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Understanding seed dispersers' movements and their consequences across rainforest gradients of structural and phenological diversity

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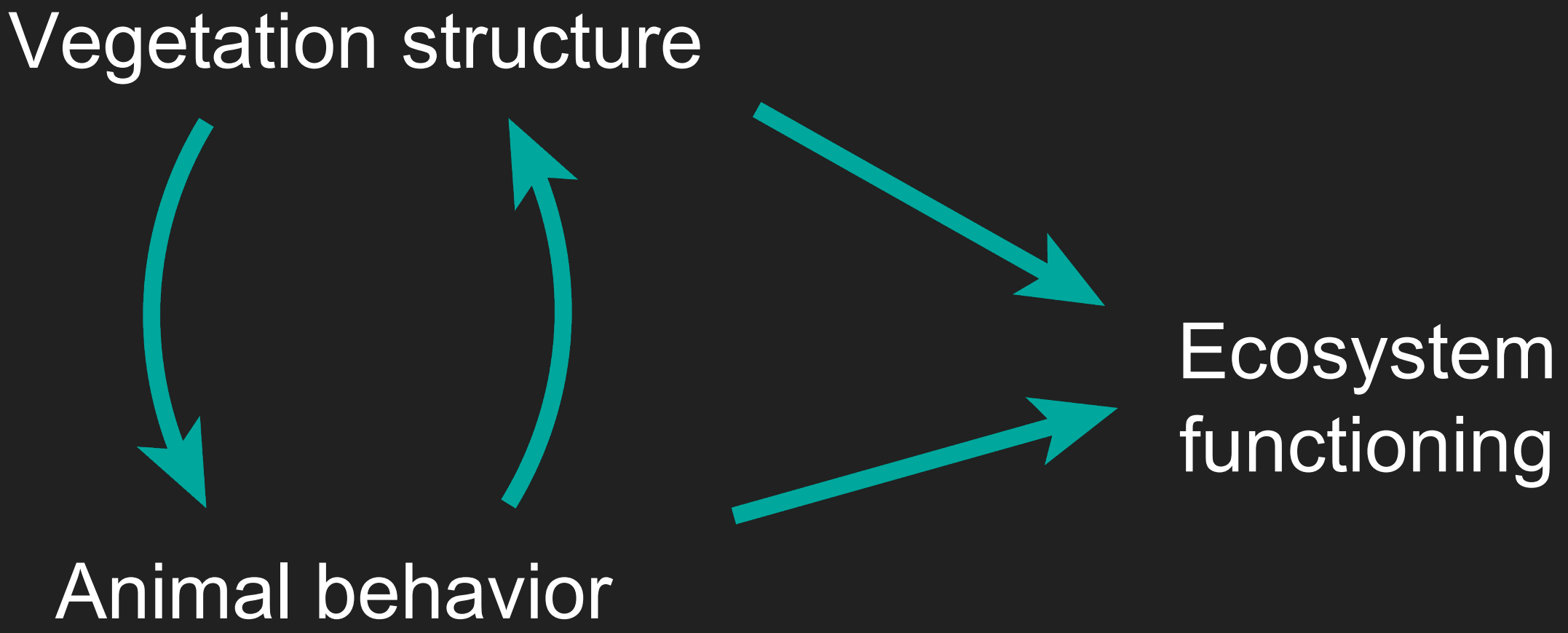


Russo et al. 2023 *Ecology Letters*

Questions

1. How do movements of seed-dispersing animals (birds, bats, primates, and antelopes) vary with 3D forest structure at local and landscape scales?

2. How are habitat selection and movements of different seed-dispersers influenced by vegetation functional diversity and phenology?

3. How do forest fragmentation and other anthropogenic disturbances influence animal movements and patterns of seed dispersal?

Dja Faunal Reserve, Cameroon

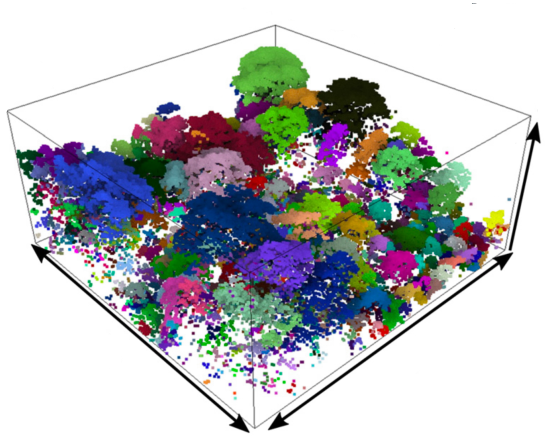
- Cameroon's largest protected area (526 km^2)
- Mature tropical lowland rainforest
- At least 312 tree species, ~90% are dispersed by vertebrates

Habitat characterization

Forest Structure

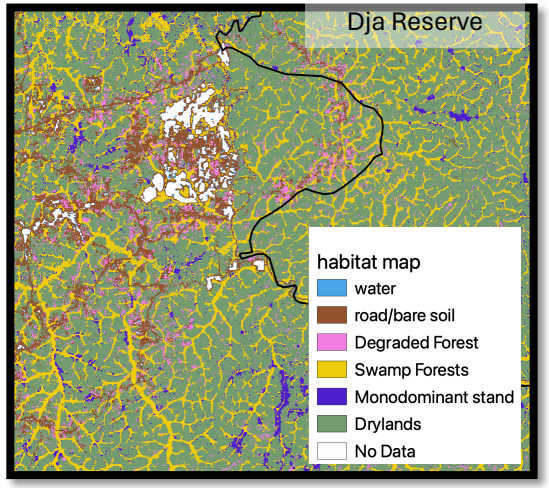
Local-scale 3D maps
Sensor: **drone LiDAR**
Point density: >100 pt/m2

Regional-scale maps
Sensor: **GEDI, Landsat 8, PALSAR, Copernicus DEM**
Spatial Resolution: 25m-100m



Land Cover

Local and Regional-scale maps
Sensor: **Sentinel-2**
Spatial Resolution: 10m



Ploton et al, (in preparation)

