Integrating Remote Sensing and Biodiversity Observations to Map and Monitor Plant Taxonomic, Phylogenetic, and Functional β-diversity in the Greater Cape Floristic Region

BIOSCAPE
Biodiversity Survey of the Cape

Xin Chen, Andrew Elmore, Daniel Spalink, Daijiang Li, Graham Durrheim, John Measey, Suzaan Kritzinger-Klopper, Nicola van Wilgen, Andrew Turner, Zishan Ebrahim, Matthew Fitzpatrick

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT
forward together
sonke siya phambili
saam vorentoe

TEXAS A&M UNIVERSITY
Ecology & Conservation Biology

THE UNIVERSITY OF ARIZONA

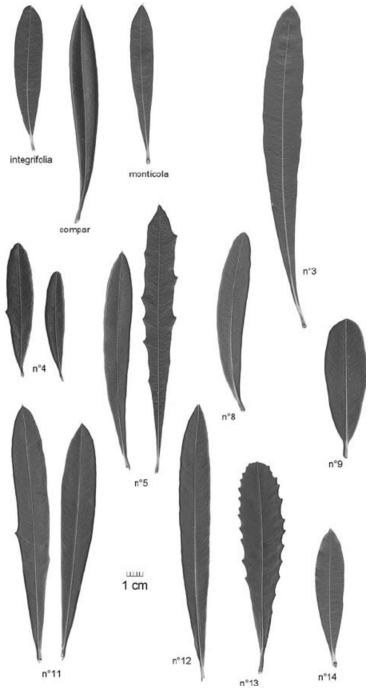
University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
APPALACHIAN LABORATORY

CapeNature

South African NATIONAL PARKS

How does our ability to measure community composition using remote sensing vary across levels of biological organization?

Functional β-diversity



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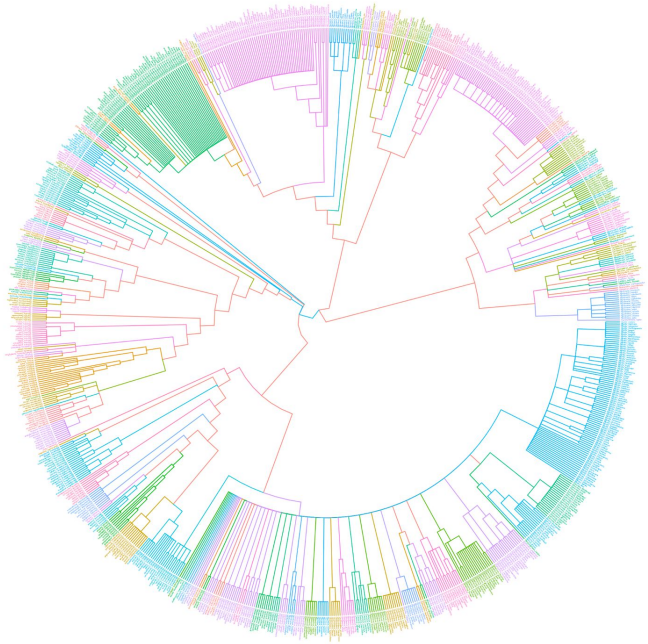
Phylogenetic β-diversity



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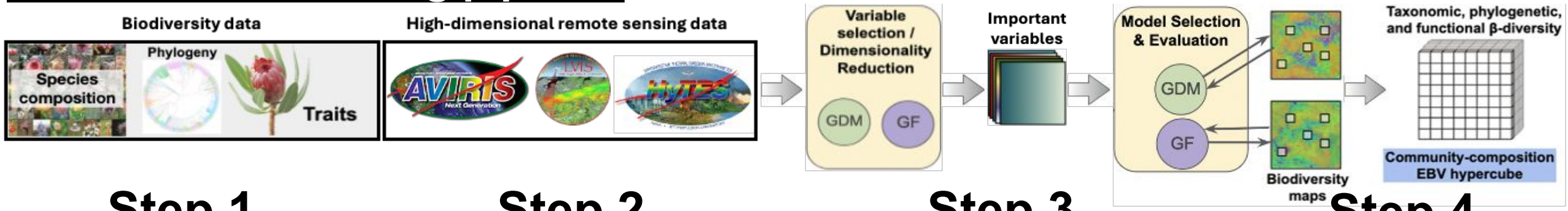
Species β-diversity

Overview of modeling pipeline



Step 1

Taxonomic β-diversity

- Species composition

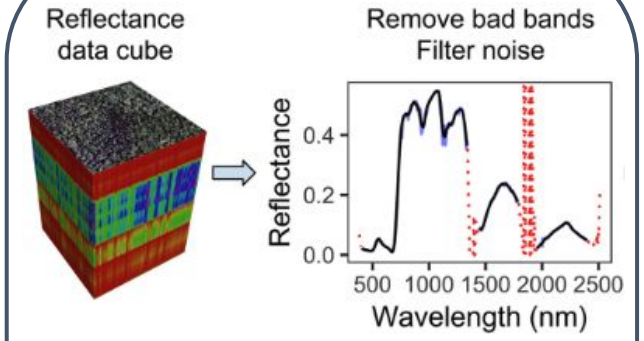
Phylogenetic β-diversity

- Megatree
- Smith & Brown 2018

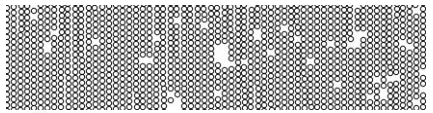
Functional β-diversity

a. Adult plant height (H)
b. Stem specific density (SSD)
c. Leaf area (LA)
d. Leaf mass per area (LMA)
e. Leaf nitrogen (Nmass)
f. Diaspore mass (SM)

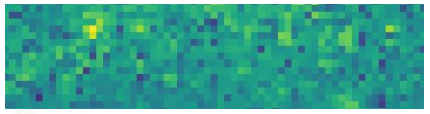
Step 2



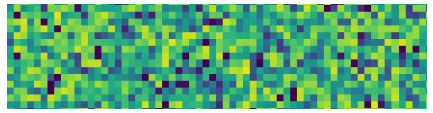
LVIS georeferenced footprints (Level 2)



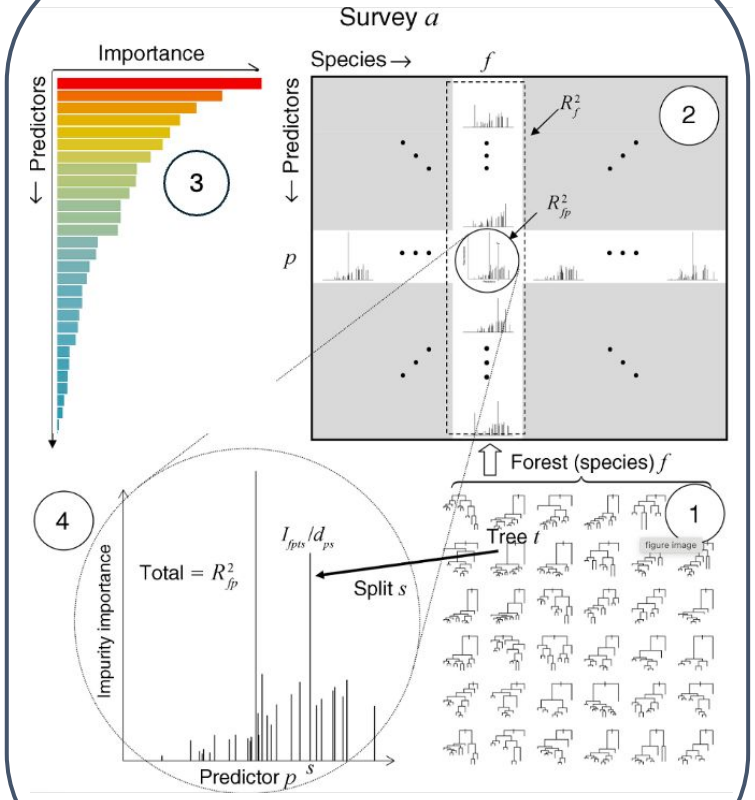
LVIS gridded vegetation structure (Level 3)



