The Bray-Curtis compositional dissimilarity between the observed and expected assemblages of taxa explained by exposure to multiple stress factors

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Introduction

Diagnostic bioassessment often uses the observed/expected (O/E) ratio to indicate anthropogenic alteration of aquatic macroinvertebrates or fish assemblages, putting focus mainly on taxa lost. E is the number of those taxa that would be expected in a sampled assemblage if the sampled stream were in a minimally disturbed reference condition, and O is the number of those taxa observed in the sample. O over E values significantly below unity indicate that a stream lost taxa possibly because of anthropogenic stress. To locally predict the expected assemblage of taxa, a River Invertebrate Prediction and Classification system (RIVPACS) type model may be used.

A GIS based method that results in Effect and Probable Cause (EPC) pie diagrams has previously been used to diagnose the responses of local fish assemblages in Ohio (USA) rivers (De Zwart et al, 2005). A large proportion of the local losses of sensitive taxa could not yet be attributed to any of the selected stress factors due to a large variability in the natural occurrence of taxa. The unattributable impact may also be due to the fact that stress may not only be indicated by the loss of taxa, but also by the occurrence of unexpected opportunist taxa.

Recent adaptations of the RIVPACS model (Van Sickle et al, 2008) enabled the calculation of a measure of Bray-Curtis compositional dissimilarity (BC) that complements O/E and summarizes the taxon-specific disparity between observed and expected assemblages, including both the loss of expected and the occurrence of unexpected taxa.

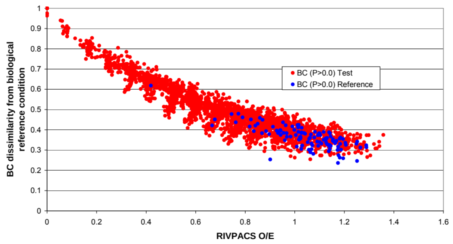
Preliminary statistical analyses demonstrate that the use of BC instead of O/E reduces the uncertainty in the attribution of causative factors.

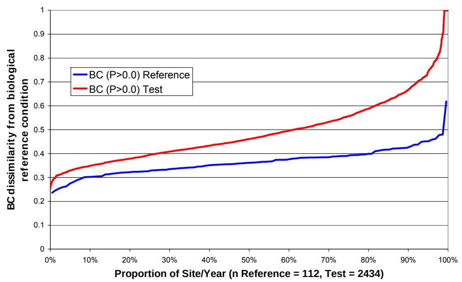
References

De Zwart D, Dyer SD, Posthuma L, Hawkins CP. 2006. Predictive models attribute effects on fish assemblages to toxicity and habitat alteration. Ecological Applications 16(4):1295-1310.

Van Sickle J. 2008. An index of compositional dissimilarity between observed and expected assemblages. Journal of the North American Benthological Society 27(2):227-235.

Bray-Curtis deviation from local biological reference condition versus O/E as an indication of the loss of taxa





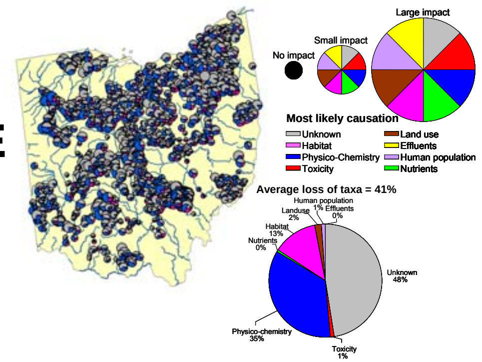
Data used

112	Reference sites selected by OEPA Expert judgement & IBI-score ≥ 46
2434	Affected sites (IBI-score < 46)
89	Fish taxa census data
5	Geographical predictors
30	Stressor predictors

