Home range estimations

Animal Movement PhD-course 4-8 September, 2023

What is a home range?

What is a home range?

Territory or home range? - Thoughts on home range definition emerged from the reasoning about territoriality.

William H. Burt 1943:

Home range then is the area, usually around a home site, over which the animal normally travels in search of food. Territory is the protected part of the home range, be it the entire home range or only the nest. Every kind of mammal may be said to have a home range, stationary or shifting.

Only those that protect some part of the home range, by fighting or agressive gestures, from others of their kind, during some phase of their lives, may be said to have territories.

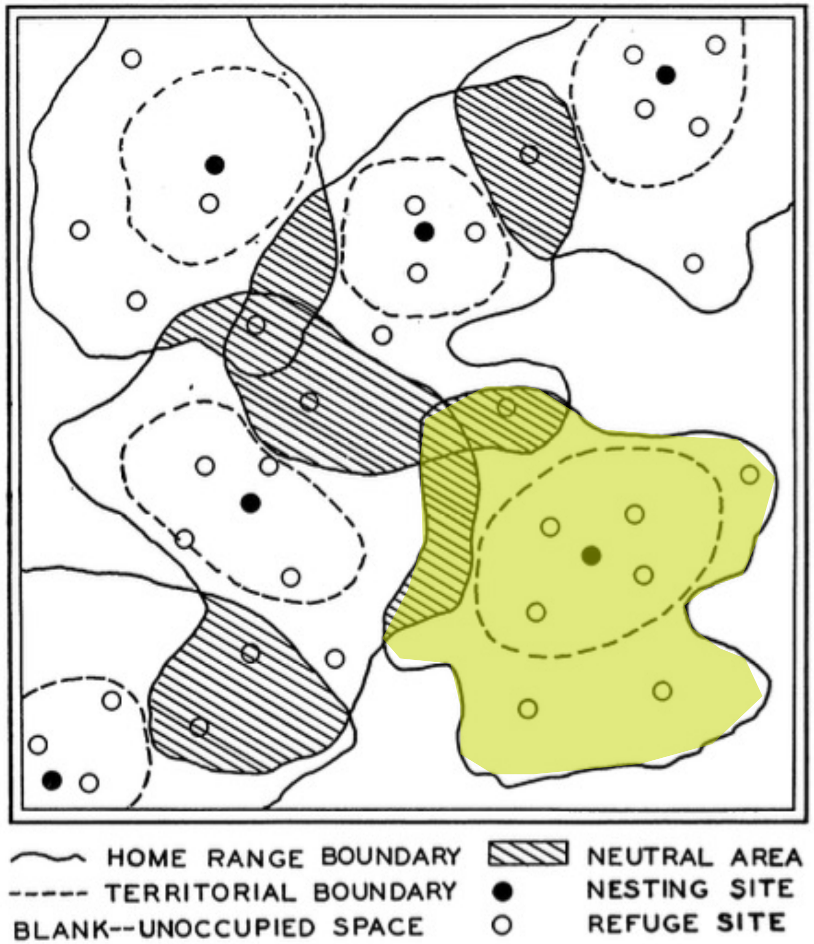


Fig. 1. Theoretical quadrat with six occupants of the same species and sex, showing territory and home range concepts as presented in text.

From Burt's definition

i) Home ranges are the consequence of behavioural and environmental processes (foraging, mating, predator avoidance…)

ii) Exploratory forays are not part of the home range, where the animal perform normal activities

iii) Temporally stable – repeated visits to places within the home range

- What are normal activities?
- When is the site fidelity enough?

Method development

- Burt presented no model or method approach estimate the home range it was a theory developed from reasoning and observation
- With movement data we may quantify animal behaviour
- With models we may put up hypothesis and infer animal behaviour

Geometric home range estimators

- Minimal Convex Polygon (MCP) – (Mohr 1947)
- Local convex hull (LoCoH) (Getz and Wilmers 2004)
- Straightforward and easy to understand

