



UNIVERSITY
OF ICELAND

Ph.D. Retreat — October 2026

Assessing the Influence of Spatial and Thematic Resolution of Satellite-derived Images on Landscape Metrics

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L. Tian, R. Sedona, M. Riedel, G. Cavallaro and C. Paris, "Assessing the Influence of Spatial and Thematic Resolution of Satellite-derived Images on Landscape Metrics," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (accepted)

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- Landscape complexity is characterized by the number, arrangement, and scaling relationships of ecosystem elements.
- Two pathways: structural complexity, and categorical complexity

CONTINUOUS PHYSICAL STRUCTURE

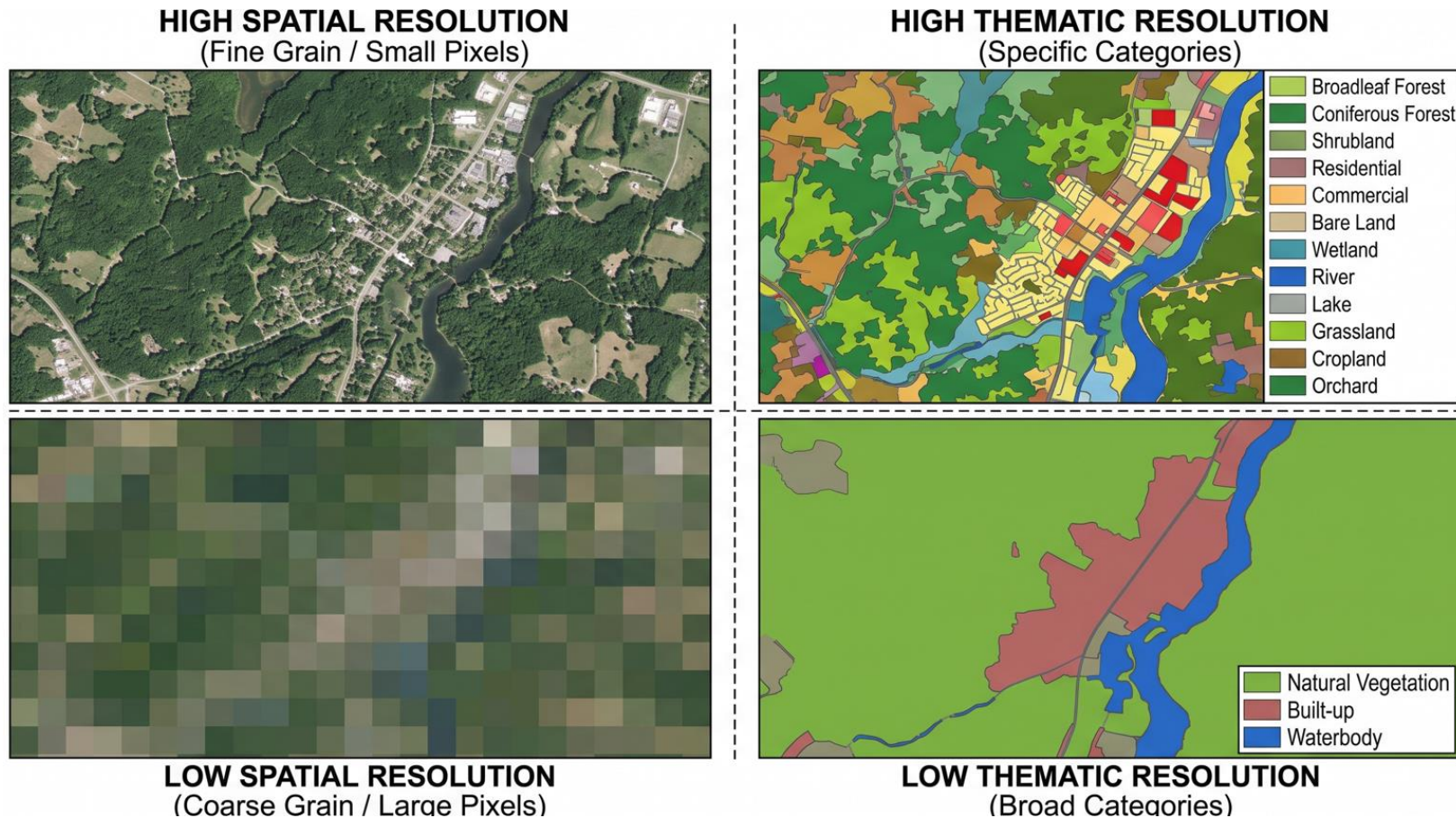


CATEGORICAL PATCHES



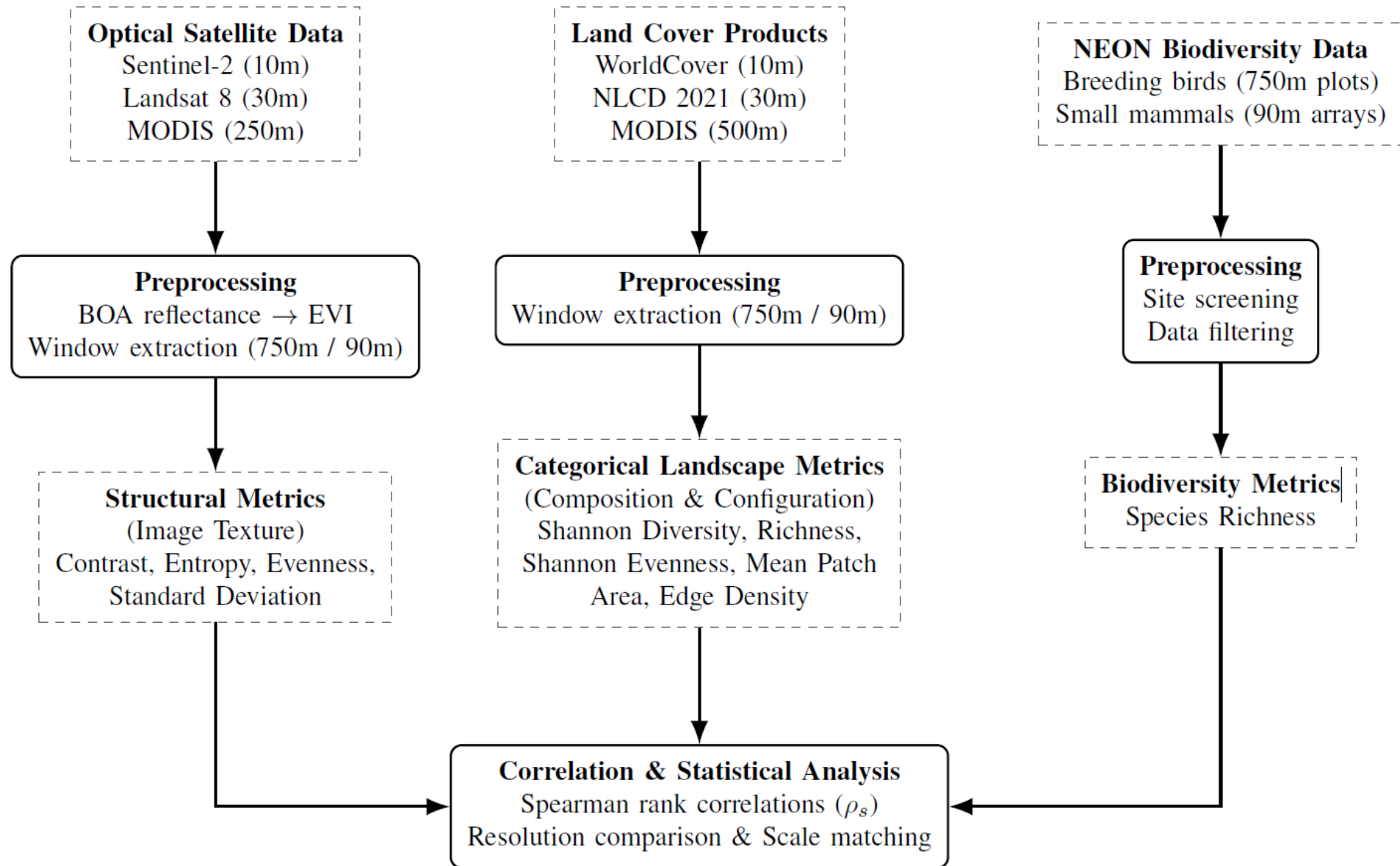
Key Question

- How do spatial resolution (pixel size) and thematic resolution (categorical legend granularity) influence landscape complexity assessments.



- Evaluate how spatial resolution influences structural metrics versus how thematic resolution influences categorical metrics.
- Compare whether high spatial resolution is equally critical for both structural and categorical assessments, or if thematic detail outweighs spatial detail for specific metrics.
- Assess the relationships between landscape complexity and species richness of breeding birds and small mammals as validation.

