Species distribution

Animal tracking 25/26

Giuliano Colosimo

University of Rome Tor Vergata

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Movement and conservation

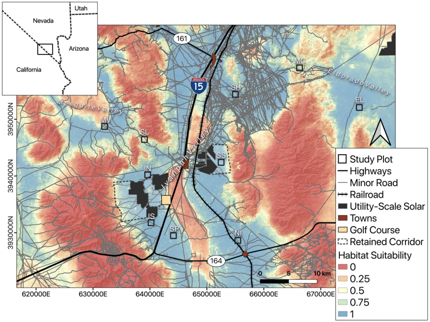
Using movement to inform conservation

- Study from Hromada et al. (2020)

Figure 1: *Gopherus agassizii*. Image source: Wikipedia

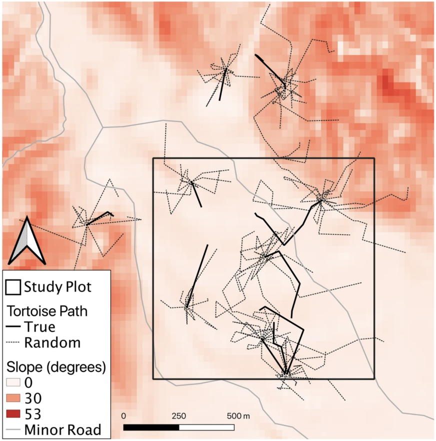
Figure 2: *Gopherus agassizii*. Image source: Wikipedia

- The authors integrate ecology and genetics to identify and maintain ecological corridors for the species *G. agassizzi*
- The aim is to identify regions of the landscape that serve to maintain or facilitate functional connections between populations of organisms through areas of inhospitable landscape
- Usage and integration of different data types:
  - Telemetry
  - Opportunistic and designed sampling schemes
  - GPS
  - Raster data



Map of study area in the Ivanpah Valley area on the Nevada/California border, USA. Shown are study plots, anthropogenic disturbances (urban areas, utility scale solar, golf course), transportation infrastructure (highways, minor roads, railroads), and mitigation corridors (white hatched areas) overlaid on a Mojave desert tortoise habitat suitability model from Nussear and Simandle 2020. Site codes (White text above study plots): MC (McCullough Pass), SH (Sheep Mountain), SS (Silverstate), SL (Stateline Pass), IN (ISEGS North), MV (Mesquite Valley), NI (Nipton), EL (Eldorado Valley), IS (ISEGS South), SP (Southpah)

Figure 3: After Hromada et al. (2020)



Example of true and random tortoise paths in the Stateline Pass study plot, San Bernardino County, CA. For each true tortoise path ten random correlated walks were generated and overlaid on covariates

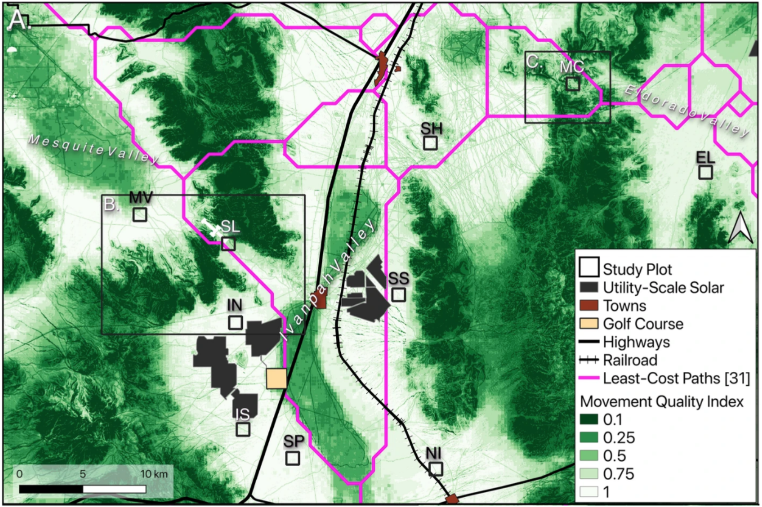


Figure 4: After Hromada et al. (2020)

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Drivers of species distribution

