

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

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# How it started ...

- First observations in mid 1950's
- Rising number of observations
- First confirmed territorial pack in 2009
- Colonization from two directions

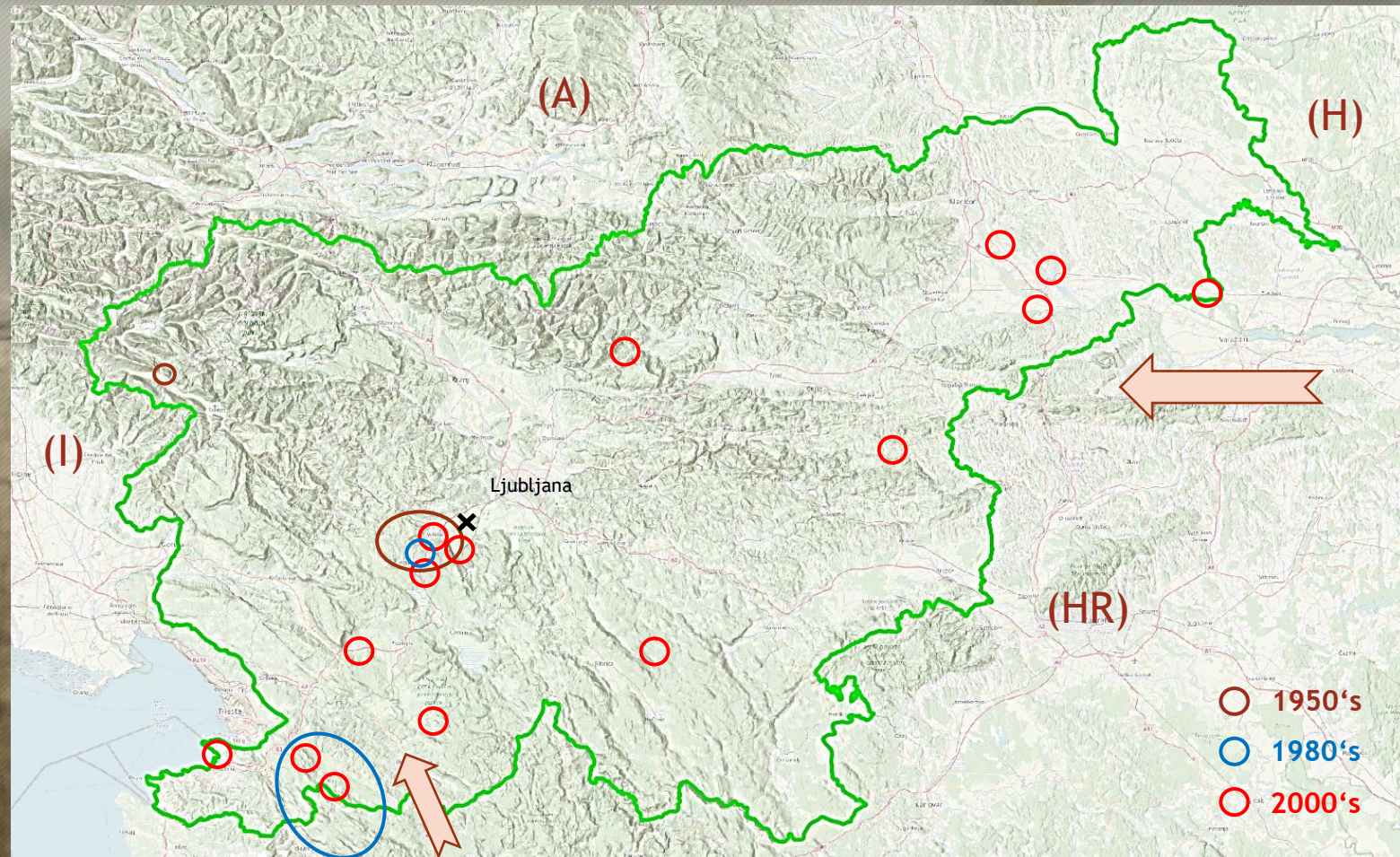


Image data: Krofel 2008.



... and how it's going.

- Estimated 250 territorial packs in 2018
- Widespread in Slovenia (Monitoring data collected)

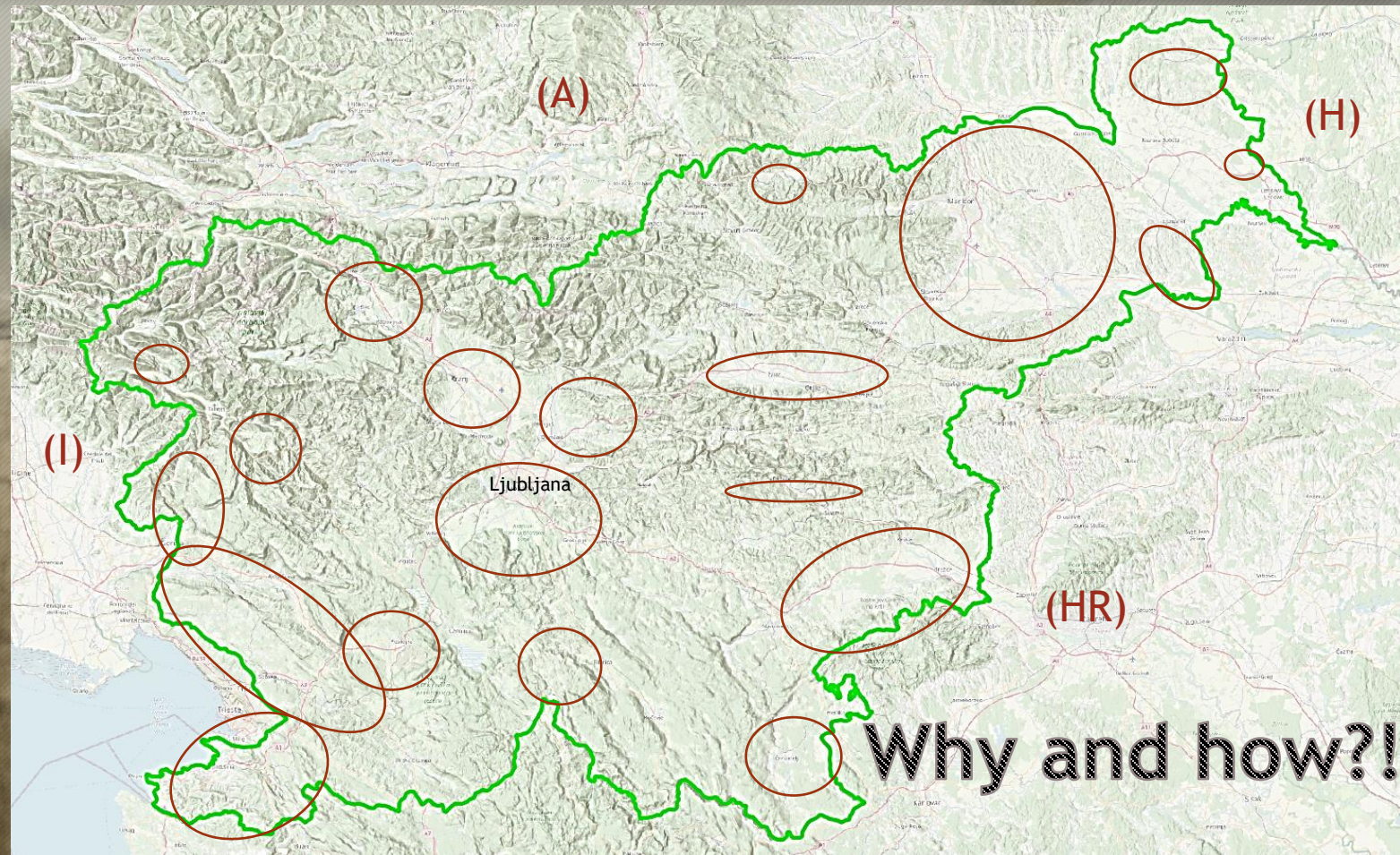


Image data: Potočnik et al. 2018.



