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ASSESSING BEHAVIOUR STATES IN A FOREST CARNIVORE IN A ROAD-DOMINATED LANDSCAPE WITH HIDDEN MARKOV MODELS

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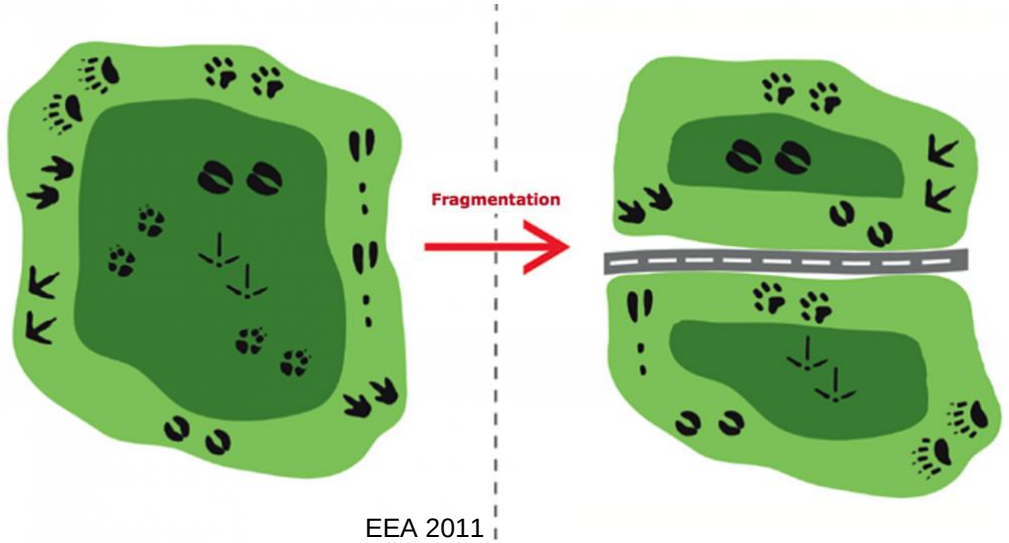
Major threats to animal movement – roads network

Anthropogenic infrastructures and land use changes

Transportation systems – the case of roads network

Road-related effects

- direct mortality i.e roadkills
- physical barrier to movement
  - **Behavioural constrains**



EEA 2011

moving successfully → Long-term population viability (e.g. gene flow)

Animal movement behaviour and roads: what we know; what is missing ?

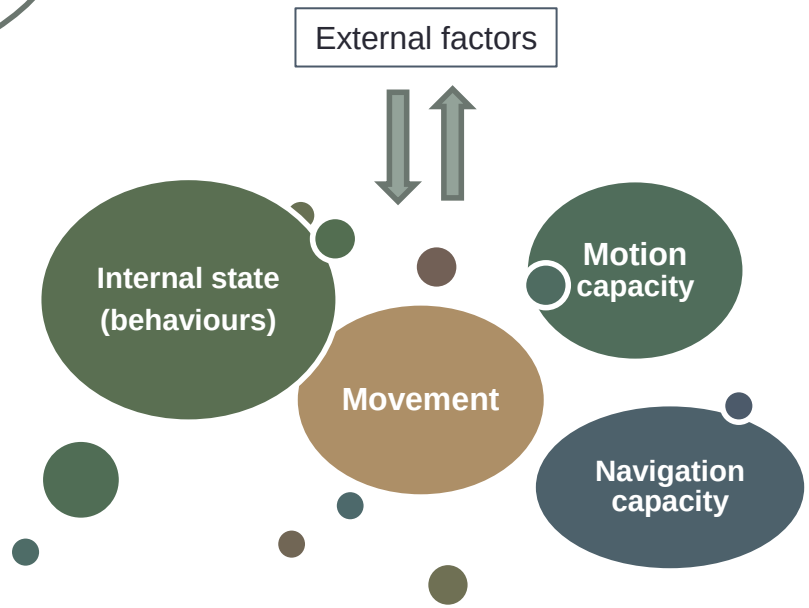
- Animal movement responses (telemetry-based studies) ⇨ extrinsic factors (e.g. habitat metrics)

Yet…

Movement patterns:

