Detection of Habitat Heterogeneity Changes Using Laser Scanning Data Targeting Birds

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ITS4.2/ERE1.11 Solutions for a resilient natural environment: opportunities and challenges of ecosystem services assessment

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Movement of species (especially for birds)

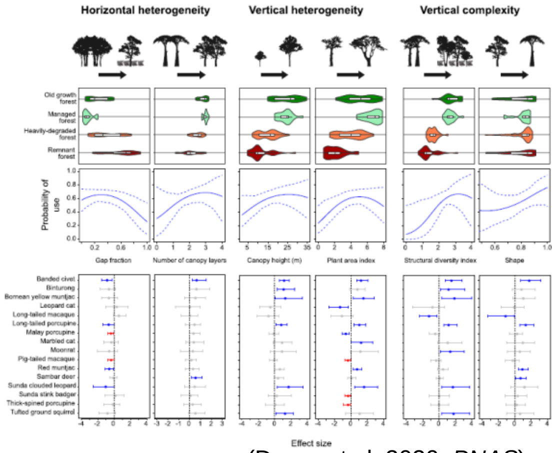
- Distinguish between upper and lower layers, how the movement of birds vary
  - Functional diversity will be different depending on canopy structure and edge effect (of patch)

- How to connect to maintain functional diversity
  - Securing connectivity and suggesting conservation measures to maintain stable functional diversity

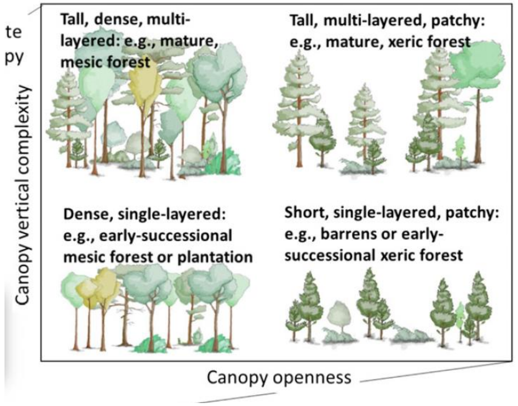
2D movement (presence / absence) vs. 3D movement (dynamic response)

Research dealing with three-dimensional structural data

- LiDAR-based research to detect biodiversity (LaRue et al. 2019) is growing, through using structural data such as analyzing heterogeneity, distribution, and height in forest structures (Matsuo et al. 2021) or identifying rugosity (Gough et al. 2020).
- For example, the technology to detect canopy structures is linked with the GEDI technology, leading to structural diversity mapping on a wide scale and further to β-diversity. (Schneider et al. 2020)



(Deere et al. 2020. *PNAS*)



(Fahey et al. 2019. *Ecology Letters*)

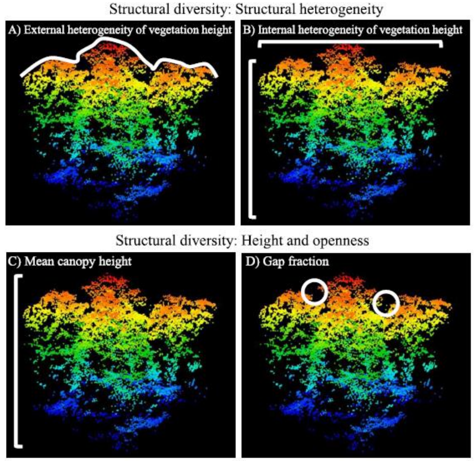
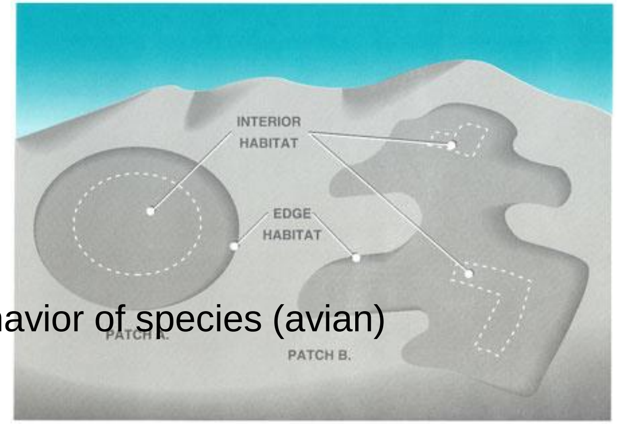


Figure 1. Structural diversity (structural heterogeneity and height and openness) within an ecosystem, which can be measured with LiDAR metrics. Structural diversity metrics describe different aspects of the type and abundance of realized vegetative niche space within an ecosystem canopy. Metrics include structural heterogeneity–external heterogeneity of vegetation height (A) and internal heterogeneity of vegetation height within the canopy (B), and height and openness—mean height of outer canopy height (C) and fraction of gaps in the canopy (D). Color scale of points represents shortest (blue) to tallest vegetation height (red) in a vertical cross-section (side view of canopy) of the vegetation in a LiDAR point cloud of a horizontal spatial area of 40 × 40 m.

(Larue et al. 2019. *Environ. Res. Lett.*)

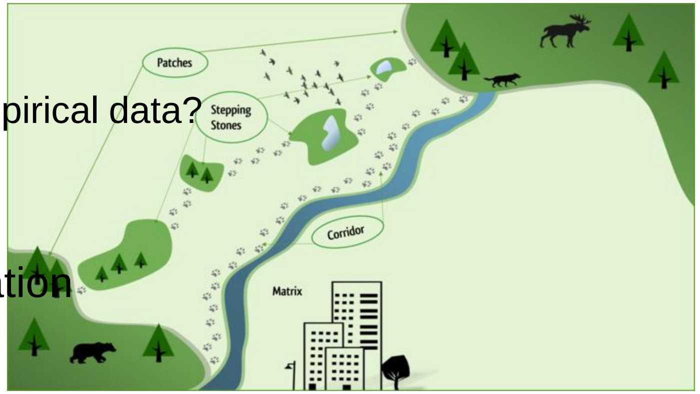
Hypothesis: 3D Structure Influences Species Habitat

- Resistance value may change when 3D structure is reflected
  - Resistance value reflecting canopy: Can target birds, insects, etc.
  - If the shape of a building or city is included as a variable, it is necessary to understand the behavior of species (avian)
- Attributes may vary depending on where individual species are in interior or edge.



