Unmarked: DYNAMIC HIERARCHICAL MODEL FOR THE EURASIAN GOLDEN JACKAL (*CANIS AUREUS*) OCCURENCE IN SLOVENIA

Authors: Rudi KRAŠEVEC[1* Msc], Maja KAJIN[1 Phd] and Hubert POTOČNIK[1 Phd]

[*] rudi.krasevec1@gmail.com

[1]University of Ljubljana, Biotechnical faculty, Department for Biology

How it started …

- First observations in mid 1950's

- Rising number ob observations

- First confirmed territorial pack in 2009

- Colonization from two directions

(A)   (H)   (I)   (HR)

Ljubljana

○ 1950's
○ 1980's
○ 2000's

Image data: Krofel 2008.

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.
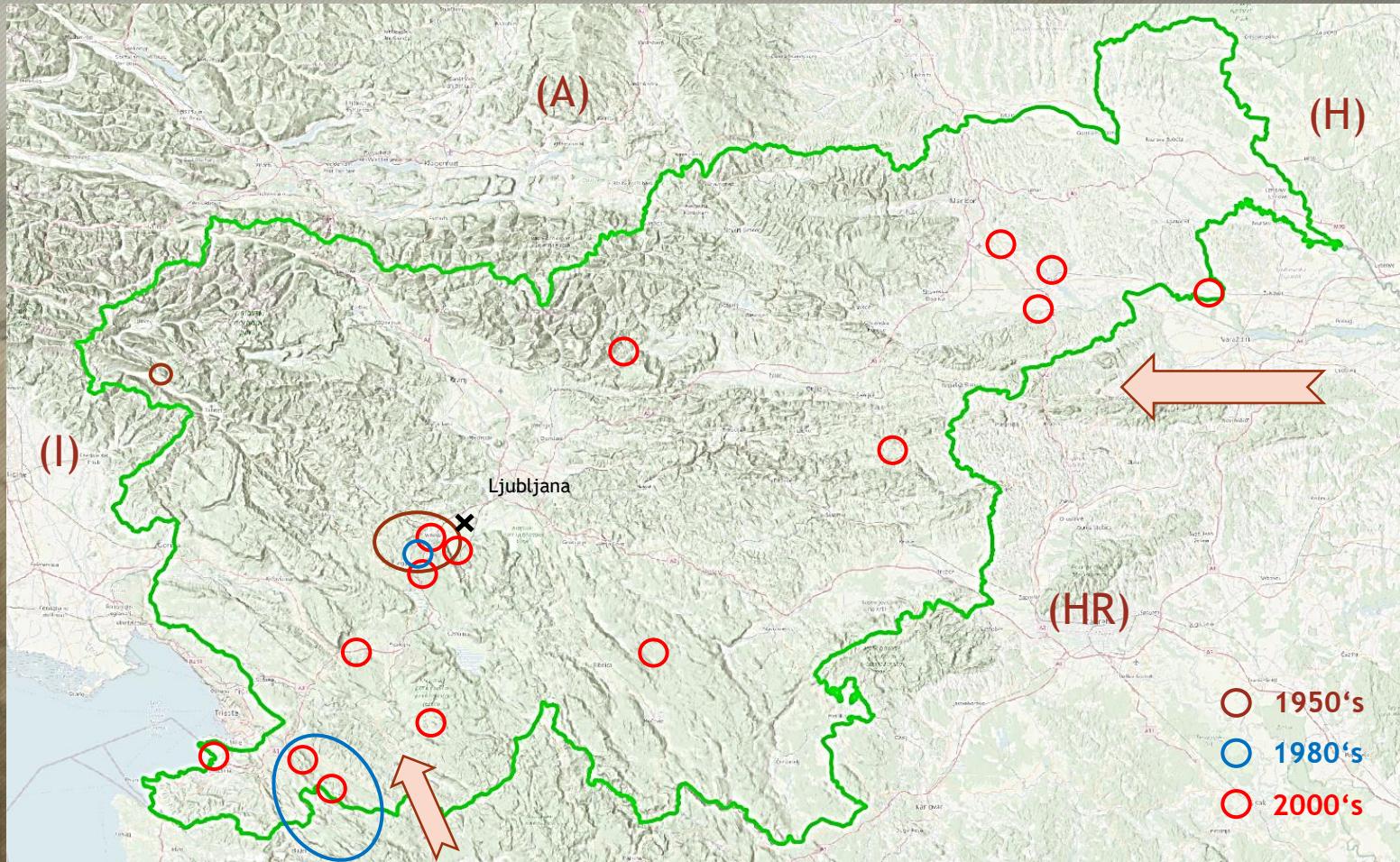
... and how it's going.

- Estimated 250 teritorrial packs in 2018

- Widespread in Slovenia (Monitoring data collected)

(A) (H) (I) (HR)

Ljubljana

Why and how?!
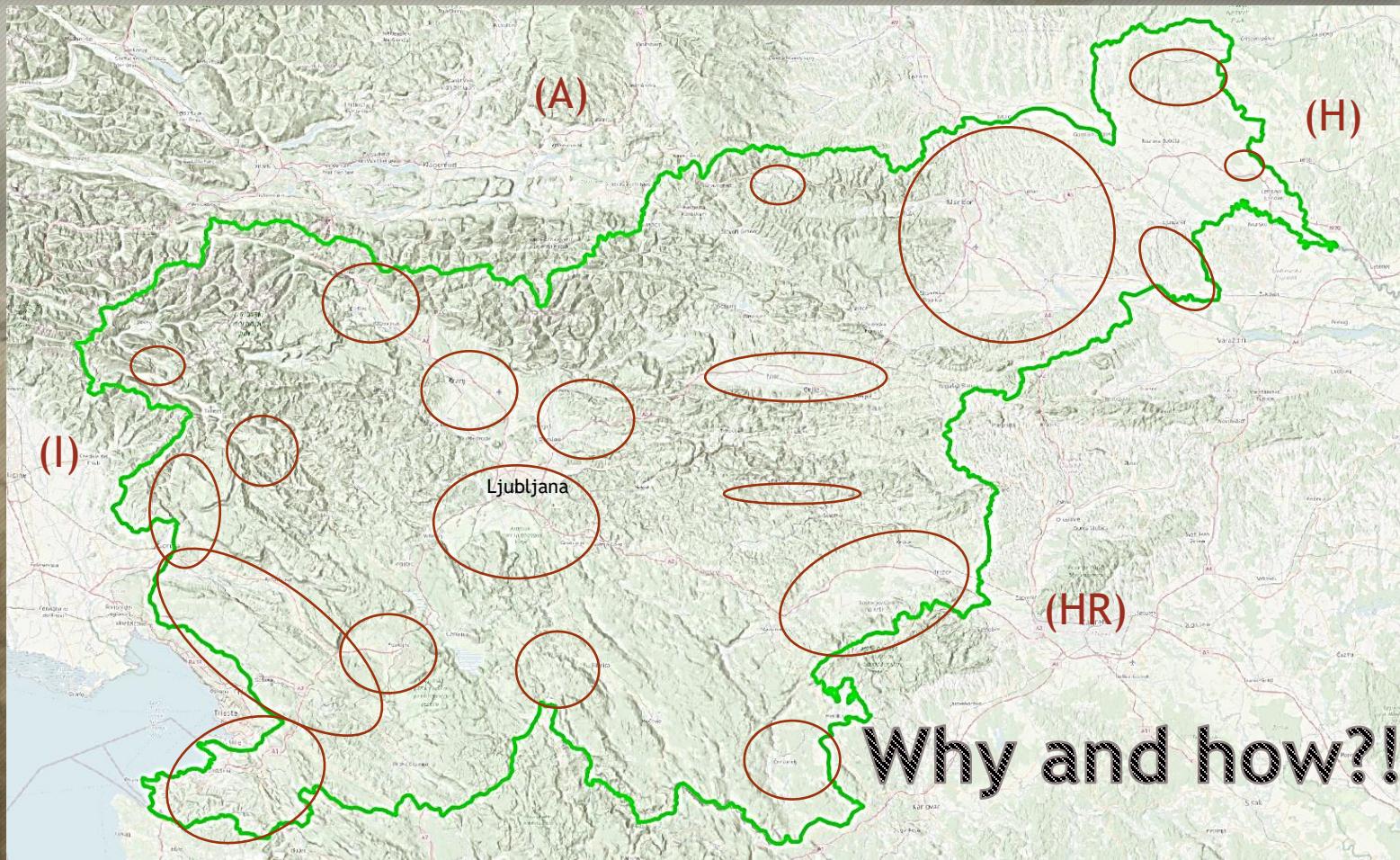
Image data: Potočnik et al. 2018.

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

Occupancy models
By MacKenzie et al. 2003

SAMPLING SITE

? This sampling site is occupied (STOP)

? This sampling site is vacant (GO)

Point pattern:
Intensity = 0.5 , M = 114 inds.