<u>outcome of behavioural decisions (e.g. foraging)</u>

- Still a poorly documented issue

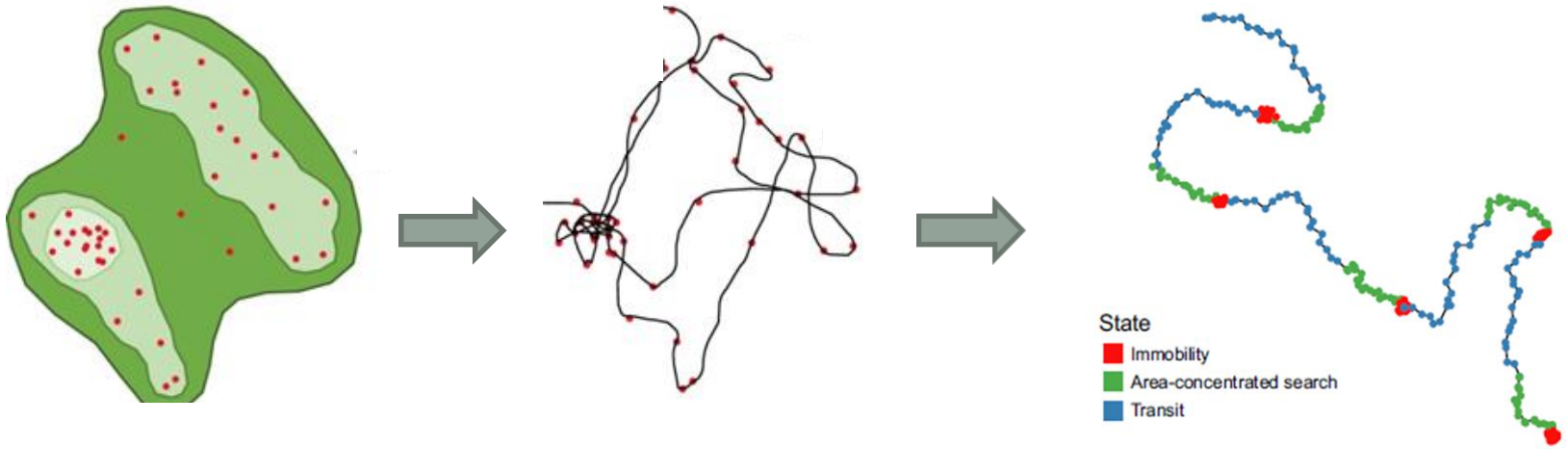


Movement ecology paradigm, Nathan et al. 2008

How can we study behavioral responses of animals to roads ?

solution?

recent movement models applied to fine-scale data - Hidden markov models



1) Spatial locations

2)Movement path

Behavioural states

Case study – the common gennet (*Genetta genetta*)

- medium-size forest carnivore
- often road-killed (Santos et al. 2011)
- roads negatively affect the movement of genets

  (Carvalho et. al. 2015)

…and the behavioural consequences ?

