Incorporating biological traits in New Zealand freshwater biomonitoring and assessment

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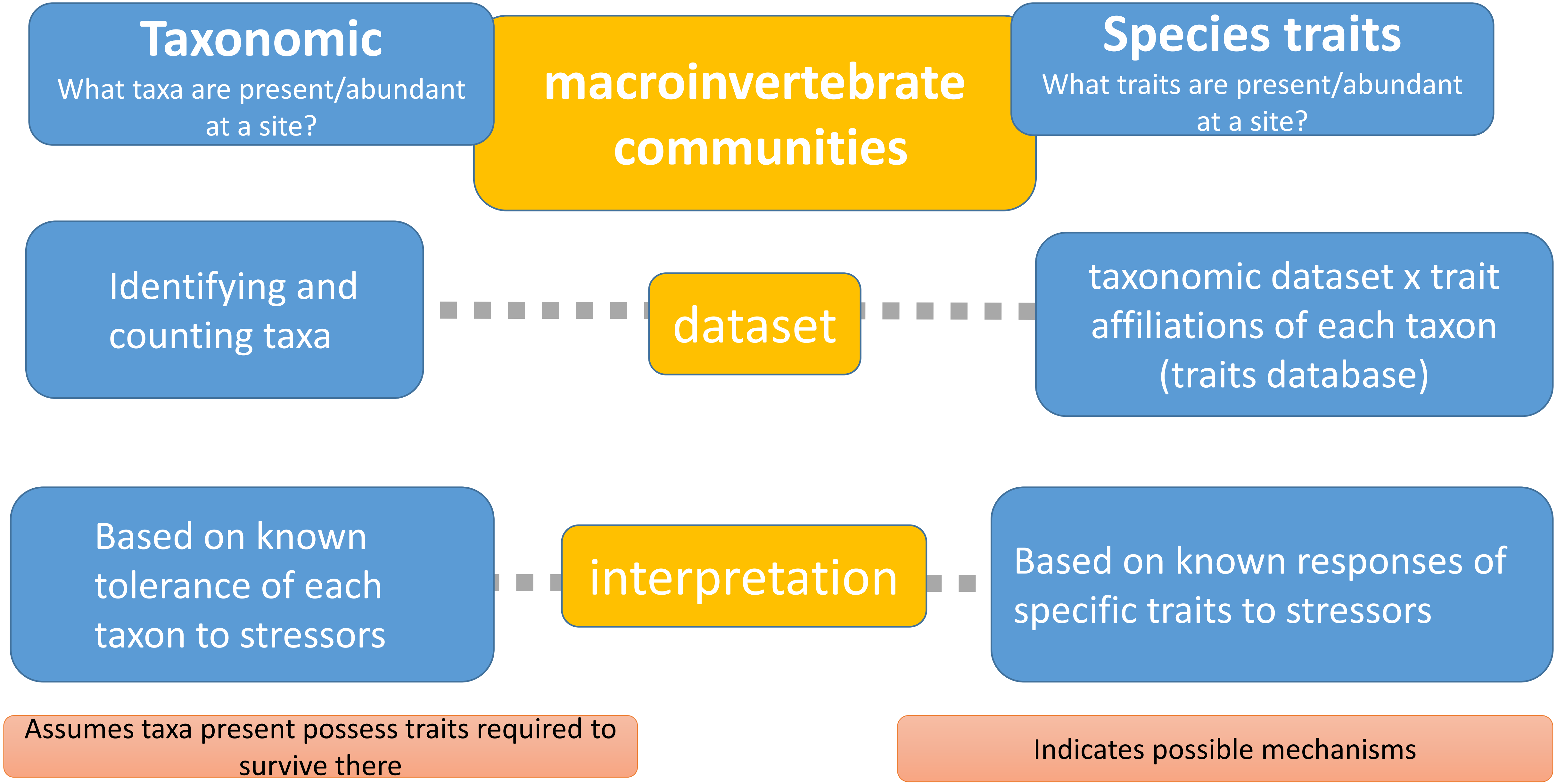
A biological or species trait is…

“a measurable property of an organism, measured in individuals and applied comparatively across species”

(McGill et al. 2006)