Abundance pattern:
Realized mean density = 1.78
**Spatial variance = 1.86**

Occurrence pattern:
Realized occupancy = 0.83

Image source: Kery & Chandler 2016
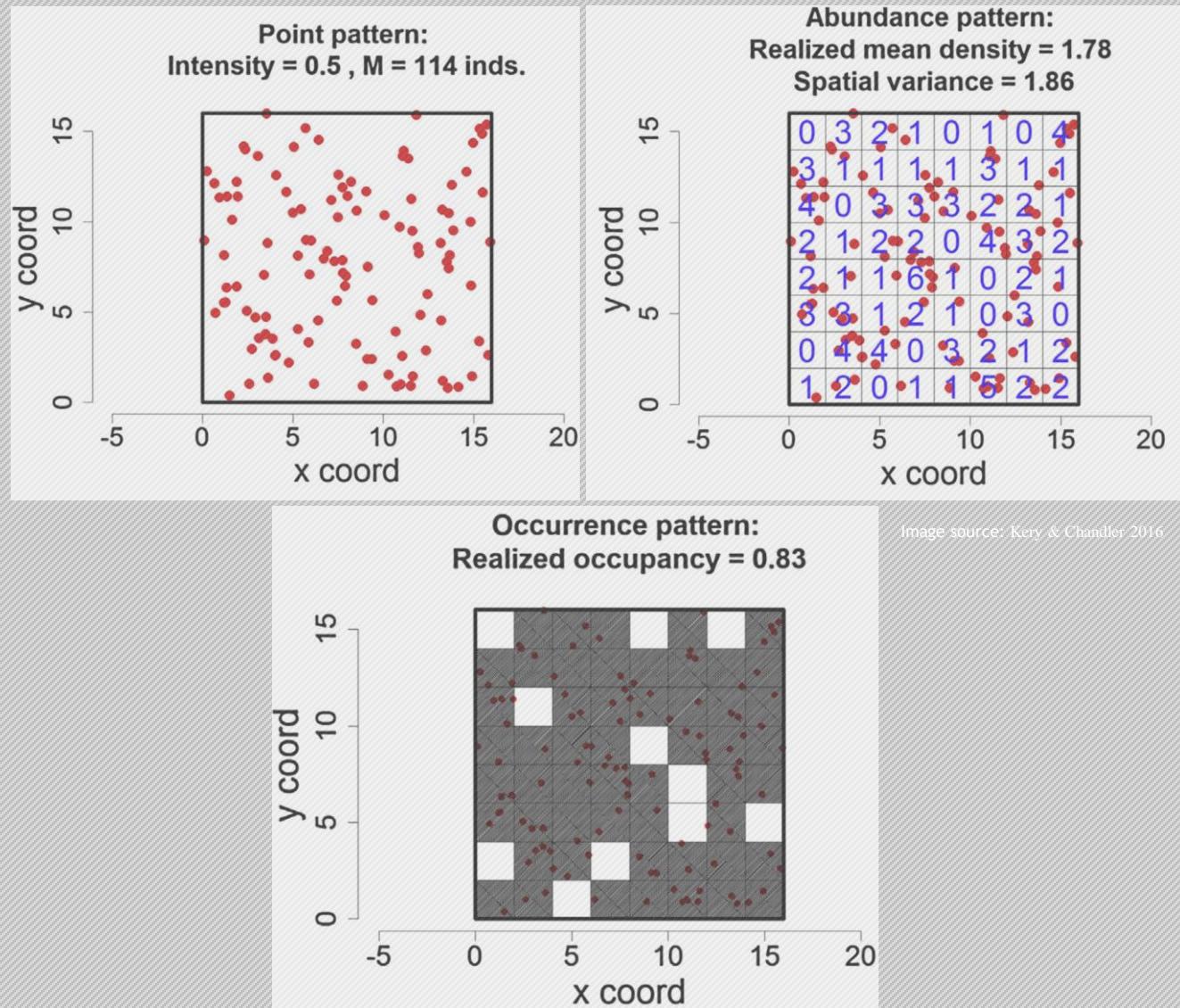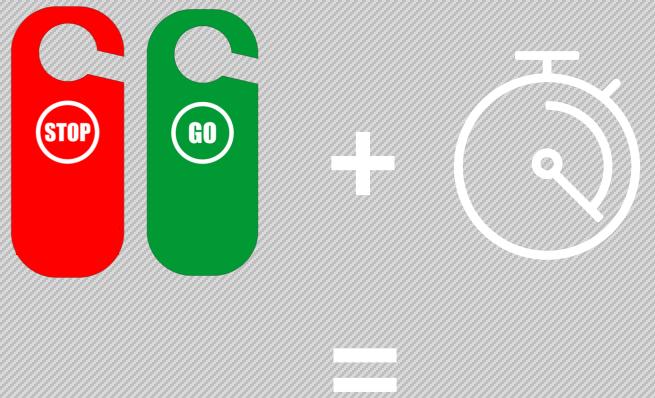
Dynamic occupancy models
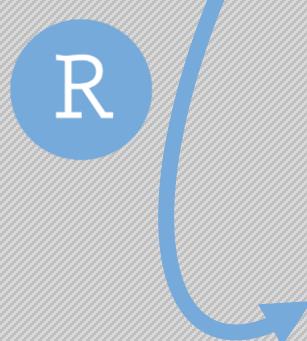
Unmarked: colext (Fiske & Chandler 2011)

Why the change?

	Year 1			Year 2			Year 3			...	t
	Obs1	Obs2	Obs3	Obs1	Obs2	Obs3	Obs1	Obs2	Obs3	...	j
Site1	0	0	0	0	0	0	0	0	0	...	t,j,1
Site2	1	0	0	0	0	0	0	0	0	...	t,j,2
Site3	0	0	1	1	1	0	0	0	0	...	t,j,3
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Site$_i$	1,1,i	1,2,i	1,3,i	2,1,i	2,2,i	2,3,i	3,1,i	3,2,i	3,3,i	...	tji

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

Dynamic occupancy models
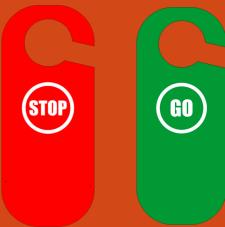
1. Detection probability (*d*)

2. Initial occupancy (*ψ1*)

3. Local extinction prob.*ε*, or survival (*φ* = 1 – *ε*)

4. Colonization prob.(*γ*)
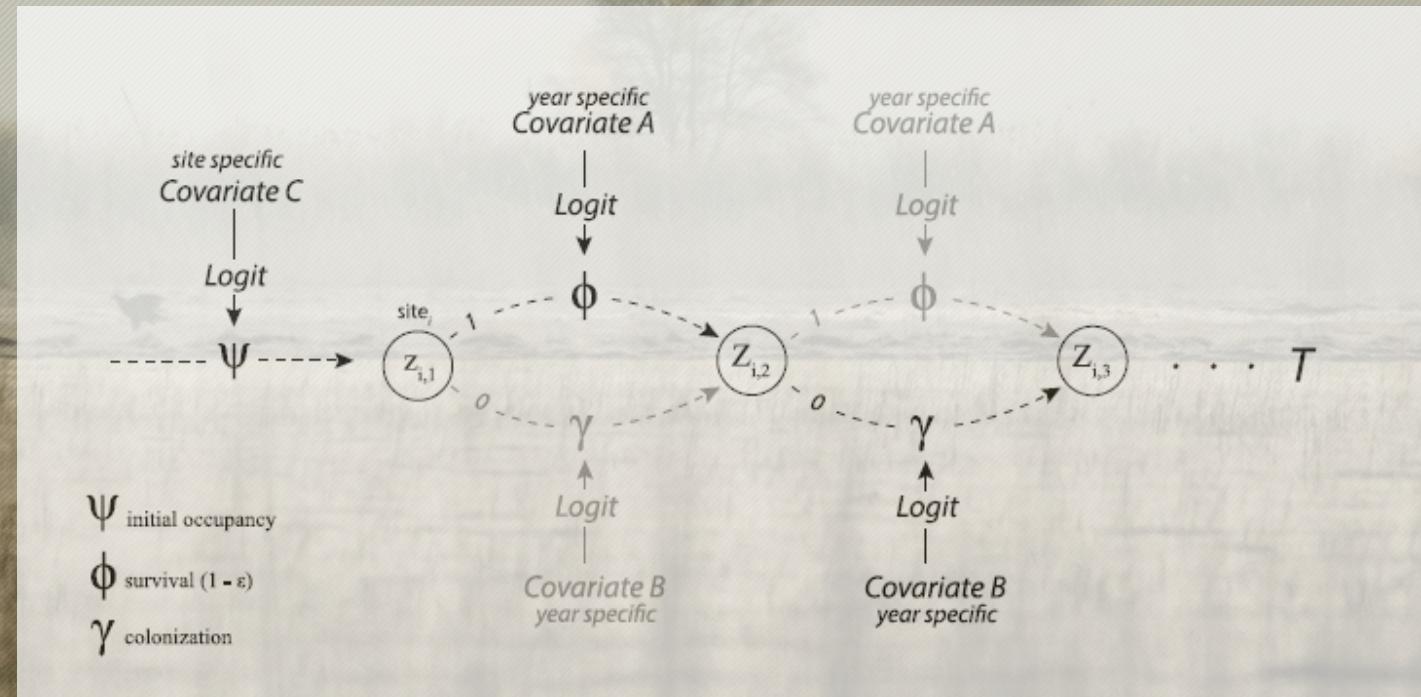
Image source: Hedlin & Franke 2017

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

Data

- National Jackal Monitoring Programme.
- Collected in Hunters information system (LISJAK).
- 1541 data on jackal presence and absence.
- Mostly howling obeservations.
- In the time interval from 28. 2. 2017 to 1. 3. 2019.

lovski
informacijski
sistem

Lisjak

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

3 x 3 km squares (415)