# Occupancy models

By MacKenzie et al. 2003

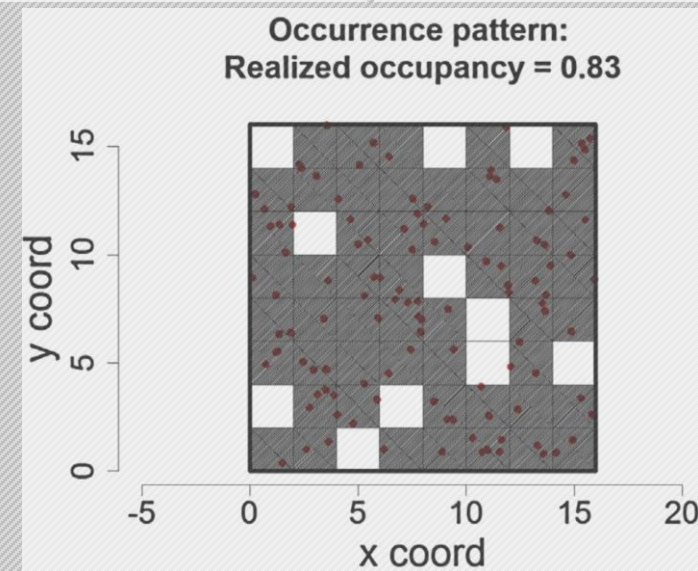
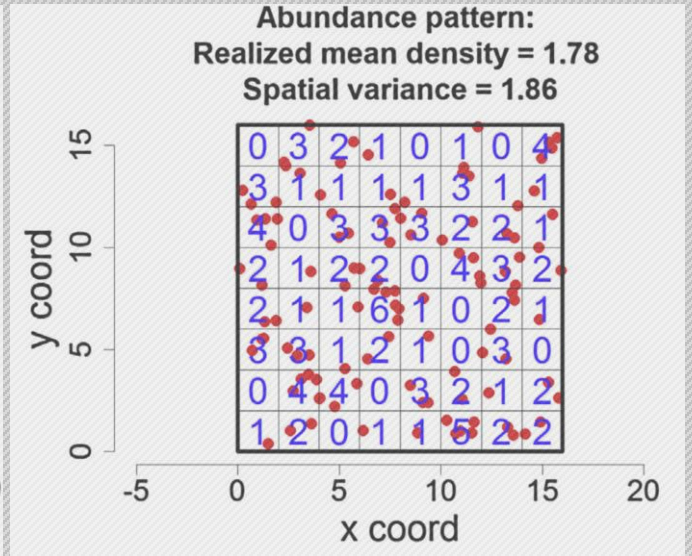
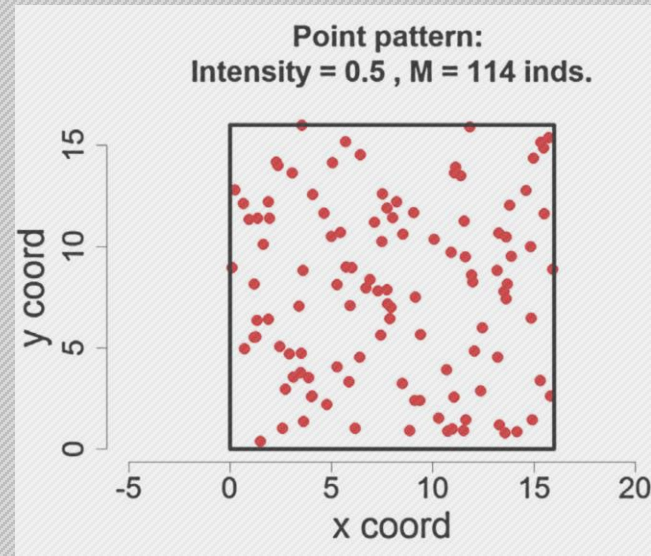
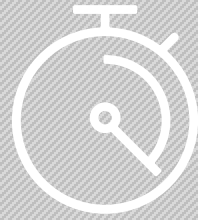


Image source: Kery & Chandler 2016



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# Dynamic occupancy models

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Unmarked: *colect* (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 <sub>j</sub>	$1_{,1,i}$	$1_{,2,i}$	$1_{,3,i}$	$2_{,1,i}$	$2_{,2,i}$	$2_{,3,i}$	$3_{,1,i}$	$3_{,2,i}$	$3_{,3,i}$	...	$t_{j,i}$



# Dynamic occupancy models



1. Detection probability ( $d$ )
2. Initial occupancy ( $\psi$ )
3. Local extinction prob.  $\epsilon$ ,  
or survival ( $\phi = 1 - \epsilon$ )
4. Colonization prob. ( $\gamma$ )

