FONDAZIONE EDMUND MACH

IRSAE International Research School in Applied Ecology

NINA HSN

San Michele all'Adige, 18-22 June 2018

Dealing with Spatio-temporal Data in Movement and Population Ecology

Introduction to Spatial Objects in Animal Ecology

F. Cagnacci, Fondazione Edmund Mach, Italy

ANIMAL ECOLOGY → SPATIAL ECOLOGY

Ecology is fundamentally spatial, with ecological processes occurring on heterogeneous landscapes.

Modelling **animal movement and distribution** is basic for all questions in animal ecology (how and why animals use specific resources, how and why animals interact with conspecifics, and how and why they compete and reproduce).

Movement is the glue that ties ecological processes together.

Movement is the point of contact between **ecology and evolution**.

(Turchin 1998; Nathan et al. 2008, PNAS; Cagnacci et al. 2010, PTRSB)

F. Cagnacci, Fondazione Edmund Mach, Italy

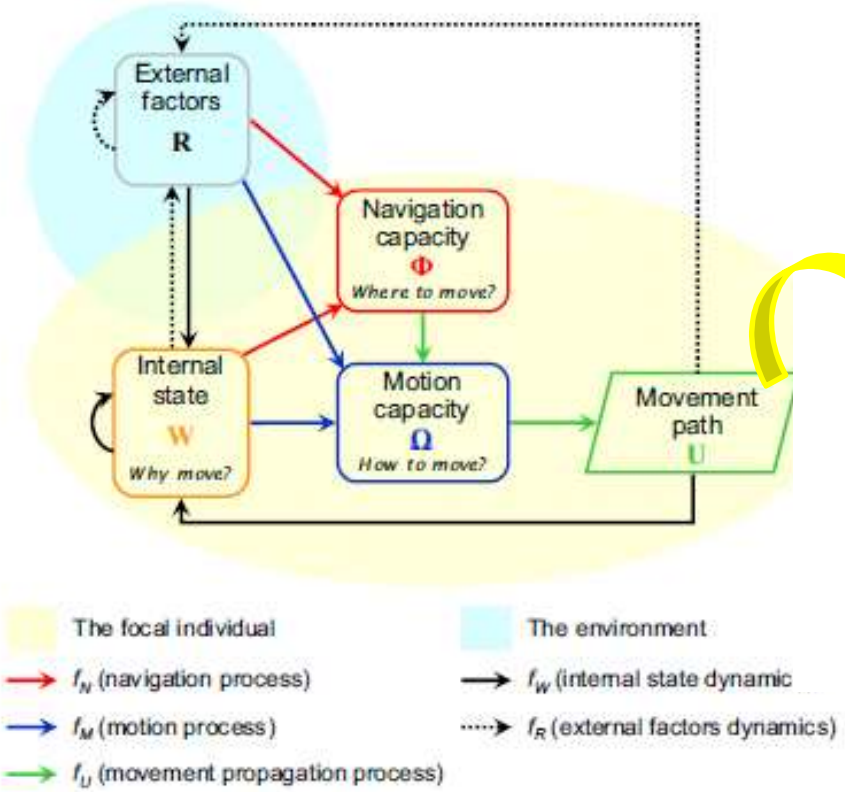
ANIMAL SPATIAL ECOLOGY WORKFLOW: QUESTIONS FIRST!!

