Supplementary Information to “Evaluating Connectivity Models for Conservation: Insights from African Lion Dispersal Patterns.” submitted to Landscape Ecology, by: Genevieve E. Finerty, Samuel A. Cushman, Dominik T. Bauer, Nicolas B. Elliot, M. Kristina Kesch, David W. Macdonald, and Andrew Loveridge.

Corresponding author: Genevieve E. Finerty, Wildlife Conservation Research Unit, Department of Zoology, University of Oxford. Email: genevieve.finerty@gmail.com

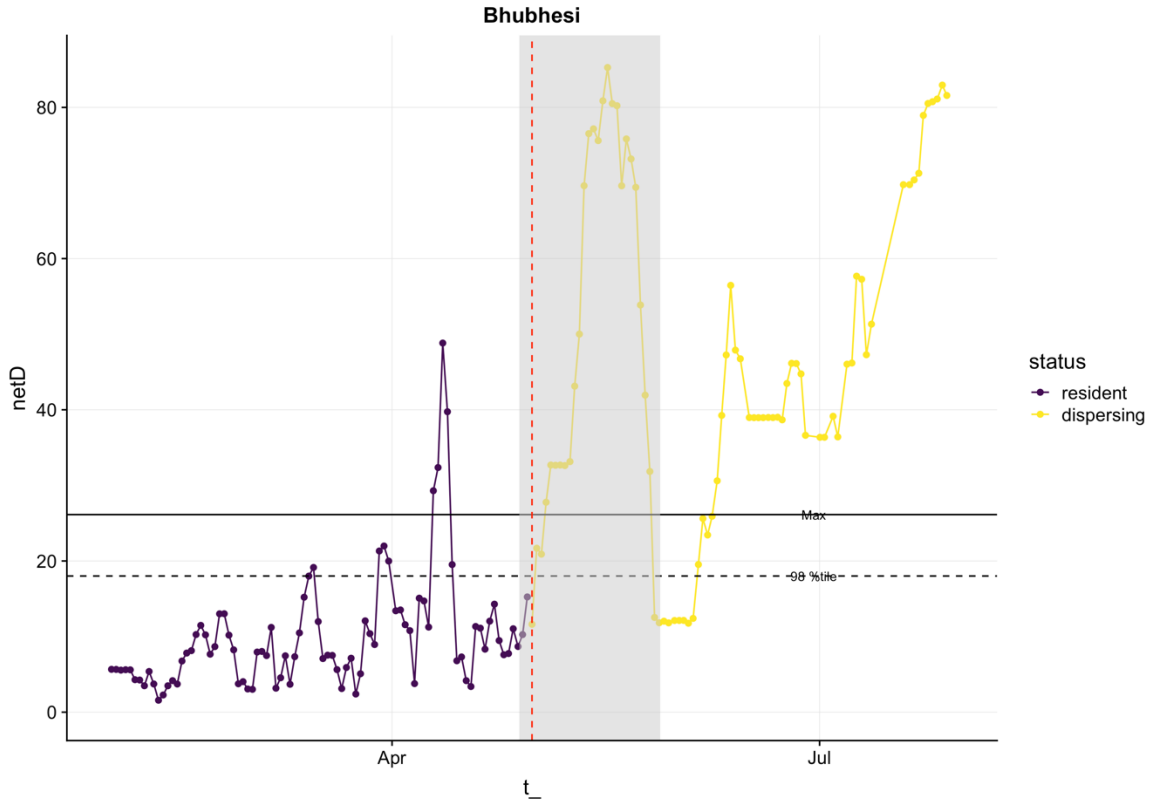
Distance-threshold approach for identifying periods of dispersal.