Phenology

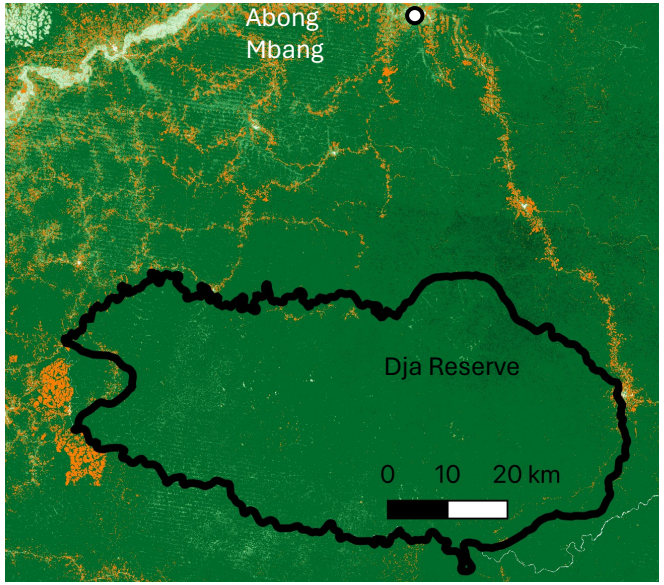
Local-scale maps
Sensor: **drone RGB**
Spatial Resolution: 0.3m
temporal resolution: monthly

Regional-scale maps
Sensor: **PlanetScope**
Spatial Resolution: 3m
temporal resolution: daily*

Biswas et al. (in preparation)

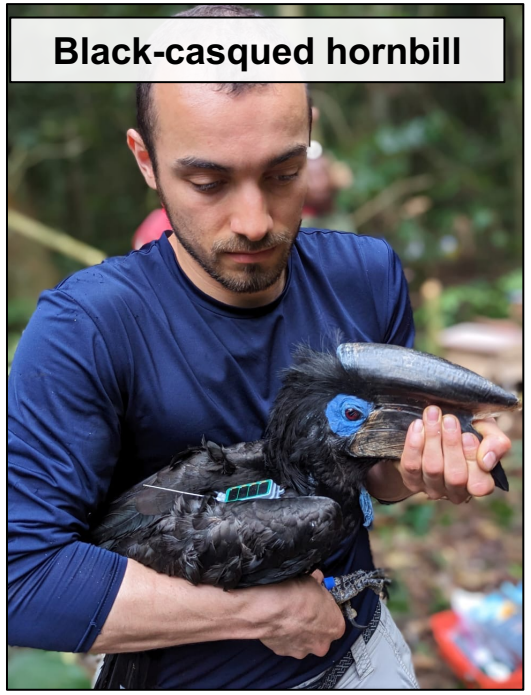
Degradation/Deforestation

Regional-scale maps
RADD, GFC, TMF
Sensor: **Sentinel-1, Landsat**
Spatial Resolution: 10m, 30m
temporal resolution: 6-12 days, annual



Animal tracking

- 25 birds tracked since April 2022
  - 16 black-casqued hornbill
  - 5 white-thighed hornbill
  - 4 great blue turaco
- 10 hammer-headed fruit bats
- Antelope dung piles and beds
- 6 years of primate survey data

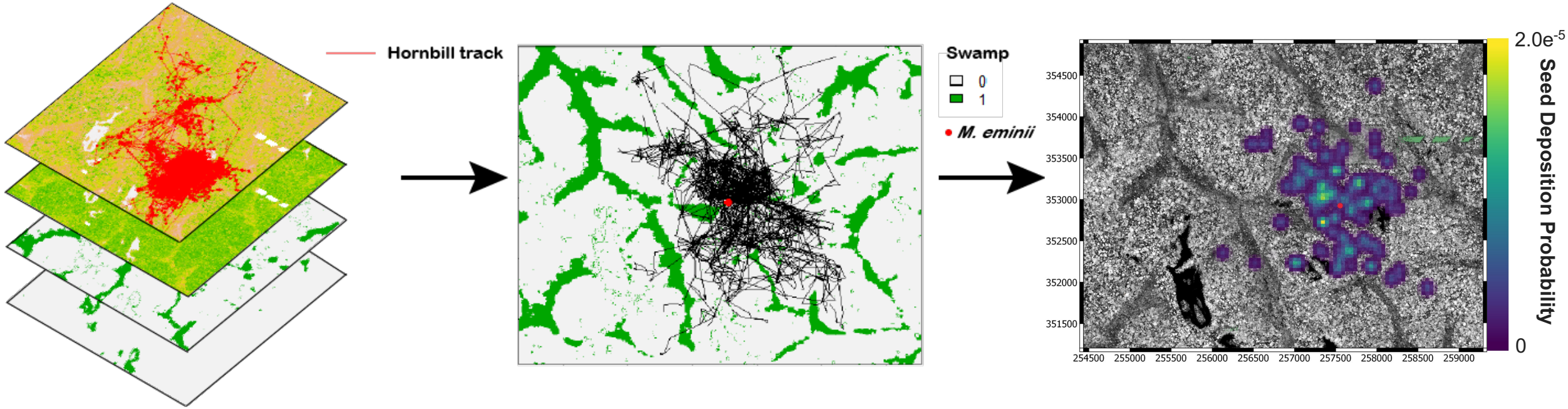


Q-1 How do movements of birds, bats, primates, and antelopes vary with 3D forest structure at local and landscape scales?