LVIS gridded canopy cover (Level 3)

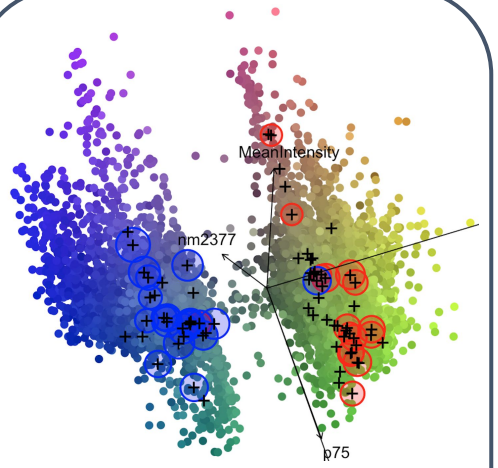


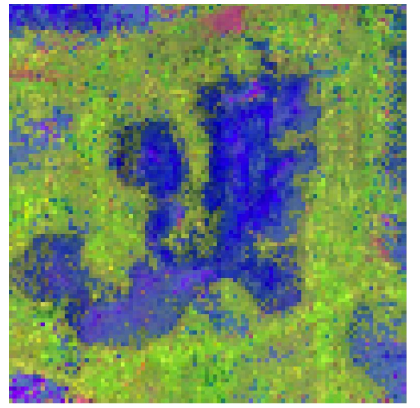
Step 3



Modified from Ellis et al. 2012

Step 4





Step 1: Biodiversity data and calculation of β-diversity

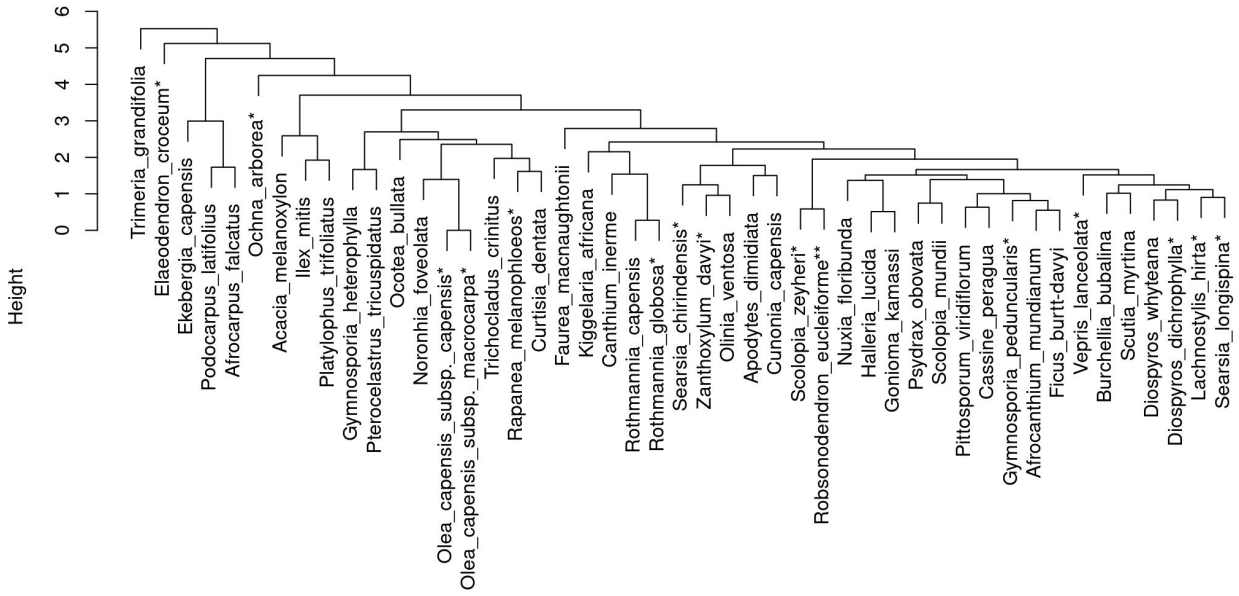


Figure Functional dendrogram

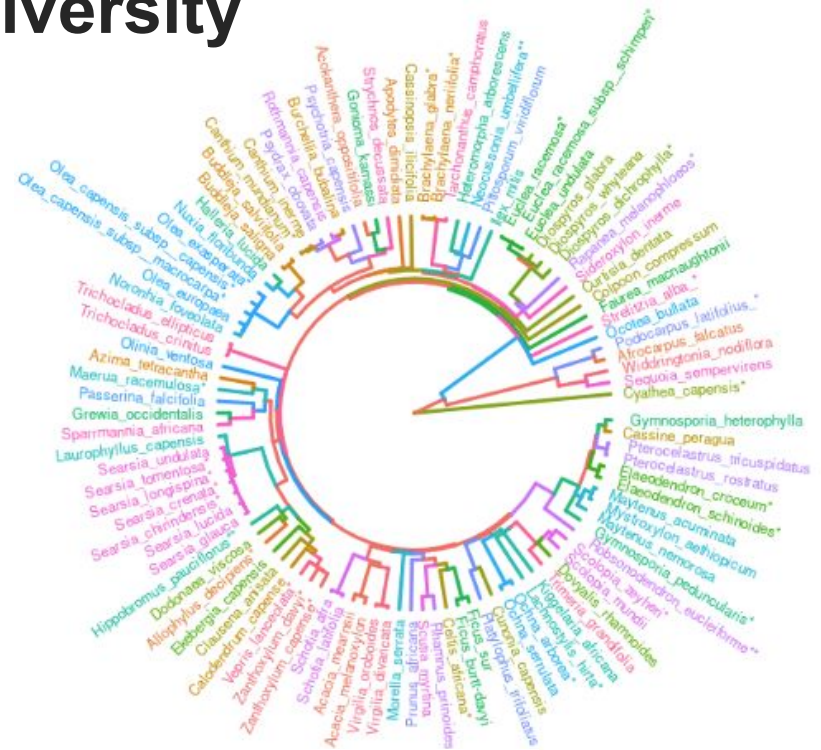
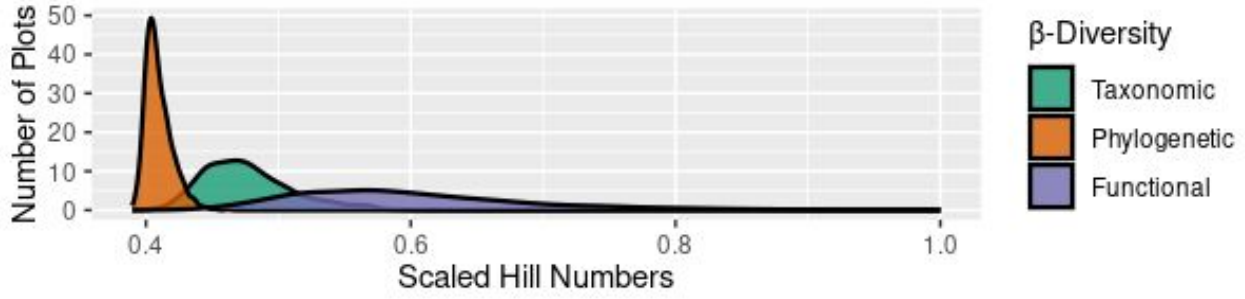
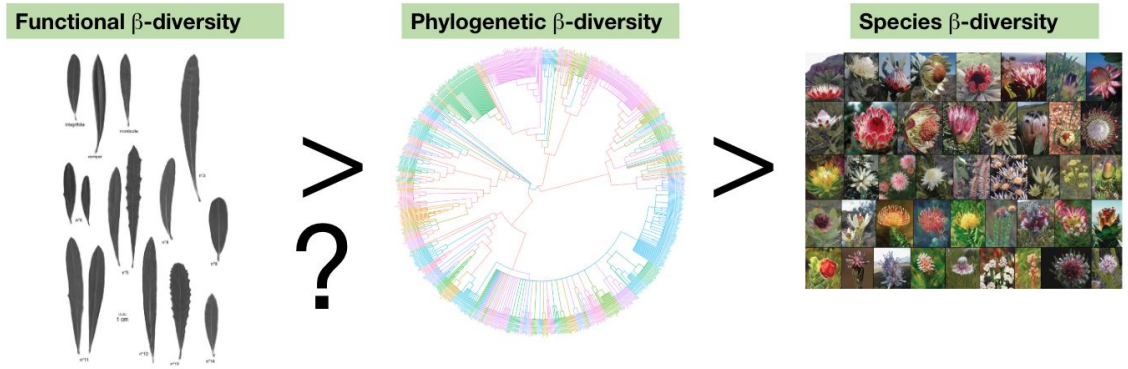
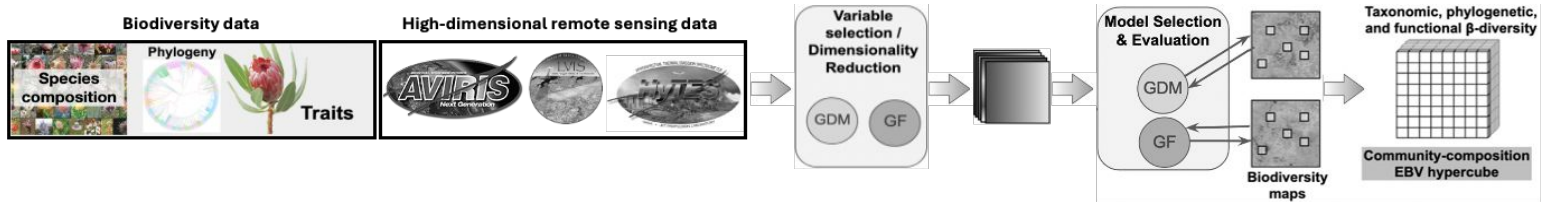


