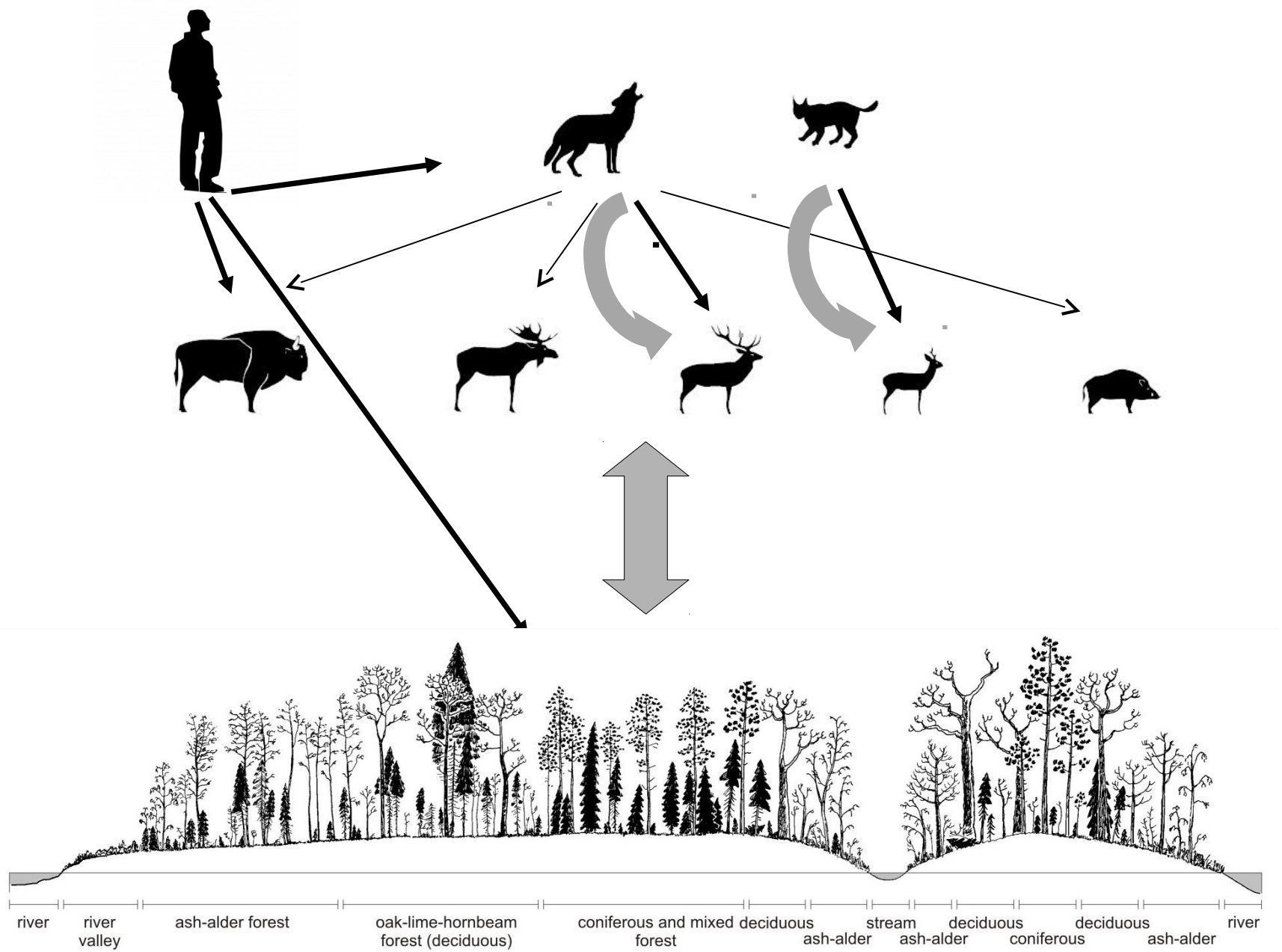
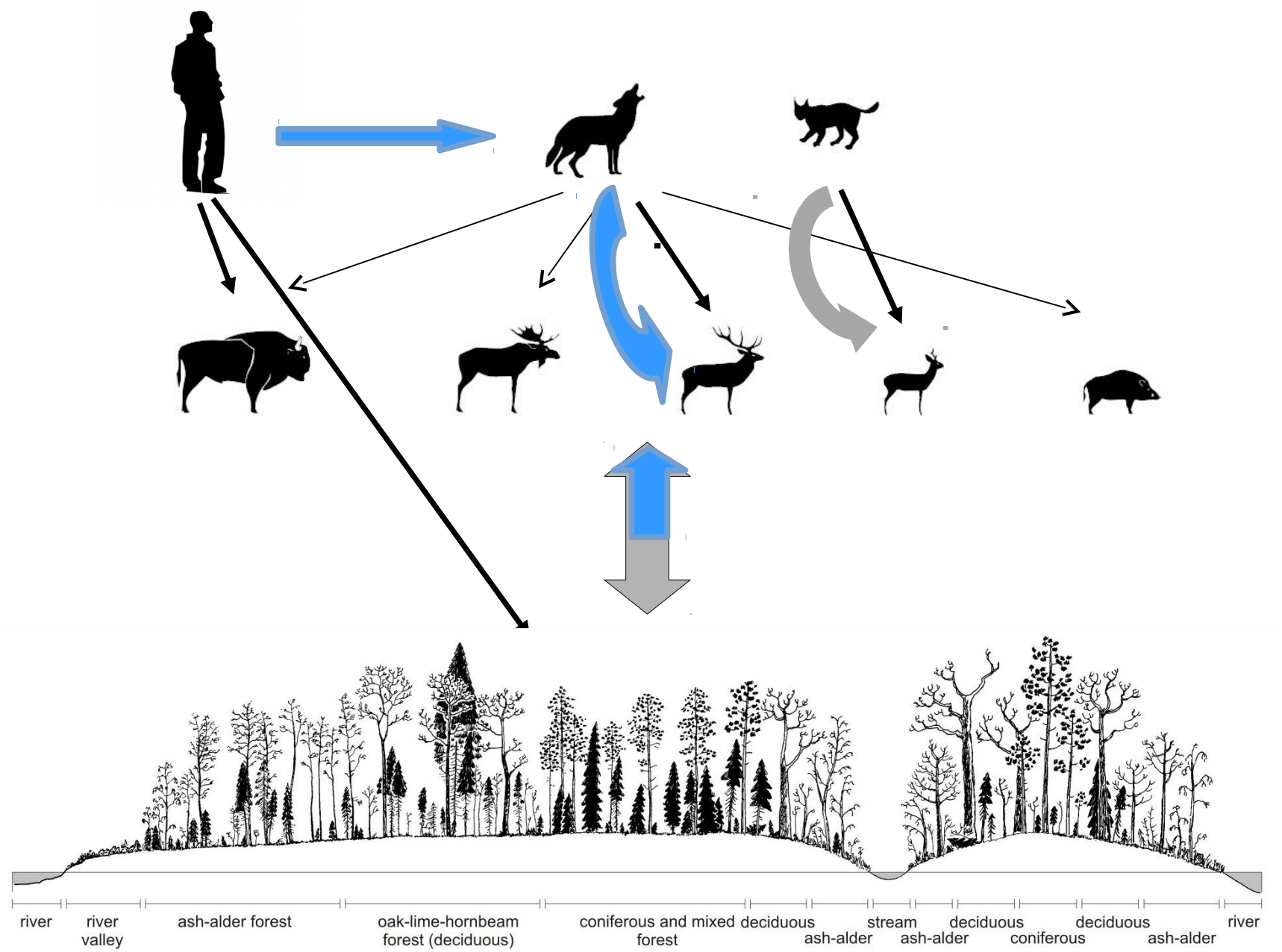
Using camera traps and remote sensing data to understand the spatial distribution of ungulates

(preliminary results)

LIFE+ ForBioSensing conference, Białowieża, 01.12.2016 r.

J.W. Bubnicki, M. Churski, D.P.J. Kuijper
IBS PAN, Białowieża


river
river valley
ash-alder forest
oak-lime-hornbeam forest (deciduous)
coniferous and mixed forest
deciduous ash-alder
stream
deciduous ash-alder
deciduous coniferous
deciduous ash-alder
river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coniferous and mixed forest
deciduous
ash-alder
stream
ash-alder
deciduous
coniferous
deciduous
ash-alder
river

Ungulates spatial distribution - food

Optimal foraging theory, Patch Choice model
MacArthur & Pianka 1966, Wilmshurst & Fryxell 1995, Kelly 1995

Food is important!

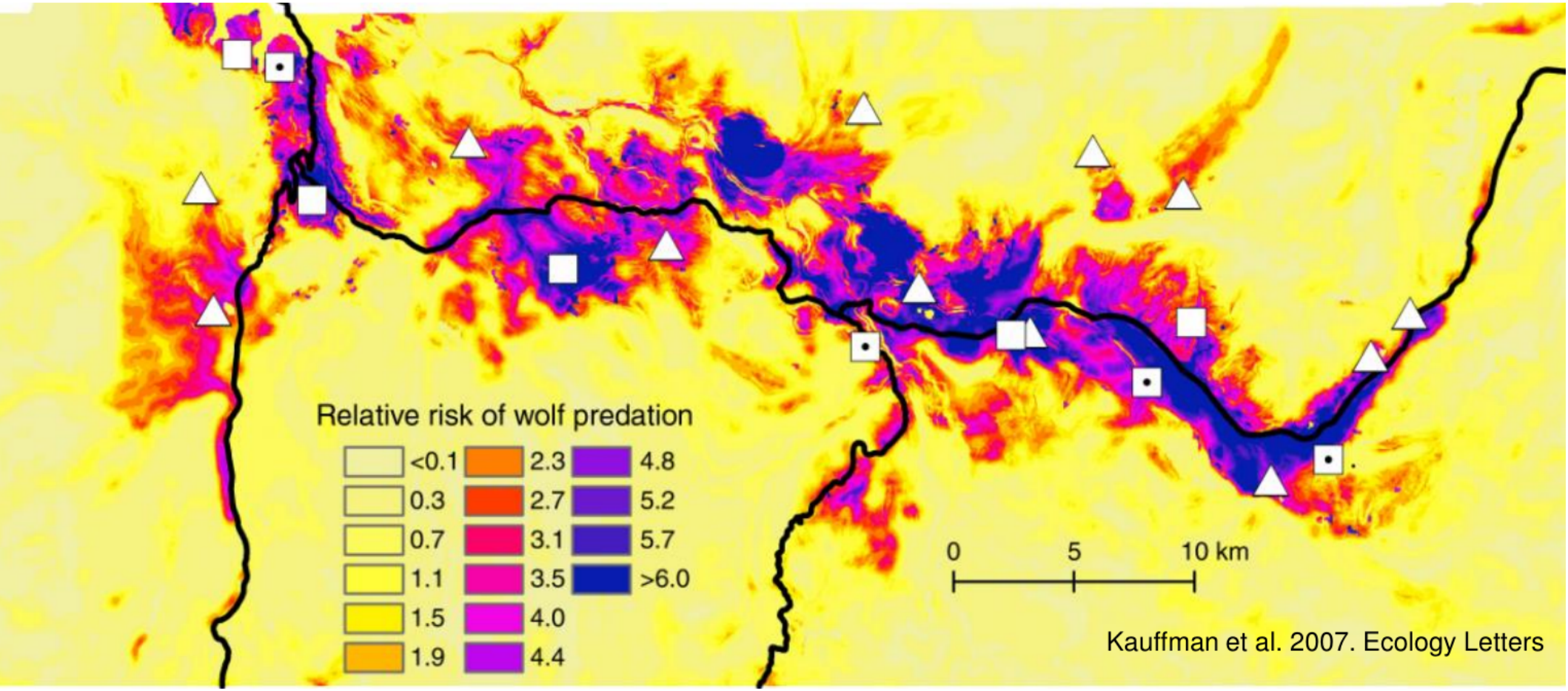
They like gaps in the forest canopy!
Kuijper et al. 2009

Ungulates spatial distribution - fear

Human pressure

Direct & indirect effects of predators

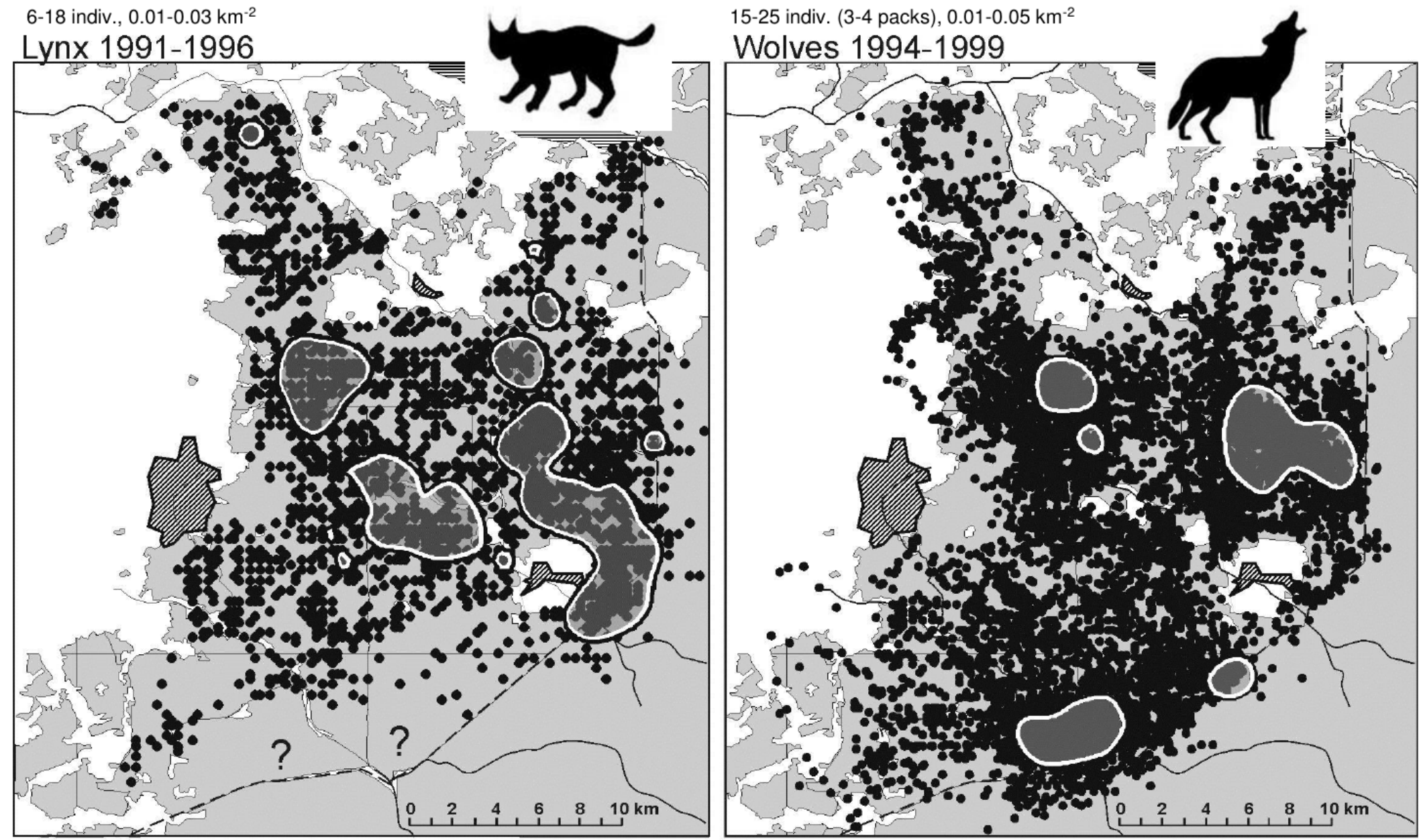
Predation not homogenously spread across landscape