@ Luis Guilherme Sousa

Aim

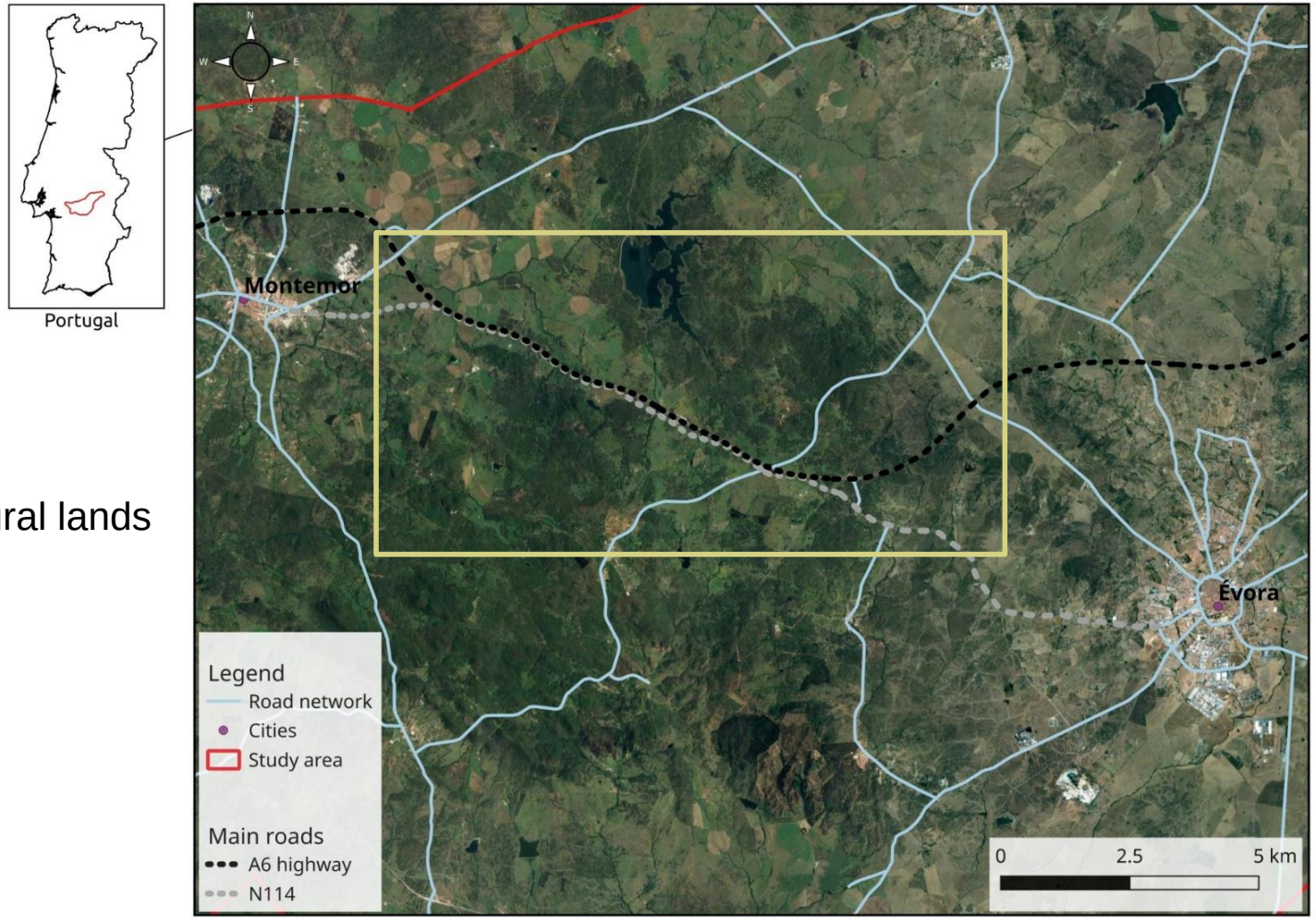
Assess the relationship between common genet (*Genetta genetta*) behaviour and road proximity within a dominant mixed forest-agricultural landscape

Hidden markov models

Study area

- Southern Portugal

Corridor: Montemor-o-Novo to Évora



Landscape

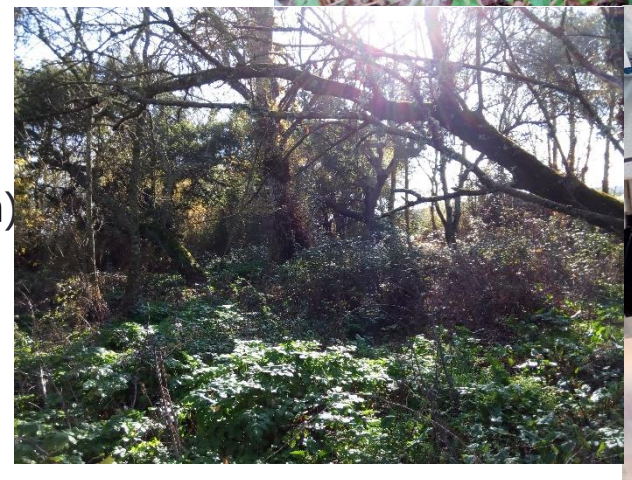
- Cork and holm woodlands + agricultural lands
- Bisected by roads

Data collection

- Live-trapping of genets (3 sessions: 2016 – 2019);
- 7 genets captured and successfully tracked;

  GPS collars (Loteck and Movetech Telemetry)

- Spatial locations: 10 min-interval (between 17h-08h)



Data analysis

1. data cleaning (removal of inaccurate fixes (DOP < 3) + other erroneous spatial locations)

2. transform spatial fixes in regular trajectories (package adehabitat LT)

(a night of tracking was defined as unit of sampling, i.e., path movement)

