Topological variables of habitat networks as predictors of species occurrence

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Biodiversity conservation requires modelling tools capable of predicting the presence or absence (i.e. occurrence-state; ψ) of species in habitat patches. Such magnitude is influenced by the quality of the patch (q_i), the cost of traversing the unsuitable landscape matrix to reach other patches (weighted connectivity; wc_i), and the position of the patch in the habitat network topology (nt_i).

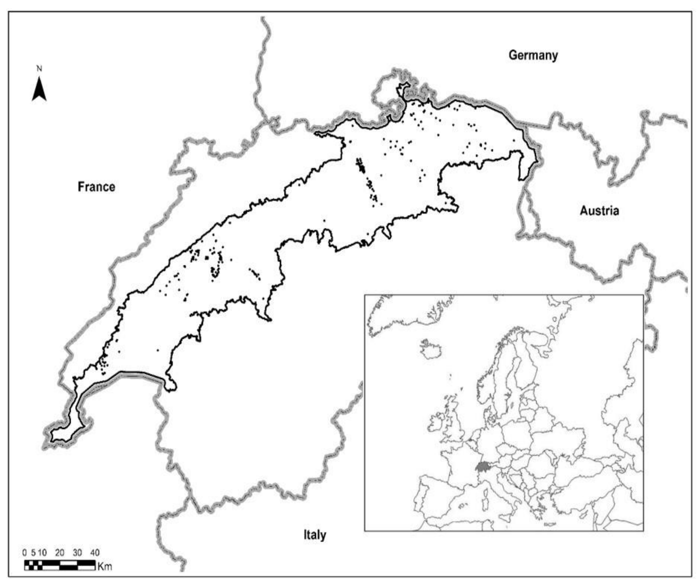
Existing approaches to predict occurrence-states are data demanding and costly, or consider only quality factors. Such shortcomings can be addressed with predictive habitat network models, but few studies have focused on their development.

We present a set of network-based models that use readily available presence-only records to predict species occurrence in habitat patches

$$\psi = f(q_i, wc_i, nt_i)$$

Conceptual equation showing the categories of variables that influence species occurrence-state

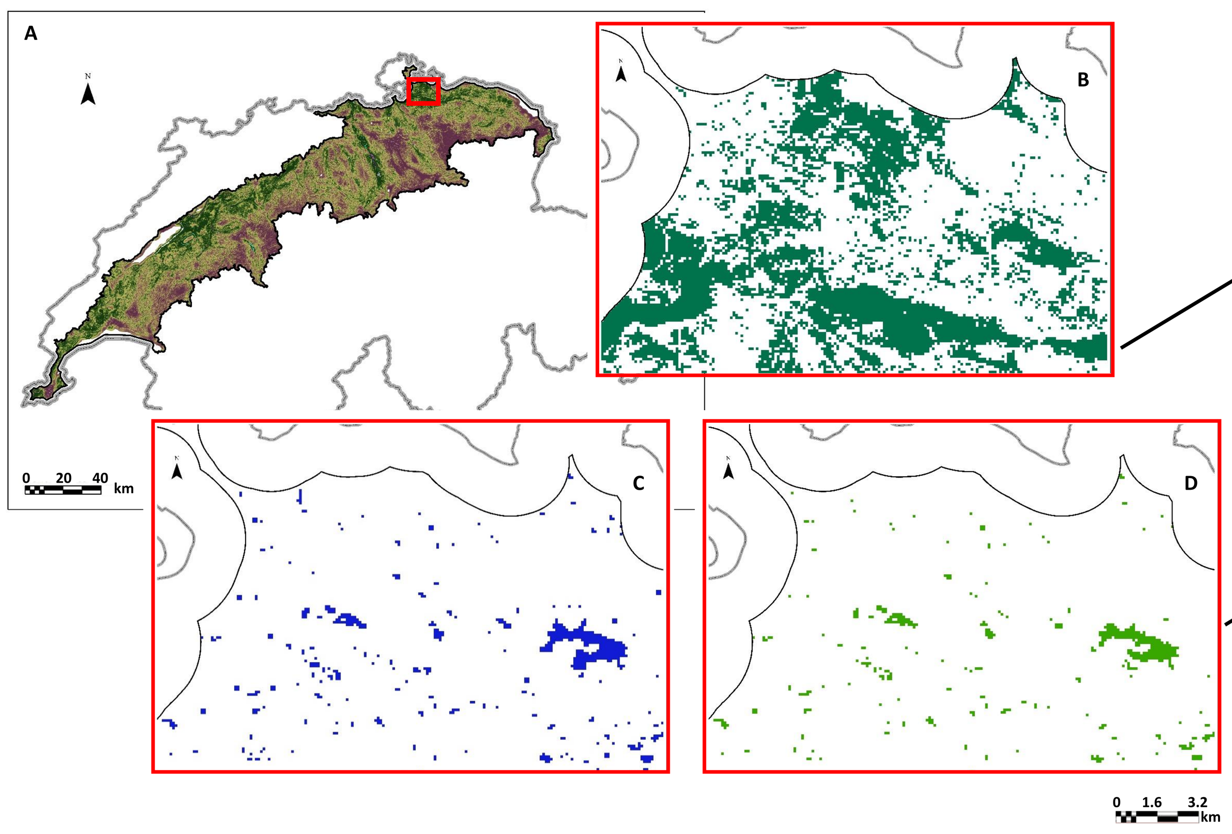
Our initial focal species: *Hyla arborea* L.