Landscape features create distinct hunting grounds and prey refugia

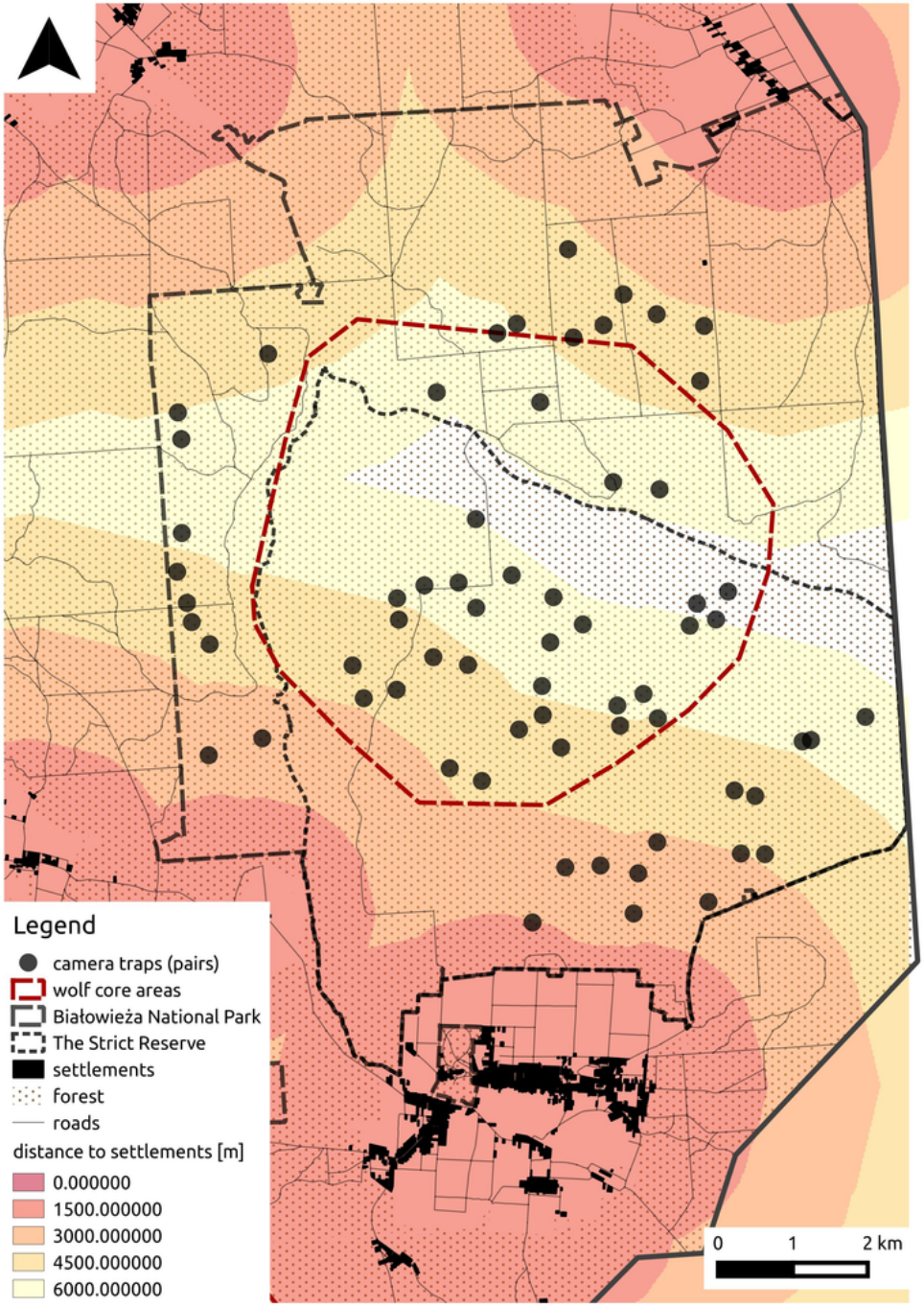
⇒ Affects behaviour, habitat choice, spatial distribution of ungulates

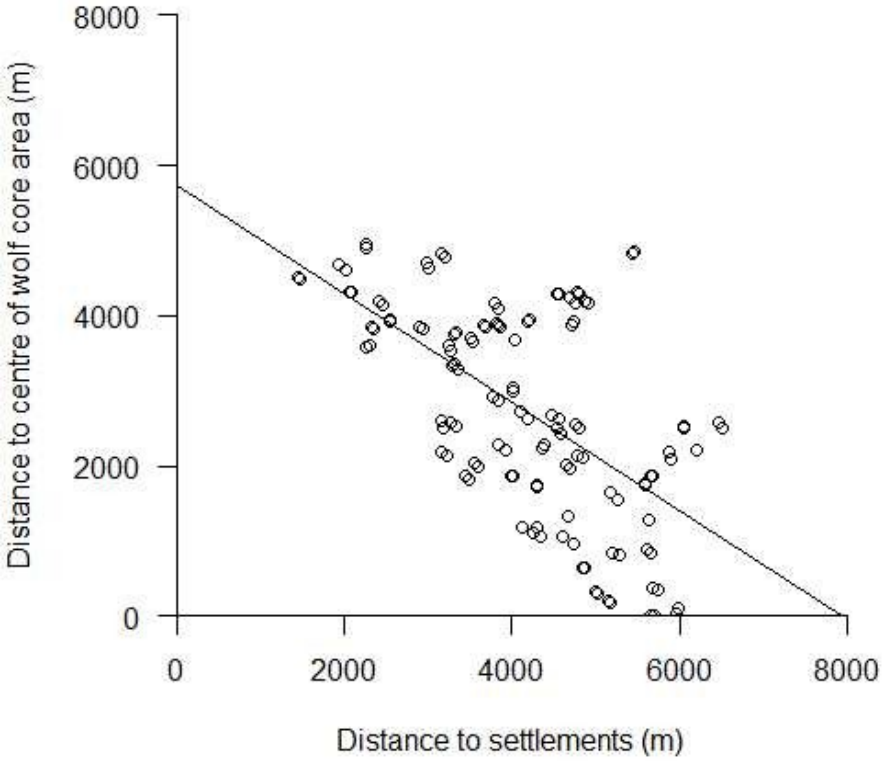
(Creel et al. 2005,Fortin *et al.* 2005; Mao *et al.* 2005, Thaker et al. 2011, Valeix et al. 2009)



Schmidt et al. 2009. Ecological Research 24: 207–214

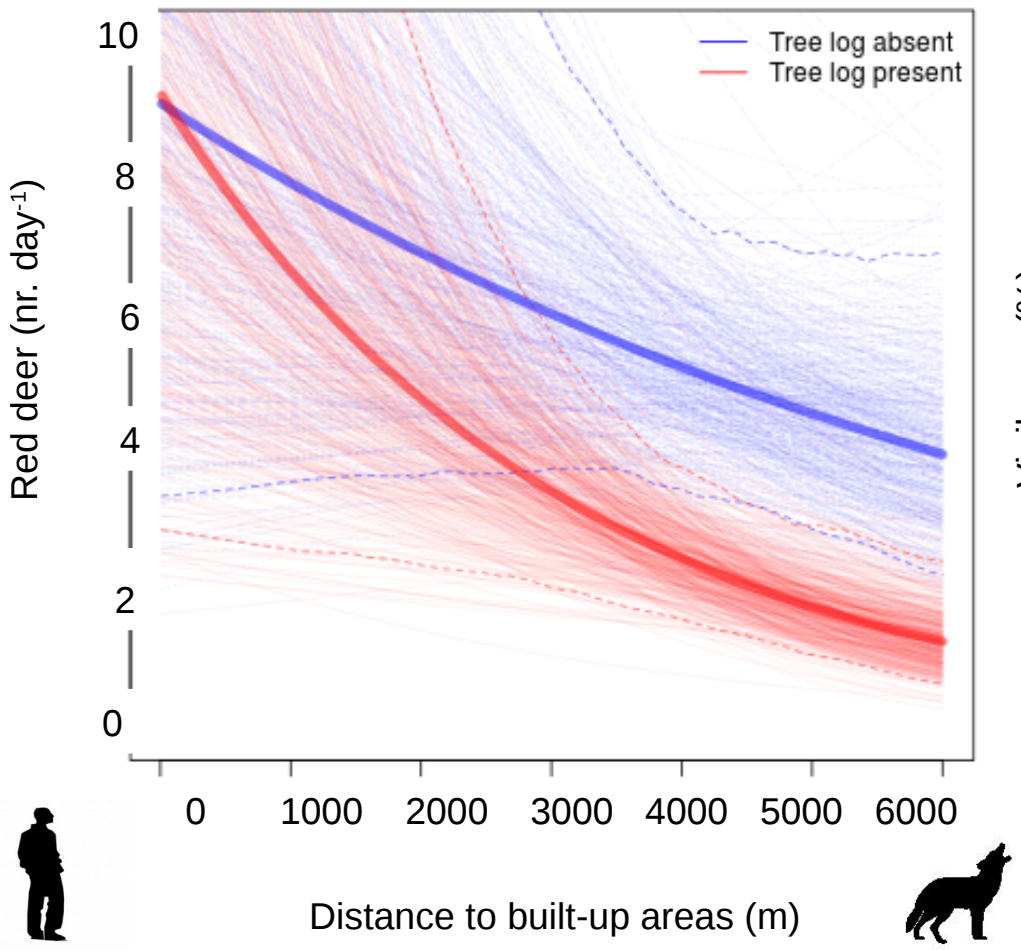
Context-dependence of tree logs: Do deer experience more fear close to wolves?

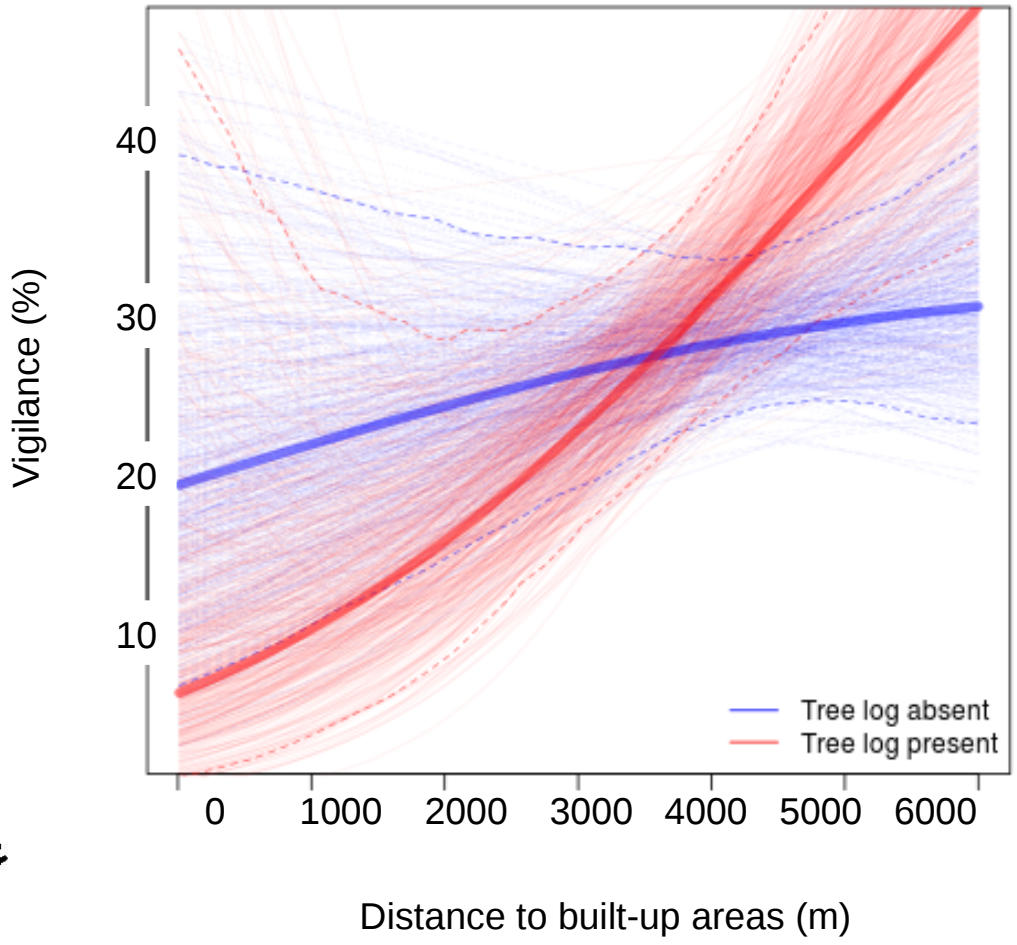




Kuijper et al. 2015

Deer fear tree logs more when far from humans but close to wolves





Tree log absent

Tree log present

Kuijper et al. 2015

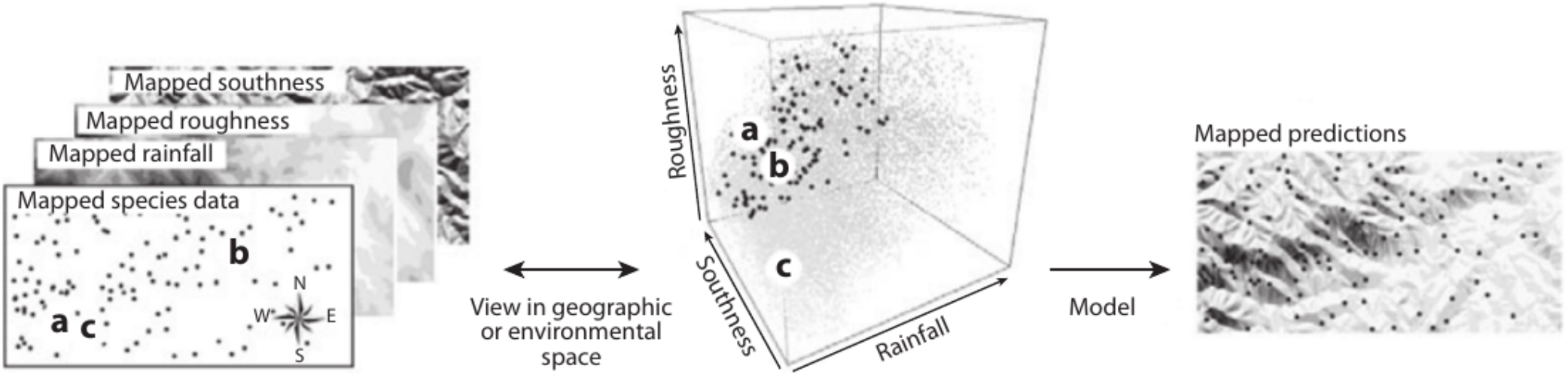
Aim of the study

testing importance of

multi-scale habitat structure,
human & natural predators,
seasonality,
inter-specific relations

in shaping ungulates spatial distribution and habitat selection

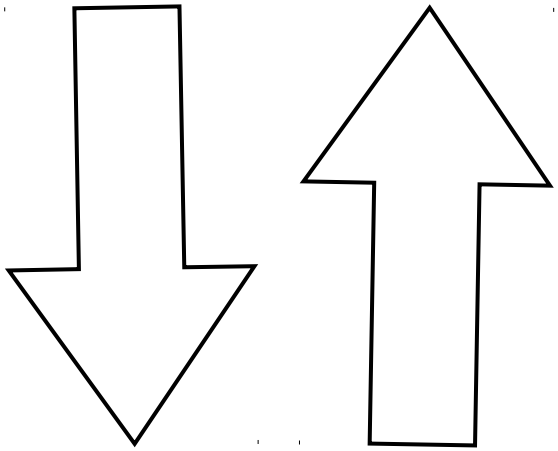
Species Distribution Models (SDM)



