Split lecture 2: How do we measure biodiversity?

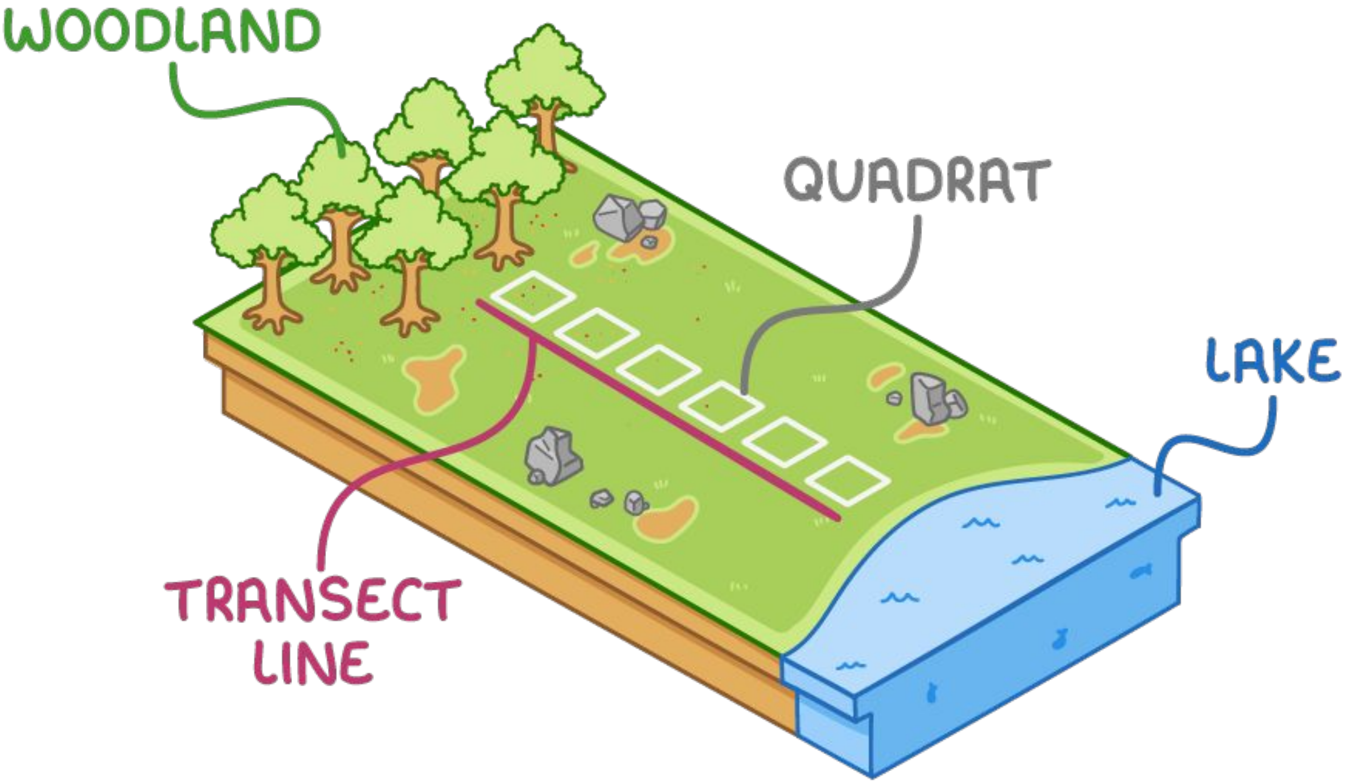
Sara Beery | 3/2/26

Some slides adapted from
Kaitlyn Gaynor and Meredith Palmer

Types of biodiversity data

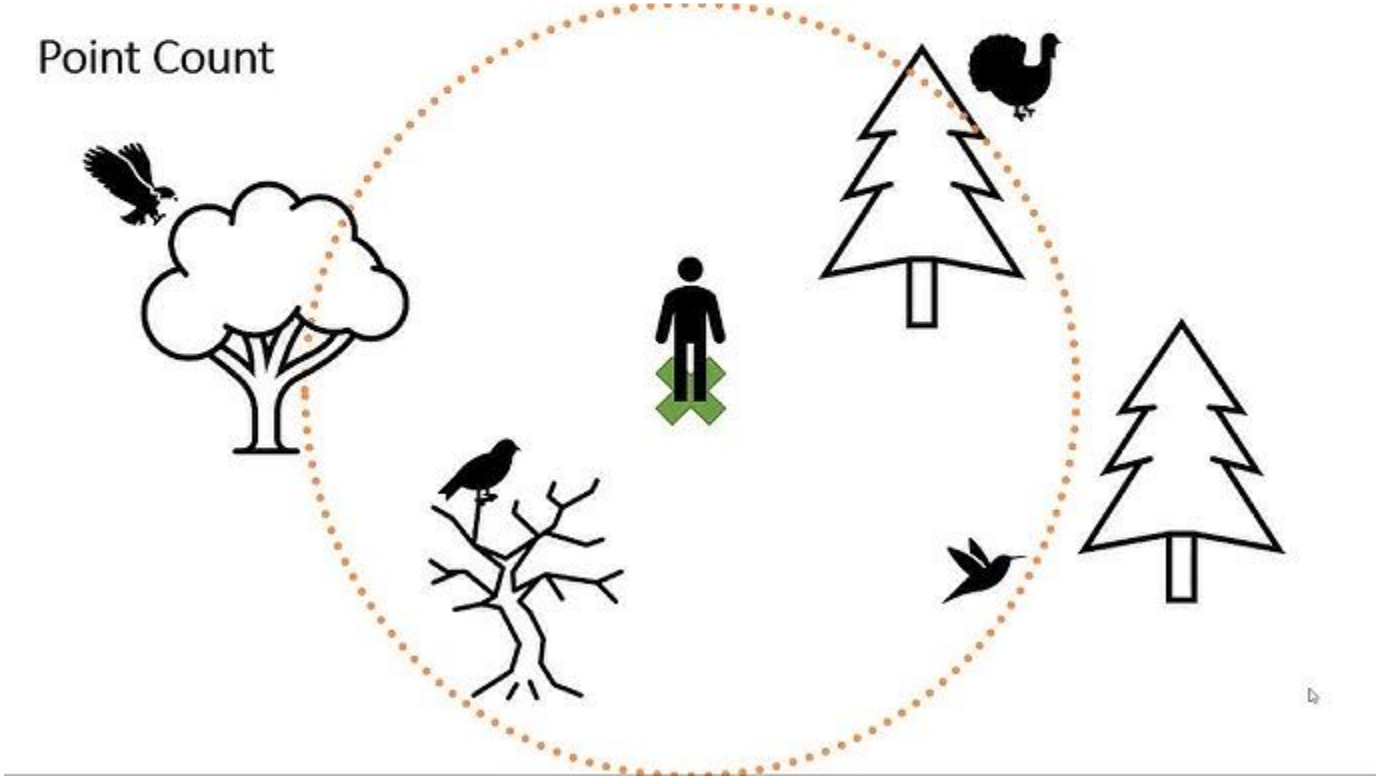
Traditional data

Transects and quadrats

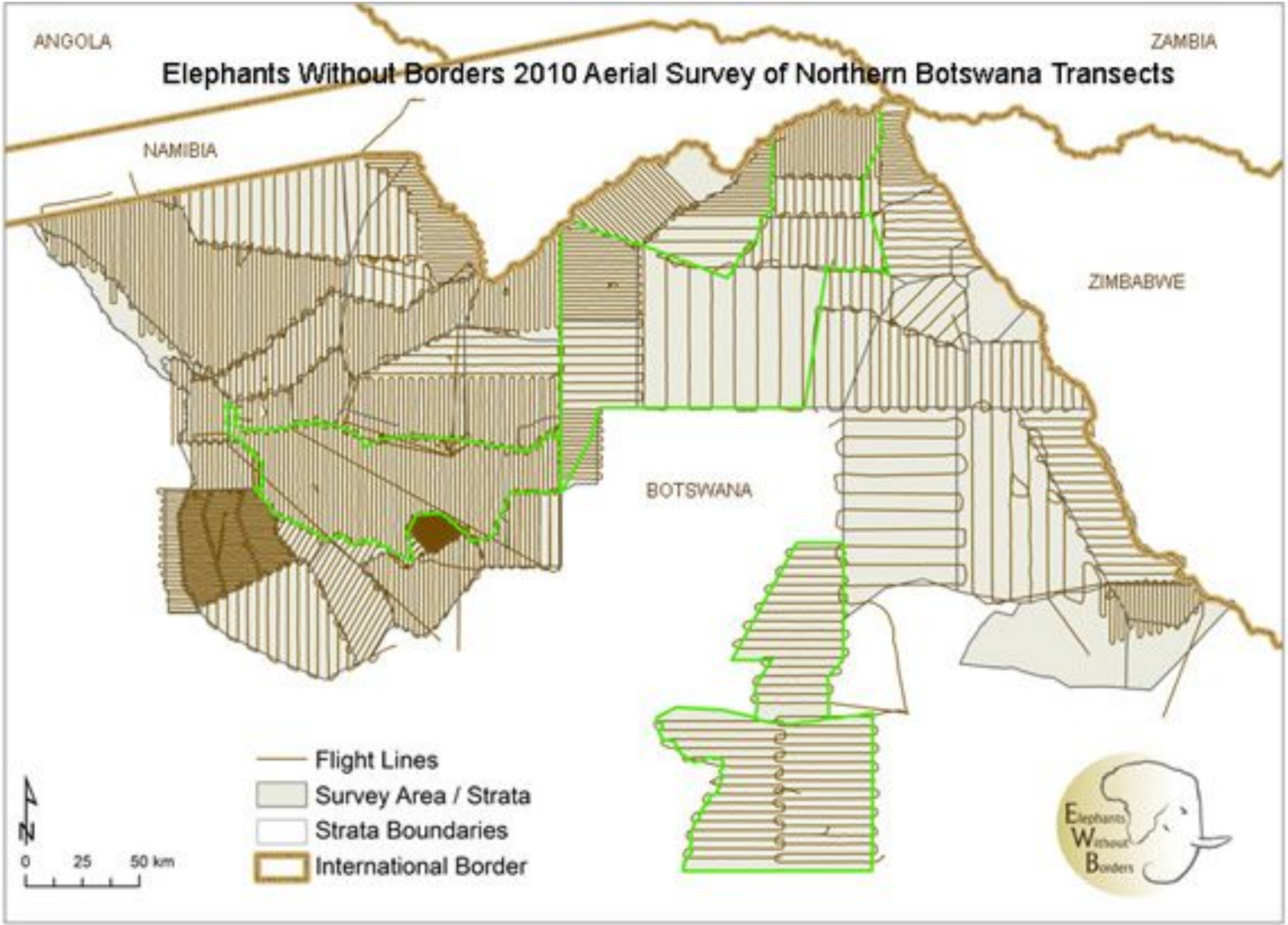


https://classnotes.ng/lesson/vegetation-sampling-techniques-quadrats-line-transects/

Point counts



How to do a point count: https://www.youtube.com/watch?v=5YnkNufKkog



Aerial surveys

https://elephantswithoutborders.org/projects/aerial-surveys/

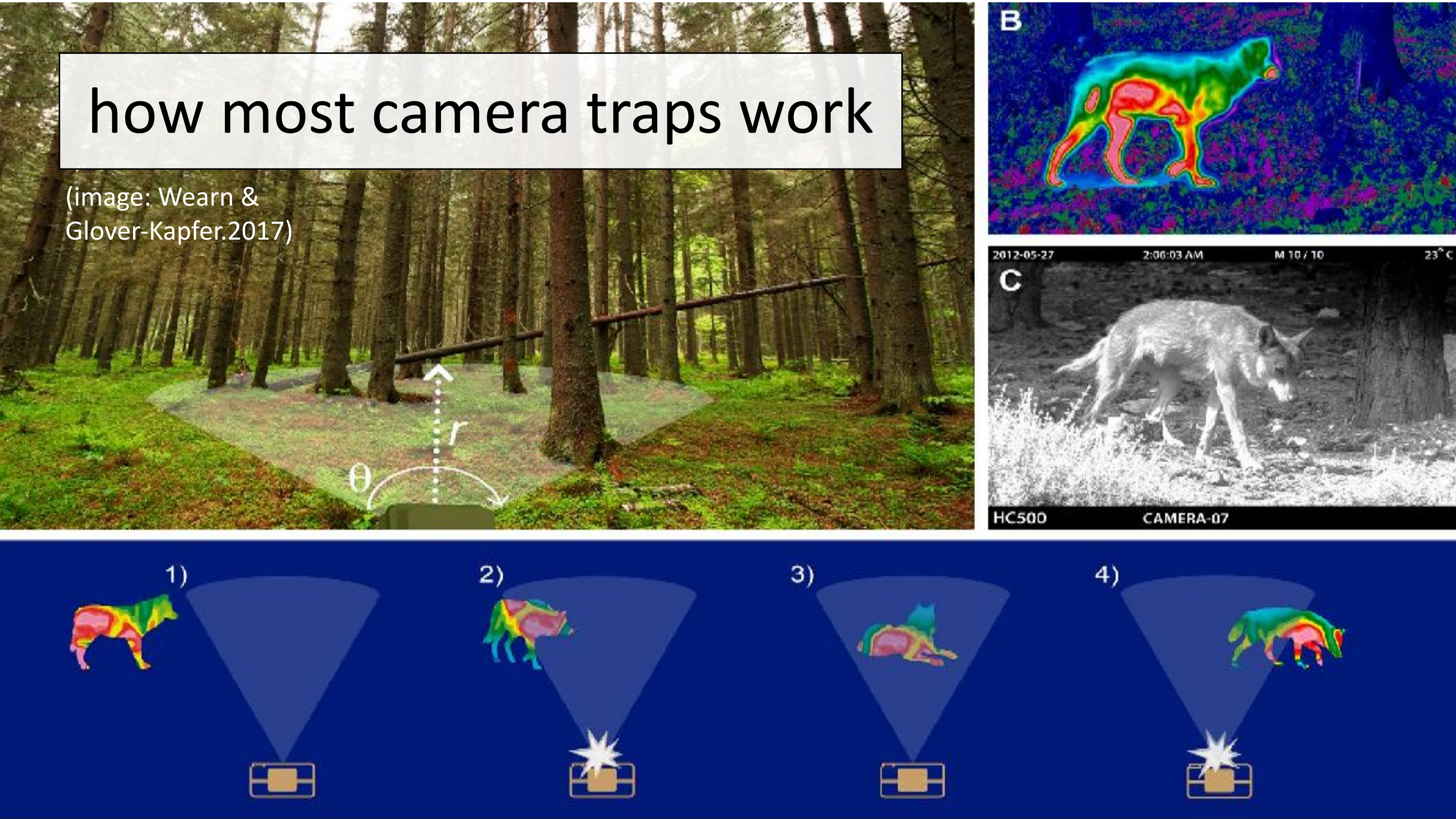
Stationary sensors

Camera traps

- device with a sensor that triggers a camera to take a photograph or video when animal is present
- image or video is used as a piece of scientific information
- easy to use to sample animals remotely without human presence
- relatively inexpensive, becoming less expensive as technology improves

how most camera traps work

(image: Wearn & Glover-Kapfer.2017)



camera trap attributes

- trigger system
- sensor type
- flash
- trigger speed
- recovery time
- detection zone
- sensitivity
- media
- delay

… among others

getting the right camera for the job

- wide variation in cost & features
- consider suitability for survey type and environment
- with research budget, often a compromise between quantity and quality
- https://www.trailcampro.com/pages/camera-traps-for-researchers

expenses

initial start-up

- cameras, cases, locks
- batteries
- SD cards + hard drives
- attachment structures + hardware
- deployment expenses (time, fuel)

maintenance

- checking cameras (time, fuel)
- identifying images (time)
- replacing cameras that fail, are damaged or stolen
- replacing batteries

