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Maximum Entropy Modeling and Omniscape for Carnivore Habitat Connectivity in the Adriatic Ionian Region

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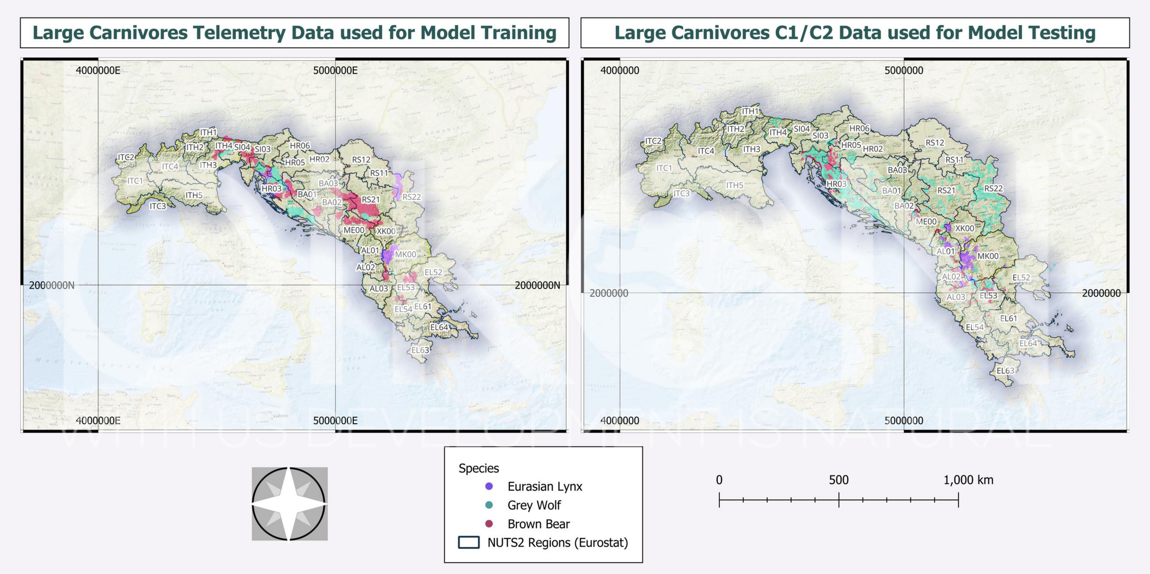
1 The challenge