+ remote sensing

Multi-scale remote sensing

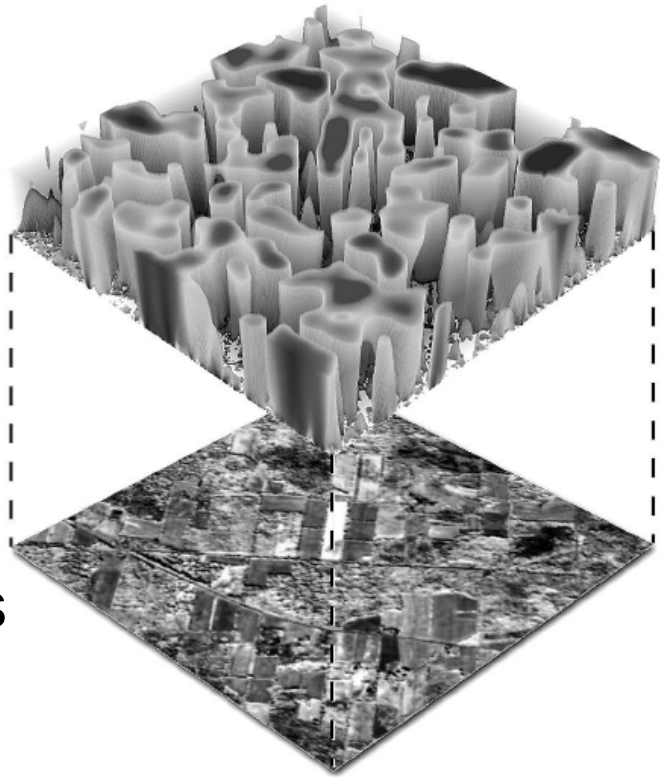
Landscape-scale habitat structure



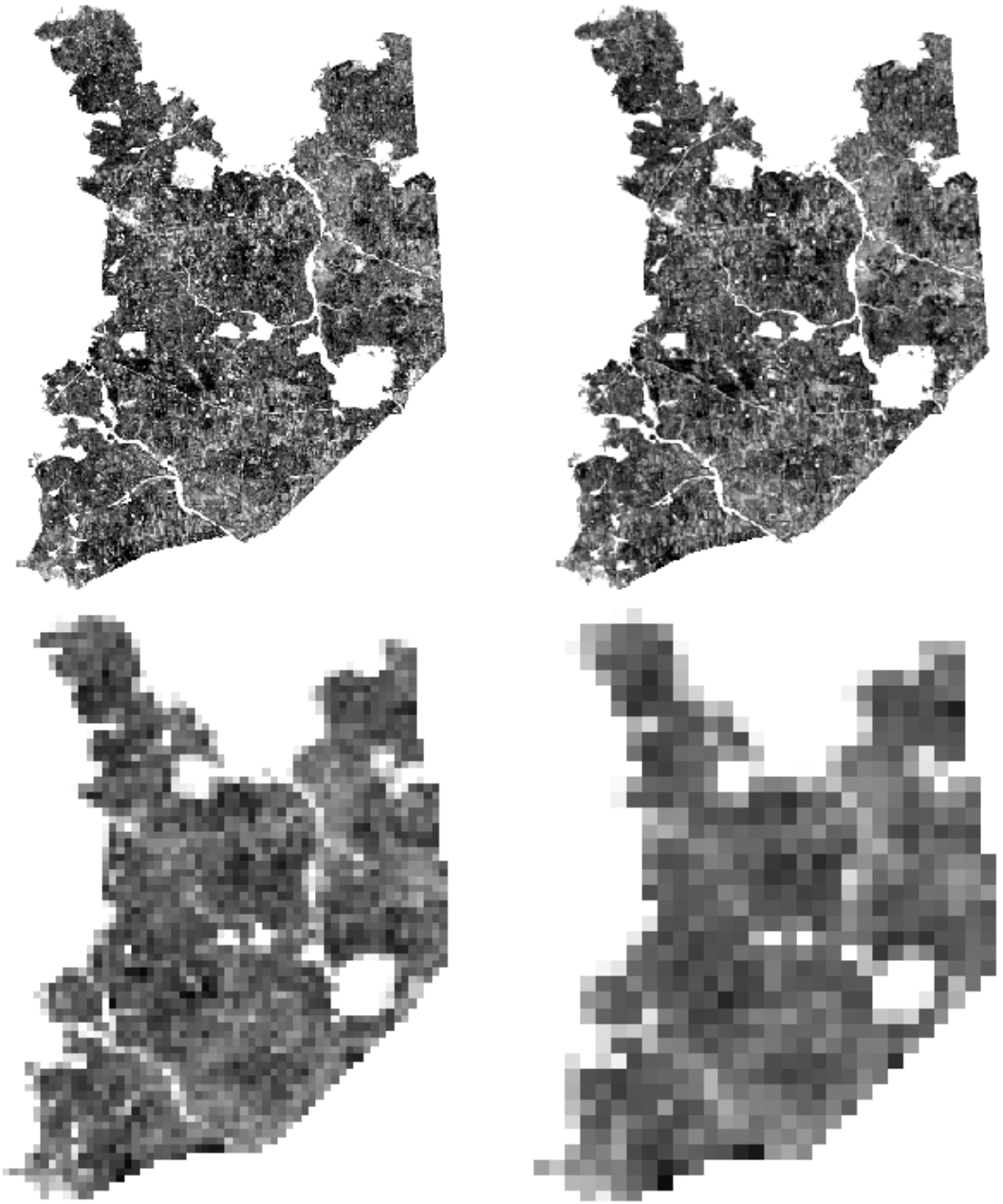
Re-sampling algorithms

Multi-resolution segmentations

Moving windows
e.g. 10x10, 100x100 pixels



Fine-scale habitat structure

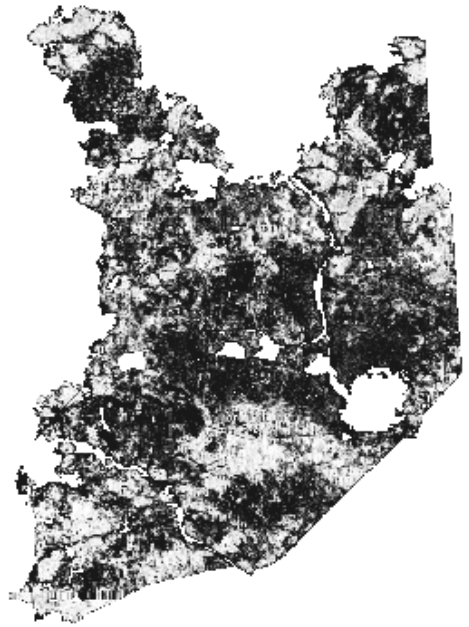


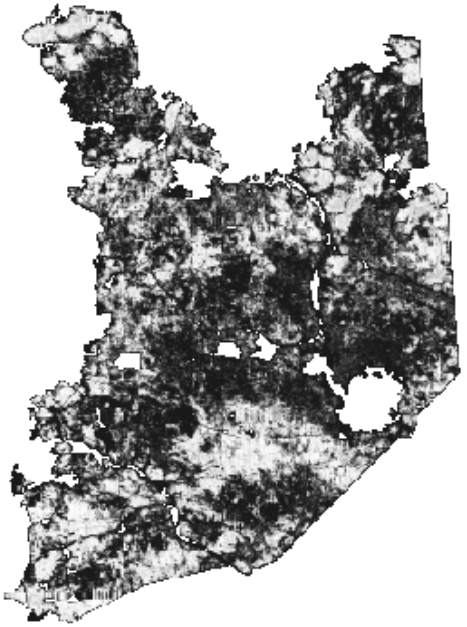
Canopy Height (LIDAR)

Canopy Openness (LIDAR)

Simple rule:

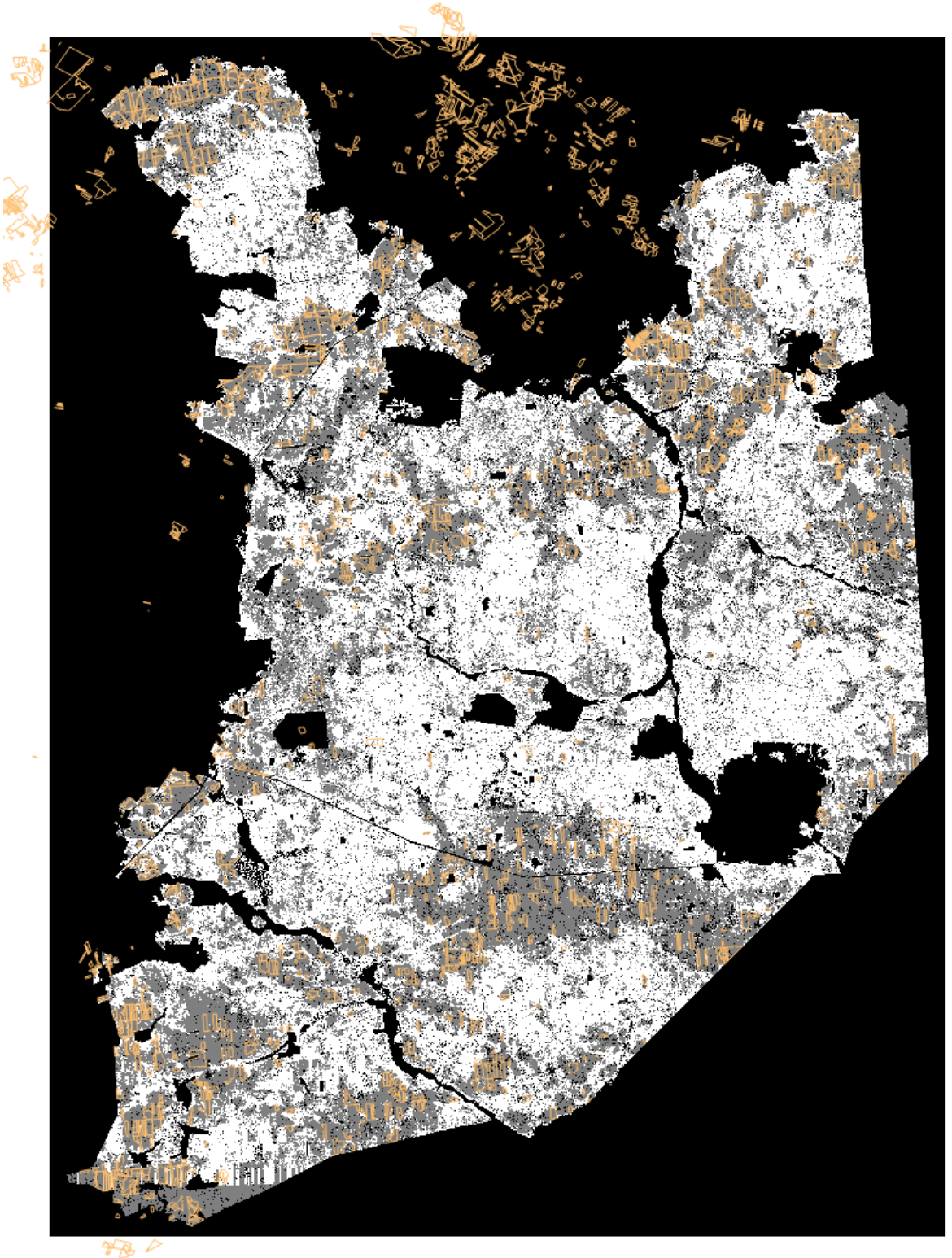
Canopy Height < 2m





% Coniferous Trees

RAPID EYE & LIDAR



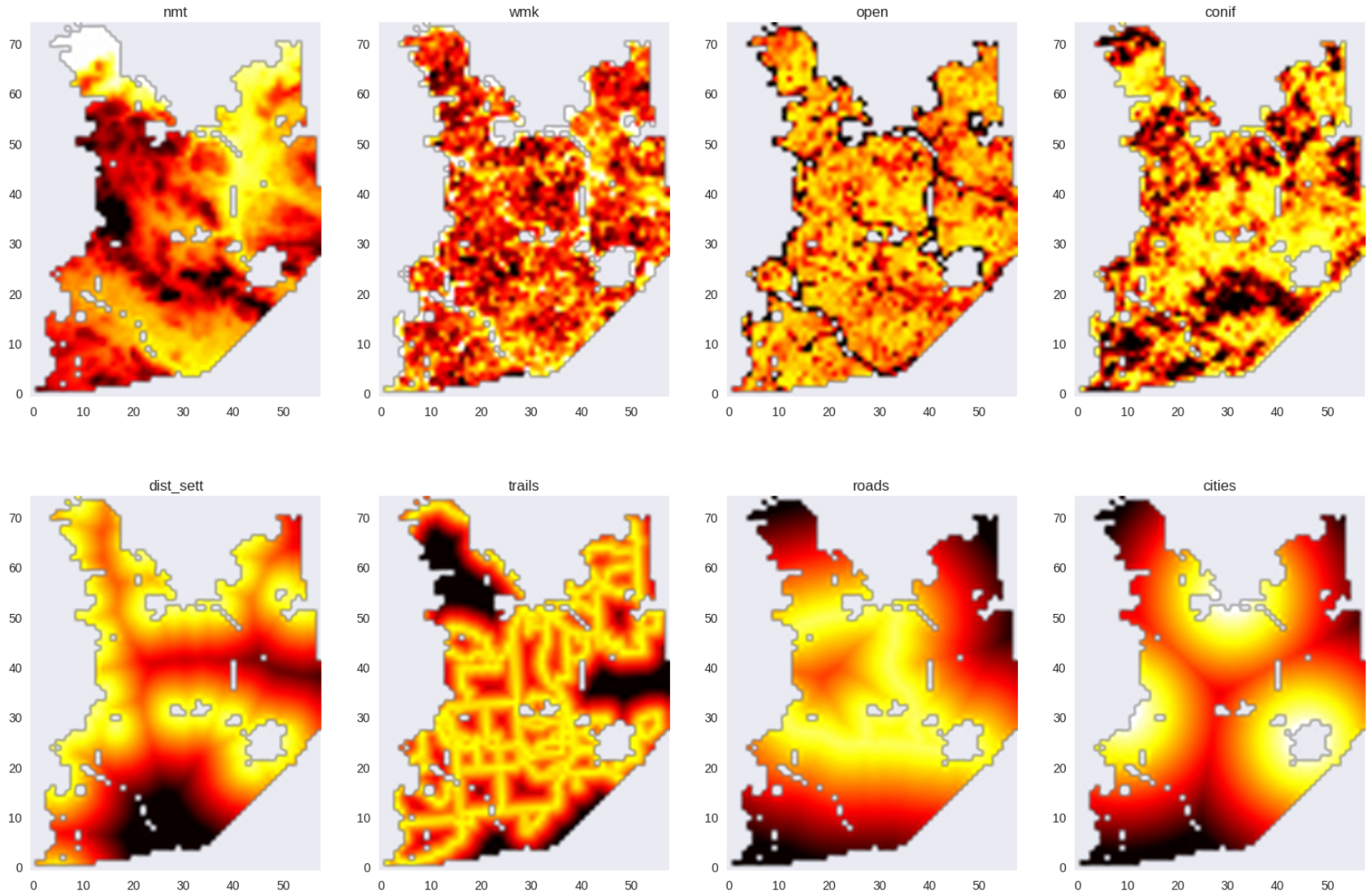
Coniferous vs Non-Coniferous pixels

Support Vector Machine (SVM) classifier

	Pred C	Pred NC	
Valid C	6622	1339	**7961**
Valid NC	933	6961	**7894**
	7555	**8300**	

