BioSCape: Intrinsic Dimensionality as a Metric for Spectral Diversity

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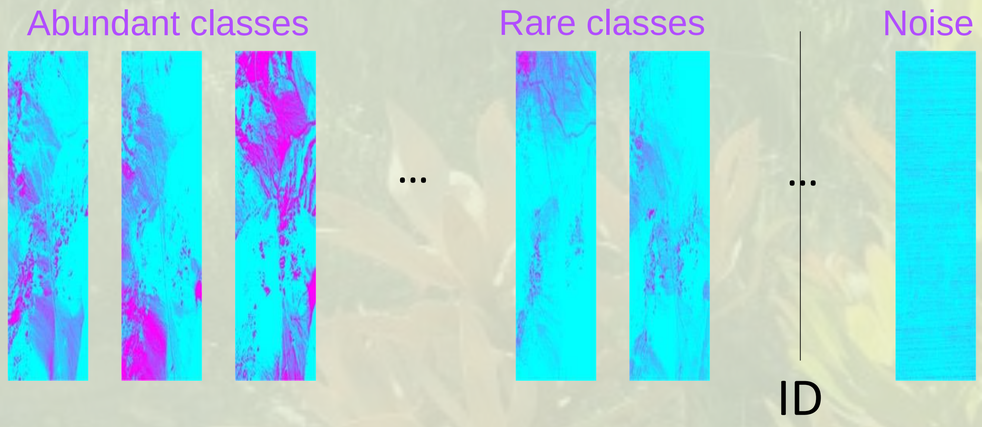
Intrinsic Dimensionality

- Defined as the dimension of the signal subspace (the number of image covariance eigenvalues greater than some threshold defined by noise)
- Can be thought of as the number of unique pieces of information contained in spectroscopic data (principal components)
- Hypothesis that ID can be used as a metric for biodiversity



The mathematical concept of intrinsic dimensionality provides a metric for spectral diversity that does not inherently require training data, making its development and validation important for the future of global biodiversity mapping.

ID and Biodiversity

- Alpha diversity: ID represents the number of spectrally distinct vegetation and soil types within each local sub-region
- Gamma diversity: ID represents the number of spectrally distinct vegetation and soil types within the entire study region
- Beta diversity: To derive beta diversity, we combine ID with Generalized Dissimilarity Modeling (GDM; Ferrier et al., 2007), which is especially appropriate in the high-turnover Fynbos biome since it considers the non-linearity encountered in a) the relationship between ecological distance and compositional dissimilarity, and b) the variation in the rate of plant compositional turnover at different positions along environmental gradients.

We define an ID-based dissimilarity metric:

$$d_{ij} = 1 - \frac{2D}{2D + K_i + K_j}$$

where K_i is the ID of region i; K_j is the ID of region j; $K_{i,j}$ is the ID (number of species present) at the union of sites i and j; and the number of common species present at the intersection of both sites can be calculated using $D = K_i + K_j - K_{(i,j)}$.

ID and Evapotranspiration

- Reduced diversity results in ecosystems that are less productive and less resistant to perturbations resulting from changing climate
- We hypothesize that increased diversity is associated with improved evapotranspiration (ET) in the Cape Floristic Region
- ET is available from MODIS (16-day record since 2000, 1 km resolution), ECOSTRESS (sub-weekly, 70 m, shown below), and HyTES (airborne, high-resolution at time of BioSCape campaign)

Region of Interest

- Existing CSIR site in the Agulhas Plain region
- Field surveys carried out in 2015 (pre-drought), 2018 (during drought), and 2022 (post-drought; planning underway)
- Historical data acquired includes 100 tree species geolocations, airborne lidar, field biomass, and species distribution of Acacia, Pine, and Eucalyptus
- CSIR team (funded by NEOFrontiers) will acquire data using a hyperspectral/lidar integrated UAV as well as field surveys
- BioSCape-ID team will acquire tree species data in sites TBD based on wider science team analysis