Drivers of species distribution

- Advances in ecological research have contributed to make the study and understanding of the distribution of biodiversity at various spatial and temporal scale a core aspect of macro-ecology and biodiversity research (Guisan, Thuiller, & Zimmermann, 2020)
- Three main condition need to met in order for a species to occupy an area and maintain a viable population:
  1. the species has to reach the site
  2. the abiotic conditions have to be suitable for the species
  3. the biotic environment must be suitable for the species

The abiotic environment

- How does the abiotic environment influence the distribution of organisms?
- What are the different types of environmental influences on species distribution?
- How do multiple variables jointly determine a species geographic distribution?
- Habitat: A description of environmental condition (abiotic and biotic) at a given locality at a particular scale of space and time, where organisms are or could potentially live
- Species can colonize a range of conditions along an environmental gradient, but in most cases the range occupies a small portion of all possible conditions

- The transition from optimal to poor performance in a specific habitat can be a smooth transition or an abrupt transition
- In conifer tree, the cambium activity allowing root growth tend to stop rather abruptly below ca. 7°C at 10cm below ground (Körner, 2021)
- Smoother transitions occur when the gradient has a linear effect on some metabolic rate, progressively lowering individual fitness
- All important variables should be considered jointly in an analysis in order to define what is known as the environmental niche of a species

- When considered jointly, the physiological responses of a given species to several environmental variables define a multidimensional volume called a species fundamental environmental niche
- For plants, the axes of the fundamental niche may typically be resource variable related to light, heat, water and nutrient variability (Guisan et al., 2020)
- If we could estimate the species fundamental niche we would be able to make predictions about where the species could live and thrive

- In practice, measuring the fundamental niche based on field observation is practically impossible as interactions with other species should be factored in
- The response of species in nature is modified by the presence of other species within the same group or across groups combined with the effects of the changing environment.These effects constrint the fundamental niche to what is known as the realized niche
- Sometimes is not possible to measure and map the variables that actually have a measurable effect on species distribution

Movement pattern analysis

Movement pattern analysis

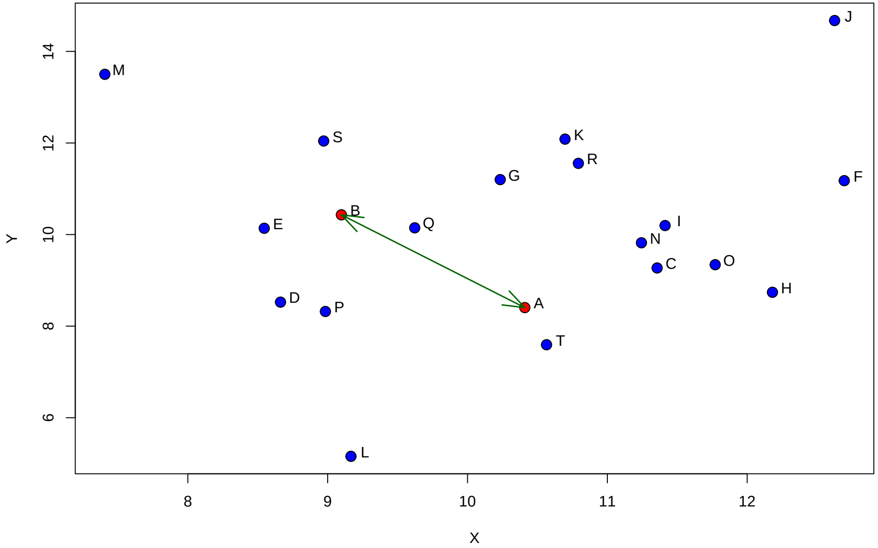
- Azimuth and turning angles:
  - direction of travel, directionality of movement, and relation to speed
  - recommended to exclude stationary segments from analysis
- Net square displacement (NSD):
  - quantifies the net squared distance traveled over time compared to an point of reference (calculates distance from each location to the point of reference)
  - point of reference (nest, den, colony) needed. If there is no point of reference, or animal is nomadic, use e.g. FPT

- First Time Passage (FTP)
  - calculates the time it takes to cross a circle of a given radius, i.e. time the animal spends in a given area at a certain spatial scale (”draws” circle around each point and calculates how long it takes to leave the circle)
  - the variance of log(fpt) can inform about the scales at which processes are likely to be changing
  - the slopes of the log(meanFPT) ∼ log(radii), can indicate the type of movement at each scale. Flatter slopes indicate more directional movement, steeper slopes more brownian movement