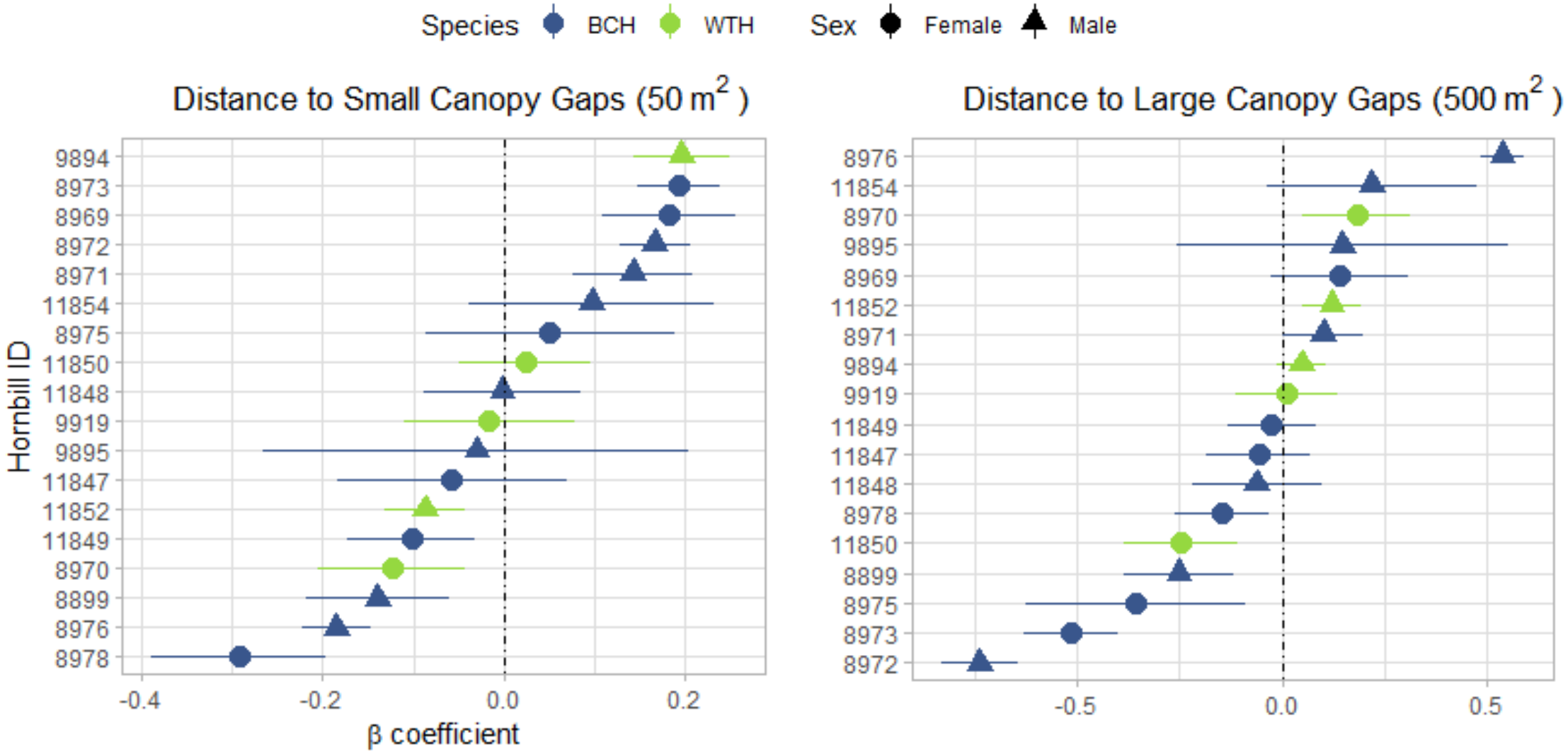
Quantify animal habitat selection

Simulate animal movements following fruiting tree visit

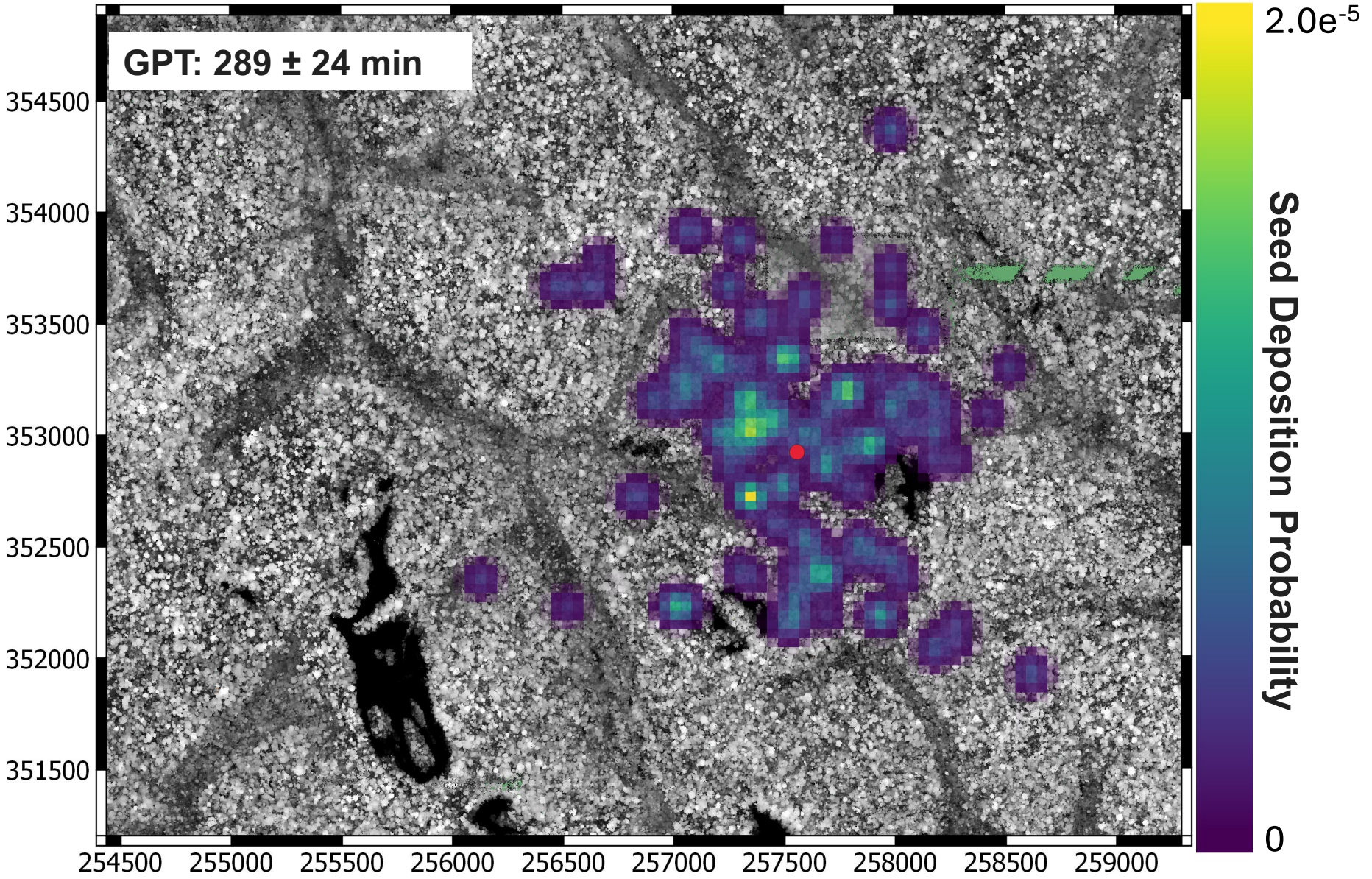
Predict spatial patterns of seed dispersal based on gut passage time