Taxonomic
What taxa are present/abundant at a site?
macroinvertebrate communities
Species traits
What traits are present/abundant at a site?
Identifying and counting taxa
dataset
taxonomic dataset x trait affiliations of each taxon (traits database)
Based on known tolerance of each taxon to stressors
interpretation
Based on known responses of specific traits to stressors
Assumes taxa present possess traits required to survive there
Indicates possible mechanisms

New Zealand Invertebrate Traits Database

- First developed in 2004 (Ngaire Phillips)
- 16 traits (2-5 categories each) = 59 categories total
- Had some knowledge gaps
- 2017 updated with additional species, recent published info and specialist knowledge
- 495 taxa, >29,000 traits scores

The database now represents the best specialist knowledge available for New Zealand benthic macroinvertebrate fauna.

Example of species traits and categories

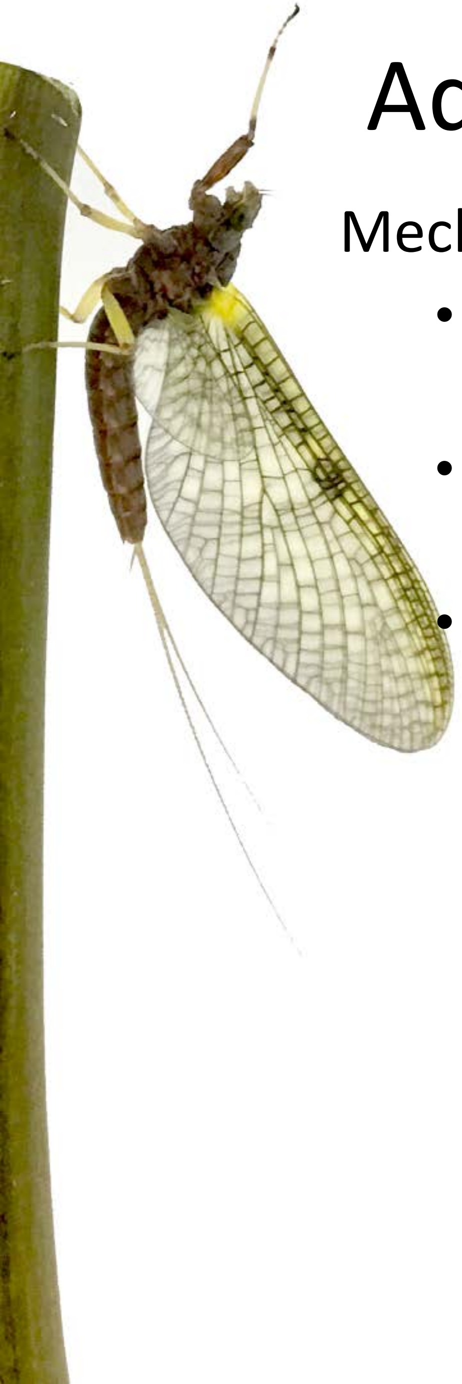
Trait	Category 1	Category 2	Category 3	Category 4
Body size	<=5 mm	5-10 mm	10-20 mm	>20 mm
Reproductive cycles/year	<1	1	>1	
Attachment to substrate	Swimmer	Crawler	Burrower	Attached

How are traits categories scored?

Trait	Categories			
Feeding	Scraper	Shredder	Filterer	Predator
Taxon 1 (Stonefly sp. A)	1	3	0	3
Taxon 2 (Caddisfly sp. A)	2	3	0	0
Taxon 3 (Caddisfly sp. B)	0	0	3	0

Affinity scores

- Strength of association with different categories (0=none, 3=high)
- Can recognise generalists vs. specialists, behaviour that changes over time



Advantages of traits, why are they useful?