Excercises

Something simple

```r
set.seed(50821)
x <- rnorm(20, 10, 2)
y <- rnorm(20, 10, 2)
df_points <- data.frame(x = x, y = y)
pts_nms <- LETTERS[1:20]
plot(df_points$x, df_points$y, pch = 21, cex = 1.5,
     bg = ifelse(pts_nms == "A" | pts_nms == "B",
                 "red", "blue"),xlab = "X",
     ylab = "Y")
text(x = df_points$x + 0.1, y = df_points$y + 0.1,
     labels = pts_nms)
arrows(df_points$x[1], df_points$y[1], df_points$x[2],
df_points$y[2], code = 3, angle = 20, col = "darkgreen",
lwd = 1.5)
```


J
M
S
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H
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P
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T
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14
12
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6
Y
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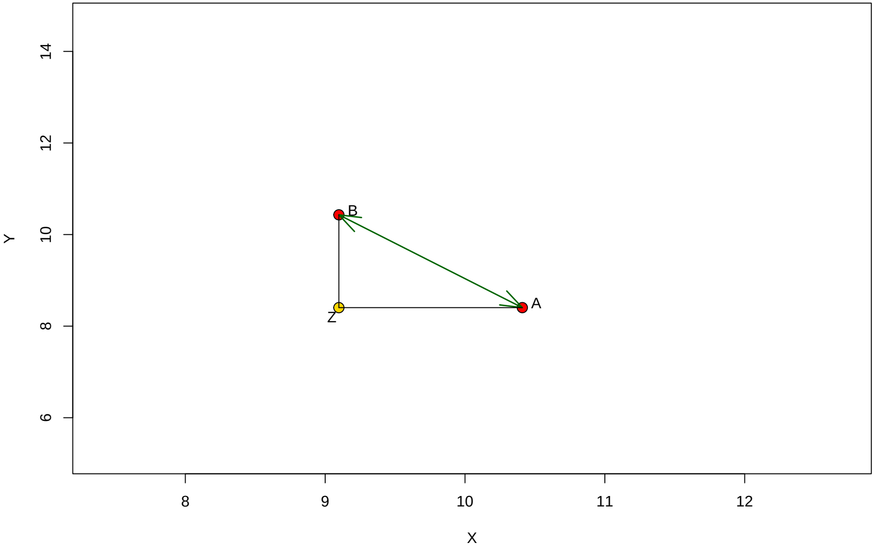
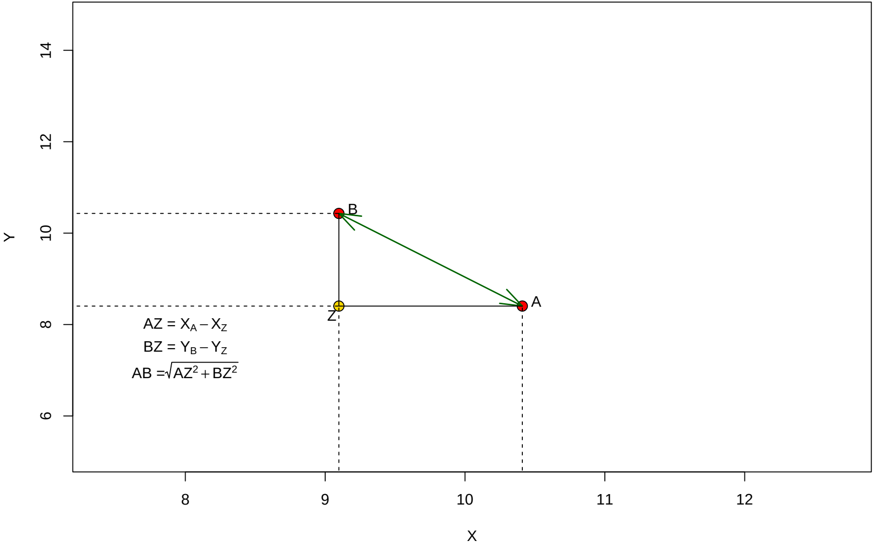
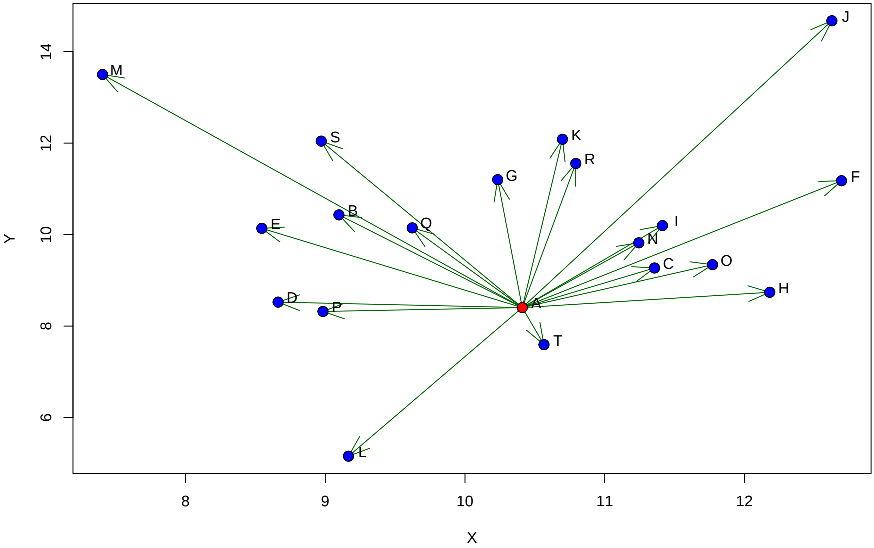
9
10
11
12
X