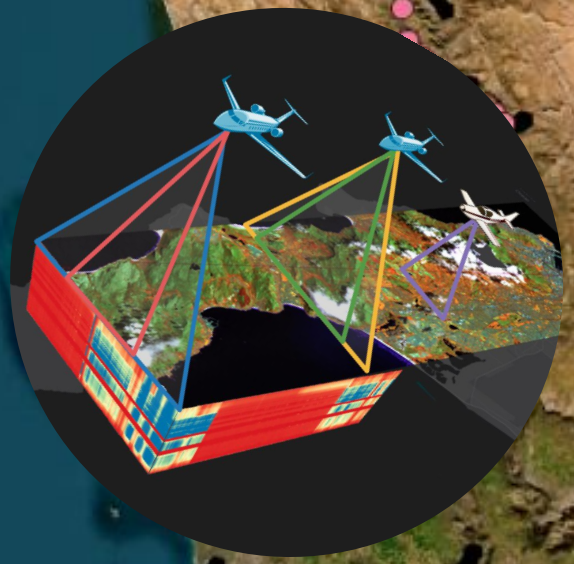
Figure Phylogenetic tree







Step 2: High-dimensional remote sensing data



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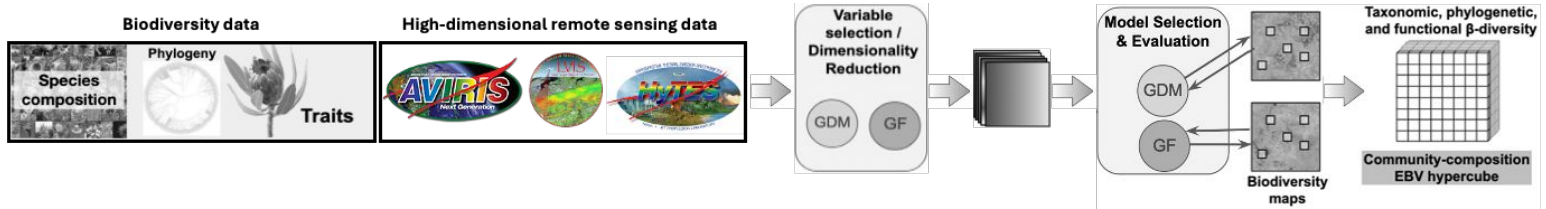
Airborne Visible / Infrared Imaging Spectrometer
AVIRIS
NEXT GENERATION

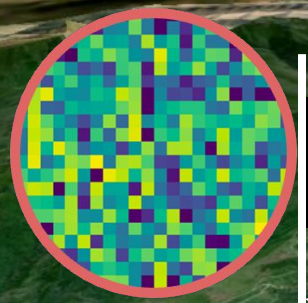
LVIS
Land, Vegetation, & Ice Sensor

- 23.5 million LiDAR footprints
- 120 hyperspectral scenes

BIOSCAPE
Biodiversity Survey of the Cape



Step 2: High-dimensional remote sensing data

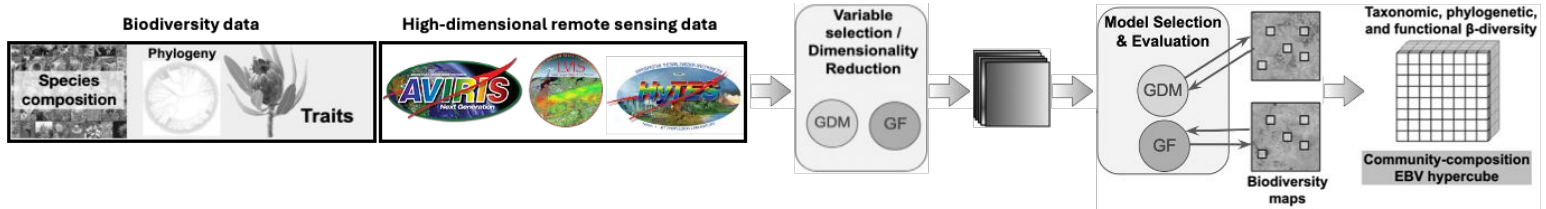


LVIS
10-m pixel

AVIRIS-NG
5-m pixel

LVIS	Land, Vegetation, and Ice Sensor (Light ranging altimeter)
AVIRIS-NG	Airborne Visible-Infrared Imaging Spectrometer (NextGen)