Study area: the densely populated Swiss Plateau

Methodological workflow

Habitat Suitability Modelling (HSM)
Mean ensemble of MaxEnt, Random Forest & GLM



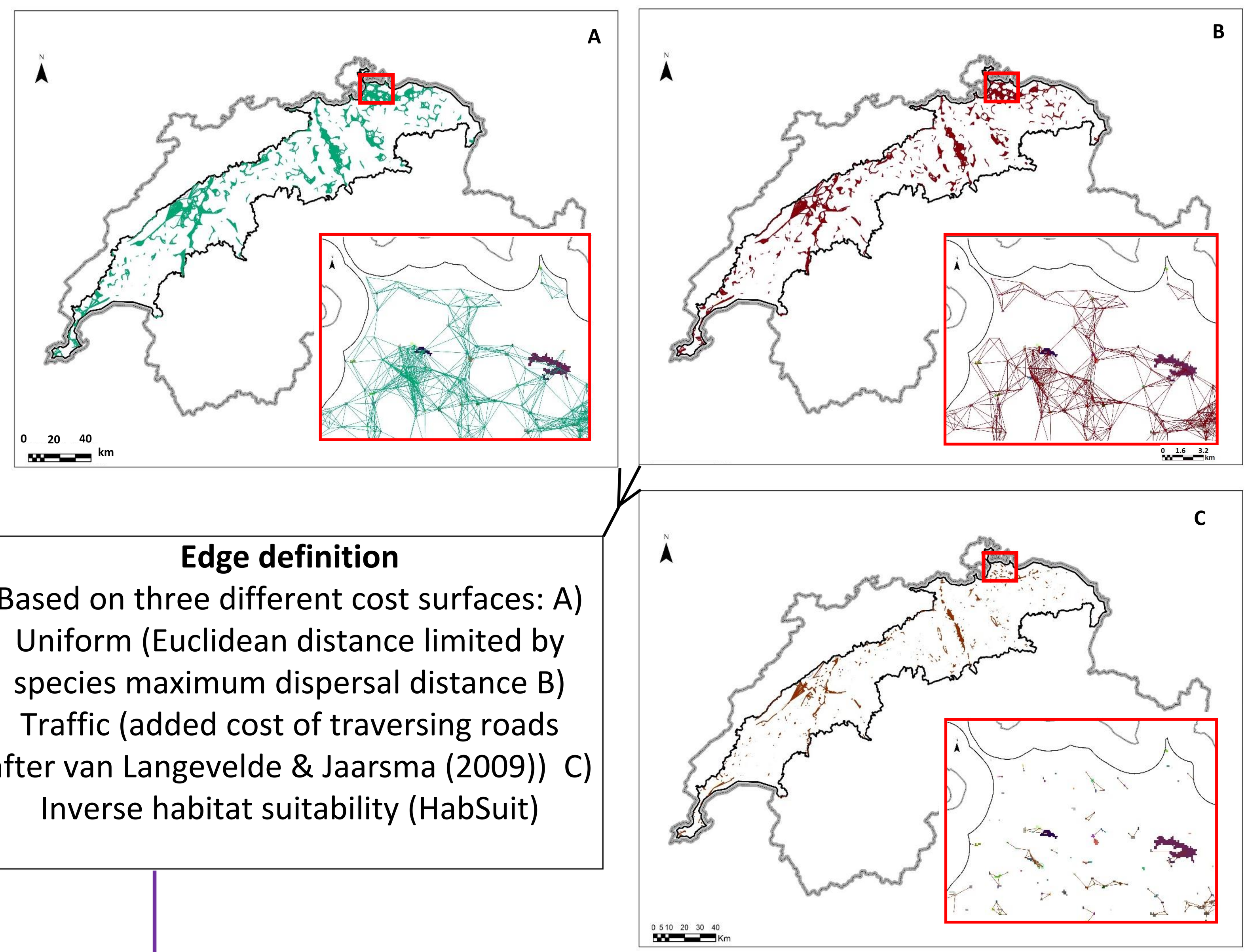
Continuous (A) and binary (B; close-up of red area in (A)) suitability maps yielded by the ensemble habitat suitability model for *H. arborea* on the Swiss Plateau. Discrete habitat patches (D) produced by the application of the mask (C). B, C and D are the same area in close-up.