3. Estimate predictors (roads proximity + landscape features important for genet's movement, Carvalho *et al*. 2015; Oeser *et al.* 2019)

Predictors	Description	
Distance to paved roads	Distance (m) to the nearest main paved road	Road features
Distance to Forests	Distance to the nearest forest patch (m)	Landscape context
Forest edge density	Density of edges between forests habitats (ha)	Landscape context
Forest patch size	Mean patch size of forest habitats (ha)	Landscape context
Distance to riparian habitats	Distance (m) to the nearest riparian habitat	Landscape context
Productivity	Vegetation greenness (based on TC greenness)	Landscape context

Non distance-based predictors: calculated through moving windows average to a scale of 100 m (COS 2015; Landsat imagery)

4. HMM (animal trajectories ~ predictors) package moveHMM; Michelot *et al.* 2016

Data analysis

HMM modeling

tunning

- 3 behavioral states
- 50 models - different sets of randomly chosen starting values (e.g. Karelus *et al*. 2019)

Model formulation

- forward selection of predictors – based on AIC
- sequence and probabilities of behavioral states

Model validation (goodness-of-fit)

- pseudo-residuals
- autocorrelation functions

Results

- 7 genets: 6 males; 1 female
- tracking days: 7 – 66 (mean = 29)
- spatial locations: 175 – 3058 (mean = 1459)