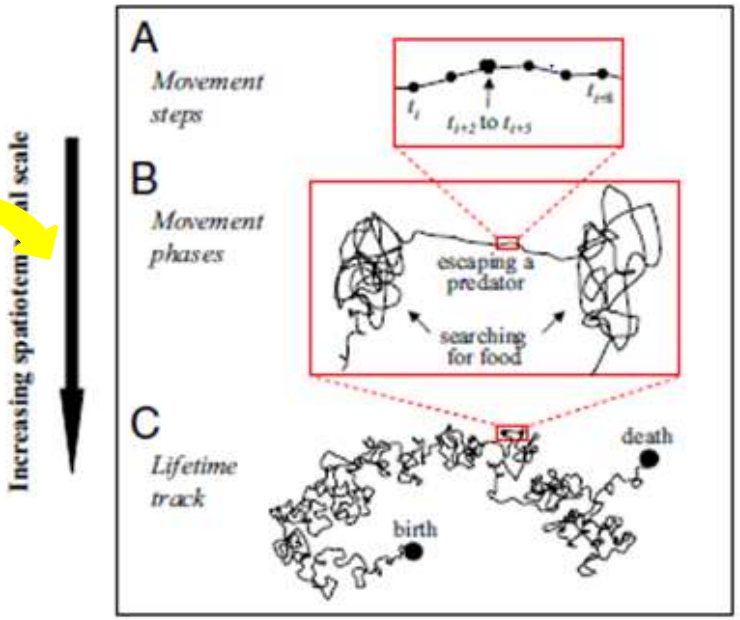
ANIMAL SPATIAL ECOLOGY WORKFLOW (2): REFERENCE SAMPLE OF INDIVIDUALLY MARKED ANIMALS

Individual marking of a representative sample of animal populations by tracking devices.

Individuals should normally be the sample unit (need to account for individual heterogeneity)

THE MOVEMENT ECOLOGY PARADIGM





From Nathan et al. 2008

MOVEMENT ECOLOGY→WILDLIFE TRACKING

Animal positions provide the elemental unit of movement paths and show where individuals interact with the ecosystems around them.

Cagnacci et al. 2010

Animal positions are *measured*
Movement ecology modelling is based on animal positions
Movement ecology questions need animal positions to be answered….

WILDLIFE TRACKING → THE HI-TECH REVOLUTION


Courtesy M. Hebblwhite


Courtesy S. Nicoloso


Courtesy J. Matthiopoulos


Courtesy J. Odden

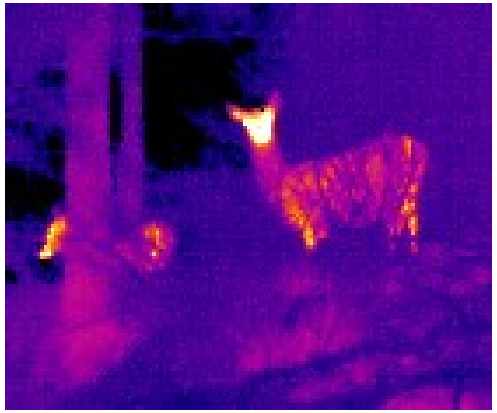
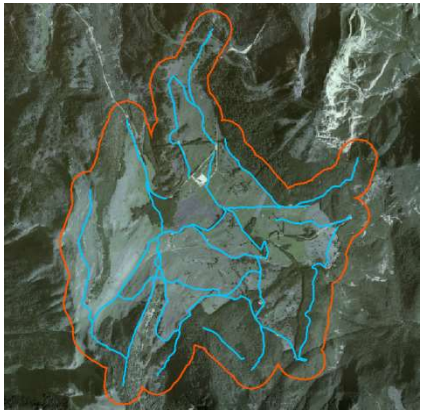
ANIMAL SPATIAL ECOLOGY WORKFLOW WORKFLOW (3): POPULATION LEVEL INFORMATION

Population parameters (density, reproduction, survival)

Marked animals are of aid: CMR/Mark-Resight, Survival models

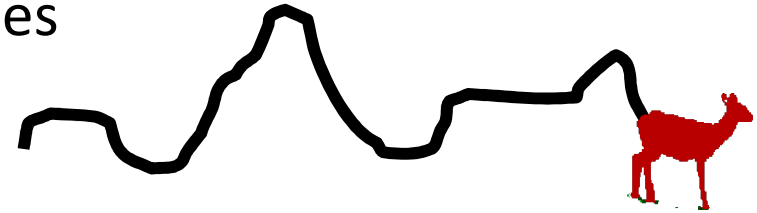
Ancillary landscape level (or population/study site) data - depending on questions (hunting bag/season, human disturbance-road traffic, tourism)