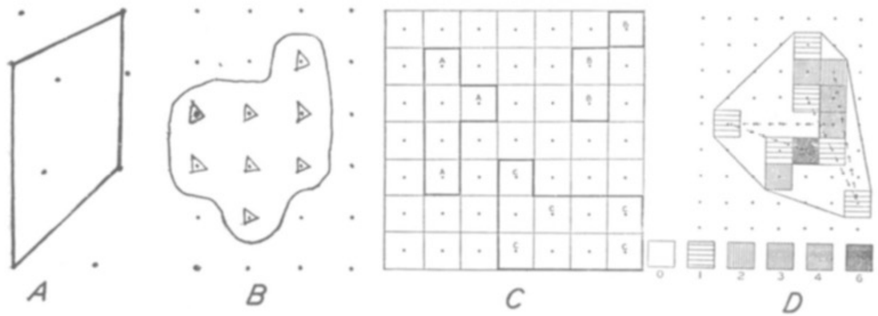
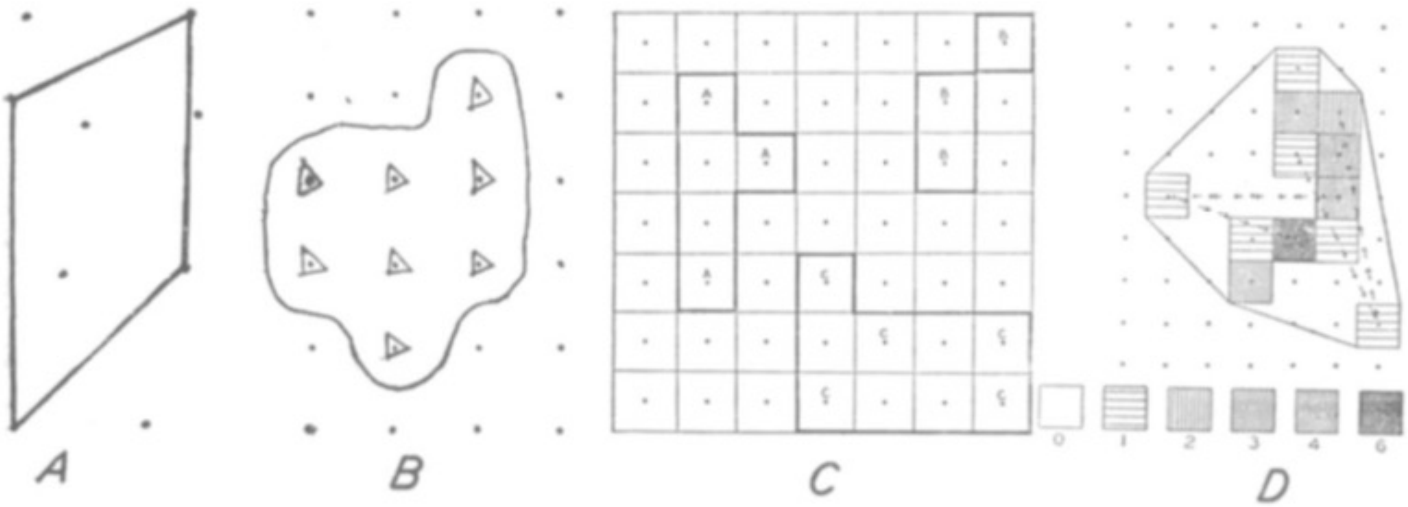


Fig. 1.—Methods of Delimiting Supposed Home Range.—A. Dalke's 1938 method, B. Burt's 1940 method, C. Haugen's 1942 method, D. Blair's 1942 method. Dots indicate position of traps. Outlines show the supposed outer limits of the home range of the animal in question. Trap-positions with letters, surrounded by triangles or enclosed in shaded grids are those in which animals were caught. Dalke's method has been called the minimum home range method. Others are modifications of the grid method. Blair's method stresses the number of times an animal is caught in each grid, which, in the case of the example was from 0 to 6 times.

MCP by Mohr 1974

Home Range.—Home range calculations were based on data furnished by 29 opossums which were caught at three or more stations, the minimum range being estimated by calculating the area enclosed by imaginary lines connecting the outermost stations visited by the individual in question as, indicated in fig. 1A.



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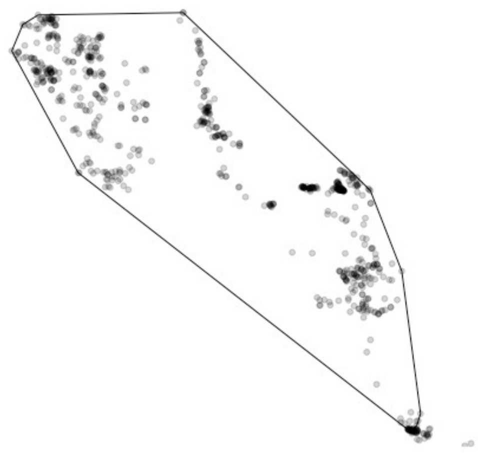
Minimum convex polygon – one reindeer

```
hr_mcp1 <- trk1 |>
  hr_mcp(trk1,
         levels = 0.95,
         keep.data = TRUE)
```



MCP 95%

Utilization distribution

- Density of use estimated – find hot spots in the landscape used by the animal
- Area used calculated using animal position during a certain time using a density estimation method
  - Kernel Density Estimation (KDE)
  - Brownian Bridge Movement Model (BBMM)
  - Auto-correlated kernel density estimation (AKDE)
  - Local Convex Hull (LoCoH)

