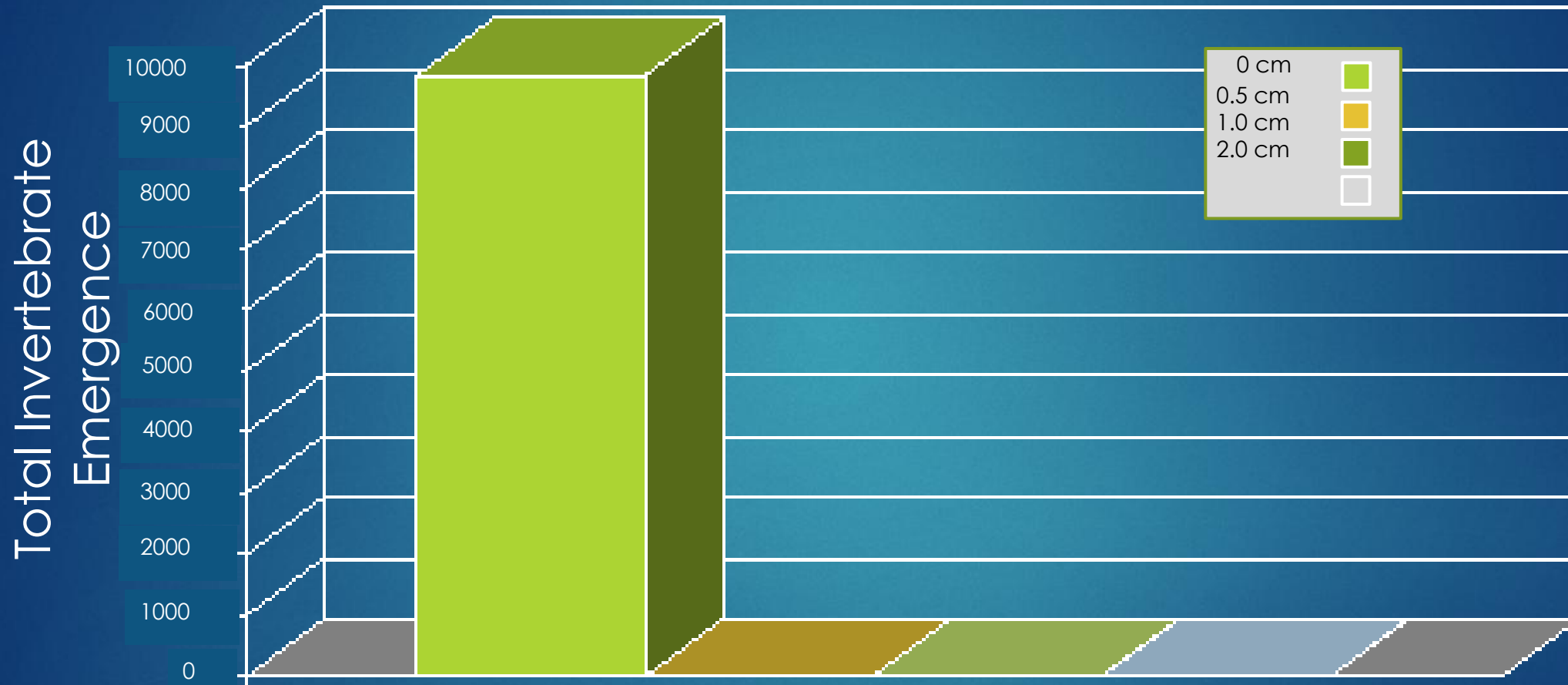


Agricultural tillage

Sediment

Turbidity

Sediment



Seasonal & Temporary Wetlands

(Hydrology – Dewatering)

- Most taxonomic groups have multiple strategies for surviving drought
 - ❑ Physiological strategies (resistance)
 - ❑ Behavioral strategies (resilience)
 - ❑ Reproductive strategies



Seasonal & Temporary Wetlands

(favors species with drought adaptations)

➤ Physiological strategies (adult, immature, embryonic)

❑ Anabiosis

- Condition of suspended animation
- Biochemical reactions within body produce proteins, fats, & carbs

❑ Anhydrobiosis

- Capability to dehydrate & then rehydrate

❑ Desiccation resistant eggs/cysts

- Brine shrimp eggs can survive 15-20 years
- Chironomid (*Polypedilum vanderplanki*) eggs can survive 17 years
- Mosquitoes have eggs that hatch when water returns

Seasonal & Temporary Wetlands

➤ Physiological strategies (continued)

❑ Athermopause

- Slowing of metabolism influenced by non-thermal factor (e.g., food)

❑ Diapause (super = >1 yr, meso = 3 mo to yr, oligo = <3 mo)