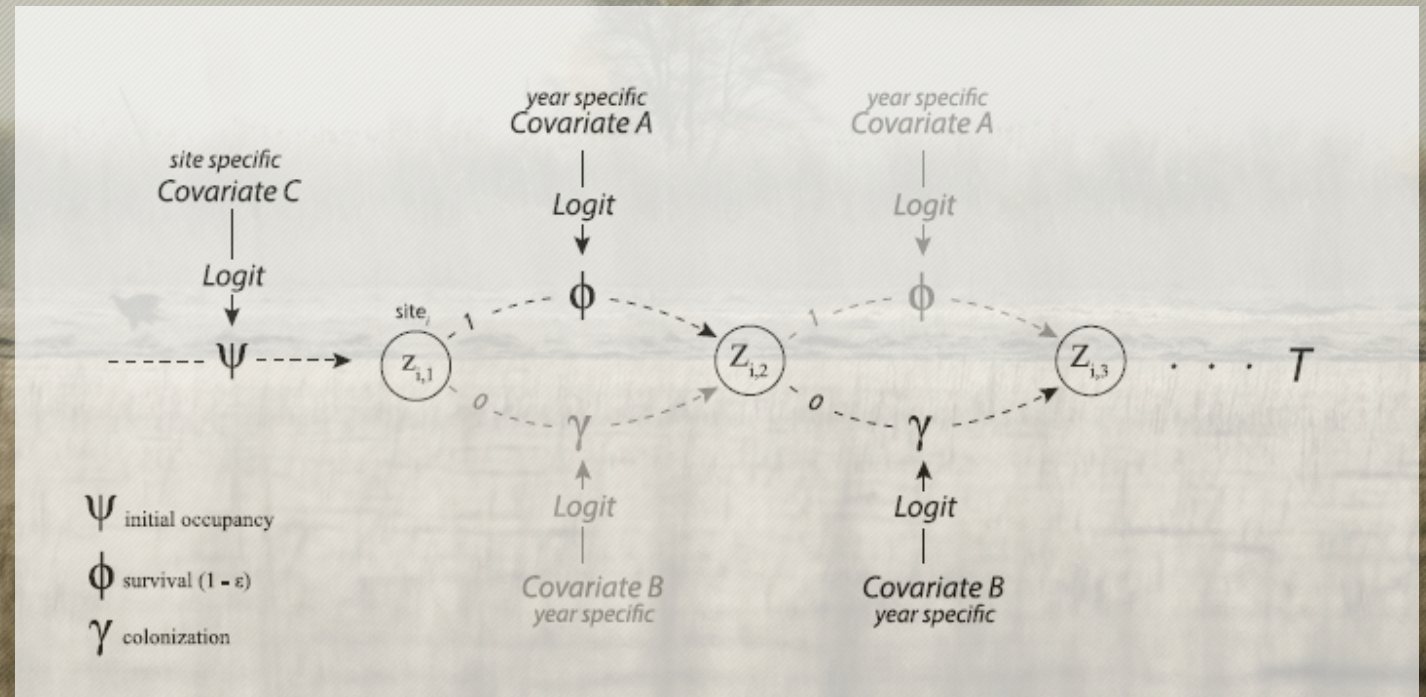


Image source: Hedlin & Franke 2017



# Data



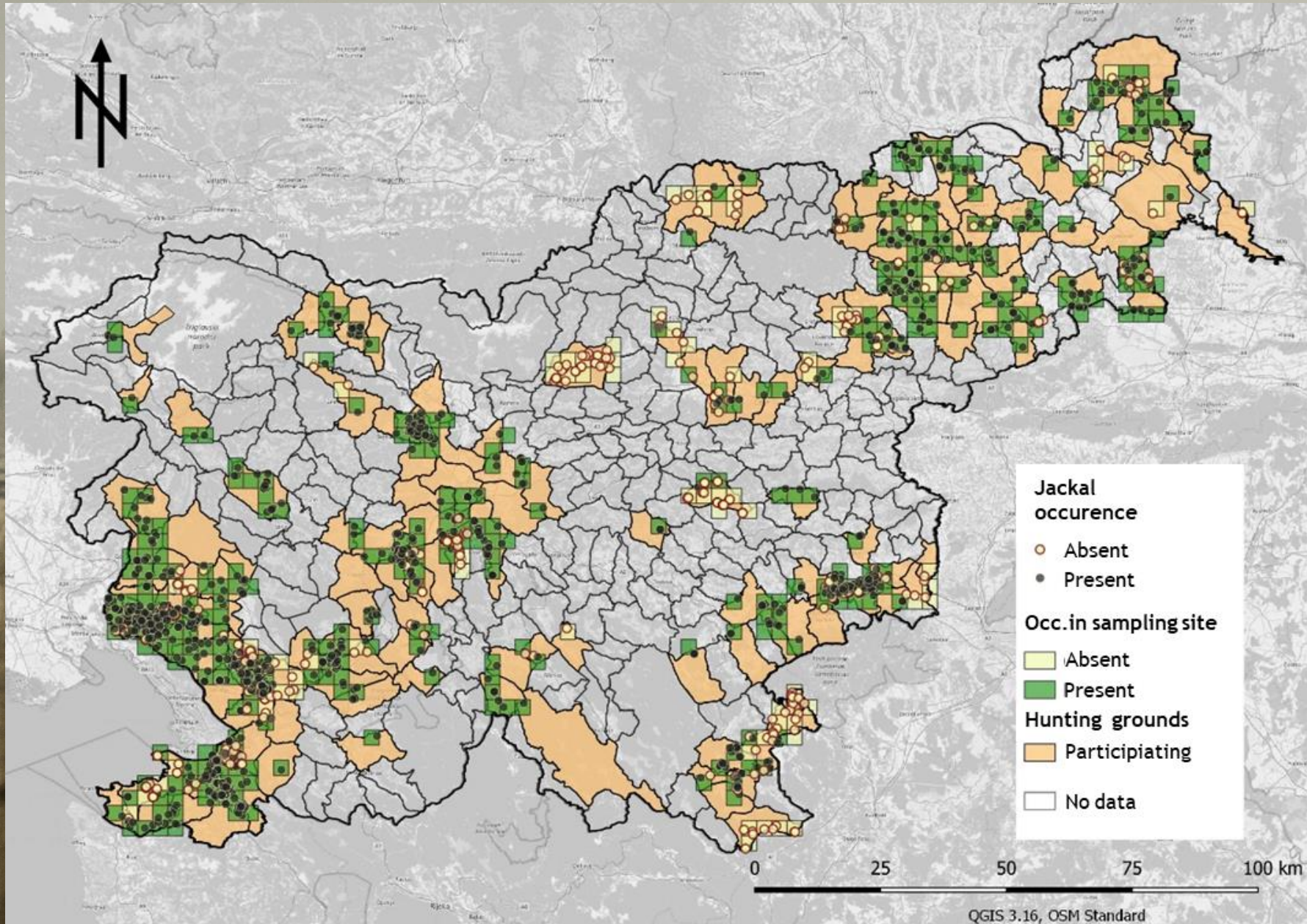
- National Jackal Monitoring Programme.
- Collected in Hunters information system (LISJAK).
- 1541 data on jackal presence and absence.
- Mostly howling observations.
- In the time interval from 28. 2. 2017 to 1. 3. 2019.

lovski  
informatijski  
sistem



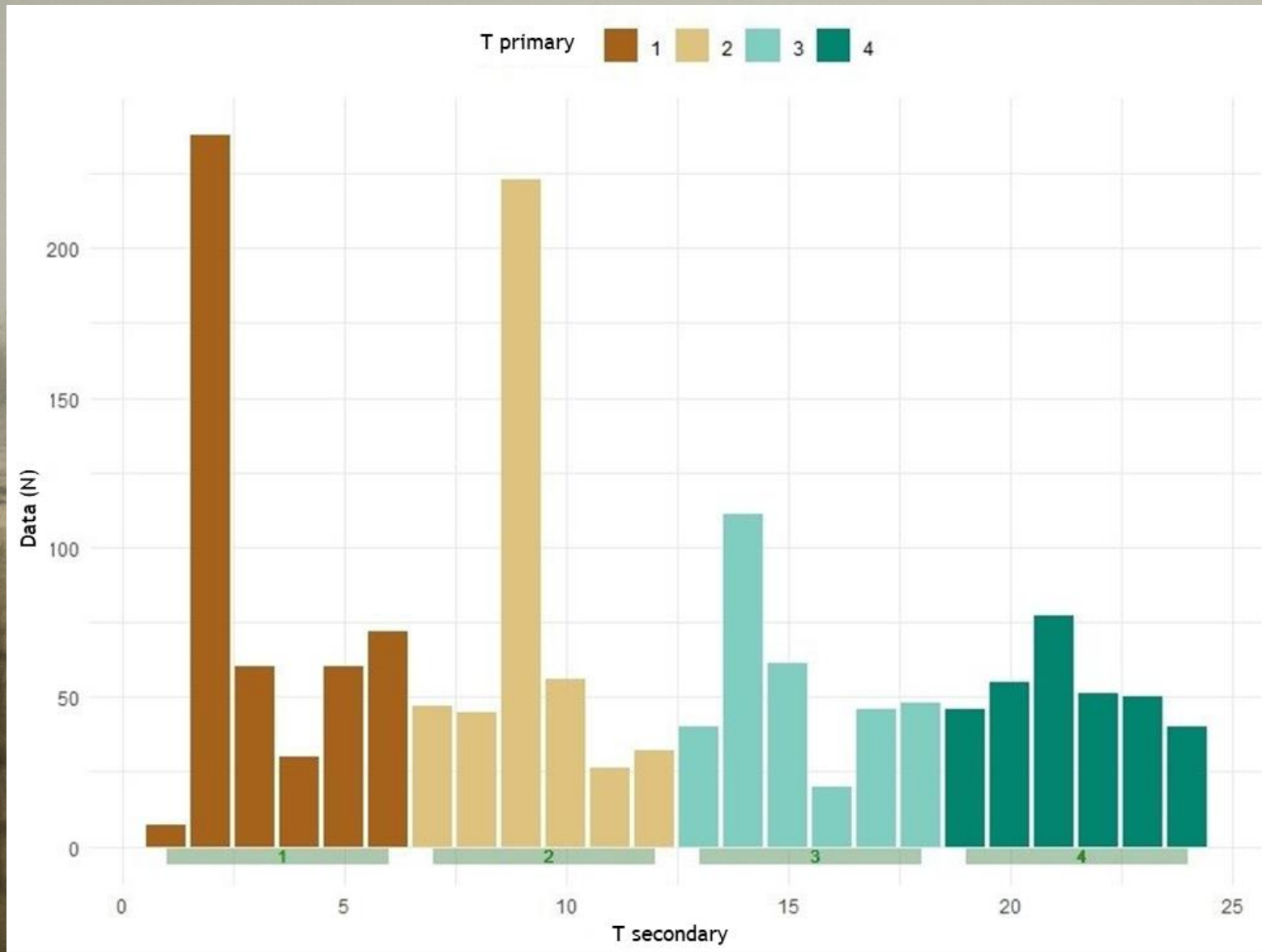
Lisjak





3 x 3 km squares (415)





Collected in time intervals:  
- T primary - months (24),  
- T secondary - seasons (4)



