ESTIMATING COASTAL ECOSYSTEM HEALTH THROUGH INDICES

A case study of anthropogenic pressures in Tampa Bay

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What is an Environmental Index?

“A composite measure that combines multiple environmental indicators into a single value…”

“ …typically developed to provide an overall snapshot of some feature”

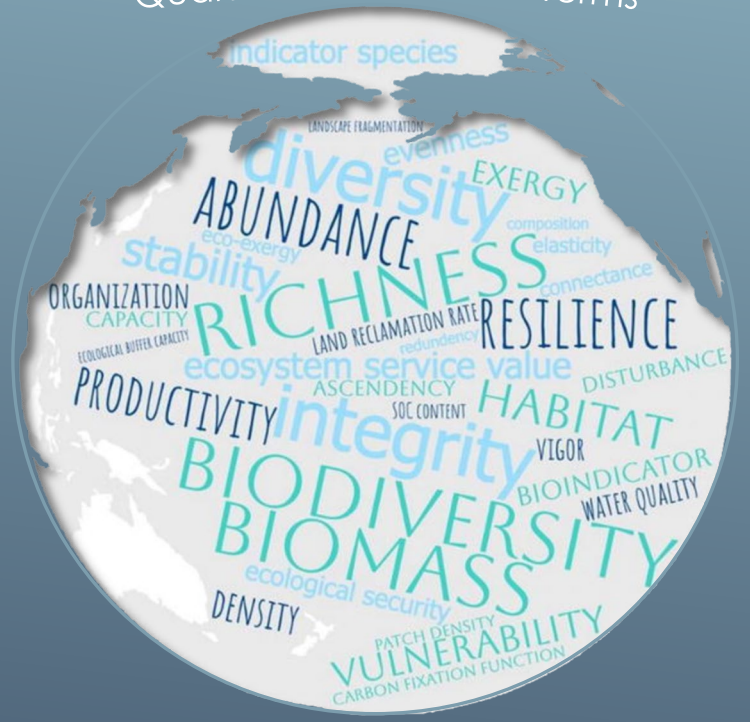
Source:
https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118445112.stat07691#:~:text=Abstract,in%20constructing%20an%20environmental%20index
https://www.linkedin.com/advice/1/how-can-you-use-environmental-indicators-indices-skills-economics#:~:text=to%20be%20featured.-,1%20What%20are%20environmental%20indicators%20and%20indices%3F,their%20environmental%20performance%20or%20impact

WHAT IS AN ENVIRONMENTAL INDEX

Example indicator term	n	Associated descriptor terms found throughout the articles included in data extraction
Richness	23	11 species richness, 1 arthropod species richness, 9 richness, 1 taxonomic richness, 1 functional richness
Integrity	21	11 ecological integrity, 1 landscape ecological integrity, 3 environmental integrity, 5 ecosystem integrity
Abundance	18	1 species abundance, 1 abundance biomass comparison ABC curve
Biomass	17	
Diversity	16	2 taxonomic diversity, 1 plant species diversity, 1 functional diversity
Resilience	15	1 resilience to disturbance factors, 1 intrinsic resilience, 1 landscape resilience
Biodiversity	14	
Ecosystem services	14	2 ecosystem service value, 1 ecosystem services demand, 1 ecosystem services supply-demand ratio
Productivity	11	1 vegetation productivity, 4 net primary productivity (NPP), 1 ecosystem functioning productivity, 1 total primary production: biomass, 1 total primary production: respiration
Habitat	9	1 habitat continuity, 1 habitat diversity, 1 habitat fragmentation, 1 habitat function, 1 habitat heterogeneity, 1 habitat provision, 1 habitat specialists, 1 habitat stress, 1 habitat topographic heterogeneity
Stability	9	1 ecological stability, 1 landscape structure stability, 1 vegetation coverage stability, 1 soil food web stability, 1 environmental stability, 1 ecosystem stability
Vulnerability	7	5 ecological vulnerability, 1 landscape vulnerability, 1 ecosystem vulnerability

Source:
Penn,Gillian et al., cabionehealth.2024.0006,CABI One Health, doi:10.1079/cabionehealth.2024.0006, CABI, General ecosystem health indicators – A scoping review, (2024)
https://www.cabidigitallibrary.org/doi/abs/10.1079/cabionehealth.2024.0006

Quantitative Indicator Terms



" [The importance of] how terminology descriptors and their use can be understood by [] stakeholders across disciplines, with implications on the dimensions of implicit intrinsic and extrinsic value statements… "

THE PROBLEM SPACE: ENVIRONMENTAL INDICES, LOST IN TRANSLATION

REFRAMING, PIVOT

- Purpose of the Study:
- Selection of the optimal or most positively impacting mitigation feature…using[ing] indices of negative environmental impact.