BIOSCAPE
Biodiversity Survey of the Cape



Step 3: Generalized dissimilarity modeling

Nonlinearity

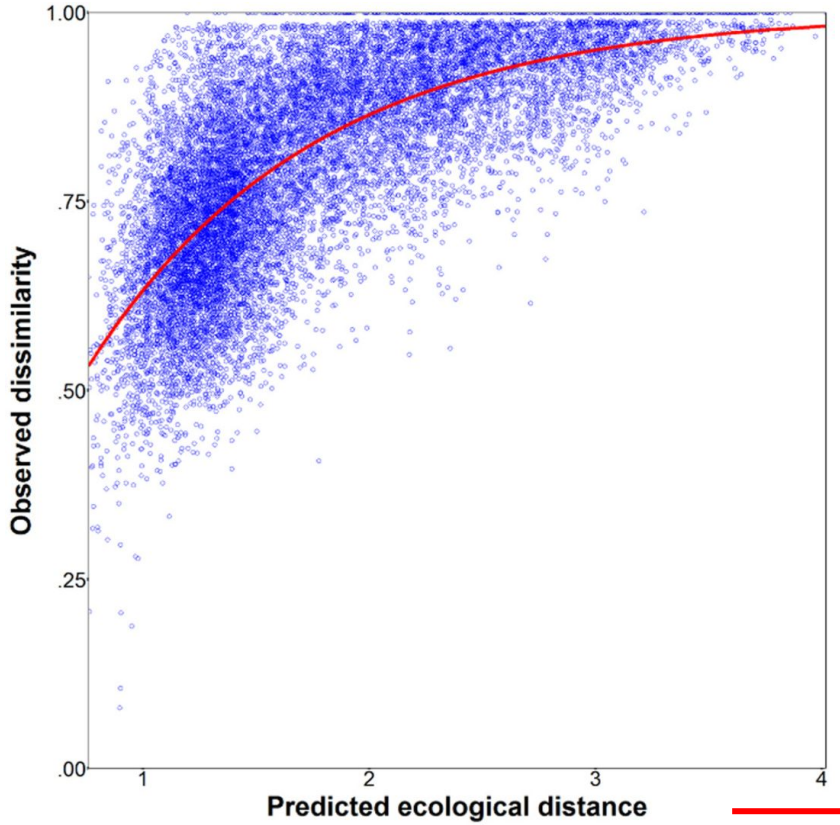


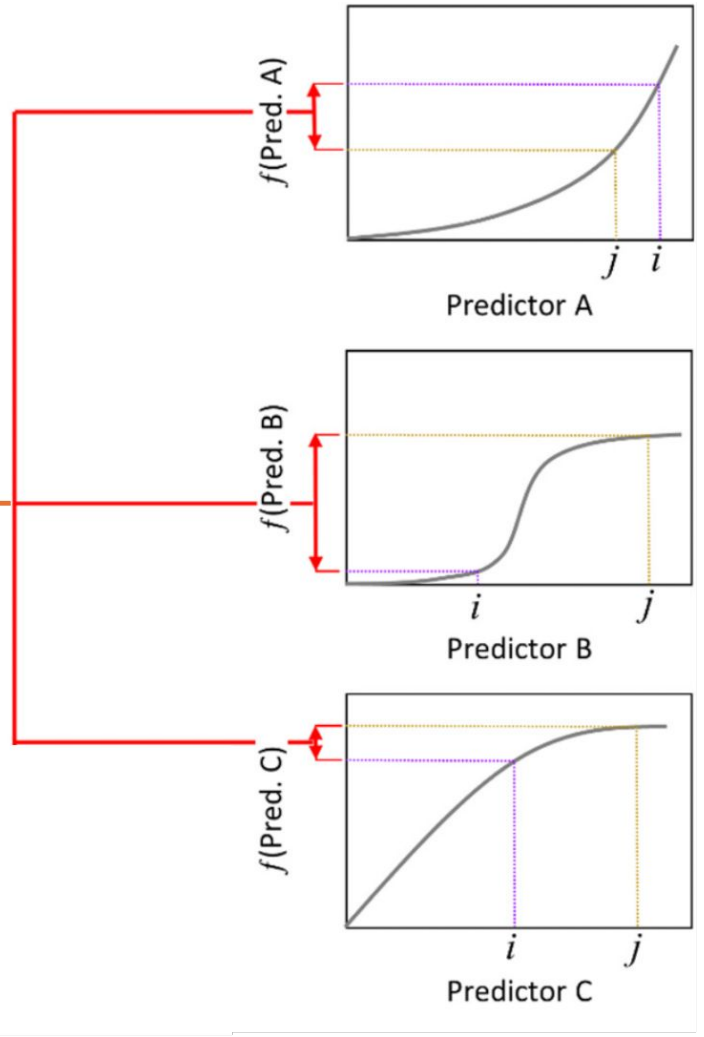
Figure. Observed β-diversity versus predicted ecological distance for functional β-diversity.