# Environmental variables



## Static



Altitude

Average

Range



Slope



Forest

Coverage

Fragmentation



Settlement distance



Snow

Annual average

Avg. Mar - Aug

Avg. Sep - Feb

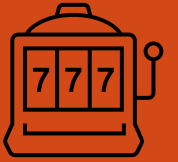
## Dynamic

Monthly snow cover duration





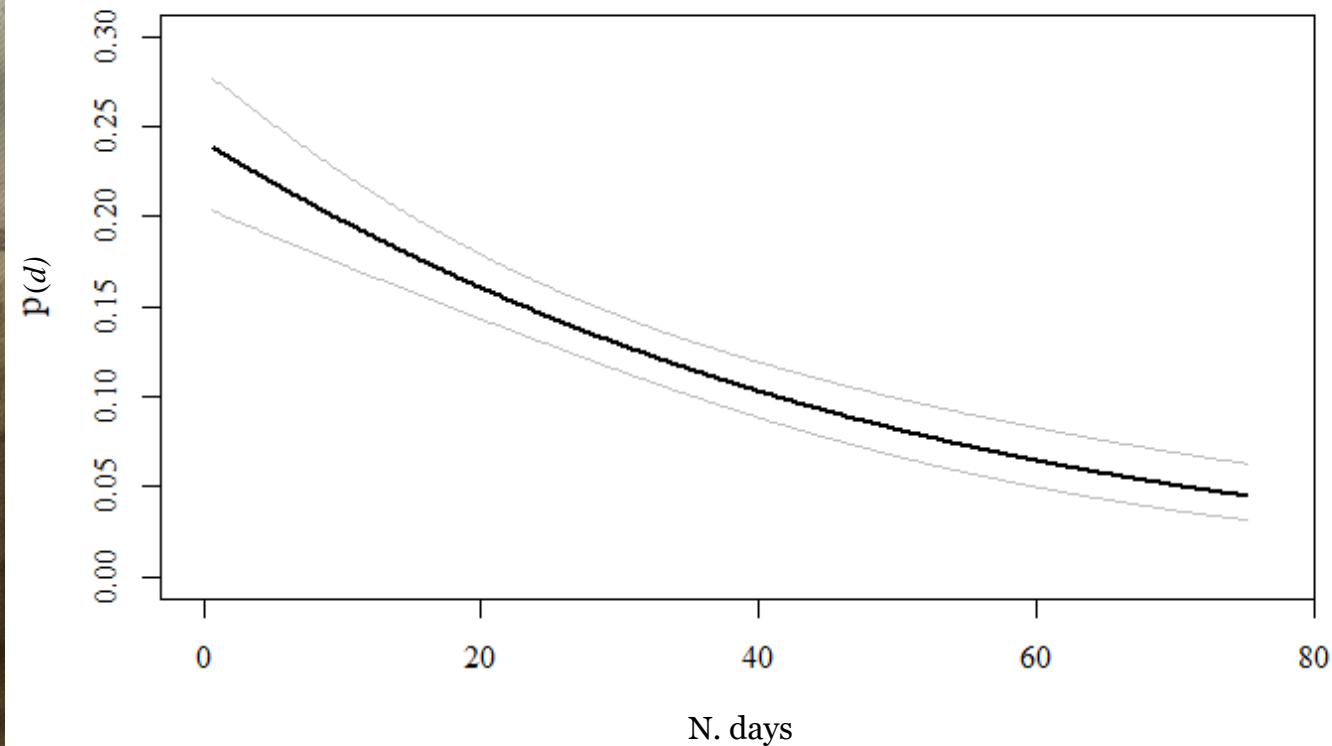
# Selection process



- Candidate set of biologically plausible models and selecting 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.



# Detection probability ( $d$ )



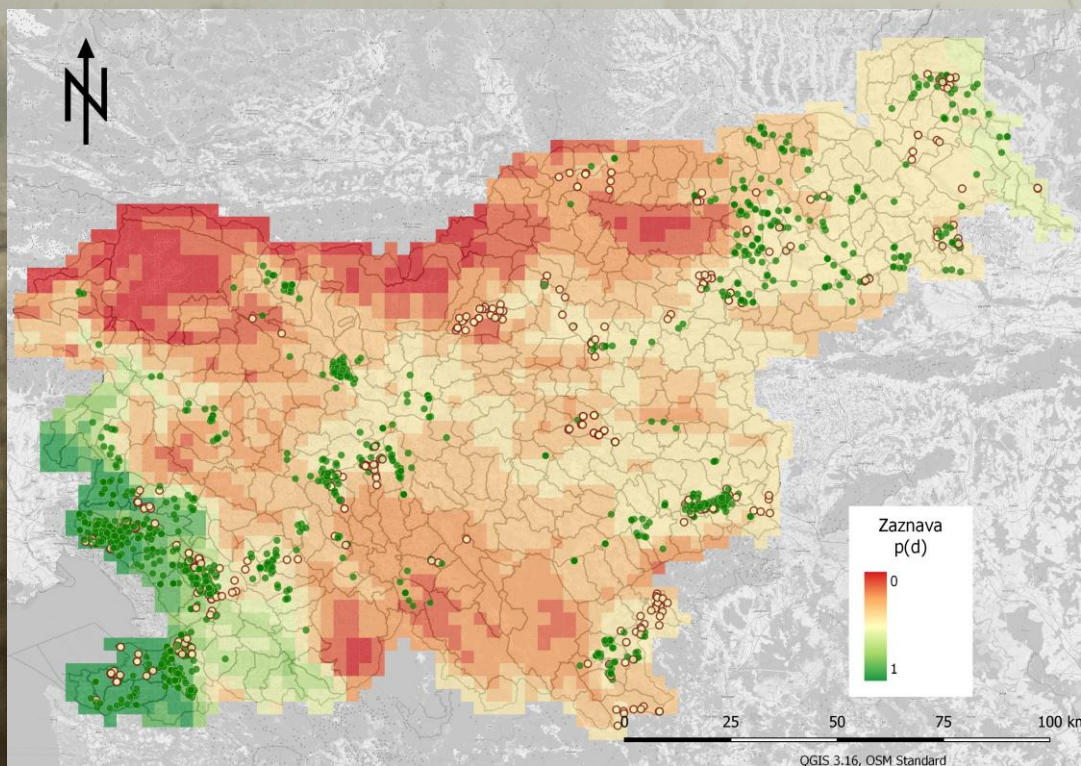
Snow cover duration from September till March



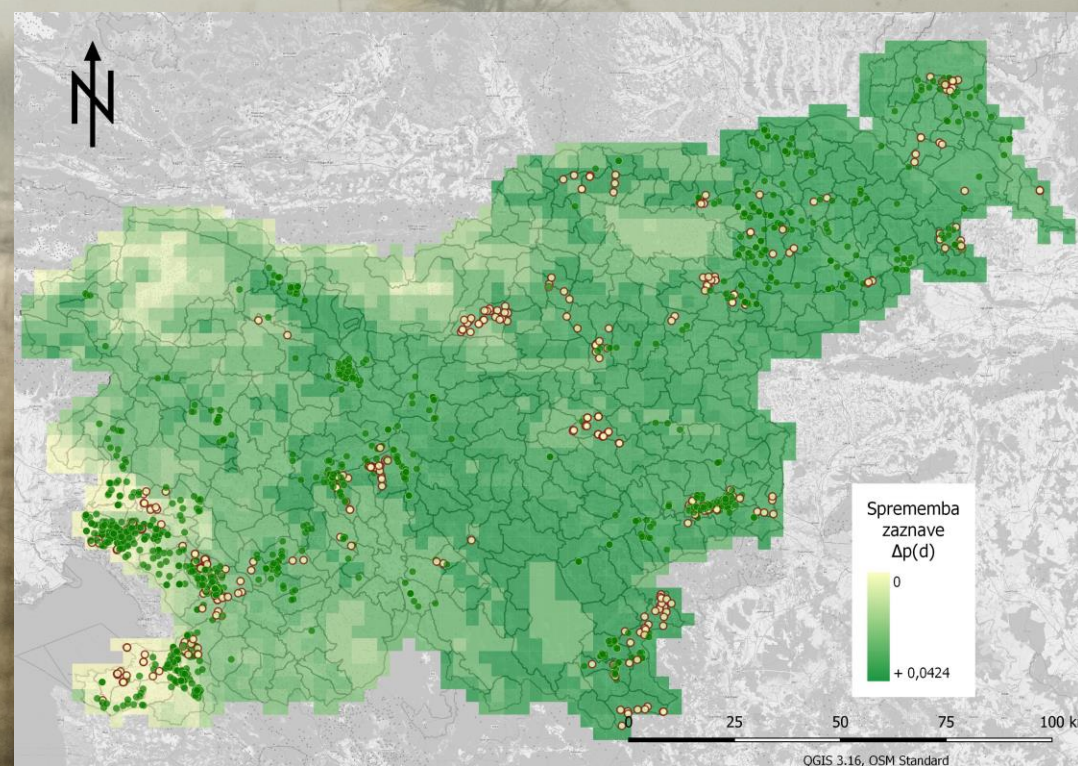
# Detection probability( $d$ )



