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

In this project we investigate how human activity influences the movement patterns of wild animals. Using GPS and Argos tracking data from red foxes, bobcats, and coyotes across rural and remote areas in England, Canada, and the US, we will 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

We will use the following wild animal tracking data published on Movebank under a Creative Commons license by three different research groups (see references):

- **Red fox** data from two sources: 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). The data can be read in Python, R, or any other script that has libraries that can interpret geospatial data (such as folium).

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

We have used data from the Movebank database and system by Kays et al. (2022). All the data sets in Movebank have the same format and table definitions, which simplifies data handling since it allows to re-use R code between data sets. A library for data ingestion, data filtering, and trajectory handling in R is provided by Bart Kranstauber (2025).

```
library("dplyr")
library("move2")
library("units")
library("rnaturalearth")

foxes_wiltshire <- movebank_download_study(
  study_id = 3179890710,
  sensor_type_id = c("gps"),
  'license-md5'='ffa36f79defe10eac9fe70f6502a17e0',
```

```
  attributes = NULL
)
foxes_bylot <- movebank_download_study(
  study_id = 1371322147,
  'license-md5'='9559cb1b1cca51e9f3fd69812e5e22dc',
  attributes = NULL
)
foxes_herschel <- movebank_download_study(
  study_id = 1371529289,
  'license-md5'='436e8205d0c2973115e2024b146a6ad5',
  attributes = NULL
)
```

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 itself shows completely different properties across the two sources Wiltshire and Bylot/Herschel.

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 throughout the day. The research team had the option to select the sampling rate remotely. They used this to save battery at times the data was considered less interesting, such as times when foxes were known to be usually static.

The Bylot/Herschel Canadian data was collected all year round, but 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.

Laube and Purves (2011) have found that the choice of temporal scale has considerable effects on the outcome of movement parameter calculations. Speed, sinuosity and turning angle of animal trajectories will differ based on the sampling interval. Based on these insights we suspect that temporal scale will also affect home range results. Therefore, to be able to compare between these dataset, 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 can conclude that finding the selection of best data points to compare involves a complex choice. It is highly likely that this choice will influence the results. The amount of influence on the results will depend on the use case. This is why we will discuss it as part of Section .

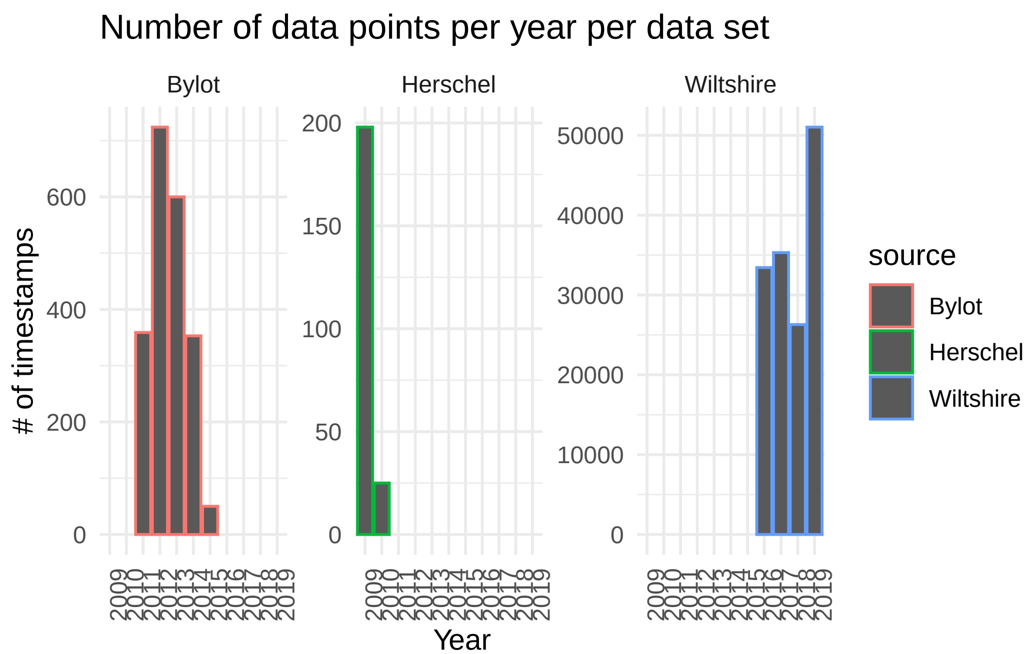

Figure 1: Overview of the number of data points per year in the three different data sets

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

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.