behavioral states

- **Resting (1)**

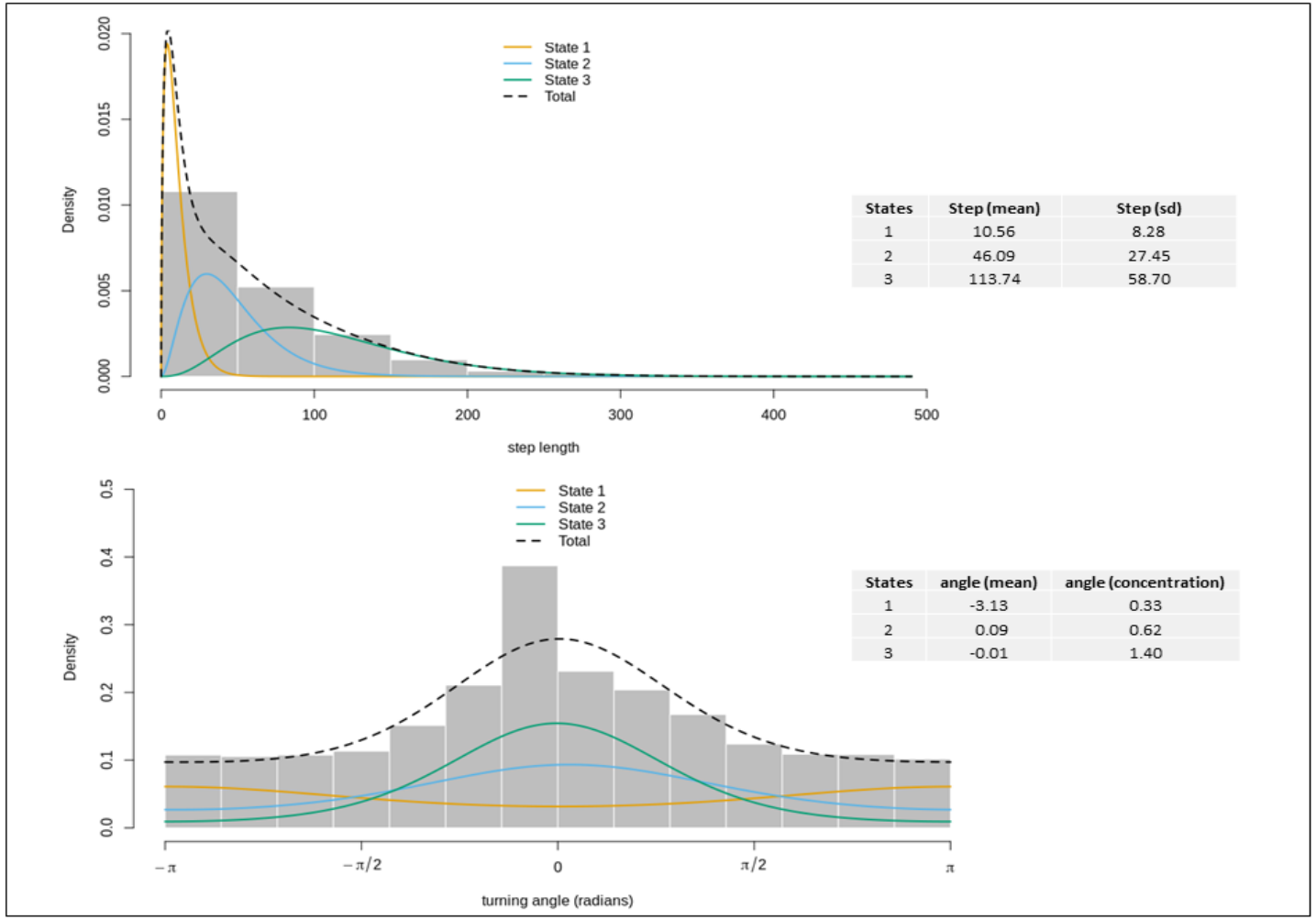
short step-lengths and highly tortuous

- **Foraging (2)**

medium step-lengths;
mix of tortuous with forward movements;

- **Transiting (3)**

larger step-lengths;
mainly linear movements;