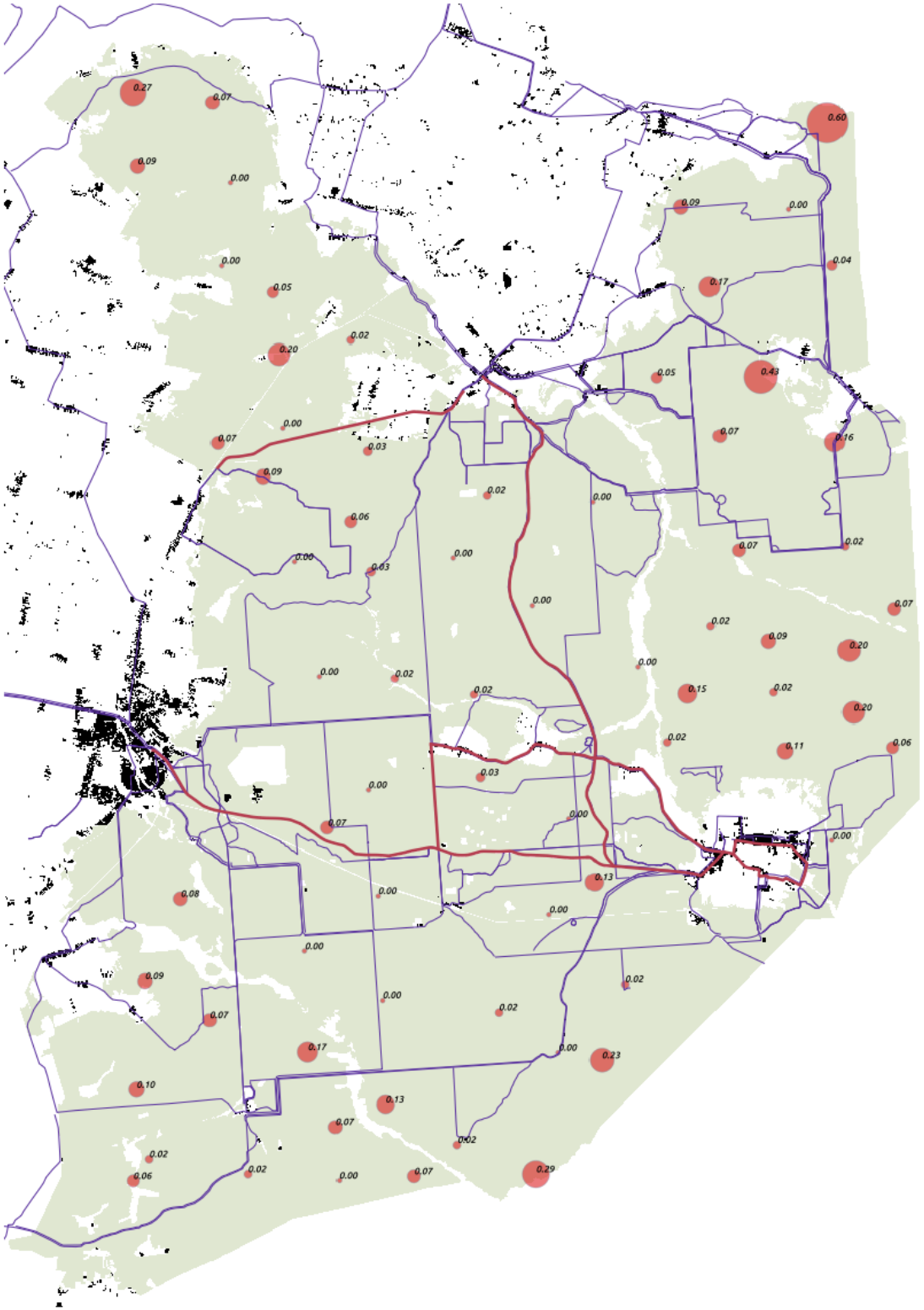
based on **Rapid Eye**
Tasseled Cup Greenness
vegetation index &

State Forest inventory db
(training & validation)


nmt
wmk
open
conif
dist_sett
trails
roads
cities
0
10
20
30
40
50
60
70

WOLF (and HUMANS) part

Autumn 2015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0.05
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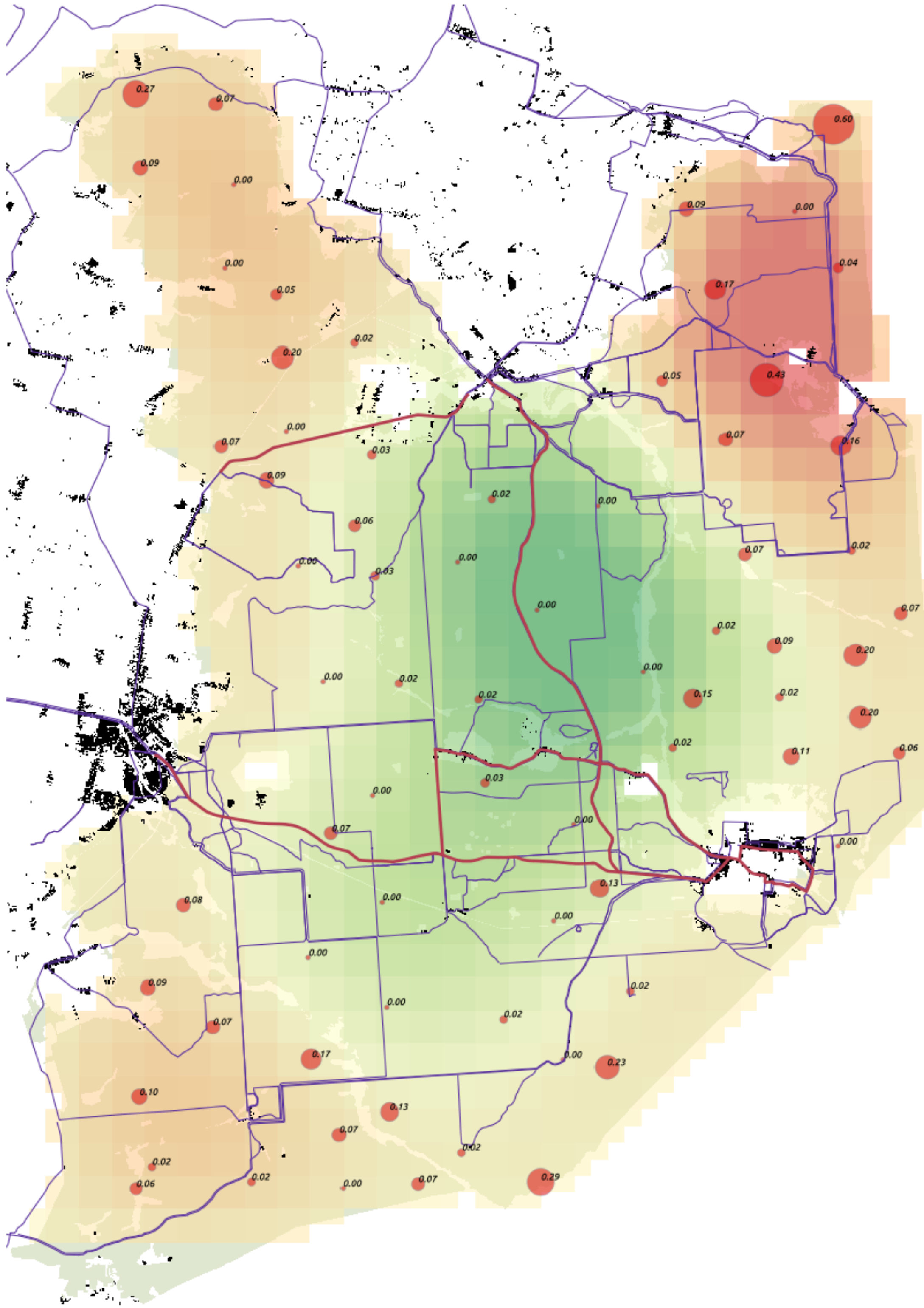
0.29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0.17
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0.23
0.10
0.13
0.07
0.02
0.02
0.02
0.00
0.07
0.06
0.29

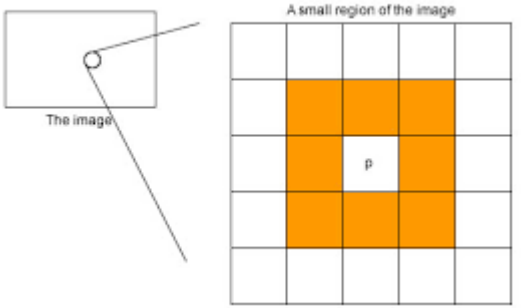
Trapping (detection) rate

$$N_s \sim Poisson(\lambda_s)$$

px=500m

$$log(\lambda_s) = x_s^{'}\beta + \omega_s + \epsilon_s + log(offset)$$

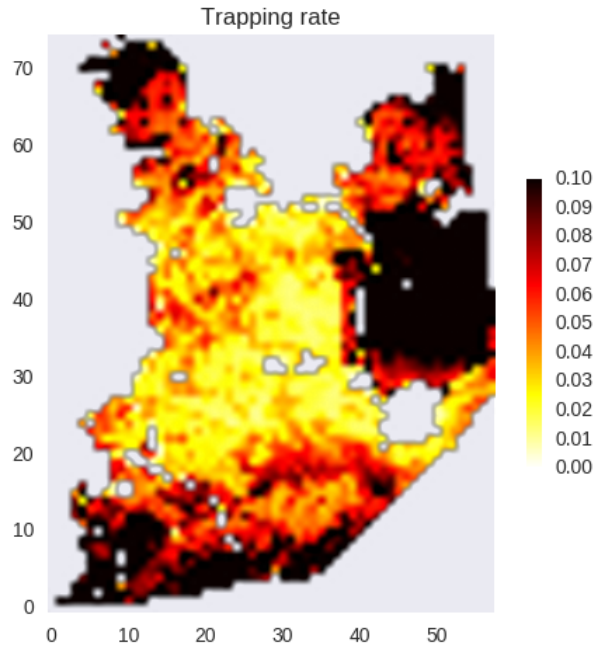
Spatial random effect
Restricted Spatial Regression (Johnson et al. 2013)



Bayesian Spatial GLMM

coded and fitted with python & pymc2

Wolf


Trapping rate
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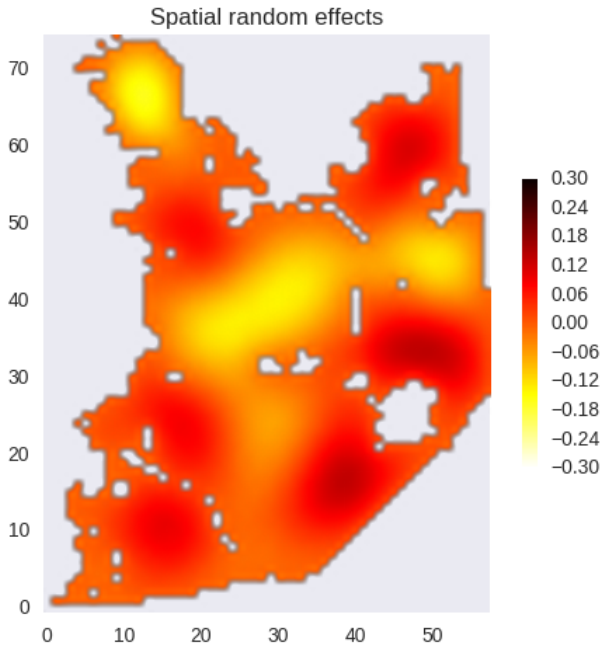
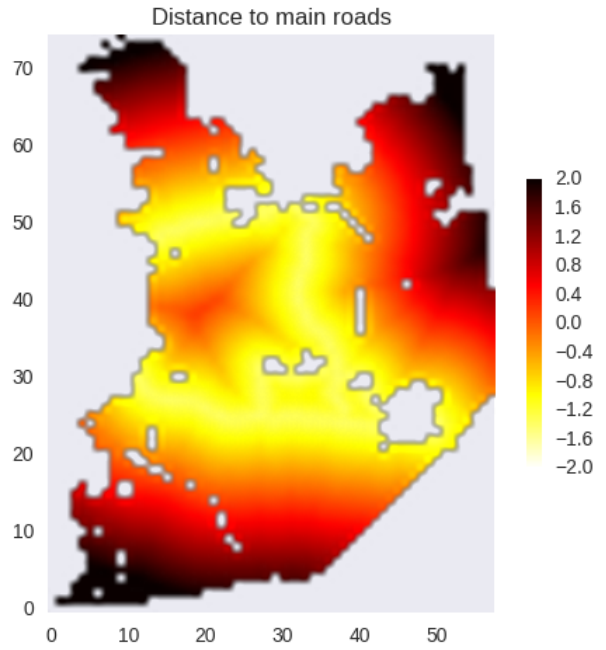
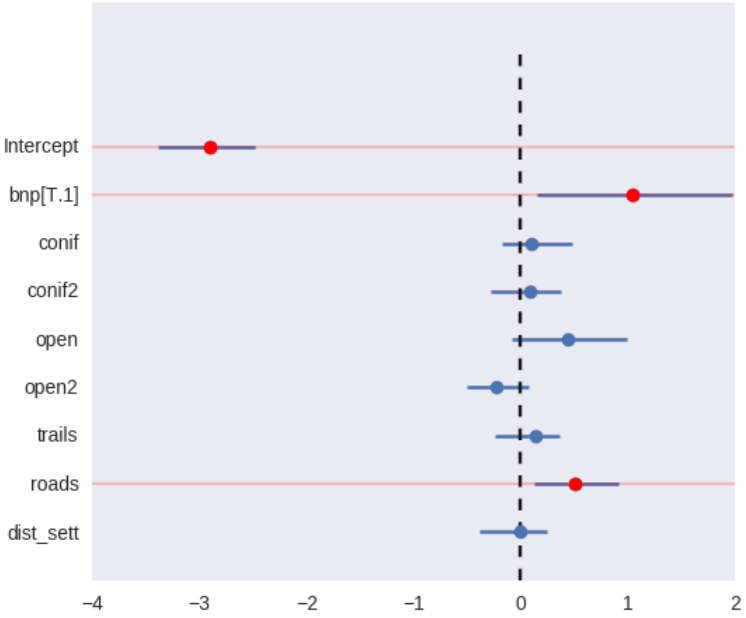

Spatial random effects
0.30
0.24
0.18
0.12
0.06
0.00
−0.06
−0.12
−0.18
−0.24
−0.30