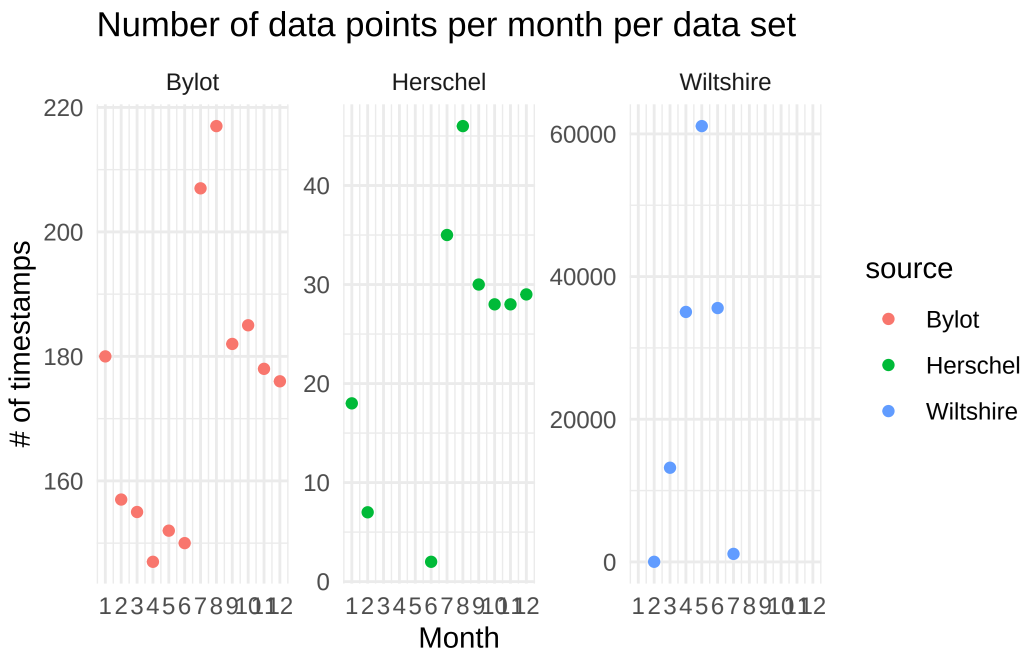

Figure 2: Overview of the number of data points per month in the three different data sets

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.

TBD: Use kernel density estimation (KDE)

TBD: There are several ways to calculate home range, we could compare (and could focus on only that)

TBD: Do this for foxes first, for bobcat and coyote data later, potentially even cross-species analysis

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

Research question 1

We start 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 in this case because it does only minimally overlap with the UK wader nesting season (see Figure 2). This leaves the Wiltshire and the Bylot data for comparison.

Given finding the selection of best data points to compare involves a complex choice that will influence the results, the first goal is to perform the simplest acceptable comparison. As a first exploratory result we will compare the median home range for the individual animals between the two locations for one year of data. The resulting home ranges are shown in Figure 4 and Figure 3. The results show that 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).

```
foxes_wiltshire_filtered <- movebank_download_study(
  study_id = 3179890710,
  sensor_type_id = c("gps"),
  'license-md5'='ffa36f79defe10eac9fe70f6502a17e0',
  timestamp_start = as.POSIXct("2019-03-15 00:00:00"),
  timestamp_end = as.POSIXct("2019-06-15 23:59:00")
)
foxes_bylot_filtered <- movebank_download_study(
  study_id = 1371322147,
  'license-md5'='9559cb1b1cca51e9f3fd69812e5e22dc',
  timestamp_start = as.POSIXct("2012-03-15 00:00:00"),
  timestamp_end = as.POSIXct("2012-06-15 23:59:00")
)
```

```
75264313 [m^2]
```

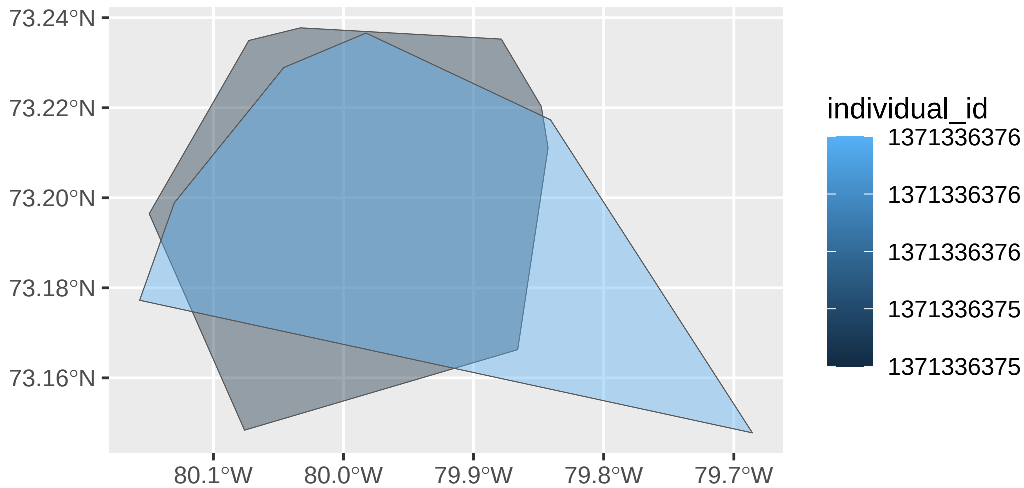

Figure 3: Home ranges calculated from UK wader nesting season 2012 for Bylot foxes

```
1052642 [m^2]
```