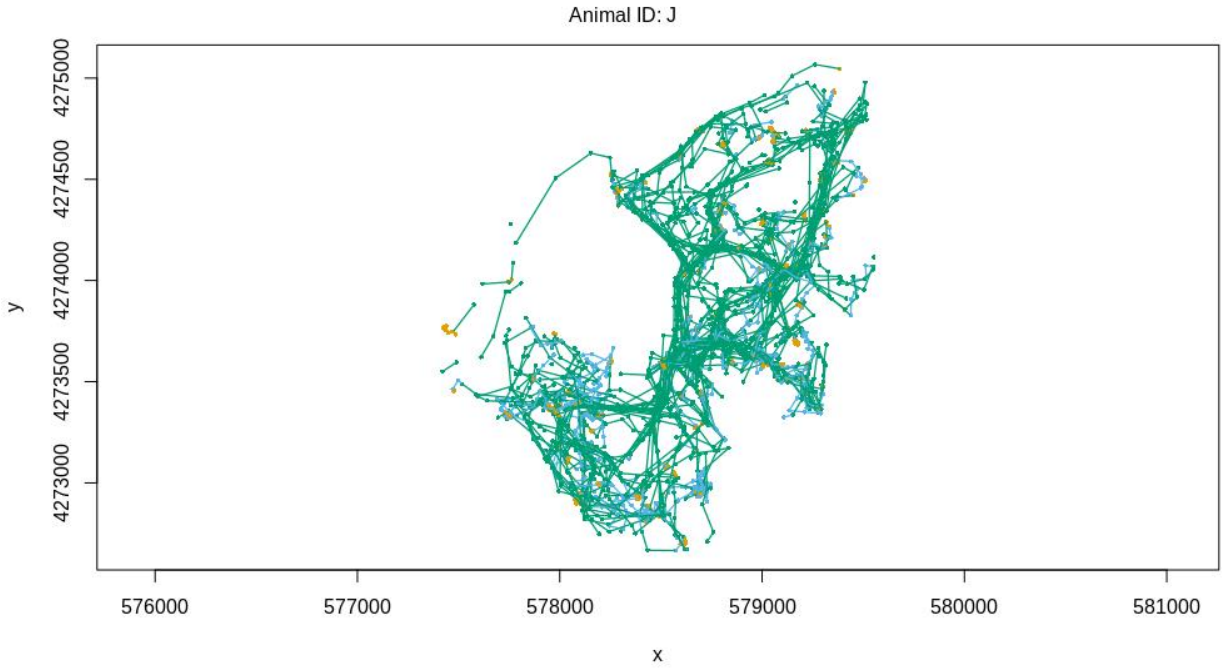


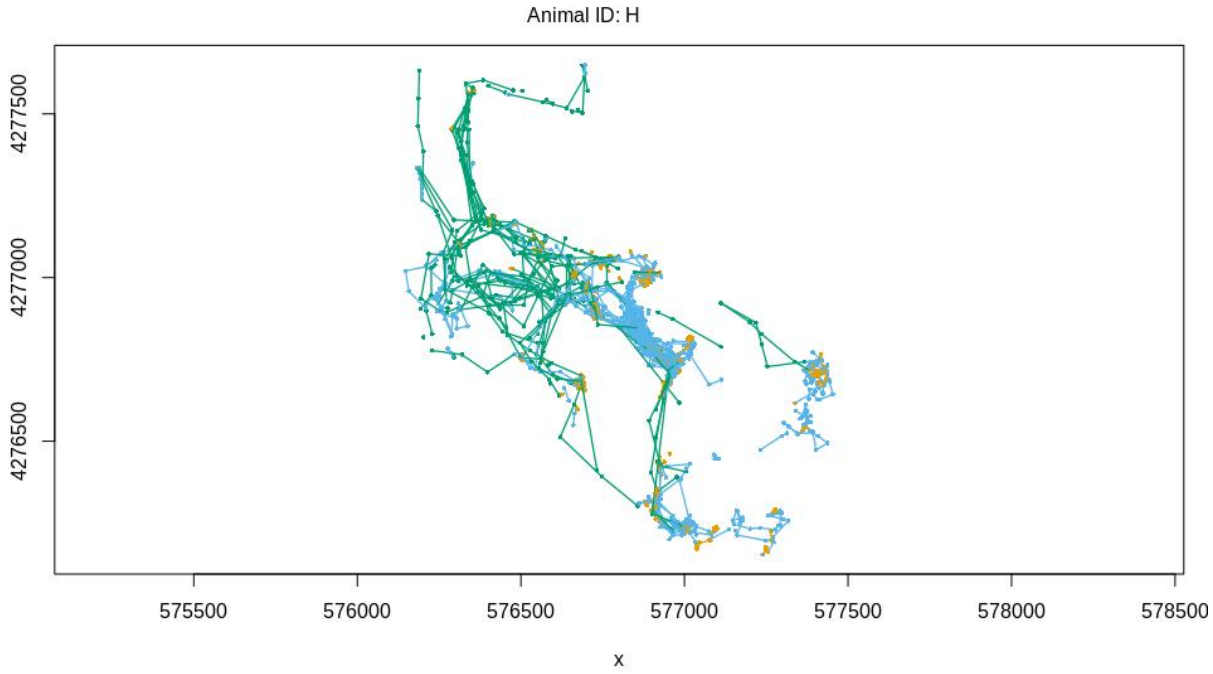
States	Step (mean)	Step (sd)
1	10.56	8.28
2	46.09	27.45
3	113.74	58.70

States	angle (mean)	angle (concentration)
1	-3.13	0.33
2	0.09	0.62
3	-0.01	1.40

histogram of step lengths and turnings angles with fitted distributions described by behavioral states

Results





Movement model ⇒

Transiting – 36.7 %
range: [6.9 – 61.5 %]

Foraging– 35.4 %
range: [20.4 – 54.3 %]

Resting– 28.0 %
range: [14.5 – 40.3 %]

