

# Interactions

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Mike Noonan, Chris Fleming

Continuous-Time Movement Modelling for Animal Tracking Data



1. Home-range overlap
2. Encounter Location Distributions
3. Pairwise distances
4. Encounter rates

## **Home-range overlap**

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# Home-range overlap

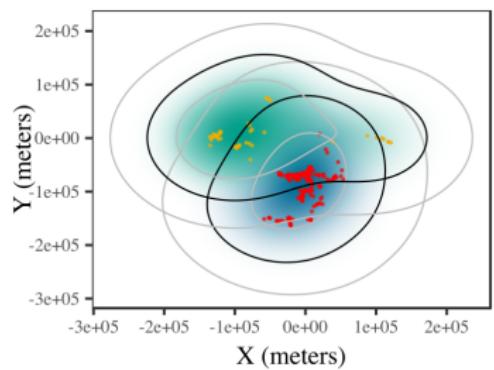


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# Home-range overlap



Home ranges quantify typical space needs.

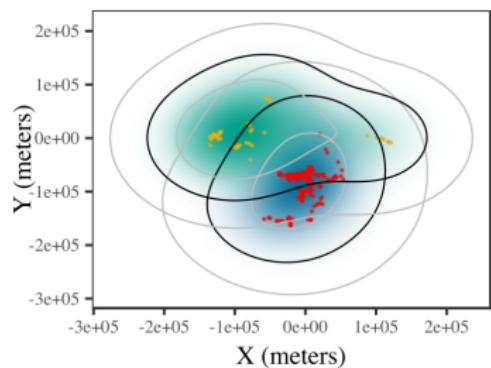


# Home-range overlap



Home ranges quantify typical space needs.

HR overlap of home ranges captures potential for interactions (many different measures used in practice; reviewed by Fieberg and Kochanny 2005, JWM).



# Statistical inference for overlap



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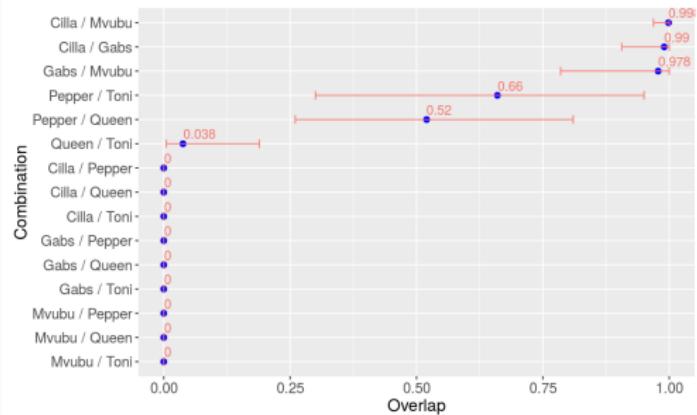
## 1. Comparable home range estimates



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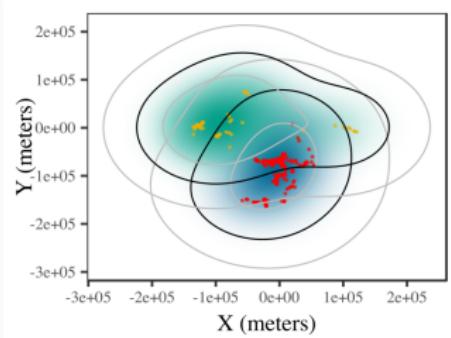
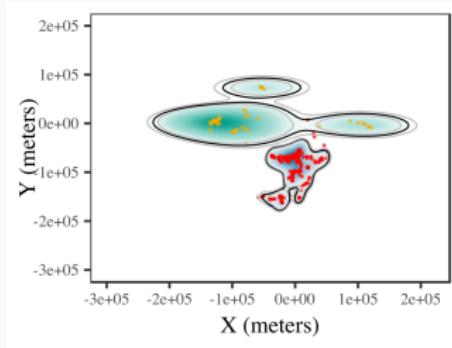
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# Comparable HR estimates



