How does human activity affect the movement patterns of wild animals?

An analysis of selected data sets from the Movebank animal tracking database

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Abstract

We investigate how human activity influences the movement patterns of wild animals. Using tracking data from red foxes, bobcats, and coyotes across rural and remote areas in England, Canada, and the US, we analyze home range sizes, temporal activity shifts, and habitat selection in relation to human footprint and land use data.

Introduction

Research questions:

1. **Access to Anthropogenic Food Sources:** Do animals in high human-impact areas exhibit smaller home ranges due to easier access to food resources?
2. **Temporal Shifts in Activity Patterns:** Do animals become more nocturnal in high human-impact areas to avoid direct human encounters?
3. **Habitat Selection in Human-Dominated Landscapes:** How do animals select habitats (e.g., forests, agriculture) under varying levels of human influence?

We will be using different data sets for each research question.

Additional challenges:

- We will be using data for purposes that it wasn't originally collected for.
- We will be using parts of data sets (missing animals in the bobcat/coyote study).
- We will be comparing between data from different studies for the same animals.
- We will be comparing data from different continents where weather conditions will differ for the same day of the year, leading to animal behavior likely also being different.
- We will be comparing data from different timezones.
- The data includes changes of timezone (winter to summer time).

Material and Methods

This section describes the data sets, the steps taken to prepare and process the different data set in use, and the methodological approach that was employed.

Data sets

The following Movebank Kays et al. (2022) data published under Creative Commons licenses will be used:

- **Red fox** data: Porteus et al. (2024) for rural areas (outskirt areas of villages in Wiltshire, UK) will be compared to red fox data from Lai et al. (2022) for highly remote areas (uninhabitated islands Bylot and Herschel, Canada)
- **Bobcat** and **coyote** data from Prugh et al. (2023) for remote areas with some rural structures (northern Washington, US)

For the human footprint data, we will use the **global 100 meter resolution terrestrial human footprint data (HFP-100)** by Gassert et al. (2023).

If required, for **land use** in Washington, US, we will rely on the General Land Use Final Data set published by Washington Spatial Data (link) and for land use in the UK on gov.uk data (link).

Data preparation and processing

Movebank

All Movebank data sets have the same format and table definitions. This simplifies data handling since it allows to re-use R code. A library for data processing and trajectory handling in R is provided by Bart Kranstauber (2025).

HRP-100

Use 2020 data and make a subset as quickly as possible since the data set is very big.

Data exploration and analysis

Red fox data

The data sets have the exact same format. But the data shows different properties across the two sources.

The Wiltshire data was collected during the UK wader nesting season, which was defined to be 15 March to 15 June, from 2016 to 2019 for 35 foxes in total. It was sampled at 10 or 60 minute rates. The research team could set the sampling rate remotely to save battery at times the data was considered less interesting.

The Bylot/Herschel Canadian data was collected all year round, at a much lower sampling rate of just once per day. The collection period was from 2011 to 2015 for Bylot and from June 2009 to Feb 2010 for Herschel, at random different afternoon times of the day. It included a much lower number of foxes, two foxes per island. Figure 1 provides an overview of the amount of data points available per year, demonstrating the fact that there is much more data from Wiltshire because of the higher number of foxes and also the higher sampling rate.