Item	10' Right	10' Left	20' R	20' L	30' R	30' L	40' R	40' L	50' R	50' L	60' R	60' L	70' R	70' L	80' R	80' L	90' R	90' L	100' R	100' L	110' R	110' L	120' R	120' L	Total Score	Total Triggers	Efficiency Rating
Spypoint Force Dark	4	5	12	13	19	20	28	28	34	35	43	42	46	46	49	40	25	28	14	14	8	10	1	2	566	656	86%
Spypoint Solar Dark	4	5	12	13	20	22	29	29	35	36	41	41	44	44	44	38	16	30	9	15	6	15	0	3	551	637	86%
Spypoint Link S Verizon	2	4	9	10	16	15	24	22	30	27	34	31	35	35	24	21	17	14	4	5	4	7	0	0	390	456	86%
Spypoint Link Dark Verizon	3	4	10	11	16	16	25	23	21	29	34	33	13	36	12	10	15	8	5	5	5	6	0	0	340	416	82%
Spypoint Link Micro ATT	1	1	6	7	13	13	20	18	25	22	31	29	31	30	8	12	8	14	3	6	2	8	0	0	308	384	80%
Bushnell Impulse	2	2	4	5	6	7	9	9	10	11	11	13	12	12	10	10	9	7	2	8	3	2	1	3	168	189	89%
Spypoint Link EVO Verizon	0	0	0	0	0	15	25	23	26	28	8	9	7	6	2	2	1	0	0	0	0	0	0	0	152	164	93%
Browning S.F. Pro XD	6	5	8	8	8	8	8	7	6	5	12	14	9	10	5	7	0	3	0	0	0	0	0	0	129	145	89%
Browning D.O. Apex	4	5	8	7	6	6	5	7	8	8	7	11	9	9	8	7	5	4	0	0	0	0	0	0	124	133	93%
Bushnell Core DS Low Glow	3	2	6	6	6	6	6	5	6	7	7	7	8	9	5	7	7	4	4	5	2	4	0	0	122	142	86%
Browning D.O. Pro XD	5	6	8	8	8	8	6	6	5	6	9	10	9	7	6	7	3	1	0	0	0	0	0	0	118	133	89%
Browning S.F. Pro X	5	5	8	7	7	6	6	6	6	8	11	8	9	9	4	8	1	0	0	0	0	0	0	0	114	124	92%
Browning Spec Ops Advantage	4	3	6	6	8	8	10	9	10	9	8	8	6	6	3	4	2	3	0	0	0	0	0	0	113	137	82%
Bushnell Core DS No Glow	3	2	6	5	7	6	6	5	6	6	7	6	7	7	6	5	8	5	4	2	1	1	0	0	111	136	82%
Bushnell Core No Glow	3	3	4	5	7	7	7	7	6	7	7	6	6	7	7	7	9	5	0	0	0	0	0	0	110	124	89%
Browning Recon Force Adv.	4	3	5	6	7																	0	0	0	109	136	80%
Bushnell Core Low Glow	2	2	4	5	7																	0	0	0	108	120	90%
Moultrie M-8000	1	1	3	3	4																	1	0	0	97	104	93%
Moultrie M-8000i	1	1	2	2	4																	3	0	0	95	102	93%
Browning S.F. Gen5	2	2	3	3	7																	0	0	0	77	104	74%
Reconyx Hyperfire 2	2	2	3	4	5																	0	0	0	75	96	78%
Browning S.F. Apex	6	5	8	6	5																	0	0	0	72	80	90%
Stealth XV4	3	3	6	5	5																	0	0	0	51	70	73%
Moultrie P120i Pano Mode	3	2	5	5	5																	0	0	0	45	47	96%
Moultrie M4000i	1	1	3	2	3																	0	0	0	44	57	77%
Reconyx SC950 4G	2	2	4	4	5																	0	0	0	41	44	93%
Stealth G34 Max	1	1	2	3	3																	0	0	0	36	49	73%
Spypoint Force 20	1	1	1	2	2	3	2	4	2	3	3	3	3	3	1	1	0	0	0	0	0	0	0	0	35	41	85%
Stealth G45NG Max	1	1	1	2	2	3	4	5	4	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	31	49	63%
Cuddeback Cuddelink IR	1	1	2	2	4	3	5	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	40	70%
Stealth DS4K Max	1	1	2	2	3	4	3	3	3	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	27	31	87%
Spartan ATT 4G	1	1	1	1	1	1	2	2	2	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	20	22	91%
Spartan USC 4G	1	1	1	1	1	1	2	2	2	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	20	22	91%
Spartan Verizon 4G	1	1	1	1	1	1	2	2	2	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	20	22	91%
Stealth WXA Wireless	1	1	2	1	1	2	2	2	3	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	20	24	83%
Covert Code Black LTE	1	1	0	0	0	0	1	1	1	1	1	1	2	2	2	2	2	0	0	0	0	0	0	0	18	39	46%
Covert Hollywood	1	1	2	1	2	2	1	2	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	15	19	79%
WGI Silent Crush	1	1	1	1	1	2	1	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	14	100%
Covert Black Maverick	1	1	1	1	2	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	20	70%
WGI Rival	1	1	1	1	1	1	1	1	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	13	13	100%
Spartan Ghost	1	1	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	8	8	78%
Covert E1	1	1	1	0	0	0	0	2	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	8	15	53%

features vary across brands and models

trigger system: non-triggered

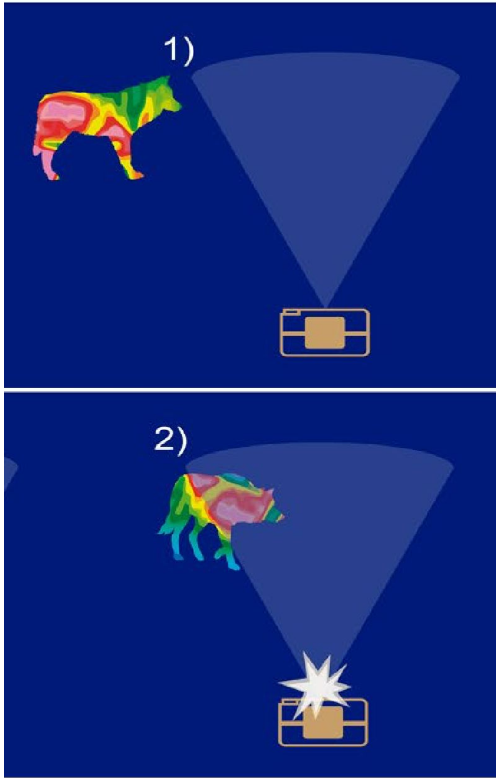
active continuously or time-lapse

- ■ **note absences**
- ○ most appropriate to survey:
  - animals in open spaces
  - in locations that have high visitation rates
  - when a continuous record is required
- ○ generate lots of images, require lot of power

trigger system: triggered

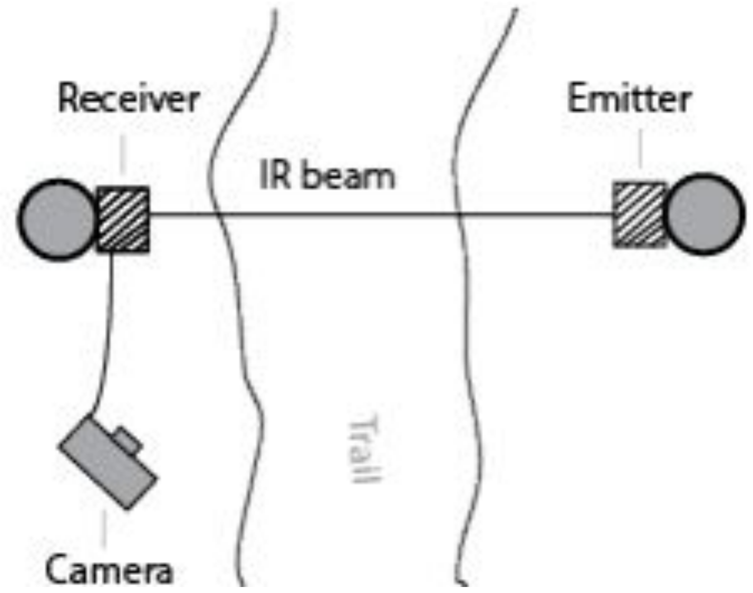
activated when event occurs (animal triggers camera)