Distance to main roads
2.0
1.6
1.2
0.8
0.4
0.0
−0.4
−0.8
−1.2
−1.6
−2.0


Intercept
bnp[T.1]
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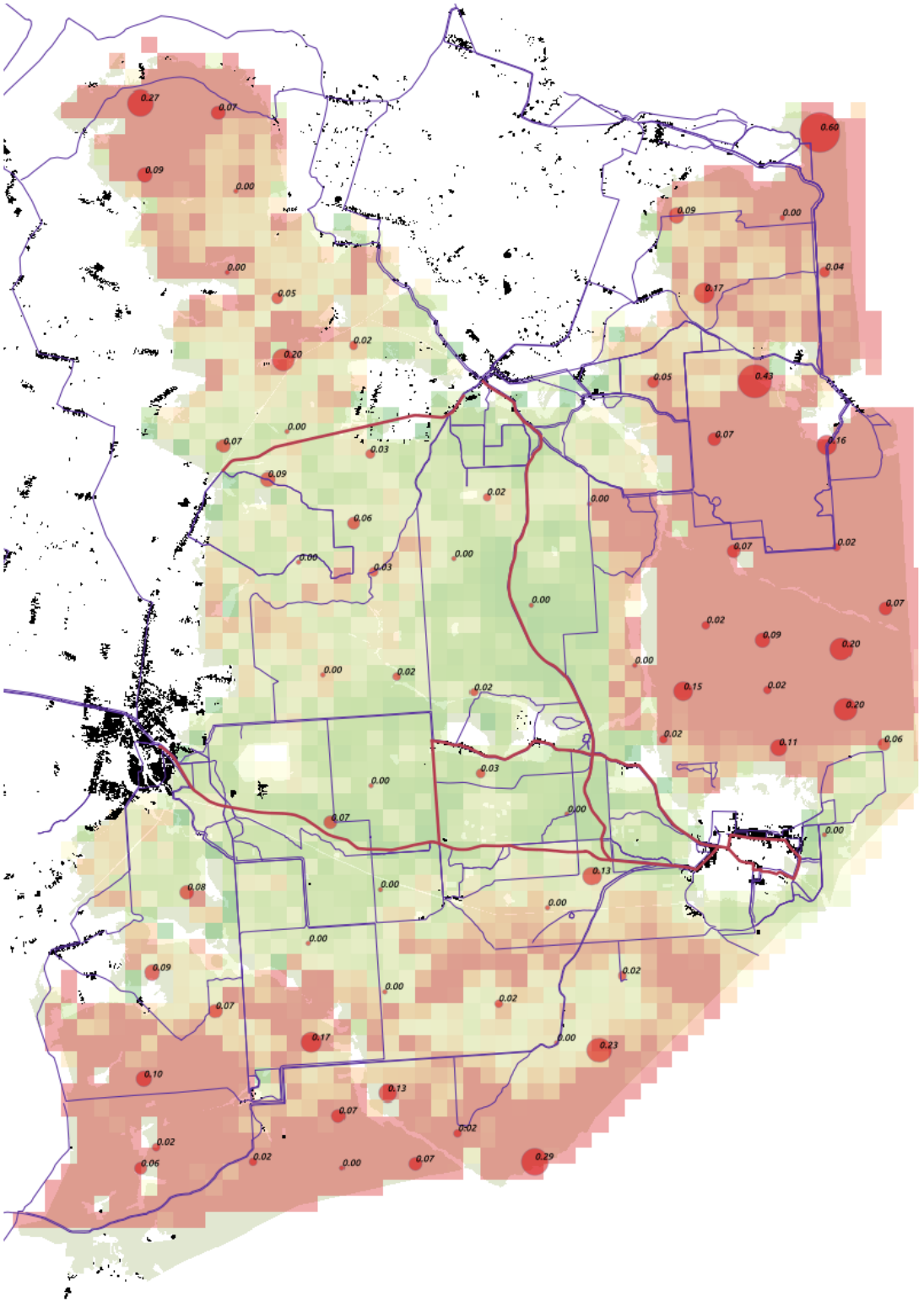
conif2
open
open2
trails
roads
dist_sett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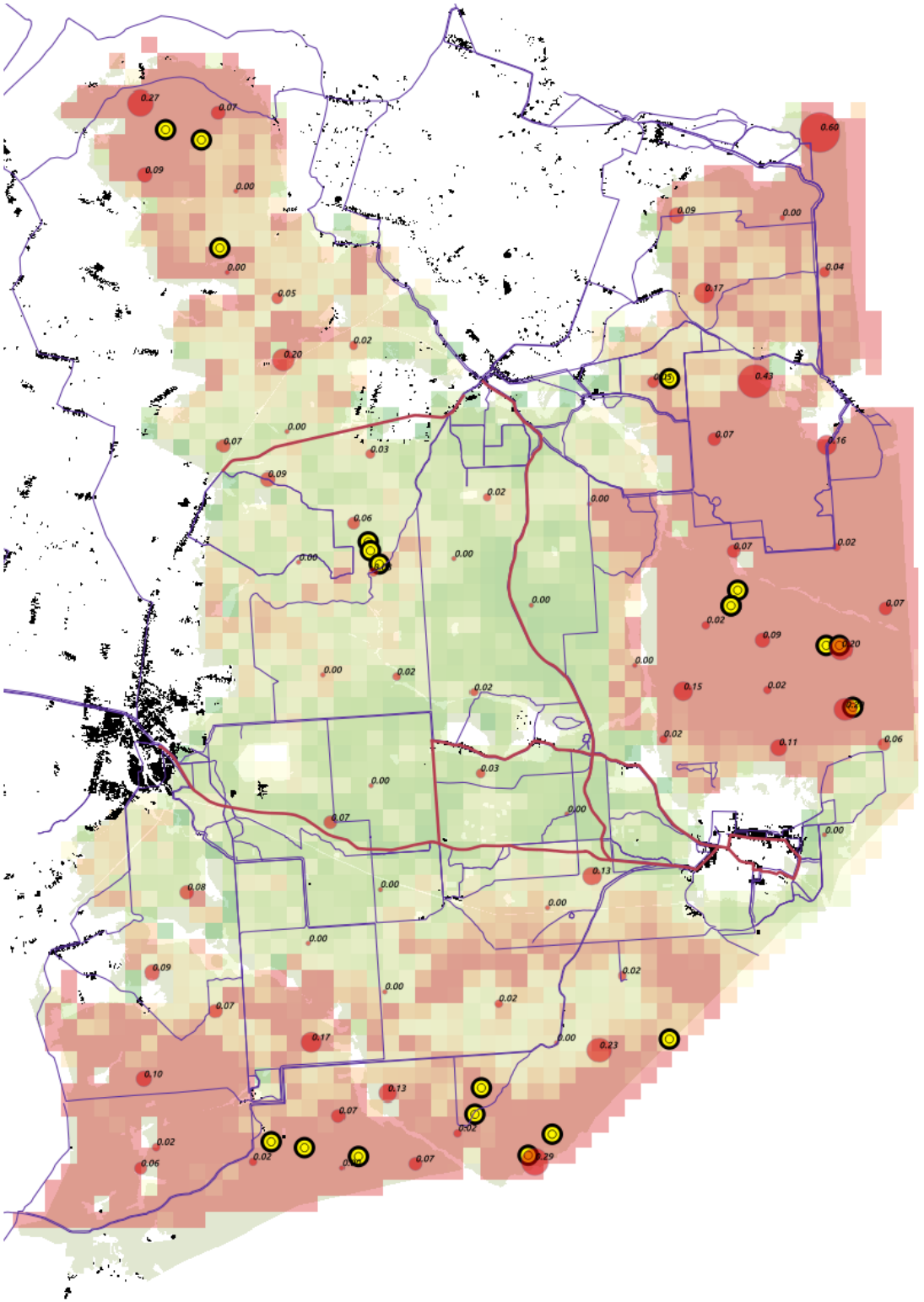