B
A
Z
14
12
10
8
6
Y
8
9
10
11
12
X


B
A
Z
$AZ = X_A - X_Z$
$BZ = Y_B - Y_Z$
$AB = \sqrt{AZ^2 + BZ^2}$
14
12
10
8
6
Y
8
9
10
11
12
X


Y
14
12
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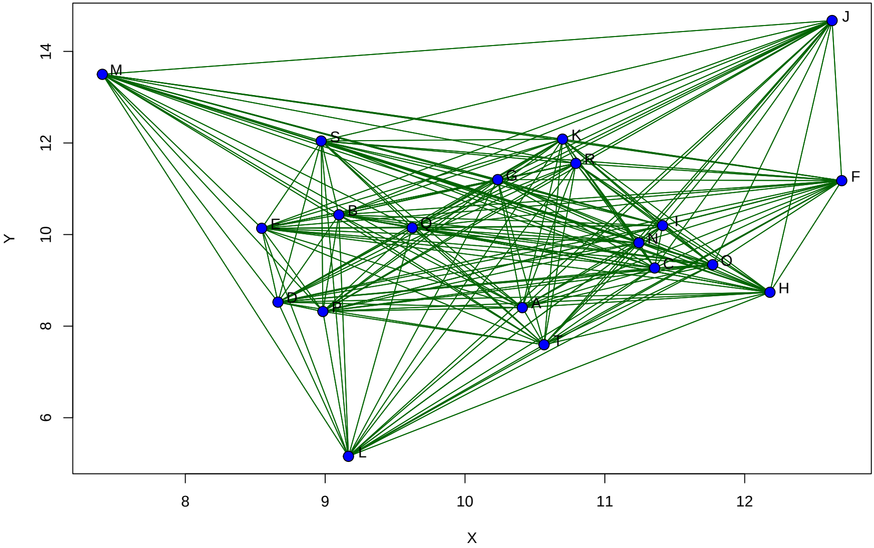
D
P
A
T
L

```r
euc_dist <- function(df_points){
  dist_mtx <- matrix(nrow = nrow(df_points), ncol = 1)
  rownames(dist_mtx) <- LETTERS[1:20]
  colnames(dist_mtx) <- LETTERS[1]

  for(i in 1:nrow(df_points)){
    dist_mtx[i,1] <-
      sqrt((df_points[i,1] -
              df_points[1,1])^2 +
             (df_points[i,2]-df_points[1,2])^2)
  }
  return(dist_mtx)
}

euc_dist(df_points)
```