- Slowing of metabolism (seasonal cues & biological clock)
- Driven by hormones
- Does not end when favorable conditions return
- Cues include photoperiod & dissolved oxygen concentration

❑ Quiescence

- Slowed metabolism to survive period of limiting factor
- Resumes activity as soon as conditions become favorable

Seasonal & Temporary Wetlands

(favors species with drought adaptations)

➤ Behavioral strategies

- ❑ Aestivation (also physiological)
 - Time of slowed metabolism (usually summer when hot & dry)
 - Shorter-term than resistant eggs
- ❑ Hibernation (also physiological)
 - Time of slowed metabolism (usually during winter when cold)
- ❑ Burrowing (use refugia habitats high in humidity)
 - Soil fissures
 - Crayfish burrows
 - Underneath algal mats
 - Benthos (depending on groundwater elevation)
- ❑ Winged dispersal (triggered by drought and other factors)

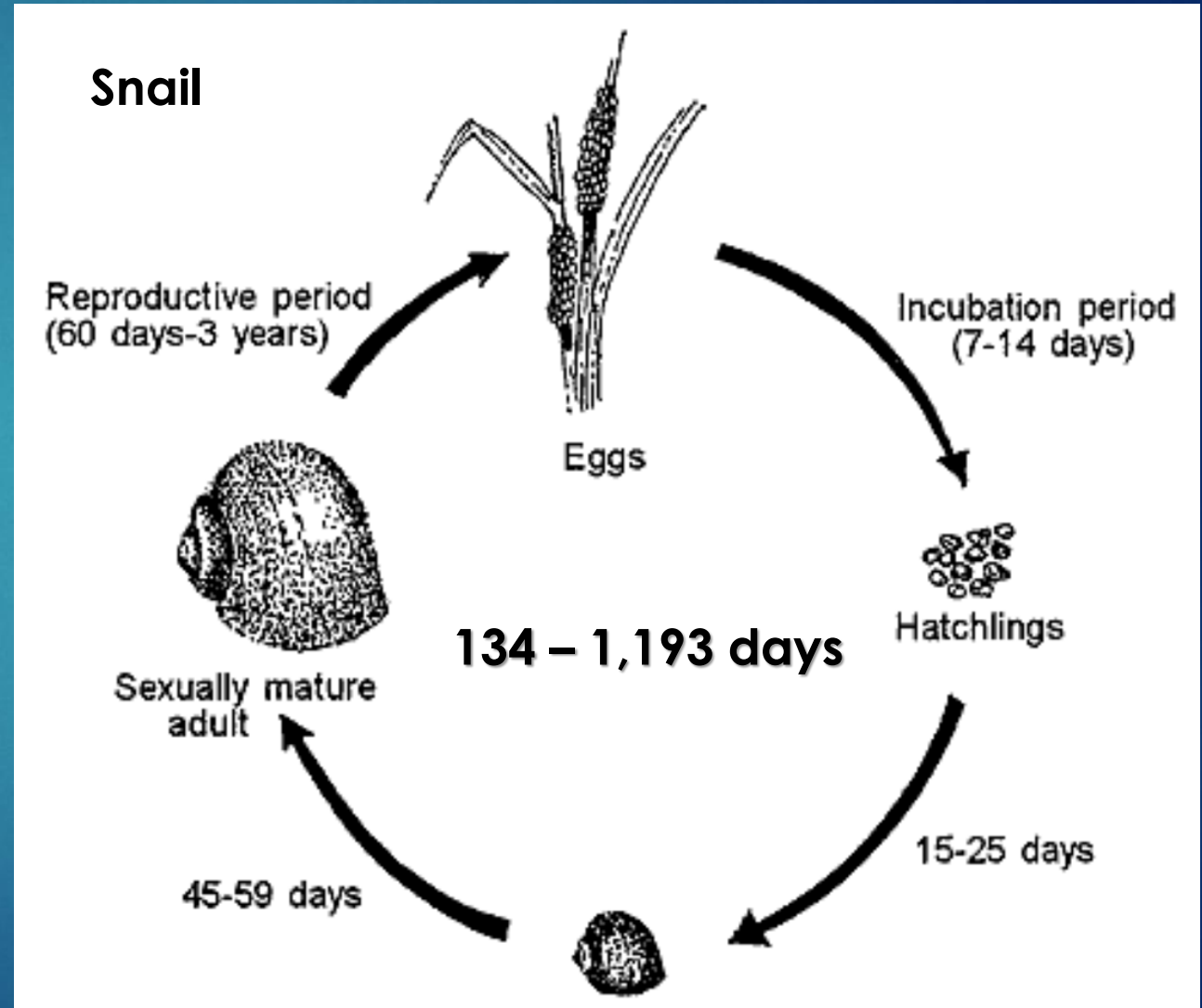
Survival Strategies of Common Macroinvertebrates