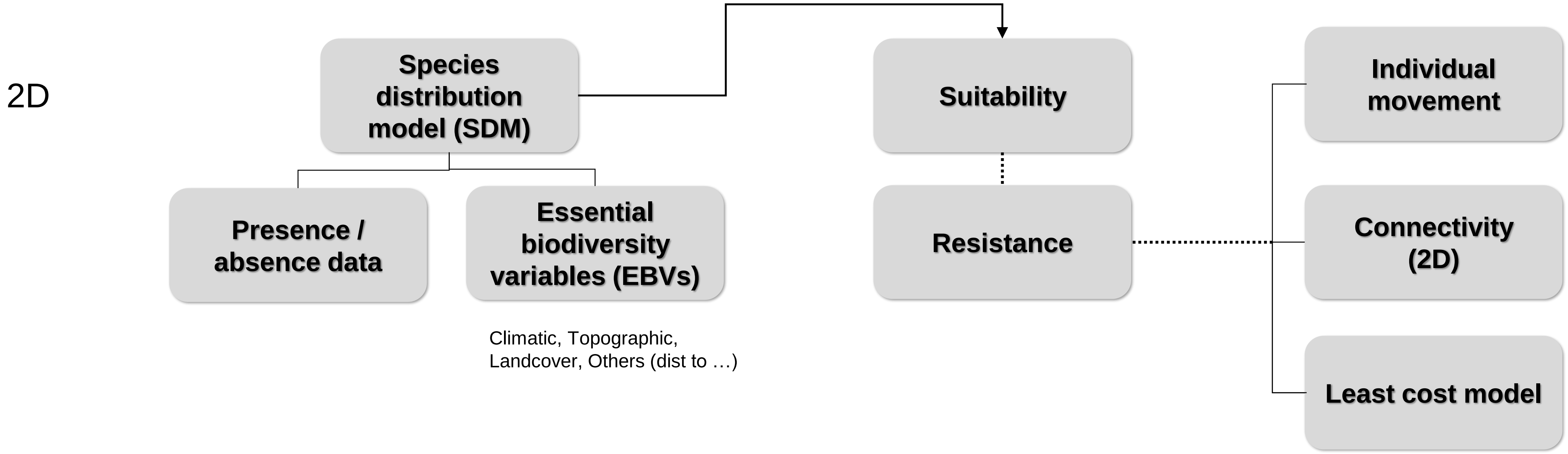
Diaz, Nancy & Apostol, Dean & Region, United. (2022). Forest landscape analysis and design : a process for developing and implementing land management objectives for landscape patterns.

- Stepping stone: It has been known that “distance” is important
  - Unlike horizontal distance, how should we look at vertical distance?
  - What will be different if you add a vertical one, unlike the horizontal one confirmed by empirical data?
- Reverse application of resistance value and habitat suitability to 3D spatial information