The Landscape Complexity Workflow



Two pathways to Characterize Complexity

Metric	Description	Equation
First-order texture		
Standard deviation	Dispersion of index	$\frac{SD_{EVI}}{\mu_{EVI}}$
Evenness	Evenness of index	$-\sum_{i=1}^n p_i \ln p_i / \ln V$
Second-order texture (Gray-Level Co-Occurrence Matrix (GLCM))		
Contrast	Exponentially weighted difference in index between adjacent pixels	$\sum_{i,j=1}^N P_{i,j} (i-j)^2$
Dissimilarity	Difference in index between adjacent pixels	$\sum_{i,j=1}^N P_{i,j} i-j $
Entropy	Disorderliness of index	$-\sum_{i,j=1}^N P_{i,j} \ln P_{i,j}$
Homogeneity	Similarity of index between adjacent pixels	$\sum_{i,j=1}^N \frac{P_{i,j}}{1+(i-j)^2}$

Metrics of structure complexity.

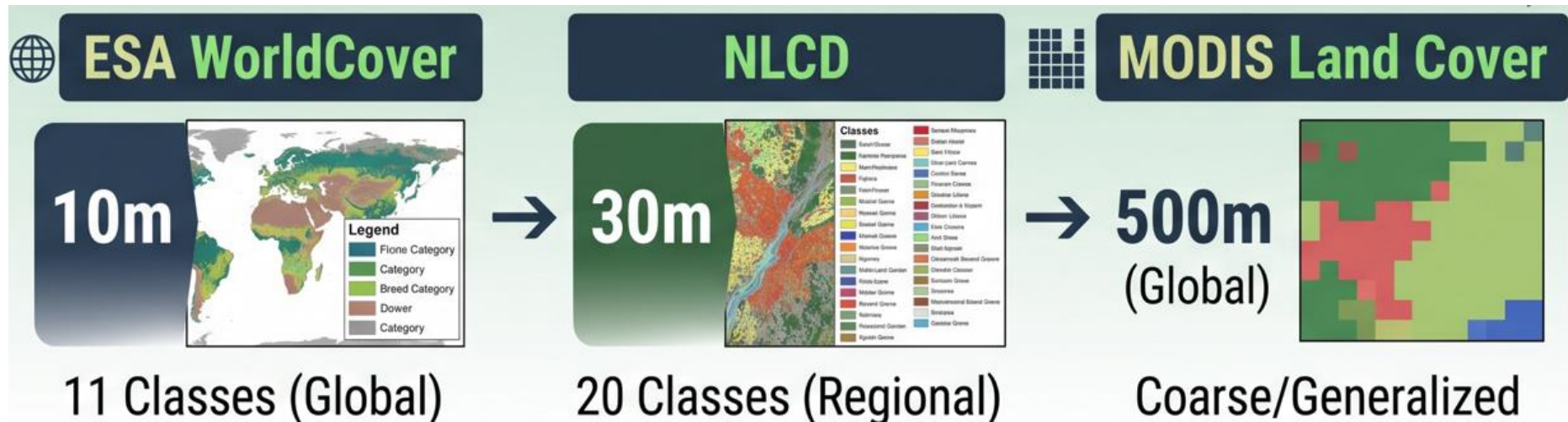
Index	Description	Equation
Compositional complexity		
Shannon diversity index (H')	A measure of the abundance and evenness of land cover categories.	$H' = -\sum_{i=1}^S p_i \ln p_i$
Simpson diversity index (D)	A diversity measure that considers the abundance and evenness of land cover categories.	$D = 1 - \sum_{i=1}^S p_i^2$
Richness (S)	A measure of the abundance of categories.	S
Shannon evenness index (J')	The ratio between the Shannon diversity index and its theoretical maximum.	$J' = \frac{H'}{\ln S}$
Simpson evenness index (E)	The ratio between the Simpson diversity index and its theoretical maximum.	$E = \frac{D}{1-\frac{1}{S}}$
Percentage natural cover (PNC)	The predominance of undeveloped land covers on a landscape.	$PNC = \frac{\sum A_{\text{natural}}}{A_{\text{total}}} \times 100\%$
Configurational complexity		
Mean patch area ($\bar{A}$)	A measure of patch structure; approaches 0 if all patches are small.	$\bar{A} = \frac{1}{n} \sum_{i=1}^n A_i$
Largest patch index (LPI)	The percentage of the landscape covered by the single largest patch.	$LPI = \frac{\max A_i}{A_{\text{total}}} \times 100\%$
Contagion ($CONTAG$)	Dispersion and interspersions of land cover classes.	$CONTAG = \left[1 + \sum_{i,j} \frac{P_{ij} \ln P_{ij}}{2 \ln m} \right] \times 100$
Edge density (ED)	The patchiness of the landscape (total edge length per area).	$ED = \frac{\sum e_i}{A_{\text{total}}}$

Metrics of categorical complexity.