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.
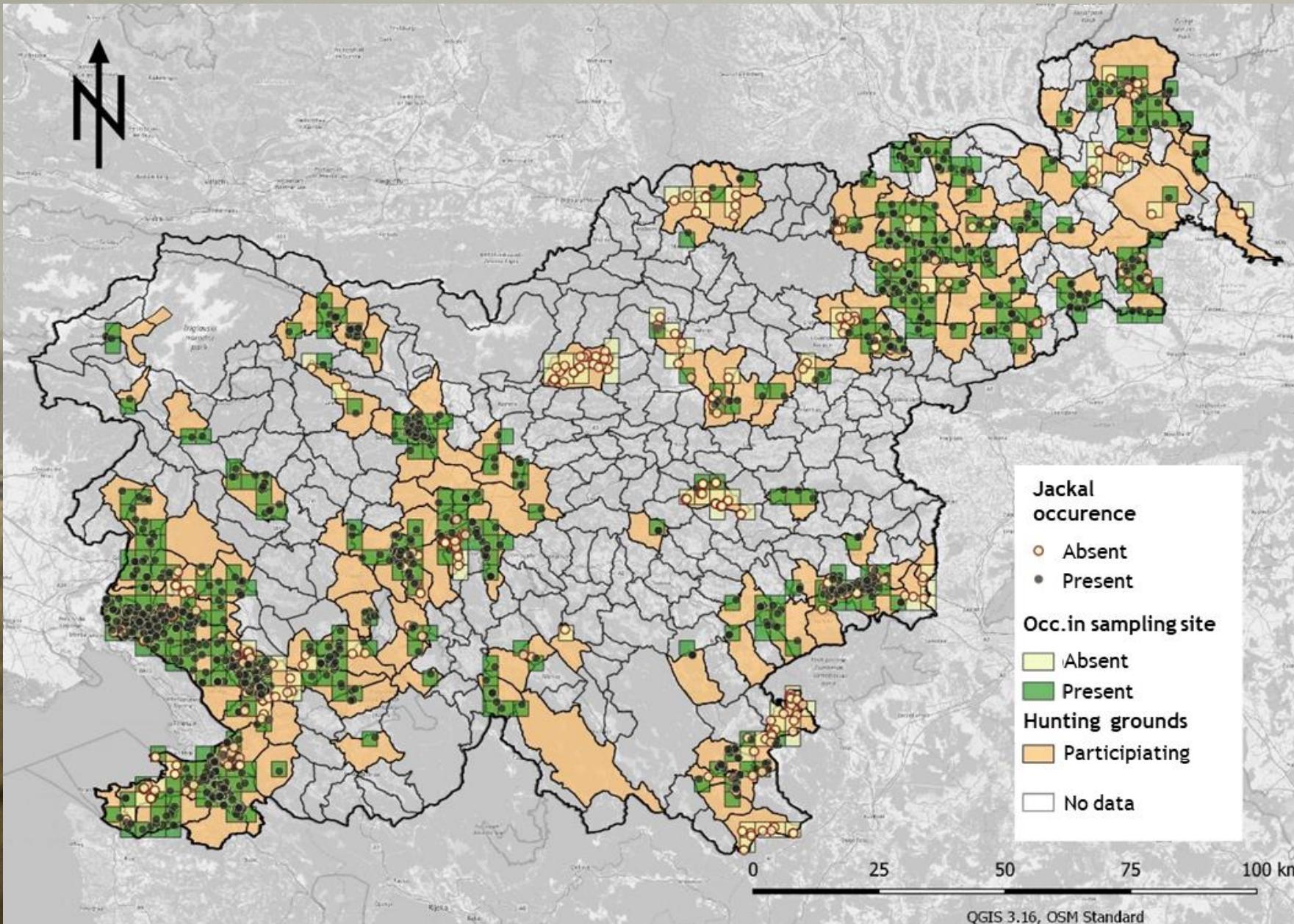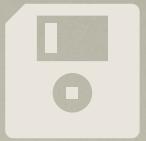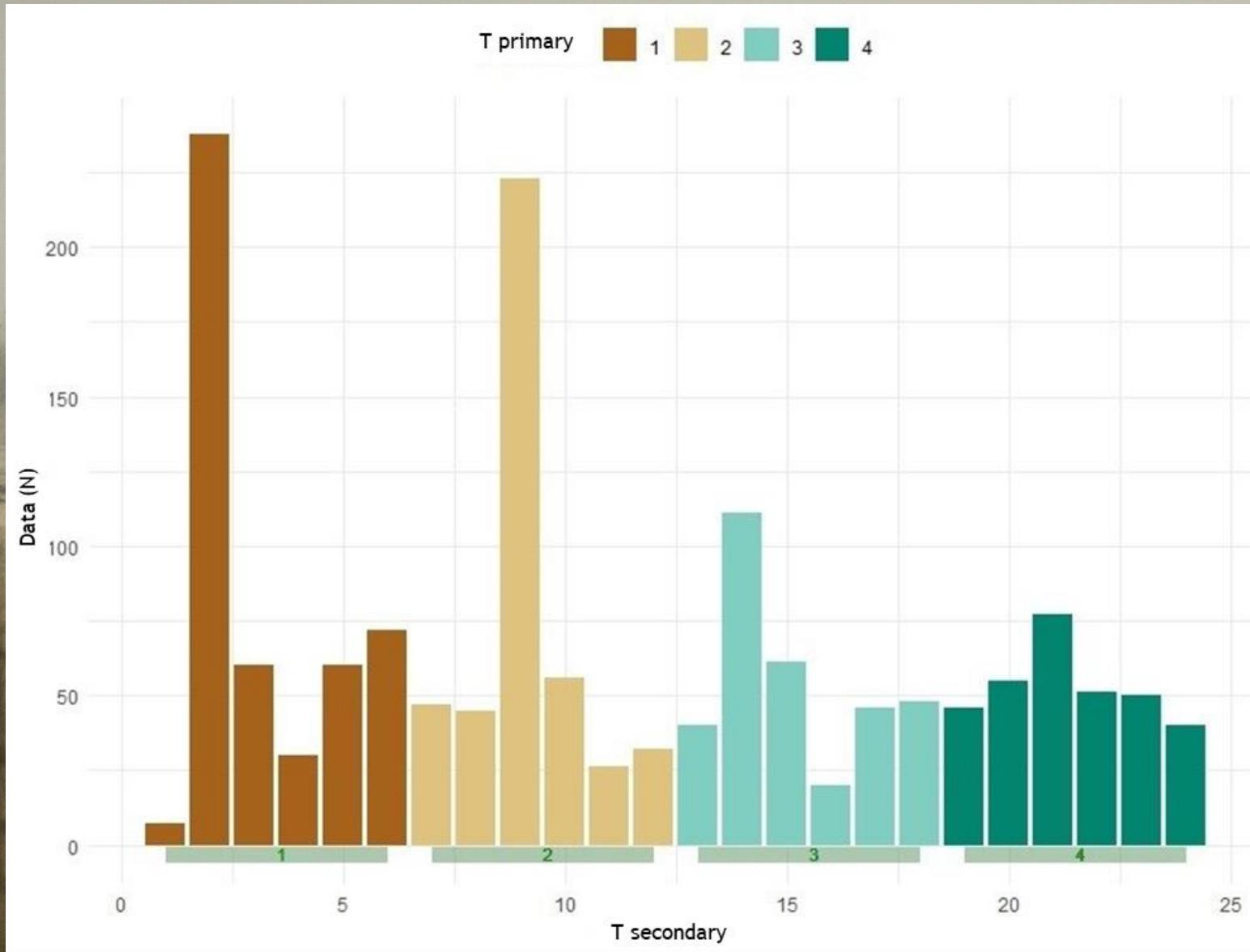
Collected in time intervals:
– T primary - months (24),
- T secondary - seasons (4)

Environmental variables

Static		
Altitude	Average	Slope
	Range	
Forest	Coverage	Settlemnt. distance
	Fragmentation	
Snow	Annual average	
	Avg. Mar - Aug	
	Avg. Sep - Feb	

Dynamic
Monthly snow cover duration

Kraševec et al. 2022. *Unmarked*: Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.
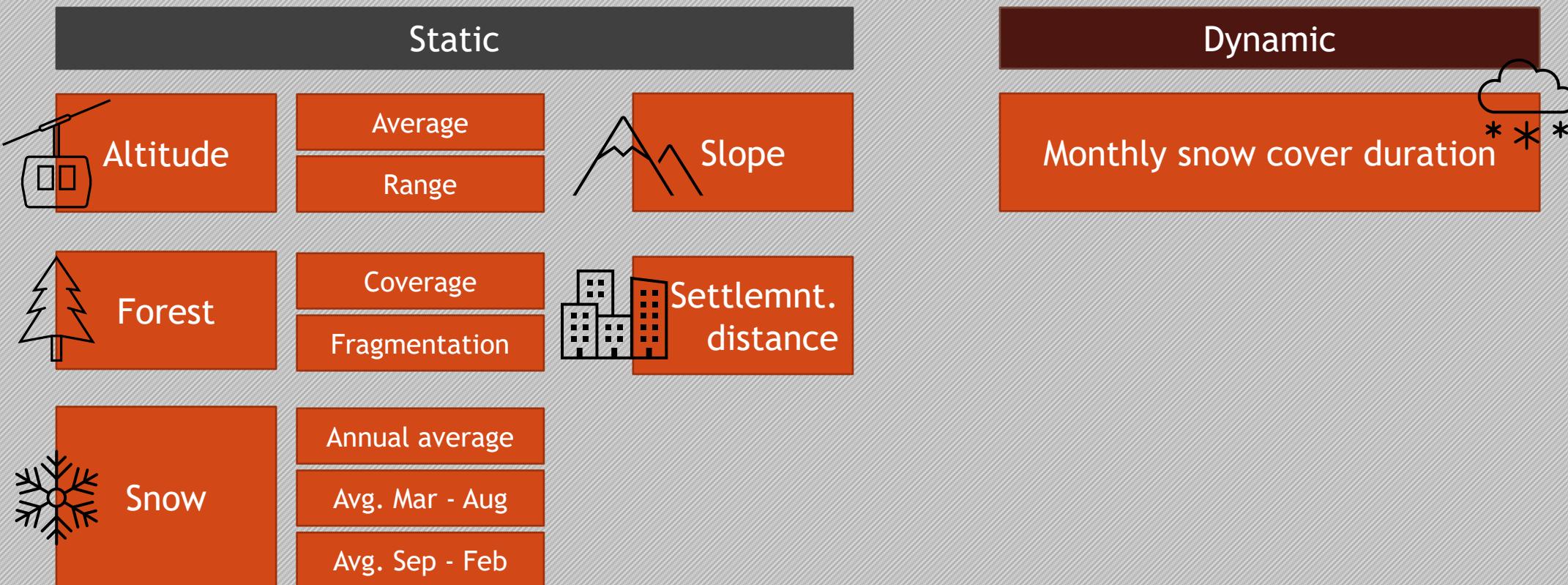
Selection process
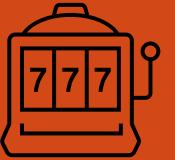
- Candidate set of biologically plausible models and selcting the one that best represented the data using Akaike's information criterion corrected for small sample sizes (AICc).

- Extrapolation of best model on national scale.

- Change of parameter values for 2050 Climate projections.