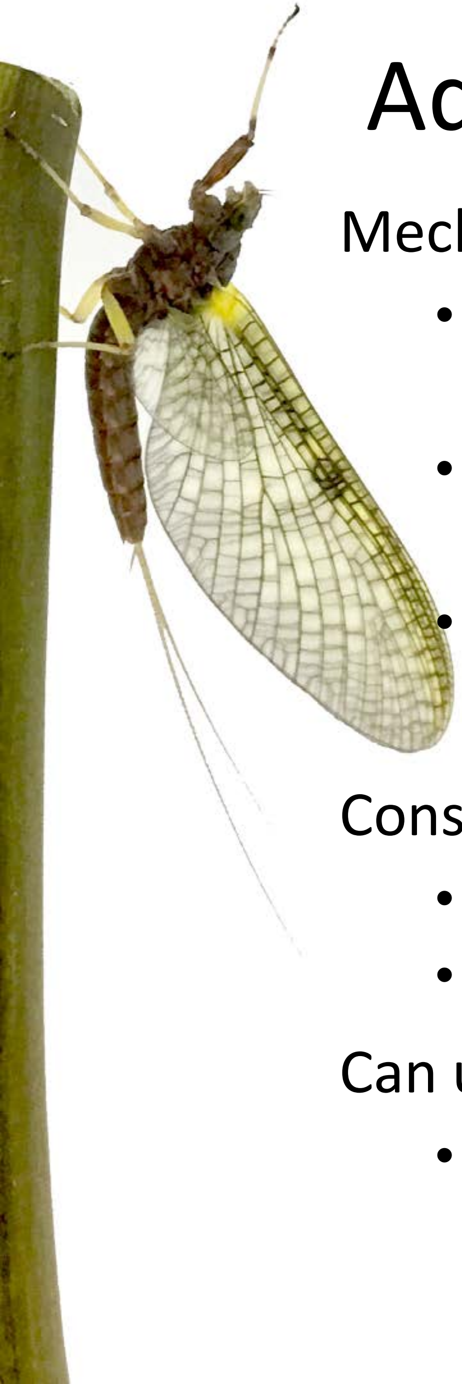
Mechanistic linkages of biotic responses to specific stressors

- Strong theoretical basis e.g., Townsend & Hildrew (1994): habitat as a trait filter…
- Stressors can include sedimentation, nutrient enrichment, stream drying…
- Traits affected may include mode of locomotion, respiration, oviposition…

Traits linked with specific stressors

Stressor	Trait	Predicted response
Fine sediment	Clingers, burrowers	-ve[1,2]
	Multivoltine	-ve[2]
	Large body size	-ve[2]
	Scrapers	-ve[2]
Intense agriculture (as DIN, DRP, %fines)	Univoltinism	-ve[3]
	Short adult life duration	-ve[3]
	Filter feeders	+ve[3]

[1]Pollard & Yuan 2010; [2]Richards et al. 1997; [3]Doledec et al. 2006



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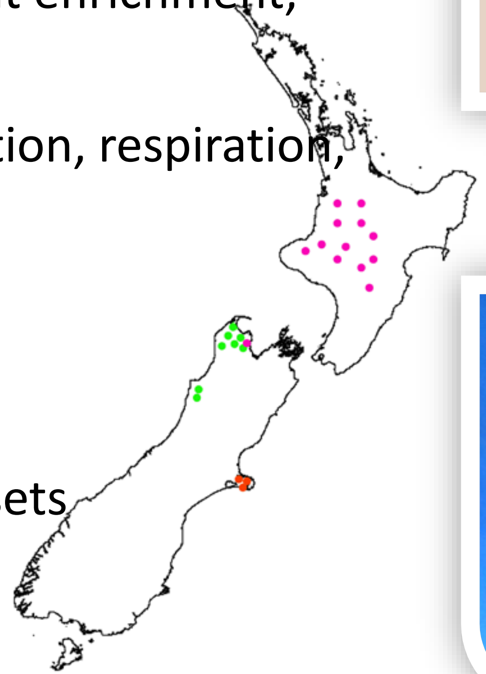


Consistent across broad spatial scales

- Avoids confounding distributional patterns
- Enables comparison with international datasets

Can use existing (taxonomic) data

- No need to collect additional data

Use of traits in MfE project (macroinvertebrates metrics)

1. Updated species trait database
2. Converted species x sites → trait x sites (based on species trait database).

How to use a traits database: matrix multiplication to get a sites x traits matrix

Log abundance x site

Sample id	Acanthophlebia	Acarina	Acroperla
30818	0	0.30103	0
41543	0	0.30103	0
41813	0	0	0
41814	0	0	0

X

Species trait database

Taxon	SIZE1	SIZE2	SIZE3	SIZE4	SIZE5	DESC1	DESC2	DESC3	DESC4
Acanthophlebia	0	0	3	0	0	0	3	1	0
Acarina	3	1	0	0	0	0	3	0	0
Acroperla	0	0	3	0	0	0	3	0	0