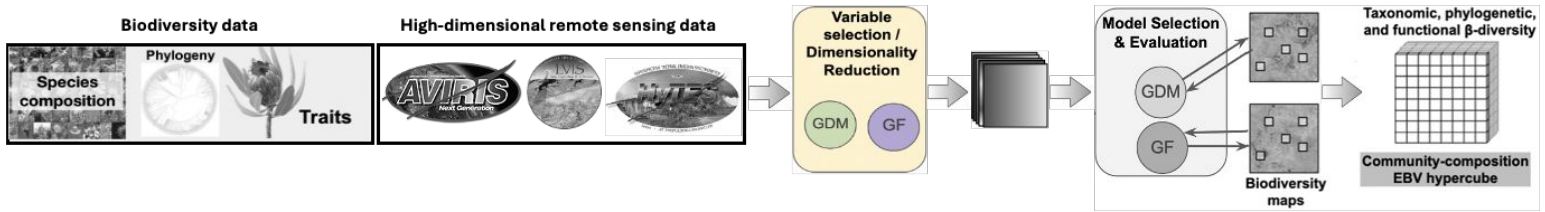
Biological dissimilarity

$$d_{ij} = 1 - e^{-\eta}$$

$$\eta = b + \sum_{p=1}^{n} \left| f_p(x_{pi}) - f_p(x_{pj}) \right|$$

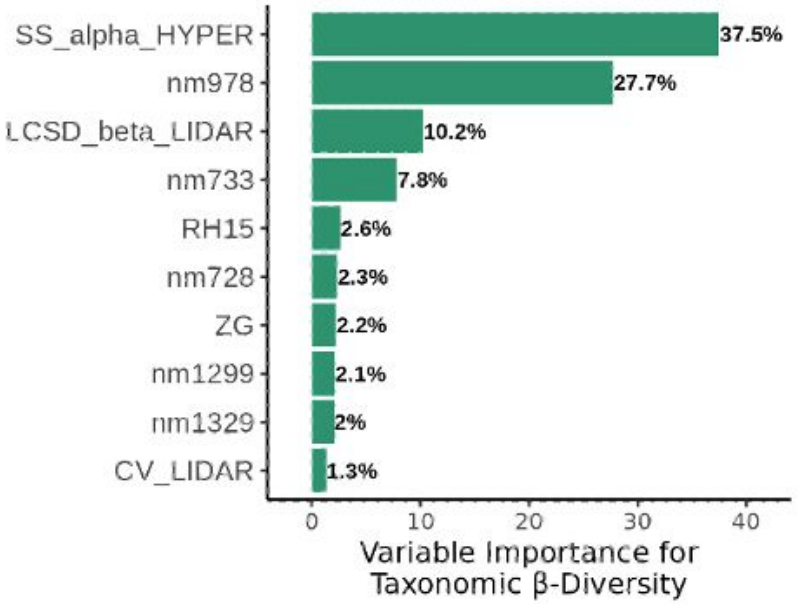
Ecological distance



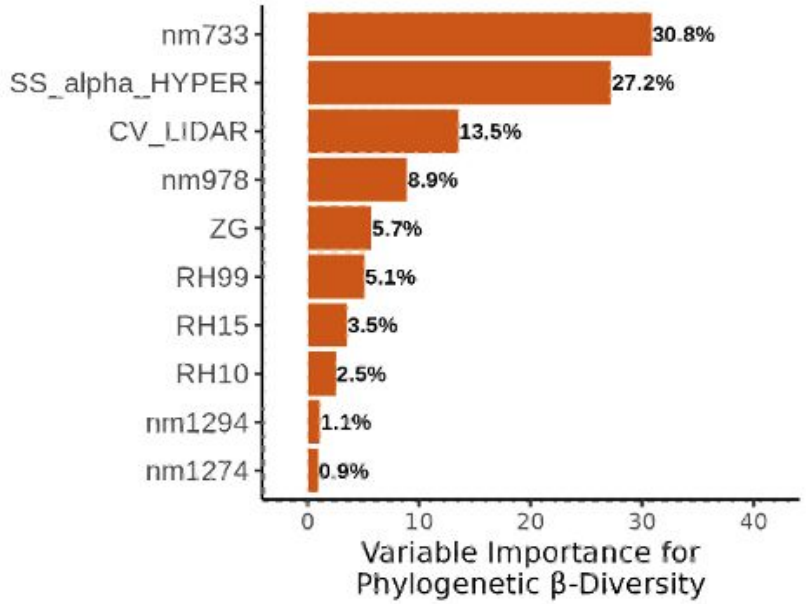


Step 3: Variable importance and variance partitioning

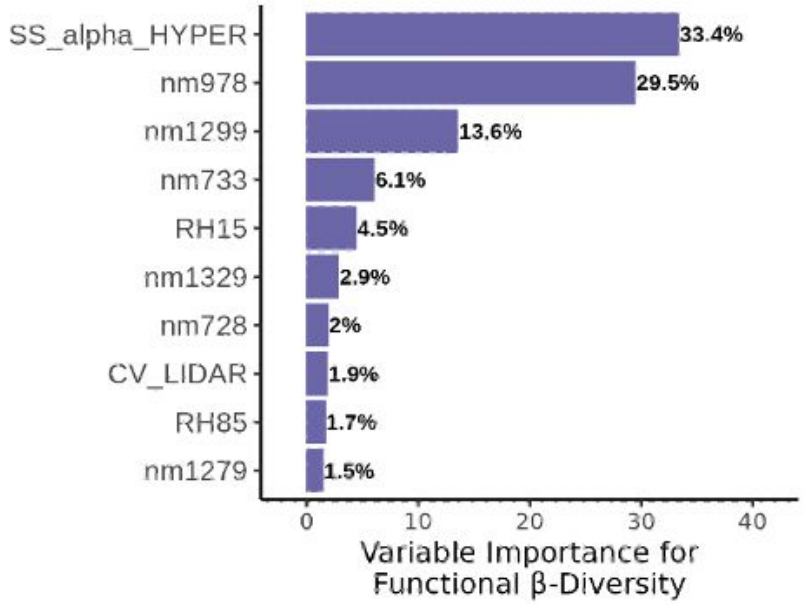
Taxonomic



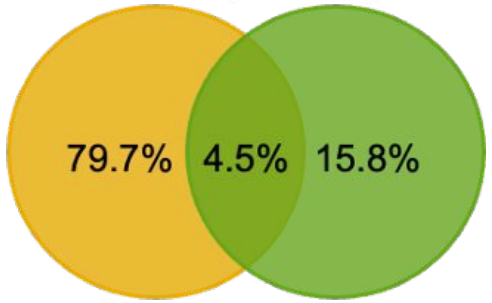
Phylogenetic

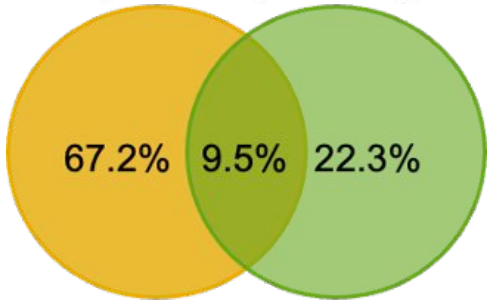


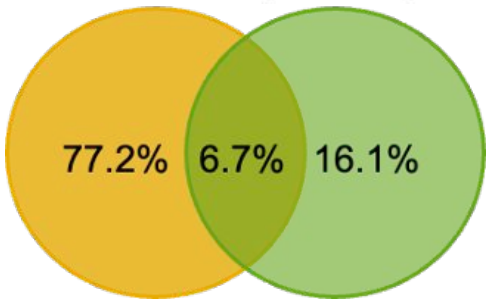
Functional

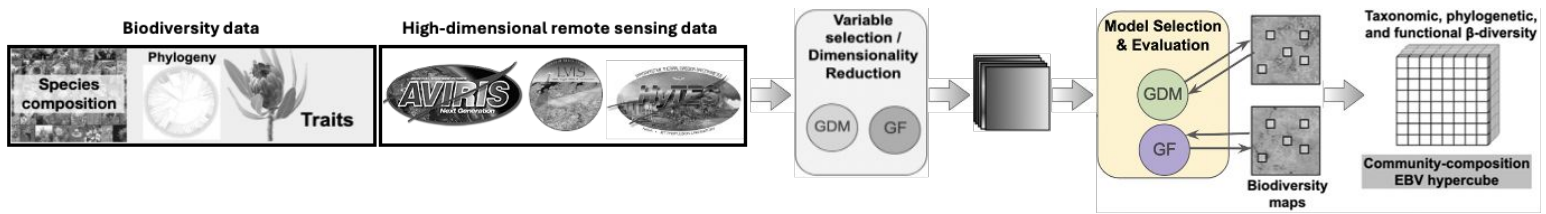


Variance Partitioning

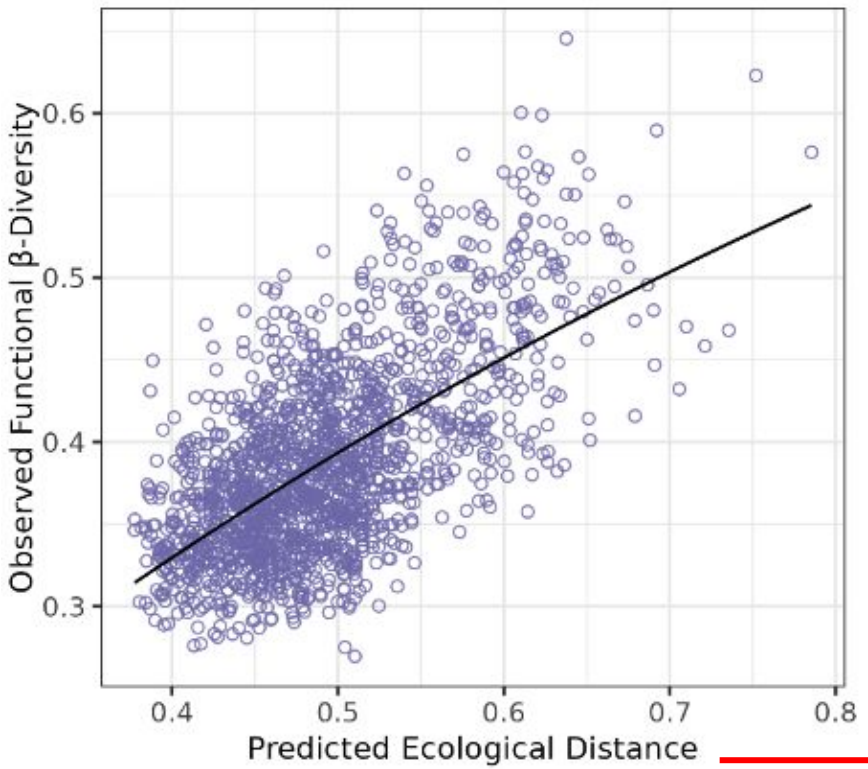