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

Detection probability (*d*)
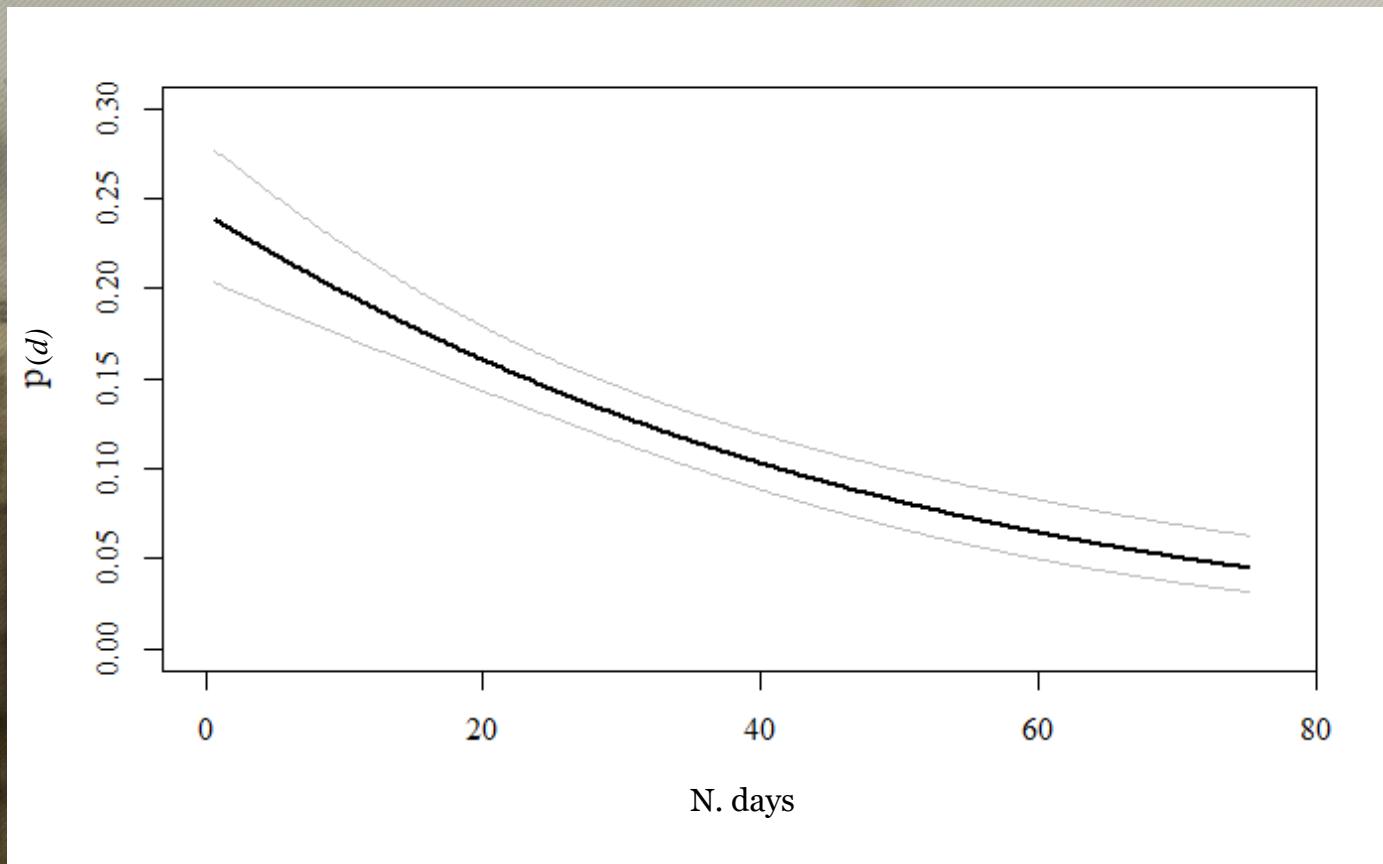
Snow cover duration from September till March

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

Detection probability(*d*)

Current

Change in 2050

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.
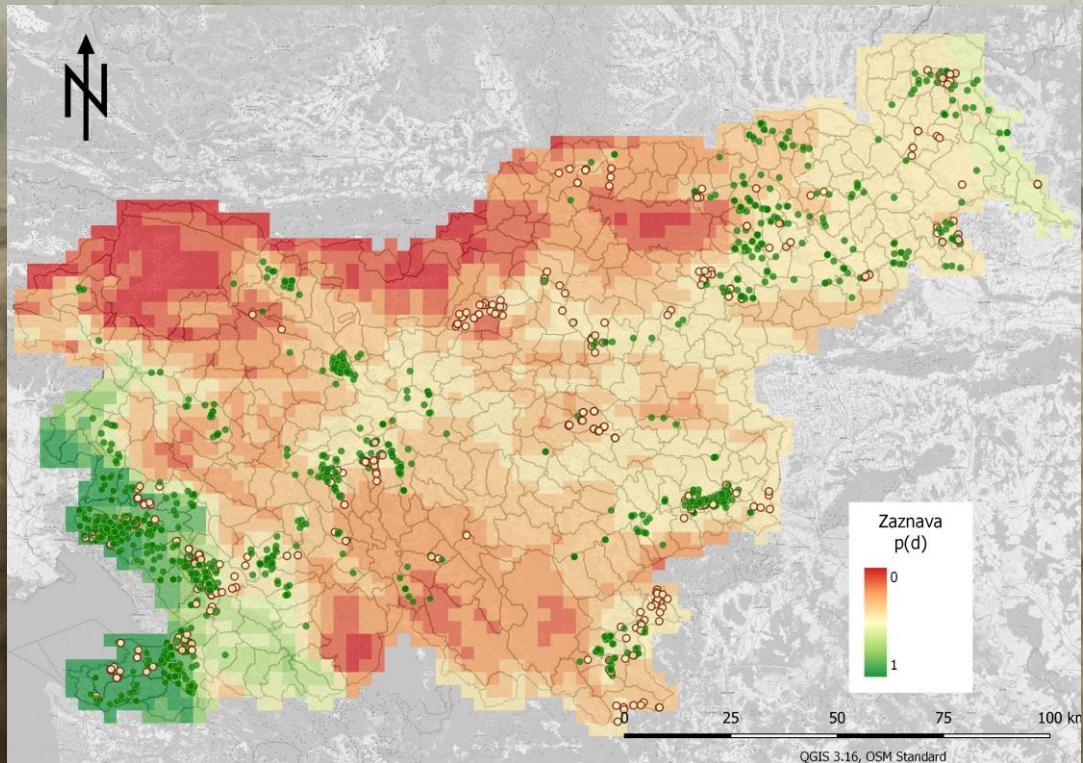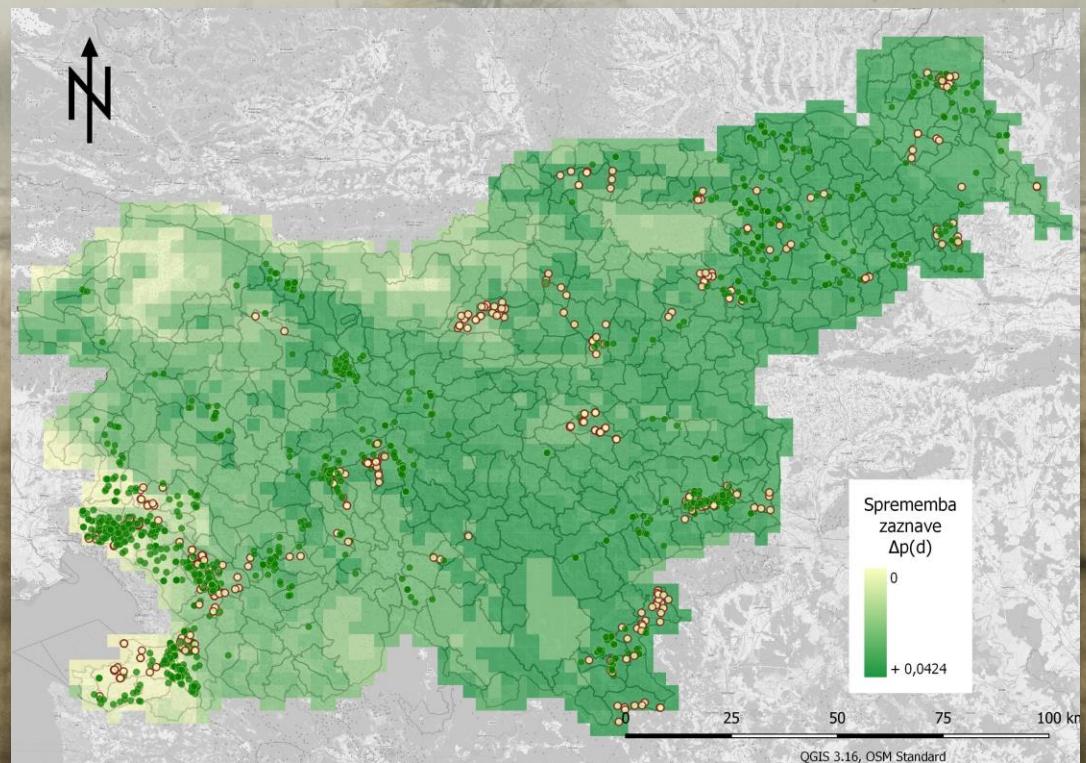
Initial occupancy (*ψ1*)
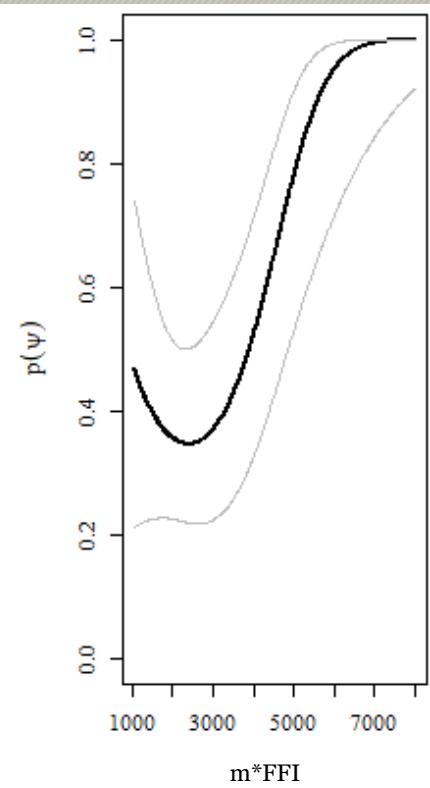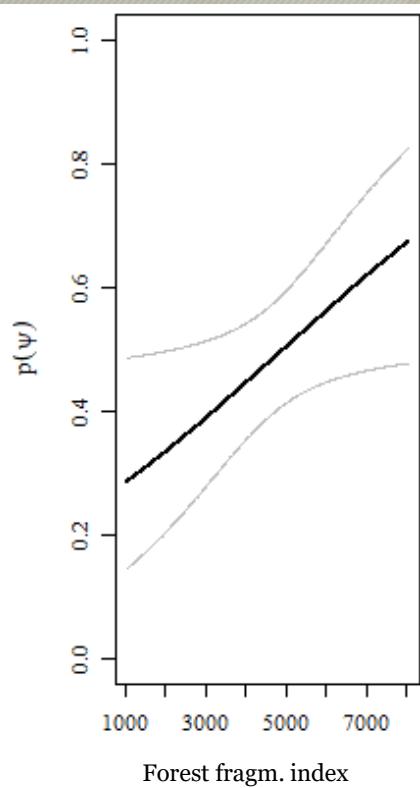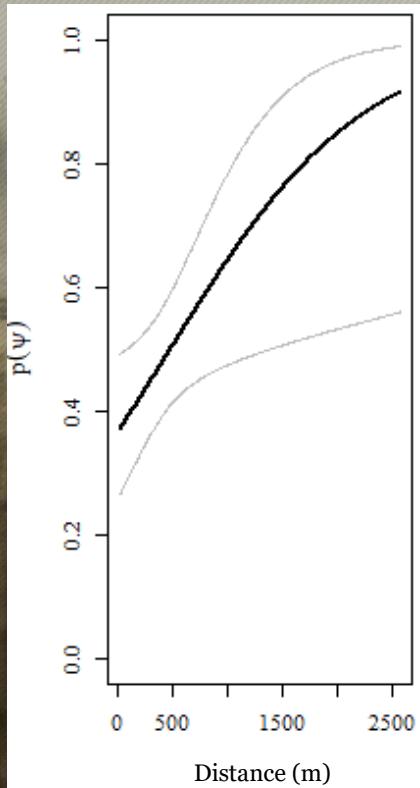
Distance from settlement*forest fragmentation index