Group	Beetle	Clam	Damselfly/ Dragonfly	Earthworm	Leech	Shrimp/ Crayfish	Snail	Water flea
Aerial adults	X		X					
Aestivation		X	X		X	X		
Anhydrobiosis					X			
Burrows	X					X		
Diapause		X	X	X			X	X
Hibernation								X
Shell sealing		X					X	
Quiescence		X	X				X	X

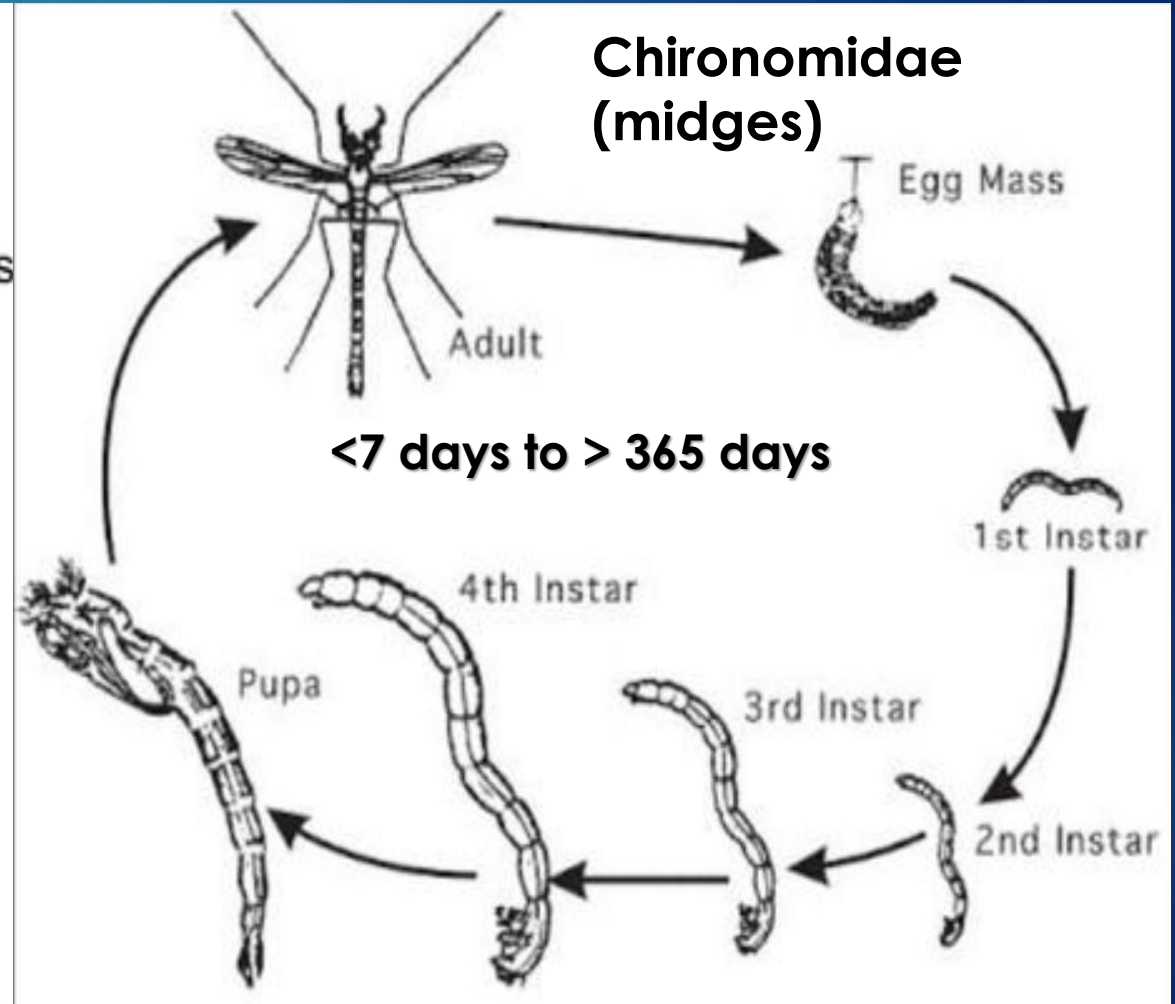
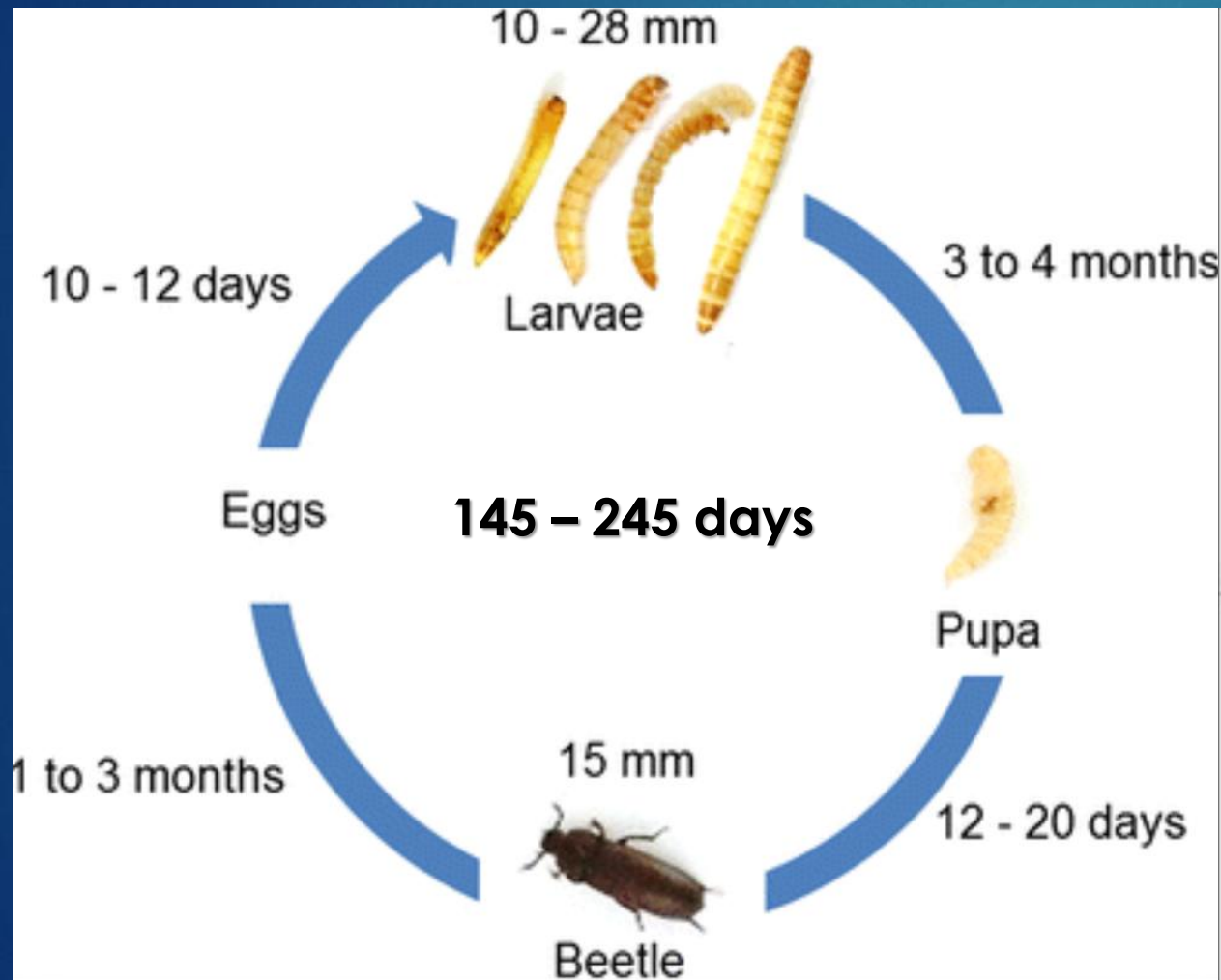
Seasonal & Temporary Wetlands