February 1989 HOME-RANG

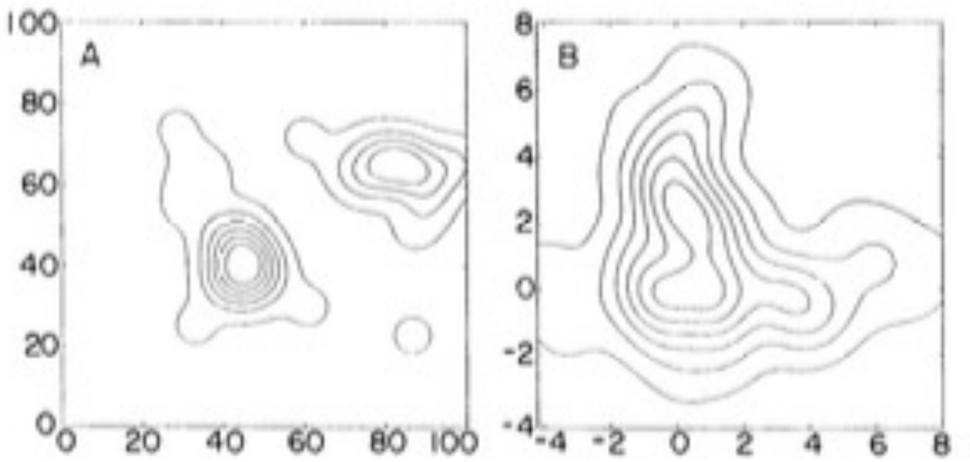


FIG. 3. Fixed kernel density estimates of the UD densities with the least-squares cross-validation choice of smoothing parameters for (A) the DC data set (h = 4.7) and (B) the SIM data set (h = 0.77).

Worton 1989

Ecology, 77(7), 1996, pp. 2075–2085

AN EVALUATION OF THE ACCURACY OF KERNEL DENSITY ESTIMATORS FOR HOME RANGE ANALYSIS[1]

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Abstract. Kernel density estimators are becoming more widely used, particularly as home range estimators. Despite extensive interest in their theoretical properties, little empirical research has been done to investigate their performance as home range estimators.

Kernel density estimation

- A probability density is placed over each observation point
- An estimate of the density is obtained over the surface using information from all observations
- Observations that are close to a point of evaluation will contribute more to the estimate than will ones that are far from it.
- Thus, the density estimate will be high in areas with many observations, and low in areas with few.
- Width of the kernels is tricky to determine..

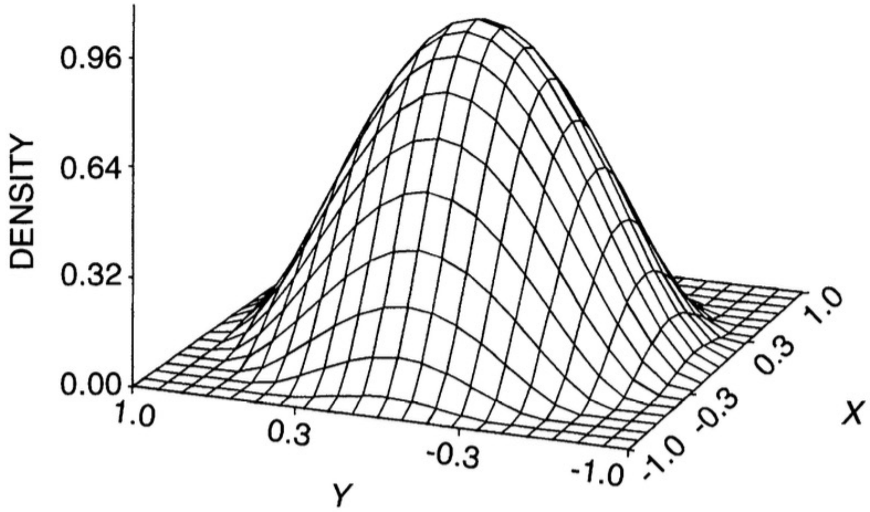


FIG. 1. Biweight kernel K_2. The kernel is a probability density; the volume under the curve integrates to 1.

Seaman and Powell 1996

- Kernel density estimator for bivariate data is defined as

$$\hat{f}(x) = [1/(nh^2)] \sum_{i=1}^{n} K\left\{\frac{(x - X_i)}{h}\right\}$$

- n – number of observations
- h – bandwidth (or smoothing parameter, window width)
- K – the kernel density
- x – vector of x,y coordinates
- Xi – series of vectors