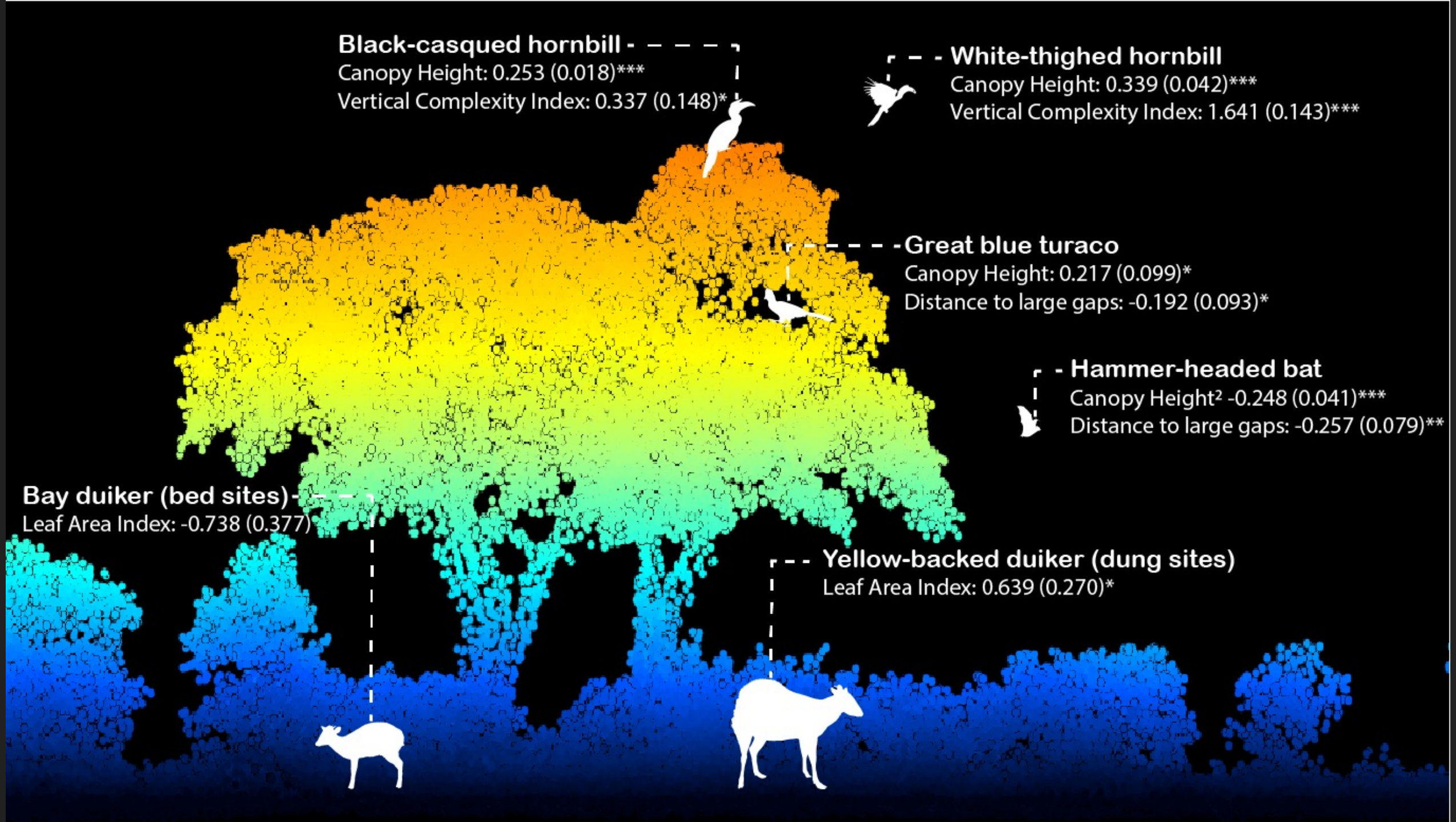
Individual hornbills vary in response to canopy gaps