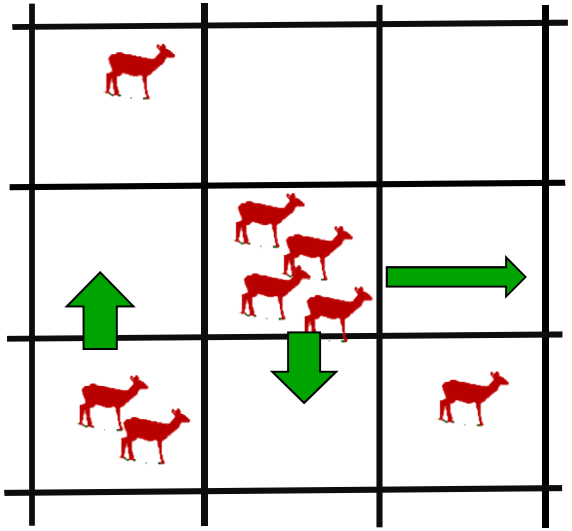



CURIOSA. L'orsa Juka guarda all'impiedi e, sopra, la distanza tra la saggiolla e l'orsa


Lagrangian: analysis of individual movement trajectories



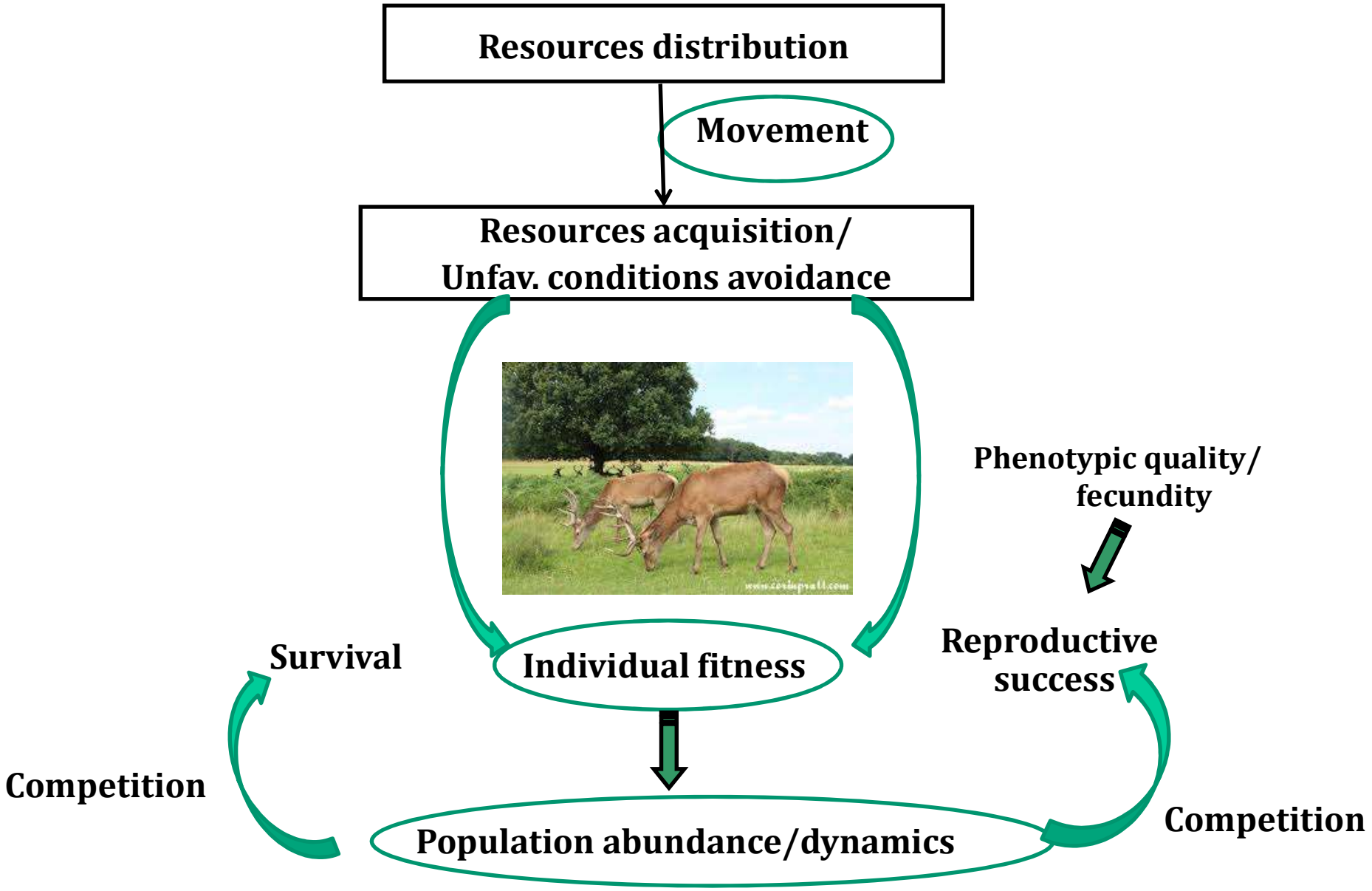
Eulerian: expected pattern of space use by an individual or a population over static landscapes (e.g., habitat occupancy modelling)