Current

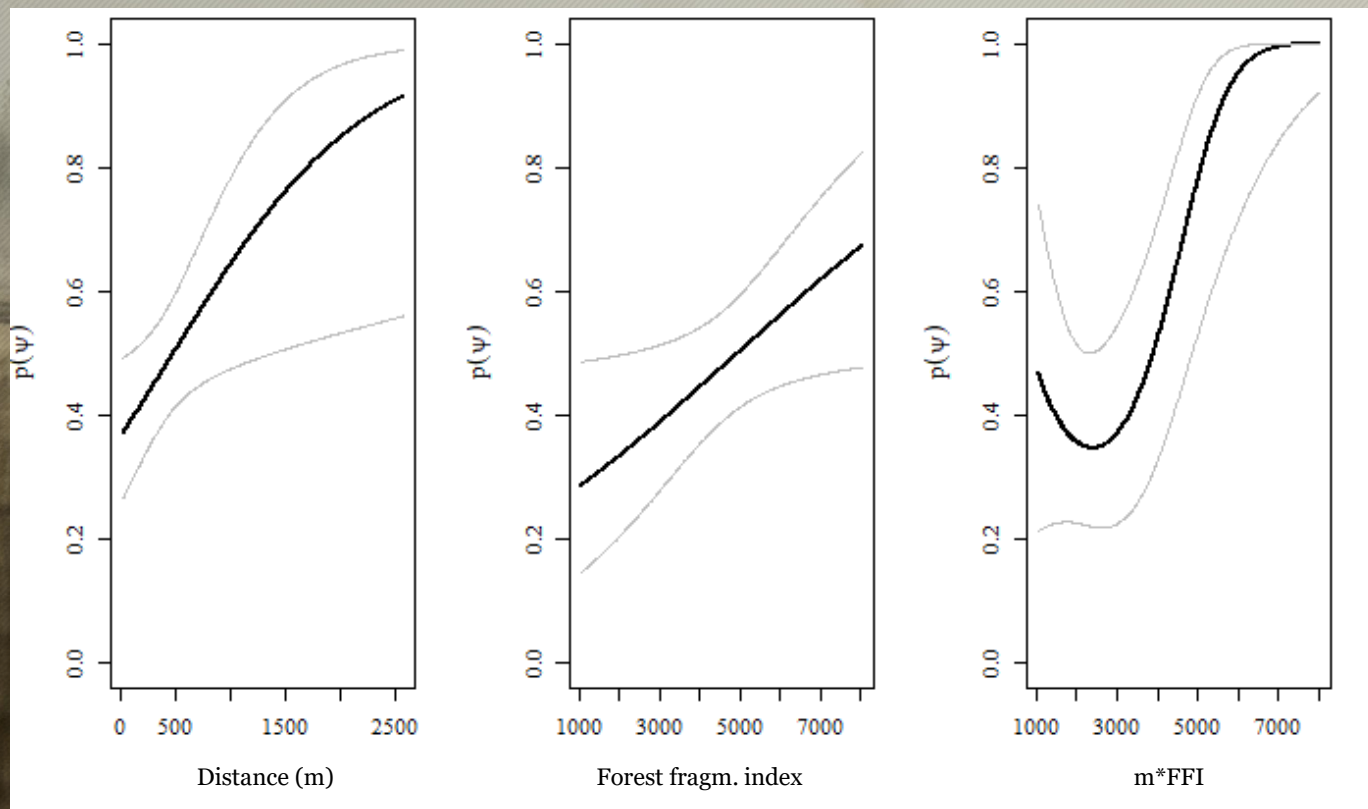


Change in 2050





# Initial occupancy ( $\psi_1$ )



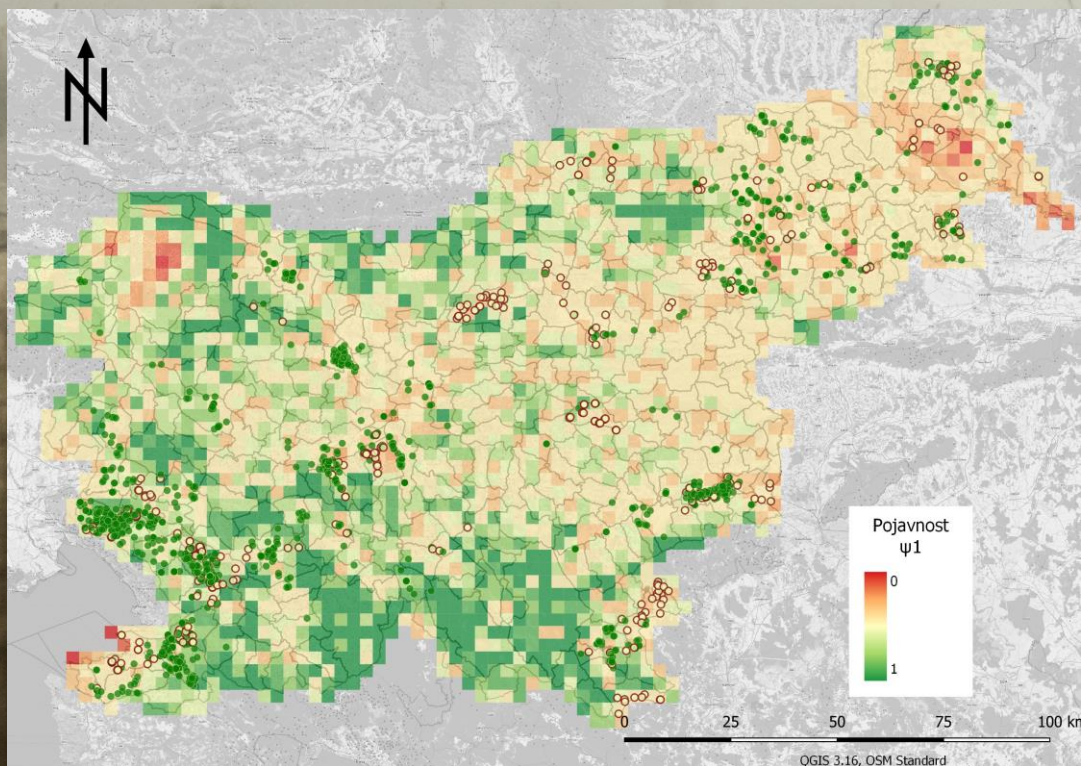
Distance from settlement\*forest  
fragmentation index



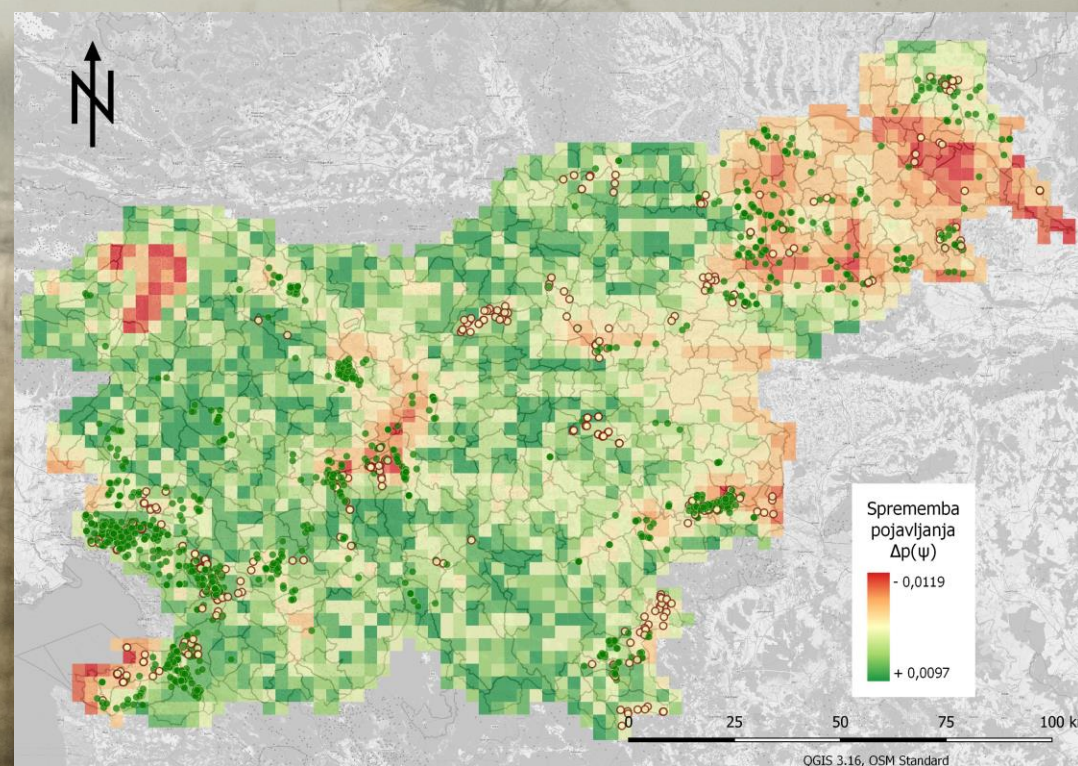
# Initial occupancy ( $\psi_1$ )