Seed shadow produced by black-casqued hornbills

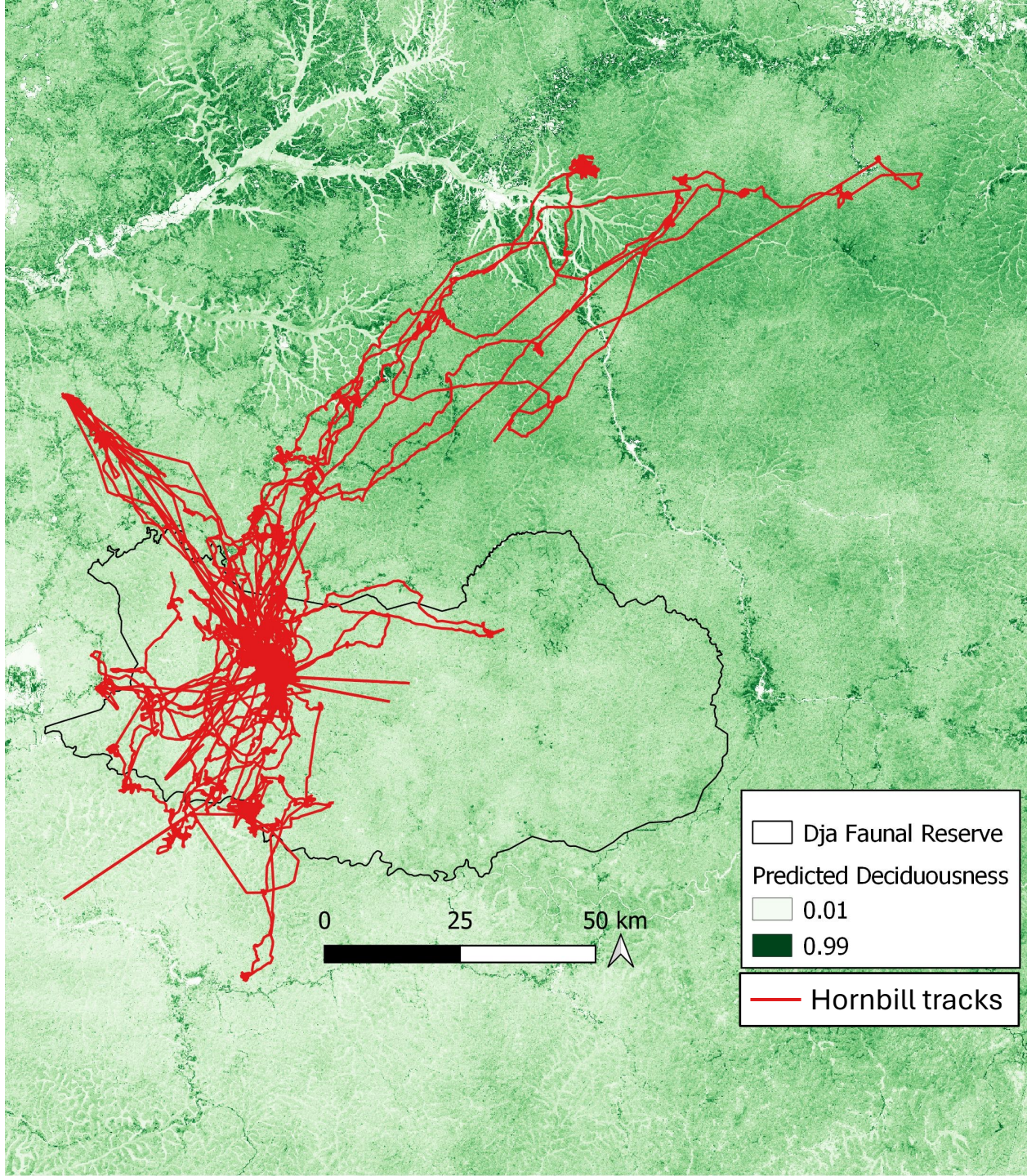


- ***Maesopsis eminii***


Black-casqued hornbill
Canopy Height: 0.253 (0.018)***
Vertical Complexity Index: 0.337 (0.148)*
White-thighed hornbill
Canopy Height: 0.339 (0.042)***
Vertical Complexity Index: 1.641 (0.143)***
Great blue turaco
Canopy Height: 0.217 (0.099)*
Distance to large gaps: -0.192 (0.093)*
Hammer-headed bat
Canopy Height² -0.248 (0.041)***
Distance to large gaps: -0.257 (0.079)**
Bay duiker (bed sites)
Leaf Area Index: -0.738 (0.377)
Yellow-backed duiker (dung sites)
Leaf Area Index: 0.639 (0.270)*

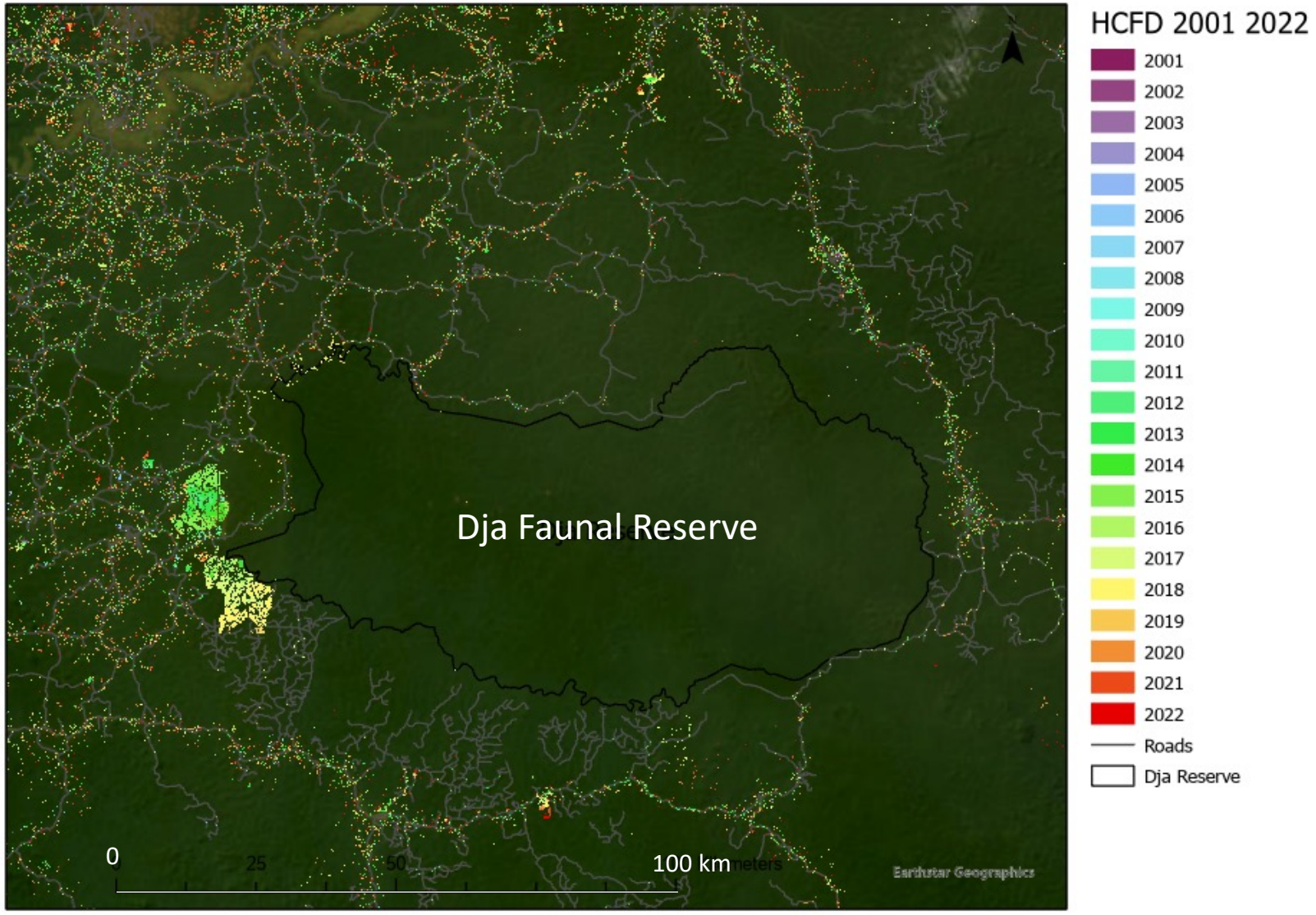
Q-2 How are habitat selection and movements of different seed-dispersers influenced by vegetation functional diversity and phenology?