Spatial Gradient

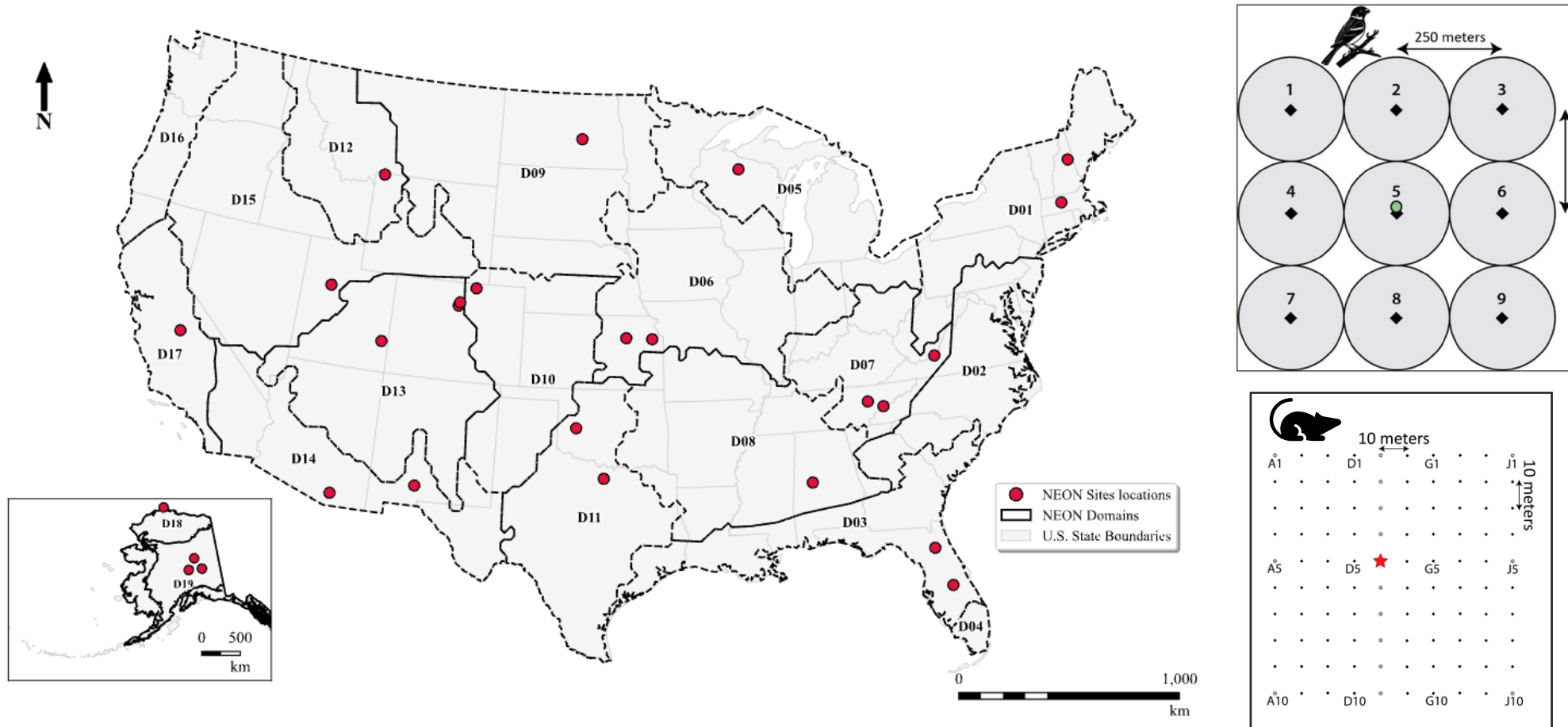


Thematic Gradient



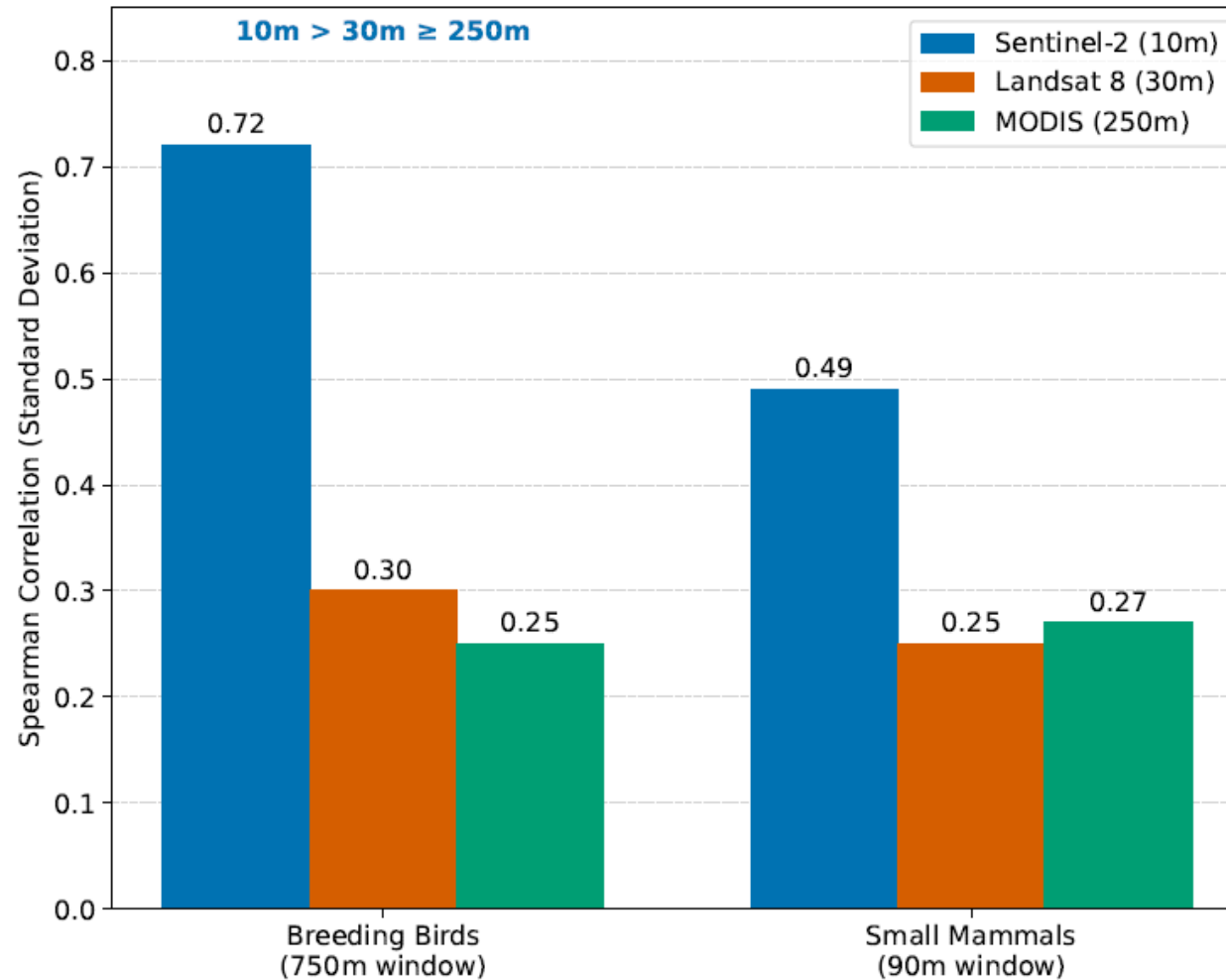
National Ecological Observatory Network (NEON)