Step 3: Observed β-diversity versus predicted ecological distance



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Ecological distance

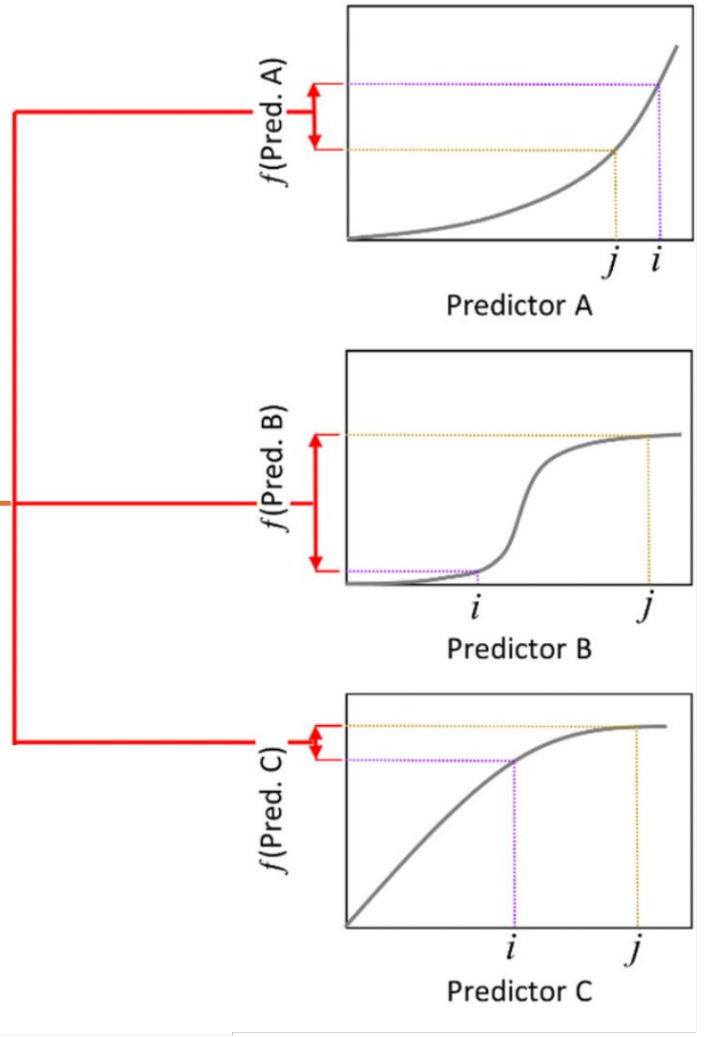
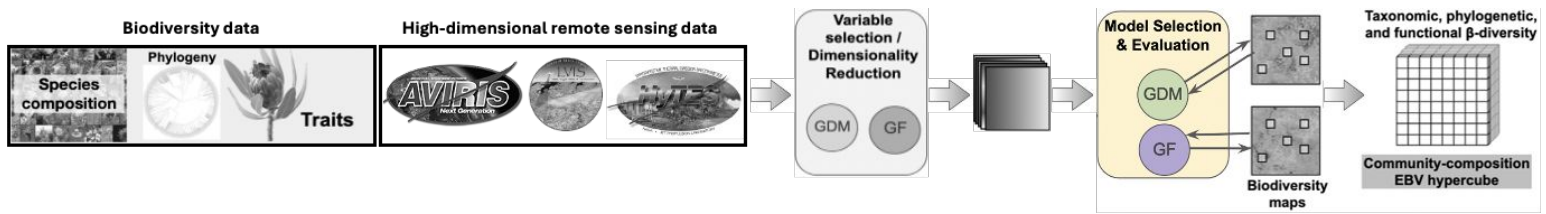


Figure. Observed β-diversity versus predicted ecological distance for functional β-diversity.



Step 3: Observed β-diversity versus predicted ecological distance

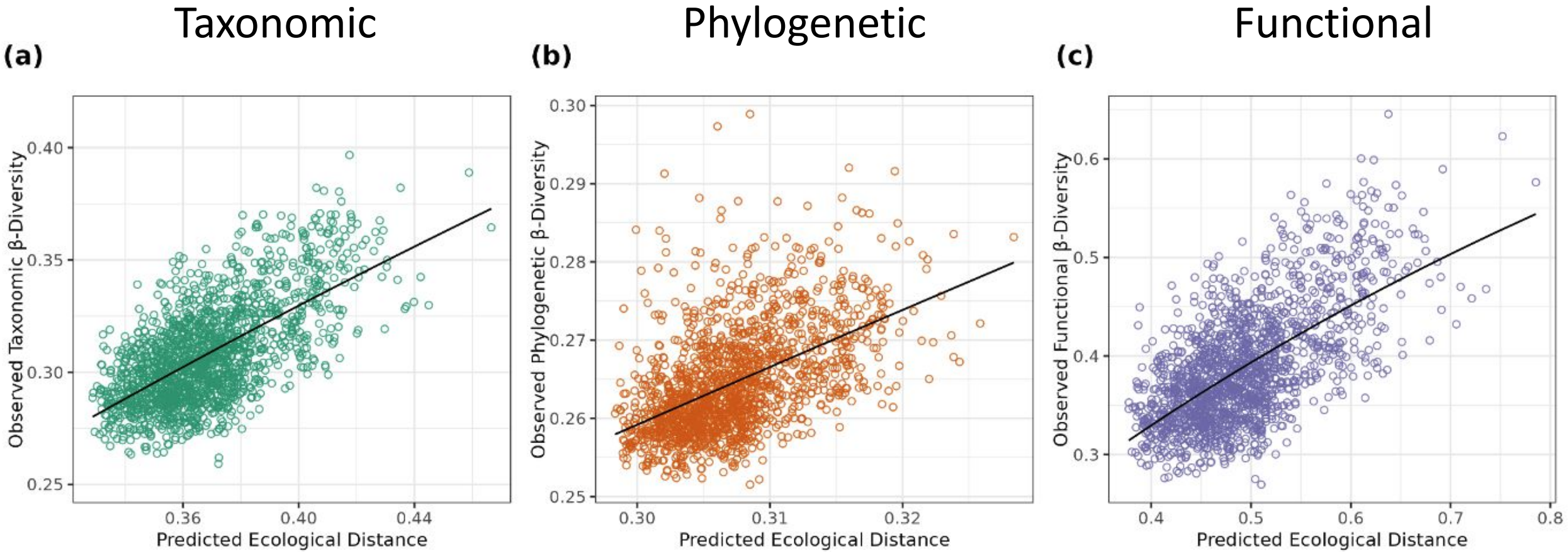
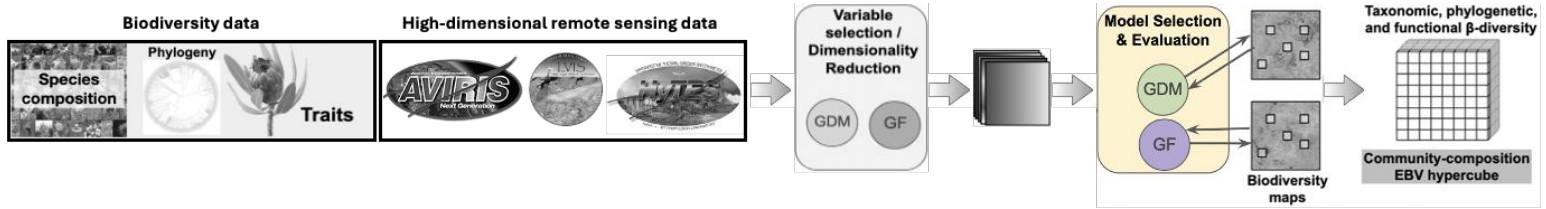


Figure. Observed β-diversity versus predicted ecological distance for (a) taxonomic, (b) phylogenetic, and (c) functional β-diversity.