- Mapped probability of deciduous tree occurrence using Sentinel-2
- Detected flowering, leaf-flush events, upscaled using Planet data
- Related hornbill movements to ground-truthed fruiting trees



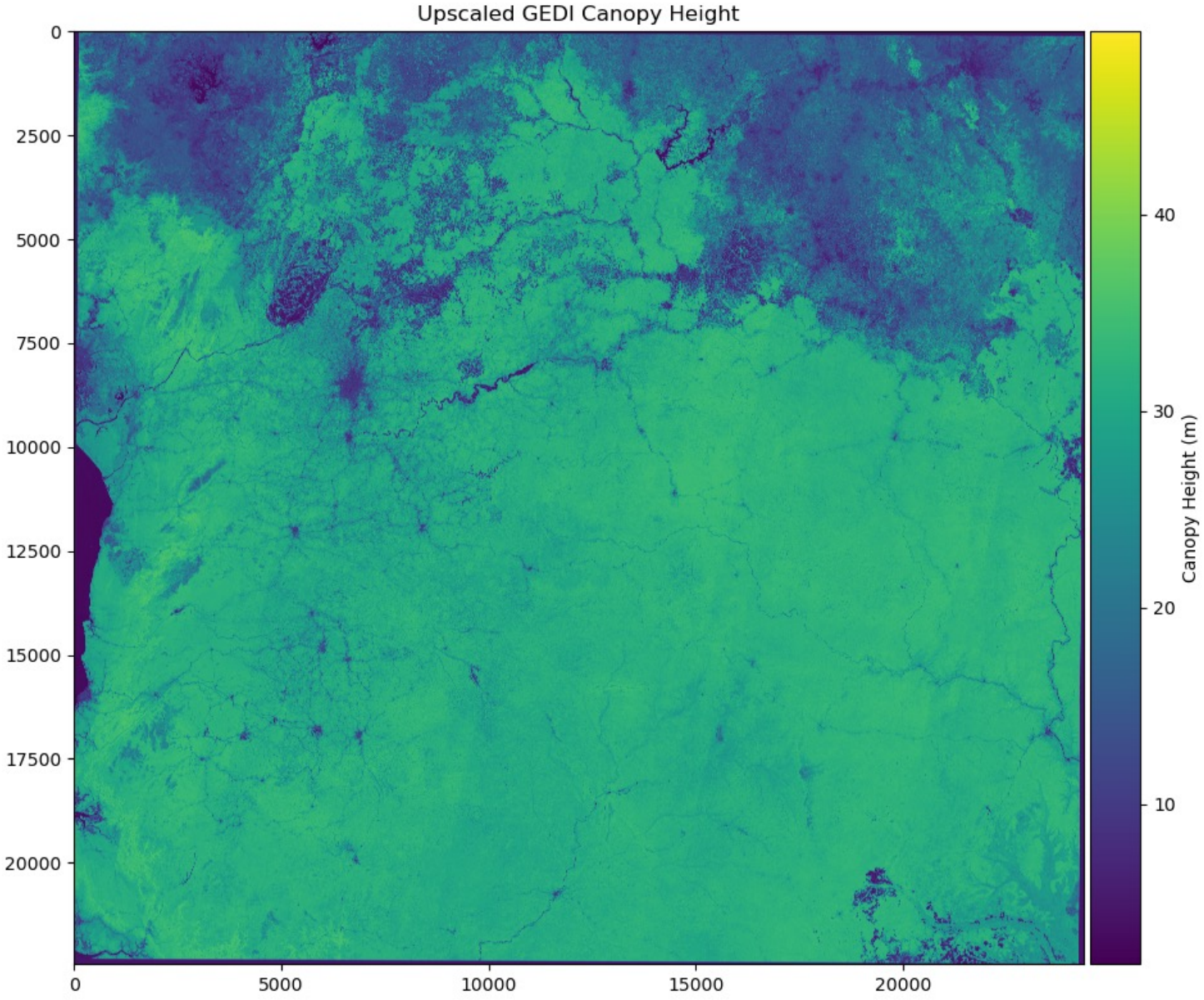
Q-3 How do forest fragmentation and other anthropogenic disturbances influence animal movements and patterns of seed dispersal?

- Large-scale forest disturbances from commercial plantations
- Small-scale disturbances from smallholder agriculture