Results

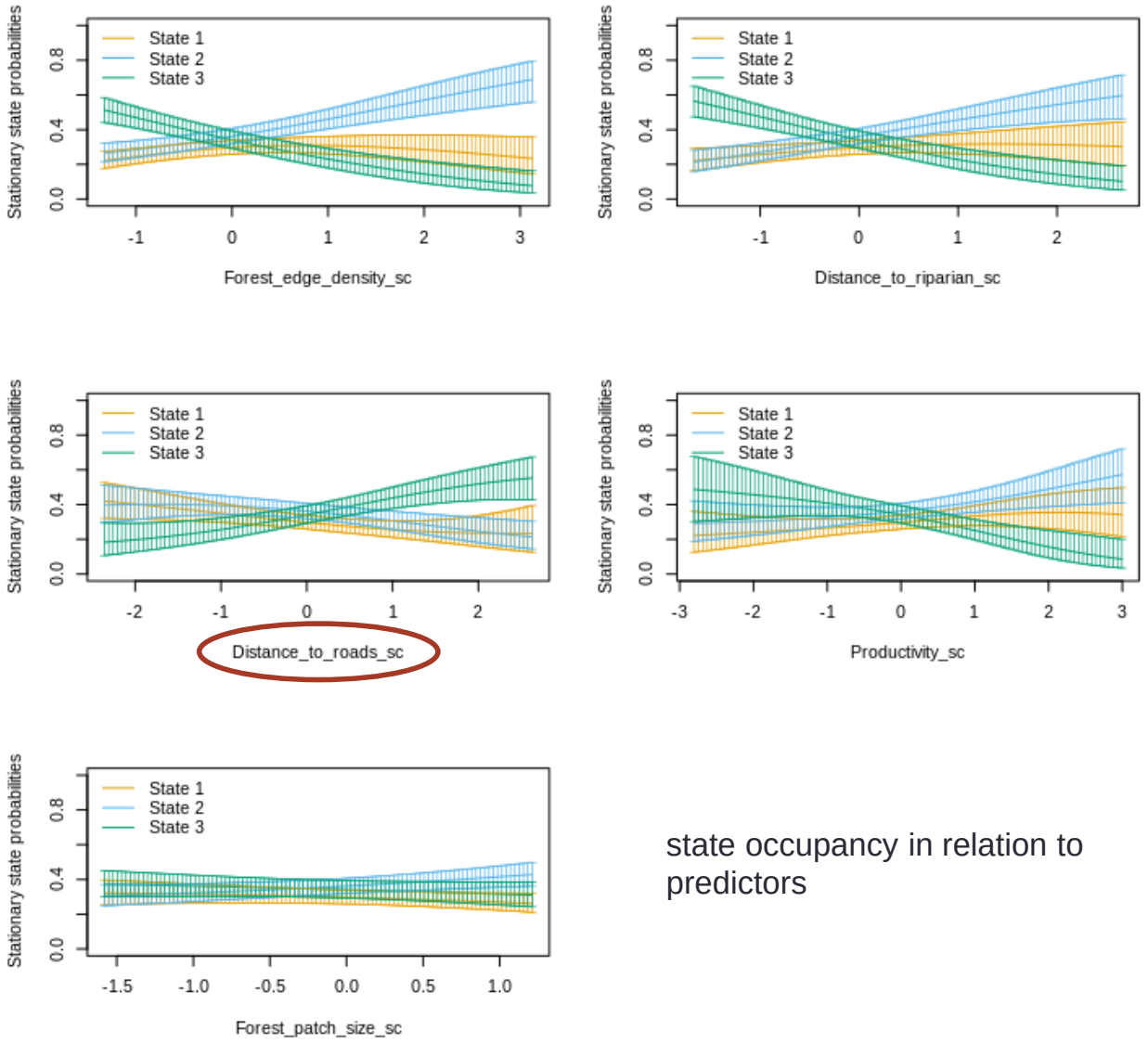
- Distance to major roads – the third most important predictor

Foraging

areas close to roads (< 500);
higher forest edge density;
productive areas;
far away from riparian habitats;

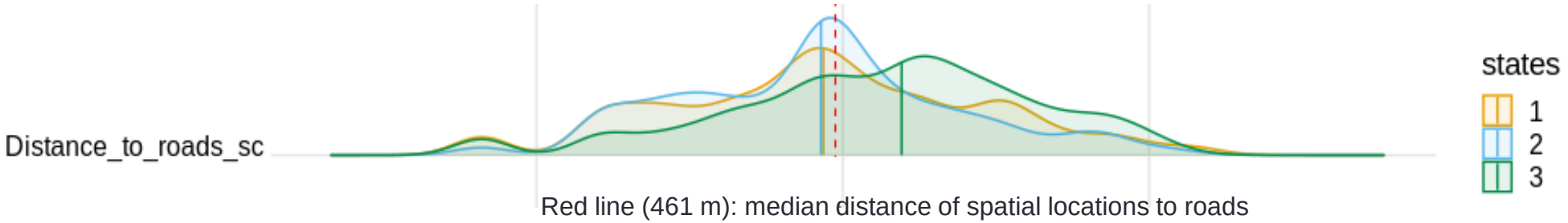
Transiting

far away from roads (> 500m);
lower forest edge density;
lower vegetative productivity;
close to riparian habitats;



state occupancy in relation to predictors

Results



Red line (461 m): median distance of spatial locations to roads

Foraging: 42.04 %

Resting: 31.03 %

Transiting : 26.93 %

Transiting – 46.58 %

Foraging– 28.56 %

Resting– 24.86 %

Take home messanges

- HMM approach is useful to disentangle behaviours underling movement patterns
- proximity of roads, along with more heterogeneous and fragmented areas, might favour foraging opportunities for genets
- genets tend to move larger distances in areas far away from roads, in more dense and homogeneous areas and along riparian habitats

Acknowledgements

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