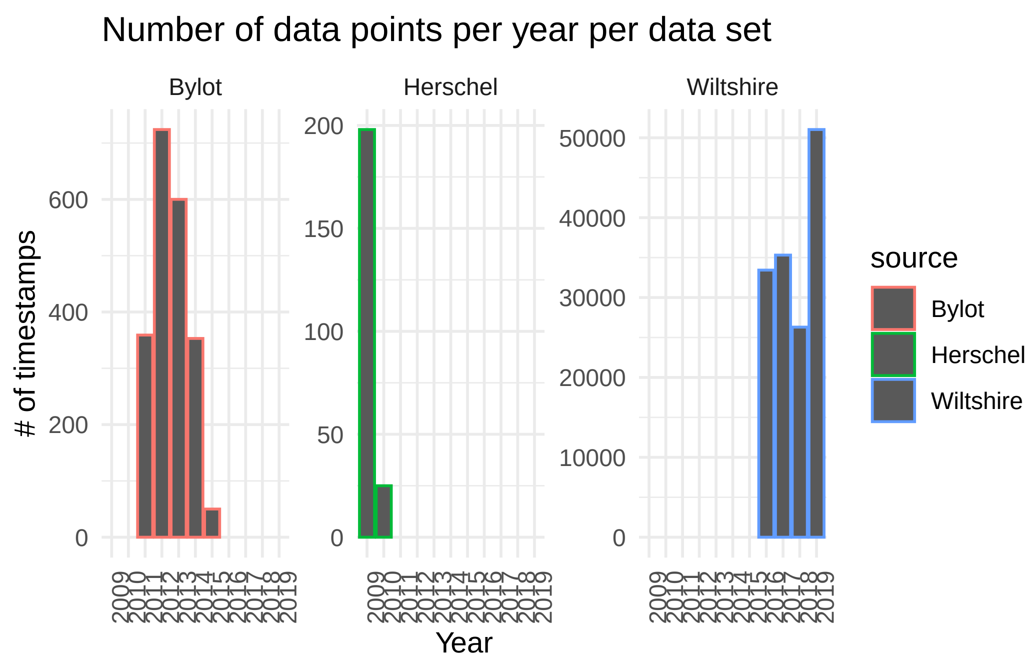

Figure 1: Overview of the number of data points per year in the three different data sets

Looking at the breakdowns by month as shown in Figure 2 shows noticeable seasonal differences in the amount of data available.

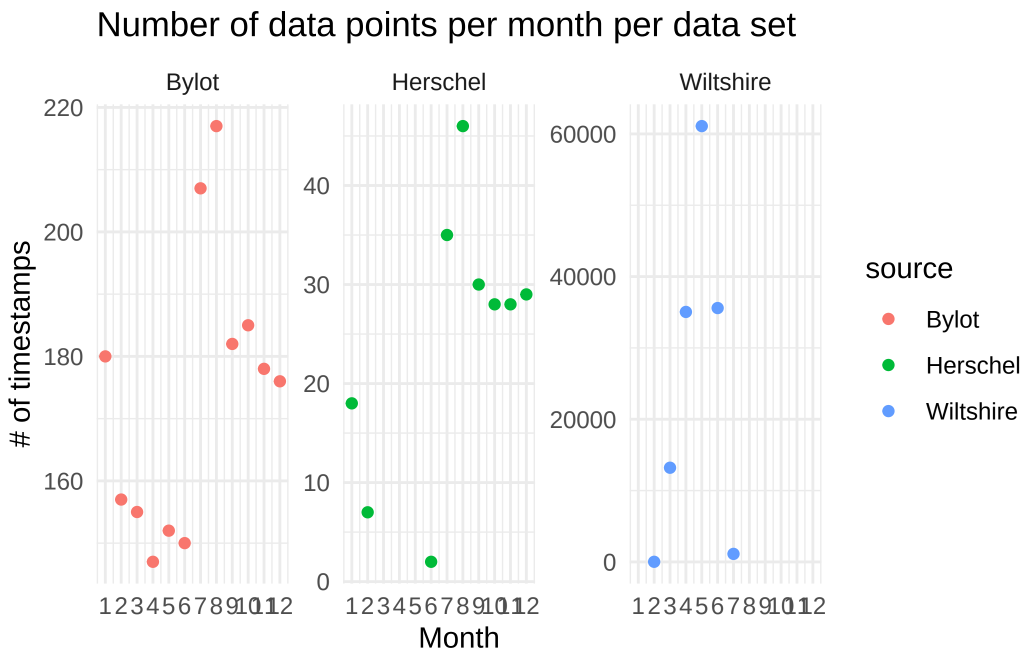

Figure 2: Overview of the number of data points per month in the three different data sets

Methodology

Trajectory Analysis:

Movement paths will be analyzed to identify patterns in speed, direction, and habitat use. Step lengths and turning angles will help infer behavioral states. Step-selection functions (SSFs) will model habitat preferences relative to availability, allowing us to quantify how animals respond to environmental covariates such as human footprint and land use.

Home Range Assessment:

Home range sizes will be calculated using minimum convex polygons (MCPs). This will provide estimates of the area used by each individual. Home ranges will be compared across regions with varying levels of human activity to test whether access to anthropogenic food sources (e.g., household waste, crops) leads to smaller home ranges due to resource concentration.