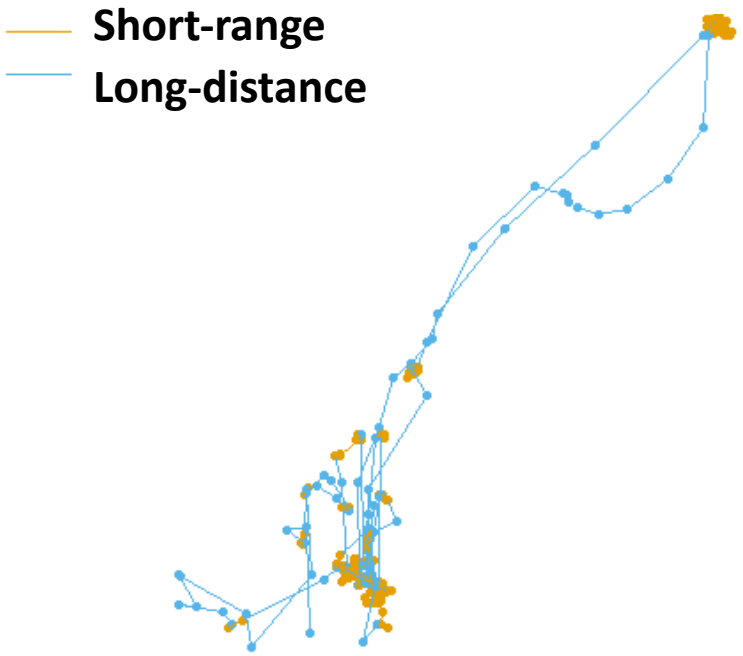


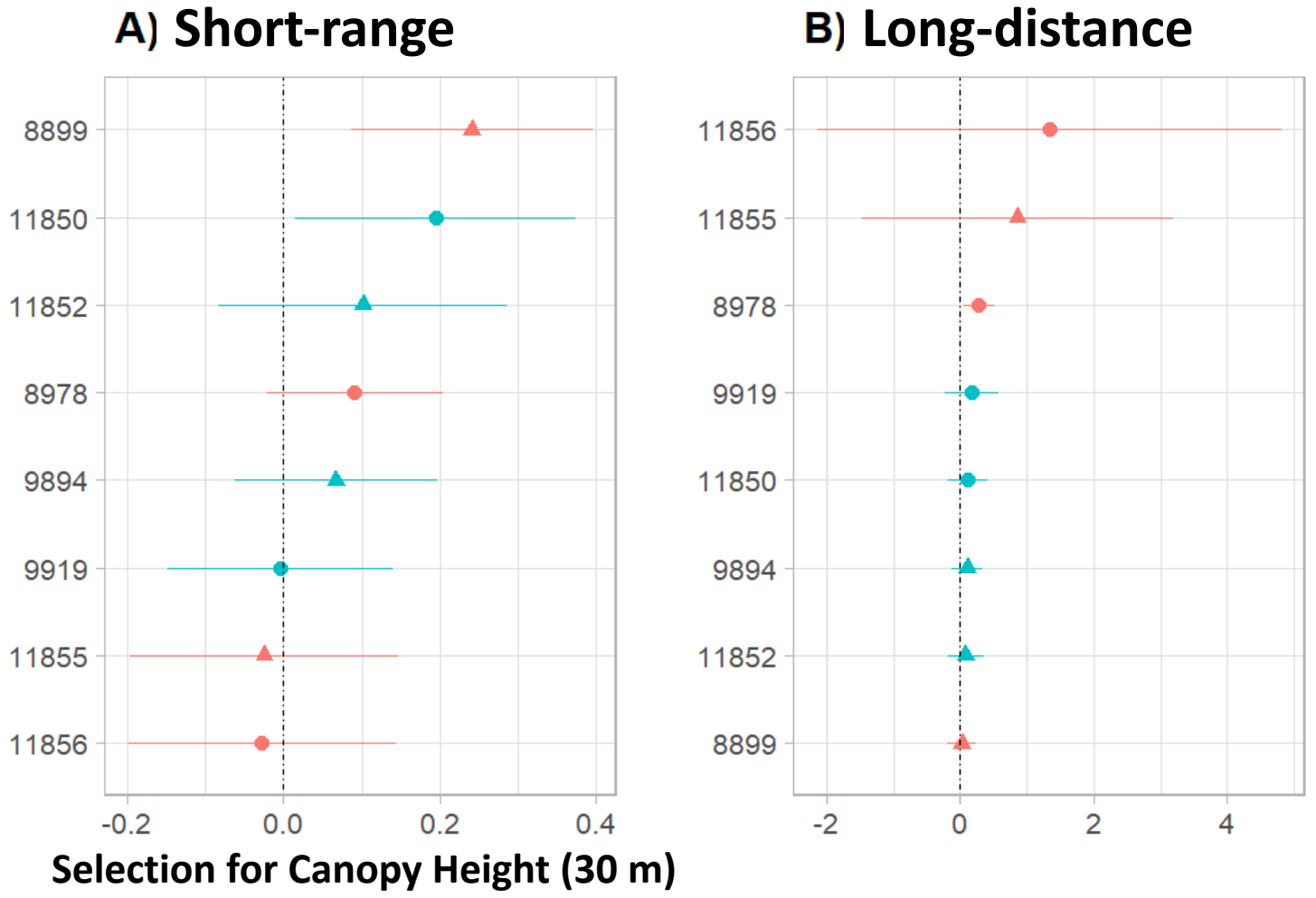
Upscaled lidar metrics using GEDI

- Upscaled using:
  - Landsat 8
  - ALOS/PALSAR
  - Copernicus DEM
- Validated canopy height estimates with GEDI
- Related upscaled canopy height to hornbill movements