SS



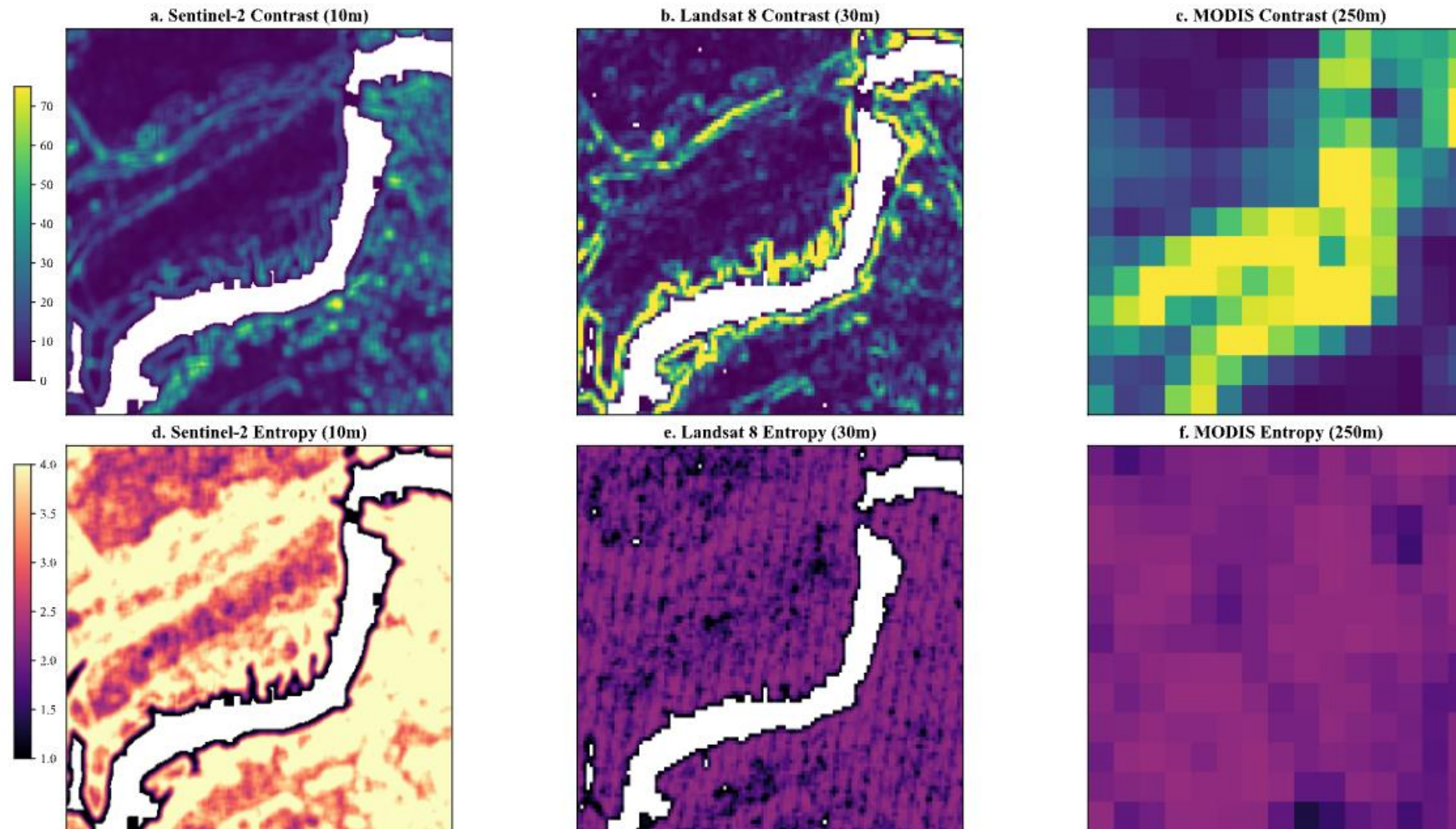
NEON site locations with insets showing sampling schematics for breeding bird survey and small mammals