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

Initial occupancy (*ψ1*)

Current

Change in 2050

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.
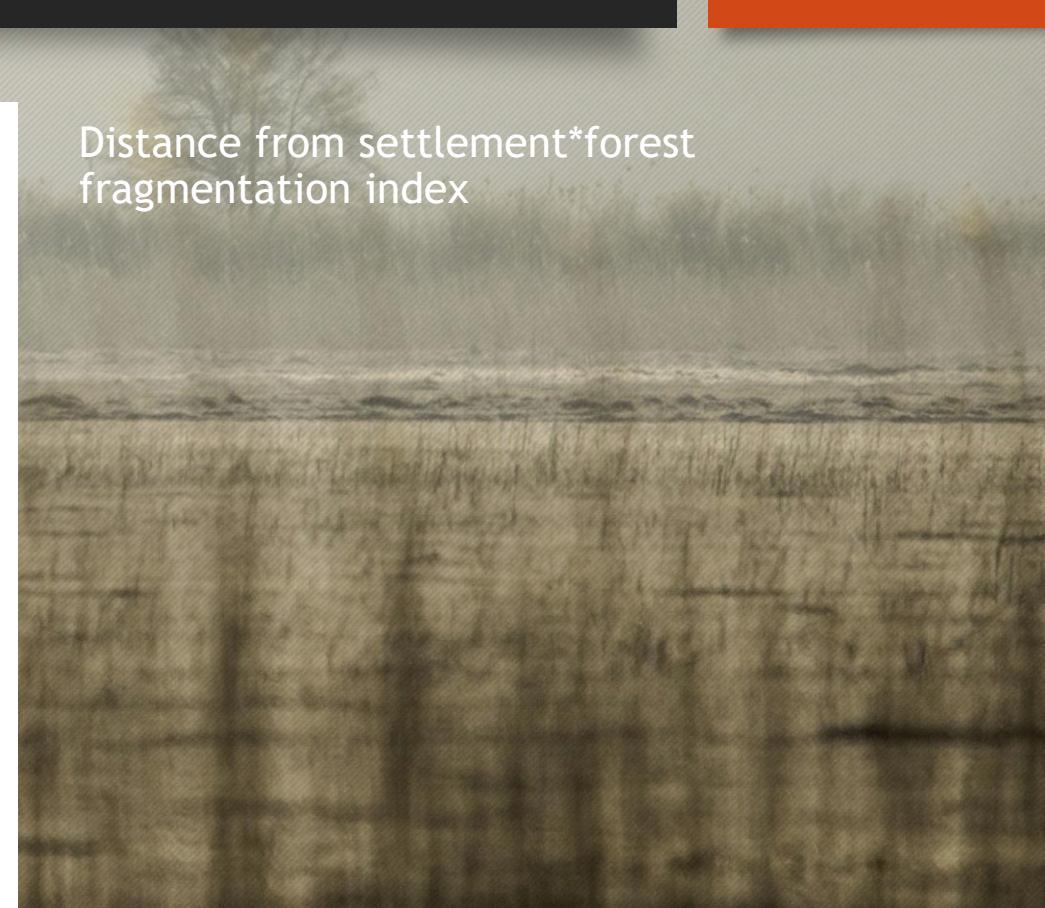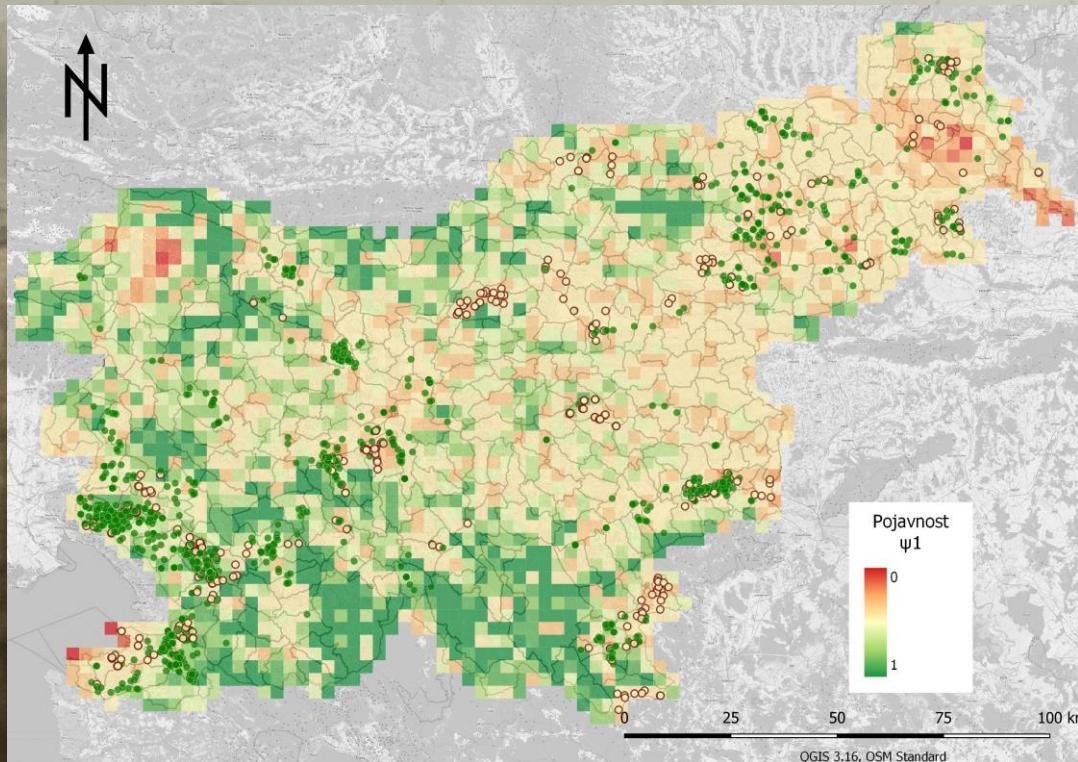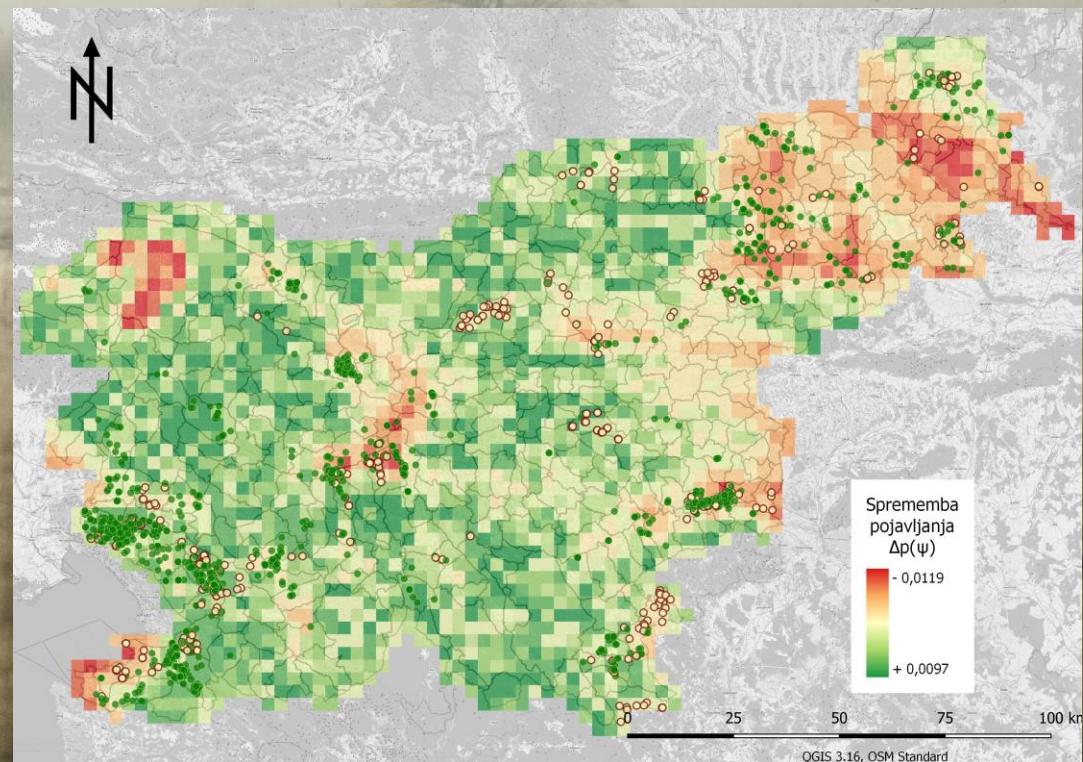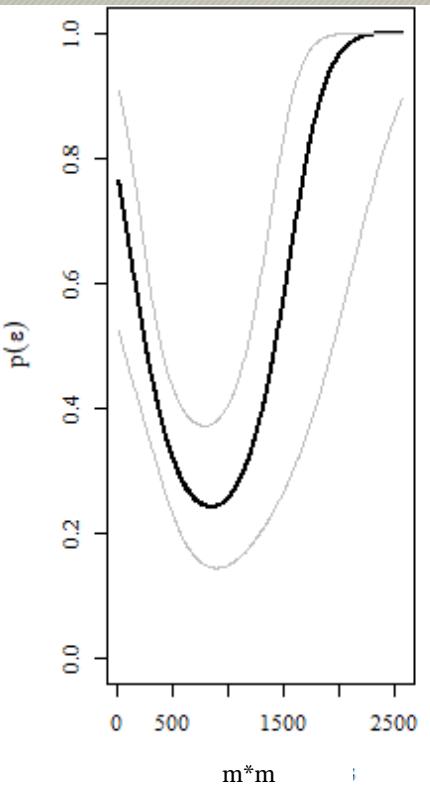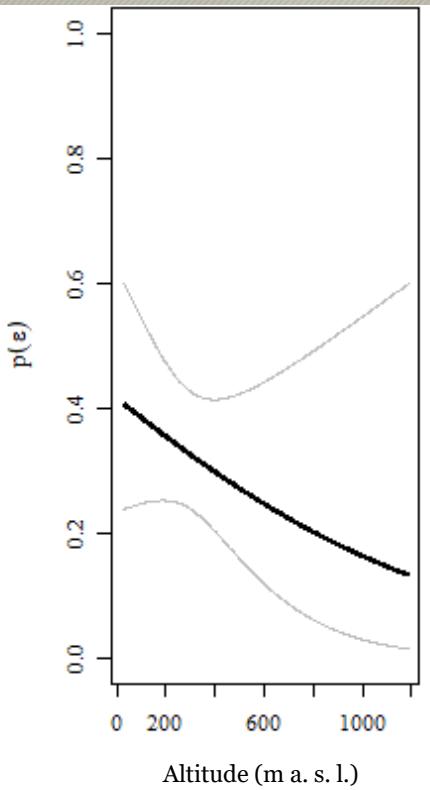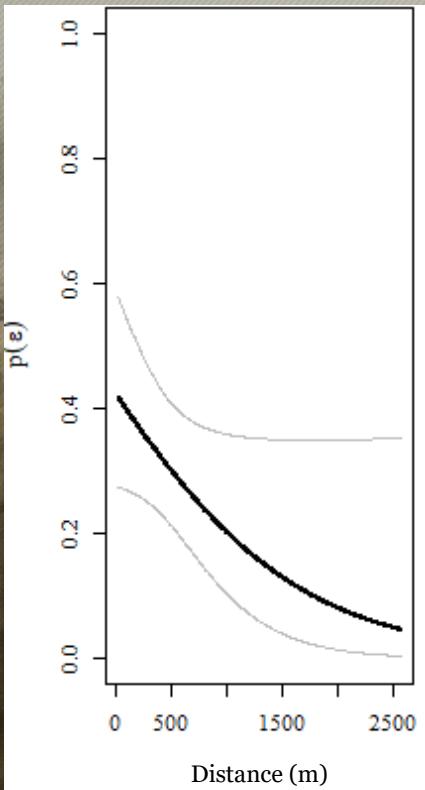
Local extinction (ε)