=

Trait proportions x site

Sample id	SIZE1	SIZE2	SIZE3	SIZE4	SIZE5	DESC1	DESC2	DESC3	DESC4
30818	38%	15%	47%	0%	0%	53%	46%	1%	0%
41543	18%	54%	21%	8%	0%	19%	69%	9%	3%
41813	17%	39%	35%	3%	5%	22%	61%	11%	6%
41814	26%	46%	25%	2%	2%	28%	67%	5%	0%

Use of traits in MfE project (macroinvertebrates metrics)

1. Updated species trait database
2. Converted species x sites → trait x sites (based on species trait database).
3. Identified traits likely to respond to stressors

Next:

Compare trait-stressor correlations with taxa-stressor correlations

Use of traits in MfE project (macroinvertebrates metrics)

Gradient forest (GF) models and multiple regressions used to link stressors with:

All 59 trait categories and 51 taxonomic-based metrics

Response to landuse (catchment scale)

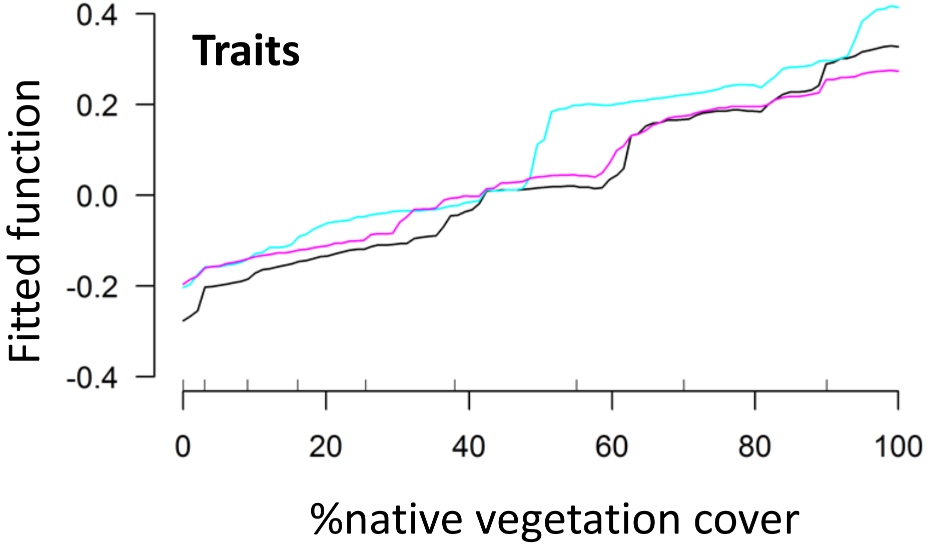
- %native vegetation and %heavy pastoral landuse

Response to specific stressors (reach scale)

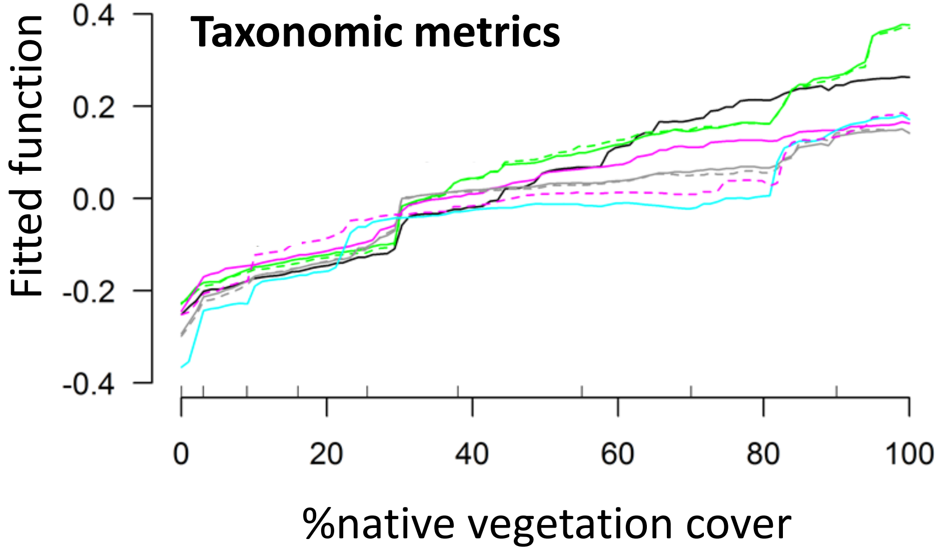
- Sediment cover (descriptor of intensity of sediment effects)
- Nutrients via chl-*a* causal pathway (descriptor of intensity of enrichment)