■ Results in Spatial Resolution: Pixel matters!



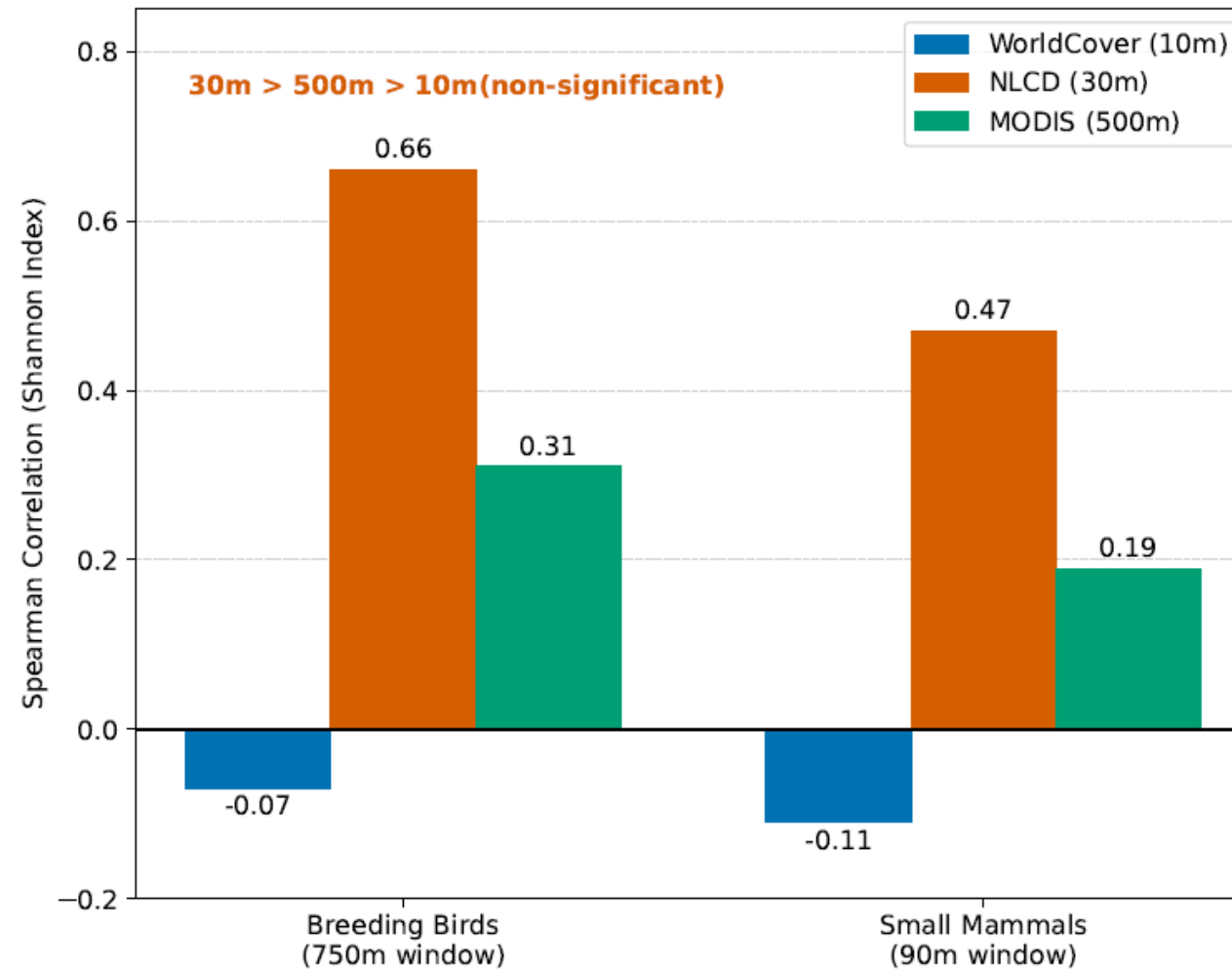
Structural complexity metrics correlate strongly with Sentinel-2 spatial resolution.