Average altitude*Settlement distance

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

Local extinction (ε)

Current

Change in 2050

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.
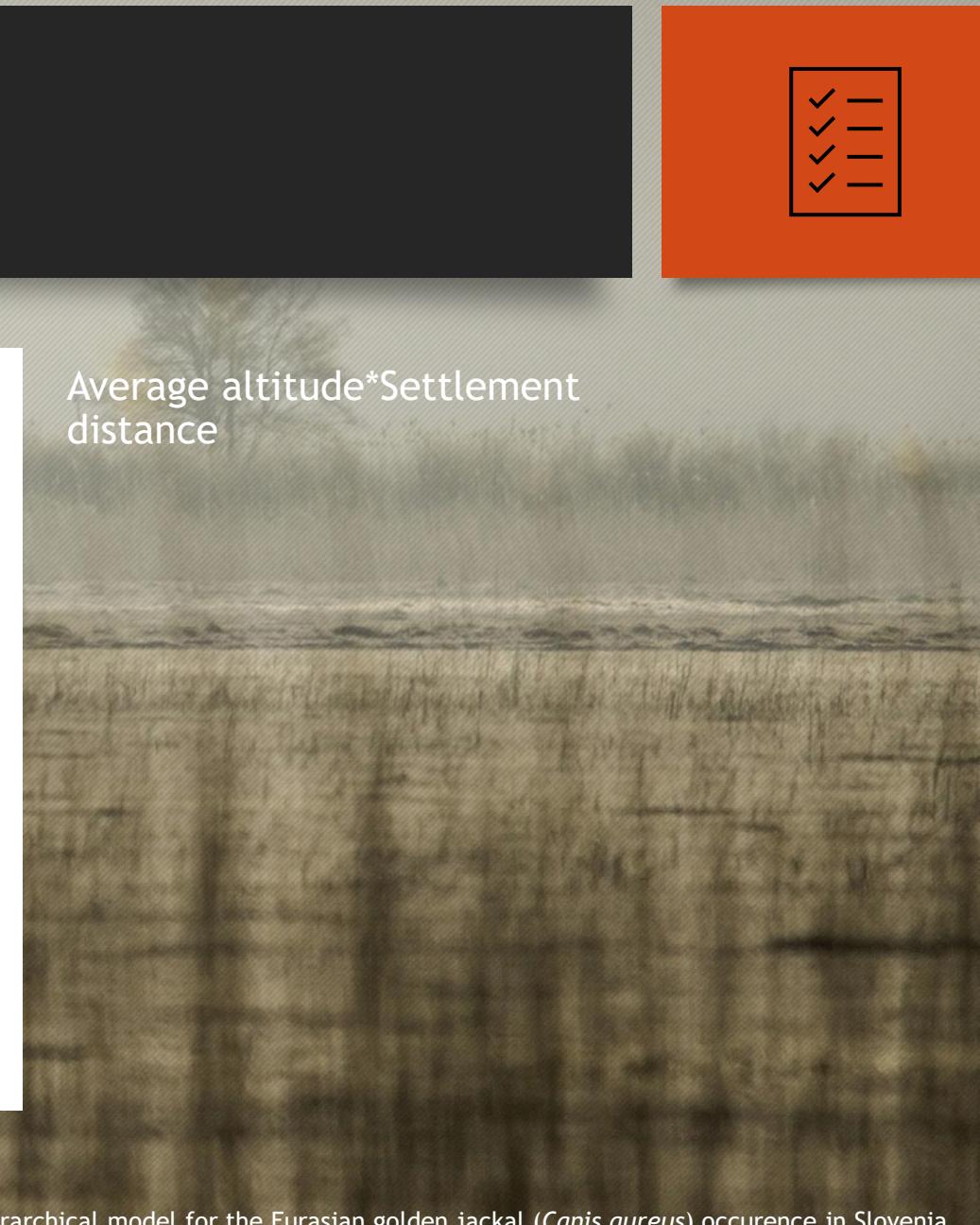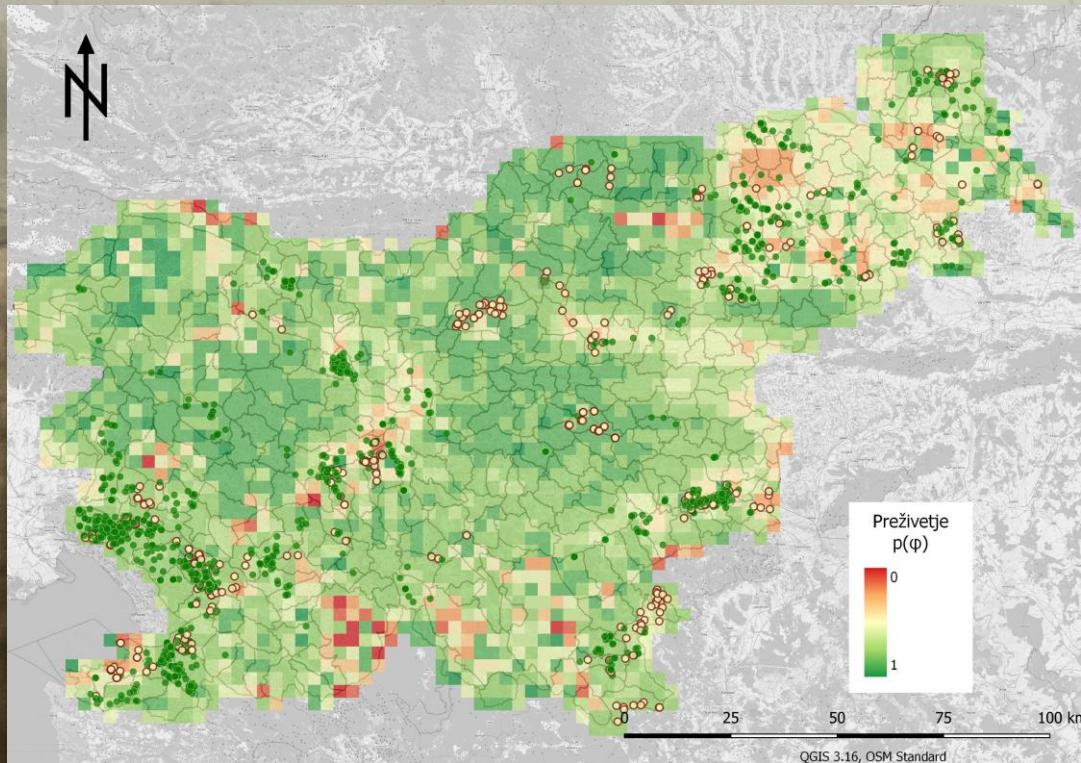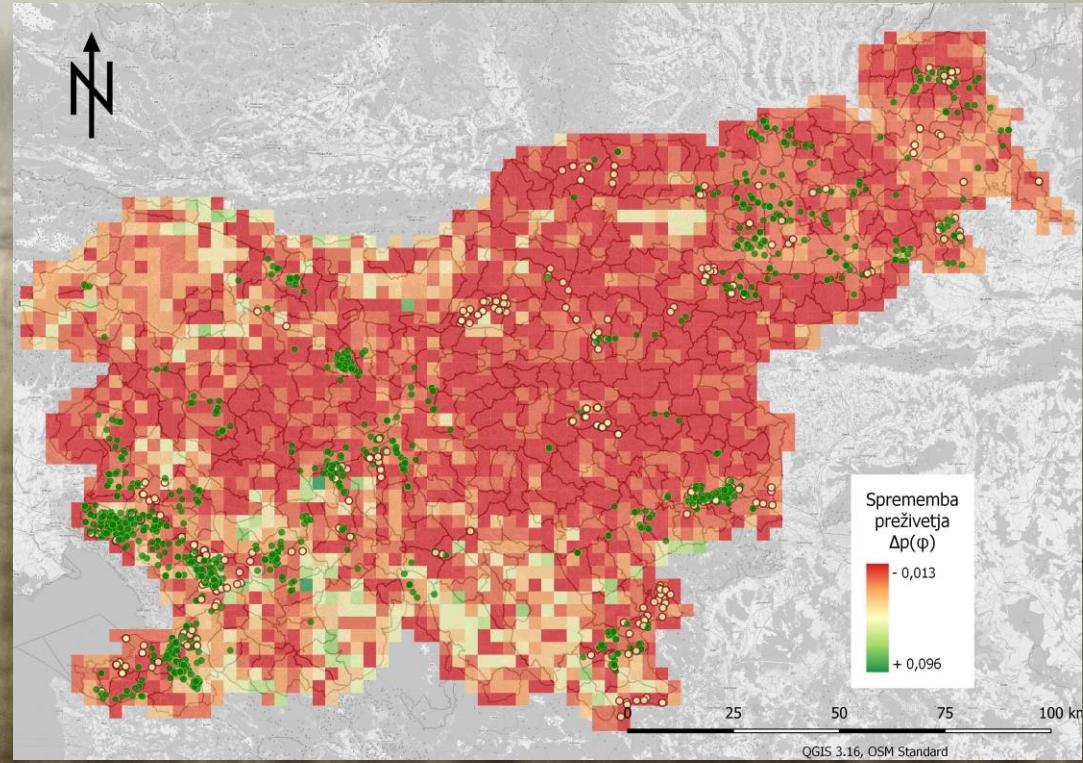
Colonization (*γ*)