We adapted a distance-threshold method from Weston et al. (2013) to estimate the point of emigration and settlement for individuals based on expected movement distances and excursion duration of dispersers in comparison to resident lions (see Fig 2 in main text). As the question does not depend on the overall shape or size of this area, we defined ‘home range’ simply as all the locations over a three-month period, and calculated distance as net displacement from the centroid of these locations. We based the distance thresholds on ranging distances of 20 known resident lions in the study area. Resident individuals were recorded up to a maximum 26.13 km from the centre of their home ranges, but over 98% of observations were within 18.01 km. Based on these values, we assumed that a lion had dispersed if it was recorded over 26.13 km from the centre of its starting ‘home range’ and did not return to within 18.01 km for the following fortnight. The choice of a fourteen-day minimum excursion reflects the fact that the longest duration of excursion by resident lions was eleven days, with a mean of two. A biological justification for this time window is that a natal disperser would have to forage independently during an excursion of 14 days, and it is therefore an indication that they are likely moving independently of the natal group.

This method was developed to describe dispersal in juvenile golden eagles who were known to begin in their natal home range (Weston et al., 2013). However, the concepts are readily transferable to other territorial species, such as lions. To confirm this, we applied the proposed method to five subadult dispersers from Elliot et al. (2014), who were known to be still with their natal group at the start of their collar

dataset, and where time of emigration had been determined by direct observations (see Figures S1 – S4). For three lions, the point of emigration fell within the window identified by Elliot et al. (2014) and for the other two, it fell shortly afterwards (within 10 days). This outcome is comparable to performance in juvenile golden eagles, where the method tended to estimate point of emigration slightly later than their reference dates (Weston et al., 2013). Although this results in the omission of some early dispersal movements, we can also be confident that all data included are from the dispersal period. The method has the added benefit of being simple to execute, repeatable, and based on easily obtained biological values from the species' movement behaviour.