We will use the red fox data for home range assessment present for a rural and a remote location. As pointed out in Section the data for the rural and the remote location differ in many aspects because it originates from two separate research groups using different setups, and because it is from geographically different locations.

Laube and Purves (2011) have found that the choice of temporal scale has considerable effects on movement parameter calculations, therefore we suspect that temporal scale will also affect home range results. To compare between data sets, we need to ensure similar sampling intervals between the data sets for an apples-to-apples comparison.

The obvious approach would be to sample a random afternoon data point for each 24 hour window to achieve similar temporal scales. However, it would not be justified to assume that foxes in remote areas will follow similar daily patterns as the ones living in rural areas. These two groups will have different activity levels because in one case humans will be present in the environment in the afternoon, and in the other case the foxes will be left undisturbed.

We conclude that selecting the data points to compare involves a complex choice that will influence the results. We decide to start exploring with the simplest possible comparison, which is to ignore the different sampling intervals and to compare the data for the same time of the year. The Herschel data can not be used since it overlaps minimally with the Wiltshire data (see Figure 2).

To asses the effect of sampling intervals, we analyse the home range for the Wiltshire foxes with a 24 hour sampling interval. For simplicity we select a random data point from every 24 hour period.

TBD? Weather conditions will differ for the same day of the year, leading to animal behavior likely also being different.

TBD? Decide if we should look at average monthly home ranges.

Temporal Activity Patterns:

Movement rates will be used to quantify diel activity shifts. We will test whether animals in high human-impact areas exhibit increased nocturnality, potentially as a strategy to avoid direct human encounters. This analysis will reveal how temporal behavior adapts to human presence.

Habitat Selection:

SSFs will quantify selection for human-modified habitats (e.g., agricultural areas, urban edges) relative to natural habitats. By comparing selection patterns across species and regions, we will assess how habitat preferences vary with human influence.

Results

The resulting home ranges are shown in Figure 3 and Figure 4. There are vast differences in home rage between the locations. The median home rage size for the foxes in Herschel (75.3~km2) is more than 50 times bigger compared to the foxes in Wiltshire (1.1 km2).

The resulting home range for the sampled data is shown in Figure 5. The median home range is half as big compared to the full amount of data points (0.56 km2).

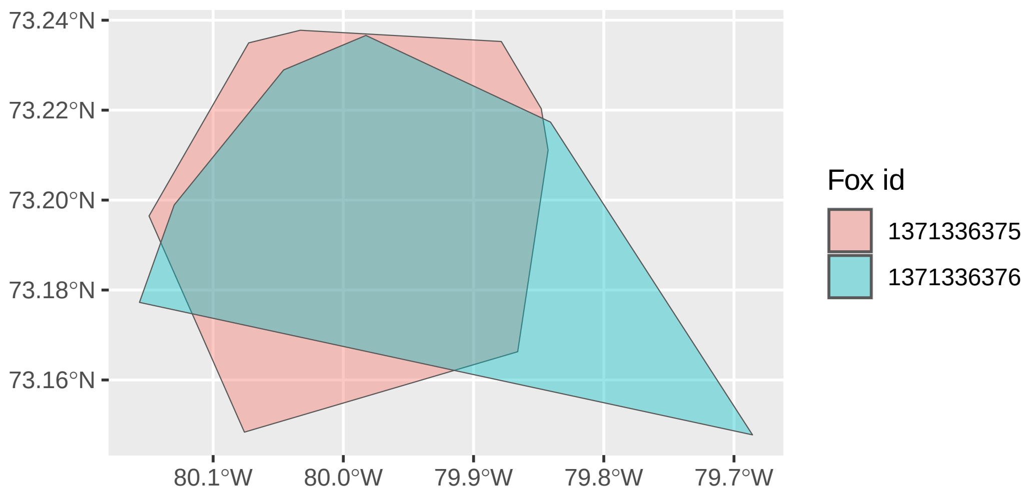

Figure 3: Home ranges for Bylot foxes (2012)