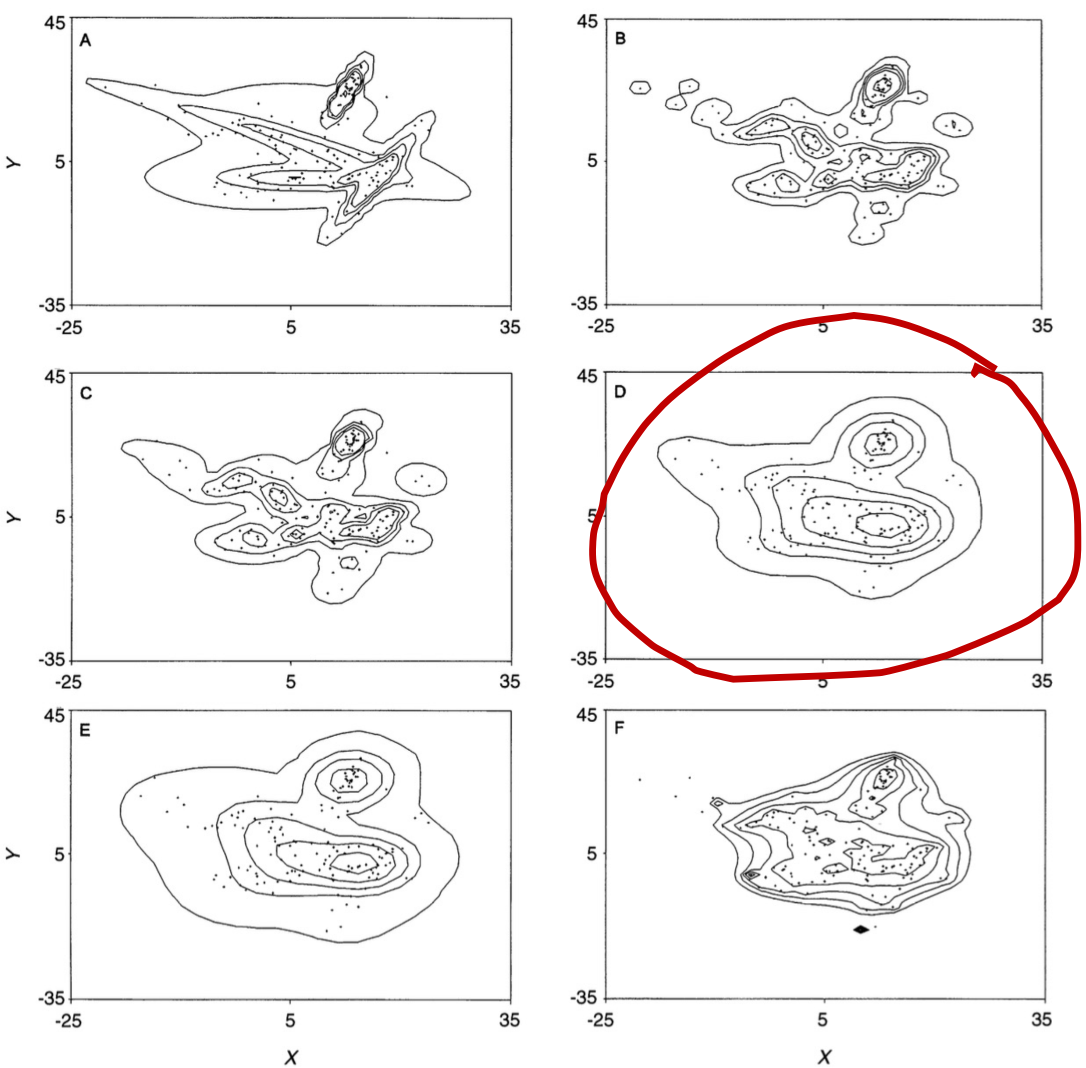
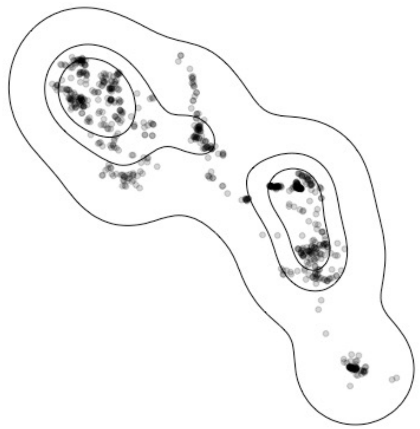


FIG. 3. Density contours of a complex simulated home range, (A) true density, (B) cross-validated fixed kernel estimate, (C) cross-validated adaptive kernel estimate, (D) h_{ref} fixed kernel estimate, (E) h_{ref} adaptive kernel estimate, (F) harmonic mean estimate. Contours represent 95, 72.5, 50, 27.5, and 5% of the volume of the home range estimate; data points mark observation locations.

Kernel home range estimator – one reindeer

```
hr_kde1 <- trk1 |>
  amt::hr_kde (
    trk1,
  h = hr_kde_ref(trk1),
  trast = make_trast(trk1),
  levels = c(0.25,0.50, 0.95),
  keep.data = TRUE)

plot(hr_kde1)
```



KDE with 25, 50 and 95 % isoplets

Different type of home ranges

Resembles Burt's definition

Range estimation

- Ex MCP, KDE and AKDE

- Range estimators extrapolate space use into the future.
  - How much space does an animal need?