Node delineation

- From the AUC-binarized output of the HSM
- The minimum Hab. Suit. Index taken as 'suitable' was 382
- Mask of water bodies

Edge definition

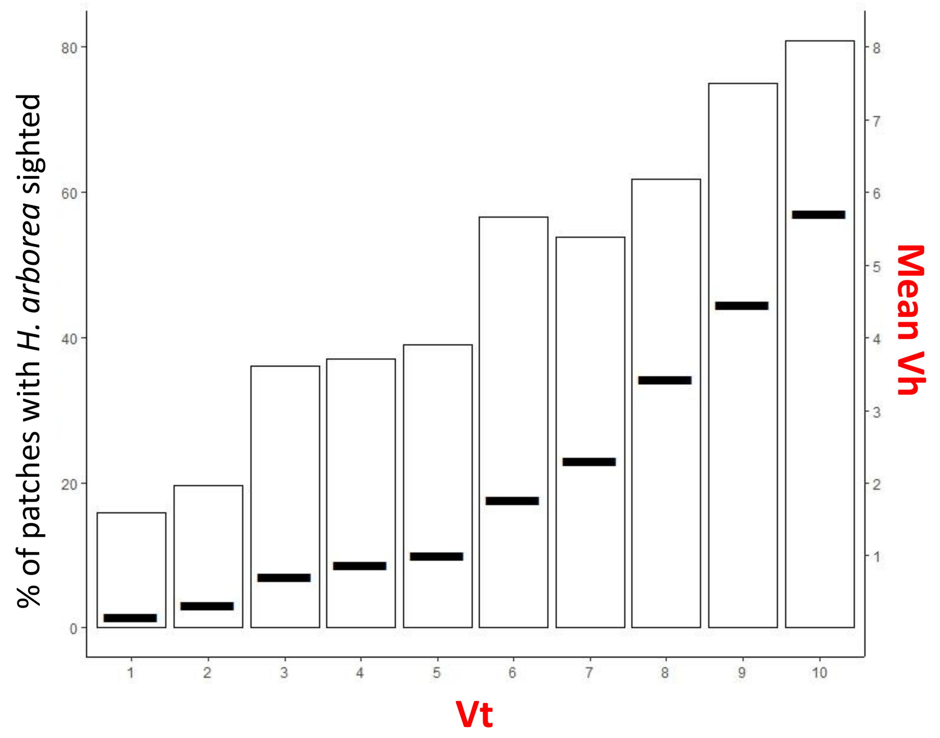
Based on three different cost surfaces: A) Uniform (Euclidean distance limited by species maximum dispersal distance B) Traffic (added cost of traversing roads after van Langevelde & Jaarsma (2009)) C) Inverse habitat suitability (HabSuit)