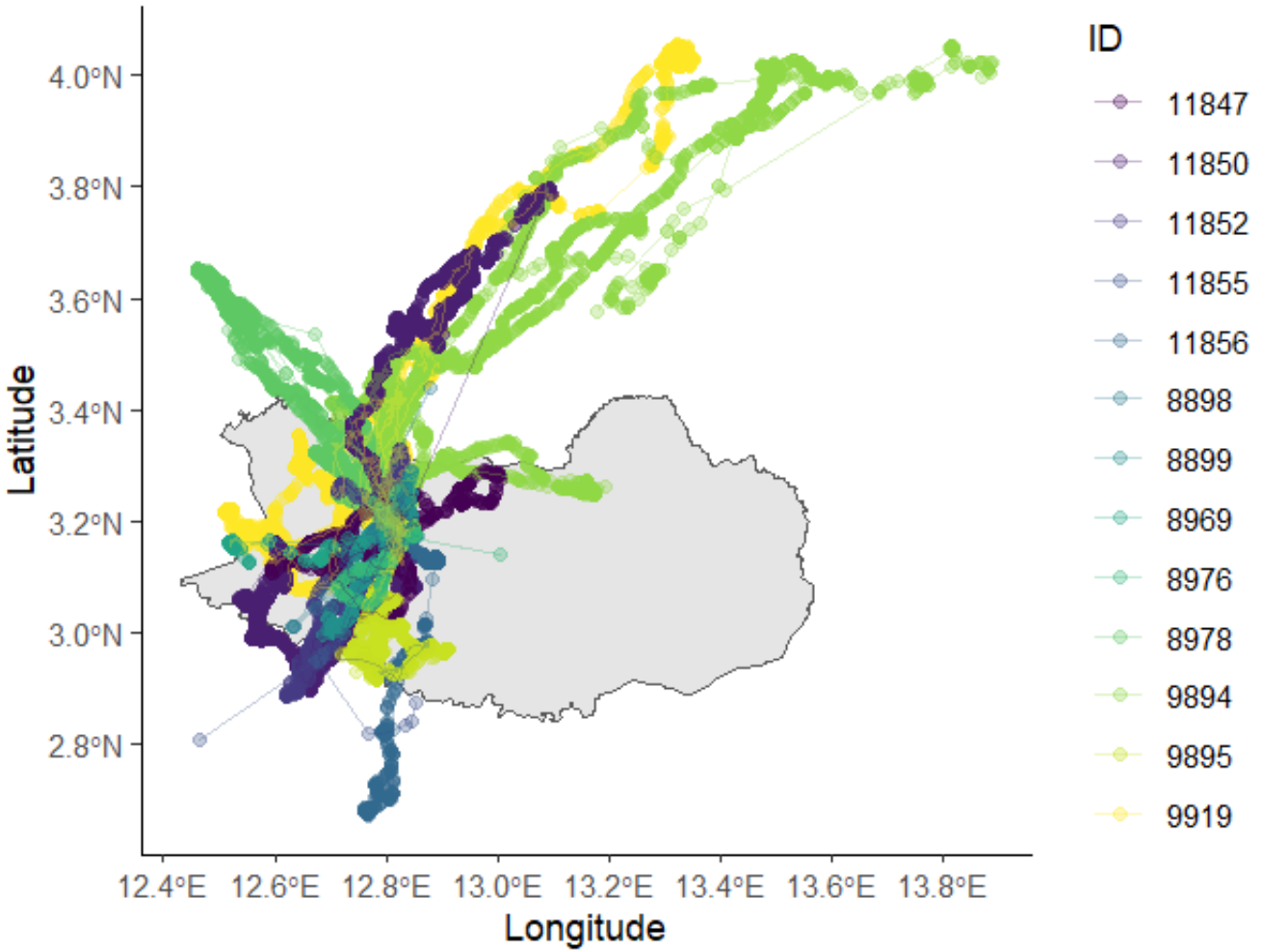
Contrasting habitat selection for short- and long-distance movements



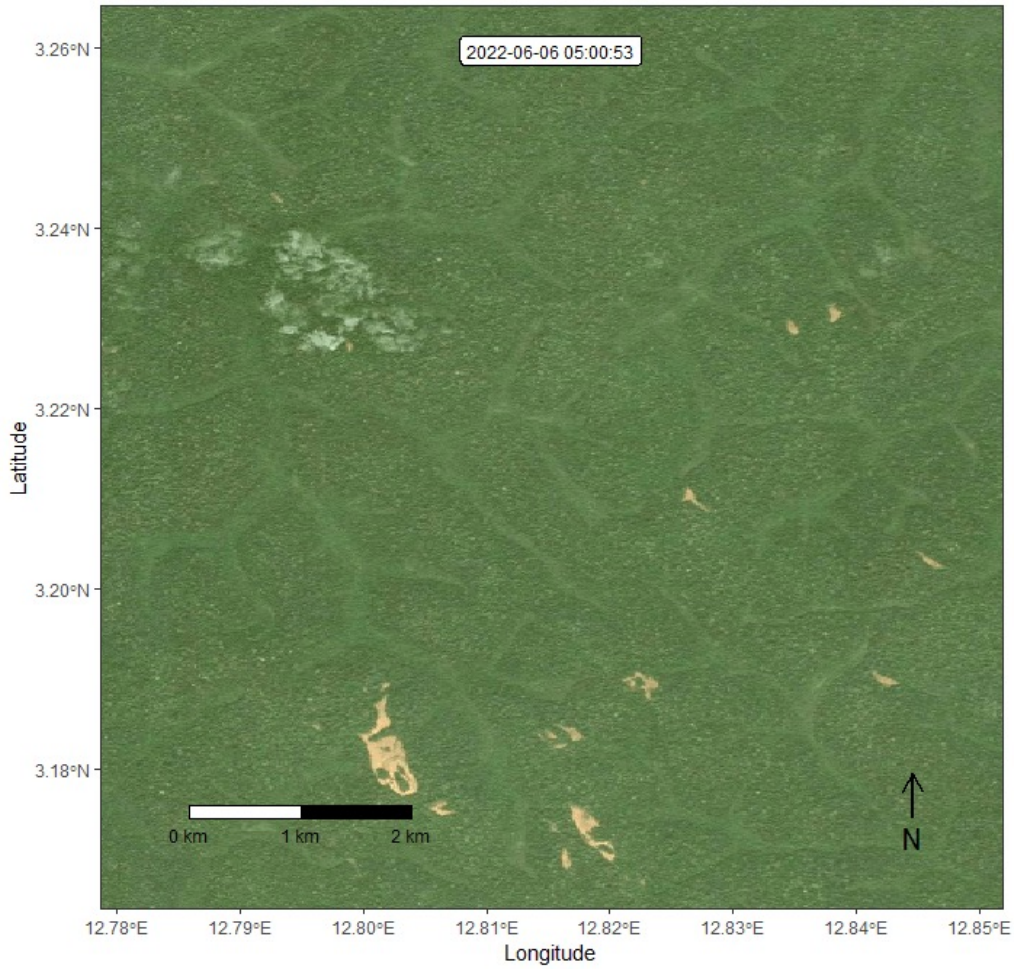


Diversity of hornbill movements

Northern vs. southern flyway



Back-and-forth movements



Summary

- Evidence for feedback between vegetation structure and seed dispersal by animals
- 3D vegetation structure is important for seed dispersers that move throughout all vegetation strata
- Movement diversity can increase the diversity of seed dispersal services available to rainforest trees

Thank you