- *indeks fragmentiranosti gozda*povprečen mesečni čas trajanja*
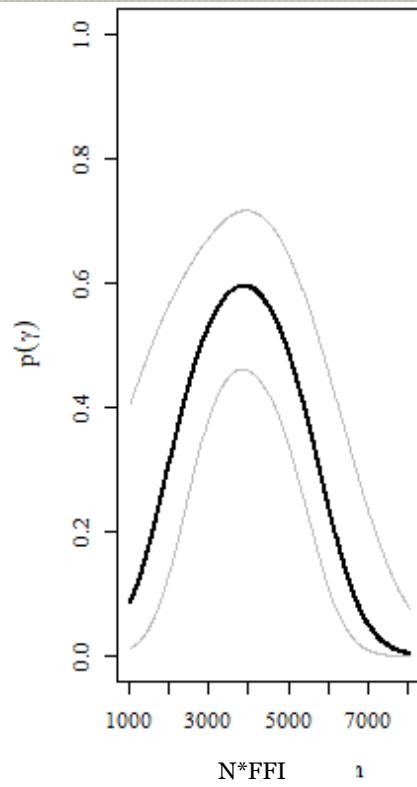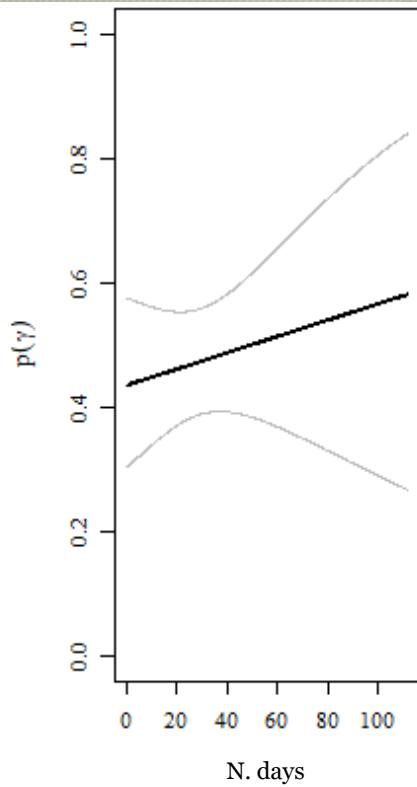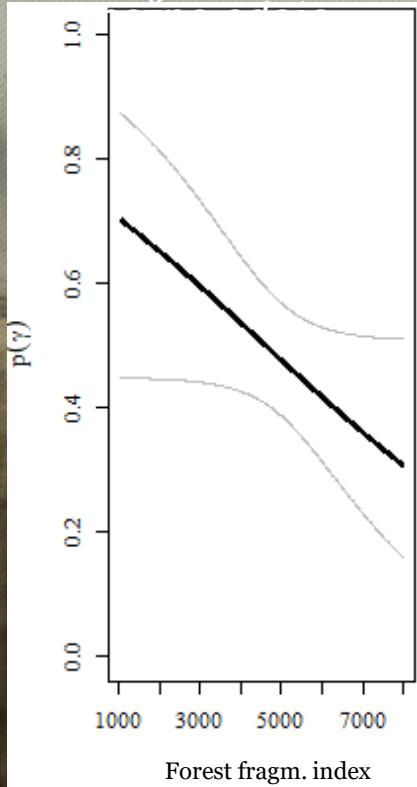
Forest fragmentation index*average annual snow cover duration

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

Colonization (γ)

Current

Change in 2050

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.
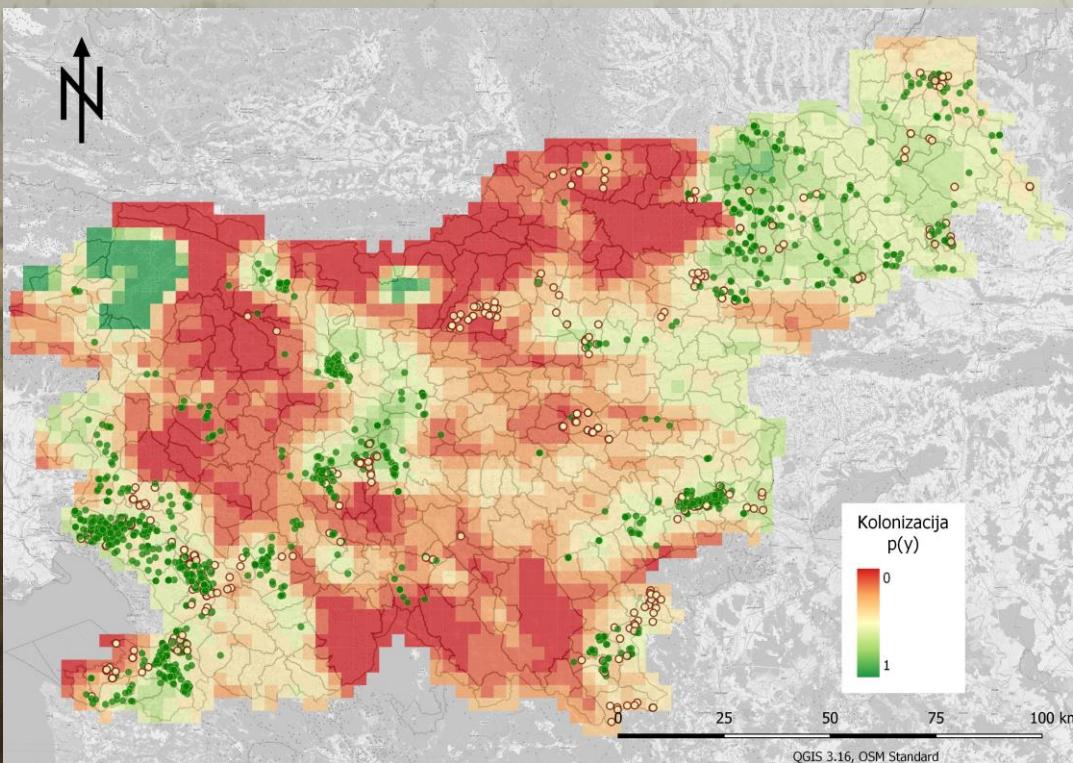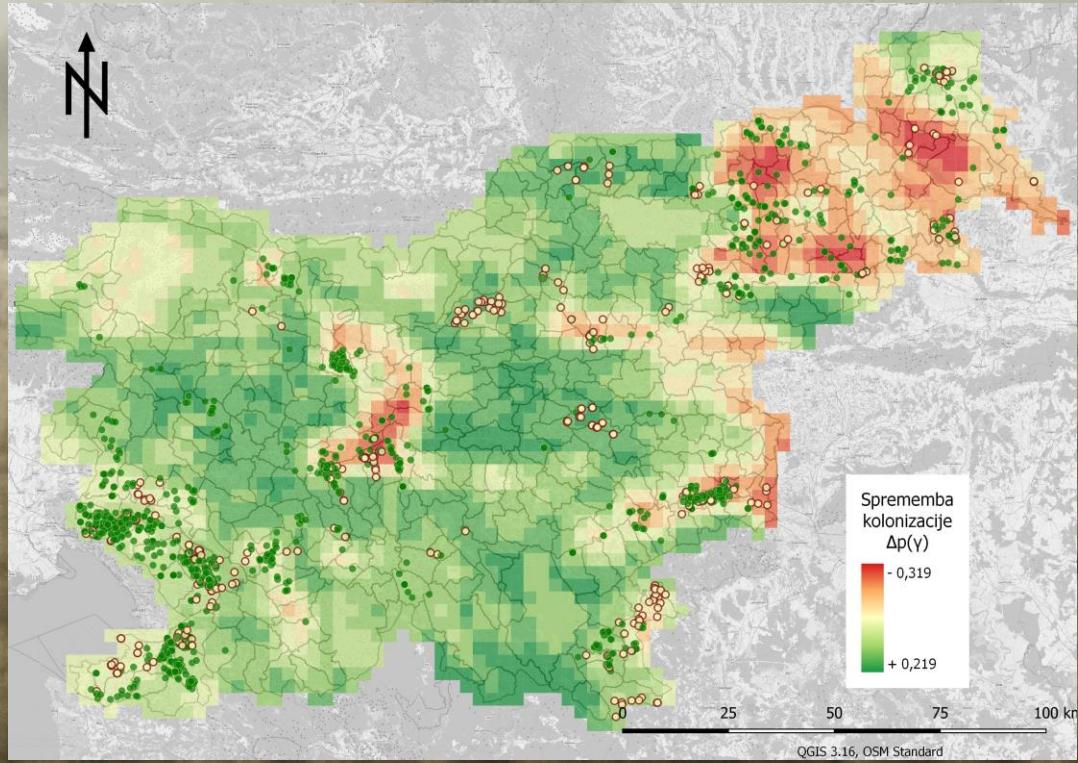
What this tell us?

a) That jackals already occupy all potential and available habitats, or

b) that there are other environmental variables besides duration of snow cover that were not accounted for in our candidate models that contribute to jackal expansion, such as changes in land use.