- **establish presence**
- most appropriate when:
  - events are infrequently or discontinuous
- infrared sensor cameras most common

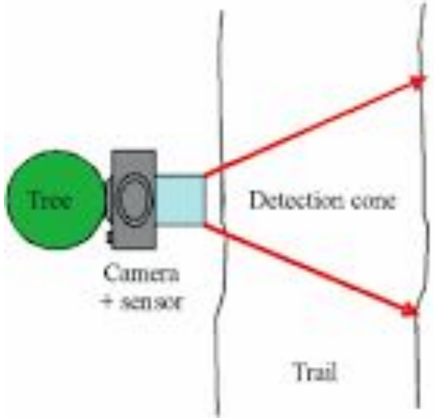


sensor types: active infrared (AIR)

- infrared beam from emitter to receiver
- triggered when animal disrupts beam
- advantages:
  - beam height adjusted to the target anima
  - emitter and receiver are separate, so camera can be placed in optimal position
- disadvantages:
  - expensive, not widely available, infrequently used
  - popular among wildlife photographers



sensor types: **passive infrared (PIR)**



- record infrared signature of detection zone
- animal entering detection zone causes a rapid change in infrared signature, triggering camera
- advantages:
  - camera and sensor are one unit: compact, easy to set up
  - has a wide detection zone
  - cheap, widely available; most commercially available camera traps
- disadvantages:
  - easily fooled by inanimate objects, such as moving veg (”false triggers”)
  - small animals, ectotherms may fail trigger

flash types: **incandescent**

- high-quality color images, little blur
- can be taken in low light conditions
- Xenon or white LED

- advantages:
  - IDing individual markings, distinguishing similar species
  - more attractive than grayscale
- disadvantages:
  - battery drain, longer recovery time before flash can be operational, lower trigger speed, noise
  - change animal natural behavior
  - alert people to camera trap presence

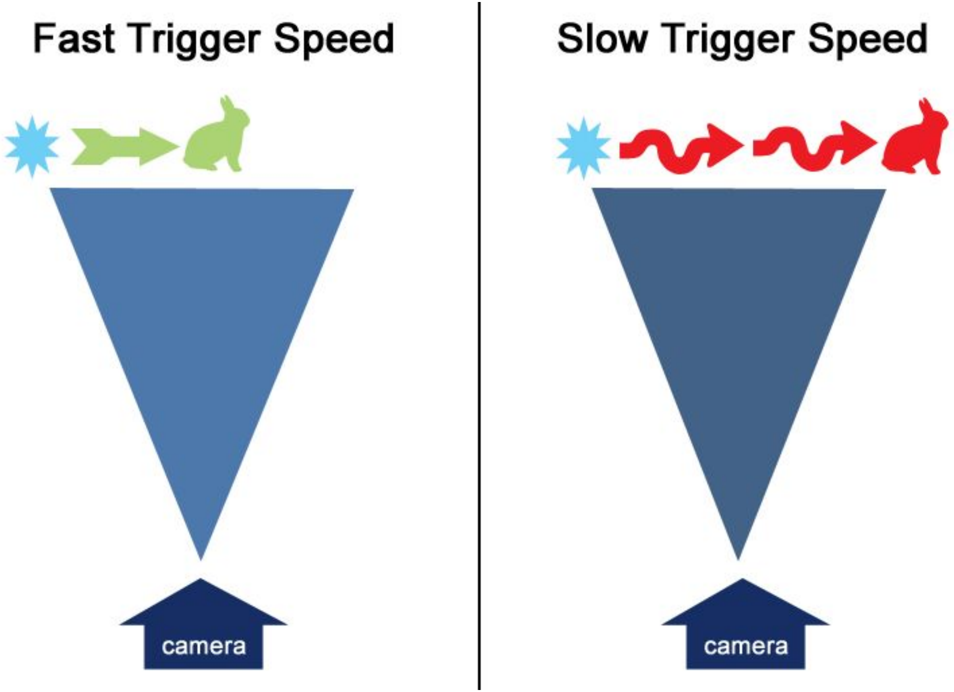
flash types: **infrared**

- bounces infrared off animals in order to illuminate scene
- color during day, grayscale images at night
- IR LEDs
- advantages:
  - invisible to most wildlife, less obtrusive
  - consume less power
  - faster trigger times, can be used for video at night
- disadvantages:
  - blurry low-quality night images esp. if fast-moving animal

trigger speed

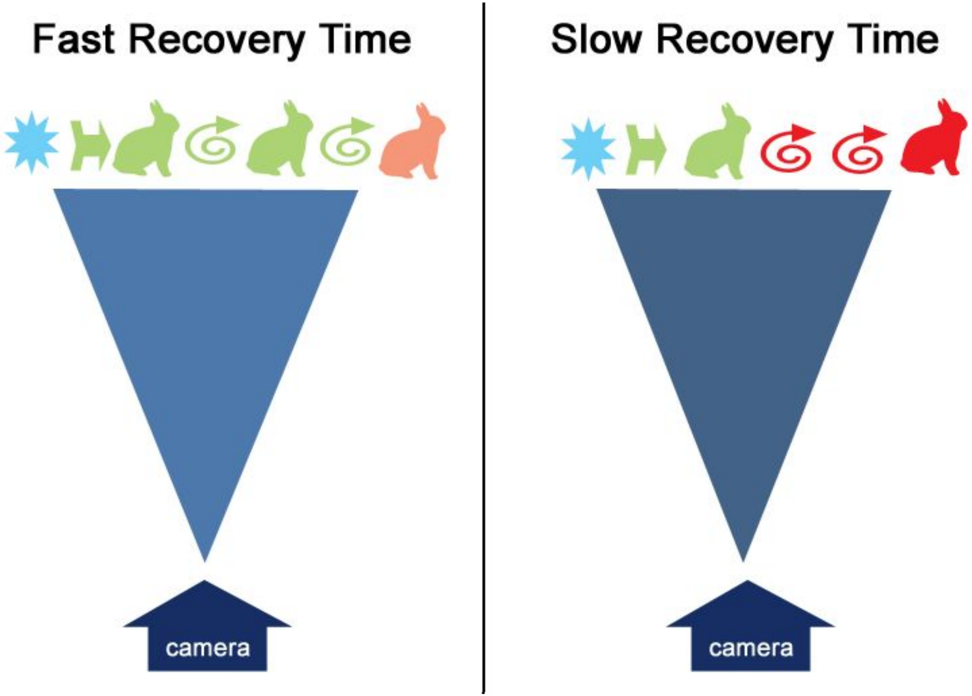
time delay between moment of **detection** and moment picture **taken**

- faster = more likely animal which was detected by camera also ends up in the picture
- slower triggers not suitable for trails
- speed less important when animals likely to remain in front of the camera for some time



recovery speed

- time between **successive triggers**
  - dependent on image processing and recharging of the flash
  - faster = better opportunity to record multiple images of the same animal
  - faster = higher chance of recording multiple animals passing in front of the camera at once