Step 3: Observed β-diversity versus predicted β-diversity

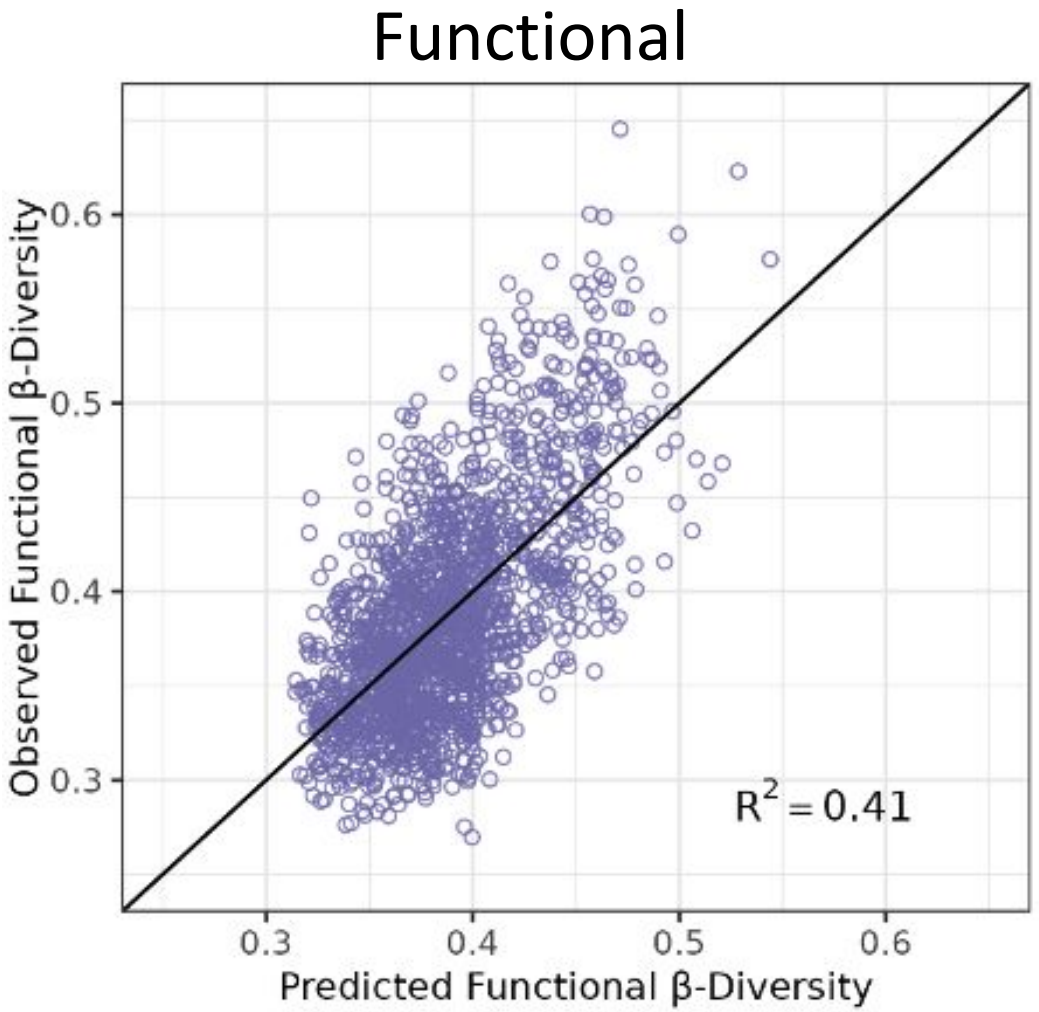
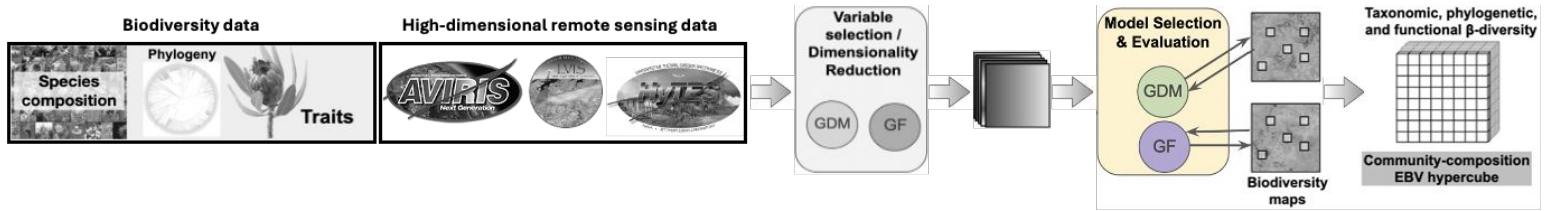
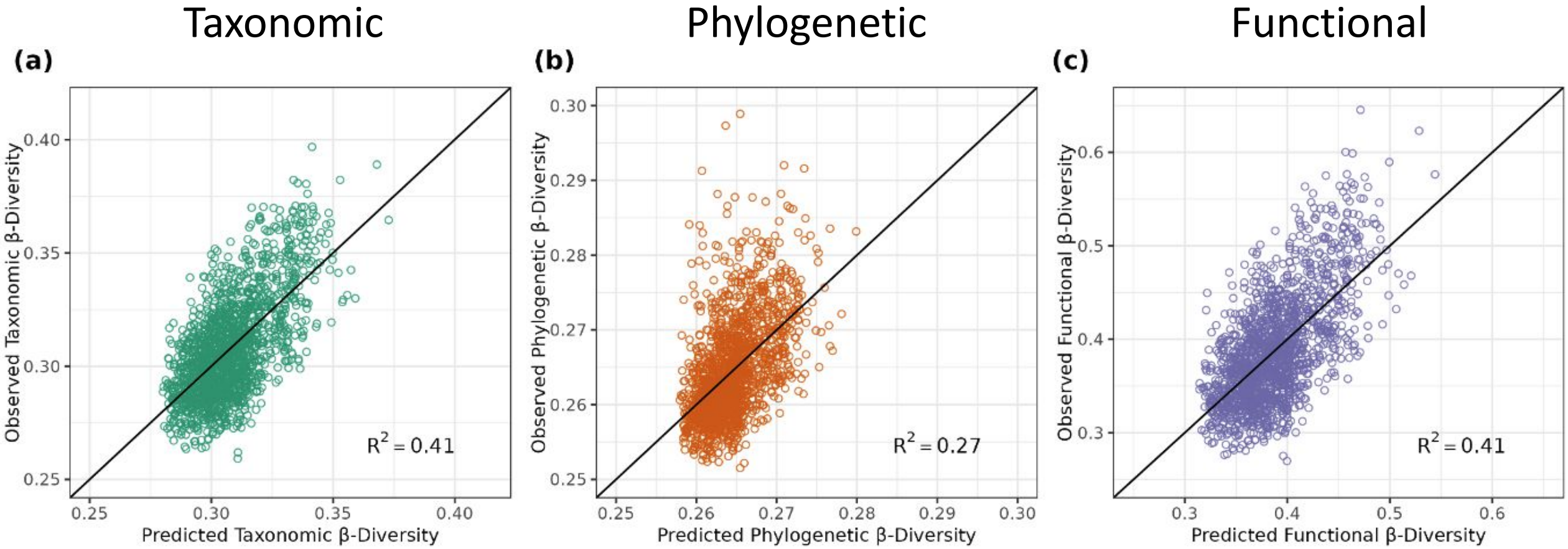


Figure. Observed β-diversity versus predicted functional β-diversity.



Step 3: Observed β-diversity versus predicted β-diversity



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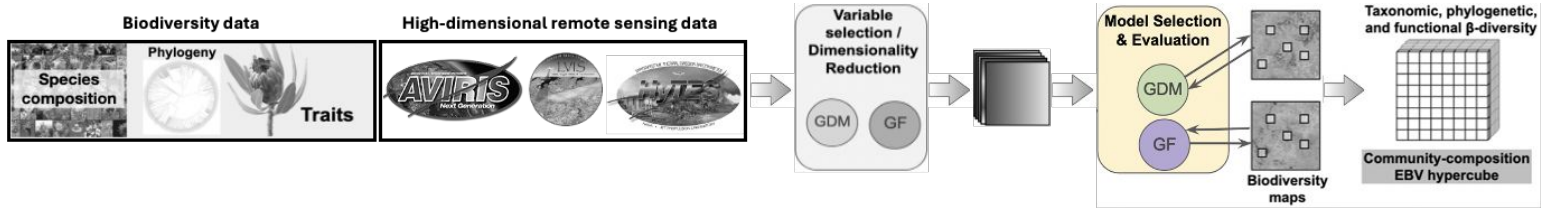
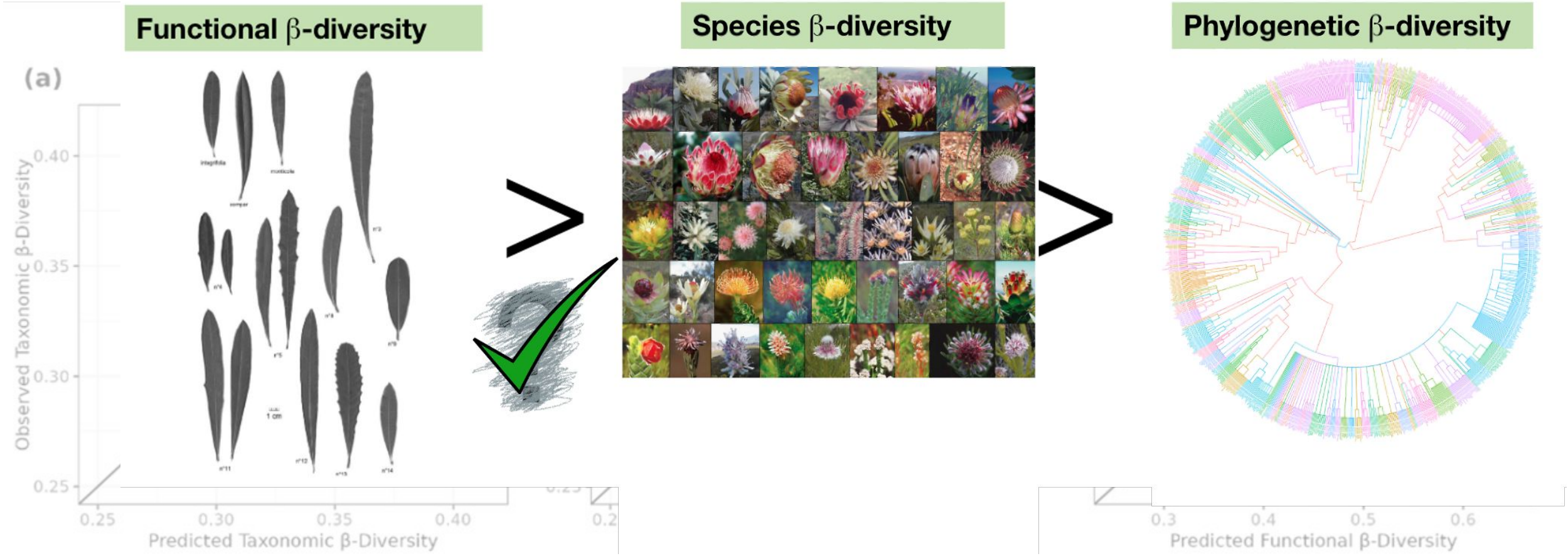