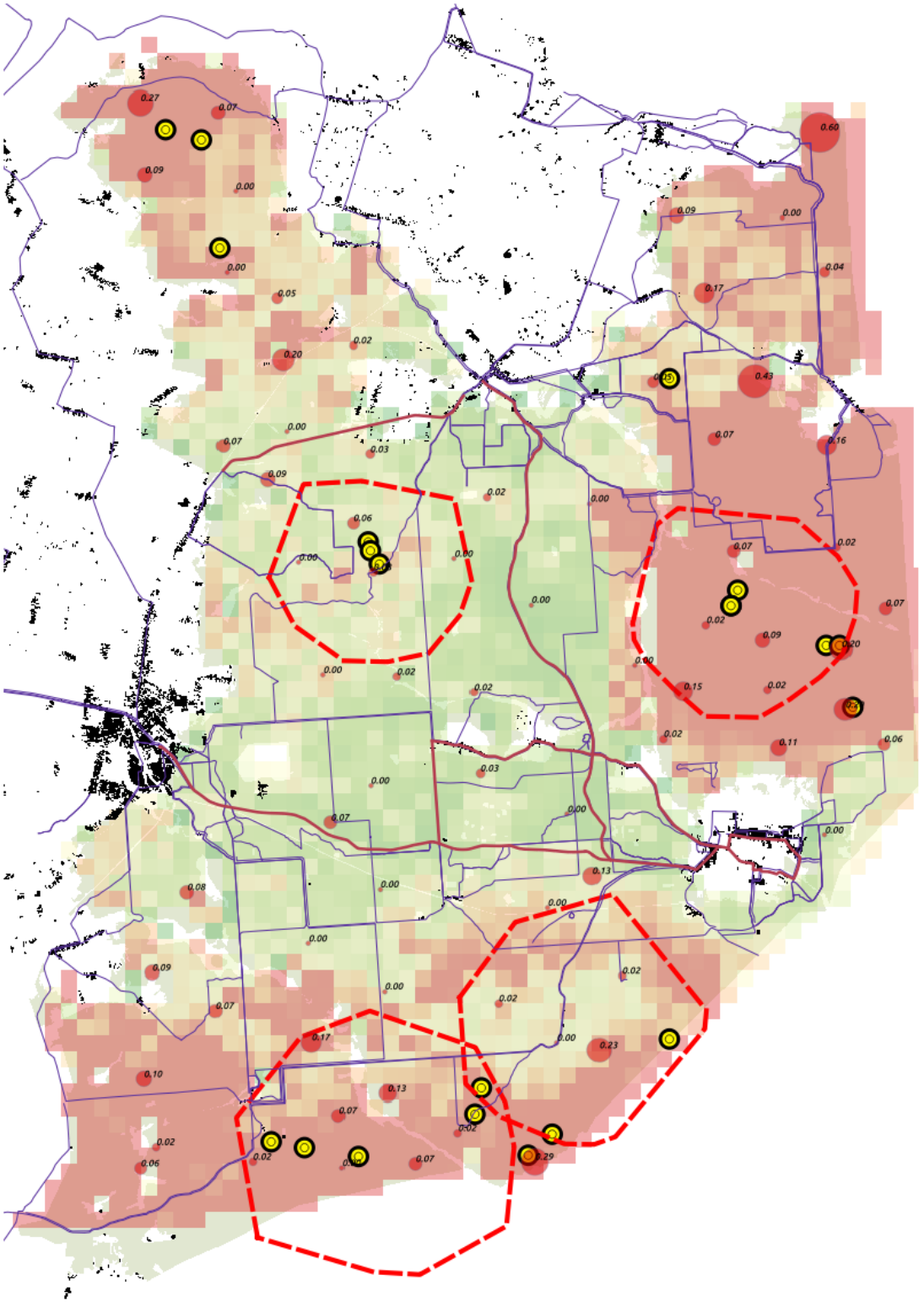

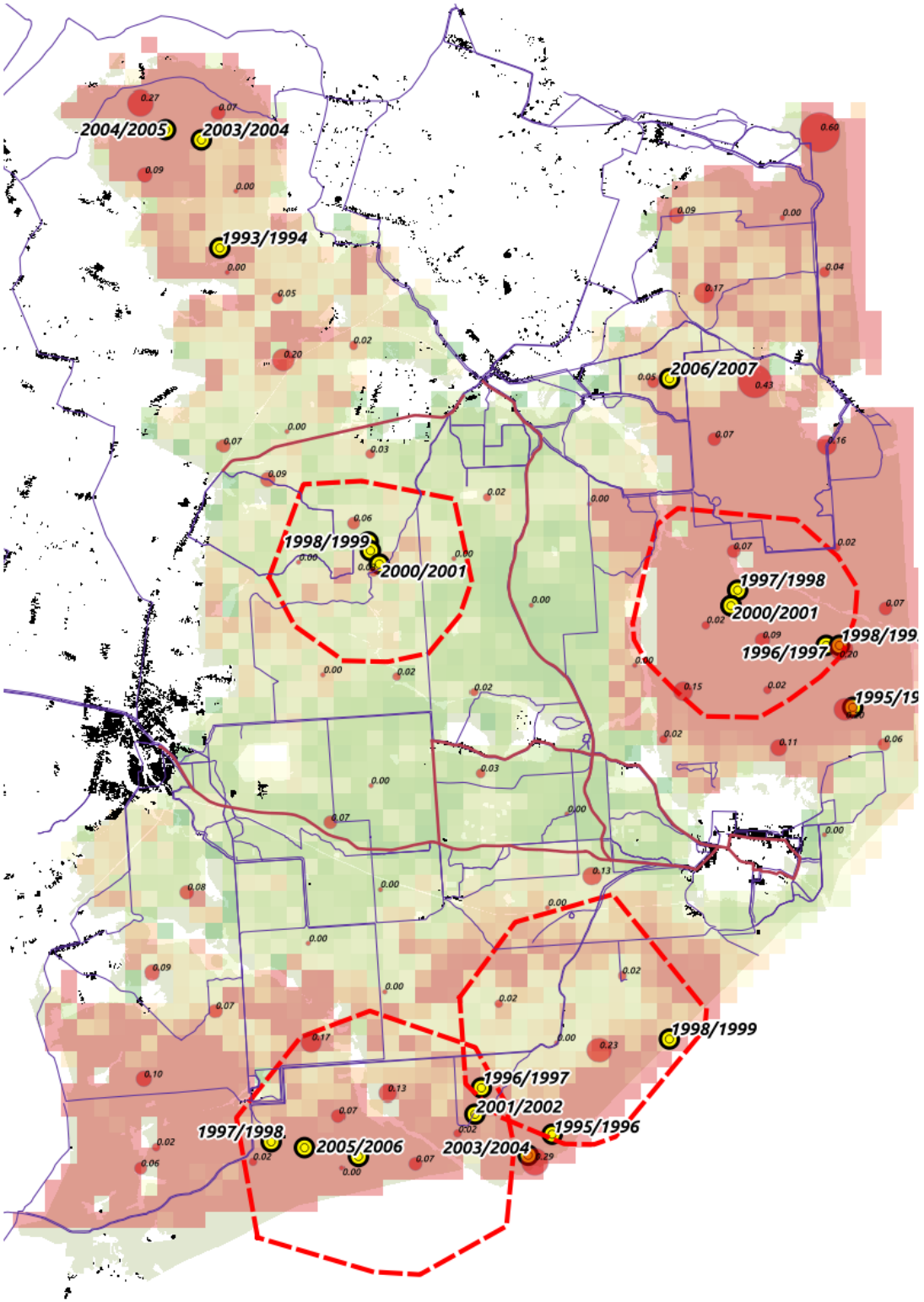
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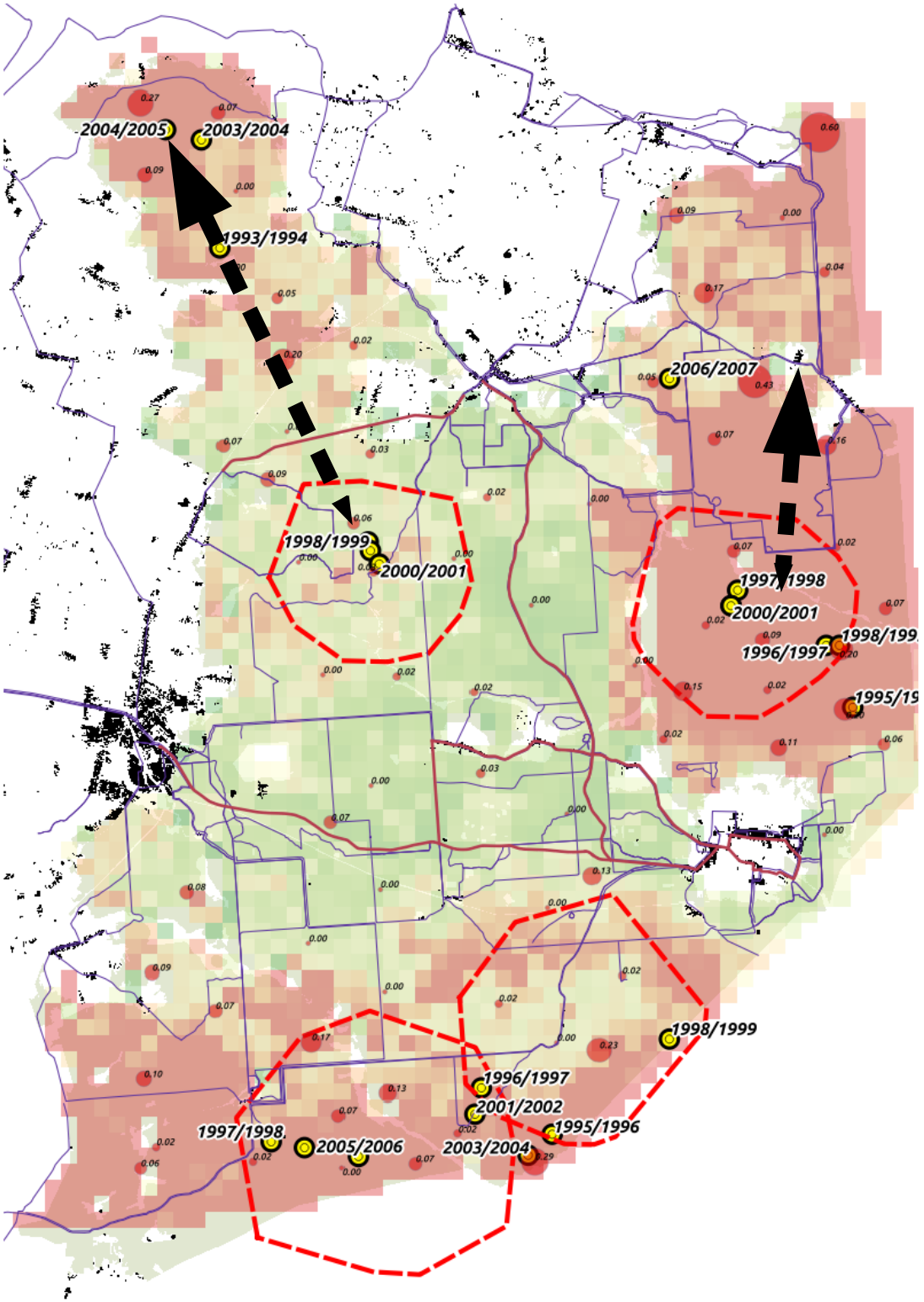
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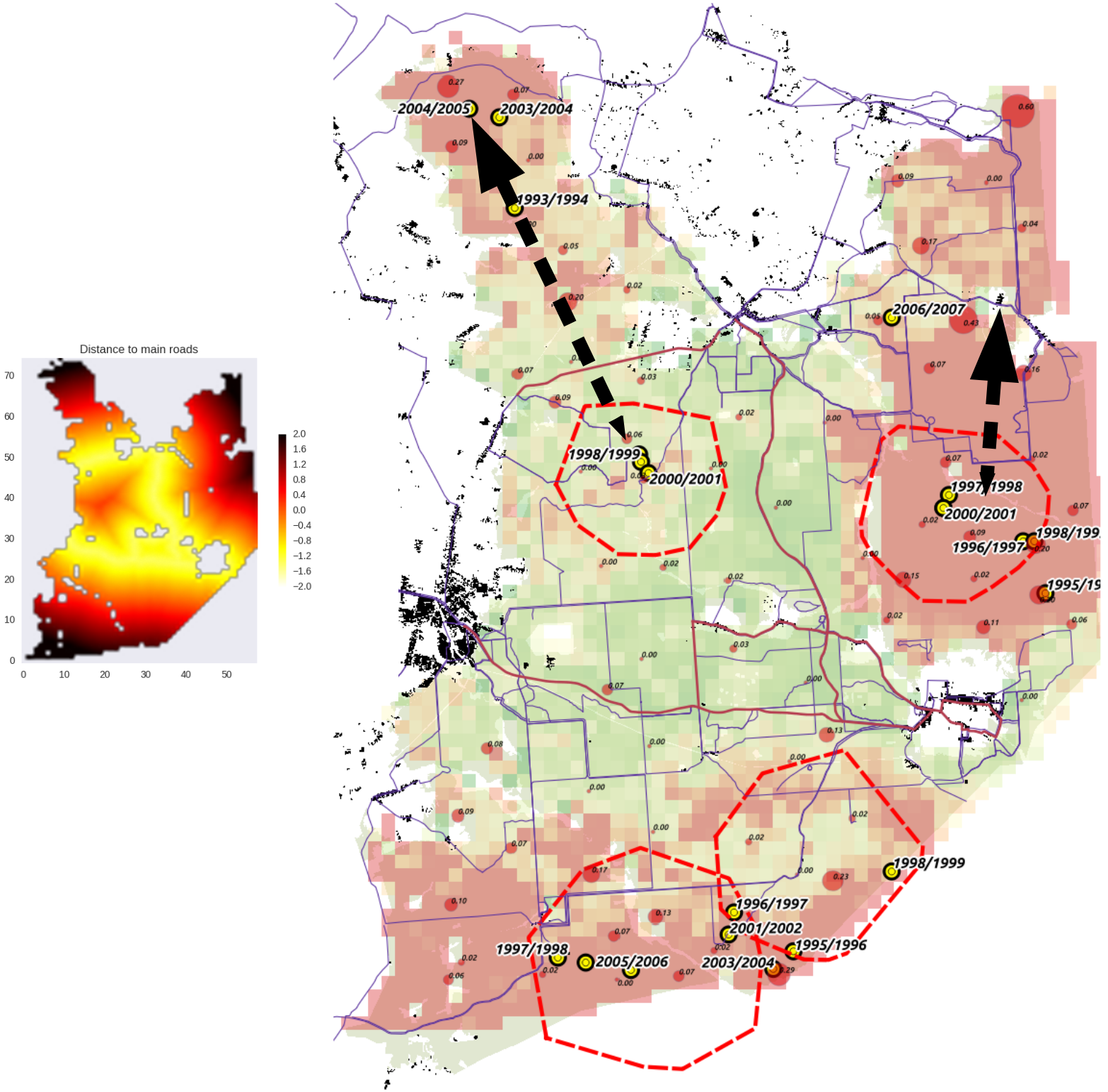
Distance to main roads
70
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30
40
50
2.0
1.6
1.2
0.8
0.4
0.0
−0.4
−0.8
−1.2
−1.6
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2004/2005
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2000/2001
1998/199
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1996/1997
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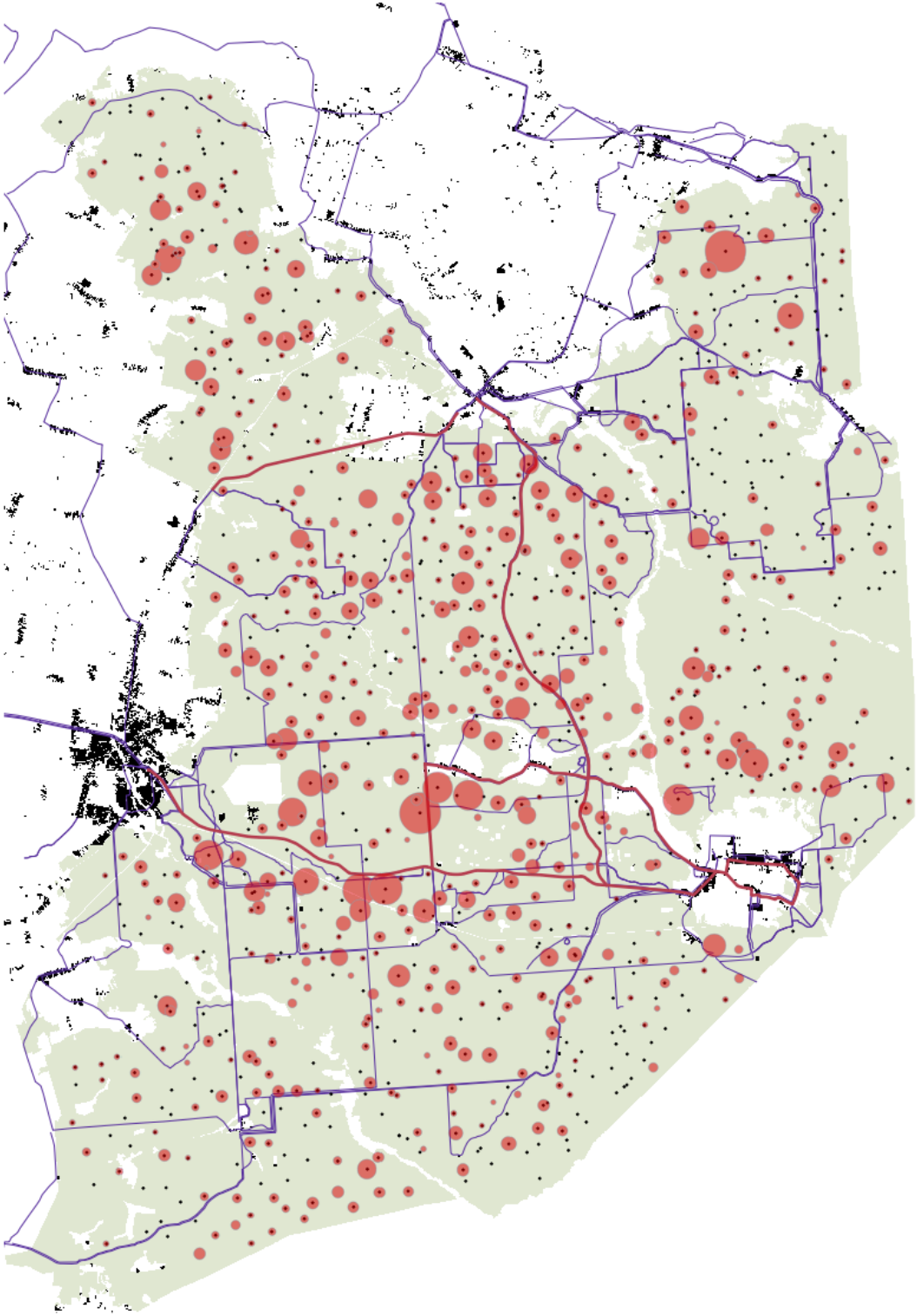
1995/1996
1997/1998
2005/2006
2003/2004

RED DEER (female) part

2012-2014



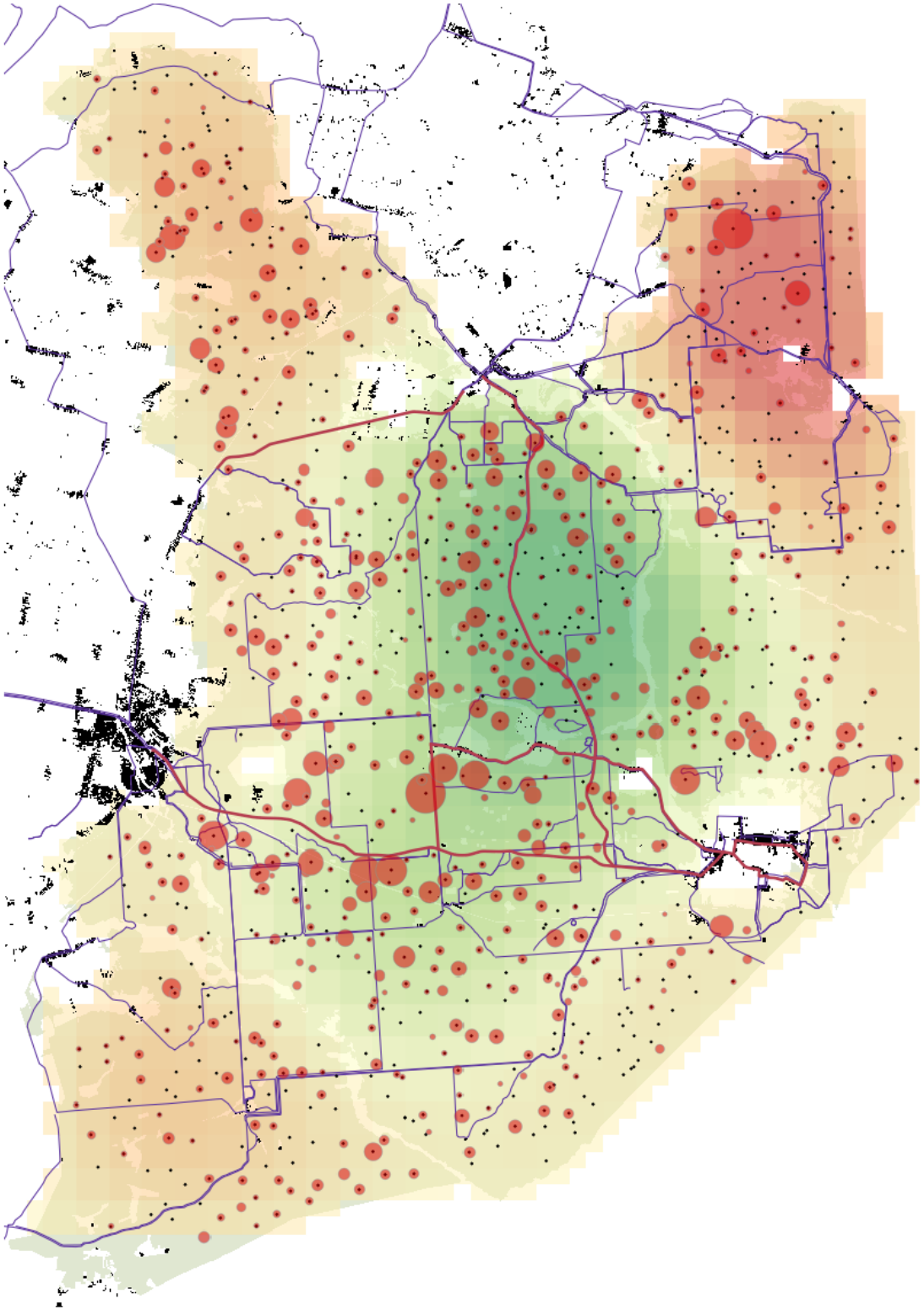
> 1000 locations

7562 videos

(> 120h)

8036 pictures

> 400 GB



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APPLICATION

TRAPPER: an open source web-based application to manage camera trapping projects

Jakub W. Bubnicki*, Marcin Churski and Dries P. J. Kuijper

Mammal Research Institute, Polish Academy of Sciences, ul. Waszkiewicza 1d, 17-230 Białowieża, Poland

Summary

1. Camera trapping is increasingly becoming an important tool in ecological research. However, the organization of large collections of multimedia files and especially efficient searching for subsets of data is a challenging task. While the development of project-specific software solutions is dominating in the camera trapping community, little attention has been paid to more flexible and open-source solutions supporting diverse camera trapping research projects.