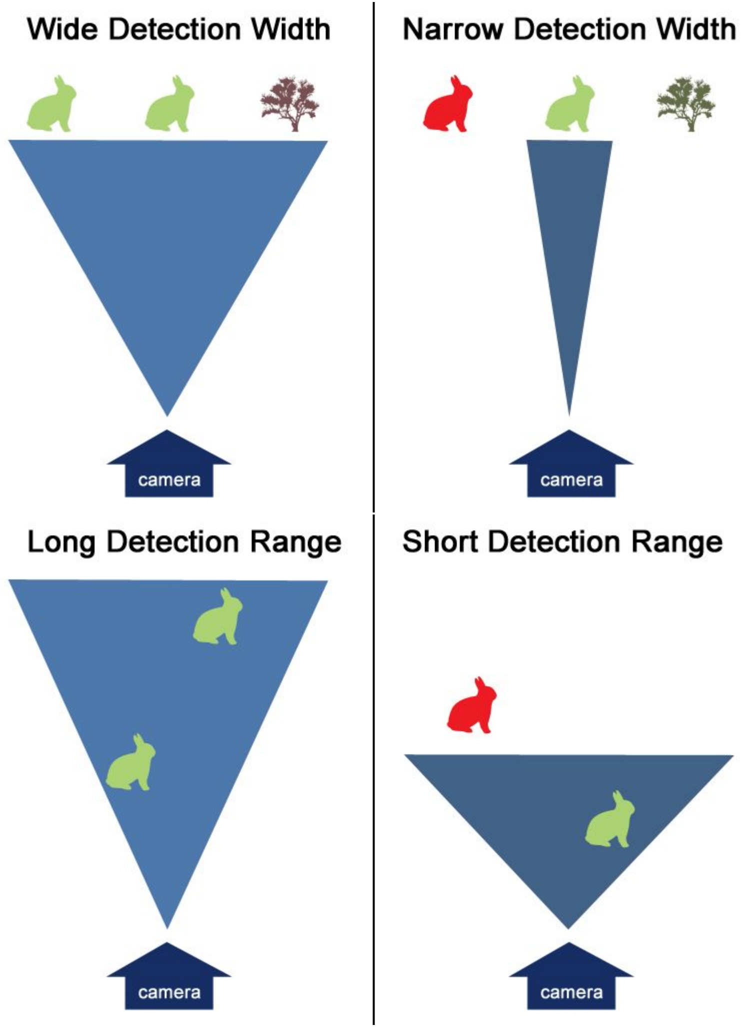


user-defined **delay**

- time interval between triggers manually set by user
  - *longer* = fewer pictures: extends battery life and frees memory card space
    - when animals expected to spend lots time in front of the camera
    - useful if lots of misfires from vegetation
  - *shorter* = when studying animals where group size information is useful
    - longer intervals may only photograph the first animal, missing any following animals

detection zone

- cone-shaped area in which the sensor is able to detect heat-motion
  - *wide* = useful when not certain where an animal will appear
  - *narrow* = sufficient for cameras on a trail (animal will always pass in front of camera)
  - *long* = when cameras are deployed in open spaces
  - can vary with environmental conditions and characteristics of animals



sensitivity

- amount of change in background infrared signature required for camera to trigger
  - *higher* = increased detection rate but more false triggers, drains battery faster
  - *lower* = less false triggers, but some animals may go undetected
  - influenced by temperature:
    - animal's body surface temp resembles ambient temp more at high temps than moderate temps

media: photo or **video**?

- advantages:
  - can increase probability of capturing animals (esp. groups)
  - allows calibration of animal speed
  - captures interesting behavior
- disadvantages:
  - quality usually lower than images
  - often max = 60 seconds
  - files considerably larger, recording uses more battery power
    - minimizes time a camera can be left in the field without checking

media: photo or **video**?

- **burst** option = good compromise
  - takes multiple pictures in rapid succession
  - image quality same as with single shot
  - chances of capturing good quality, useful picture higher

batteries

- typically 8 AA per camera
  - can have external battery packs or solar options
- rechargeable vs. non-rechargeable
- non-rechargeable: alkaline vs. lithium

batteries

rechargeable vs. **non-rechargeable**

- choice depends on budget, camera type, how long cameras deployed
- many models **do not operate** on rechargeable batteries!
- rechargeable batteries lower voltage, less charge
- non-rechargeable cheaper (per battery) but more frequent replacement, wasteful

non-rechargeable batteries

alkaline vs. **lithium**

- **alkaline** cheapest, widely available
    - voltage drops quickly
    - will shut down < 6V
    - flash becomes weaker, reduces detection distance
    - Poor performance in cold
- **lithium** better
    - hold charge well, long battery life, high initial power output
    - more expensive
    - can last >6 months

memory

- **memory cards** store camera images
  - up to 64 GB storage (SDHD)
  - larger memory = less likely to fills up between camera checks
  - sometimes fail, resulting in lost images
    - format each card before use
    - always have spares with you
- **hard drives** back up images after collection

protection

- prevent damage or theft from animals or humans
- protective metal cases
  - “security boxes”
  - addition of spines, other deterrents
- locks
  - cases
  - security cables
- information and communication

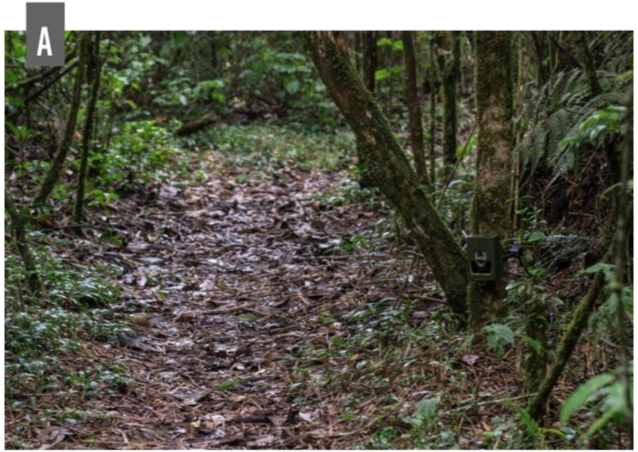
set-up: attachment

- what are you attaching camera to?
  - natural structure, pole, cement + post?
- how are you attaching?
  - straps, cables, bolts?
  - drills and equipment to attach
- height
  - shoulder height of target species
    - smaller species will be overlooked if camera is too high but larger species will still be detected
    - for multi-species survey, better to place camera too low than too high

set-up: placement

- angle
  - place perpendicular (90°) to travel direction
  - due to delay between animal detection and picture taken, can position camera at 60° angle so animal remains in view longer
  - perpendicular to ground surface

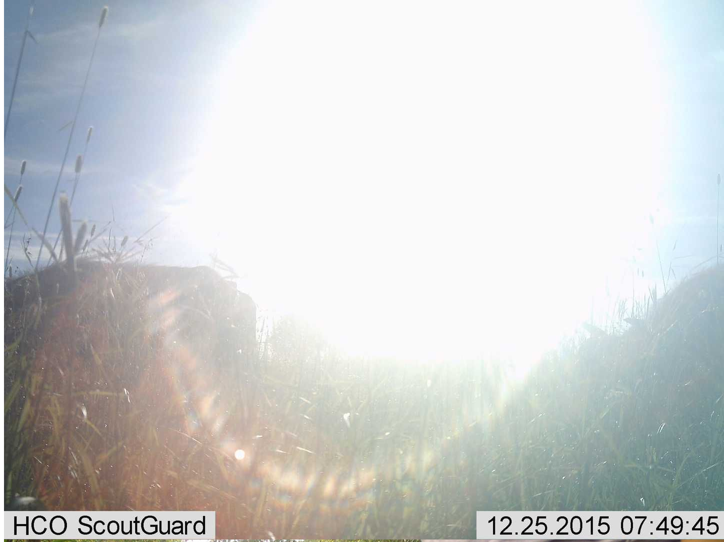
- distance to animal
  - influenced by trigger speed, detection zone, flash strength, sensor sensitivity, target range, and size of target species
  - for mid-sized animals, place 2-5 m from trail



set-up: field of view

- direction
  - avoid pointing cameras directly into sunrise/sunset
    - glare and heat may cause false triggers, influence the quality of the image

- clearing vegetation
  - remove vegetation between where animal may appear and camera
    - can obstruct view of animal
    - can cause false triggers
  - however, try and alter overall habitat as little as possible

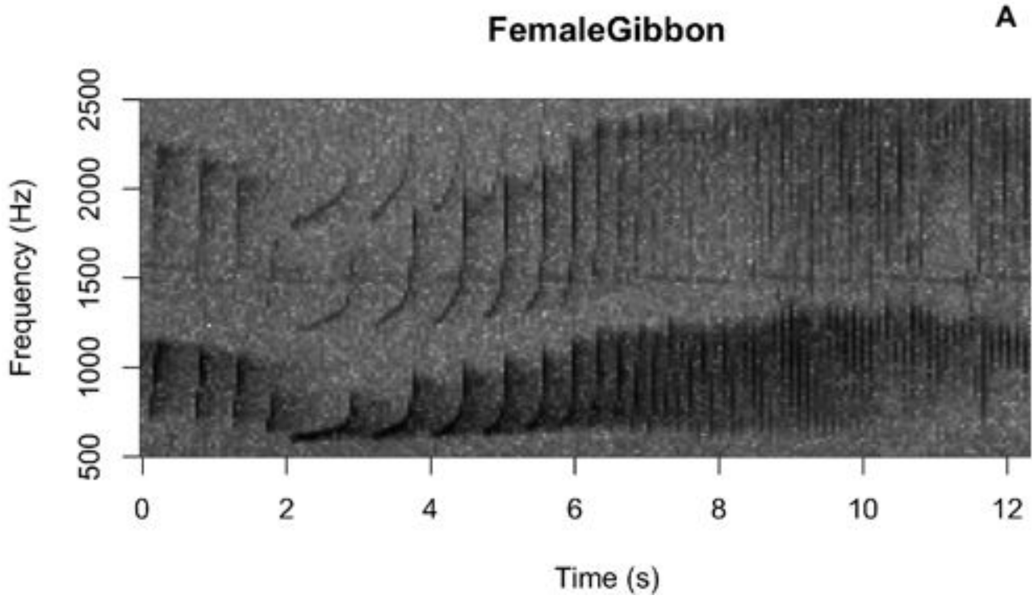


checking cameras

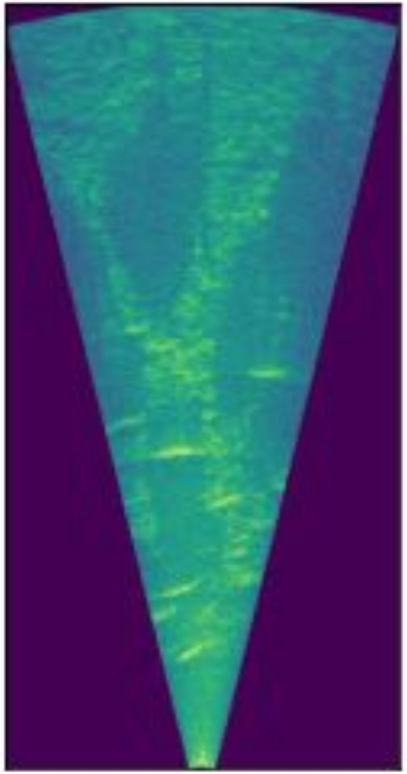
- need to be checked regularly
  - change batteries
  - collect the memory card
  - ensure cameras are present/working

- how often depends on local conditions, camera type, battery type, capture rate
  - first check ideally be no later than five days after the cameras set up
  - second check performed ~3 weeks later
  - from this, frequency of further checks can be determined

Other stationary sensors: bioacoustics, sonar



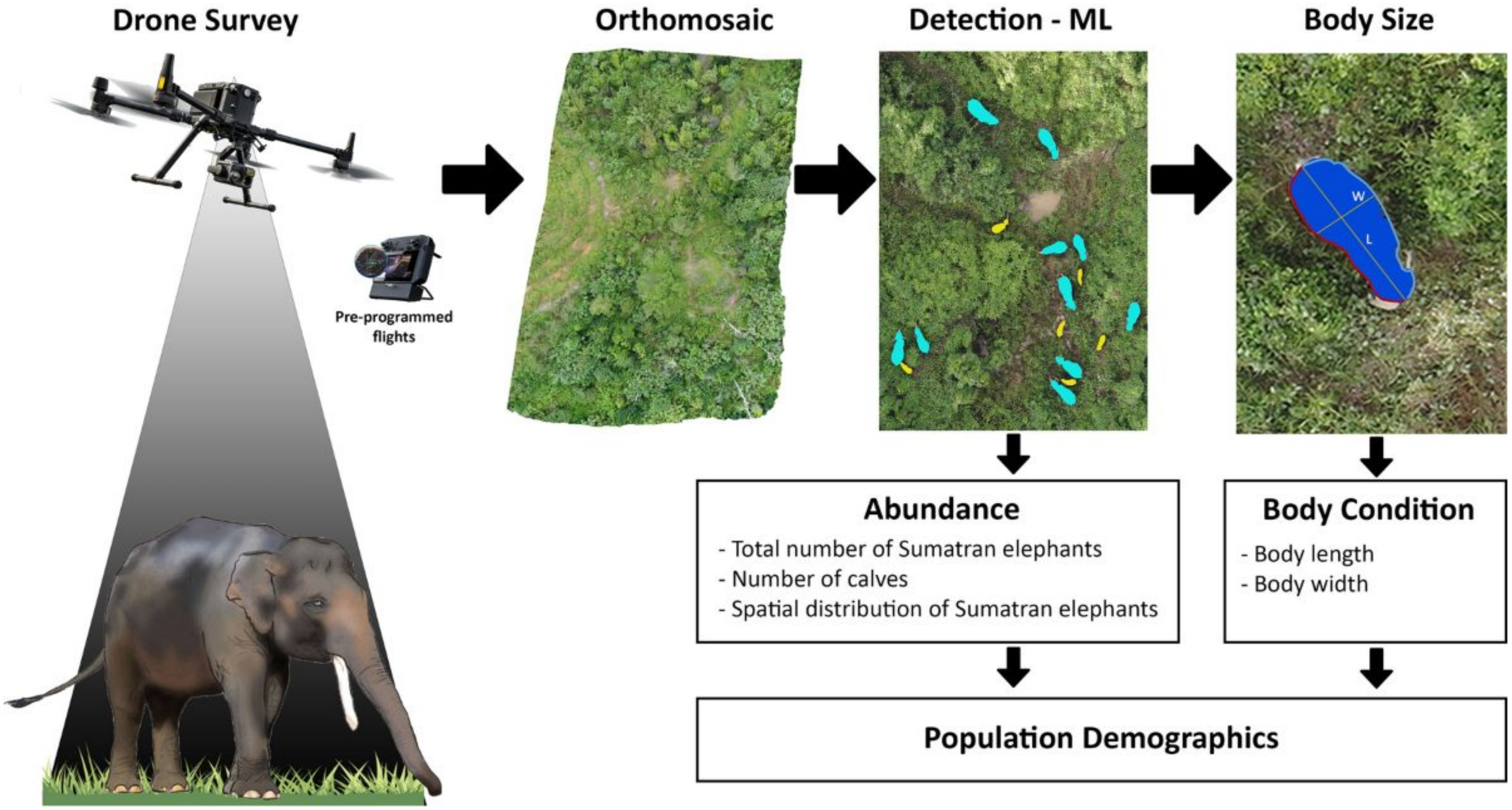
https://bookdown.org/denajane13/BIONB_2210_Summer_2021/field-lab-3-introduction-to-bioacoustics.html



MIT/Caltech Fish Counting Project

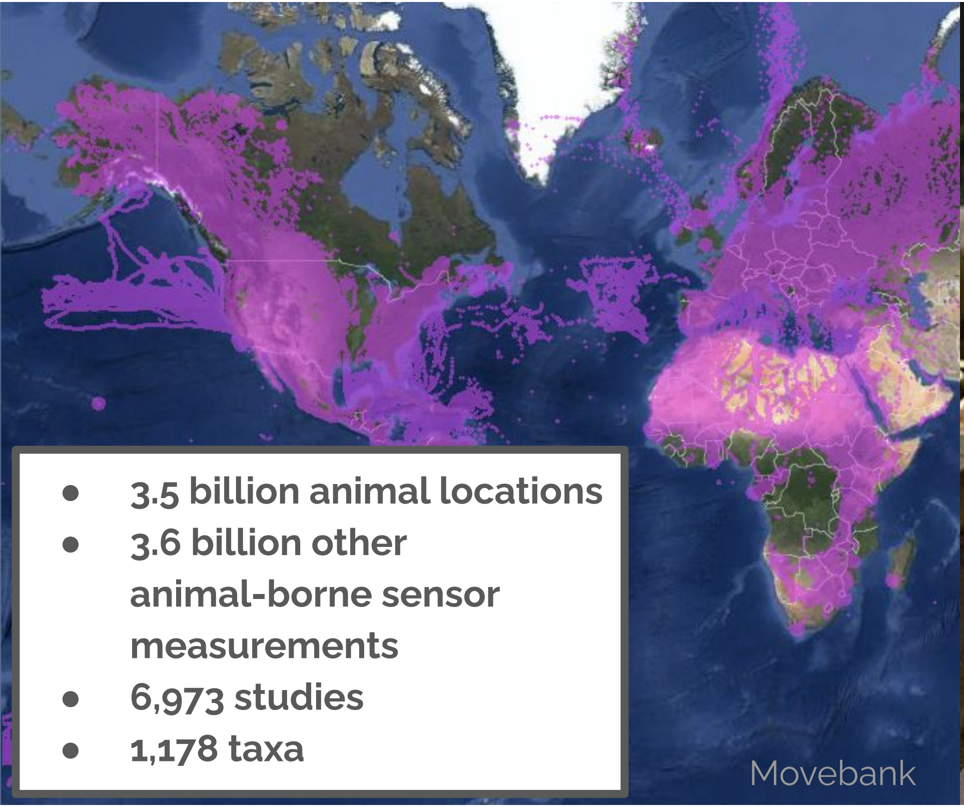
Mobile sensors

Drones

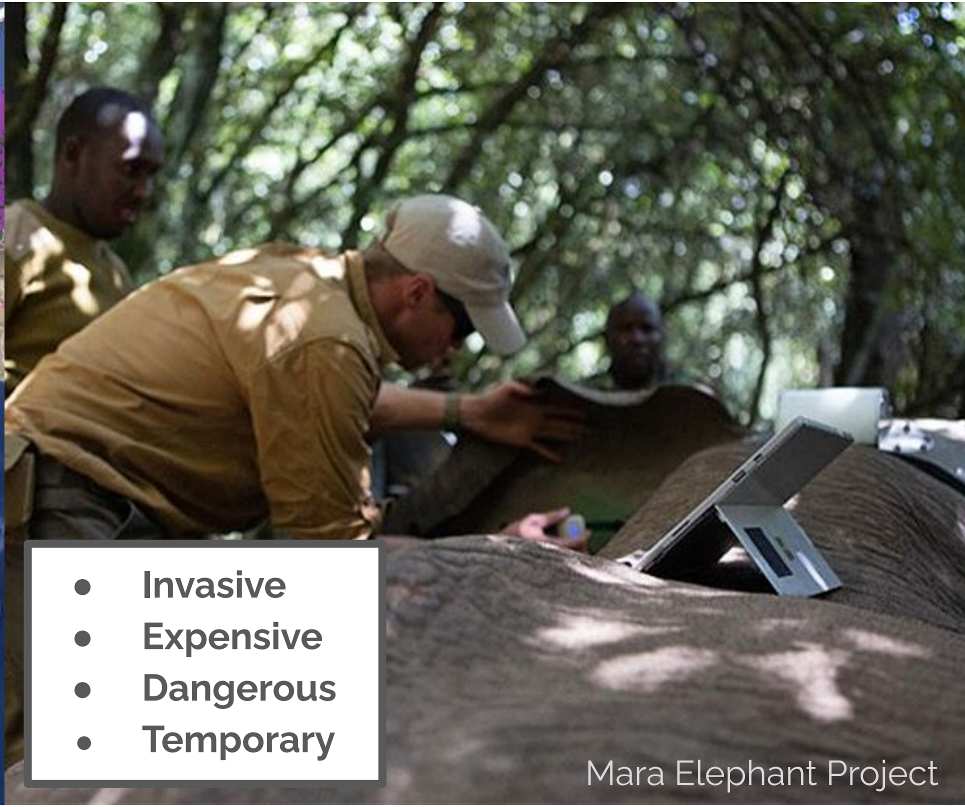


https://www.nature.com/articles/s41598-023-48635-y

GPS Trajectories

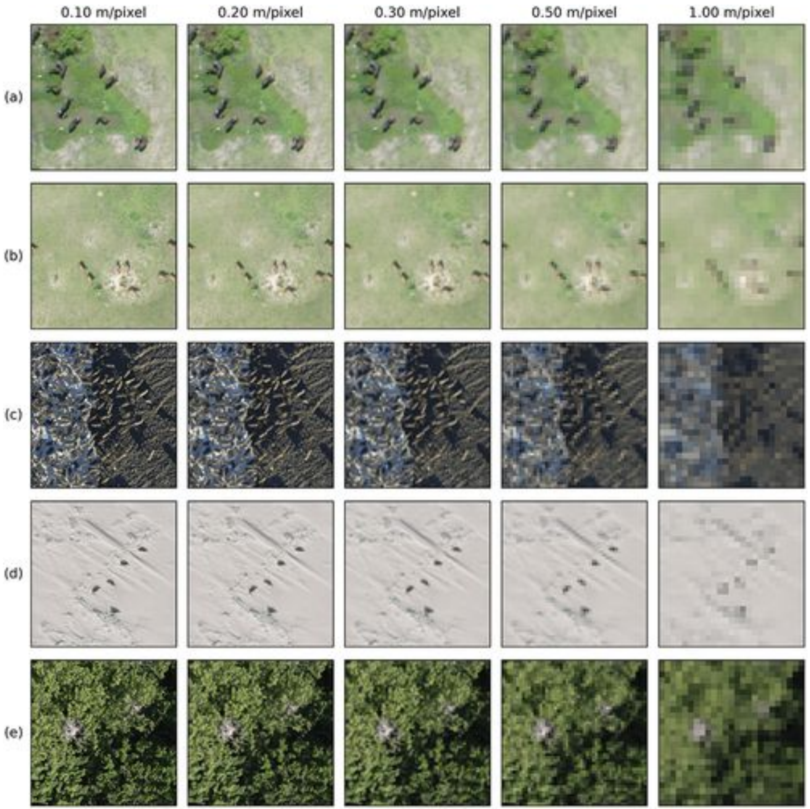


- 3.5 billion animal locations
- 3.6 billion other animal-borne sensor measurements
- 6,973 studies
- 1,178 taxa