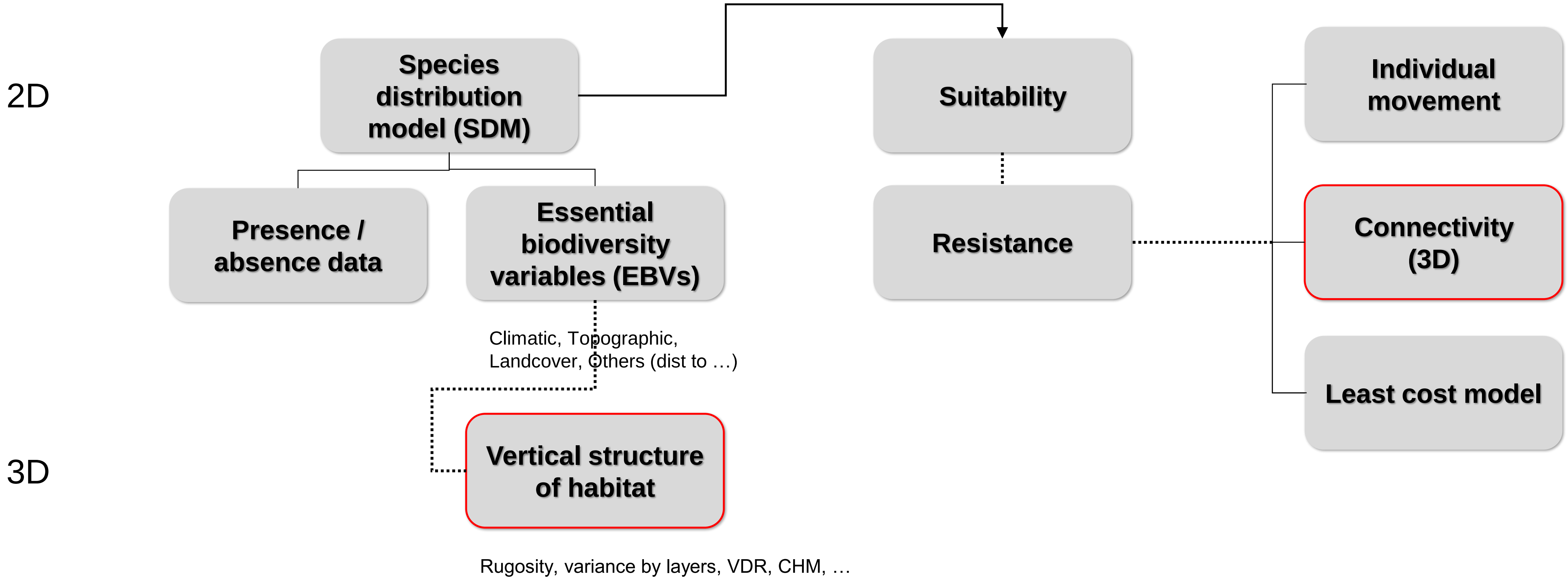


https://www.ealt.ca/blog/conservation-in-a-fragmented-landscape

Methods framework

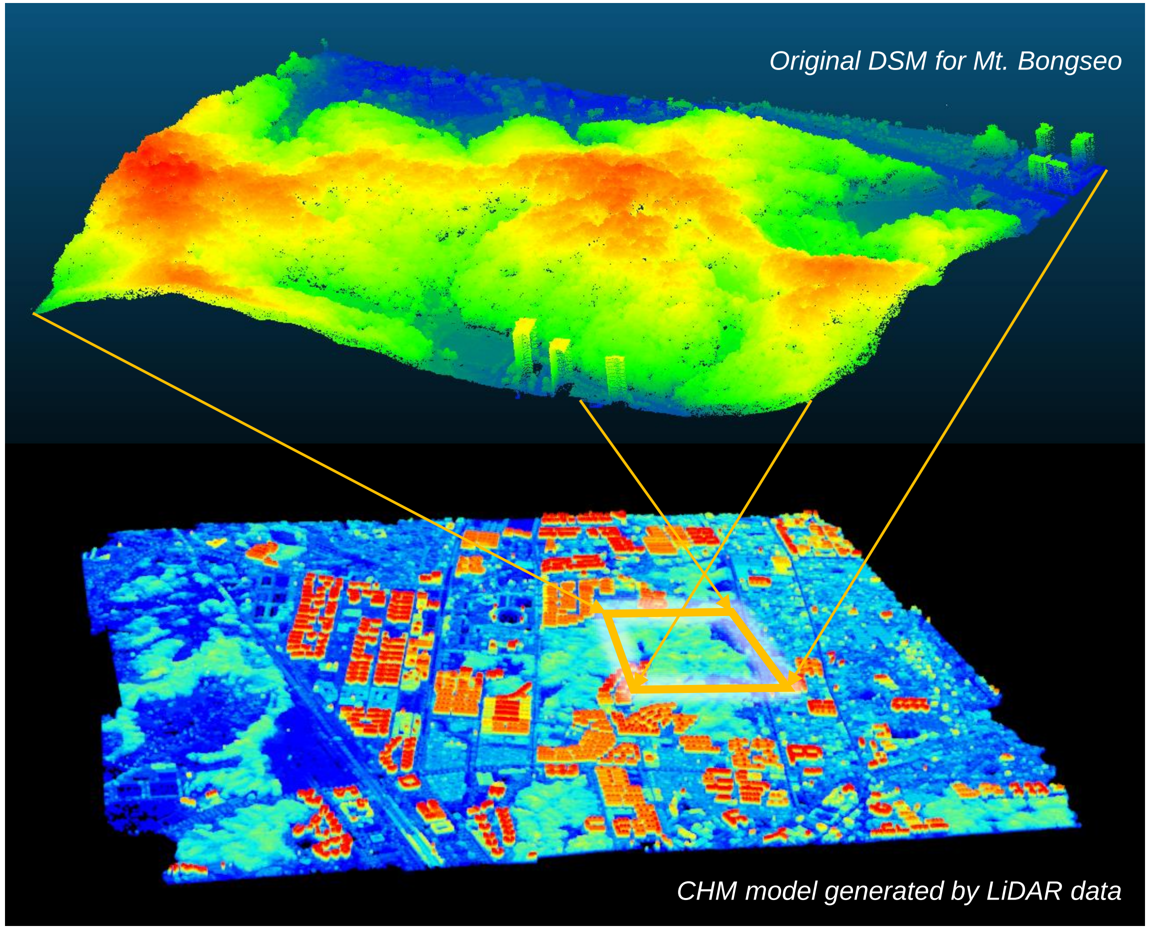


Methods framework



Study site

- Cheonan, South Korea
- Airborne LiDAR data were provided by Samah Aircraft for research purposes, and in 2018, 10 flight routes (50% lateral overlap) were set at an altitude of 1000 m centered on Mt. Bongseo in the site to acquire point cloud data. (5pts/m2)



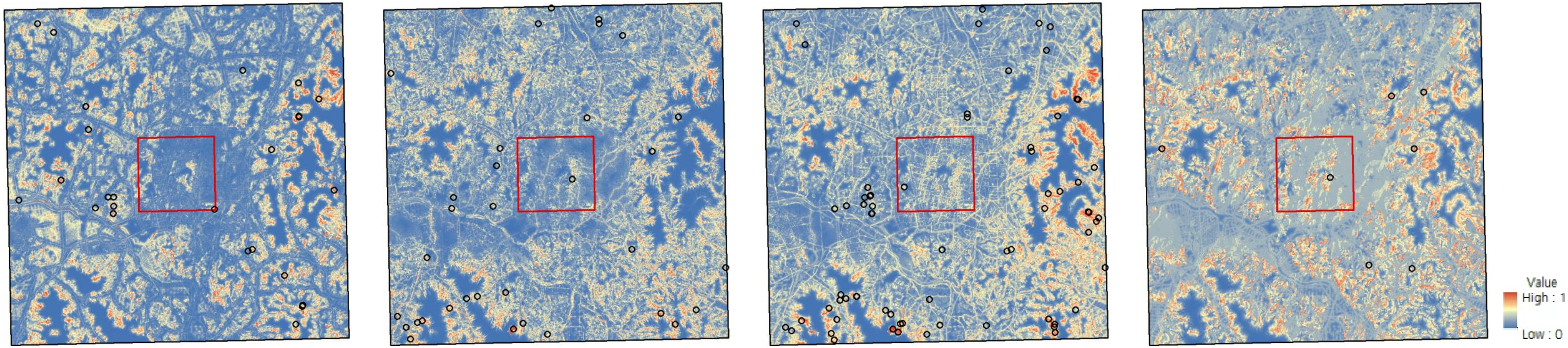
Species Distribution (MaxEnt)