Current

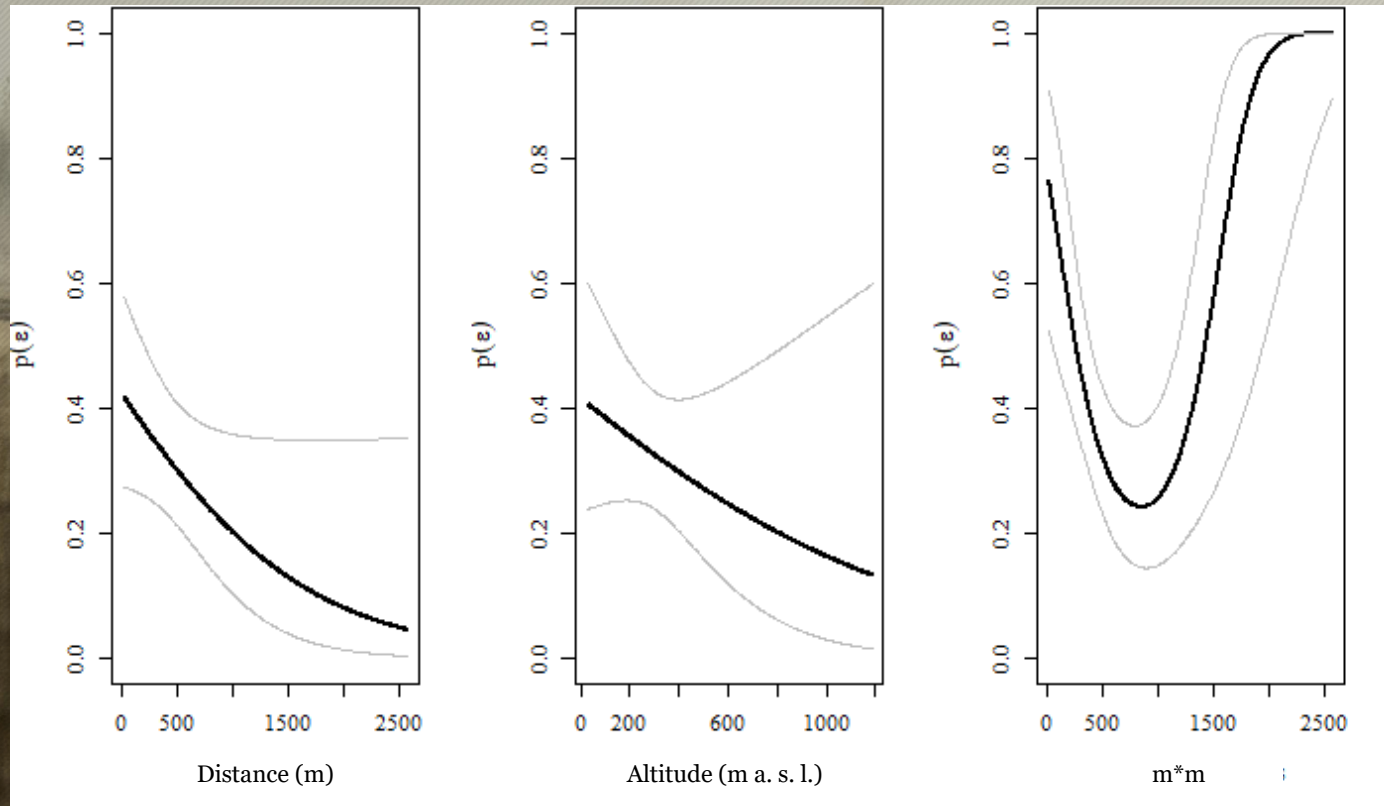


Change in 2050





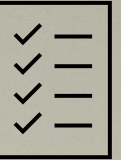
# Local extinction ( $\epsilon$ )



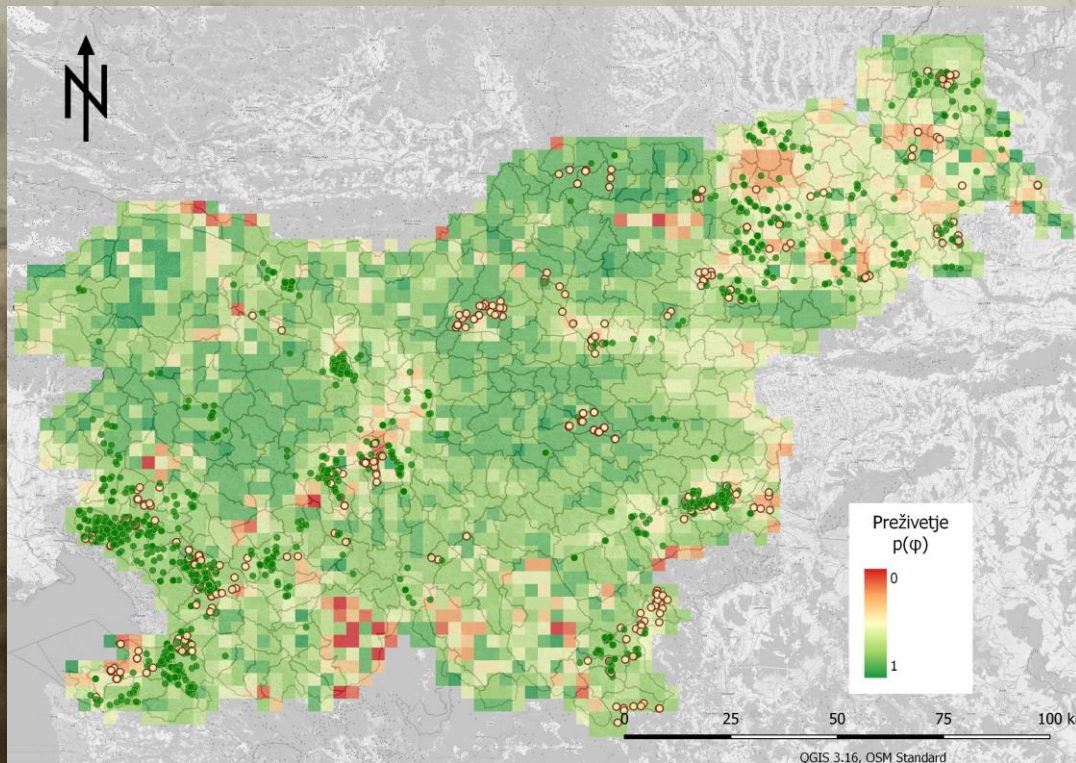
Average altitude\*Settlement distance



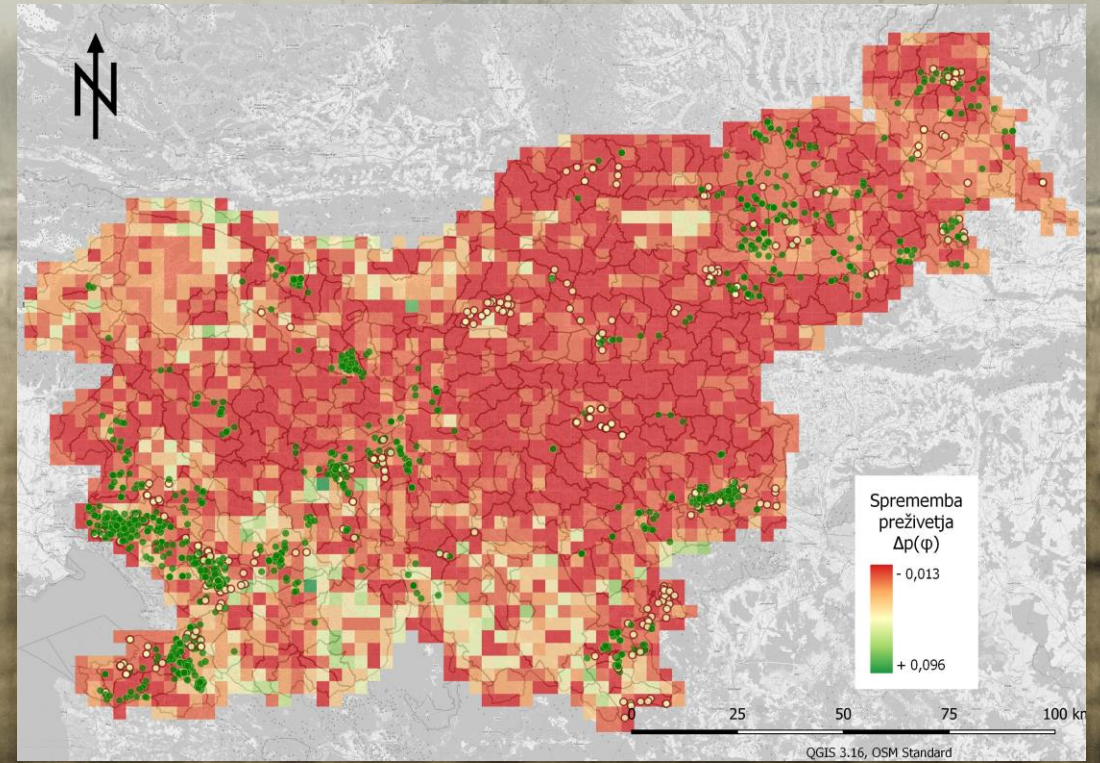
# Local extinction ( $\epsilon$ )