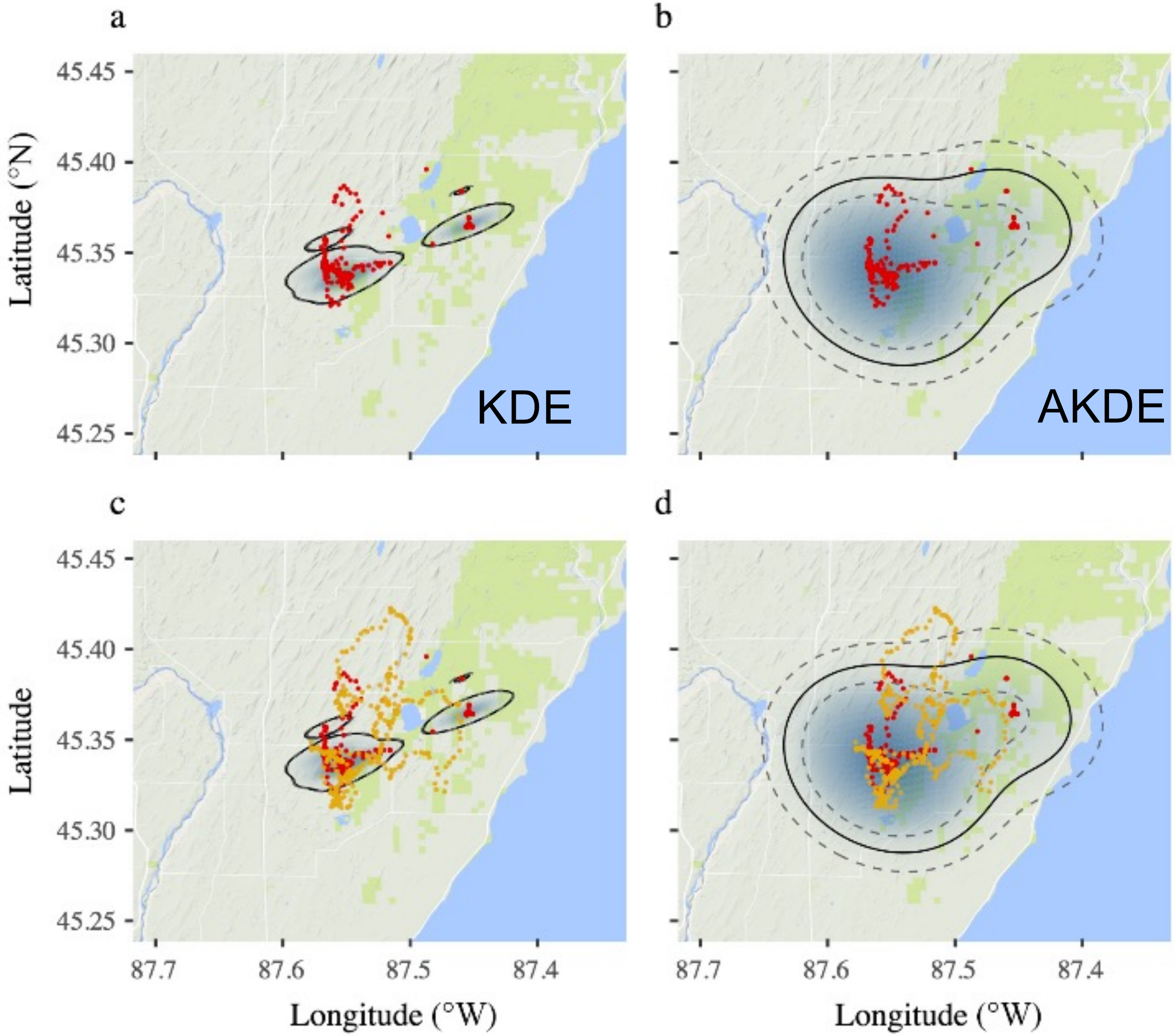
Occurrence estimation

- BBMM

- Occurrence estimators interpolate within the sampling period
  - Where did the animal go during the study period?
  - Why did it go there?

AKDE - Autocorrelated-Gaussian reference function

- Early estimators (MCP, KDE etc) assumes independence between positions.
- Less of a problem with few positions – radio telemetry. GPS-collars with frequent positioning have increased the problem with autocorrelation.
- Although its been a known problem it has been hard to control or check on the effect of autocorrelation in a good way.
- Noonon et al. 2019 evaluation of effects of autocorrelation and find that AKDE can handle autocorrelation in terms of…



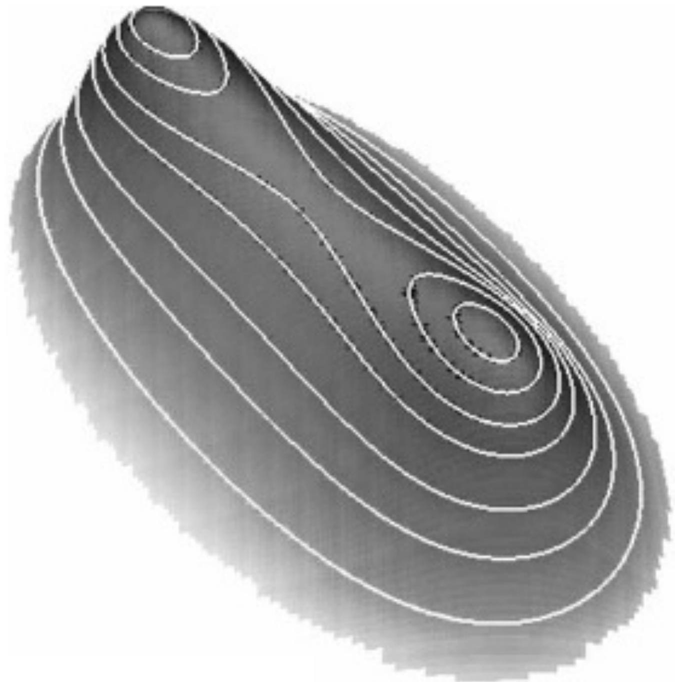
Home range estimated from the red dots

KDE underestimates and fail to include possible new area (orange dots) of the animal