Bias in HR ests propagates into bias in overlap



# Bhattacharya coefficient



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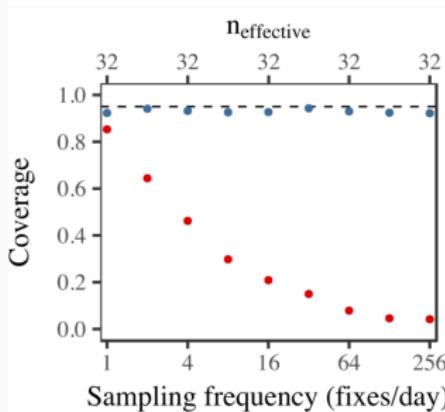
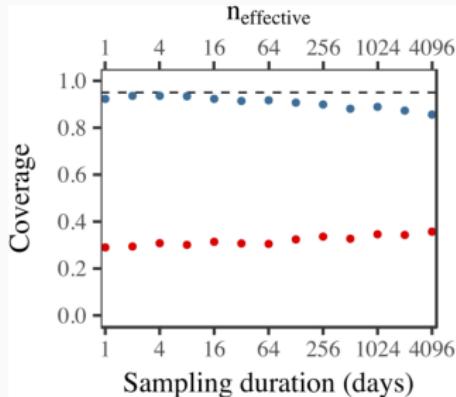
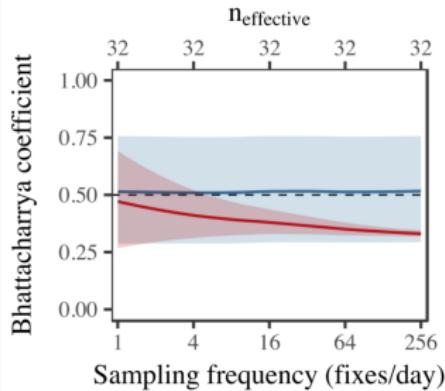
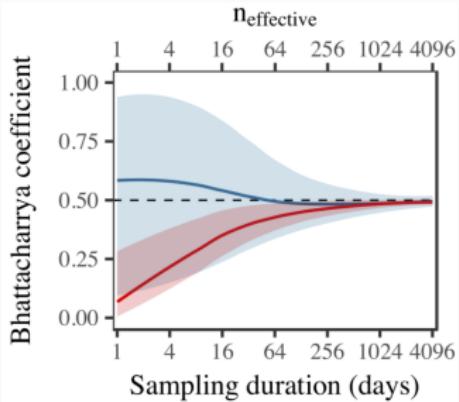
$$D_B(p_1, p_2) = \frac{1}{8}(\mu_1 - \mu_2)^T \Sigma^{-1}(\mu_1 - \mu_2) + \frac{1}{2} \ln \left( \frac{\det \Sigma}{\sqrt{\det \Sigma_1 \det \Sigma_2}} \right)$$
$$BC = e^{-D_B(p_1, p_2)}$$

Measure of overlap of two prob disttributions.

Already familiar to, and in use by ecologists.

Mathematically tractable: 1st order bias correction and error propagation possible

# Behaviour of the estimator





## **Encounter Location Distributions**

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The home range describes long-run space use  
(spatially defined PDF).

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Home-range overlap describes the potential for  
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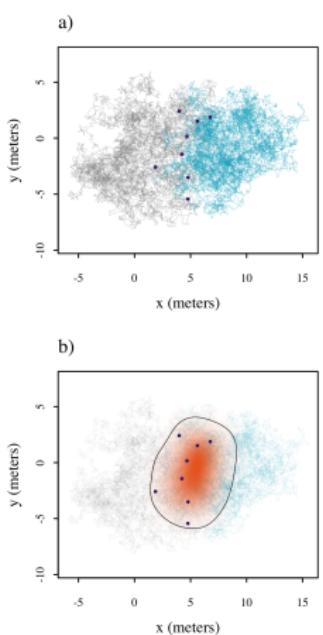
The home range describes long-run space use (spatially defined PDF).

Home-range overlap describes the potential for interactions (single number).

The Conditional Distribution of Encounters (CDE) describes the long-term encounter location probabilities for movement within home ranges.

The CDE between individuals i and j is given by:

$$\text{CDE}_{ij}(\mathbf{r}) = \frac{p_i(\mathbf{r}) p_j(\mathbf{r})}{\iint d^2\mathbf{r}' p_i(\mathbf{r}') p_j(\mathbf{r}')}}$$



# Simulation examples

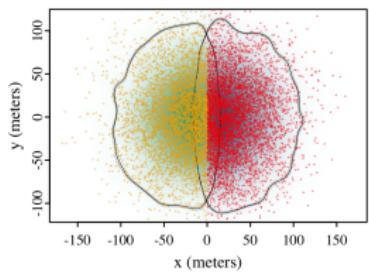


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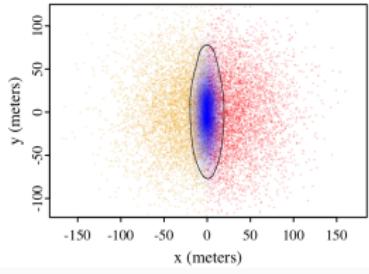
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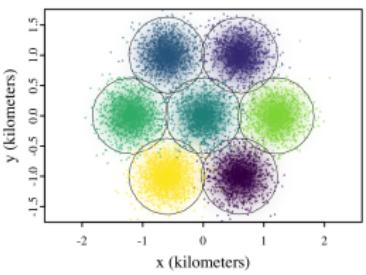
b)