Spatial Homogenization



Visual comparison of spatial homogenization in structural texture metrics across different sensor resolutions

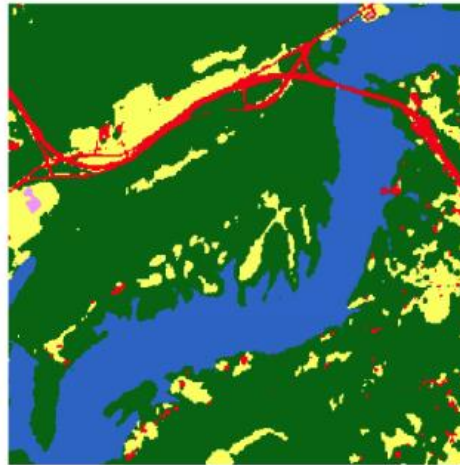
Results in Thematic Resolution: Legend matters!



Compositional complexity metrics correlate strongly with NLCD thematic resolution.

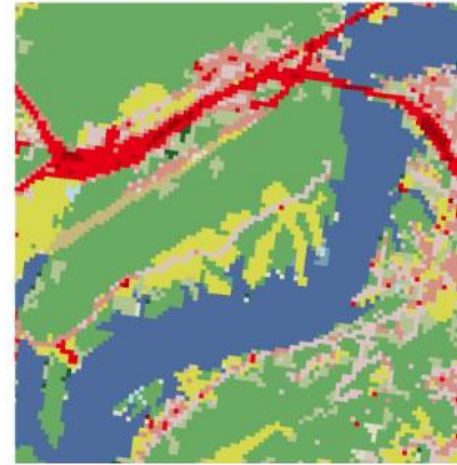
Thematic Homogenization

(a) WorldCover (10m)



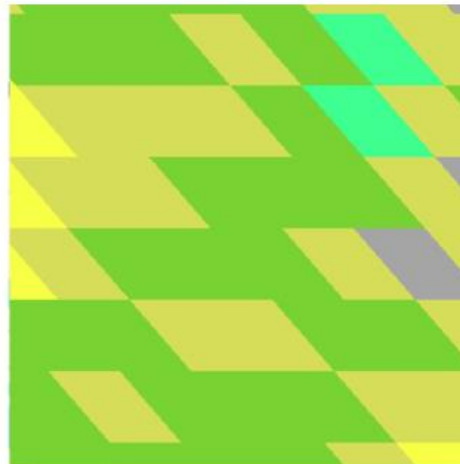
- Tree cover
- Shrubland
- Grassland
- Cropland
- Built-up
- Bare / sparse vegetation
- Snow and ice
- Permanent water bodies
- Herbaceous wetland
- Mangroves
- Moss and lichen

(b) NLCD (30m)



- Open Water
- Perennial Ice/Snow
- Developed, Open Space
- Developed, Low Intensity
- Developed, Med Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

(c) MODIS (500m)



