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Estimating Weights for Constructing Environmental Indices

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Generating Aggregated Indices

How to generate a single “score” that reflects the status (health or pressure) of an ecosystem.

- Normalisation of indicators (scaled in all sorts of ways)
- Linear or multiplicative weighting.

$$I = \sum_i \alpha_i Z_i$$

or

$$I = \prod_i Z_i^{\alpha_i}$$

- Weights (α_i) need to be estimated objectively... as possible.

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The indicators

1. Cleared land
2. Population
3. Sediment input
4. Nutrient input
5. Freshwater flow
6. Disturbed habitat
7. Tidal flow and
8. Fishing.

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One approach to establish weights

- Establish weightings based on experts' opinions on the relative importance of the indicators.
- Opinions are derived from pairwise comparisons.
- A version of the Bradley-Terry model allows ML estimates of indicator importance to be derived from these comparisons but including a specific term to estimate the effect of specific expert bias.

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The model

Consider the indicators to have true weightings

$$\alpha_1, ..., \alpha_7; \quad \alpha_i \geq 0, \quad \forall \ \ i; \quad \alpha_1 = 1$$

BT model is

$$\log(x_{ii'}) = \alpha_i - \alpha_{i'} + \epsilon_i \quad i \neq i'.$$

and $x_{ii'}$ is the relative importance of indicator i over i'. Now include an expert specific bias term for each comparison to allow for differences in opinions among experts. For expert k we propose the model

$$\log(x_{ii'k}) = (\alpha_i - \alpha_{i'}) + (\beta_{ik} - \beta_{i'k}) + \epsilon_i \qquad (1)$$

$k = 1, \ldots, K$ experts, and $\beta_{ik} \sim N(0, \sigma^2)$.

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Expert's Relative Importance

Row indicator over column indicator	Cleared land	Population	Sediment input	Nutrient input	Freshwater flow	Distributed habitat	Tidal flow	Fishing
Cleared land	1							
Population		1						
Sediment input			1					
Nutrient input				1				
Freshwater flow					1			
Distributed habitat						1		
Tidal flow							1	
Fishing								1

Table 1: The relative importance of the row indicator compared to the column indicator.

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Estimated weights, $\widehat{\alpha}_i$

Used R's lmer function to estimate parameters.

	$\widehat{\alpha}_i$		
	lower	est.	upper
ClearedLand		1.00	
Population	0.41	1.00	2.43
SedimentInput	0.97	2.36	5.77
NutrientInput	1.41	3.43	8.37
FreshwaterFlow	0.53	1.29	3.16
DisturbedHabitat	0.77	1.89	4.60
TidalFlow	0.47	1.15	2.80
Fishing	0.23	0.55	1.34

Table 2: Estimates and 95% CI for weightings

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Expert bias, $\widehat{\beta_{ik}}$

	Expert				
	A	B	C	D	E
ClearedLand	0.42	1.33	-0.77	-0.92	-0.05
Population	0.29	0.99	-0.85	-1.13	0.70
SedimentInput	-0.03	0.06	0.13	0.20	-0.36
NutrientInput	-0.42	0.18	-0.19	-0.17	0.59
FreshwaterFlow	0.17	-0.76	0.53	0.77	-0.70
DisturbedHabitat	-0.26	-0.61	0.08	0.15	0.64
TidalFlow	0.31	-0.81	0.41	0.75	-0.67
Fishing	-0.48	-0.38	0.66	0.36	-0.16

Table 3: Estimates of expert bias by indicator

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Expert bias

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Table 4: Estimates of expert bias by indicator

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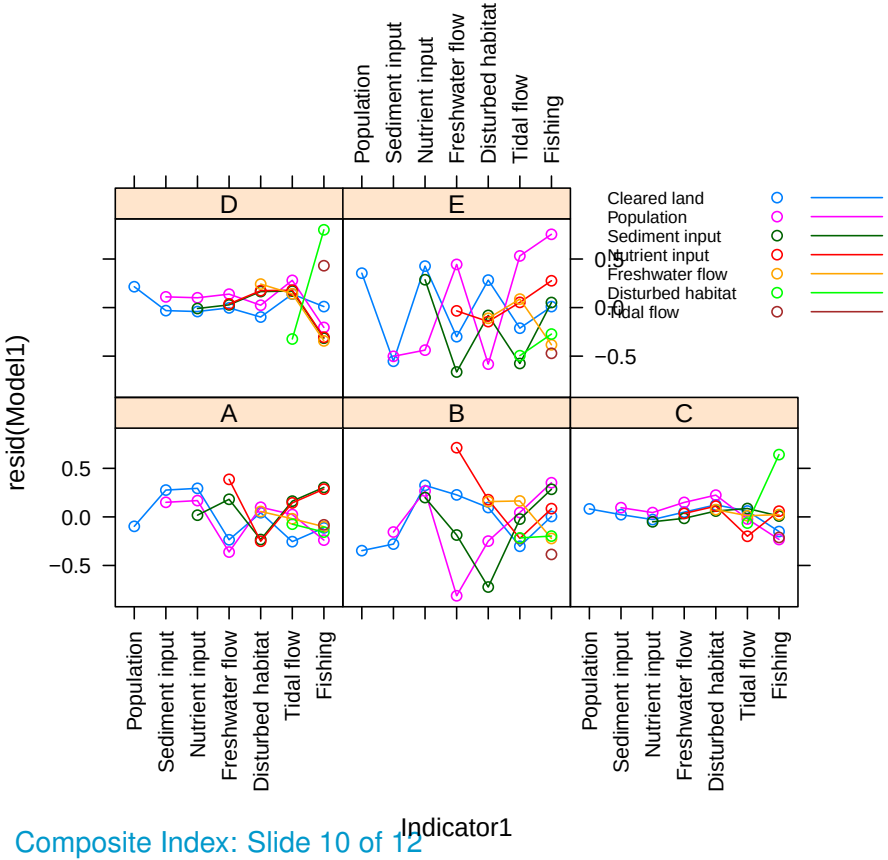
Residuals



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Thank you

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