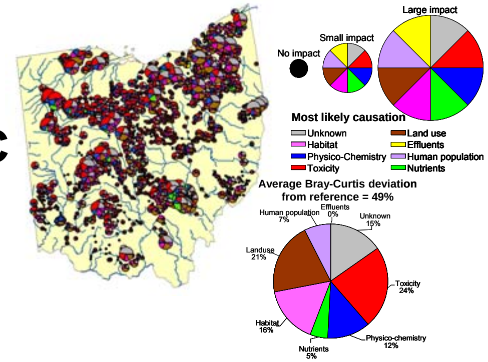
Clean/Dirty	Code	Group	Description
Clean	LAT	Geography	Latitude
Clean	LONG	Geography	Longitude
Clean	LOGDA	Geography	Log Drainage Area
Clean	LOGFLOW	Geography	Log Annual Average Flow
Clean	LOGSLOPE	Geography	Log Slope
Dirty	ChannelC	Habitat	Channel in catchment
Dirty	CoverC	Habitat	Cover in catchment
Dirty	PoolC	Habitat	Pool in catchment
Dirty	RiffleC	Habitat	Riffle in catchment
Dirty	RiparianC	Habitat	Riparian in catchment
Dirty	SubstrateC	Habitat	Substrate in catchment
Dirty	PopDensW	Human population	Human population density in watershed opstream
Dirty	AvgIncW	Human population	Average $ Income in watershed upstream
Dirty	AgrW	Land use	Relative area of agriculture in watershed upstream
Dirty	ForW	Land use	Relative area of forest in watershed
Dirty	UrbW	Land use	Relative urbanized area in watershed upstream
Dirty	#Industries	Land use	# of Industries in watershed upstream
Dirty	#Dams	Land use	# of Dams in watershed upstream
Dirty	Ptot	Nutrients	Total Phospohorous measured
Dirty	NO3N	Nutrients	NO3N measured
Dirty	TKN	Nutrients	Total Kjeldahl Nitrogen measured
Dirty	NO2N	Nutrients	NO2N measured
Dirty	Ammonia	Nutrients	Total Ammonia measured
Dirty	msPAFraIN	Toxicity	msPAF Industrial chemicals measured
Dirty	msPAFraHH	Toxicity	msPAF Household products modelled
Dirty	msPAFraEE	Toxicity	msPAF estrogens modelled
Dirty	msPAFraPH	Toxicity	msPAF pharmaceuticals modelled
Dirty	PsMsPAFraPP	Toxicity	pseudo msPAF pesticides modelled
Dirty	PctEffAnnW	Waste water	Annual percentage of effluents in watershed upstream
Dirty	#CSO	Waste water	# of combined Sewer Overflows in watershed upstream
Dirty	pH	Water chemistry	pH measured
Dirty	HARD	Water chemistry	Hardness measured
Dirty	TSS	Water chemistry	Total suspended solids measured
Dirty	BOD	Water chemistry	BOD measured
Dirty	COND	Water chemistry	Conductivity measured

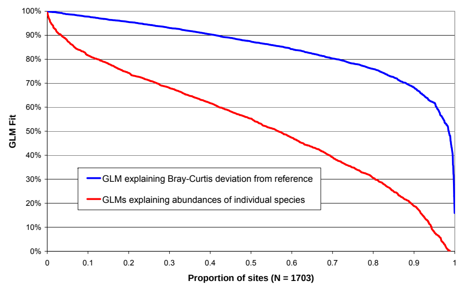
EPC (Effect Probable Cause)-maps based on RIVPACS O/E loss of species and Bray-Curtis reference dissimilarity

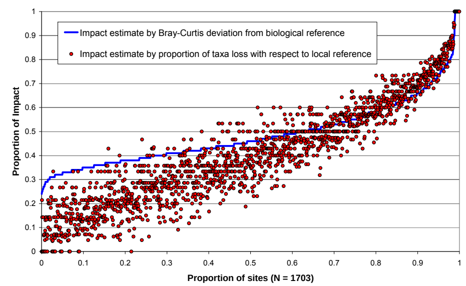
O/E



BC







Conclusions

- Compared to the O over E method of estimating impact, the use of Bray-Curtis deviation from biological reference condition indeed reduces the average unkown causality (from 48 to 15%)
- Lost taxa most strongly associated with physico-chemical and habitat deterioration
- Bray-Curtis deviation from biological reference condition mainly associated with toxicity, landuse and habitat deterioration
- Difference in the attribution of impact to the most probable causes between the two methods not yet fully understood
- However, the BC-method adresses the loss and appearance of all taxa, including rare species. O/E only loss of common taxa. Obviously there is a lot of explanatory capacity in the rare species