The different habitat networks of *Hyla arborea* on the Swiss Plateau with nodes and edges (and corresponding close-ups) based on three different cost surfaces: uniform (A), traffic (B), inverse habitat suitability (HabSuit; C)

Absence determination

Parametrization of the response variable (occurrence-state). Determination of absences based on comparative sampling intensity considering a threshold of visits to a patch (Vt) determined by observations of other amphibian species



Sampling-intensity-based absence definition. Vt: Number of times a patch was visited. Vh: Number of times the focal species is recorded (horizontal black lines). For *H. arborea,* when Vt ≥ 5 and Vh = 0, species is declared absent from a patch.

Predictor calculation for evaluation of the network models

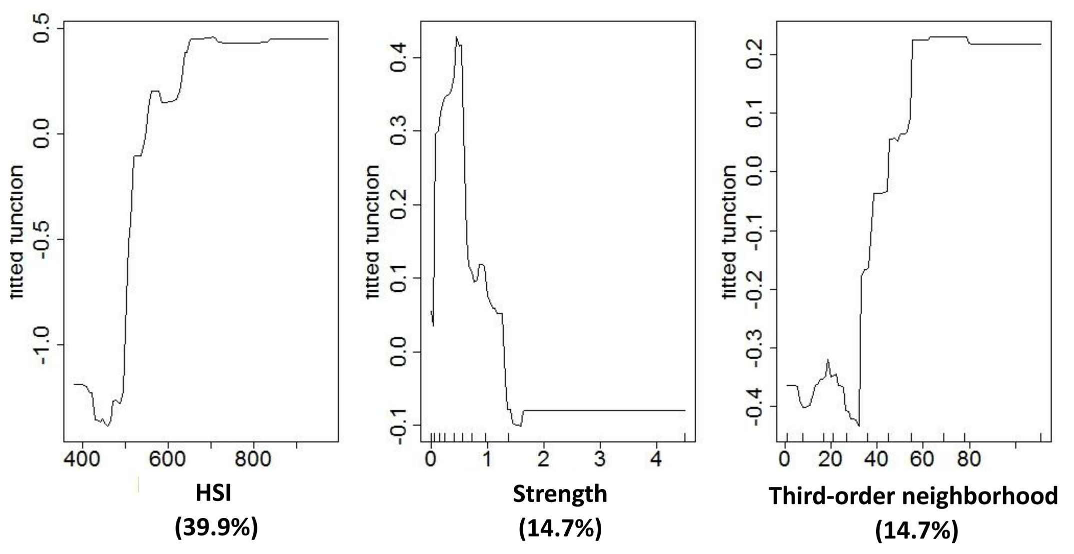
Category	Predictor
nt	Degree
nt	Third-order neighborhood
nt	Betweenness centrality
wc	Strength
nt & q	Habitat Availability
q	Habitat Suitability Index
q	Patch area