	A
A	0.000000
B	2.414167
C	1.282681
D	1.751160
E	2.544453
F	3.592613
G	2.801517
H	1.802247
I	2.054070
J	6.649383



J
M
S
K
R
G
F
B
E
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I
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D
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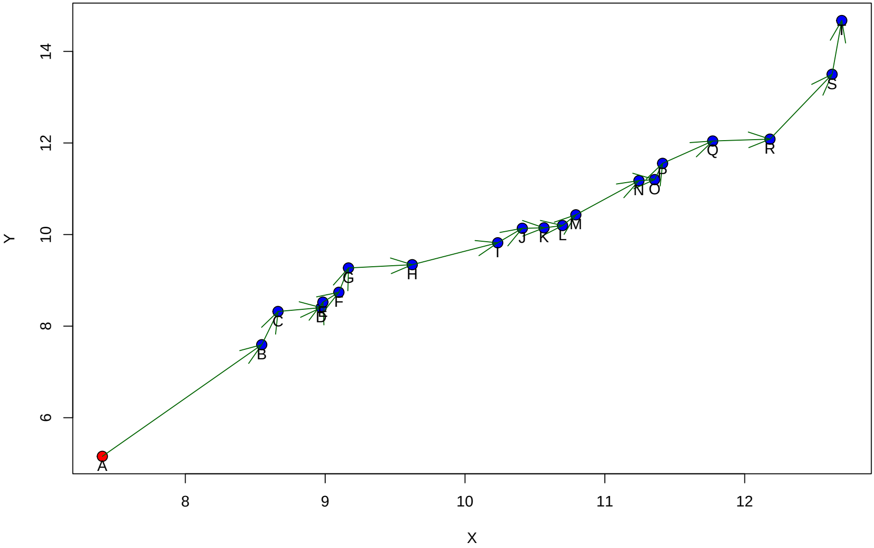
T
L
14
12
10
8
6
Y
8
9
10
11
12
X

	A	B	C	D	E	F
A	0.000000	2.4141666	1.2826811	1.751160	2.5444525	3.592613
B	2.414167	0.0000000	2.5388500	1.955946	0.6252556	3.672660
C	1.282681	2.5388500	0.0000000	2.794740	2.9403092	2.329524
D	1.751160	1.9559462	2.7947398	0.000000	1.6169204	4.826038
E	2.544453	0.6252556	2.9403092	1.616920	0.0000000	4.276272
F	3.592613	3.6726595	2.3295243	4.826038	4.2762723	0.000000
G	2.801517	1.3718953	2.2324902	3.103333	1.9947632	2.460264
H	1.802247	3.5161964	0.9806848	3.524455	3.8936970	2.491238
I	2.054070	2.3266417	0.9282625	3.218867	2.8671848	1.613286
J	6.649383	5.5174180	5.5505464	7.315697	6.1009107	3.497288
K	3.690800	2.3000563	2.8896266	4.100266	2.9014825	2.192833
L	3.477481	5.2747974	4.6600109	3.404943	5.0186601	6.977837
M	5.914324	3.5037243	5.7864689	5.131440	3.5504843	5.774936
N	1.643442	2.2308794	0.5614954	2.888260	2.7159267	1.986021
O	1.653084	2.8864797	0.4213270	3.214264	3.3214075	2.054179



A
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Q
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S
T
X
Y
8
9
10
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12
6
8
10
12
14

	D_b_P	CD_b_P
1	2.6906061	2.690606
2	0.7349518	3.425558
3	0.3201418	3.745700
4	0.1204112	3.866111
5	0.2437853	4.109896
6	0.5352549	4.645151
7	0.4615268	5.106678
8	0.7763202	5.882998
9	0.3619635	6.244962
10	0.1556230	6.400585
11	0.1414979	6.542082
12	0.2528249	6.794907
13	0.8718972	7.666805
14	0.1146396	7.781444
15	0.3590293	8.140473

Creating a Simple Feature object from scratch

```r
my_point_sfg1 = st_point(c(1, 5))
my_point_sfg2 = st_point(c(3, 3))
my_point_sfc = st_sfc(my_point_sfg1,
                      my_point_sfg2, crs = 4326)
my_df = data.frame(name = c("first", "second"))
my_point_sf = st_sf(my_df, geometry = my_point_sfc)
my_point_sf
```

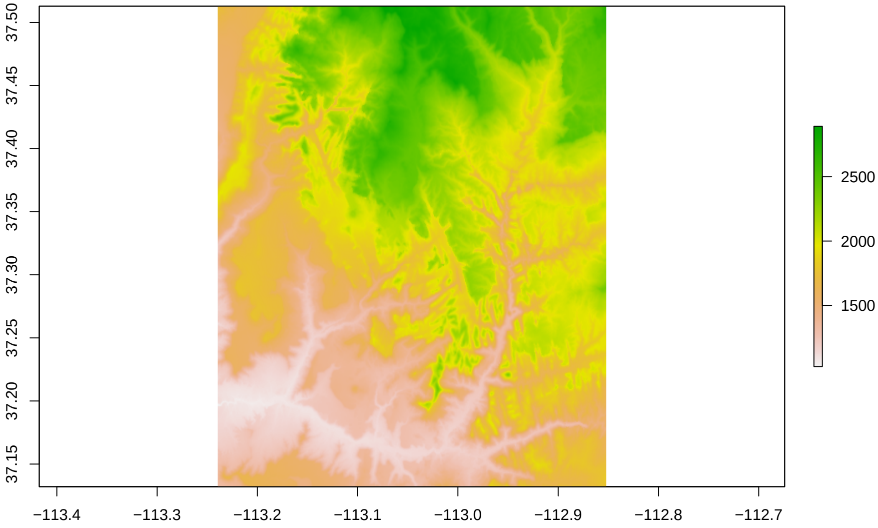
```
Simple feature collection with 2 features and 1 field
Geometry type: POINT
Dimension:     XY
Bounding box:  xmin: 1 ymin: 3 xmax: 3 ymax: 5
Geodetic CRS:  WGS 84
    name    geometry
1  first POINT (1 5)
2 second POINT (3 3)
```

Raster objects

```
# shuttle radar topography mission
raster_filepath = system.file("raster/srtm.tif",
                              package = "spDataLarge")
new_raster = raster(raster_filepath)
new_raster
```

```
class       : RasterLayer
dimensions  : 457, 465, 212505  (nrow, ncol, ncell)
resolution  : 0.0008333333, 0.0008333333  (x, y)
extent      : -113.2396, -112.8521, 37.13208, 37.51292  (xmin,
crs         : +proj=longlat +datum=WGS84 +no_defs
source      : srtm.tif
names       : srtm
values      : 1024, 2892  (min, max)
```

```r
plot(new_raster)
```

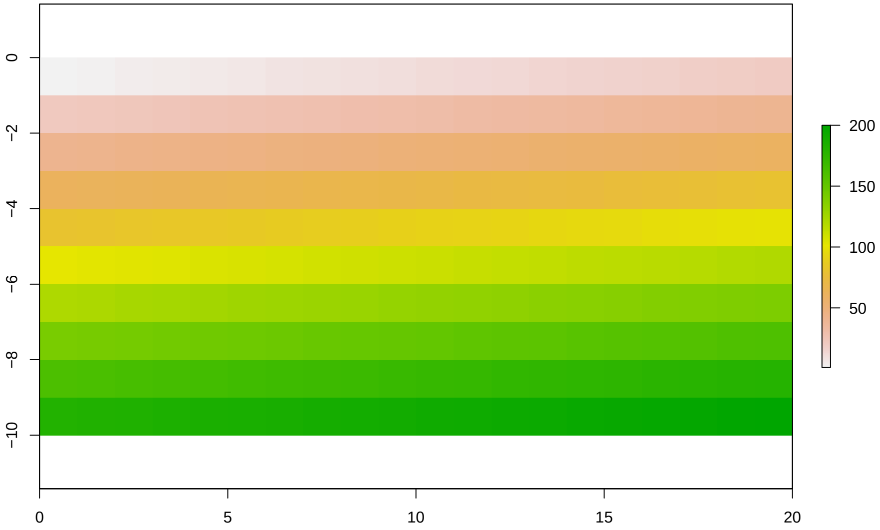


Creating a raster from scratch

```
# create raster
my_raster = raster(nrows = 10, ncols = 20,
                   xmn = 0, xmx = 20, ymn = -10, ymx = 0,
                   crs = "+init=epsg:4326",
                   vals = 1:200)
my_raster
```

```
class       : RasterLayer
dimensions  : 10, 20, 200  (nrow, ncol, ncell)
resolution  : 1, 1  (x, y)
extent      : 0, 20, -10, 0  (xmin, xmax, ymin, ymax)
crs         : +proj=longlat +datum=WGS84 +no_defs
source      : memory
names       : layer
values      : 1, 200  (min, max)
```

```
plot(my_raster)
```

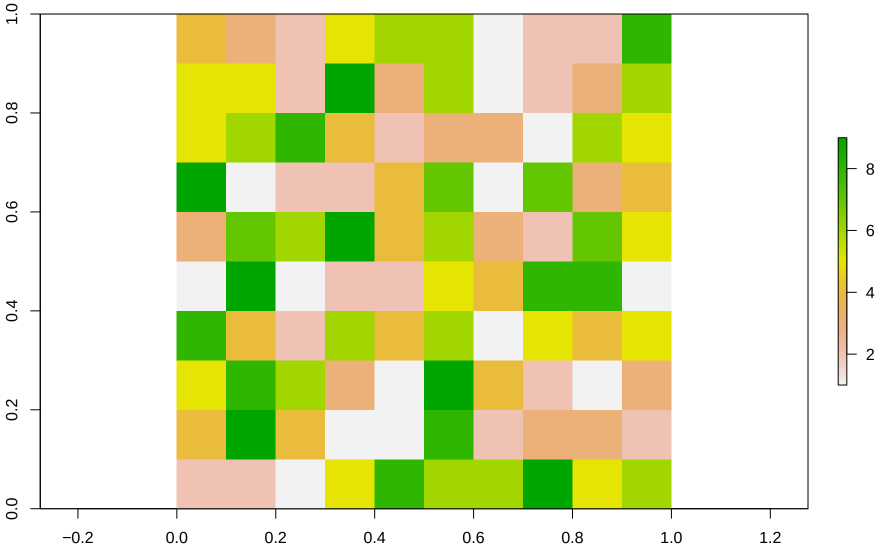


Creating a raster from scratch

```r
r = raster(matrix(sample(1:9, 100, replace = TRUE), 10, 10))
r
```

```
class       : RasterLayer
dimensions  : 10, 10, 100  (nrow, ncol, ncell)
resolution  : 0.1, 0.1  (x, y)
extent      : 0, 1, 0, 1  (xmin, xmax, ymin, ymax)
crs         : NA
source      : memory
names       : layer
values      : 1, 9  (min, max)
```

```
plot(r)
```



Install libraries

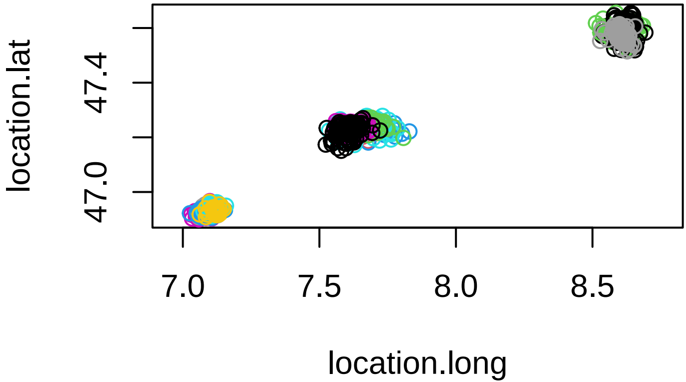
```r
install.packages("move2")
install.packages("mapdata")
install.packages("scales")
install.packages("ggmap")
install.packages("mapproj")
install.packages("ggsn")
# or devtools::install_github('oswaldosantos/ggsn')
install.packages("lubridate")
install.packages("circular")
install.packages("adehabitatLT")
```

Load libraries

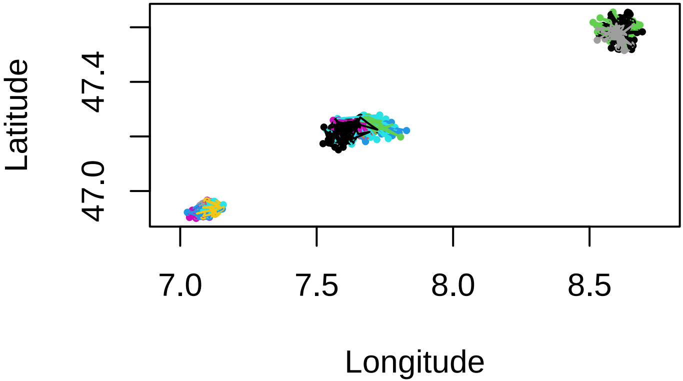
```r
library(move2)
library(dplyr)
library(sf)
library(readr)
library(mapdata)
library(scales)
library(ggmap)
library(mapproj)
library(ggsn)
library(lubridate)
library(circular)
library(adehabitatLT)
```