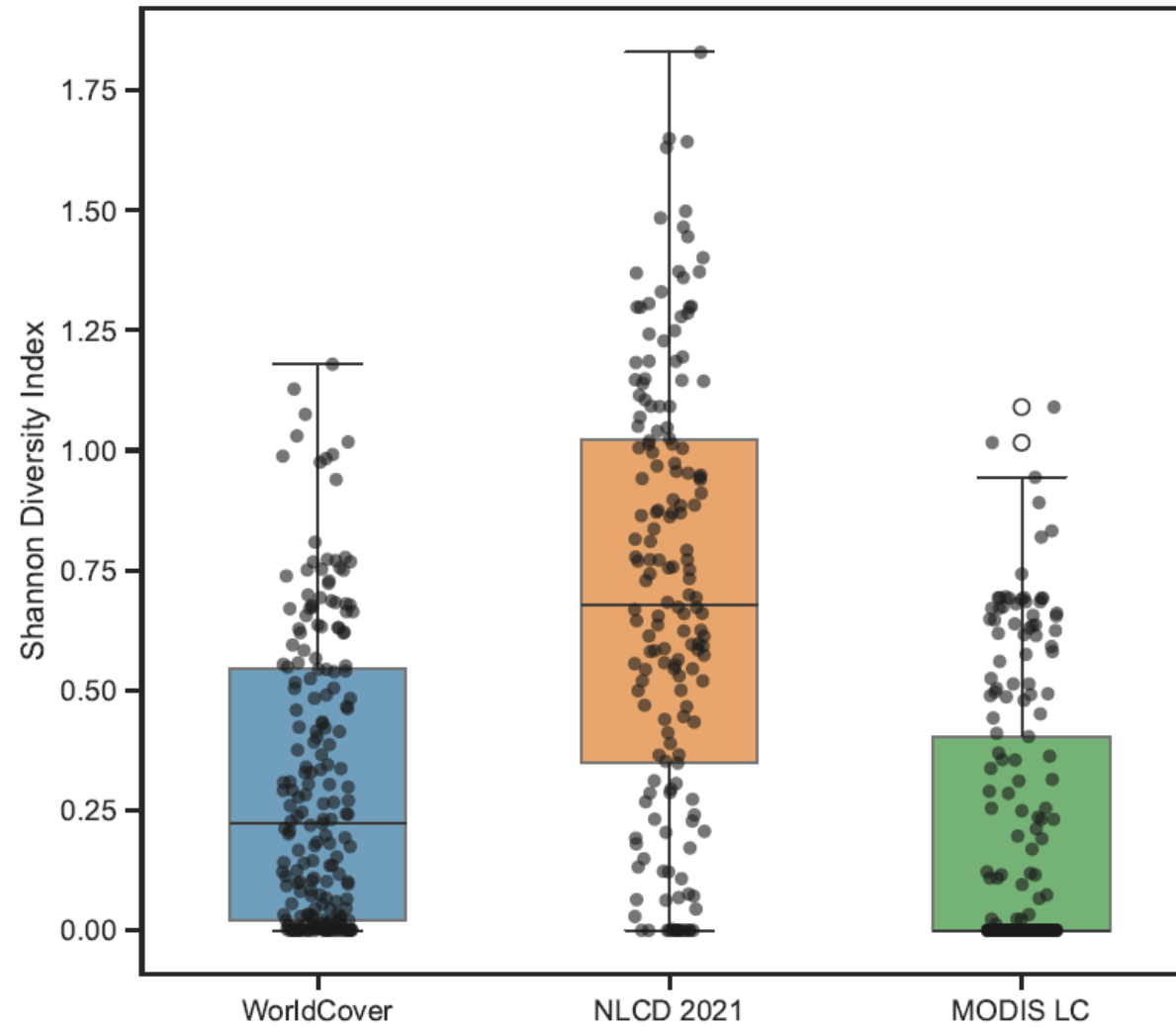
- Evergreen Needleleaf
- Evergreen Broadleaf
- Deciduous Needleleaf
- Deciduous Broadleaf
- Mixed Forests
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-up
- Cropland/Natural Veg
- Snow and Ice
- Barren
- Water Bodies

(d) Sentinel 2 true color (10m)



Visual comparison of land cover classifications and optical baseline imagery for a selected NEON site

Thematic Homogenization



Box plots of Shannon Diversity at the macro-scale (750m).

- Data selection must align directly with the specific remote sensing and Earth observation task.
- If the task requires assessing physical vegetation structure, prioritize high spatial resolution.
- If the task requires assessing landscape composition or categorical habitats, high thematic resolution and semantic detail needs to be considered.



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Thank you!

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