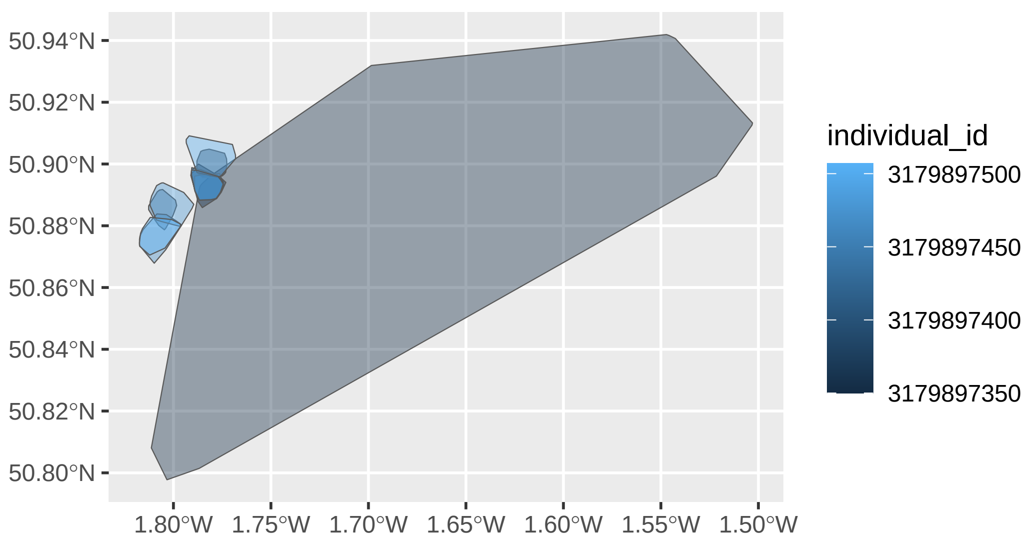

Figure 4: Home ranges calculated from rom UK wader nesting season 2019 for Wiltshire foxes

To confirm these results with similar sampling intervals, we plot 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. The resulting home range is shown in Figure 5. The influence from the different sampling interval can clearly be seen since the median home range is only half as with the full amount of data points (0.56 km2).

```r
foxes_wiltshire_filtered_sampled_24h <- foxes_wiltshire_filtered |>
  mt_filter_per_interval(unit = "24 hours")
```

```
563807.7 [m^2]
```

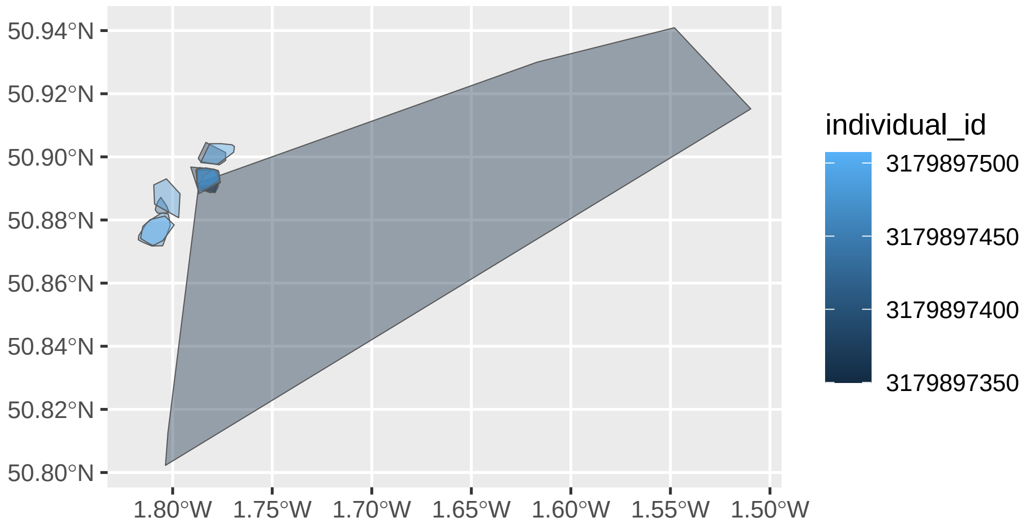

Figure 5: Home ranges calculated from rom UK wader nesting season 2019 for Wiltshire foxes (24 hour sampling interval)

Discussion

Research question 1

The home range numbers show a very clear result that demonstrates huge differences. The influence of aspects like sampling intervals can be demonstrated but plays a secondary role.

TBD regional differences in activity due to weather conditions. Weather conditions will differ for the same day of the year, leading to animal behavior likely also being different.

These differences will with near certainty be influenced by availability of food, but very likely also by many other factors that we are not able to understand or control.

TBD

- Wortlimit mit Patrick besprechen
- Runder Bericht in dem die research questions zu Ende beantwortet werden

Appendix

Wordcount

```
wordcountaddin::word_count("index.qmd")
```

```
[1] 1594
```

Use of Large Language Models and Generative AI

Elke used NotebookLM (2025) for interactively querying the set of research papers cited in the references.

References

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