Great Spotted Woodpecker
Dendrocopos major

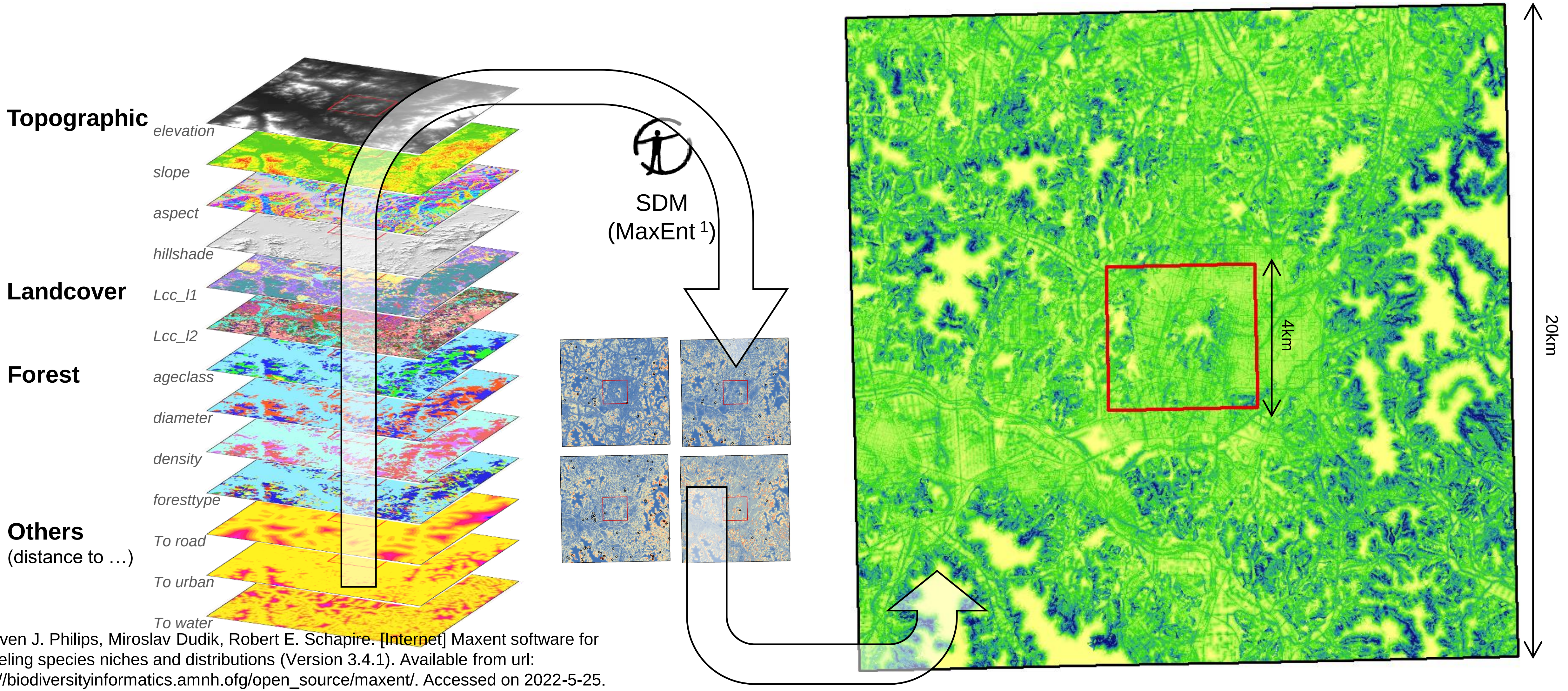
Dollarbird
Eurystomus orientalis

Black-naped Oriole
Oriolus chinensis

Oriental Scops-Owl
Otus sunia

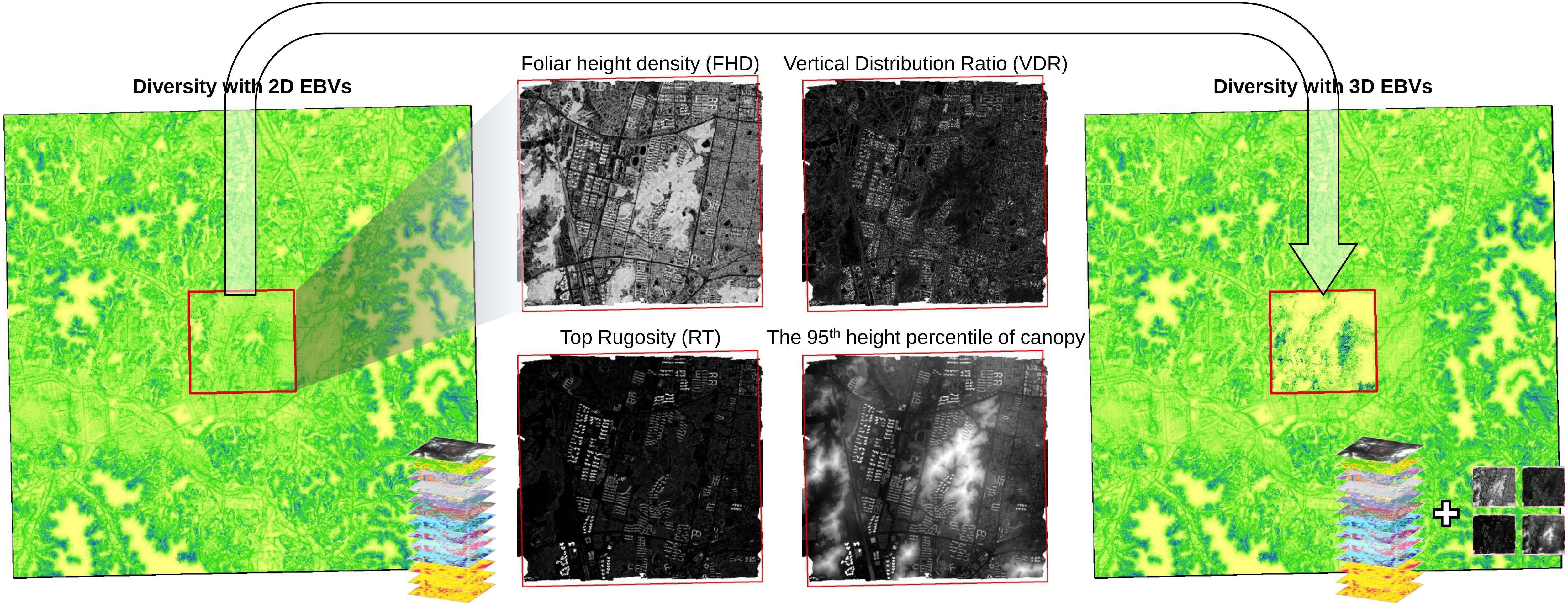


Essential Biodiversity Variables (EBVs) to Species Diversity (SD)



[1] Steven J. Philips, Miroslav Dudik, Robert E. Schapire. [Internet] Maxent software for modeling species niches and distributions (Version 3.4.1). Available from url: http://biodiversityinformatics.amnh.ofg/open_source/maxent/. Accessed on 2022-5-25.