Noonan et al. 2019

Brownian Bridge Movement Model

- Time dependent home range estimation



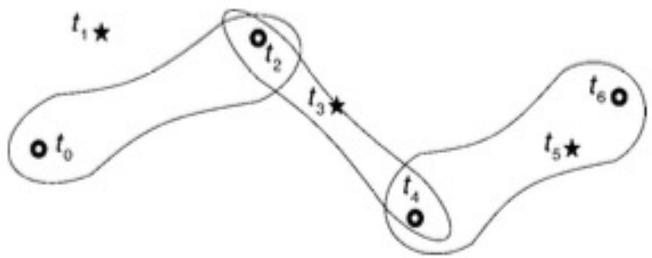


FIG. 2. Example of three Brownian bridges connecting even observations at time intervals $[t_0, t_2]$, $[t_2, t_4]$, and $[t_4, t_6]$. The in-between observations at times t_1, t_3, and t_5 are independent observations from these Brownian bridges and can be used to estimate the Brownian motion variance parameter.

ty for the fraction of time spent in
ted using the Brownian bridge
; were 280 m and 20 min apart.
ce σ^2_m was 642 m^2, and the standard
puted location error was 28.85 m.
respond to the observed locations.

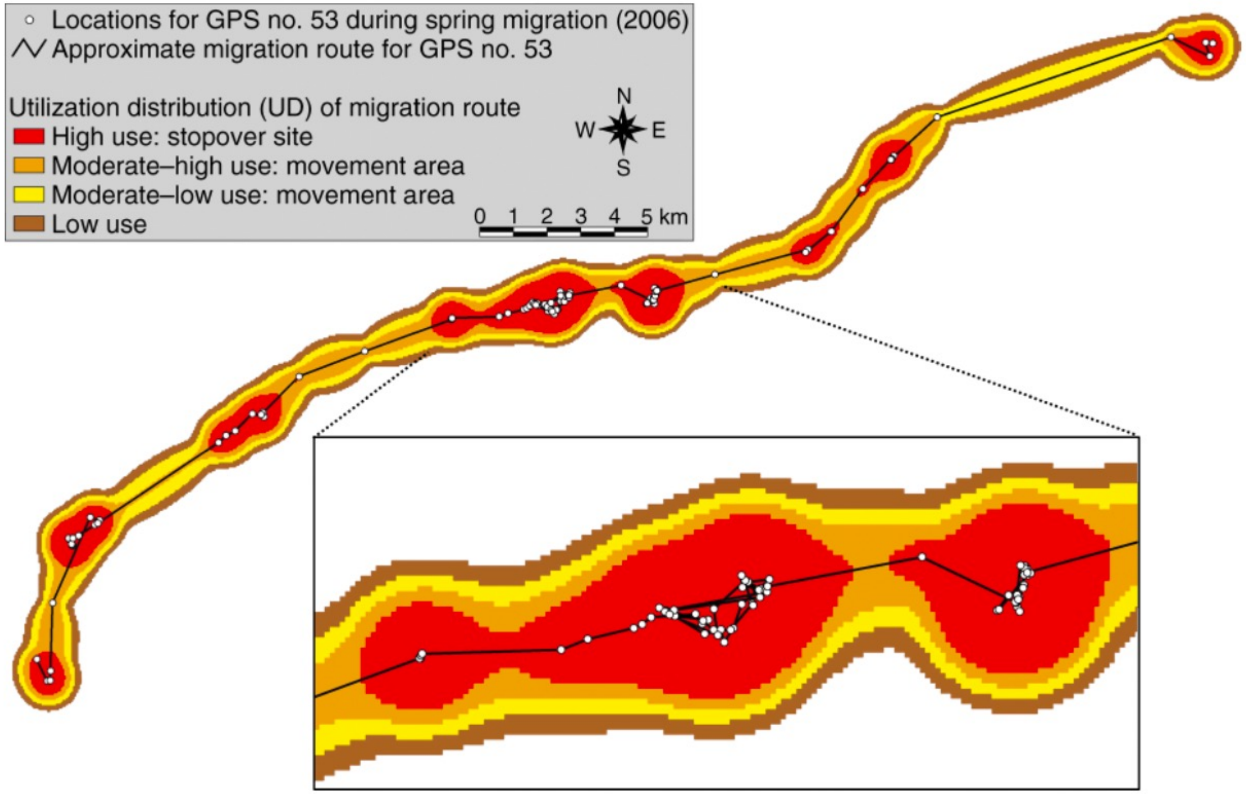
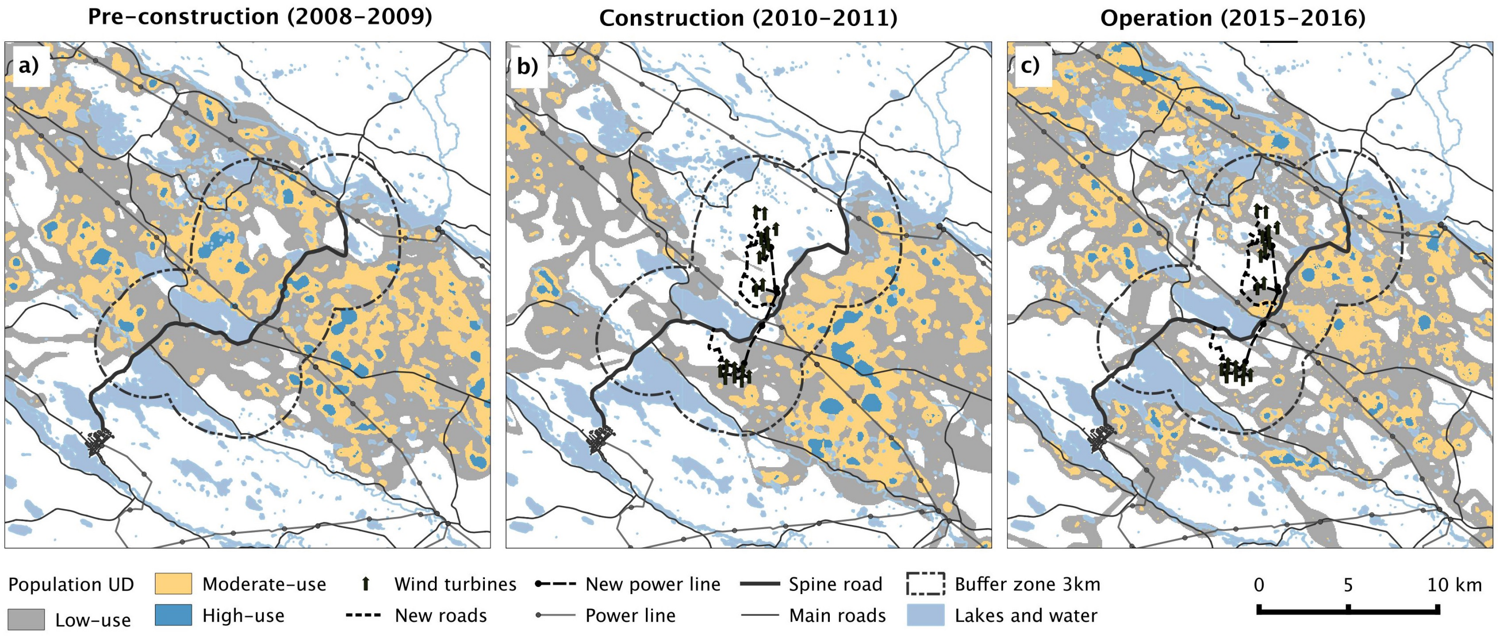


FIG. 2. Utilization distribution (UD) estimated for individual mule deer (*Odocoileus hemionus*; GPS no. 53) during spring migration of 2006. High-use areas correspond with stopover sites, where the deer spent most time (i.e., tortuous movements). Moderate-use areas located between stopover sites correspond with migratory segments through which mule deer moved quickly in one direction. Low-use areas reflect the uncertainty in the entire route.

Sawyer et al. 2009 - on mule deer migration

Adapted on reindeer data around wind farms



What is the animal doing?

- More data not necessary better – need to know what we are estimating
- Decision-making processes shaped by natural selection
- Link the home range to the cognitive map of the animal