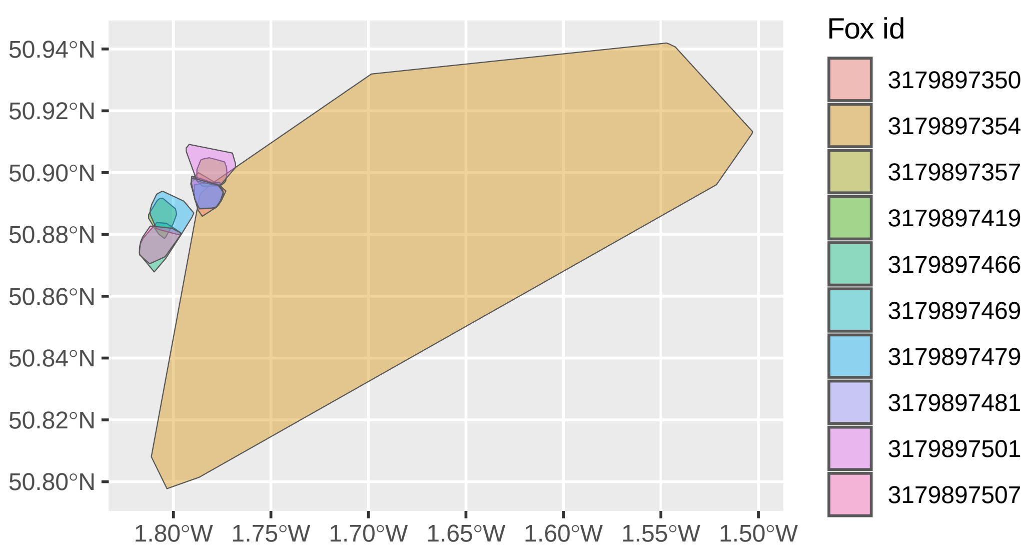

Figure 4: Home ranges for Wiltshire foxes (2019)

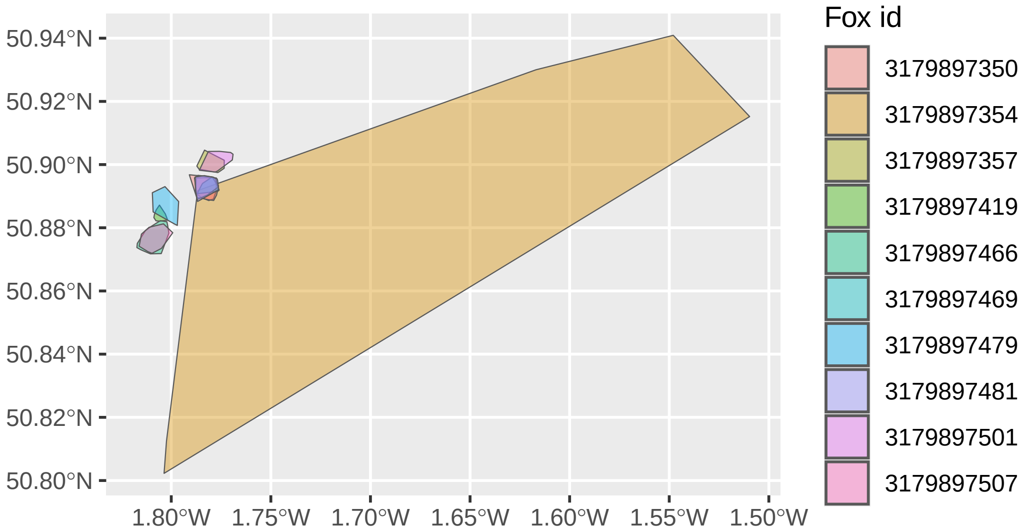

Figure 5: Home ranges calculated from rom UK wader nesting season 2019 for Wiltshire foxes (24 hour sampling interval)

Discussion

Research question 1

The fox home range results differ enormously between rural and remote areas. The influence of technical aspects like sampling intervals plays a role, albeit it is secondary in comparison. We can conclude that availability of food massively impacts fox behavior, but other factors such as human presence are also relevant. We are not able to distinguish between these influences.

TBD

- Runder Bericht in dem die research questions zu Ende beantwortet werden

Appendix

Don't do

- There are several ways to calculate home range, we could compare (and could focus on only that)
- Do home range for foxes first, for bobcat and coyote data later, potentially even cross-species analysis
- Use kernel density estimation (KDE)

Wordcount

Use of Large Language Models and Generative AI

Elke used NotebookLM (2025) for querying the papers cited in the references.

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