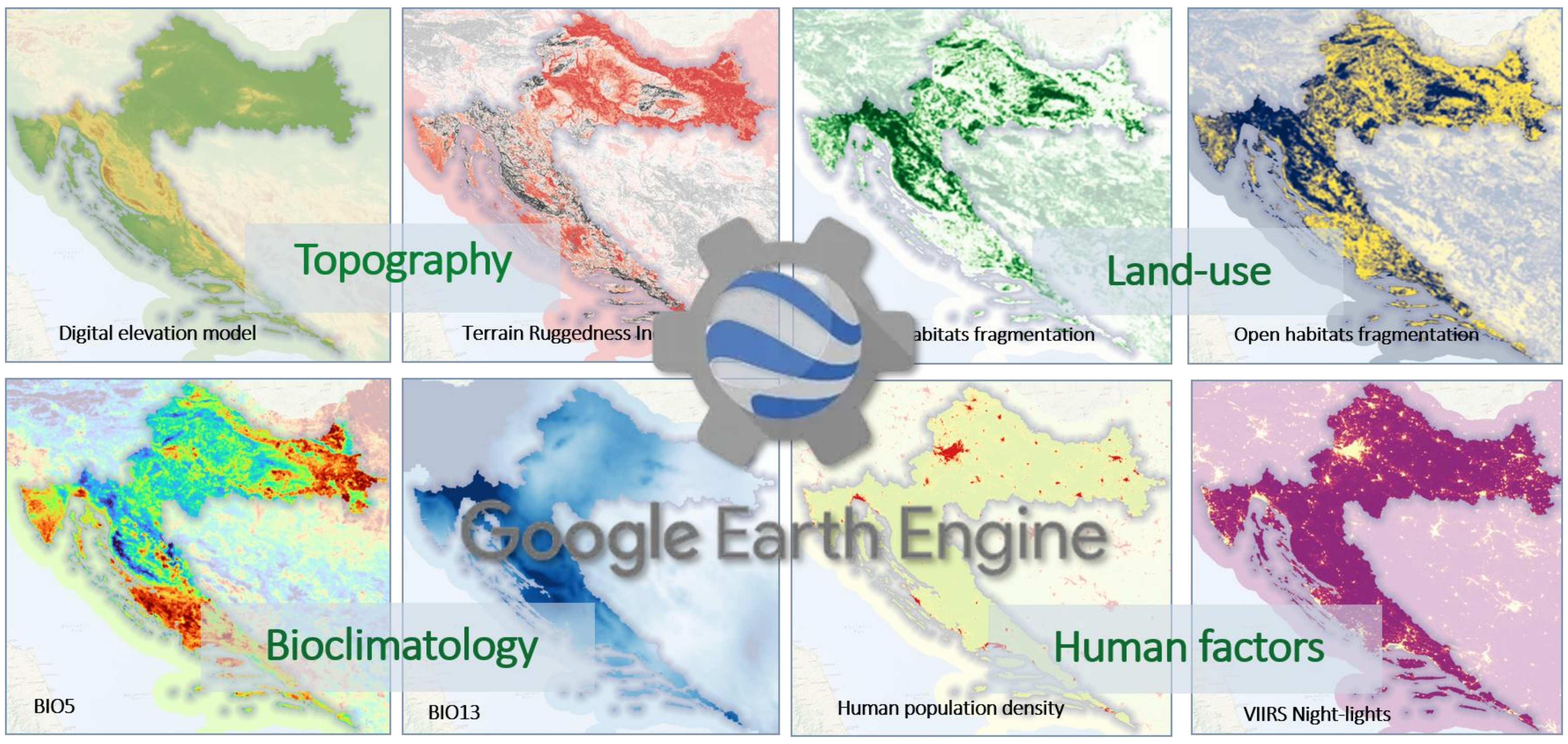
Large carnivores need vast, connected territories, yet roads, settlements and land-use change keep breaking their range into isolated patches. As keystone predators, the brown bear, grey wolf and Eurasian lynx rely on movement between core habitats to keep gene flow and populations viable. We map where suitable habitat lies and, crucially, how well it stays connected across the Adriatic–Ionian region.

Study area: Adriatic–Ionian region



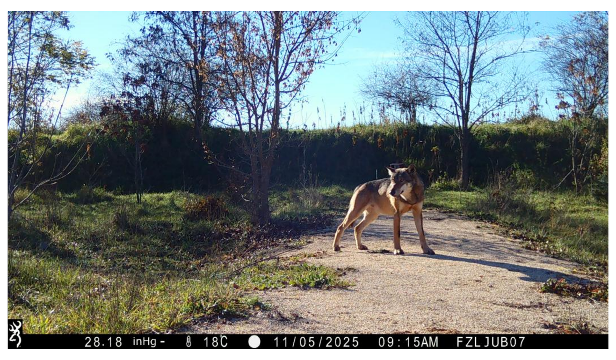
Project area spanning the Italian Alps, the Dinarides and the Pindos, nine countries, mapped by NUTS-2 region. Occurrence records: telemetry (training) and standardized C1/C2 field data (testing); for all three species.

2 Data & Google Earth Engine



Brown bear *Ursus arctos*

Forest–mountain specialist; the largest, most continuous core areas.



Grey wolf *Canis lupus*

The most adaptable; uses mixed farmland and forest mosaics.

Eurasian lynx *Lynx lynx*

The most restricted; needs dense, well-connected forest.