- Originally evaluating performance of models through predictions of diversity (through the Shannon Diversity Index)

- New approach:
  Test along with Shannon Diversity Index as an engineered feature, to predict well established, academically vetted peer-reviewed local index

- Data Issues

- Existing Information

- Unexpected findings during EDA

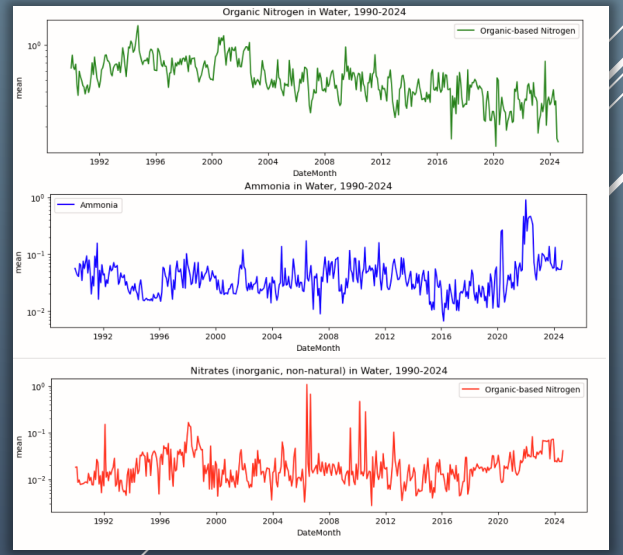
TBEP TAMPA BAY ESTUARY PROGRAM

Hypothesis:

There is a statistically significant relationship between a proposed A.P. Index with well established, academically vetted indices of ecosystem health of Tampa Bay.

- Artificial, Harmful Nitrate Concentrations (Associated With Fertilizer)
- Population Growth (Annual change, Total, Region specific)
- Coastal Development
  - Land Sales
  - Annual New Construction
  - Change in Land Use

Residential Construction Emphasis on "waterfront"



Transform then standardize data, using weights to adjust for relative Impact of a given feature. This is adjustable to any localized system.

$$API = \omega_1 z_1 + \omega_2 z_2 + \cdots + \omega_n z_n$$

Weighted Sum Model
(Aggregate Index)

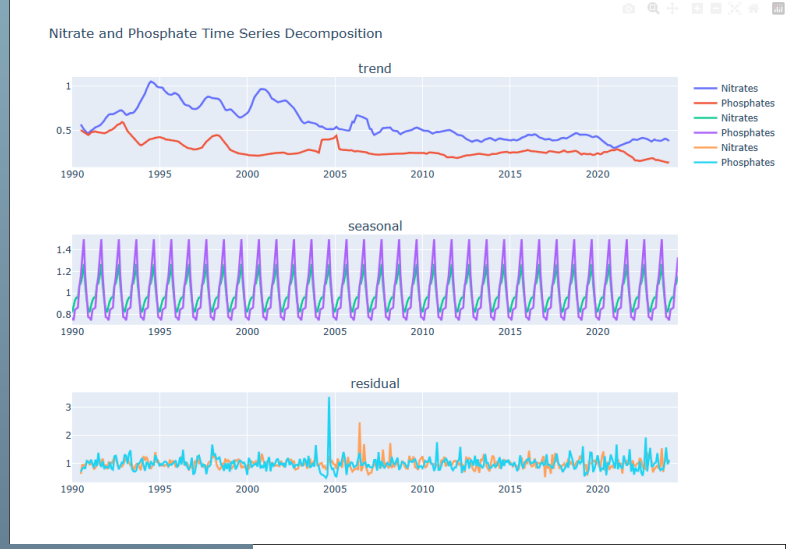
ANTHROPOGENIC PRESSURE INDEX

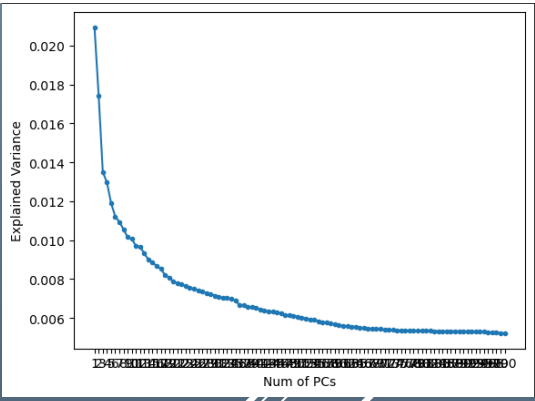
Modelling Approaches

- **Linear Regression**
- **Lasso, Ridge Regression (L1/L2 Regularization)**
- **SARIMAX**
  - **Seasonal decomposition**
- **Recurrent Neural Network**
  - **Long Short Term Memory ******

First Model: Multivariate Linear Regression.
Score: 0.2523

RNN (LSTM): Predicting TBNI using iterations of API, Shannon Diversity Index, WQI
Loss, MSE: 0.035,
n = 45,431
Using Train-Test-Validation Datasets





MODELLING APPROACHES & PERFORMANCE

There's a method more readily accessible and understandable to the general population without…having to be a scientist!

- Complete processing of large dataset
- Cross-Validation
- Github Repository
- Further applications

IMPLICATIONS & NEXT STEPS

And many thanks to our instructors for all their guidance!