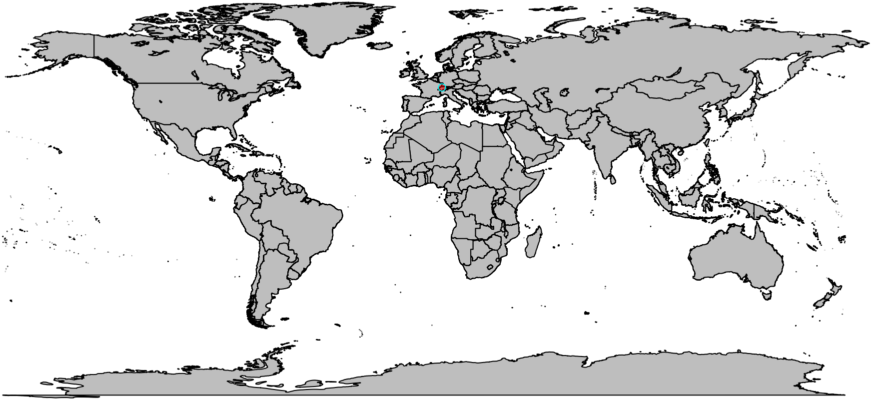
```
Formal class 'MoveStack' [package "move"] with 17 slots
  ..@ trackId                 : Factor w/ 17 levels "X21","X42"
  ..@ timestamps              : POSIXct[1:1740], format: "2002-
06-02 22:55:11" "2002-06-02 23:04:30" ...
  ..@ idData                  :'data.frame': 17 obs. of  7 vari
  .. ..$ visible                          : Factor w/ 1 level "t
  .. ..$ manually.marked.outlier          : logi [1:17] NA NA NA
  .. ..$ sensor.type                      : Factor w/ 1 level "r
transmitter": 1 1 1 1 1 1 1 1 1 1 ...
  .. ..$ individual.taxon.canonical.name: Factor w/ 1 level "V
  .. ..$ tag.local.identifier             : Factor w/ 17 levels
  .. ..$ individual.local.identifier      : Factor w/ 17 levels
  .. ..$ study.name                       : Factor w/ 1 level "P
colored bat Safi Switzerland": 1 1 1 1 1 1 1 1 1 1 ...
  ..@ sensor                  : Factor w/ 1 level "radio-
transmitter": 1 1 1 1 1 1 1 1 1 1 ...
  ..@ data                    :'data.frame': 1740 obs. of  2 va
  .. ..$ event.id : int [1:1740] 16309975 16309976 16309877 16
  .. ..$ timestamp: POSIXct[1:1740], format: "2002-06-
```

```r
plot(bat_1918503)
```

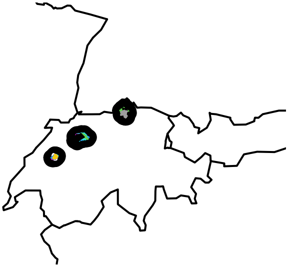


```r
plot(bat_1918503, xlab="Longitude",
     ylab="Latitude", type="b", pch=16, cex=0.5)
```





```r
e<-bbox(extent(bat_1918503)*5)
map('worldHires', xlim = e[1, ], ylim = e[2, ])
points(bat_1918503)
lines(bat_1918503)
```



References

References I

Guisan, A., Thuiller, W., & Zimmermann, N. E. (2020). *Habitat Suitability and Distribution Models (With Applications in R)*. Ecology, biodiversity and conservation (p. 462). Cambridge, United Kingdom: Cambridge University Press.

Hromada, S. J., Esque, T. C., Vandergast, A. G., Dutcher, K. E., Mitchell, C. I., Gray, M. E., Chang, T., et al. (2020). Using movement to inform conservation corridor design for mojave desert tortoise. *Movement Ecology*, *8*(1). Springer Science; Business Media LLC. Retrieved from https://doi.org/10.1186%2Fs40462-020-00224-8

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