2. We used state of the art and well-recognized open source software components and programming language PYTHON to design and implement TRAPPER, a flexible data base driven web application to manage, classify, integrate, share and re-use data in camera trapping projects.

3. The main features of TRAPPER are: (i) it is fully open-source, (ii) it facilitates analysis of videos as well as images, (iii) it provides spatial filtering and web-mapping, (iv) it allows flexible implementation of specific data collection protocols, (v) it is a multi-user and role based system which facilitates collaborative work on camera trapping projects, (vi) it supports data re-use and (re)discovery.

4. TRAPPER can therefore be widely used by ecologists working with a variety of camera trap studies, alone or in collaboration with each other.

Key-words: data base, data intensive science, data management, django, monitoring, python

Occupancy probability

px=500m

$$z_s \sim Bernoulli(\psi_s)$$

$$logit(\psi_s) = x'_{1s}\beta_1 + \omega_s$$

Spatial random effect (Johnson et al. 2013)

Abundance

px=500m

$$N_s|z_s \sim Poisson(z_s\lambda_s)$$

$$log(\lambda_s) = x'_{2s}\beta_2$$

Detection rate

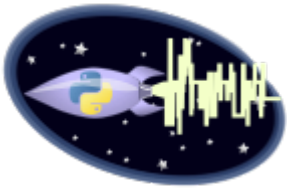
px=100m

$$y_s|N_s \sim Poisson(N_s\nu_s)$$

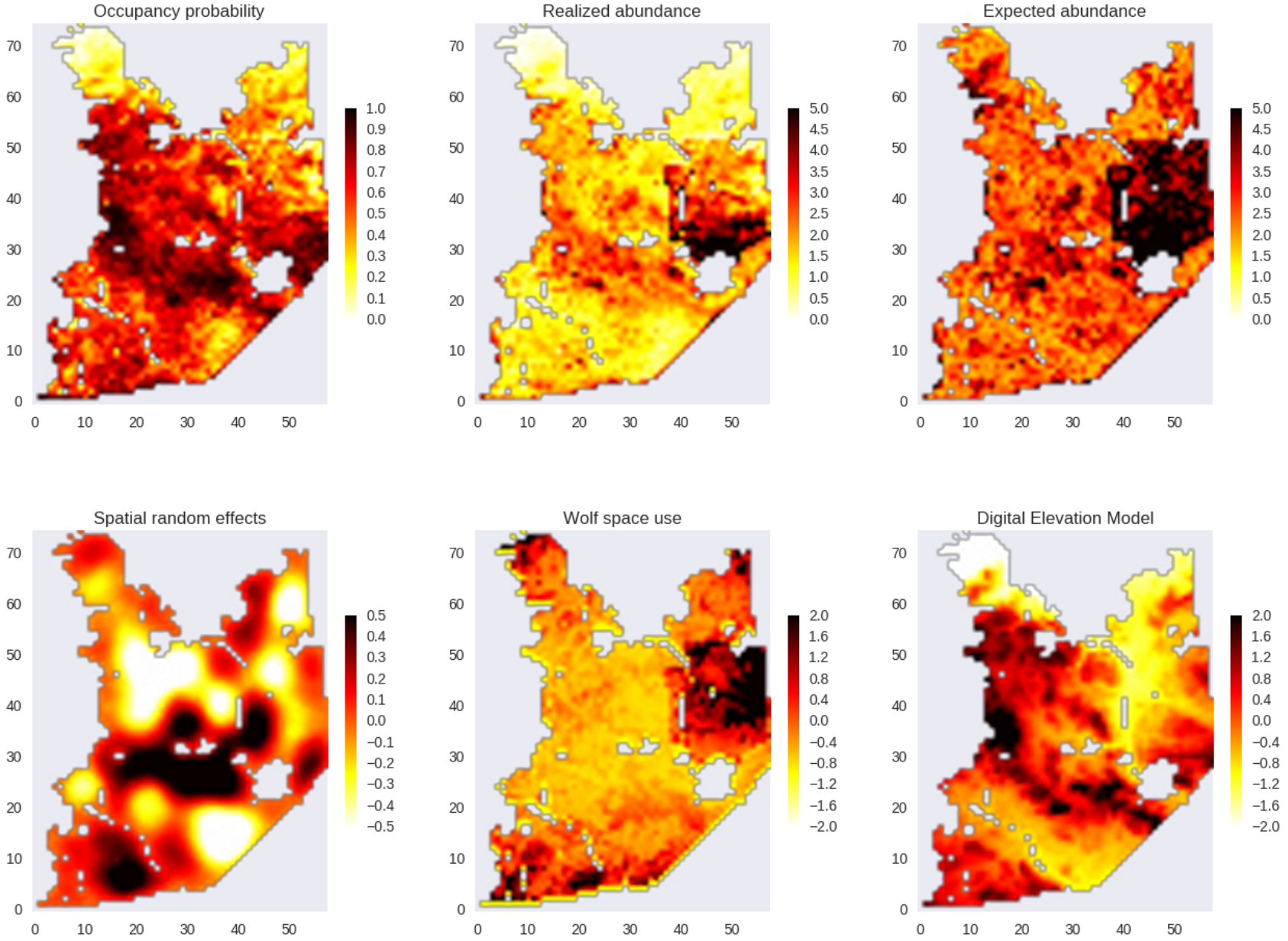
$$log(\nu_s) = x'_{3s}\beta_3 + log(offset) + \epsilon_s$$

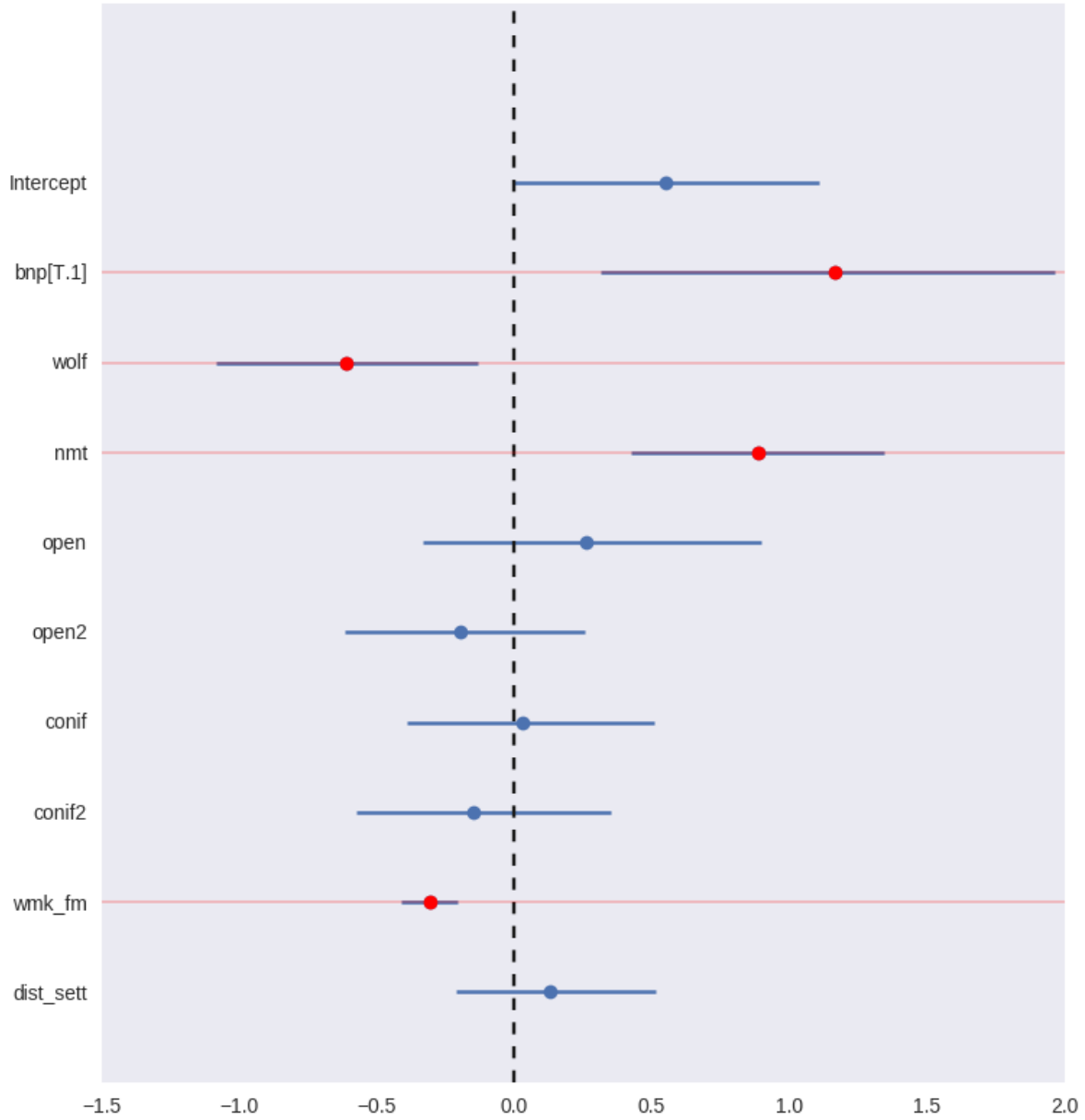
Bayesian Hierarchical Spatial GLMM

coded and fitted with python & pymc2



Red Deer Female, Green Season (April-September)