Step 3: Model evaluation



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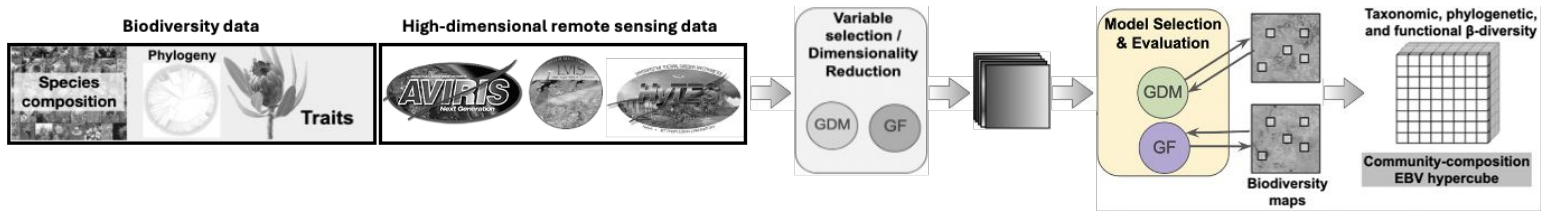


Step 4: Mapping β-diversity in environmental space

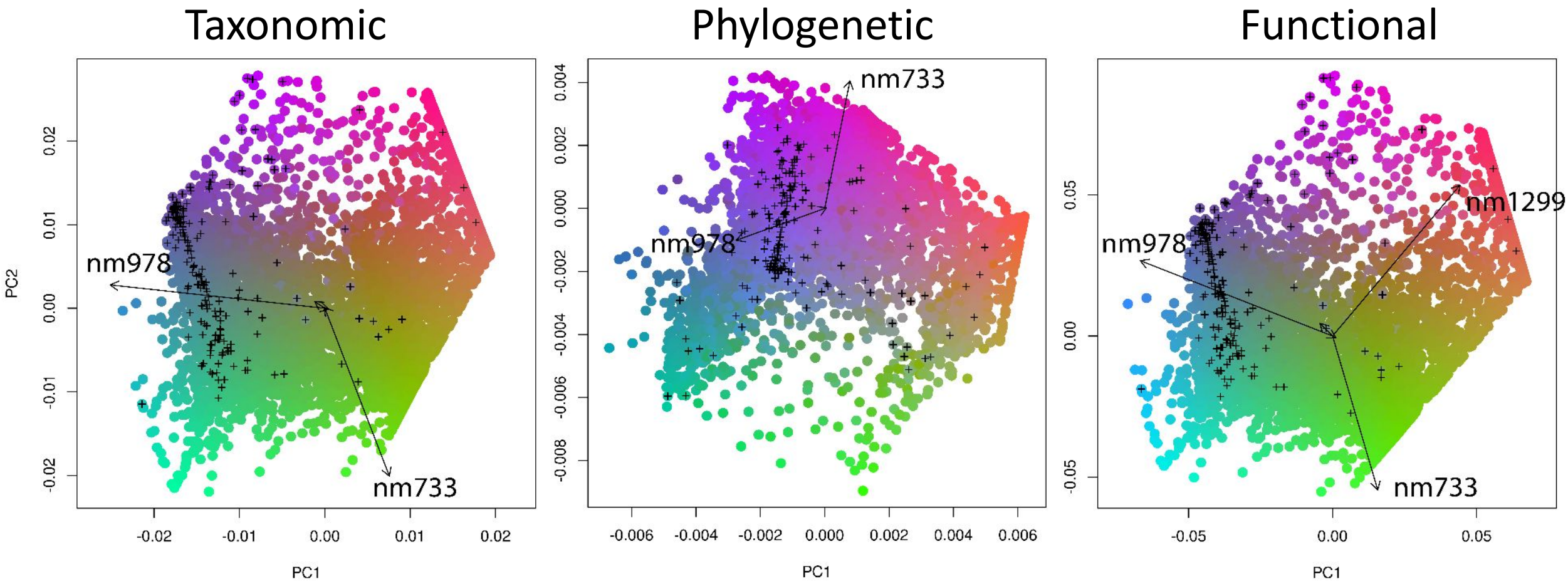
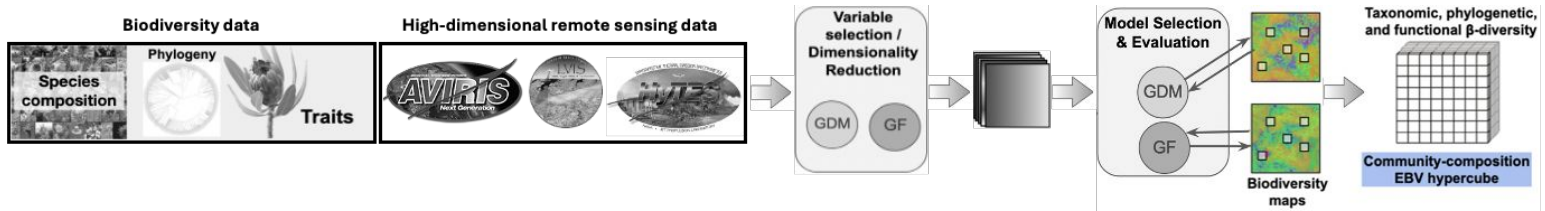


Figure. Biplots of predicted vegetation composition in rescaled biological space for each dimension of β-diversity. Plus symbols indicate forest plots used in model fitting. Color similarity indicates the expected compositional similarity of each pixel's plant community.



Step 4: Mapping β-diversity across geographic space

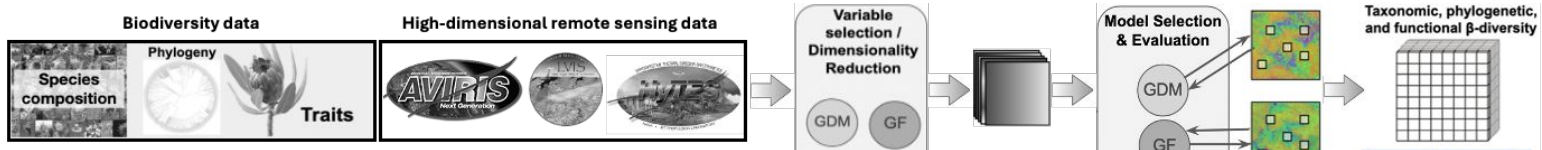
True RGB composite

False color composite

Taxonomic

Phylogenetic

Functional



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Thank you
2 min Q&A