Fig S1 – S5 The following figures show net squared displacement from the centroid of the first three months of GPS points for each of our five subadult male lions with labelled dispersal data. The grey shaded boxes represent the 30-day window where dispersal was estimated to occur based on field observation of the last time subadults were seen with their natal prides (Elliot et al. 2014c, a, b). The red dashed lines indicate the point of dispersal estimated from movement data alone. In two cases (Lucky and Vanilla Ice), the movement point of dispersal fell outside of the observation-derived window by a margin of days (5 and 10 days, respectively), showing overall high agreement between the two approaches.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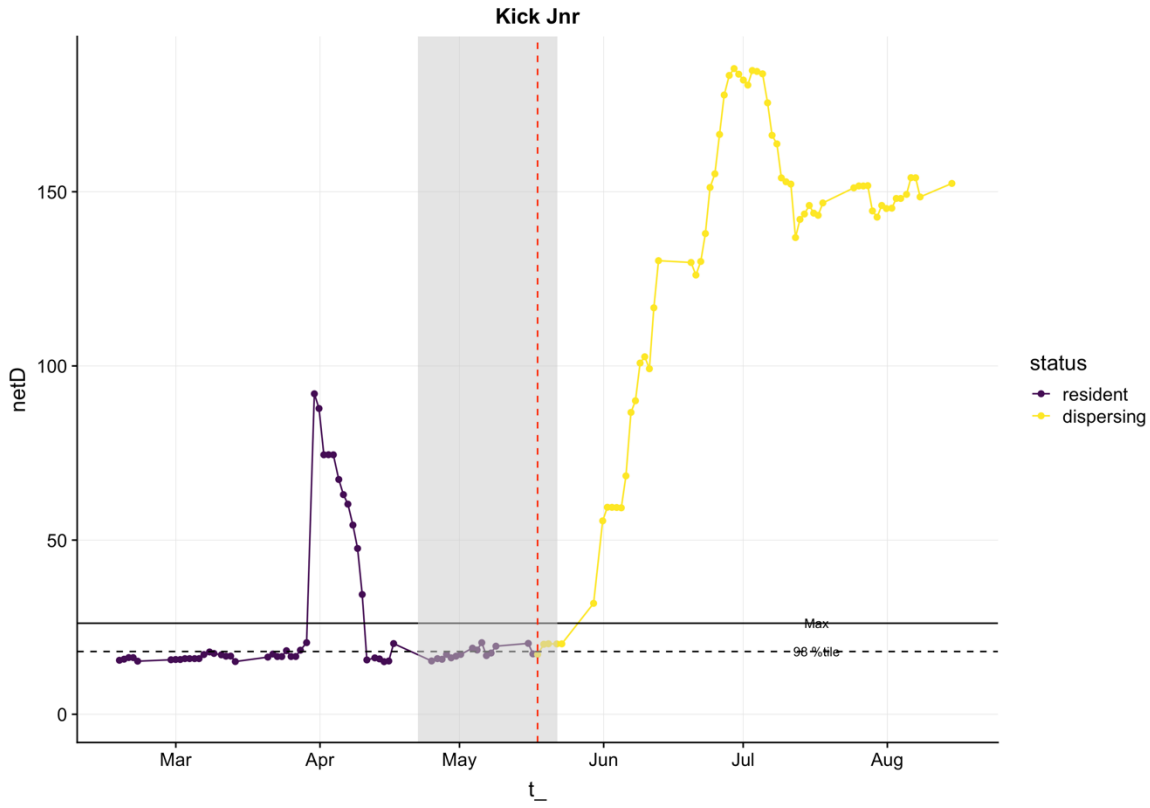
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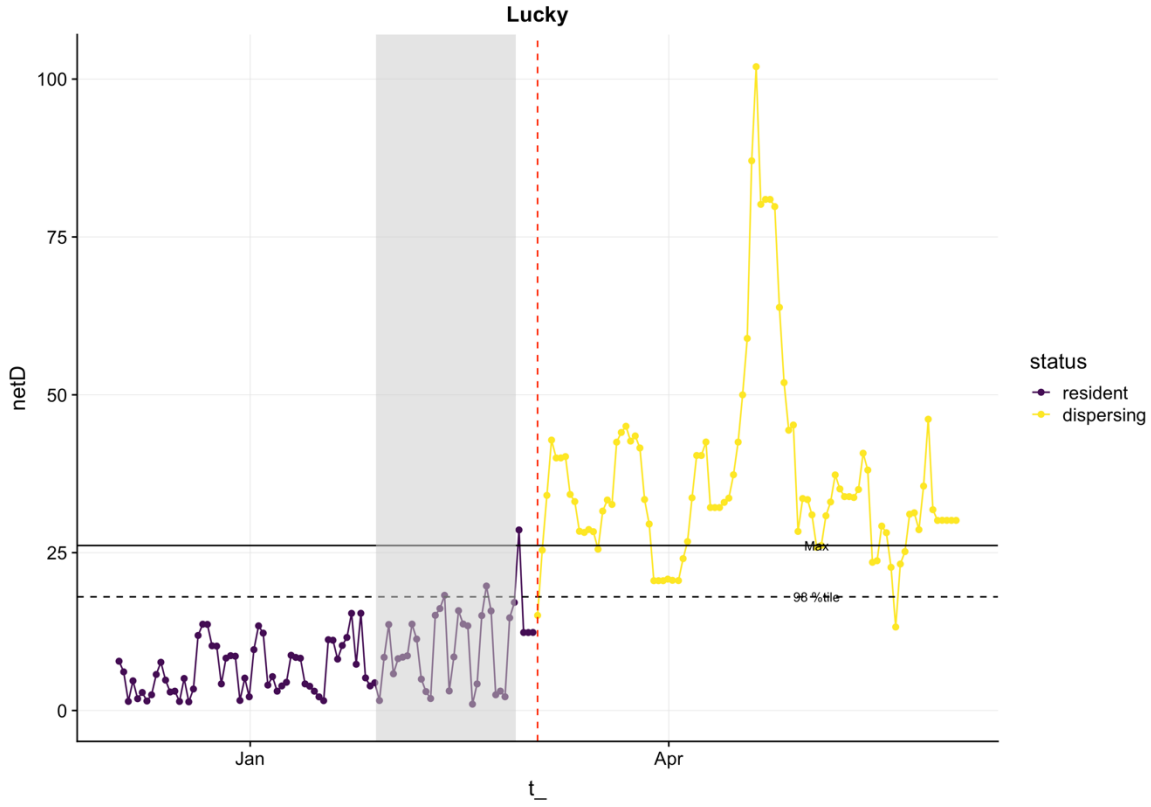
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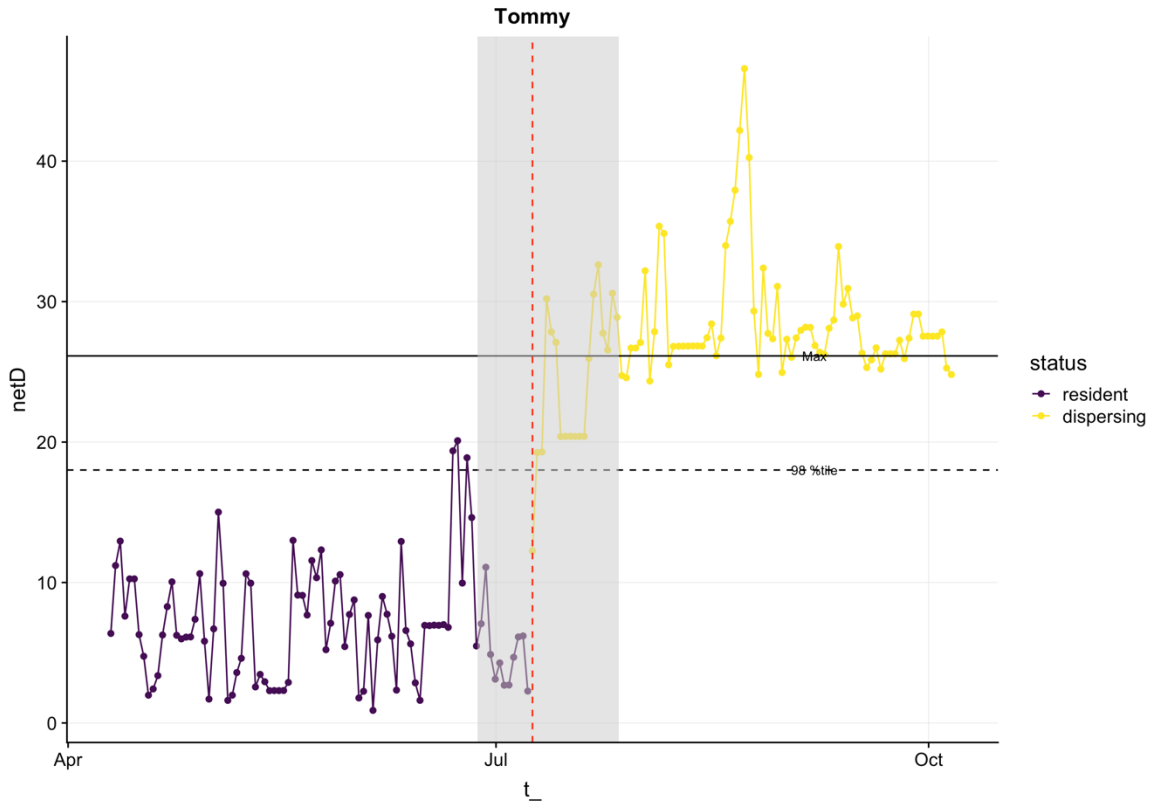
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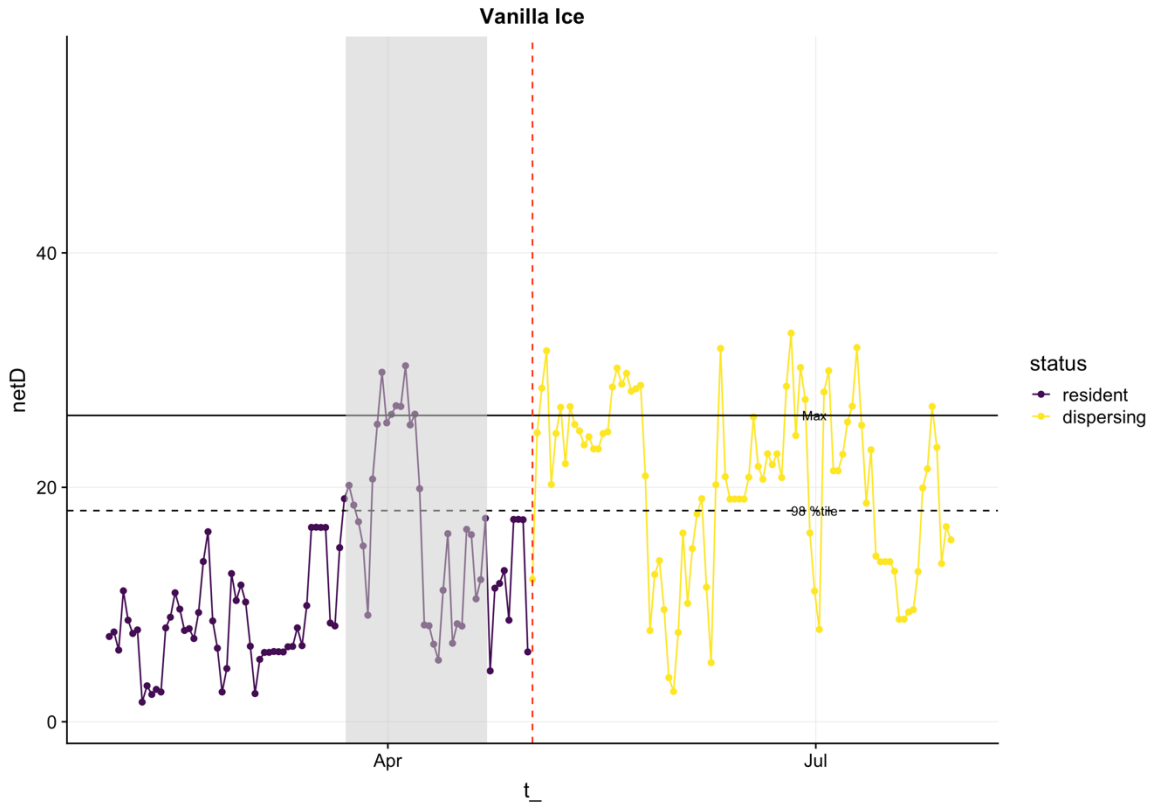