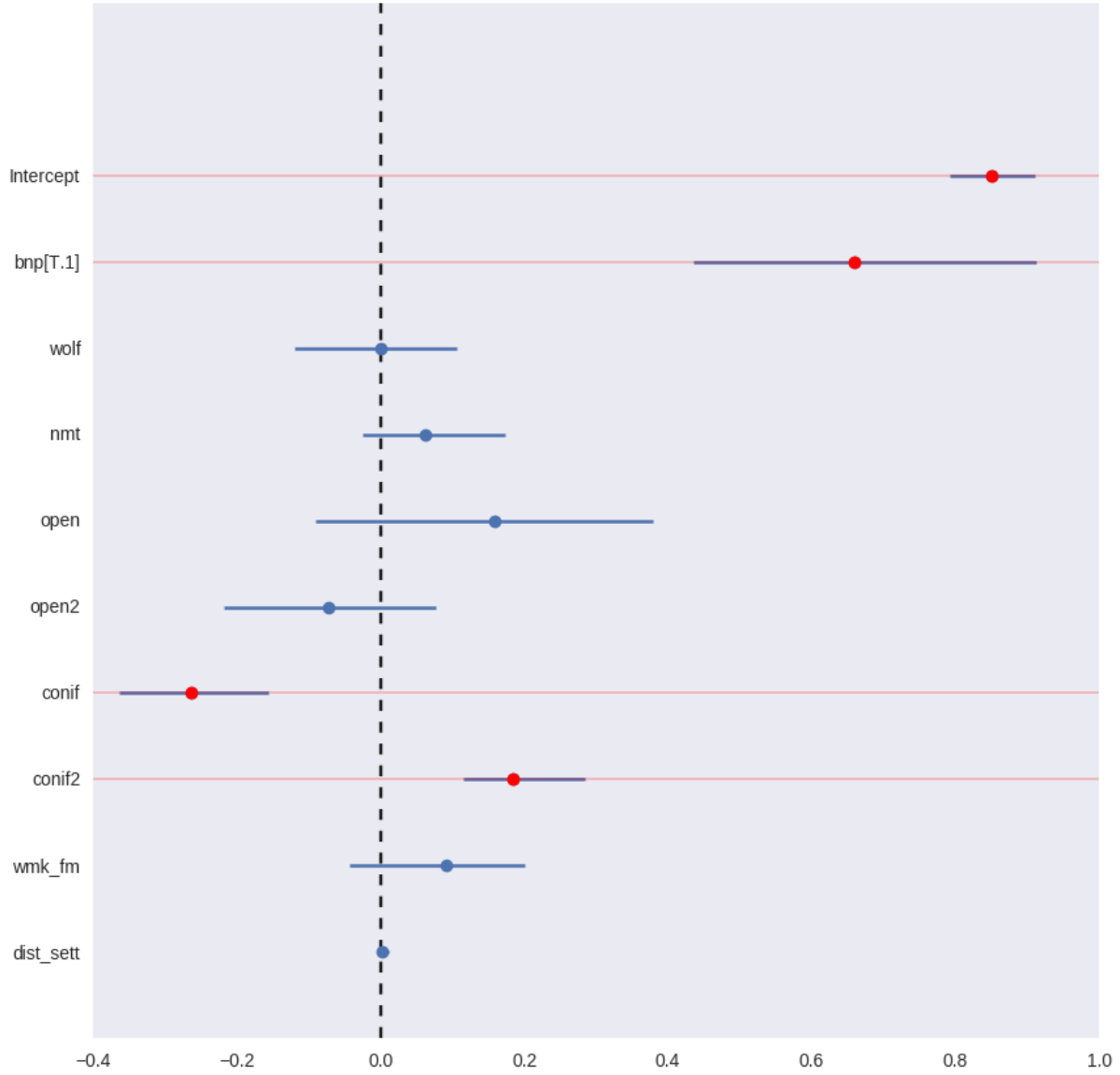


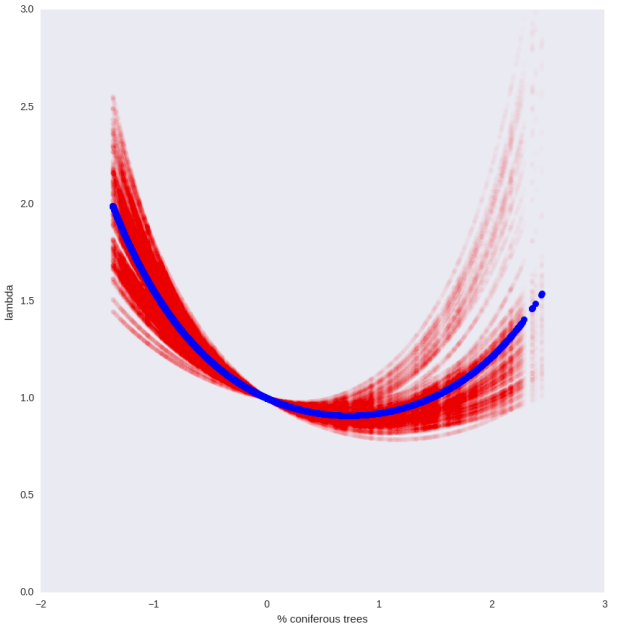


Occupancy probability

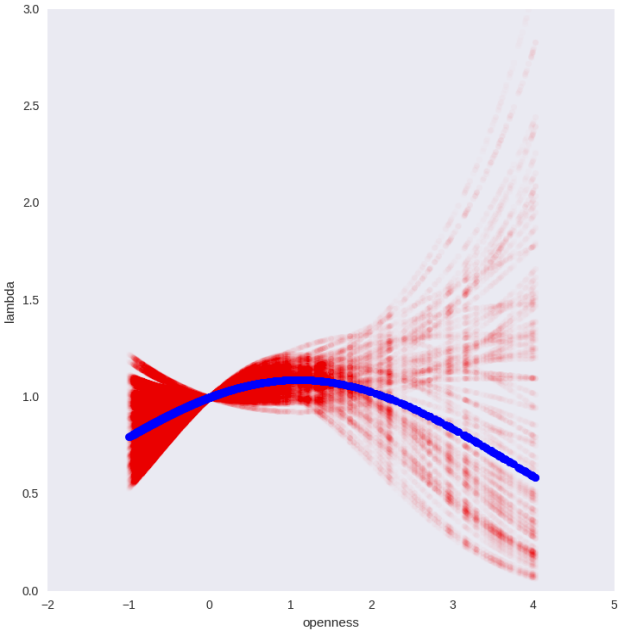
$$z_s \sim Bernoulli(\psi_s)$$

$$logit(\psi_s) = x'_{1s}\beta_1 + \omega_s$$





% coniferous

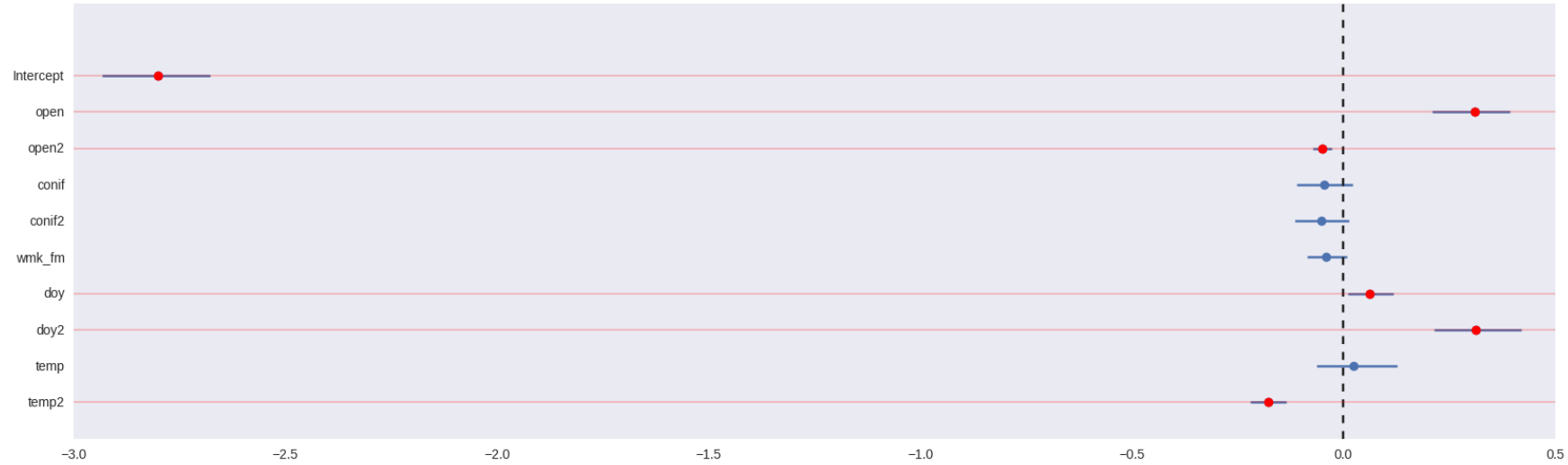


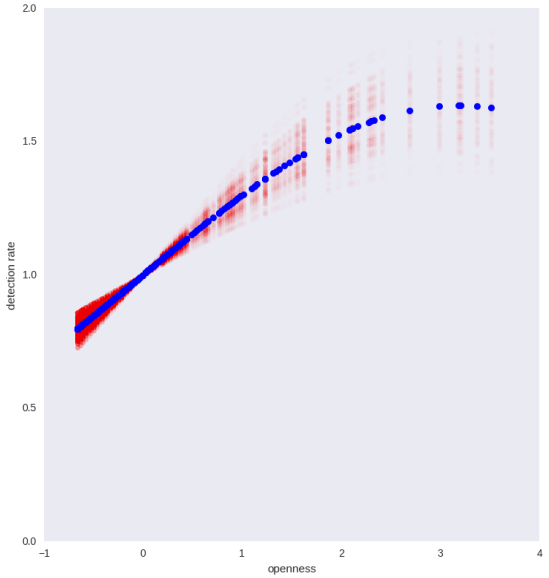
Canopy openness

Abundance

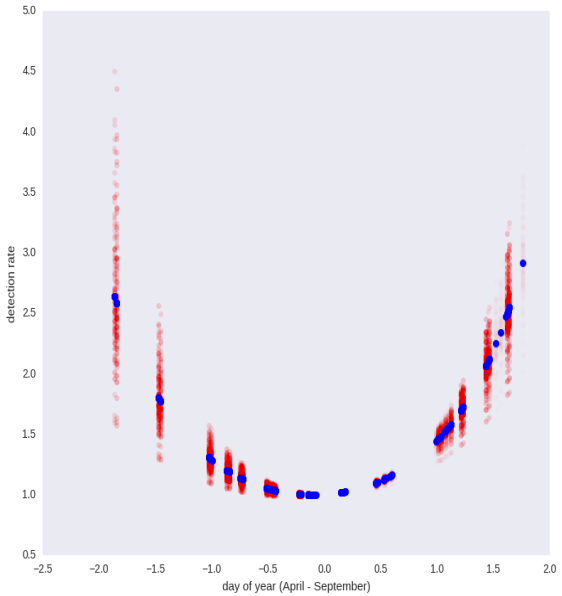
$$N_s|z_s \sim Poisson(z_s\lambda_s)$$

$$log(\lambda_s) = x'_{2s}\beta_2$$

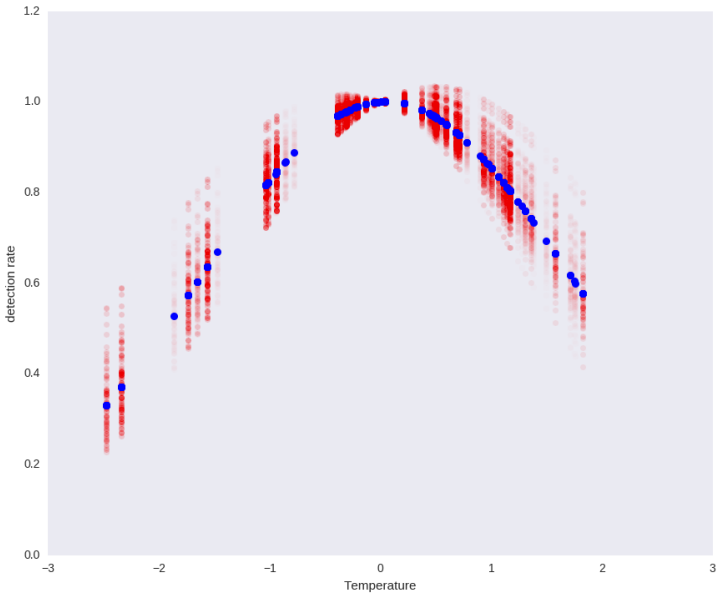




Canopy openness



Day of year

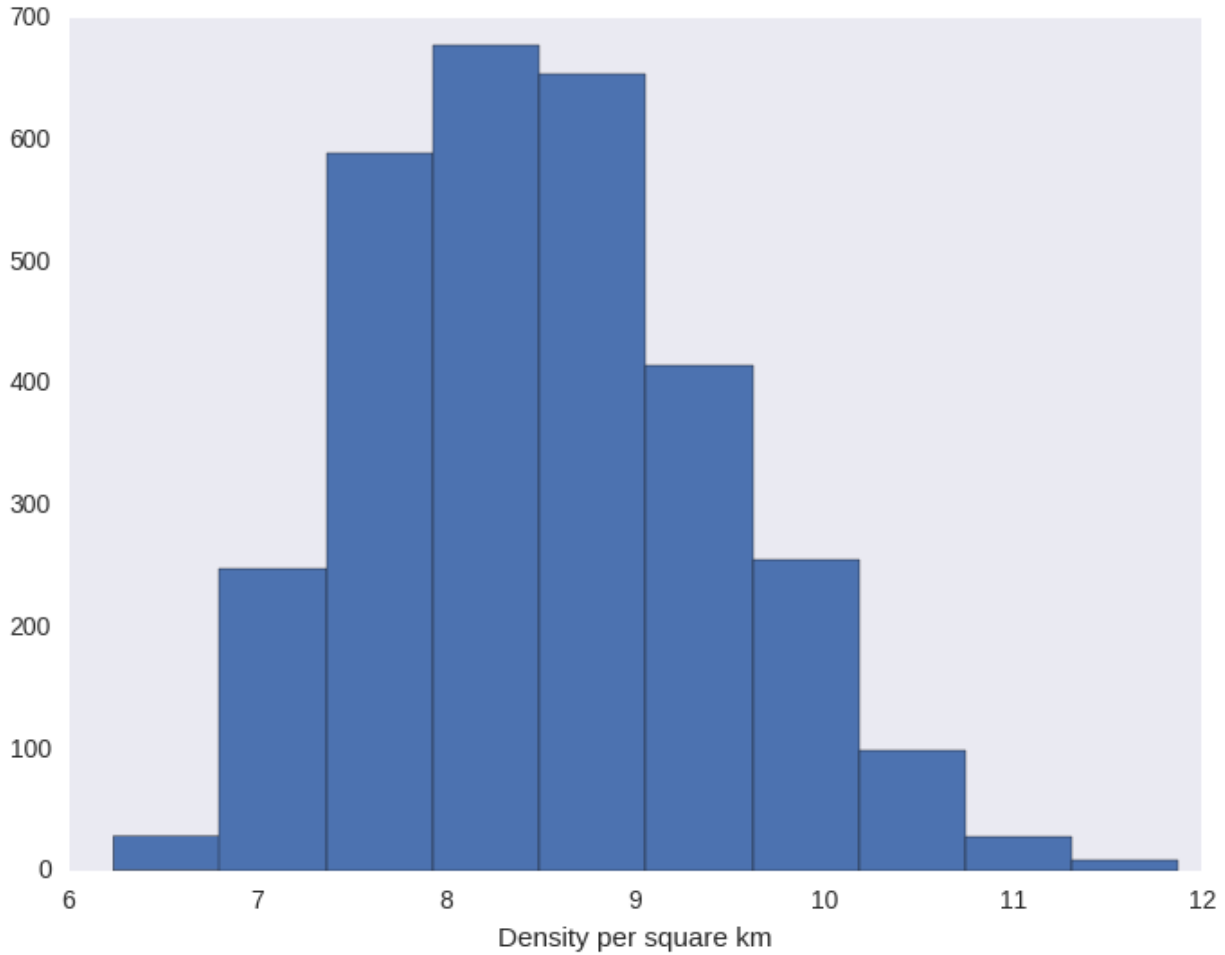


Temperature

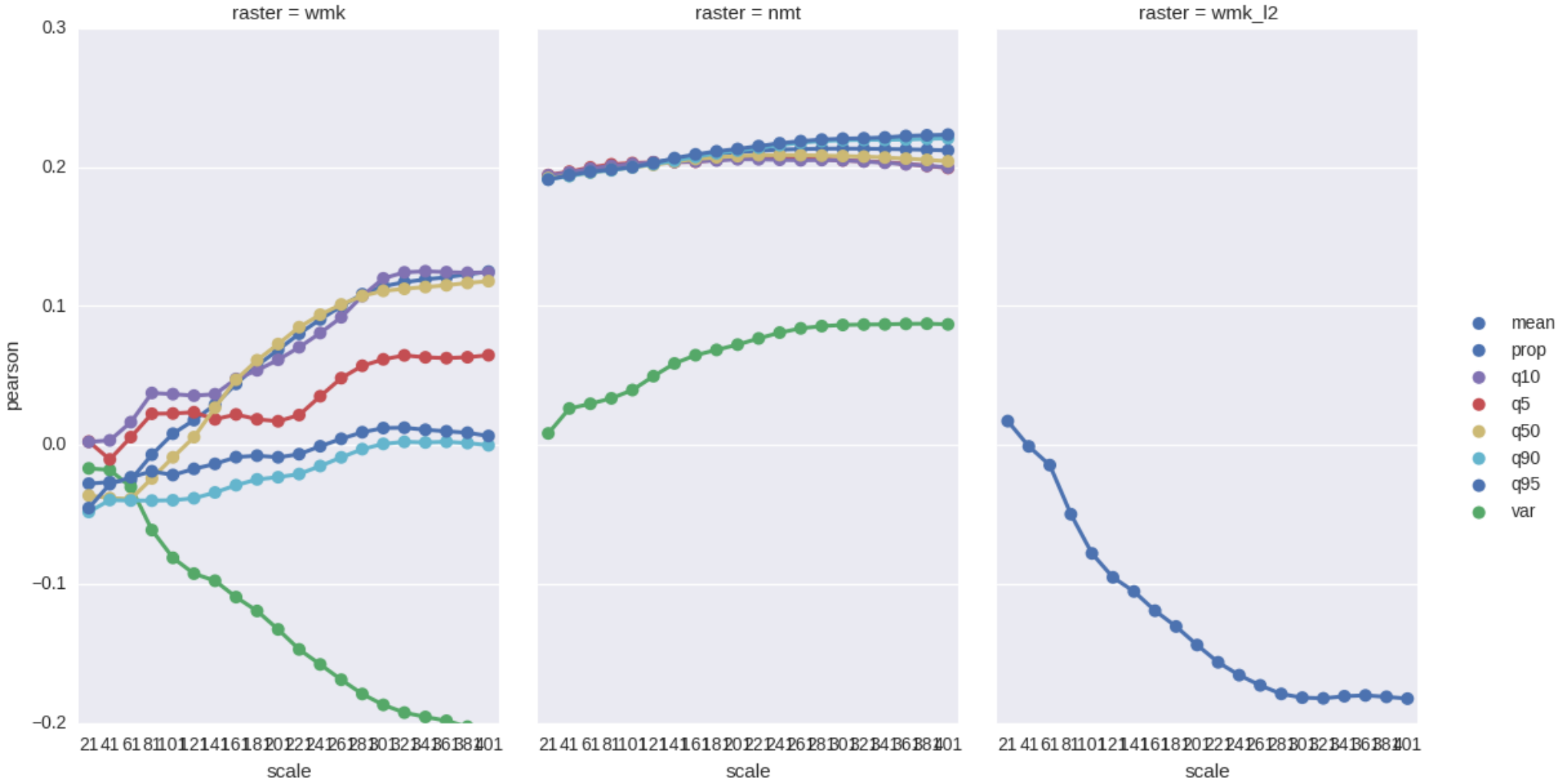
Detection rate

$$y_s|N_s \sim Poisson(N_s\nu_s)$$

$$log(\nu_s) = x'_{3s}\beta_3 + log(offset) + \epsilon_s$$


700
600
500
400
300
200
100
0
6
7
8
9
10
11
12
Density per square km

One more idea ...



Take home message

Camera trapping

+

Multi-resolution remote sensing

+

Hierarchical Bayesian modeling

=

Powerful combination for advanced ecological research