➤ Reproductive strategies (R-selection)

- ❑ Diverse life-cycles
- ❑ Rapid growth & development
- ❑ Early age of reproduction
- ❑ High reproductive potential
 - Dragonflies/damselflies 1-2 generations/year
 - Snails 1-3 generations/year
 - Mosquitoes up to 20 generations/year



Seasonal & Temporary Wetlands



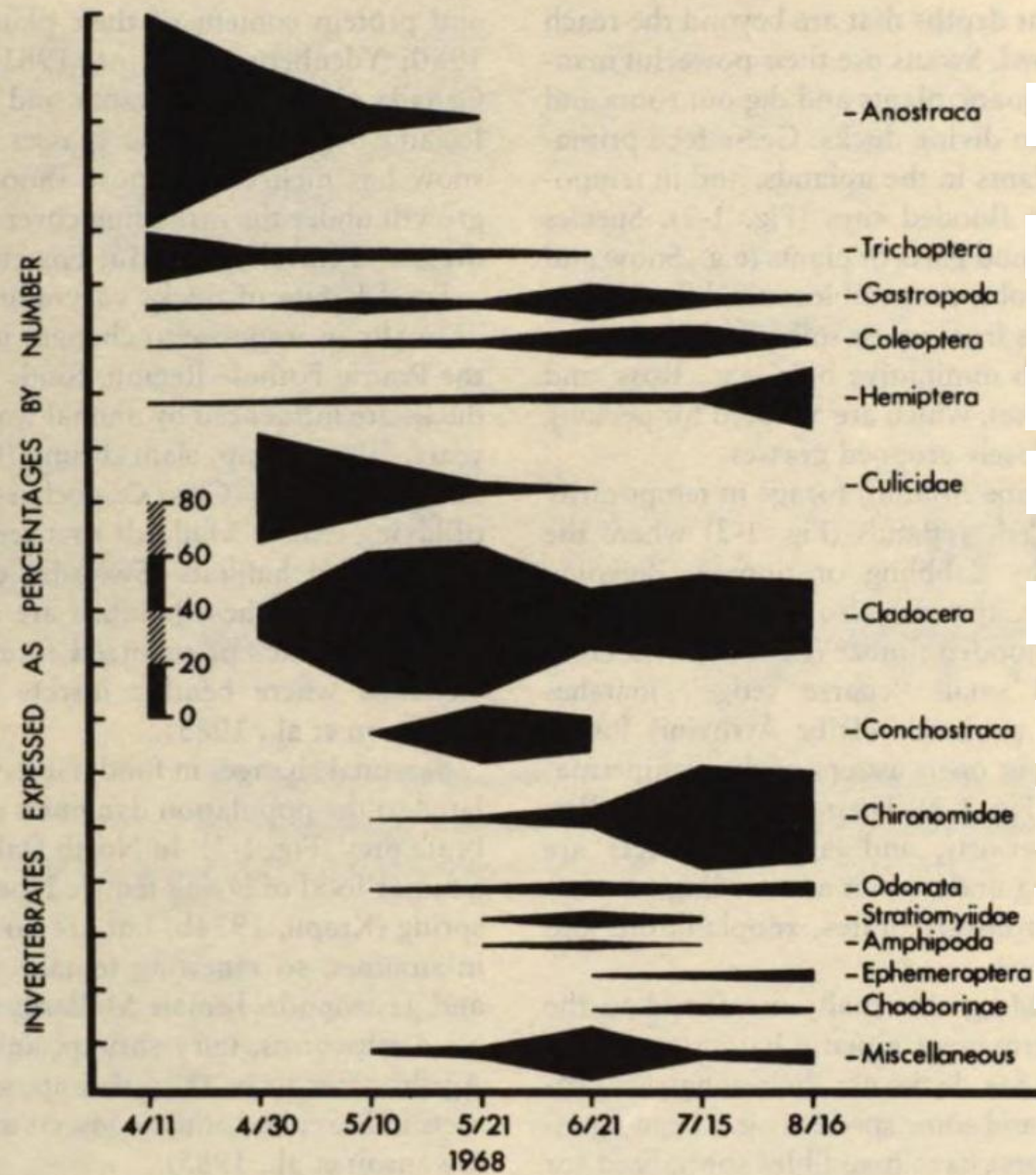
Invertebrate Response (Hydrology – Flooding)

- **Stimulates emergence of resident species from resting stages**
 - ❑ Typically in combination with temperature and, in some cases, other cues (e.g, dissolved oxygen)
- **Initiates colonization from outside the basin**
 - ❑ Floodwater (riverine-associated) or run-off
 - ❑ Aerial dispersal (e.g., insects)
 - ❑ Vertebrate movement into basin (e.g., waterbirds)



Invertebrate Response (Hydrology – Flooding)

- **Population response (species & number) is variable within and among years depending on**
 - ❑ **Concentration of available nutrients**
 - Nutrients in source water (river, run-off)
 - Plant community composition and status of decomposition
 - Years since last dry (extent of oxidation)
 - Frequency, extent and duration of flooding during current year
- **Response may be**
 - ❑ **Short-lived or protracted**
 - ❑ **Peaks may range from single to multiple**



Fairy shrimp

Caddisfly

Snail

Beetle

True Bugs

Mosquito

Water flea

Clam shrimp

Midge

Soldier fly

Mayfly

Dragon/damselfly

Sideswimmer

Phantom midge

Figure 1-3. Temporal changes in the abundance of macroinvertebrate populations inhabiting a seasonal wetland in North Dakota (after Swanson et al., 1974).