We created one further extension to the method to account for occasions where the start of a dataset occurs during the dispersal period, making the definition of dispersal onset based on a distance from initial home range irrelevant. In this case it was necessary to determine if the individual was broadly resident or not at the start of the dataset, and if not, when was the first time it was. To do this we used a moving window of three-months to find the first point in the dataset where a candidate disperser's mean ranging values from the centroid of the window was within the observed range for resident lions, then estimate a more precise date of settlement using the converse criteria for dispersal. Specifically, for an animal to be classified as settled it must go below the maximum ranging threshold and then not go above the 98th percentile of ranging distances for more than 14 days. As dispersal may include short periods of temporary residence, we added the criteria that to be classified as having an established range, an animal must remain settled for at least three months (as in Elliot et al. 2014). All labelling of dispersal data was carried out in R (R Core Team 2020).

This method identified a total of 28 dispersal events, with 19 examples of natal dispersal (13 males, 6 females) and nine of adult dispersal (3 males, 6 females). We extracted GPS locations from these dispersal periods (n=39,066). Median net displacement of dispersal events was 59 km (range 26 - 208 km).

References

Elliot NB, Cushman SA, Loveridge AJ, et al (2014a) Movements vary according to dispersal stage, group size and rainfall: the case of the African lion. Ecology 95:140427004909008. https://doi.org/10.1890/13-1793.1

Elliot NB, Cushman SA, Macdonald DW, Loveridge AJ (2014b) The devil is in the dispersers: predictions of landscape connectivity change with demography. J Appl Ecol 51:1169–1178. https://doi.org/10.1111/1365-2664.12282

Elliot NB, Valeix M, Macdonald DW, Loveridge AJ (2014c) Social relationships affect dispersal timing revealing a delayed infanticide in African lions. Oikos 123:1049–1056. https://doi.org/10.1111/oik.01266

R Core Team (2020) R: A Language and Environment for Statistical Computing

Weston ED, Whitfield DP, Travis JMJ, Lambin X (2013) When do young birds disperse ? Tests from studies of golden eagles in Scotland. BioMed Cent Ecol 13: