Space Use and Resource Selection II

Movement Models

Parameter Estimation

statistical model of movement parameters such as speed or turtousity
(many packages)

Home Range Estimation

want to know where an animal is spending time
(adehabitatHR, ctmm)

Behavior Segmentation

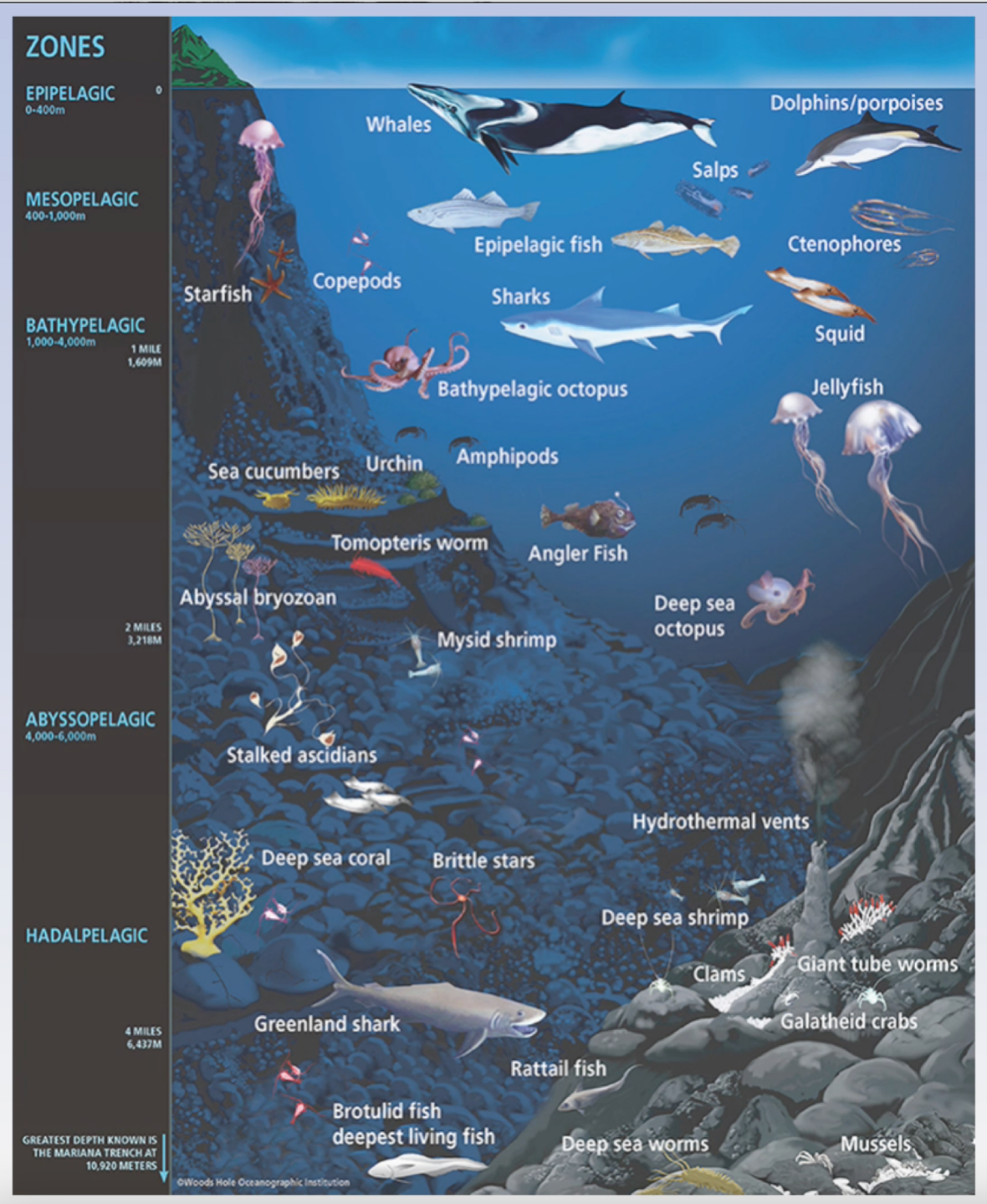
what behavioral state the animal was in at each time step
(moveHMM, momentuHMM)

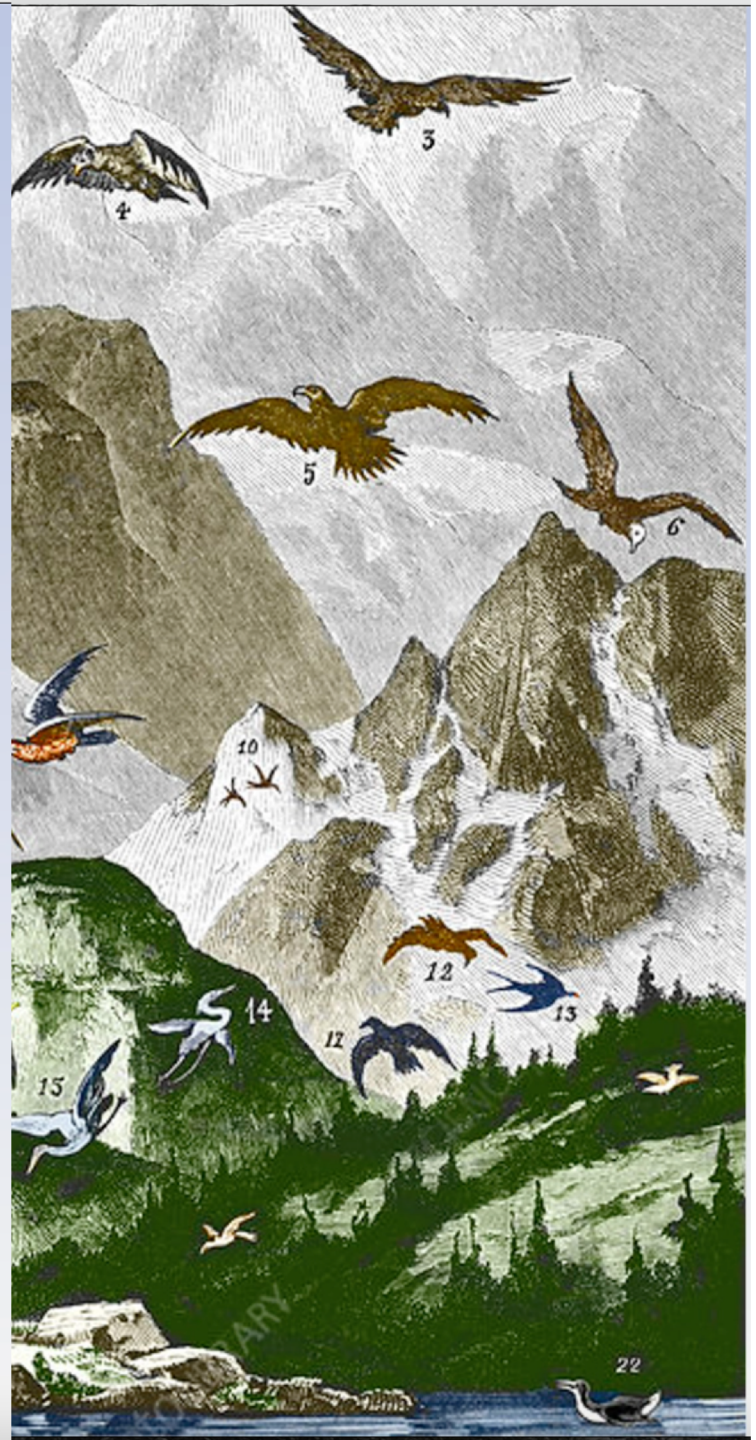
Path Reconstruction

how to reconstruct a path from data that are noisy?
(crawl, foieGras)

Step Selection Analyses

understand how animals make movement decisions based on the environment
(amt, adehabitatLT, others)





What about 3D Space Use?

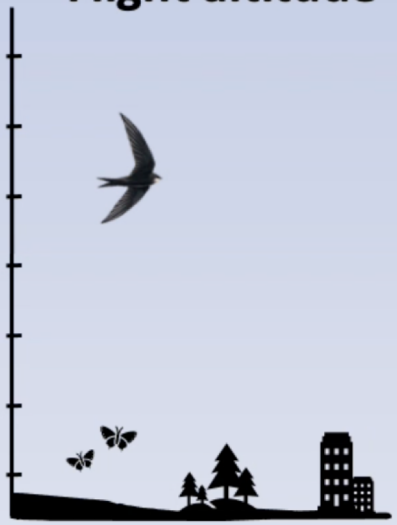
Volumetric Space Use

- Seascape ecology and Aeroecology
- A case where the availability of data has limited the development of analytical methods?
- Exploring movements in 2D can miss the point when the conditions or resources vary along the height/ depth dimension (currents or prey)
- Requires multi-sensor electronic tags, depth or altitude -> with x, y, and z coordinates

What proximate factors determine flight altitude during migration?

Predators
Conspecifics
Prey
Biotic

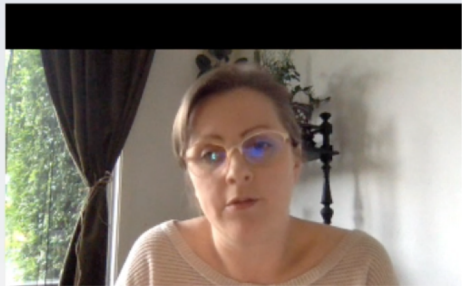
Flight altitude



Physiology
Heart/lung capacity
Weight
Wing loading/ flight mode
Maneuverability
Vision
Orientation cues

Anthropogenic
Light pollution?
Heat pollution?
Sound pollution?
Buildings
Wind power etc

Environmental factors
Weather
Wind
Temperature
Sun radiation
Cloud cover
Visibility
Convection
Vegetation
Topography



Cecilia Nilsson, Lund University

3D Kernel Density Estimation

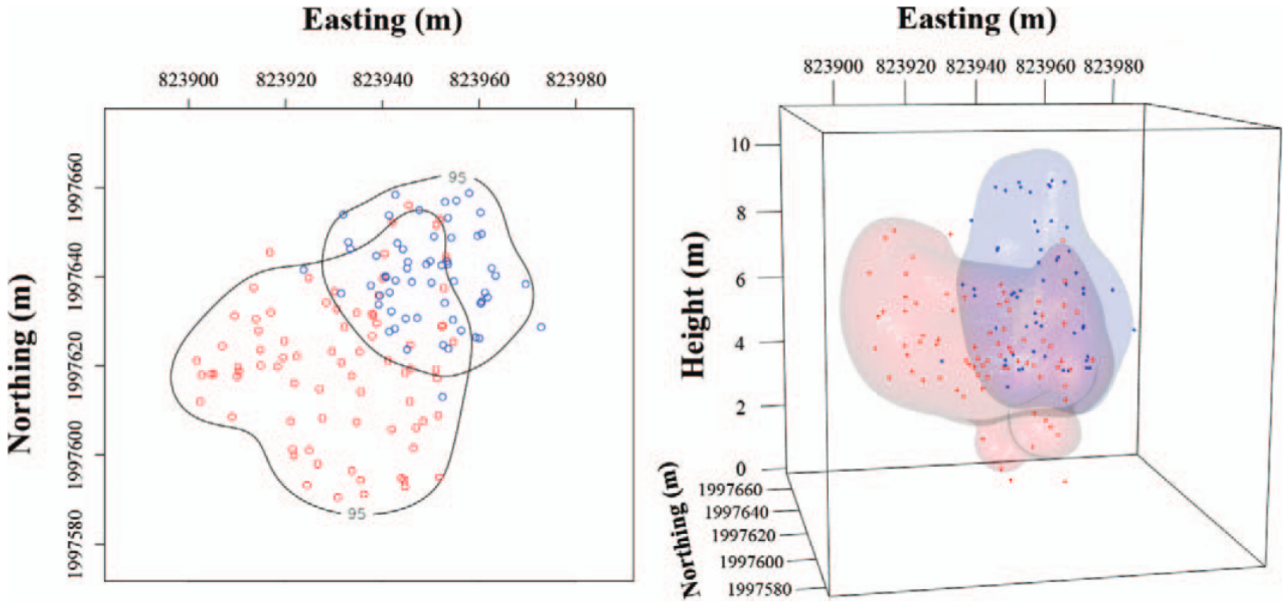
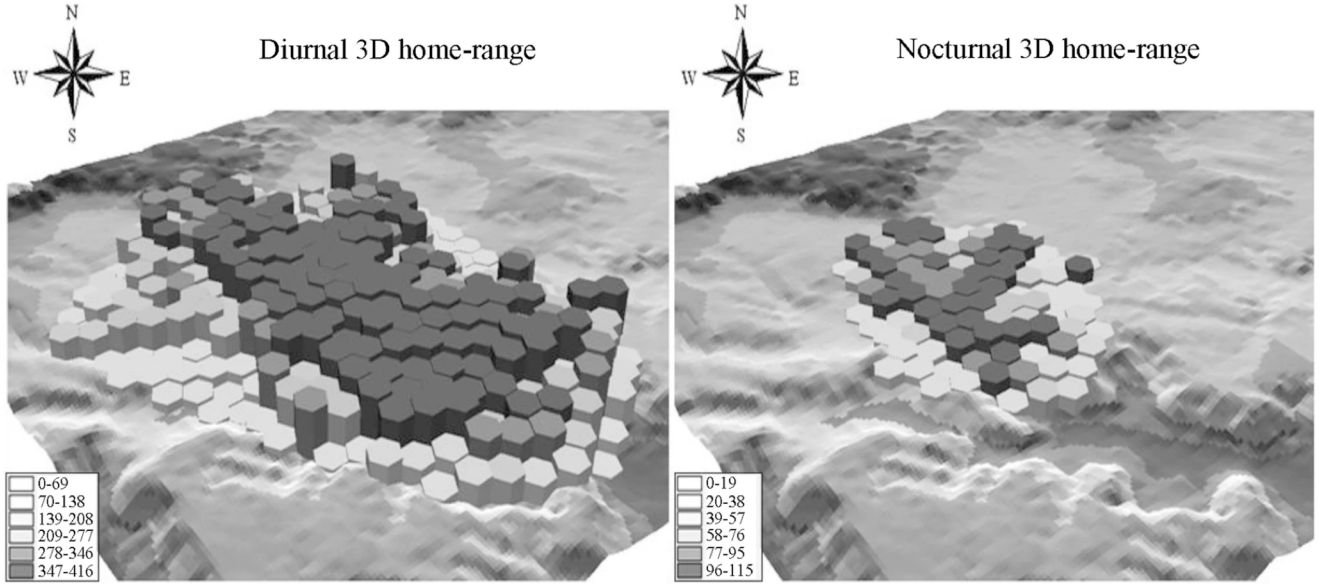


FIGURE 1. Overlapping 95% utilization distributions of 2 neighboring American Redstarts (red = 79 locations, blue = 70 locations) wintering in Jamaica, in 2 dimensions (left panel) and 3 dimensions (right panel).

Cooper et al., 2014



A new methodology for computing birds' 3D home ranges

Alessandro Ferrarini, Giuseppe Giglio, Stefania Caterina Pellegrino, Anna Grazia Frassanito & Marco Gustin

Avian Research **9**, Article number: 19 (2018) | Cite this article

Paper discussion: Monday

Wright *et al. Movement Ecology* (2017) 5:3
DOI 10.1186/s40462-017-0094-0

Movement Ecology

RESEARCH Open Access

Fine-scale foraging movements by fish-eating killer whales (*Orcinus orca*) relate to the vertical distributions and escape responses of salmonid prey (*Oncorhynchus* spp.)

Brianna M. Wright[1,2,3*], John K. B. Ford[2,3], Graeme M. Ellis[3], Volker B. Deecke[4], Ari Daniel Shapiro[5], Brian C. Battaile[1,2] and Andrew W. Trites[1,2]

Abstract

Background: We sought to quantitatively describe the fine-scale foraging behavior of northern resident killer whales (*Orcinus orca*), a population of fish-eating killer whales that feeds almost exclusively on Pacific salmon (*Oncorhynchus* spp.). To reconstruct the underwater movements of these specialist predators, we deployed 34 biologging Dtags on 32 individuals and collected high-resolution, three-dimensional accelerometry and acoustic data. We used the resulting dive paths to compare killer whale foraging behavior to the distributions of different

Hierarchy of Resource Selection

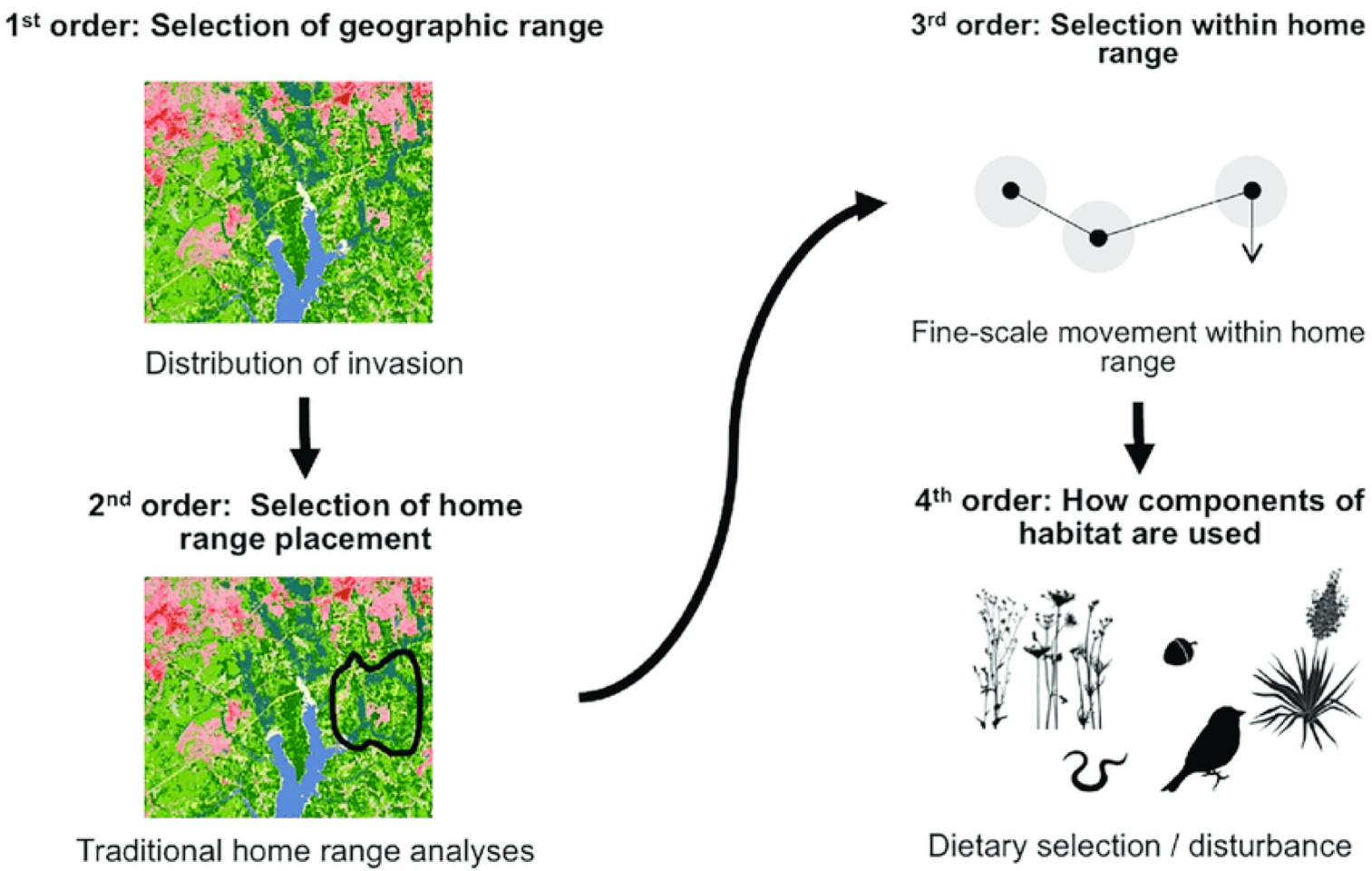
How to evaluate resource and space use?

1st order- Geographical range

2nd order- Individual home range

3rd order- Individual step selection of components within home range

4th order- Individual procurement of food (or shelter) at each step



From Johnson 1980 Ecology

Study Designs for Resource Use and Availability

Design I: *Use measured for population/ species* (individual animals not identified) defined by variation in density, abundance and occupancy across a resource gradient in a study area (management unit, administrative area, composite of individual home ranges)

Design II: *Use measured for individuals* but *availability measured at the population level* -- availability within the study area

Design III: *Use measured for individuals* and *availability measured for each animal* -- availability within a home range

Design IV: *Use measured for individuals multiple times* with paired measures of availability for each location -- availability along the movement path

From Thomas and Taylor 2006 JWM

Resource selection

- Probability of use or density of locations as a function of resources, risks, and environmental conditions
- Assessing if some habitats are preferred or selected over other habitats
- Requires "used" and "available" habitats in the study design
- How you define “availability” matters
- Key is to define relevant to the species, individual, or behavior

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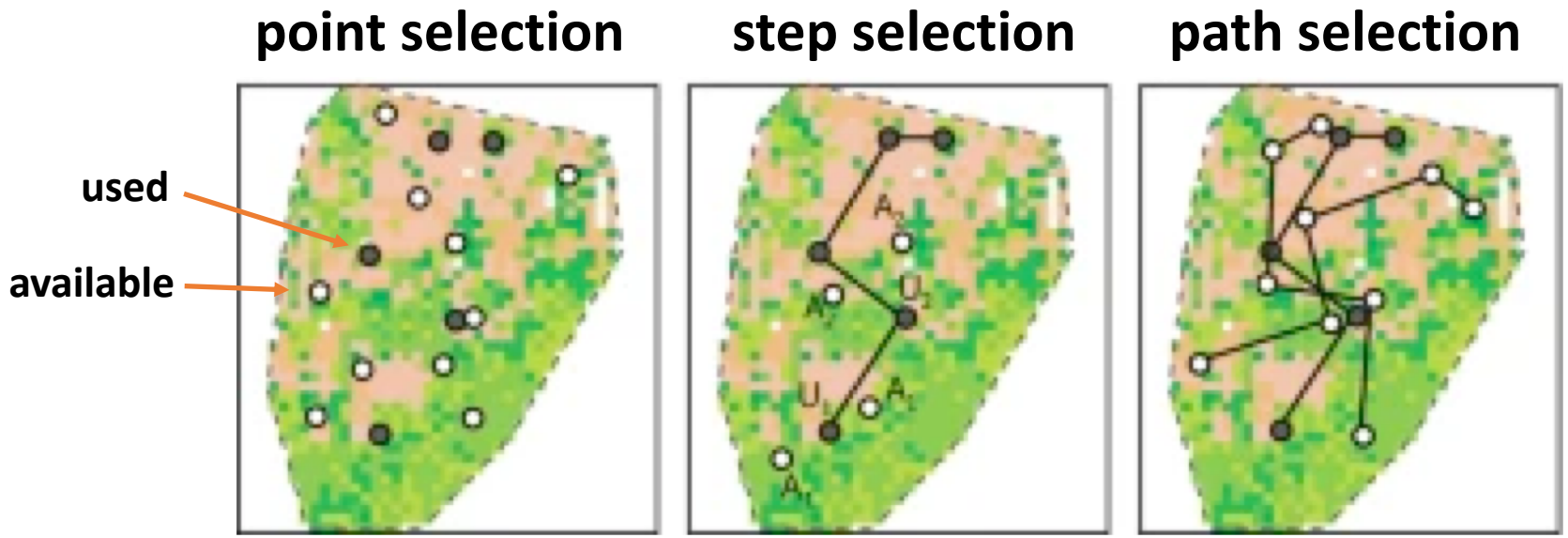
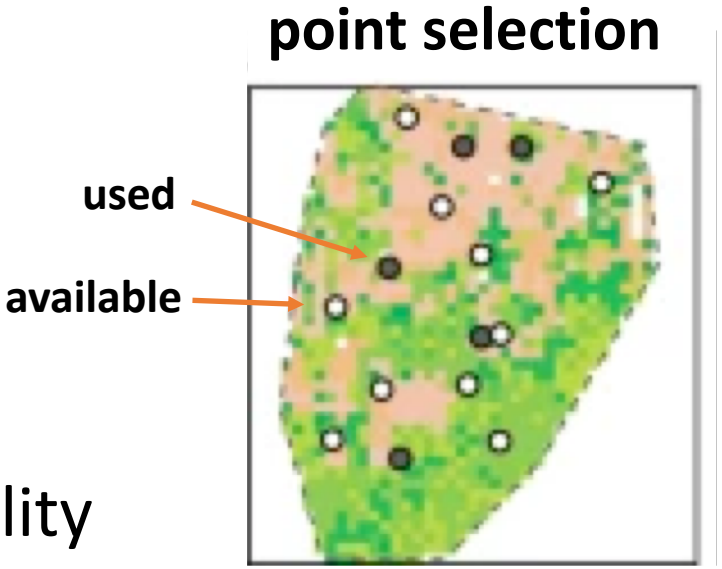
Resource selection functions

- Statistical models that quantify variation in resource use, function that is proportional to the probability of use of a resource unit
- The RSF attempts to quantify that preference or avoidance
- Collect data on *used locations* -> Define and collect data on *available but not used locations or paths*

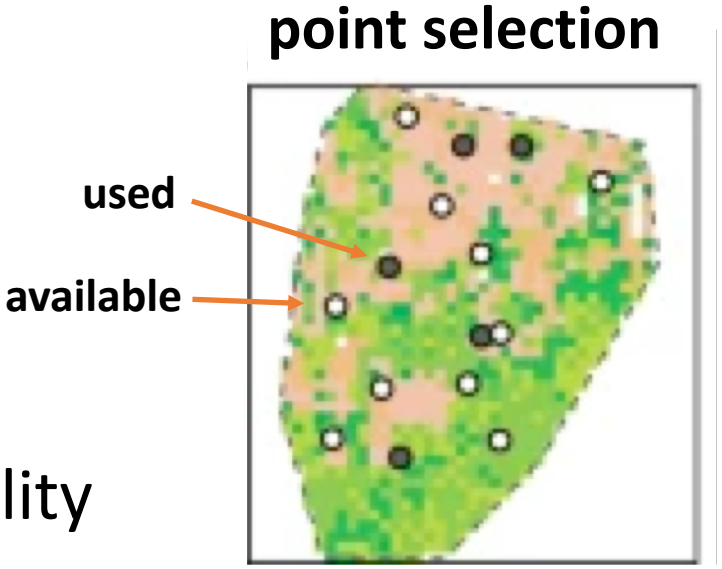


Point selection



- Points without reference to trajectory or movement
- For categorical “habitat” proportional use vs availability
- Random selection of “available” locations
- Within study area or home range? -- What Design Level is the study?

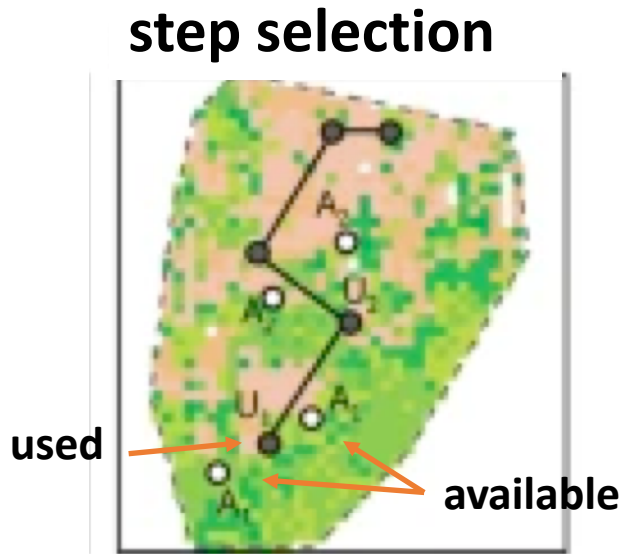
Point selection



- Points without reference to trajectory or movement
- For categorical “habitat” proportional use vs availability
- Random selection of “available” locations
- But is it avoidance of one type or selection of another?
- Compositional analysis
- Point process models of the relationship between used and unused grid cells:
    - Logistic regression- binary data, yes/no
    - Point process models (count data on a log scale, >0)

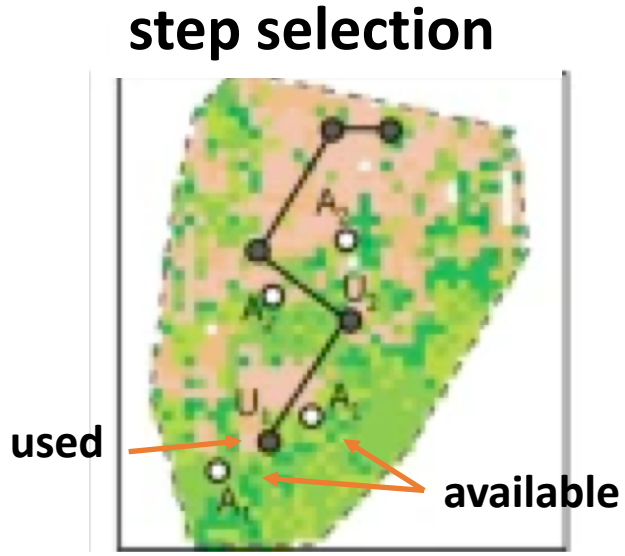
Step selection

- Use at time *t* is contrasted with availability at time *t*
- What Design Level is the study?
- *How would you generate “available” points?*

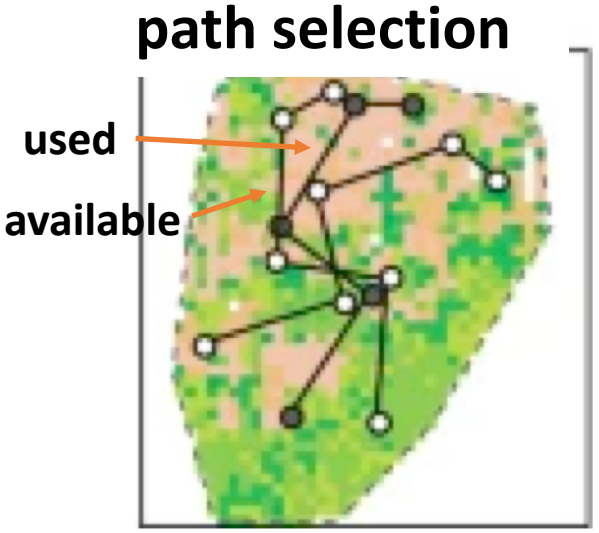


Step selection

- Use at time *t* is contrasted with availability at time *t*
- *Movement trajectories used to define: 1) step length, 2) turning angles between locations*
- These parameters are used to identify matched points that are potentially available, a “choice set”
- Matched case-control design: discreet choice and related conditional logit models
- Resources at the end step or along the entire step?
- Available points selected through observed step distribution or a parametric distribution fit to the observed step lengths?

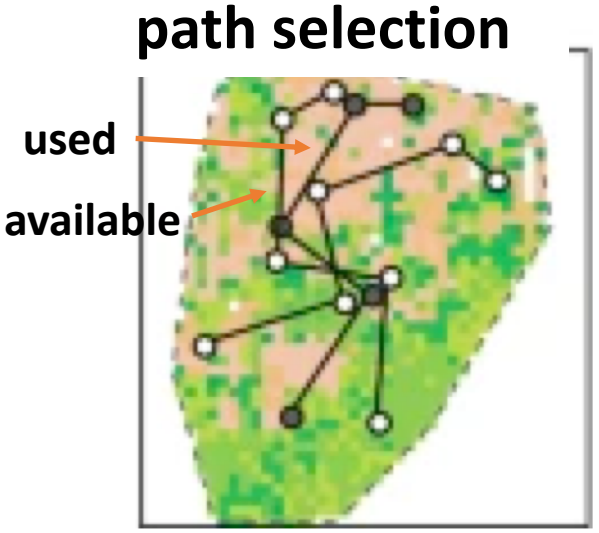


Path selection



- Alternative to step selection is to consider entire paths (or relevant components of them)
- *Reduce issues of temporal autocorrelation between steps, may provide more useful information on selection during the movement process*
- *How would you generate “available” paths?*

Path selection



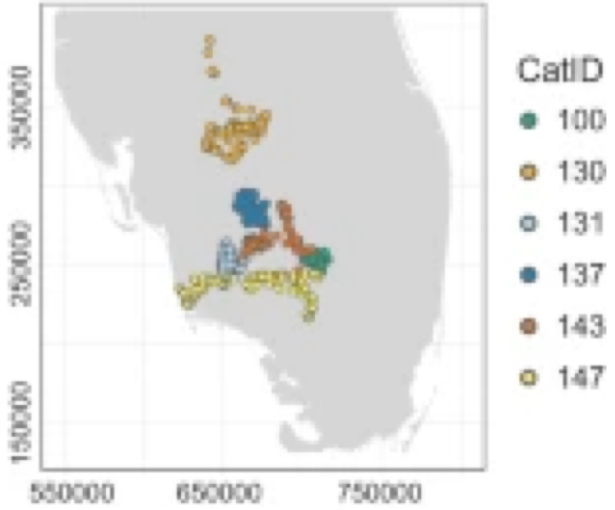
- Alternative to step selection is to consider entire paths (or relevant components of them)
- *Reduce issues of temporal autocorrelation between steps, may provide more useful information on selection during the movement process*
- Random path generation: from the components of the used path steps, rotate and/or shift the used path
- Used for: resistance of the matrix to movement, individual variability in dispersal

Florida Panther

- Critically endangered, up from 10 to 200 animals left in the wild
- Historic range throughout Gulf Coast states, now only in southwestern Florida
- Space use important for conservation (wildlife crossings, development)- GPS tracking
- Locations every 1-3 days

a

b



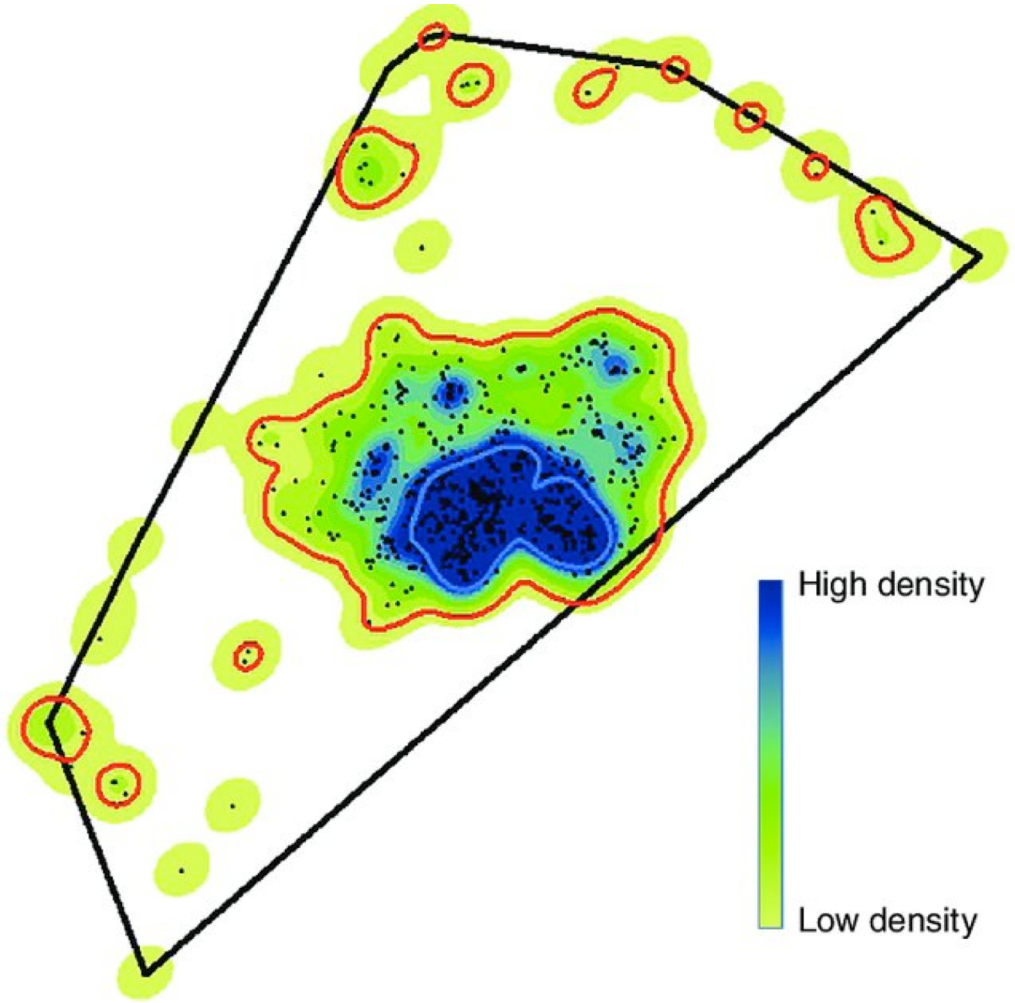
c

CatID	Sex	Age	# Locations	# Months monitored
100	Male	Adult	127	11
131	Male	Adult	118	11
137	Male	Adult	131	11
130	Male	Sub-adult	85	9
143	Male	Sub-adult	129	11
147	Male	Sub-adult	123	9

Home Range Analysis Methods -R

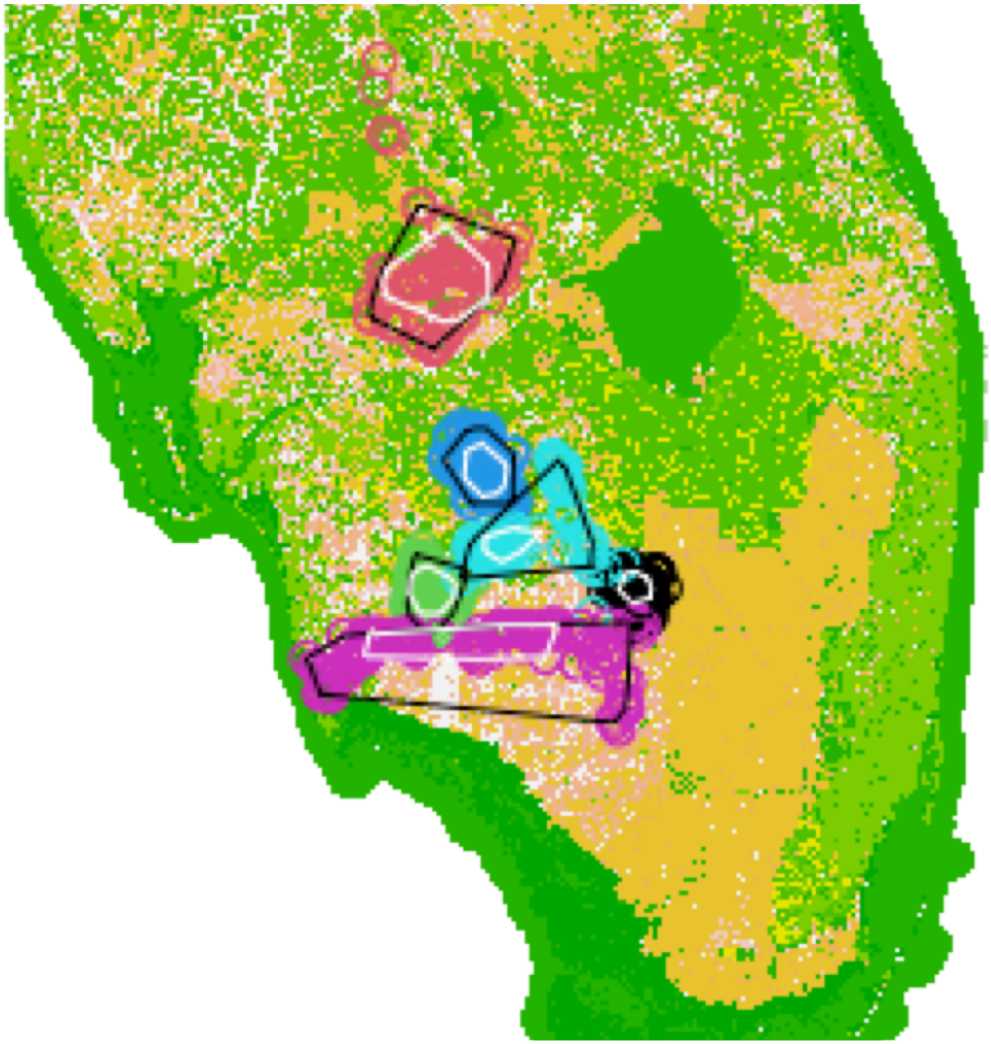
- MCP
- KDE
- Movement-based models, we discussed Brownian Bridge Models

R recitation



Minimum convex polygon (MCP)

- The simplest definition - by far - MCP simply draws a tight polygon around the observations.
- problematic because it includes space that is clearly not used. Redeemed by its incredible simplicity.



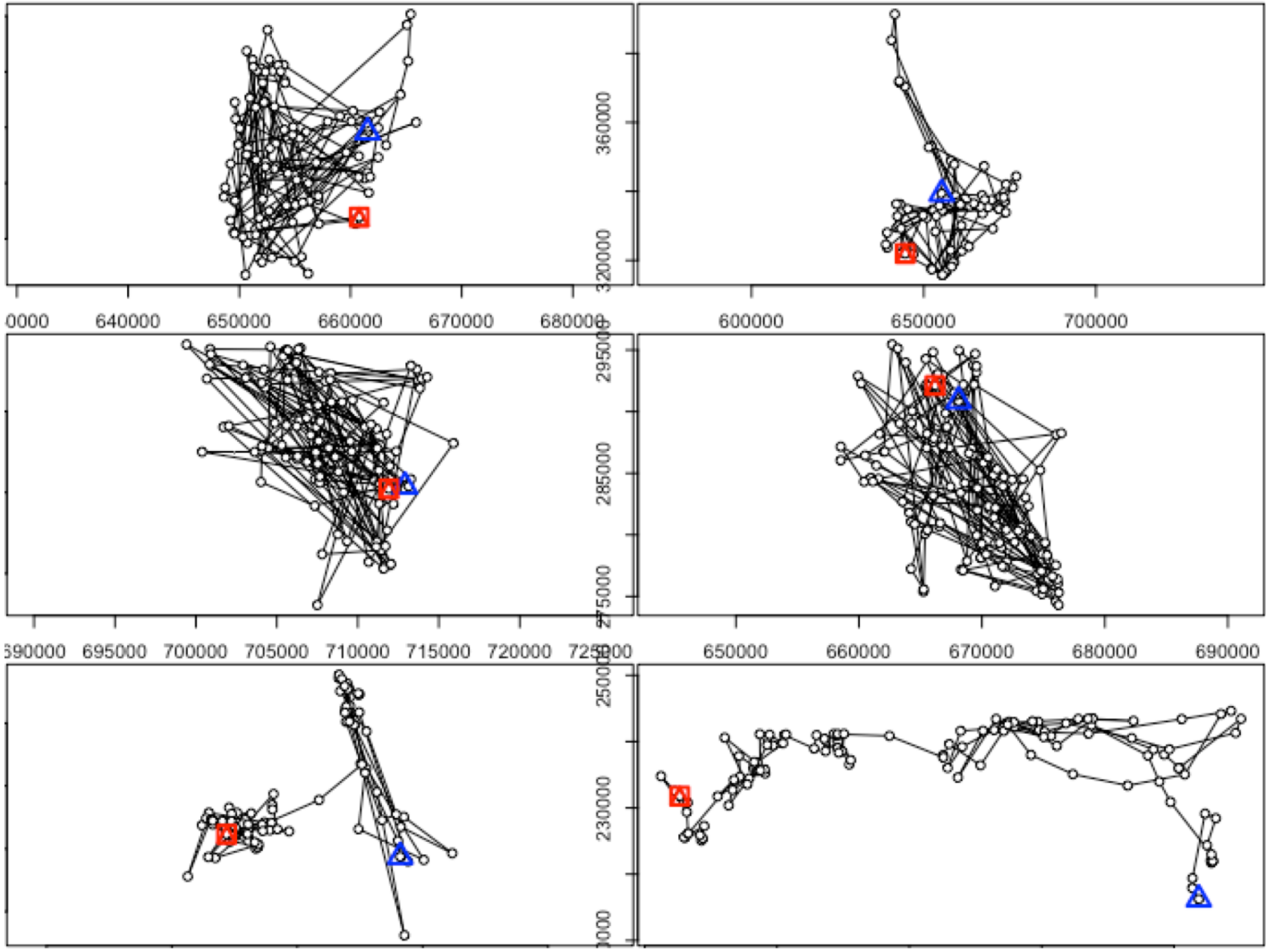
Kernel Density Estimation (KDE)

1. Kernel smoothing distribution:

- Bivariate normal distribution (bivariate because in the x and y dimension)
- Non-normal approach (epa)
- **kern** = "bivnorm", a bivariate normal kernel, "epa", an Epanechnikov kernel is used.

Brownian Bridge Models

- Requires tracking trajectory data with real-time information
- Parameters:
- **sig1** – related to the speed of the animal, estimated from the data, depending on the variability fit separately for each animal, related to the animal's mobility, is a feature of the particular animal under observation. Empirical estimate obtained from the location data.
- **sig2** – related to the ***h*** in KDE, reflects the error in the location (e.g., from biotelemetry) is assumed to be normally distributed, with mean centered on the estimated location and variance either known or estimated via independent experiment.
- **grid** - sets the grain for the analysis (impacts computation time)



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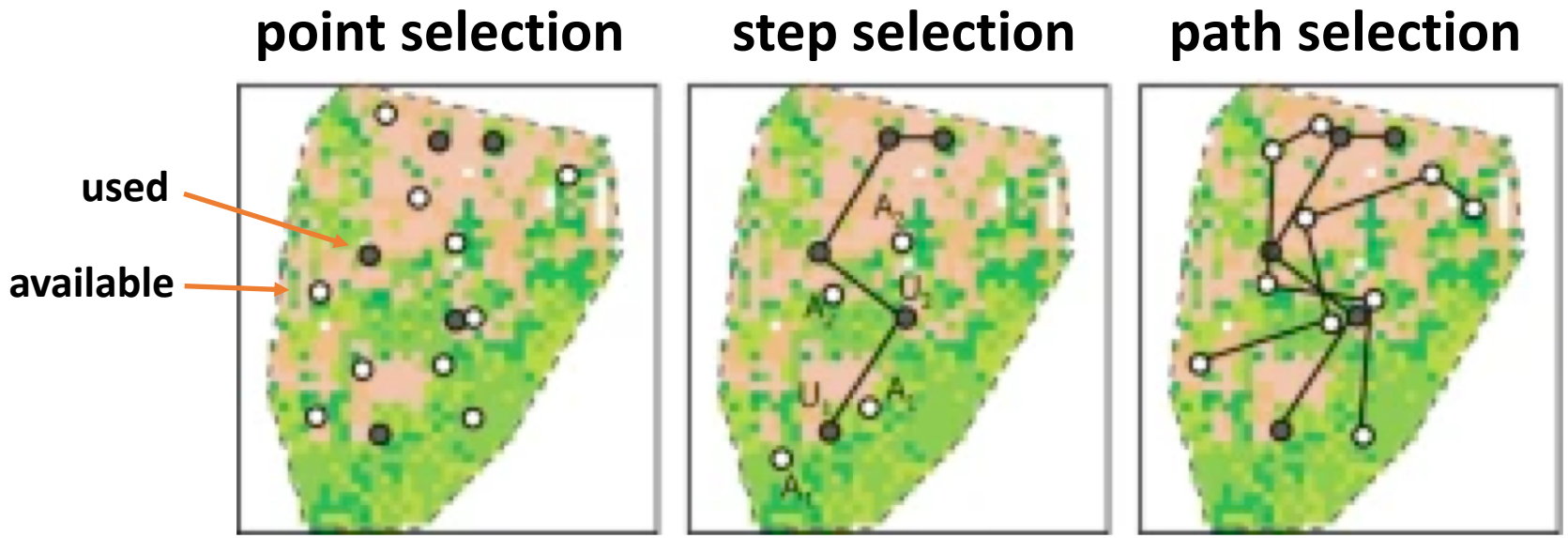


Point selection- categorical variables

Design II: *Use measured for individuals* but *availability measured at the population level* -- availability within the study area

- Extract land-cover points at use points (extract)
- Generate 1000 random points (sampleRandom)
- Extract land-cover categories at these points
- Manly's Selection ratios for design II (widesII measures the selection ratio: used/available)

Point selection- categorical variables

Design III: *Use measured for individuals* and *availability measured for each animal* -- availability within a home range

- Derive available points within the home range of individuals
- Take 200 samples from each individual home range based on a 99% MCP for each individual
- Extract land-cover categories at these points
- Manly's Selection ratios for design III (widesIII measures the selection ratio: used/available)

Point selection - categorical variables

Design II: *Use measured for individuals* but *availability measured at the population level* -- availability within the study area

- Manly's Selection ratios useful when covariates of interest are categorical
- Assumes individuals are independent samples and that selection is the same among individuals
- Do not accommodate cases when covariates are continuous (proportion of wet and dry forest)
- Regression-based RSF (logistic- glm) -- Parameter interpretation

- Inhomogeneous point process model

Step selection

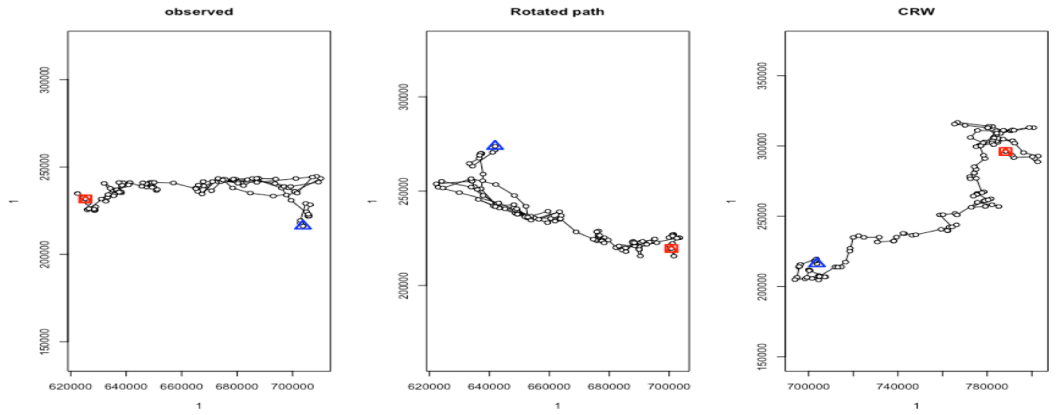
Design IV: *Use measured for individuals multiple times* with paired measures of availability for each location -- availability along the movement path

- Trajectory files for each cat (we created for the Brownian Bridge models) include: 1) original x-y locations, 2) change in coordinates, 3) distance moved, 4) change in time, 5) mean sq displacement, 6) absolute and relative angle changed
- Calculate avg step length and turn angles
- Location selected at time t relative to alternative
- Available locations at time t based on the avg step length and turn angles
- Example: 3 available for each use step

Path selection

Design IV: *Use measured for individuals multiple times* with paired measures of availability for each location -- availability along the movement path

- Also uses the trajectory data
- Randomly shifts the paths to identify “available”
- Can also use correlated random walk to generate “available”
- Included in the code but not going to walk through



Paper discussion: Monday Nov 7

Wright *et al. Movement Ecology* (2017) 5:3
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Project updates: Wednesday Nov 9

Written report: updated version of the proposal that responds to our comments and adds 4 items below emailed to us by beginning of class (11am)

In class presentation: <6 minute with one slide per topic

Topics:

1. statement of the specific prediction(s) you will test with the analysis (including the predictor and response variables)
2. explanations of the data that will be used in the study and their status, including summaries of sample sizes and spatial and temporal distribution and resolution
3. explanation of and justification for the analytical approach (mentioning R packages and functions to the extent possible) that will be used to address the predictions
4. explanation of progress or current status of the analysis and/or planned workflow

Homework 6: Wed Nov 16

- Home Range and Resource Selection
- Posted on Slack by the end of day today
- Will move due date to Wednesday (Monday on syllabus) so you can focus on your projects this week

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Parameter Estimation

statistical model of movement parameters such as speed or turtousity
(many packages)

Home Range Estimation

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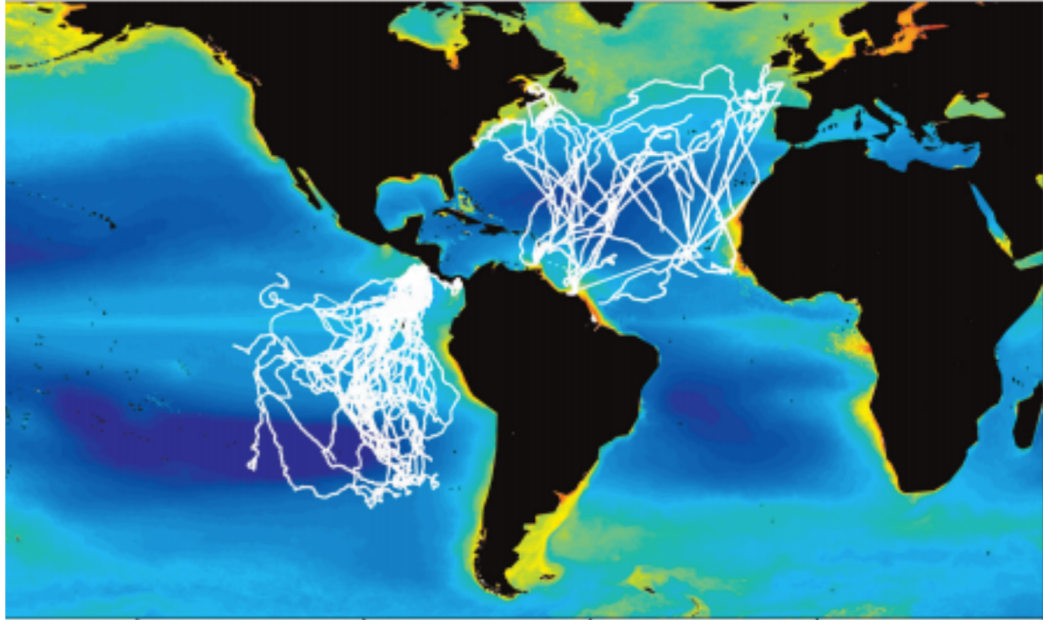
Step Selection Analyses

understand how animals make movement decisions based on the environment
(amt, adehabitatLT , others)

Learning Objectives

1. Define habitat, space use, resource selection, home range
2. Identify key considerations in measuring space and resource use from animal tracking data
3. Explain methodologies for measuring space use and resource use



Home Range	**DeGroote, Anand, Liao**
SDM	**Drzewicki, Groves**
Migratory Connectivity, isotope assignment	**Endyke, Ibrahim**
Landscape metrics	**Massa, Eubanks**
Other spatial models	**Williams, McHale, Roth**