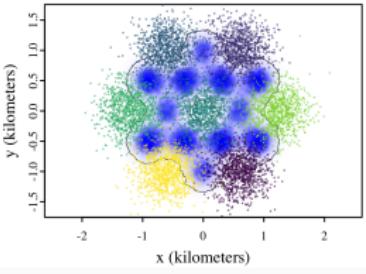
e)



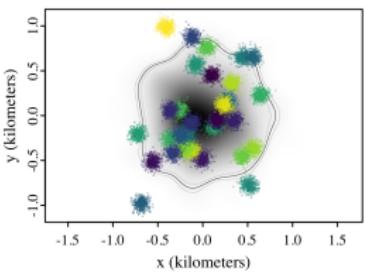
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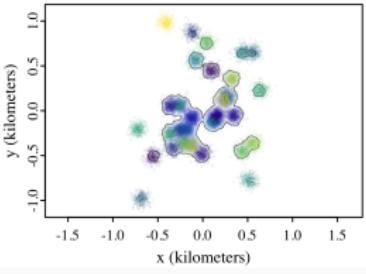
d)



c)



f)

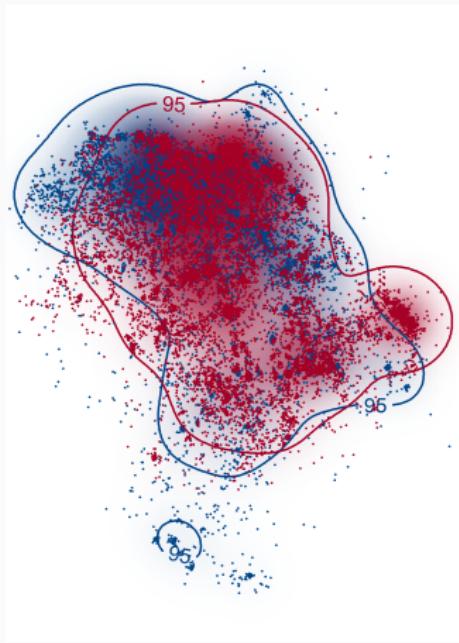




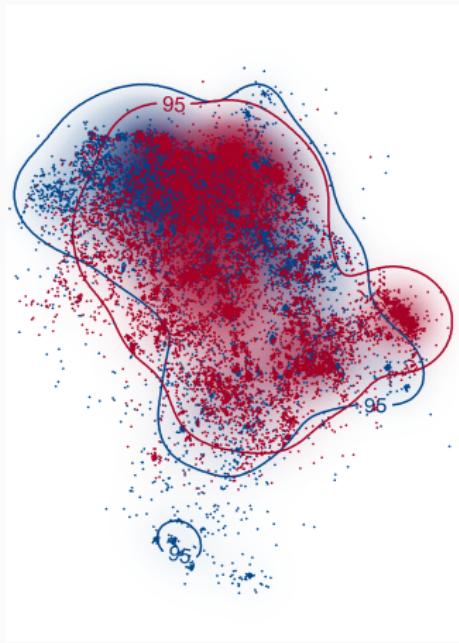
## Pairwise distances

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# Spatio-temporal interactions



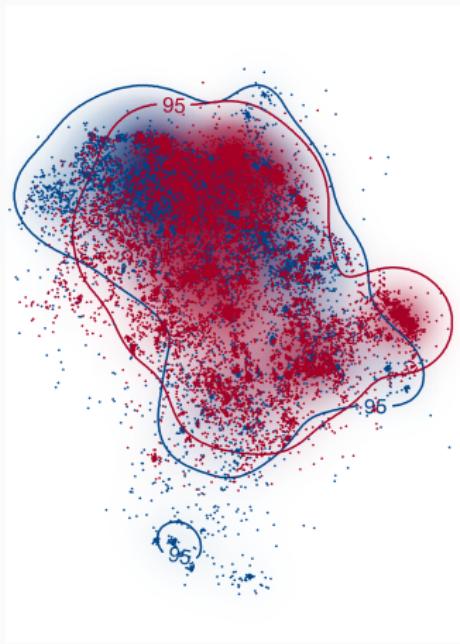
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...but says nothing about whether animals share the same space at the same time.

# Spatio-temporal interactions



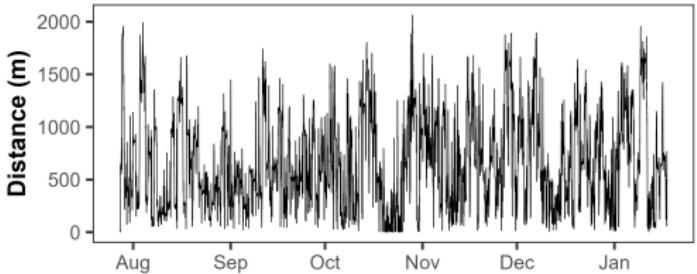
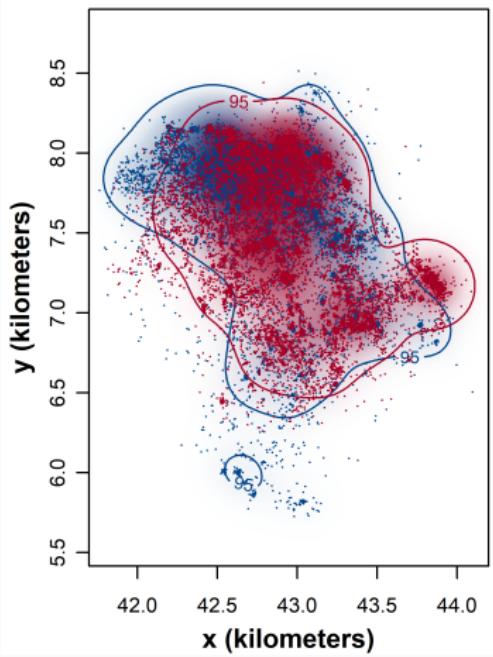
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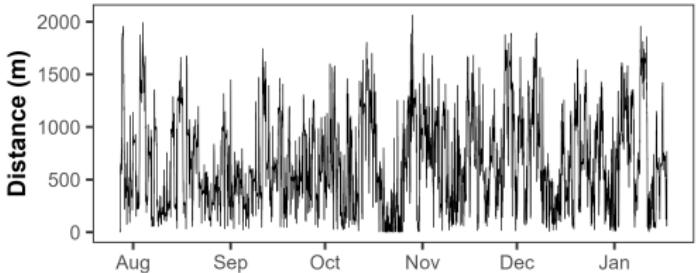
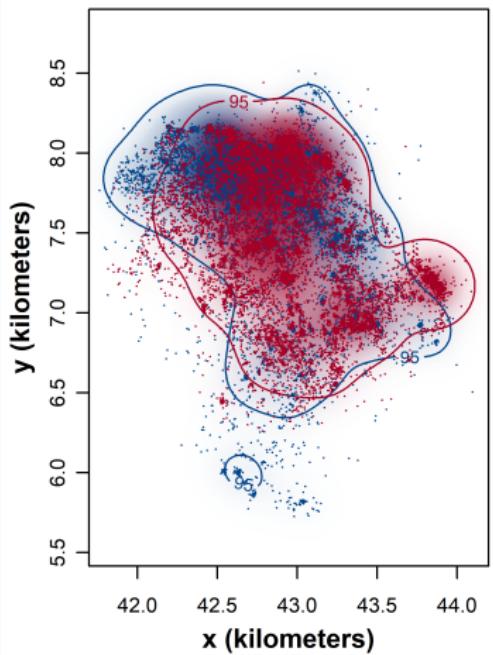
Pairwise separation distances are a good place to start for understanding if pairs of individuals are attracted to, or avoid, one another.



# Proximity ratio

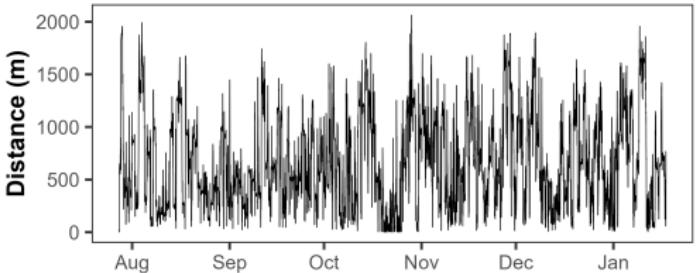
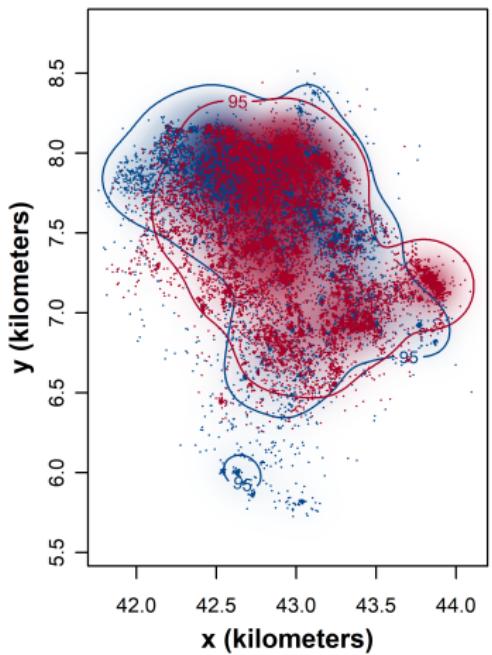


# Proximity ratio



Separation distances can provide useful descriptions of pairs of animals

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Separation distances can provide useful descriptions of pairs of animals

... but are these meaningful (or what are they saying about relationships)?



## **Encounter rates**

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# Encounter rates

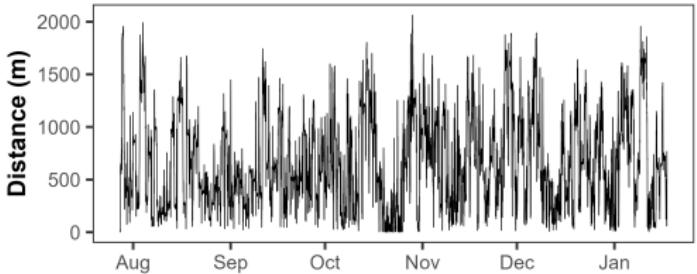
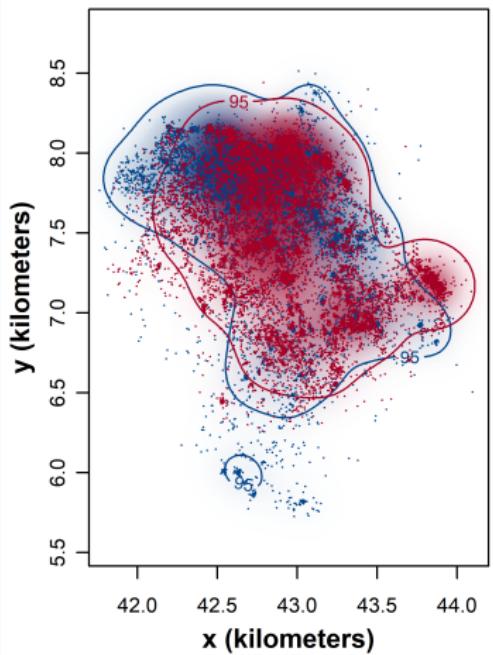


We're often interested in linking individual behaviour with higher-level ecological processes.

For many processes, this is governed by how an individual's movement behaviour translates to encounter rates.

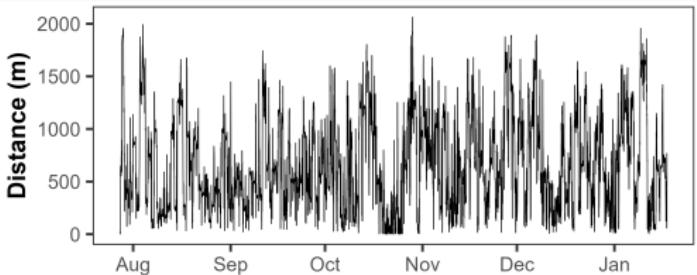
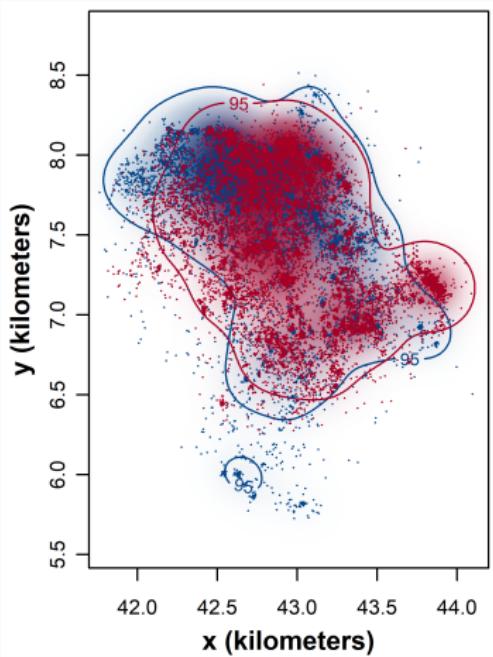


# Encounter rates



The observed separation distances contain information on encounter events (and by extension encounter rates)

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... but are dependent on individuals' perceptual ranges.