How did traits perform? Landuse

3 of the top 5 ranked metrics were traits



- low body flexibility (e.g., some EPT)
- max. no. descendants > 3000 (e.g., some mayflies, *Paratya*, *Echyridella*)
- adult or larval aquatic stage (e.g., mayflies, stoneflies - excl. taxa with pupae)

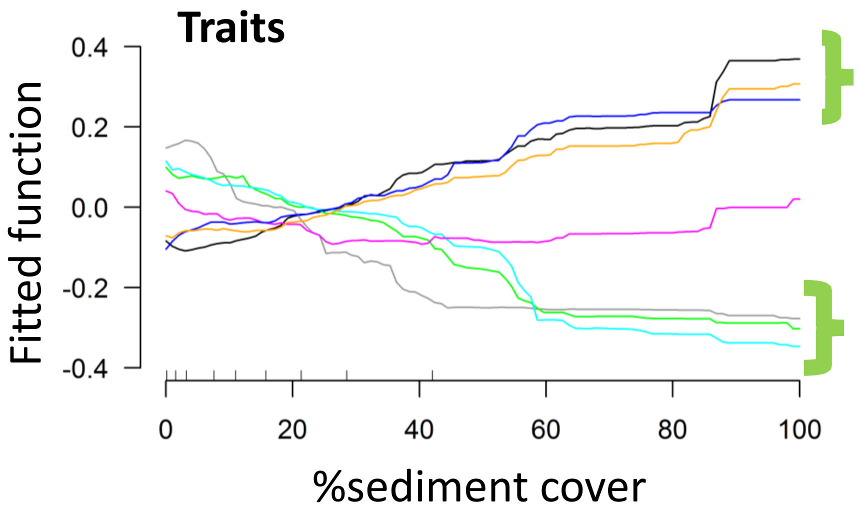


similar gradual increase for all taxonomic metrics with increasing native vegetation cover (increase presence of sensitive taxa)

Clapcott et al. (2017). Macroinvertebrate metrics for the NPS-FM

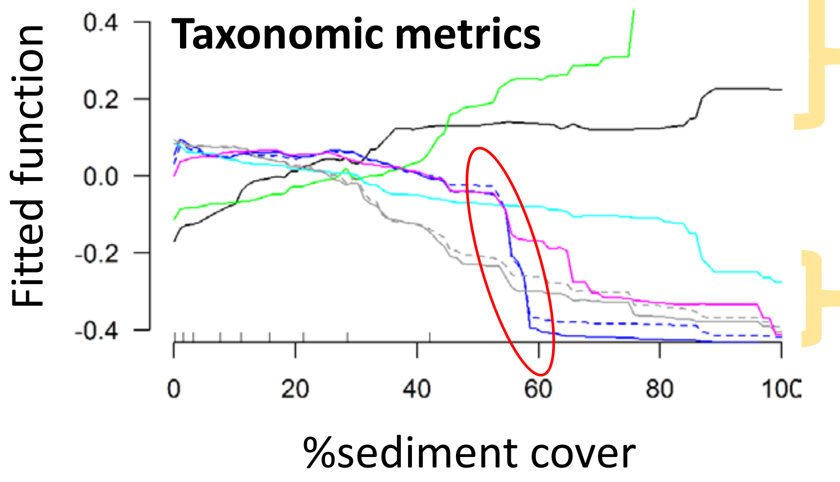
How did traits perform? Sediment

7 of the top 15 ranked metrics were traits, mixed response with increasing sediment gradient



- lay submerged eggs (mixture of insect & non-insect taxa)
- more than 1 reproductive cycle/year (e.g., Diptera & Mollusca)
- smaller body size ≤ 5mm (e.g., Crustacea, Chiron., micro-caddis)

- crawlers (some Diptera, all EPT)
- very high (>3000) descendants per individual
- life duration of adult ≤1 day