Importance of Aquatic Invertebrates

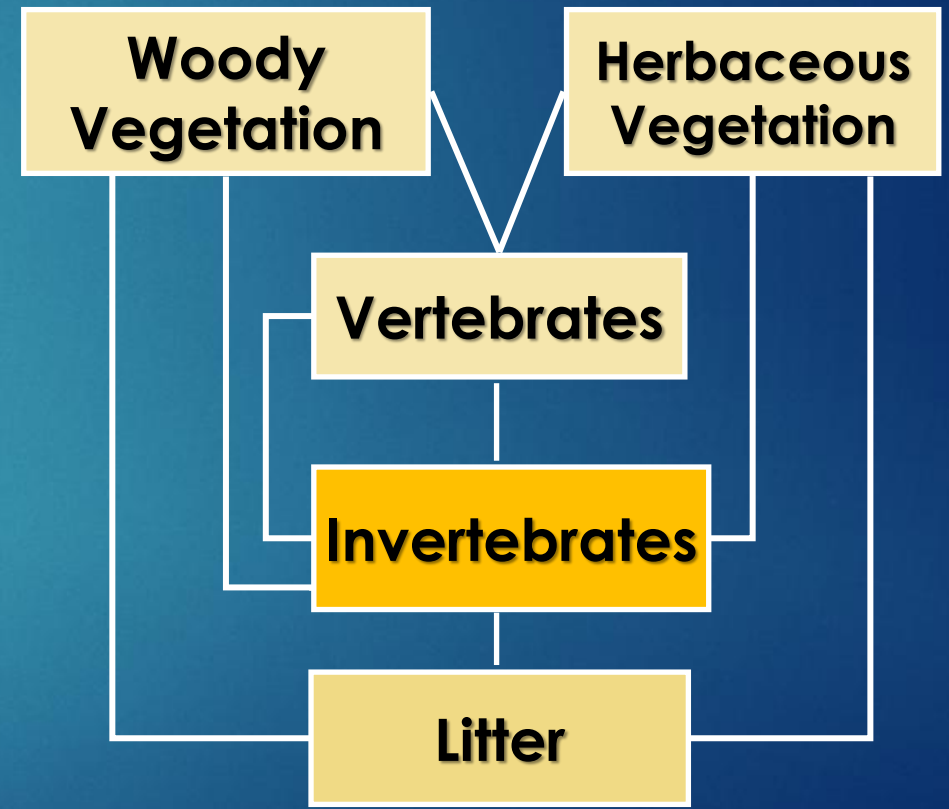
➤ Critical link in the function and structure of wetlands

❑ Decomposition

- Nutrient cycling
- Transfer of energy within food web

❑ Soil structure maintenance

- Create channels for gas, O₂ & H₂O movement
- Transporting organic residue to lower horizons



Functional Feeding Groups

➤ Shredders

- ❑ Forage on plant material
- ❑ Convert particulate organic matter from coarse (CPOM) to fine (FPOM)