What does this tell us?

Best habitats in
the Julian Alps
mts.?

Validation and
verification

Modelled Jackal distribution

Probability of occurence: 0 (red) to 1 (green)

Wolf pack status 2018/2019:
- Dispersion
- Imigrant
- Unknown
- New
- Established

0   25   50   75   100 km

QGIS 3.16. OSM Standard

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.
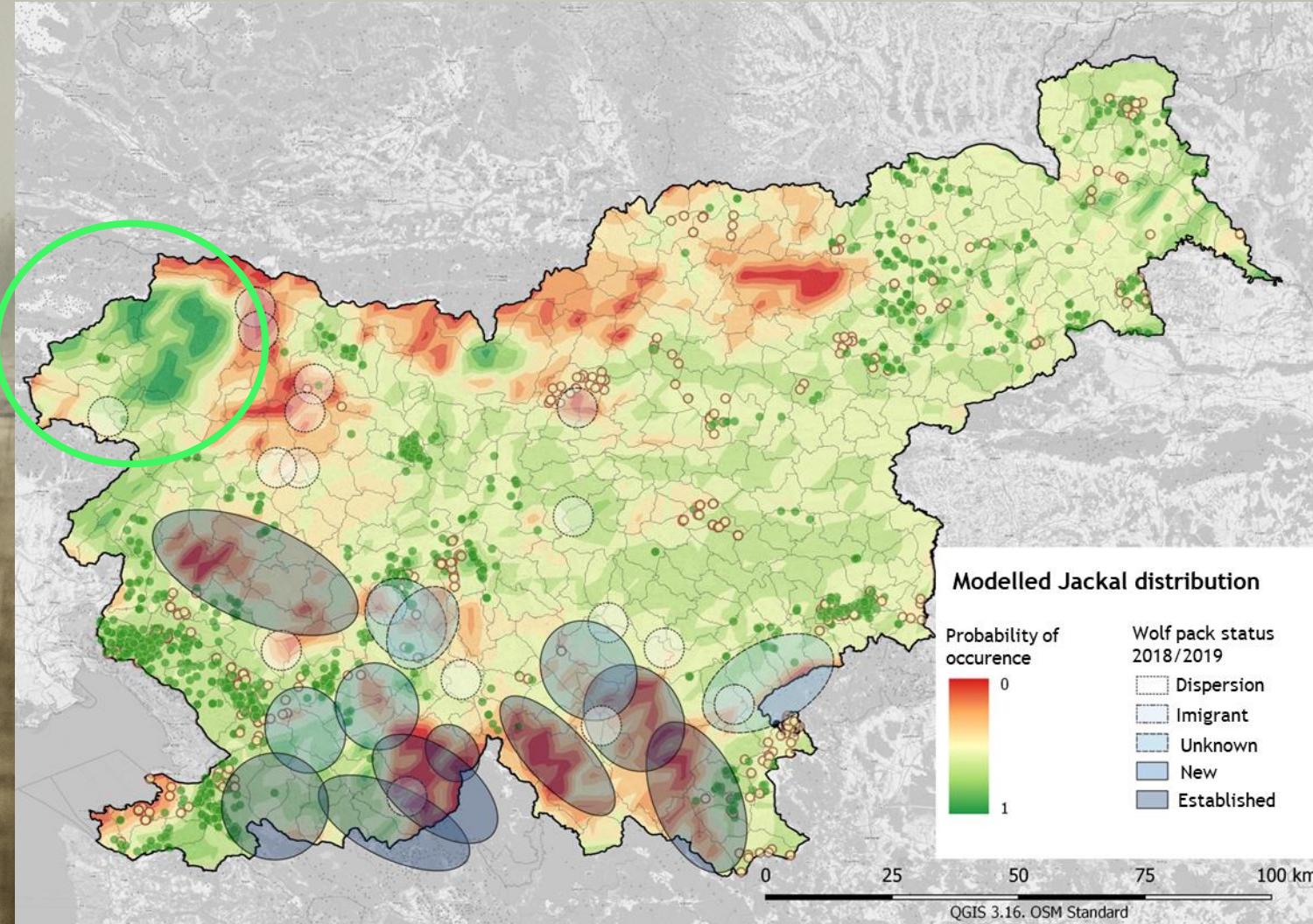
Further research perspectives
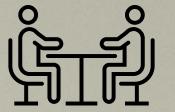
Possible different habitat preferences to wolves?
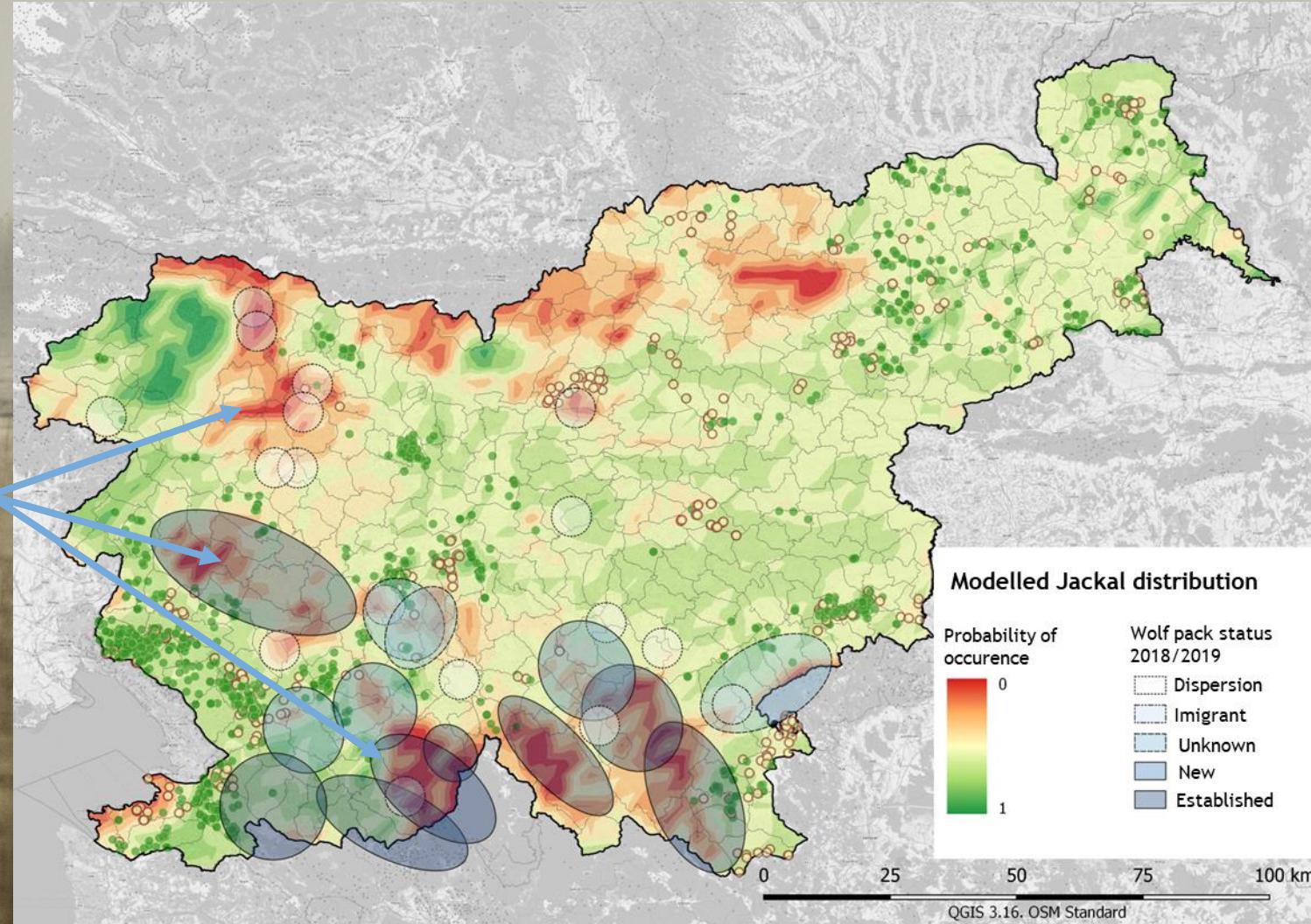
Modelled Jackal distribution

Probability of occurence
0
1

Wolf pack status 2018/2019
Dispersion
Imigrant
Unknown
New
Established

0   25   50   75   100 km

QGIS 3.16. OSM Standard

Kraševec et al. 2022. *Unmarked:* Dynamic hierarchical model for the Eurasian golden jackal (*Canis aureus*) occurence in Slovenia.

Thank you for your attention!

Sources

- Fiske I., Chandler R. 2011. Unmarked: An {R} Package for Fitting Hierarchical Models of Wildlife Occurrence and Abundance. Journal of Statistical Software, 43, 10: 1–23

- Hedlin E., Franke A. 2017. Accounting for imperfect detection in estimates of yearly site occupancy. V: Applied Raptor Ecology: Essentials from Gyrfalcon Research. 1. izd. Anderson D. L., McClure C. J. W., Franke A. (ur.). Boise, The Preregrine fund: 183–206

- Kery M., Chandler R. 2016. Dynamic occupancy models in unmarked. https://cran.r-project.org/package=unmarked (20. 12. 2020)

- Krofel M. 2008. Šakali v Sloveniji. Lovec, 91, 1: 8–10

- MacKenzie D. I., Nichols J. D., Hines J. E., Knutson M. G., Franklin A. B. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology, 84, 8, doi: 10.1890/02-3090: 8 str.

- Potočnik H., Boljte B., Flajšman K., Jelenčič M., Kavčič I., Kljun F., Konec M., Kuralt Ž., Levanič T., Majić Skrbinšek A., Pokorny B., Skrbinšek T., Stronen A. V., Kos I. 2018. Prostorska Razporeditev, Številčnost, Ocena Populacijskih Trendov in Potencialno Širjenje Areala Vrste Zlati Šakal (Canis Aureus L.) V Sloveniji (V1-1626). Ljubljana, Ministrstvo za kmetijstvo, gozdarstvo in prehrano: 139 str.