Model fitting

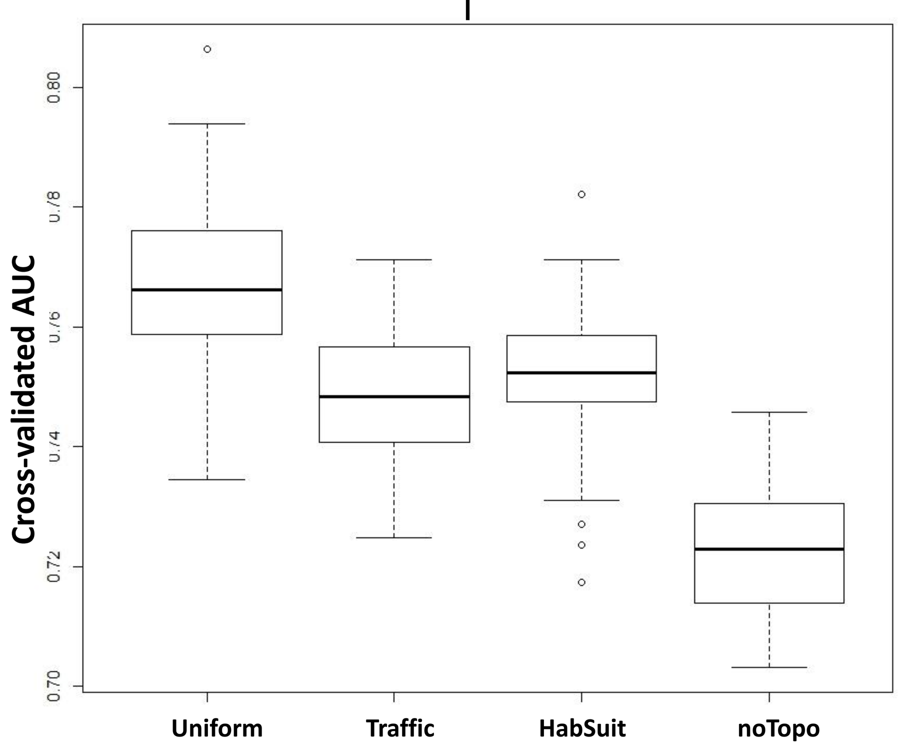
Fitting of the three network models (uniform, traffic, HabSuit), and a model without topological predictors (noTopo) with 100 runs of boosted regression trees

Mean relative importance of seven predictors over 100 runs of boosted regression trees (BRTs) for the four models (Uniform, Traffic and HabSuit networks, noTopo) for occurrence-state of Hyla arborea in the Swiss Plateau

Predictor	Mean relative importance Uniform	Traffic	HabSuit	noTopo
Habitat Suitability Index (HSI)	37.72	44.20	50.21	83.65
Strength	15.29	12.15	8.90	-
Third-order neighborhood	13.76	18.76	14.98	-
Betweenness centrality	11.10	5.02	2.38	-
Degree	8.93	5.81	0.64	-
Habitat availability	7.82	8.15	15.65	-
Patch area	5.34	5.87	7.21	16.34



Partial dependence plots of the three most important predictors over 100 runs of boosted regression trees (BRTs) for the best performing model (uniform) for occurrence-state of *H. arborea* in the Swiss Plateau



Distributions (Boxplot, above) and mean value (table, below) of the cross-validated AUC scores over 100 runs for four models (Uniform, Traffic and HabSuit networks, noTopo) for *H. arborea* presences in the Swiss Plateau

	Uniform	Traffic	HabSuit	noTopo
Mean Cross-validated AUC	**0.7668**	**0.7486**	**0.7524**	**0.7229**

Discussion

- Topological variables are important for the determination of occurrence-state of a species in habitat patches
- Habitat suitability index as the most important variable also indicates (see partial dependence plots) a possible use of this kind of models to fine-tune HSM
- Third-order neighborhood, as the most consistent topological variable (always above 13%) indicates the scale at which the topology of the network is ecologically relevant for occurrence
- Patch size was consistently at the bottom of the variable importance, which contradicts habitat amount hypothesis (Fahrig & Triantis, 2013)
- Cost surface definition influences what kind of variables are more important to predict occurrence-state

Perspectives:

- Incorporating multiple species for conservation management
- Add time dimension, dynamic influence of adjacent patches
- Generic approach, application in different contexts

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van Langevelde, F. & Jaarsma, C.F. (2009) Modeling the Effect of Traffic Calming on Local Animal Population Persistence. *Ecology and Society*, 14, 39.