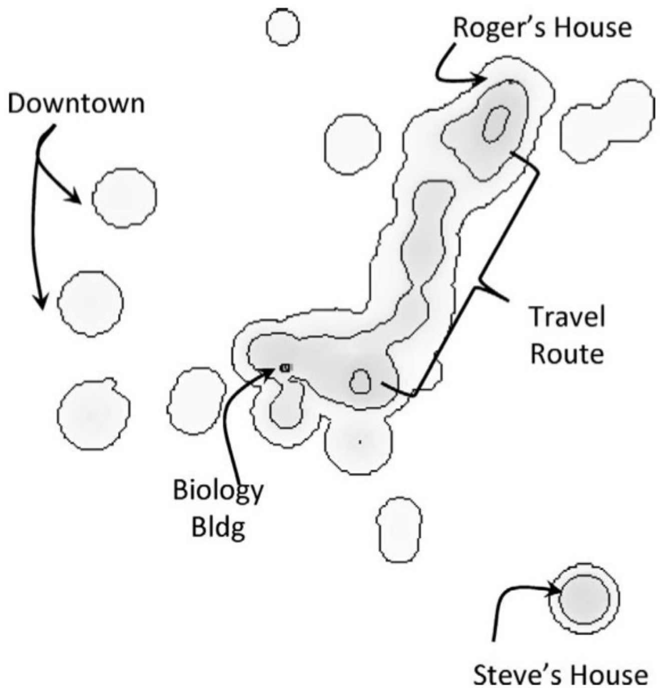
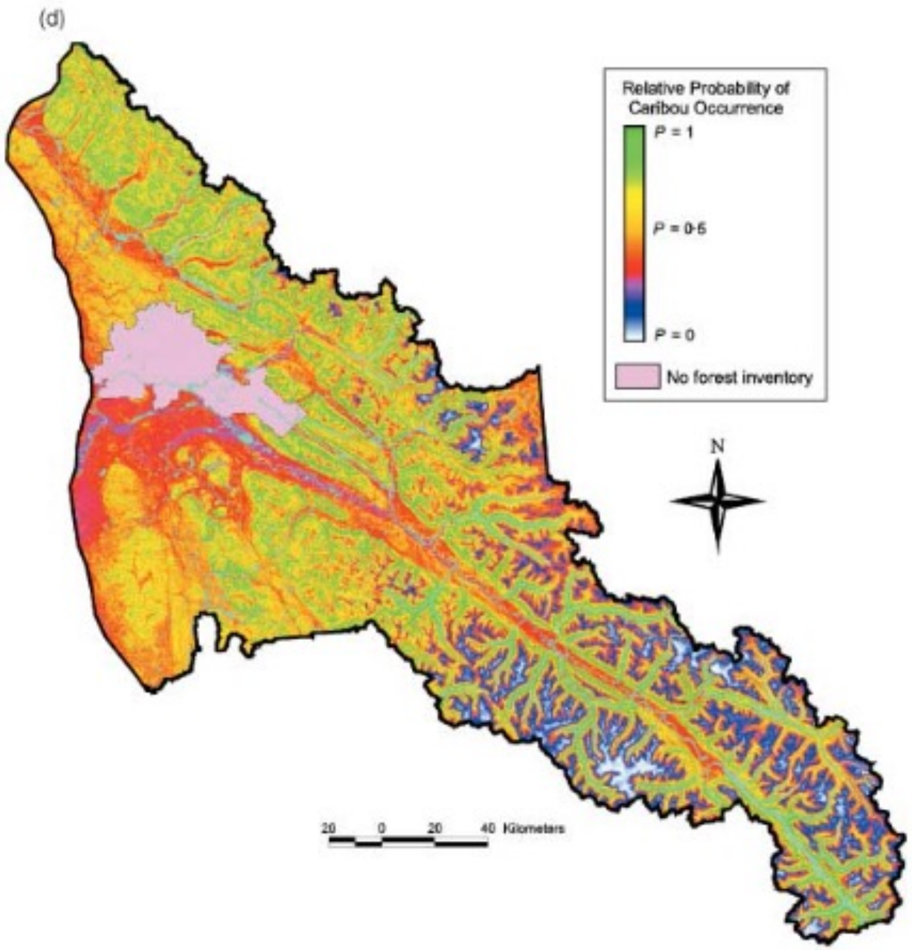


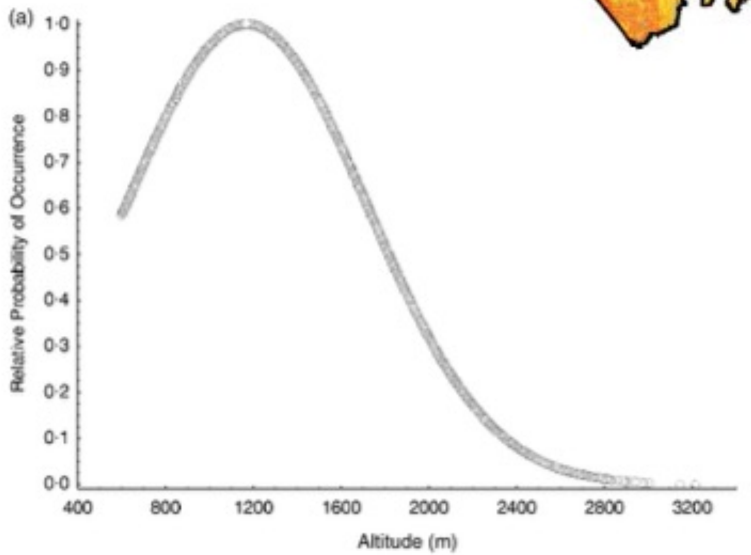
FIG. 1.—The 95% kernel estimate of Roger's home range in Laramie, Wyoming, where he spent sabbatical at the University of Wyoming in 1990–1991. Roger's house, the Biology Building on the university campus, Steve Buskirk's (a friend) house, and areas in downtown Laramie frequented by Roger are noted.

Powell & Mitchell 2012

Next step…

- Habitat selection





Johnson et al. 2004