Vertical structures added to EBVs

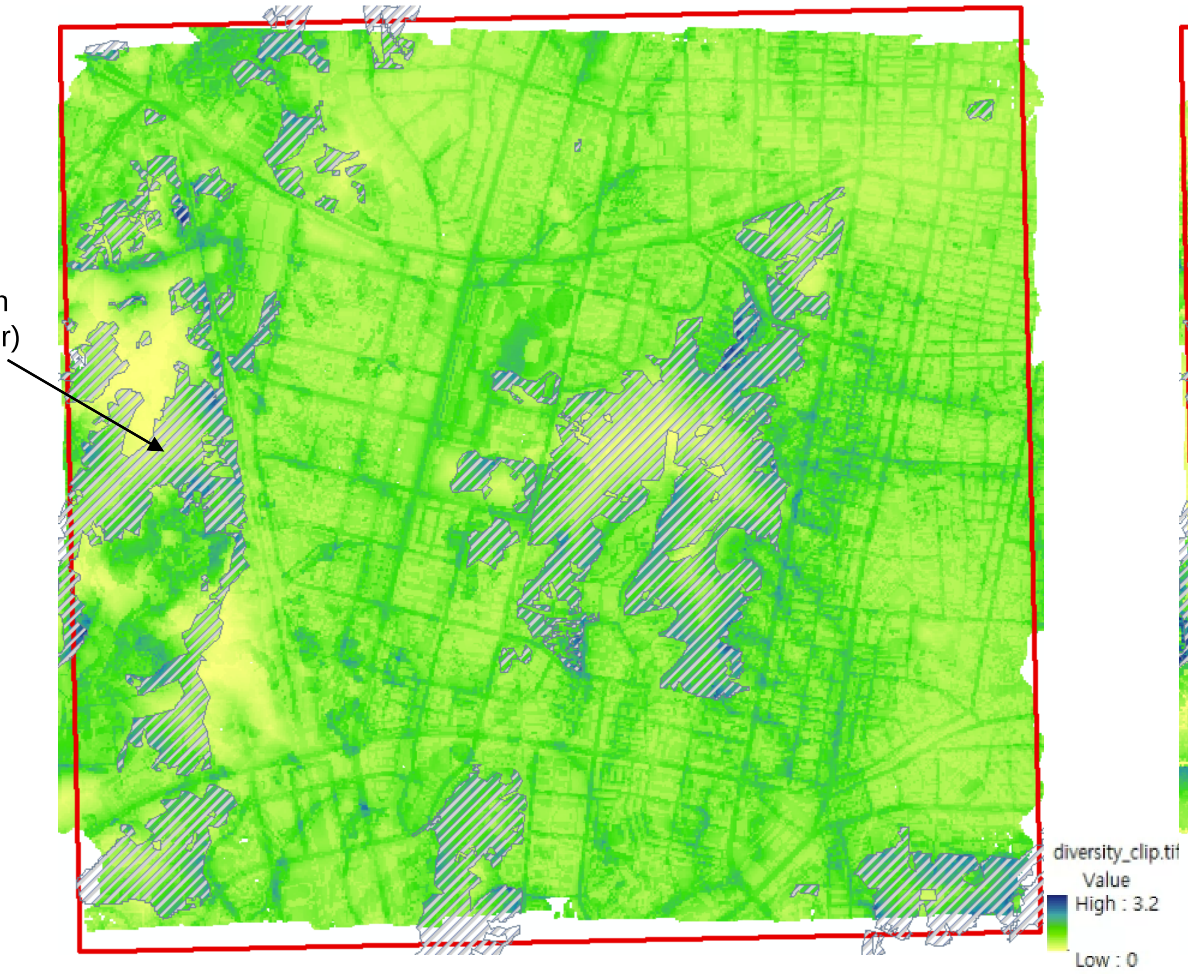


Calculation was executed using R code by
Atkins, J. W., Stovall, A. E. L., & Alberto Silva, C. (2022). Open-Source tools in R for forestry and forest ecology. *Forest Ecology and Management, 503*, 119813. https://doi.org/10.1016/j.foreco.2021.119813

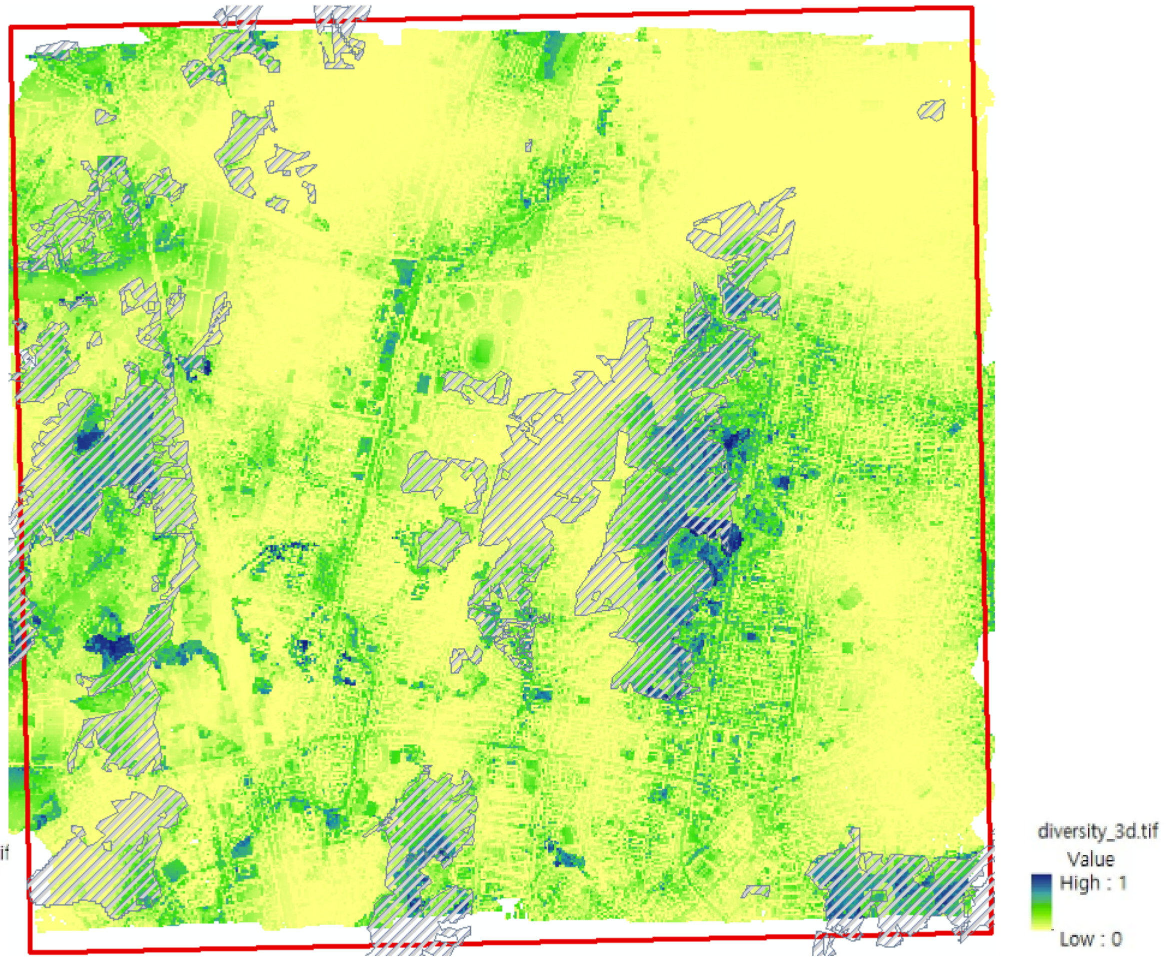
Results (diversity)