Mechanistic understanding: process of individual movement

← →

patterns of space use


Resources distribution
Movement
Resources acquisition/
Unfav. conditions avoidance
Phenotypic quality/
fecundity
Survival
Individual fitness
Reproductive
success
Competition
Population abundance/dynamics
Competition

ANIMAL SPATIAL ECOLOGY WORKFLOW (4): ENVIRONMENTAL DATA (EXTERNAL FACTORS)

Bio-telemetry/population data: state variables of individuals & phenomena …

…to be matched with robust environmental and climatic datasets (sensor deployments, remote sensing)→ weather metrics, habitat distribution, fragmentation, landscape diversity-vs biodiversity

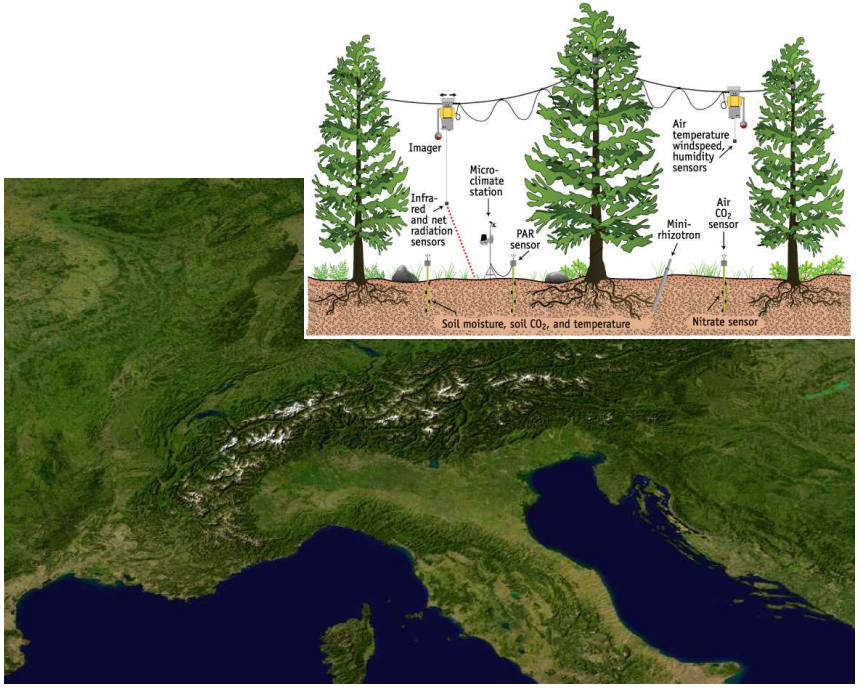


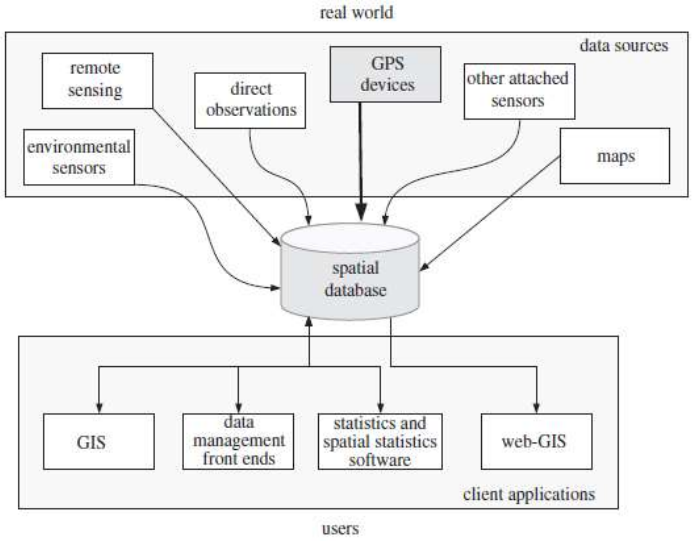
Table 1. List of ecological indicators from selected data sources.

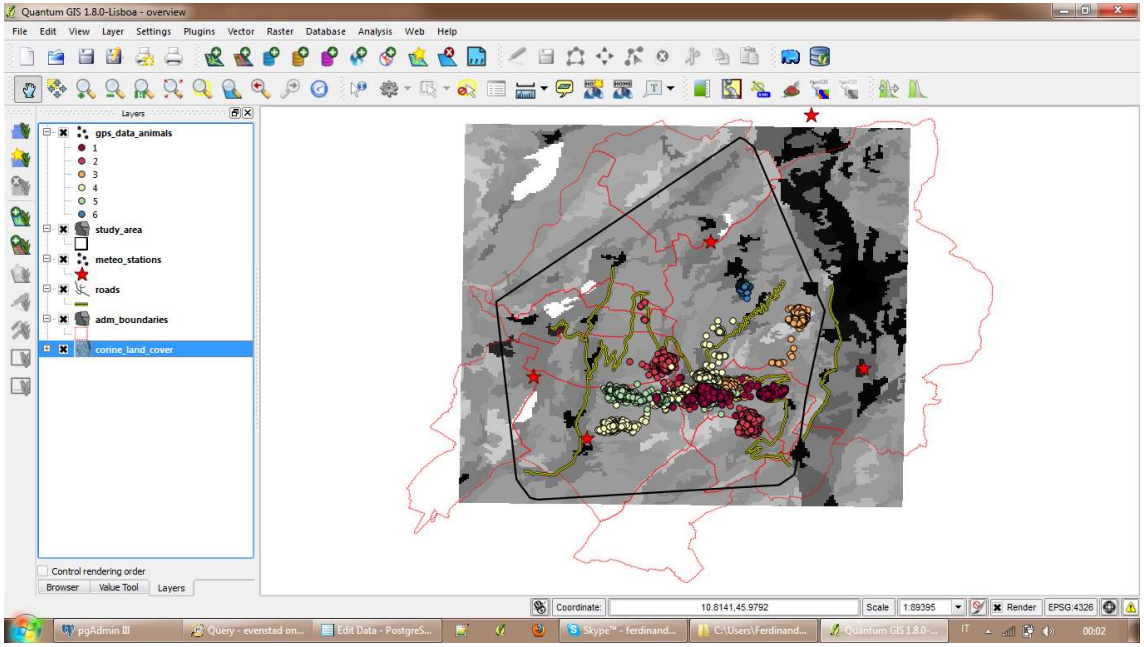
ecological indicator	generated from	dataset source
daily/monthly/annual minimum, mean, maximum temperatures (°C), trends, growing degree days	MODIS land surface temperature (LST): land surface temperatures, 4 maps per day, spatial resolution 1 km, period 2000–today	NASA EOS, USA, https://wist.echo.nasa.gov (free of charge)
phenological status, duration of growing season	MODIS vegetation indices (NDVI/EVI): 1 map per 16 days, spatial resolution 250 m, period 2000–today; SPOT Vegetation VGT, 1 map per 10 days, spatial resolution 1 km, period 1998–today	NASA EOS, USA, https://wist.echo.nasa.gov; VITO Belgium, http://www.vgt.vito.be (free of charge)
snow extent	MODIS maximum snow extent: 1 map per 8 days, spatial resolution 500 m, period 2000–today	NASA EOS, USA, https://wist.echo.nasa.gov (free of charge)
daily/monthly/annual actual, mean, total precipitation (mm)	GPCP: worldwide accumulated daily precipitation in millimetres, spatial resolution 1 arc degree, period 1997–2008	NOAA, USA, http://www1.ncdc.noaa.gov/pub/data/gpcp/1dd/data (free of charge)
fraction of absorbed photosynthetically active radiation and leaf area index	MODIS FPAR/LAI: 1 map per 8 days, spatial resolution 1 km, period 2000–today	NASA EOS, USA, https://wist.echo.nasa.gov (free of charge)
gross/net primary production (biomass)	MODIS GPP/NPP: 1 map per 8 days, spatial resolution 1 km, period 2000–today	NASA EOS, USA, https://wist.echo.nasa.gov (free of charge)
land cover/land use maps, derived habitat maps (high-level data processing)	LANDSAT satellite series: spatial resolution 15 m/30 m, period 1972 today; ASTER: spatial resolution 15 m/30 m, period 2000–today	USGS Earth Explorer, http://earthexplorer.usgs.gov (free of charge); NASA EOS, USA, https://wist.echo.nasa.gov (nominal fee)
daily photoperiod, including cast shadows, geomorphological parameters (e.g. slope, aspect, curvature), flow accumulation	digital elevation model (DEM)	SRTM (spatial resolution 90 m), http://www2.jpl.nasa.gov/srtm governmental data at higher resolution (free of charge); ASTER GDEM, http://www.gdem.aster.ersdac.or.jp (free of charge)
habitat structure from 3D vegetation model (high-level data processing)	LiDAR data which permit to separate digital elevation model from digital surface model	governmental data (expensive, except part of US free of charge)

WILDLIFE TRACKING WORKFLOW (5): DATA MANAGEMENT, INCLUDING BIAS ANALYSIS

Good practice data mangement → consistenly and robustly organised.