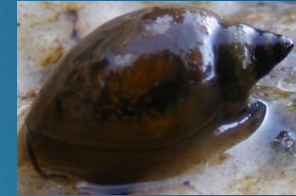
➤ Plant piercers

- ❑ Pierce plant/algae tissue and remove fluids



➤ Scrapers & Grazers

- ❑ Scrape algae and bacteria from plant material



➤ Collector-Gatherer & Collector-filterer

- ❑ Collect decomposing FPOM from water column

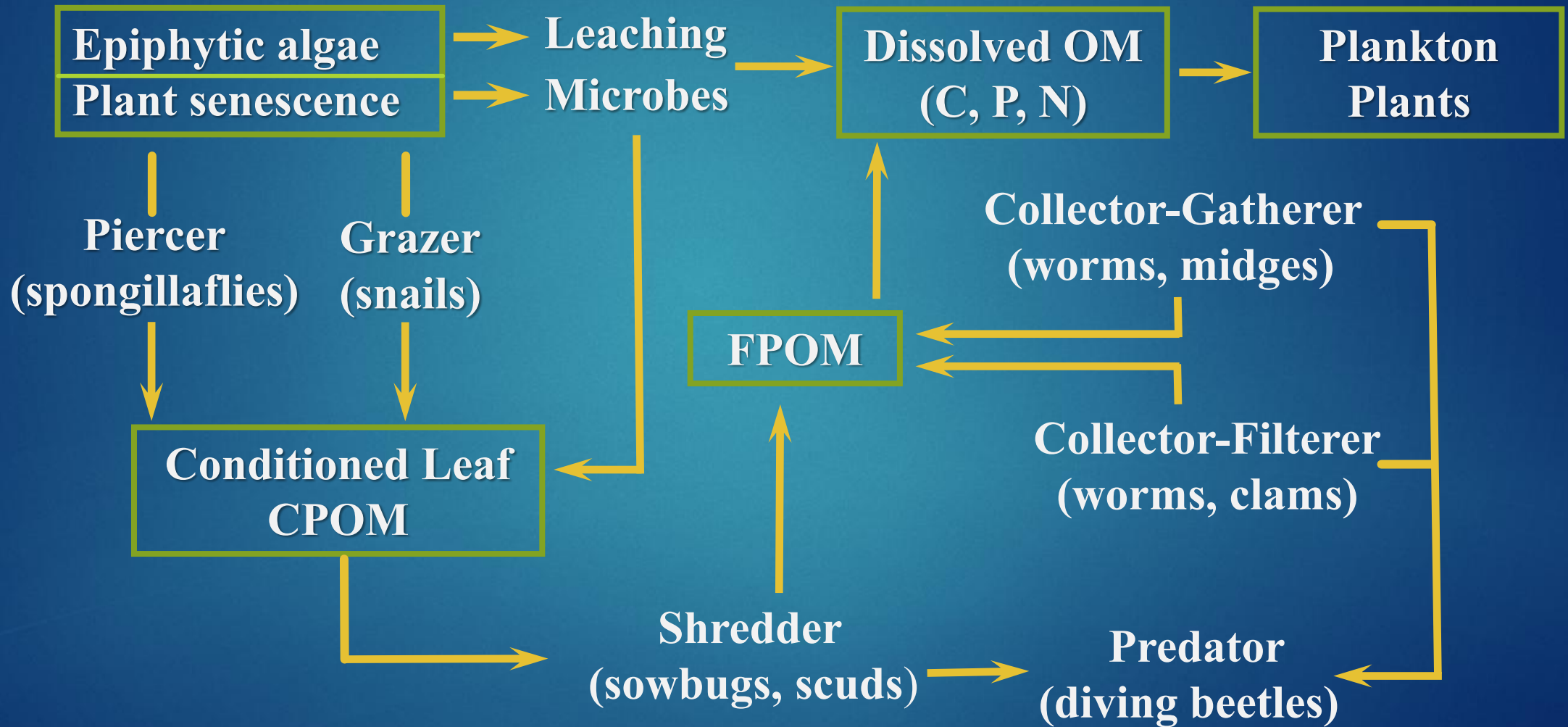


➤ Predators

- ❑ Consume live animal tissue
 - Engulfers ingest whole animal (dragonfly/damselfly naiads)
 - Piercers suck fluids from tissue (true bugs)