3 Modeling framework

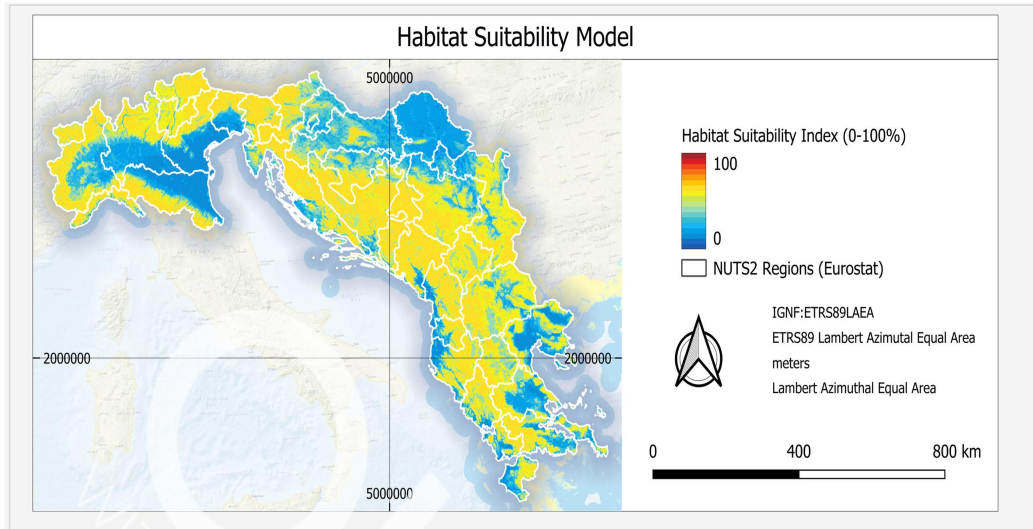
- MaxEnt: presence-only suitability at 100 m; evaluated with AUC and the Boyce index
- Omniscape: circuit theory; omnidirectional current through a moving window
- Resistance derived from inverse suitability via a negative-exponential transform

$$R = 100 - 99\,\frac{1 - e^{-k\,\cdot\,HSI}}{1 - e^{-k}} \qquad k = 8$$

Occurrence › GEE predictors › MaxEnt HSI › Resistance › Omniscape

Cloud-native workflow: the whole predictor stack is generated, clamped in time and validated inside Google Earth Engine, with no local data downloads.

4 Results



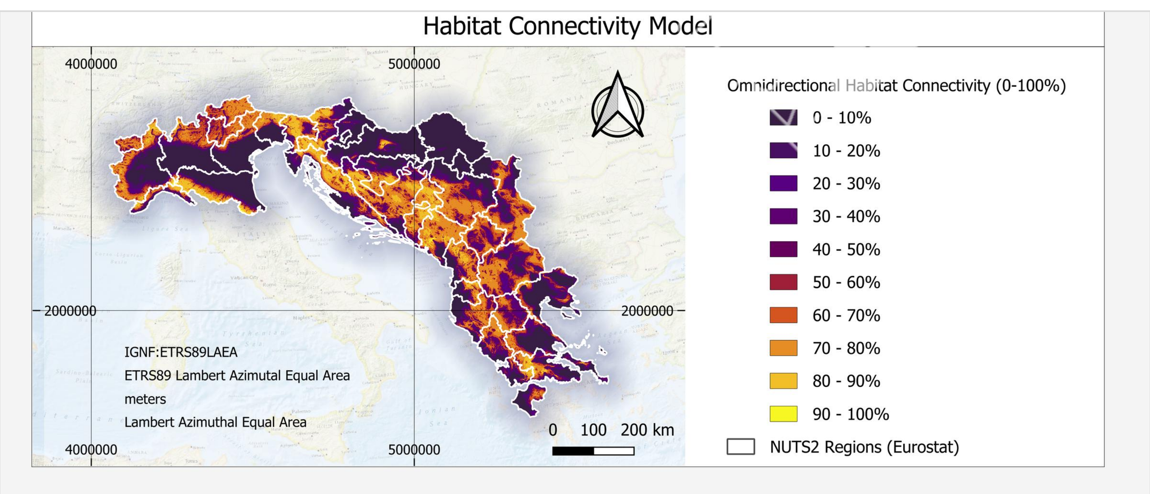
Combined MaxEnt suitability (cloglog, 100 m). Independent validation: AUC 0.89, Boyce index 0.97.

- **High discrimination**: AUC 0.88–0.95 (lynx 0.95, bear 0.90, wolf 0.88; combined 0.89)
- **Well calibrated model**: Boyce index 0.94–0.97, validated on an independent C1/C2 dataset (12,266 records)
- ~164k spatio-temporally thinned telemetry training points; 8 predictors selected by feature importance

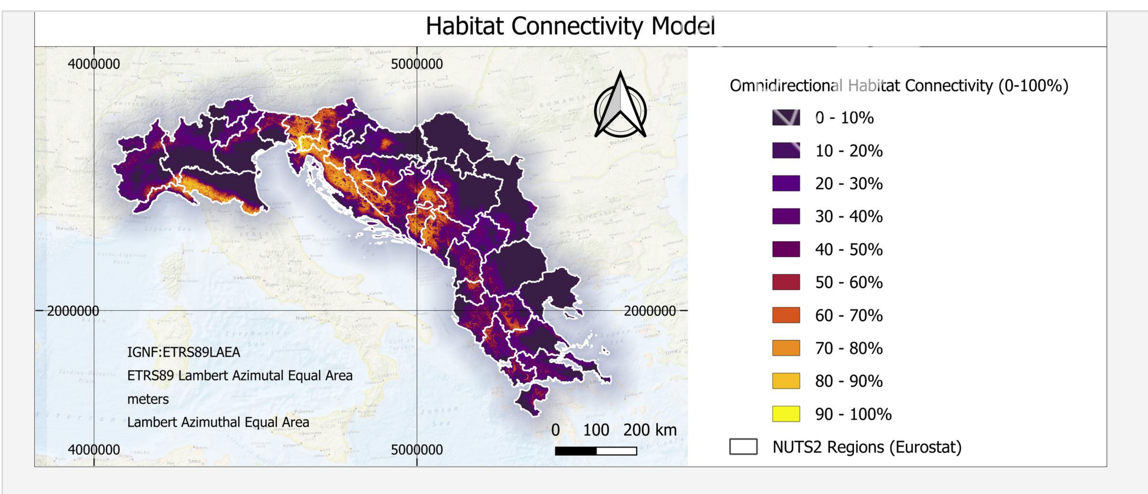
Only about a third of core habitat is protected. Carnivore connectivity must therefore be secured beyond park boundaries.

5 Habitat connectivity: our key finding

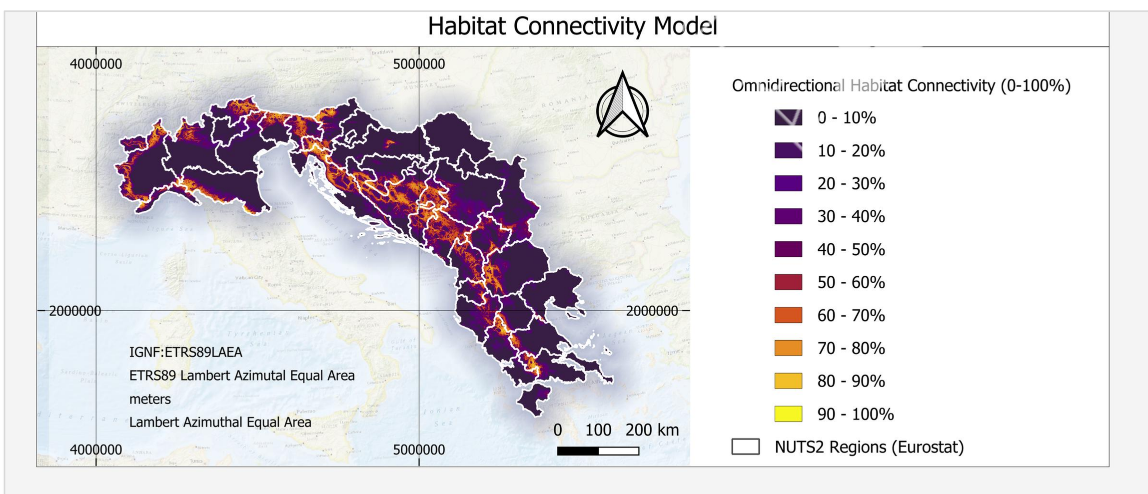
Warm colours highlight high omnidirectional current, i.e. the routes carnivores actually use; *cool purples mean high landscape resistance.*



Brown bear *(Ursus arctos)*
Depends on continuous forested mountain corridors.



Grey wolf *(Canis lupus)*
Crosses farmland; the most permeable network.



Eurasian lynx *(Lynx lynx)*
Confined to connected forest; most fragmentation-sensitive.

Mountains — above all the Dinarides — form the region's connective backbone. The model pinpoints bottlenecks at major highways and urban sprawl, and transboundary corridors that need coordinated cross-border protection.

Conclusions & policy

- Populations remain connected but the links are fragile
- Embed high-resolution connectivity maps in national spatial plans
- Enforce Avoid–Minimise–Restore in core areas; steer agri-forestry subsidies to corridors

Toward near-real-time

Next, in an ESA-funded project, we replace static layers (e.g. CORINE) with **Sentinel-1, -2, and -3 + Landsat** imagery to generate predictors, moving to near-real-time habitat and connectivity monitoring that reacts to landscape change as it happens.

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