Full awareness of spatial and geographical implications

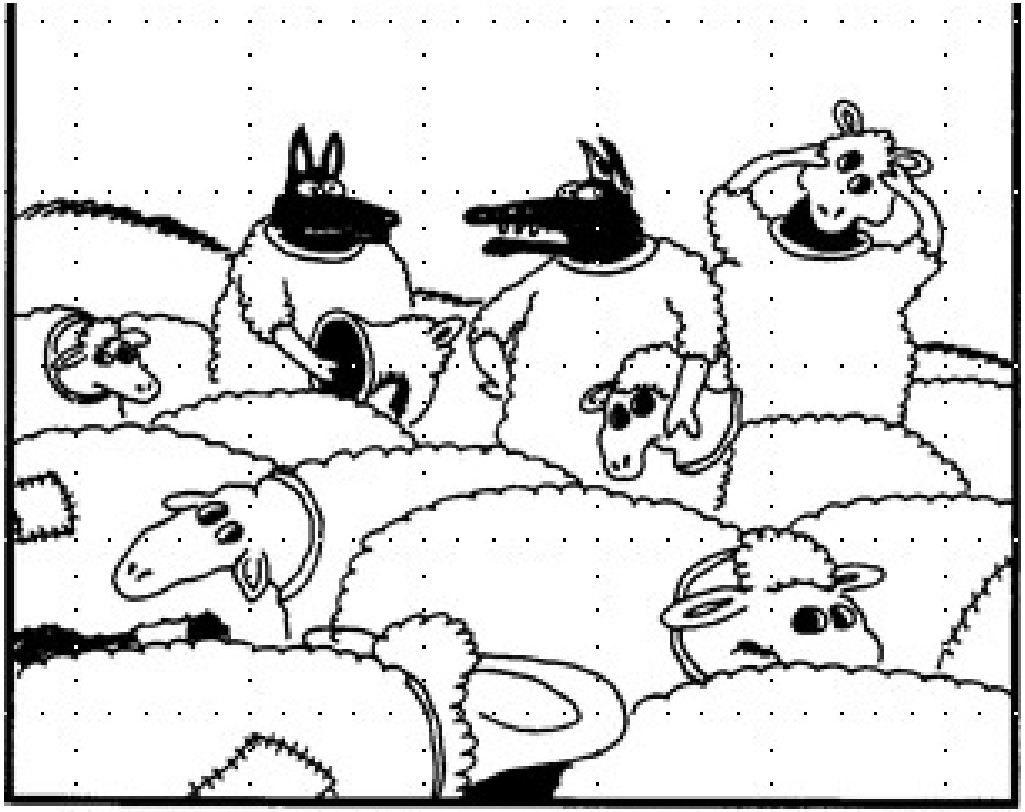




https://github.com/feurbano/data_management_2018

Monday, 18th June	08.30-12.30: Arrivals 12.30-13.30: Lunch 13.30-14.30: Introduction to Spatial Objects in Animal Ecology (Cagnacci) 14.30-15.15: Introduction to Data Management and Spatial Database (Urbano) 15.15-16.00: Installation of PostgreSQL/PostGIS and Connection to the DB (De Groeve) 16.00-18.00: SQL and Spatial SQL (Urbano) 18.00-18.30: Science Happy Hour: Flash talks from students, in presence of experts
Tuesday, 19th June	08.30-12.30: SQL and Spatial SQL (Urbano) 12.30-13.30: Lunch 13.30-14.00: The Ecological Context Built from Satellites (Rocchini) 14.00-18.00: Movement Ecology Data Management with PostgreSQL/PostGIS (Urbano) 18.00-18.30: Science Happy Hour: Flash talks from students, in presence of experts
Wednesday, 20th June	08.30-12.30: Movement Ecology Data Management with PostgreSQL/PostGIS (Urbano) 12.30-13.30: Lunch 13.30-14.00: Dealing with Acceleration Data (Berger) 14.00-16.00: Movement Ecology Data Management with PostgreSQL/PostGIS (Urbano) 16.00-18.00: Movement Ecology Data Analysis with R (Basille) 18.00-18.30: Science Happy Hour: Flash talks from students, in presence of experts
Thursday, 21th June	08.30-12.30: Movement Ecology Data Analysis with R (Basille) 12.30-13.30: Lunch 13.30-14.00: Data Sharing and Data Standards for a Better Science (Davidson) 14.00-18.00: From Population Data to Spatial Modelling (Nilsen) 18.00-18.30: Science Happy Hour: Flash talks from students, in presence of experts
Friday, 22th June	08.30-12.30: Resource Selection Analysis in Movement Ecology (Van Loon) 12.30-13.30: Lunch 13.30-14.00: Science Happy Hour: Flash talks from students, in presence of experts 14.00-15.00: Wrapping up: Take home message and Questions

https://github.com/feurbano/data_management_2018/blob/master/program.md



Thank you…Enjoy the Summer Course!