Focal patch
(forest layer)

Diversity with 2D EBVs

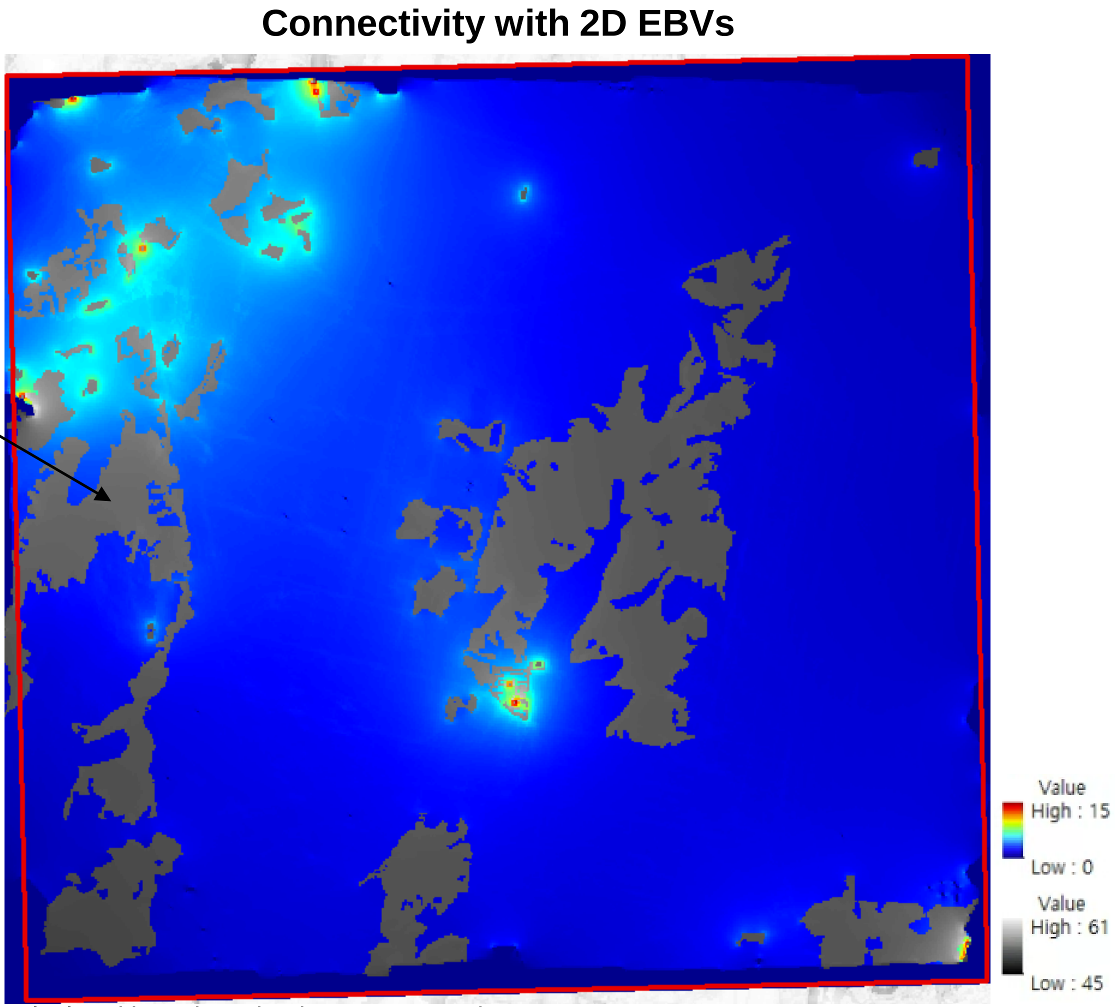


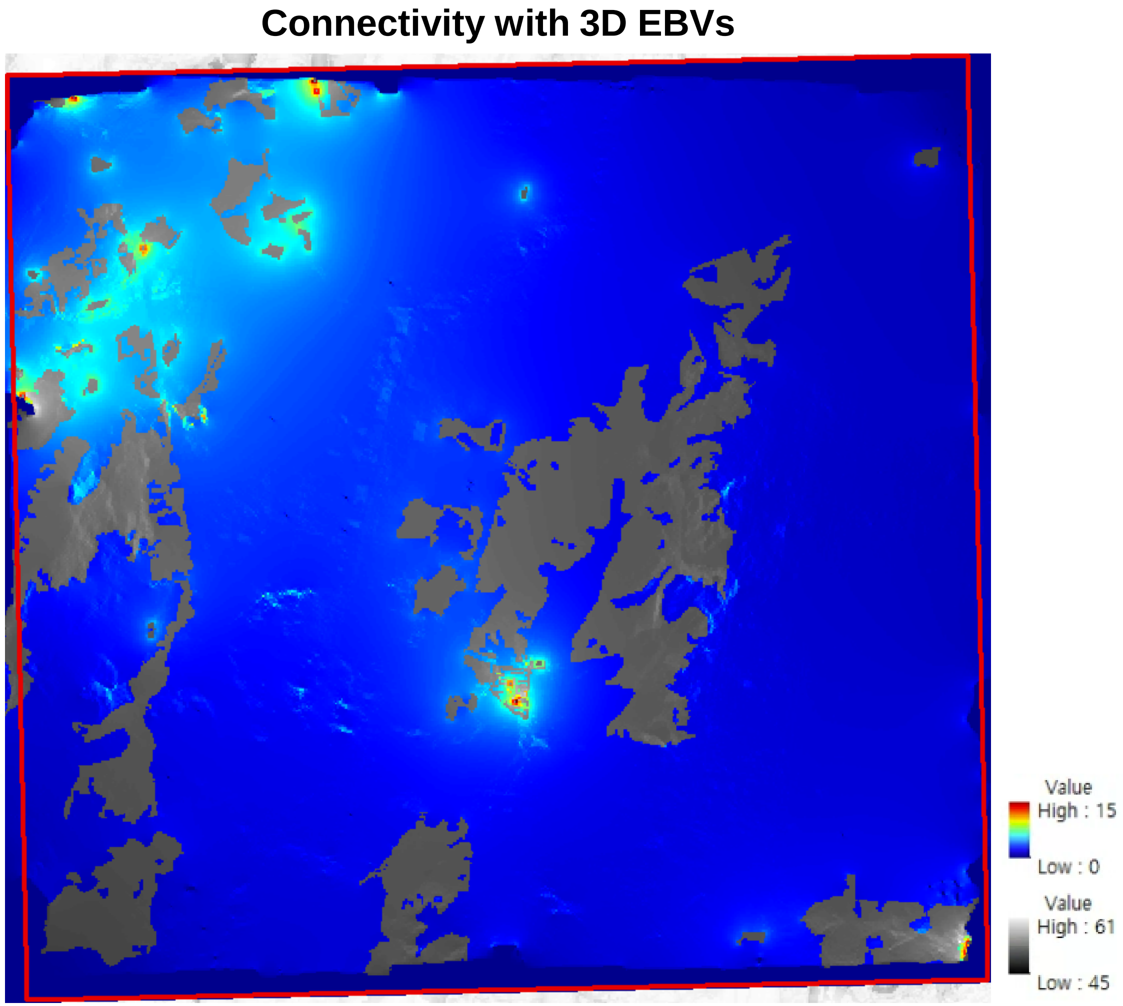
Diversity with 3D EBVs



Results (connectivity)

Focal patch
(forest layer)



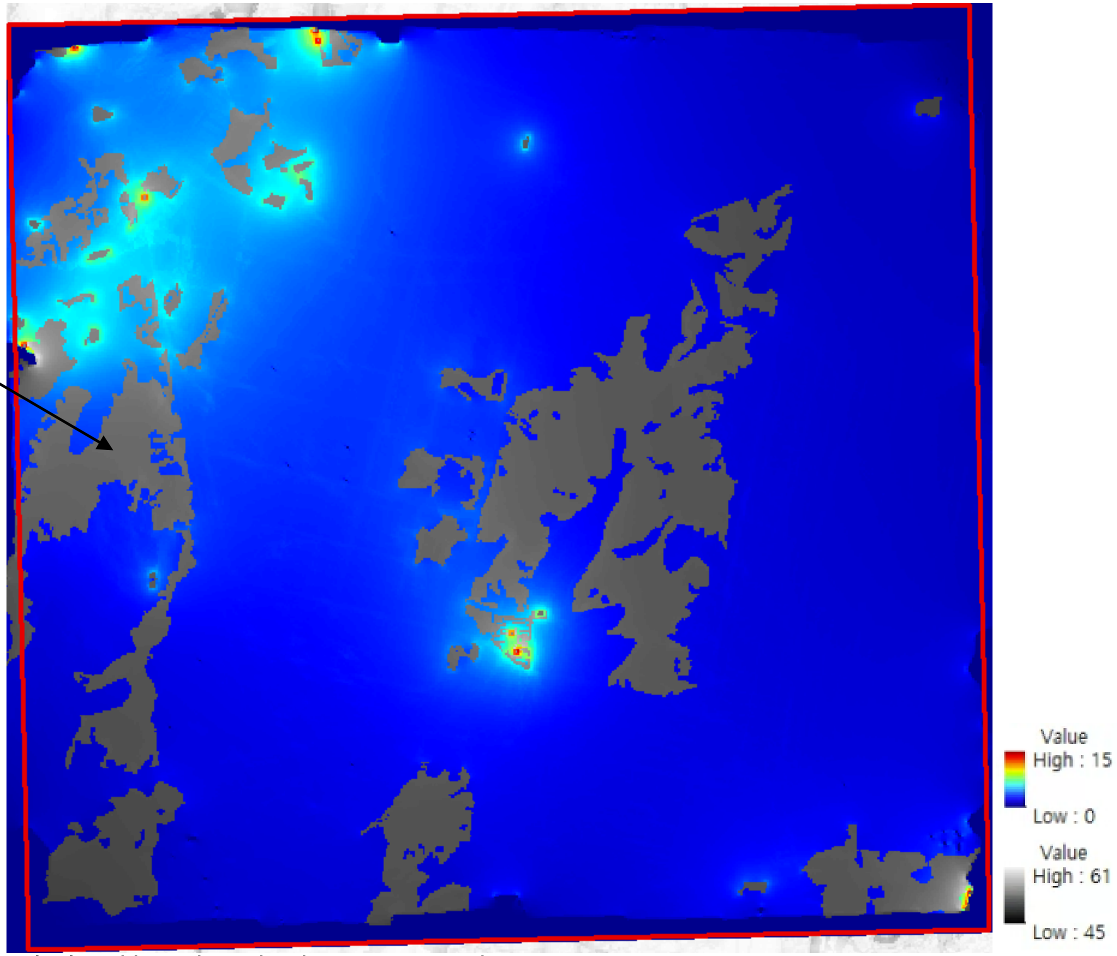


Connectivity was calculated by using Circuitscape v.4.0.5 by
Anantharaman, R., Hall, K., Shah, V. B., Edelman, A. (2020). Circuitscape in Julia: High Performance Connectivity Modelling to Support Conservation Decisions. *Proceedings of the JuliaCon Conferences, 1*(1), 58. 119813. https://doi.org/10.21105/jcon.00058