Current



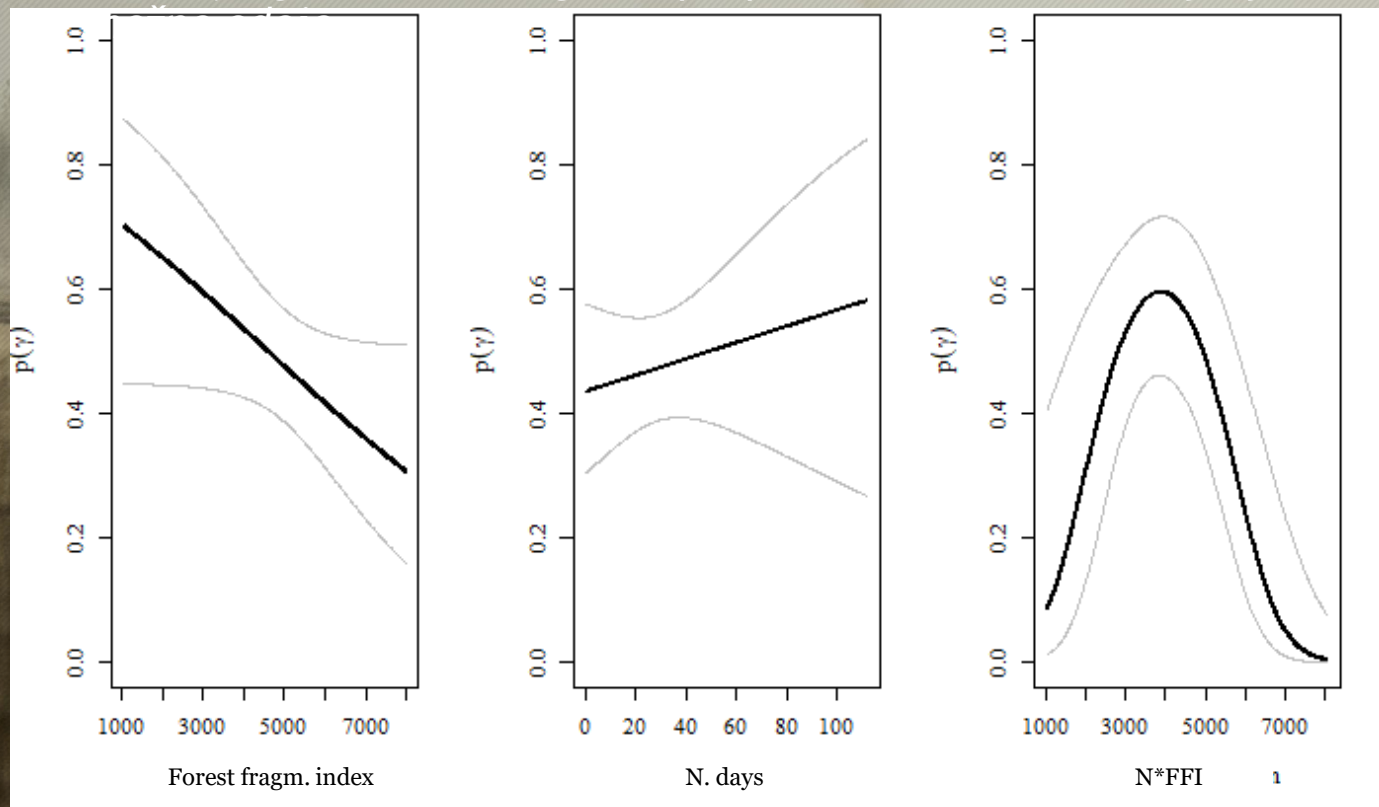
Change in 2050





# Colonization ( $\gamma$ )

- *indeks fragmentiranosti gozda\* povprečen mesečni čas trajanja*

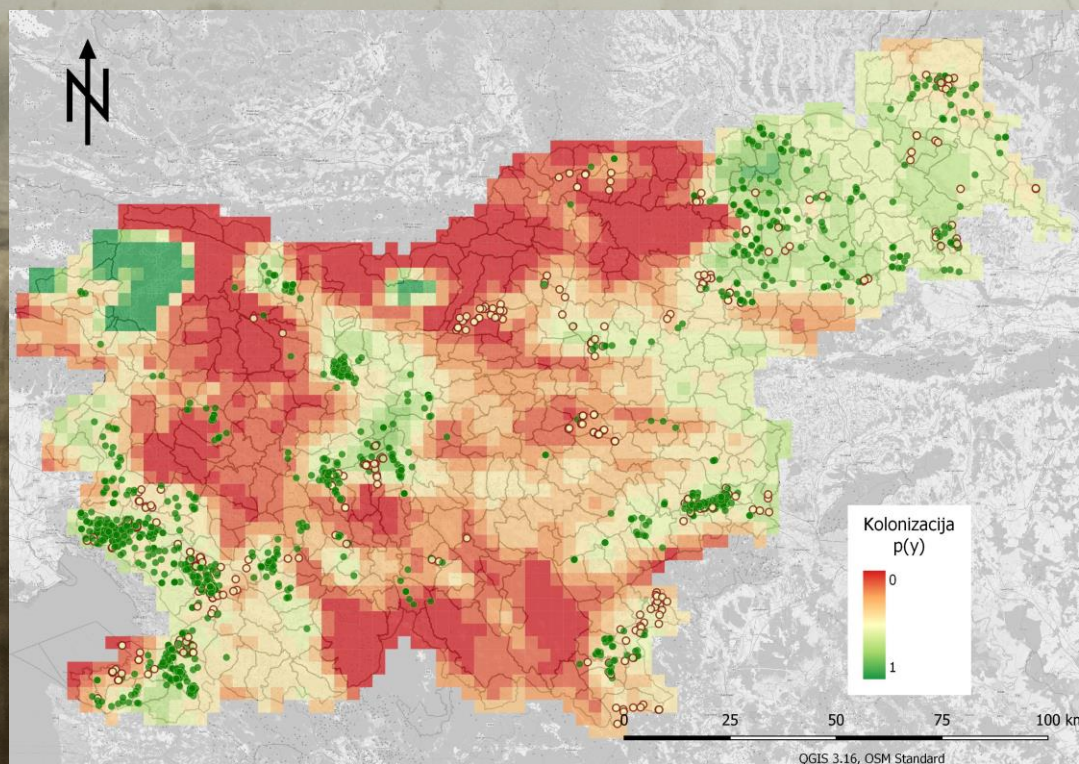


Forest fragmentation index\*average annual snow cover duration

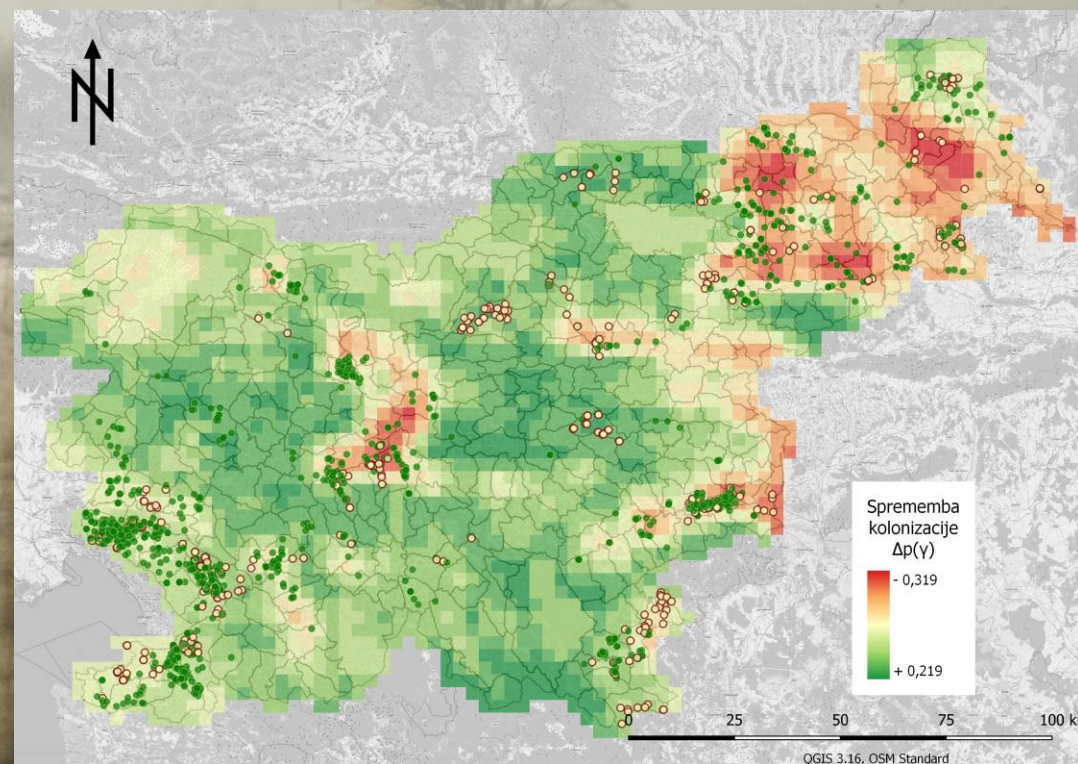


# Colonization ( $\gamma$ )

Current



Change in 2050





# 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.

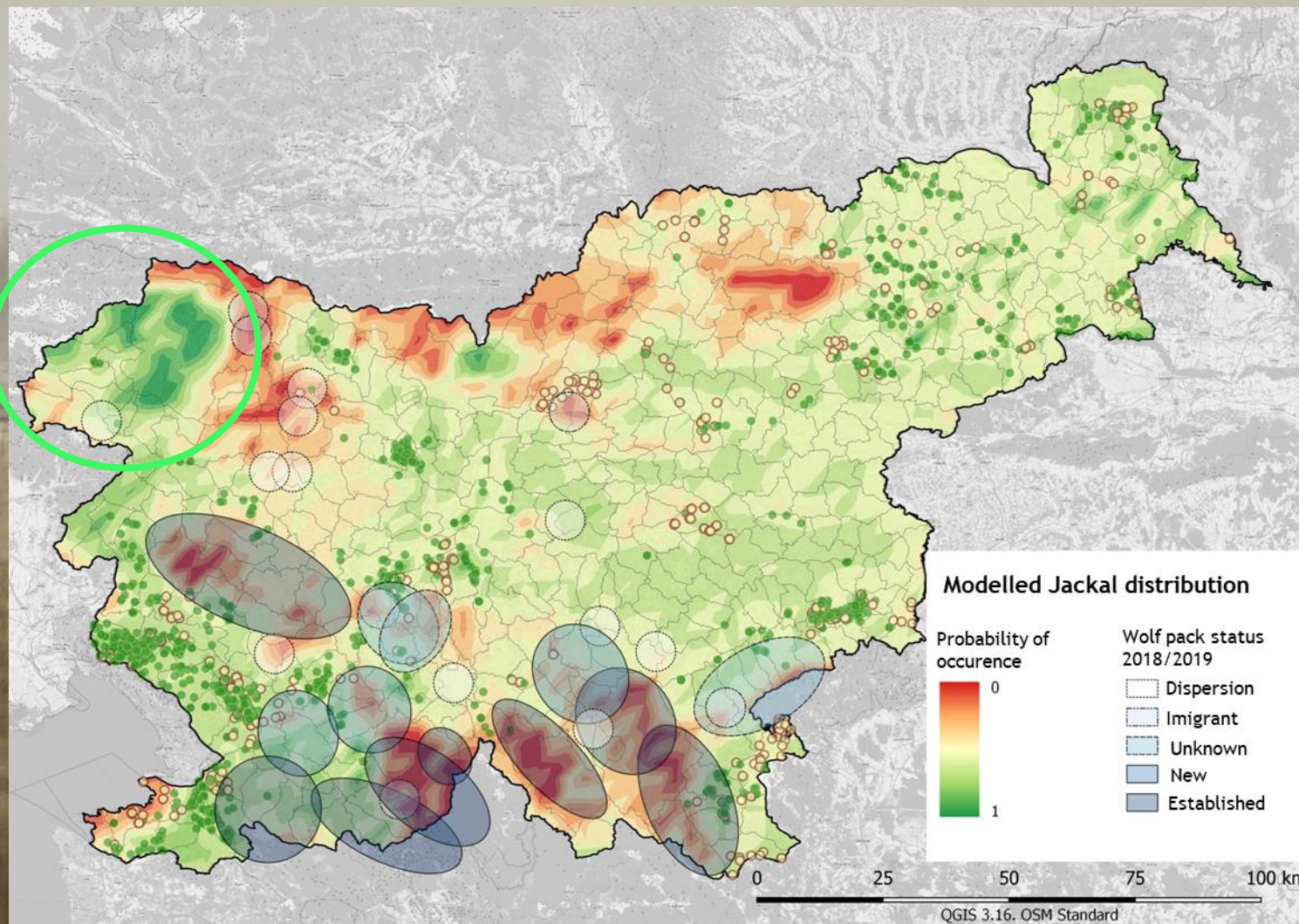


# What does this tell us?



Best habitats in the Julian Alps mts.?

Validation and verification