Decomposition & Nutrient Cycling

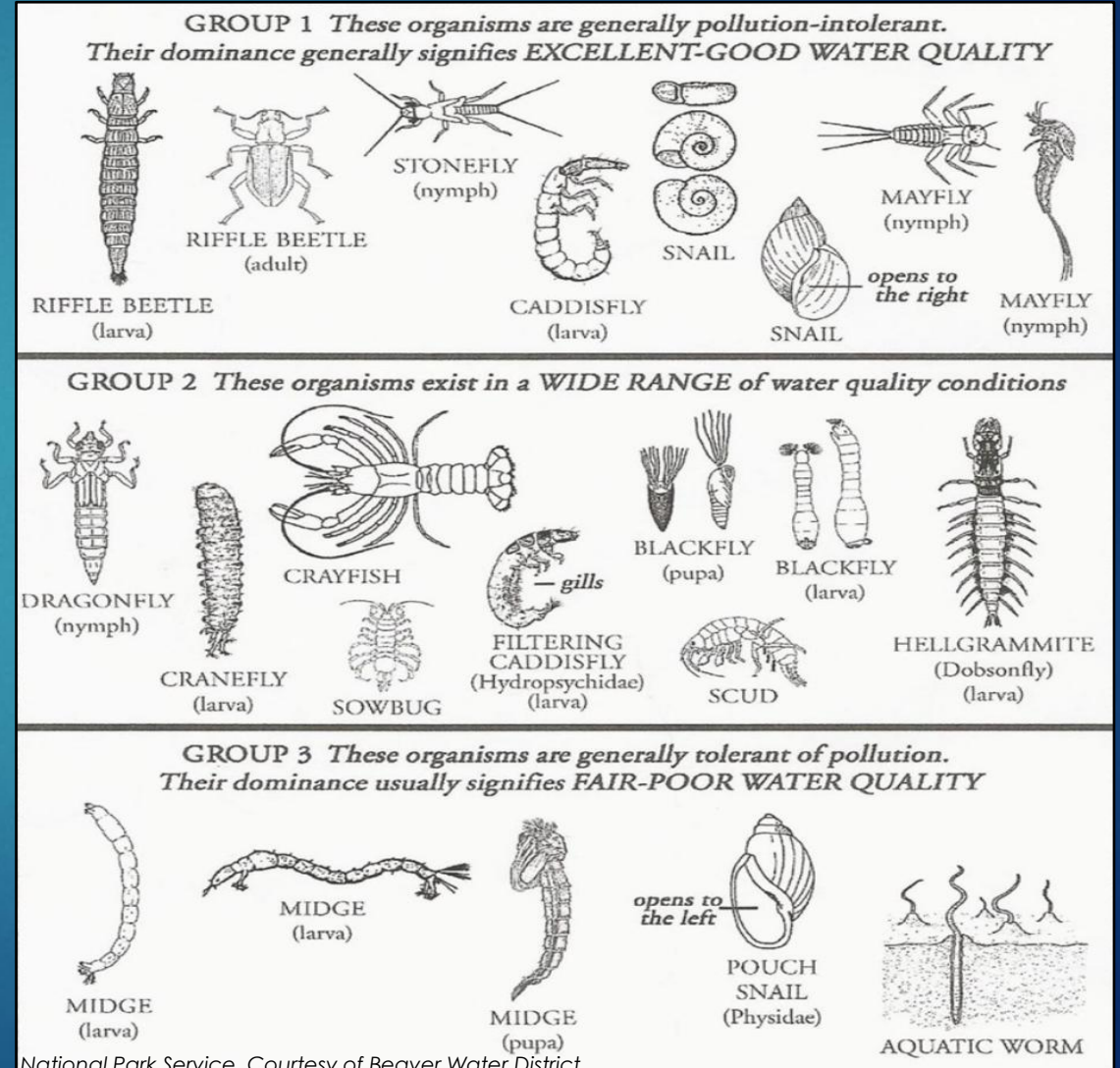


Importance of Aquatic Invertebrates

- **Maintaining the integrity of functional invertebrate foraging groups is critical for**
 - ❑ Proper functioning of wetland systems
 - ❑ Transfer of energy and nutrients to higher trophic organisms
- **Invertebrate assemblages are diverse & redundant (multiple species have similar task), but imbalances can occur due to**
 - ❑ Long-term stable conditions (e.g., deep water)
 - ❑ Catastrophic events
 - ❑ Duration & magnitude of imbalance can vary from short- to long-term
 - ❑ Solutions may require management of varying intensity

Importance of Aquatic Invertebrates

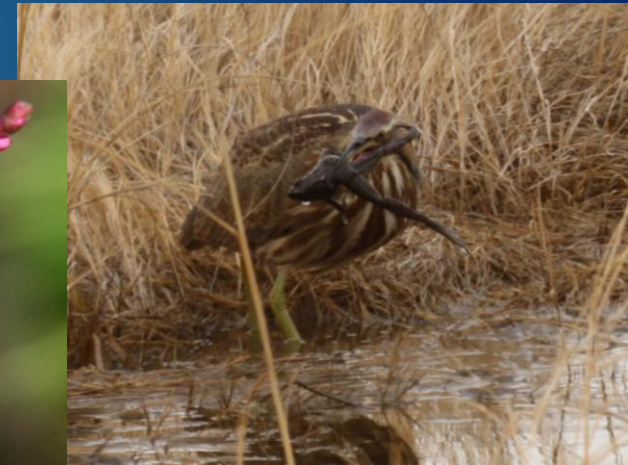
- Bio-indicators of
 - ❑ Water quality
 - ❑ Toxicological impacts
 - ❑ Ecosystem conditions
- Monitoring provides early indications of imbalances that affect management potential



Importance of Aquatic Invertebrates

➤ All life stages provide critical food resources for diversity of vertebrates

- ❑ Birds
- ❑ Bats
- ❑ Fish
- ❑ Amphibians
- ❑ Reptiles



Nutrition

Species	Energy (kcal/g)		Weight (%)				
	Gross	TME	Fat	Fiber	Ash	NFE	Protein
Backswimmer							64.4
Brine fly	5.41						
Dragonfly	5.88						
Earthworm			7.7	0.4	19.4	12.3	60.2
Fairy shrimp			8.6	3.9		1.5	71.9
Midges (larvae)	4.30		5.8		9.2	14.9	66.4
Sideswimmer	4.02		5.9	8.4	22.2	16.5	47.0
Shrimp, grass shrimp	3.32	2.02	1.2		6.7	11.7	46.8
Snail, Lymnaeid	0.92		0.7		64.2		16.9
Snail, Planorbid	1.02		1.1		73.3		12.2
Snail (w/o shell)			0.1	0.7		21.9	58.9
Snail (with shell)			0.7	12.4		5.8	16.9
Water boatman	5.63						71.4
Waterflea			1.5	7.3		10.9	49.7

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Snail, Planorbid	1.02		1.1		73.3		12.2
Waterflea			1.5	7.3		10.9	49.7
Beggarticks	5.17		15.0	19.7	7.2	27.5	25.0
Barnyardgrass	3.90	2.61	2.4	23.1	18.0	40.5	8.3
Chufa flatsedge (tubers)	4.26		6.9	9.0	2.5	55.4	6.7
Smartweed, Pennsylvania	4.32	1.08	2.3	21.8	4.9	65.3	9.0
Pin oak	5.06	2.60	18.9	14.7	1.6	58.6	6.4
Corn	4.44		3.8	2.3	1.5	79.8	10.8