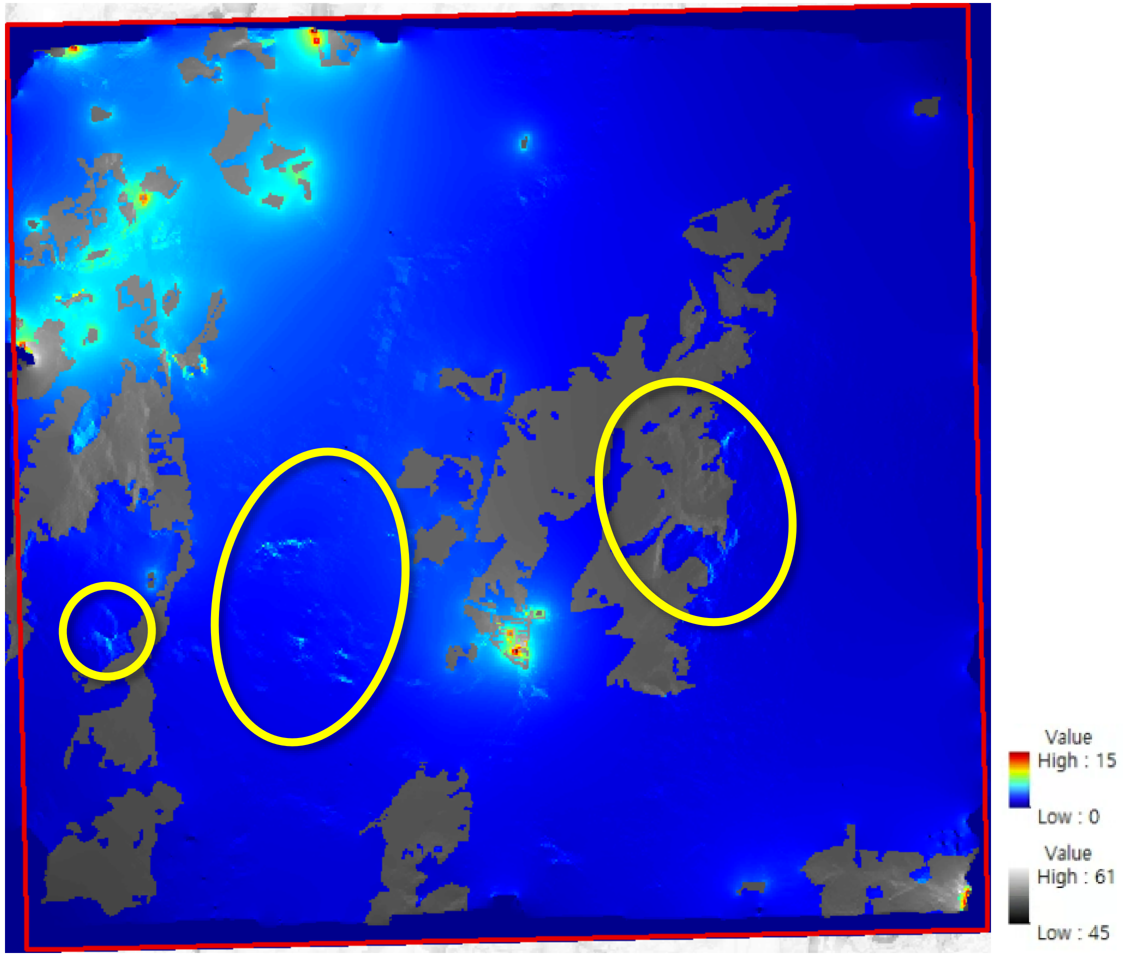
Results (connectivity)

Focal patch
(forest layer)

Connectivity with 2D EBVs



Connectivity with 3D EBVs



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Limitations and Future plan

- Most connectivity studies so far have been conducted on two-dimensional surfaces, and resistance value-based studies on species data, topography and vegetation structure, and habitat quality have been performed.
- In this study, we try to detect changes in pattern of species due to vertical structures with lidar-based 3D data.
- The actual species distribution should be supplemented with field survey data (to be implemented in June), and the frame should be reconstructed so that the impact of each forest structure and urban structure can be analyzed separately.

EBVs

Horizontal: gap fraction, canopy density …
Vertical: num. of layers, VDR, heterogeneity …
Micro-climate: radiation, temperature, relative humidity, …
Topographic: elevation, slope, aspect, …
Others: species abundance, richness, forest type, wetlands, …

Acquire and apply structural variables using UAV and LiDAR data

Deere et al. 2020, Muller et al. 2017, Sheehan et al. 2019, Goetz et al. 2007, Buler et al. 2007, Shao et al. 2018, Schut et al. 2014, …

Conclusion

- Change from spatial patterning of two-dimensional planar surfaces to realization of complex ecosystems through three-dimensional structure mapping
  - Providing new ecological insights such as urban ecological networks using green spaces and three-dimensional structures of buildings
  - With the development of technologies such as remote detection and LiDAR, it is possible to interpret data that could not be obtained before.
- The movement of organisms and the resulting flow of ecosystem services are shaped by landscape connectivity.
  - Individuals in an ecosystem are typically migratory and are exposed to habitats and various structures within that system.
  - It is difficult to derive an accurate resistance surface value because it suffers from landscape heterogeneity at various resolution scales, such as feeding activities and demands according to seasonal changes.
- Spatial technology to create vast and complex big data sets, future direction
  - Integration of large and heterogeneous data types and understanding and decision-making in ecosystem dynamics
  - Transforming 3D-based scientific discoveries into information, communication with managers is key

Thank you for listening.

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