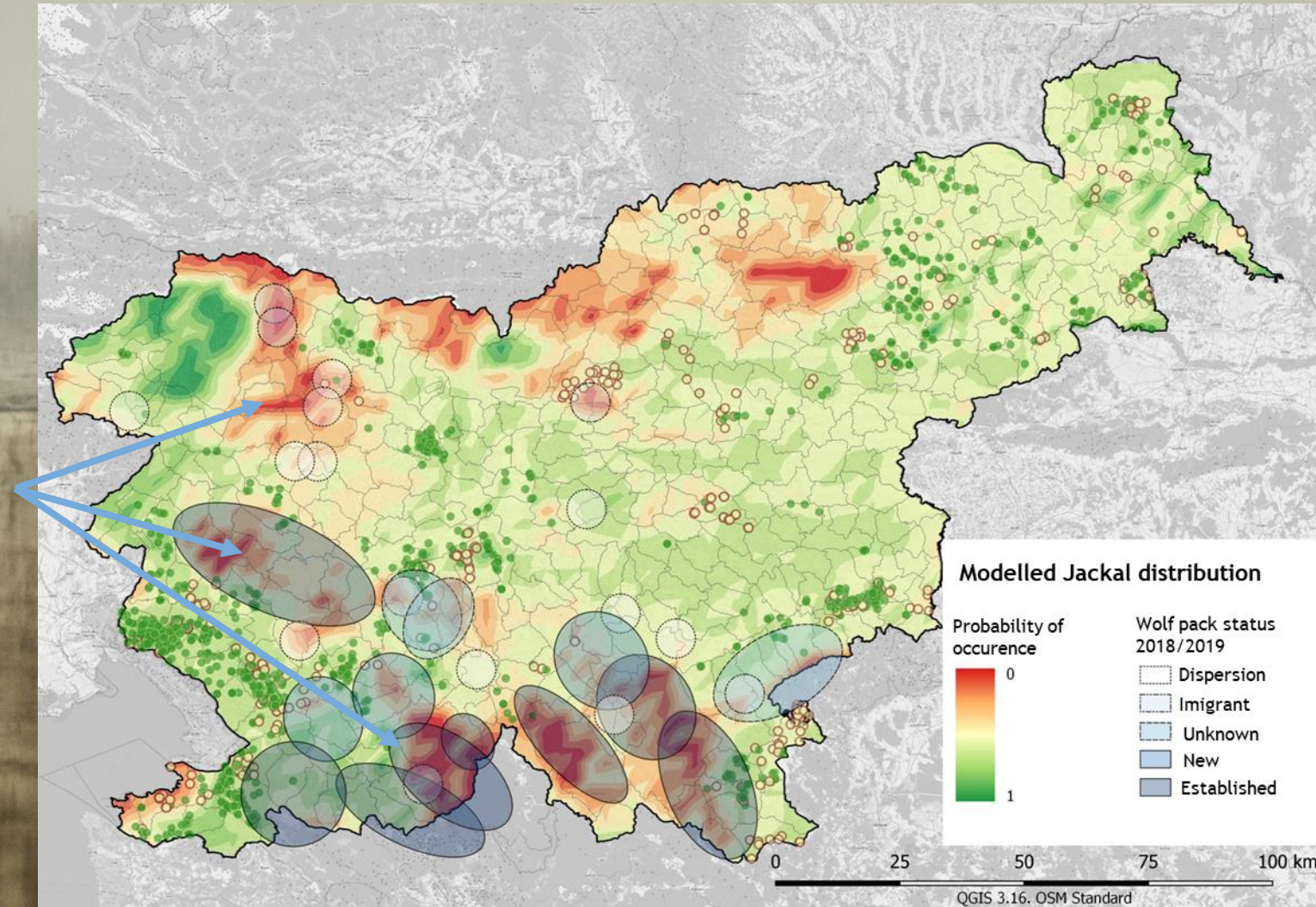





# Further research perspectives



Possible different habitat preferences to wolves?





A misty landscape with a field of tall grass in the foreground, a line of reeds in the middle ground, and a single tree on the horizon. The text "Thank you for your attention!" is overlaid in white, underlined font.

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
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- 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.
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