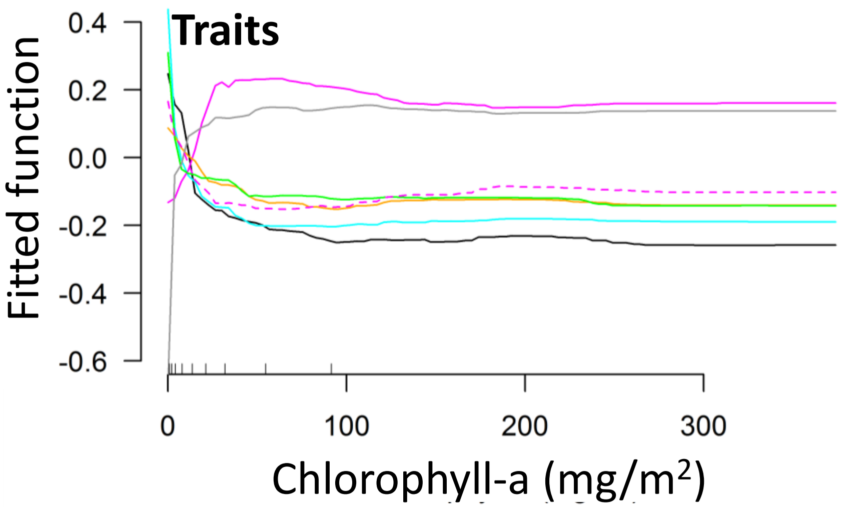
- increased: metrics summarising sediment tolerant taxa

- decreased: metrics summarising sediment intolerant taxa (esp. EPT taxa)

Clapcott et al. (2017). Macroinvertebrate metrics for the NPS-FM

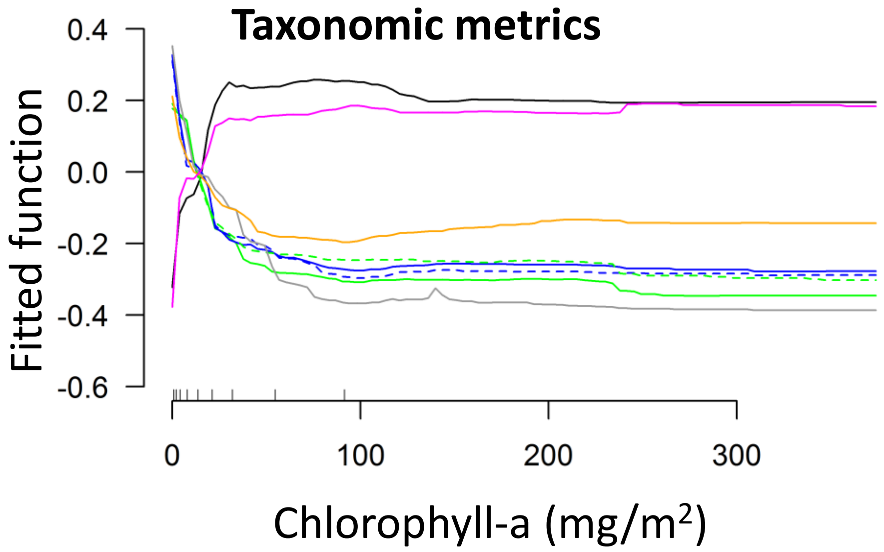
How did traits perform? Chlorophyll-*a*

7 of the top 15 ranked metrics were traits.



- low dissemination potential (all stages)
- hermaphrodite (mostly Mollusca)

- male and female reproductive technique
- single reproductive cycle per year
- low body flexibility
- adult or larvae stage in water
- life duration of adult ≤1 day



- metrics summarising tolerant taxa increased

- general stream metrics summarising sensitive taxa decreased

Clapcott et al. (2017). Macroinvertebrate metrics for the NPS-FM

Conclusions

Are traits useful for biomonitoring?

- Respond to sediment and chlorophyll-*a* gradient
- Little overlap between traits and specific stressors
- Potential diagnostic power, but…

Should traits and taxonomic metrics be used together?

- Suitable for stream health assessment as they can discriminate between stressors
- Multiple-metrics for environmental health assessment and reporting are globally recognised

Is there room for improvement?

- Sensitivity limited by the amount of traits information available
- Greater sensitivity could be anticipated as more information becomes available
- Requires more work…

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