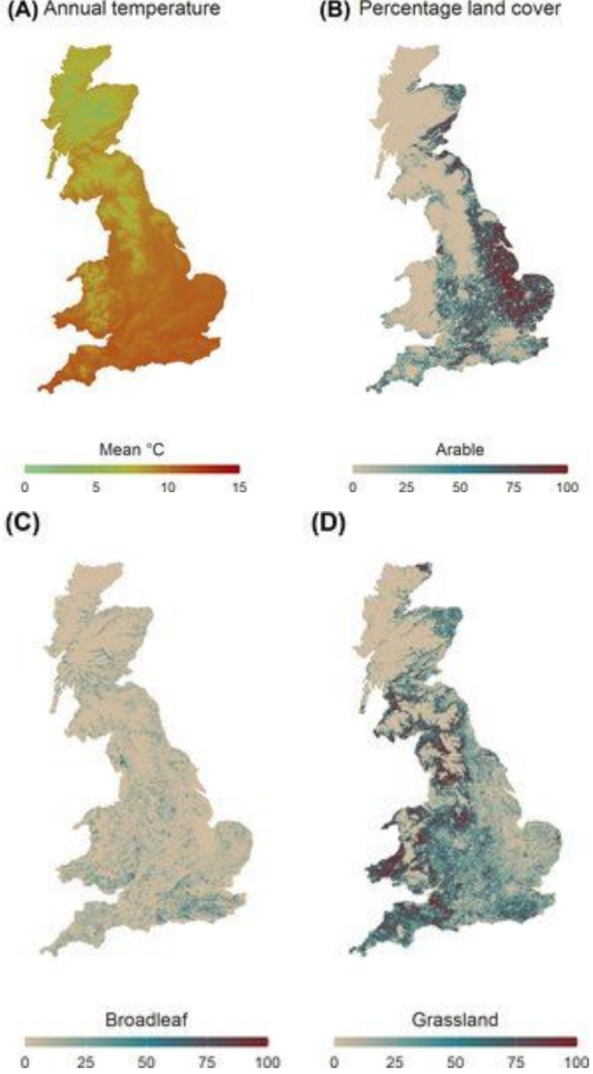


- Invasive
- Expensive
- Dangerous
- Temporary

Satellites



https://www.tandfonline.com/doi/full/10.1080/15481603.2024.2348863

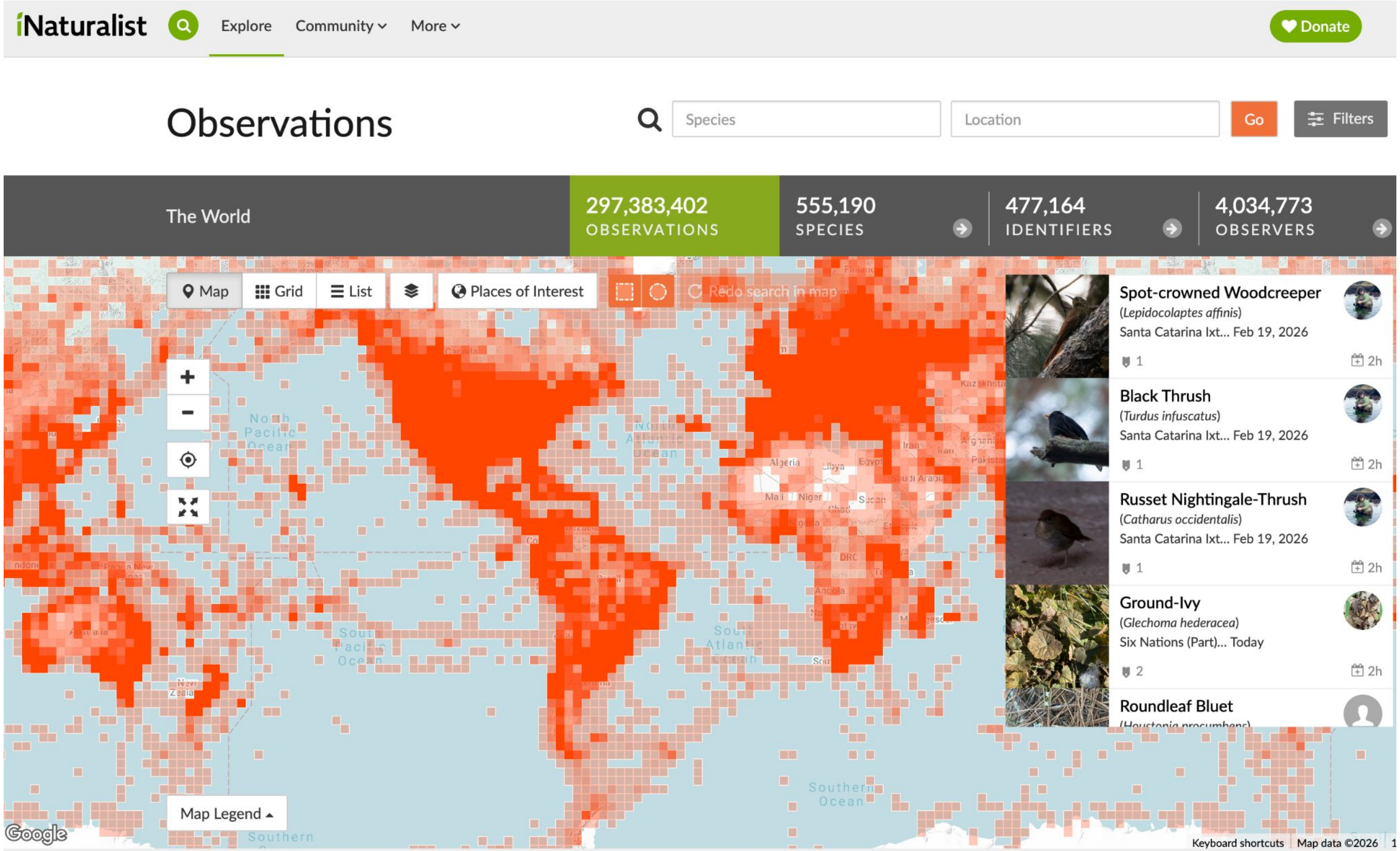


https://www.researchgate.net/publication/370353040_Integrated_species_distribution_models_fitted_in_INLA_are_sensitive_to_mesh_parameterisation/

Opportunistic data

Citizen science

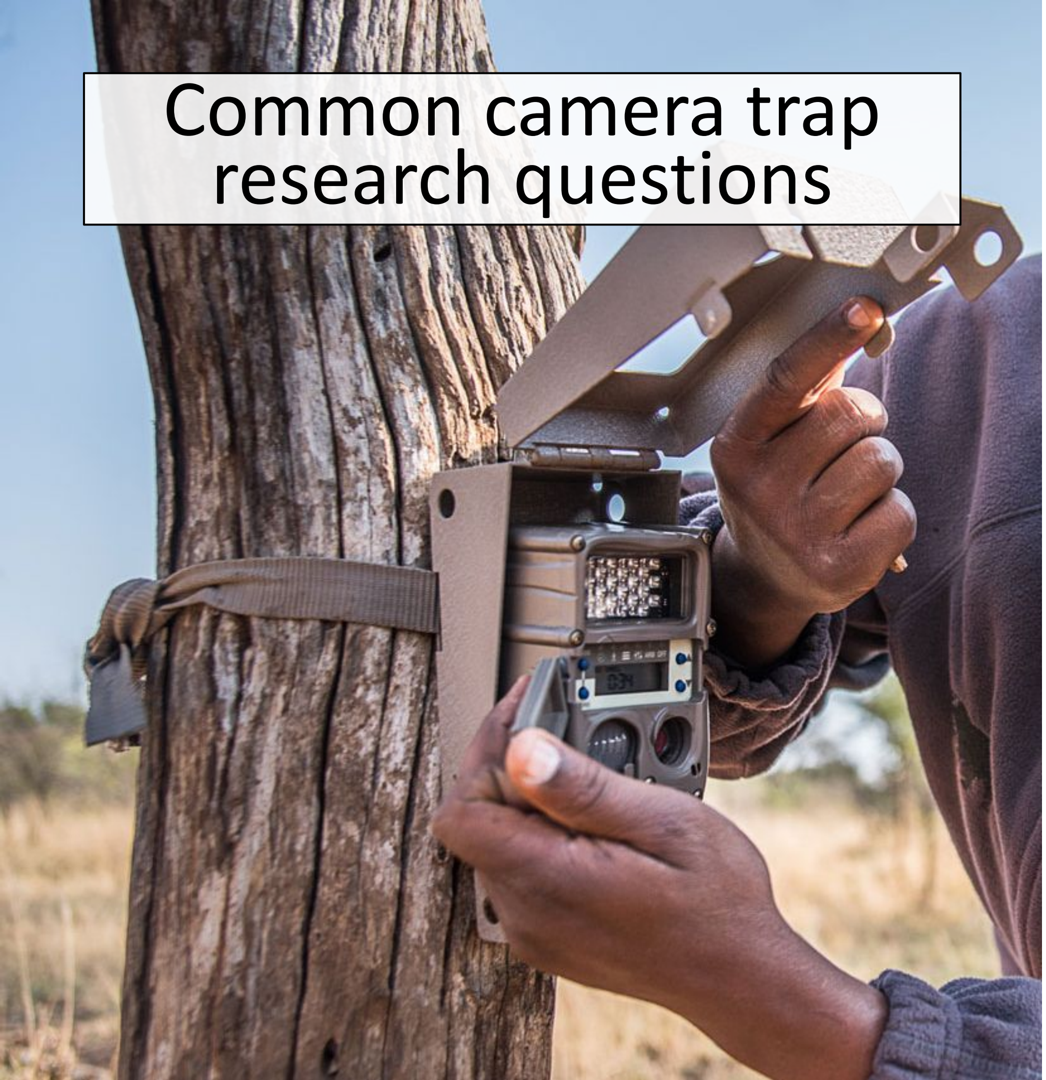
https://www.inaturalist.org/observations?subview=map



Common biodiversity measurements

- Richness (how many species)
- Distribution
  - Habitat suitability
- Abundance
- Movement
  - Home range
  - Connectivity
- Demography
  - E.g. birth and death rates
- Trophic interaction
  - Biotic
  - Abiotic
- Phylogeny
- Phenology

Common camera trap research questions



which species are present?

how diverse are ecological communities?

how are species distributed across space?

how abundant is a species?

understanding animal behavior

well-designed camera trap surveys answer the following:

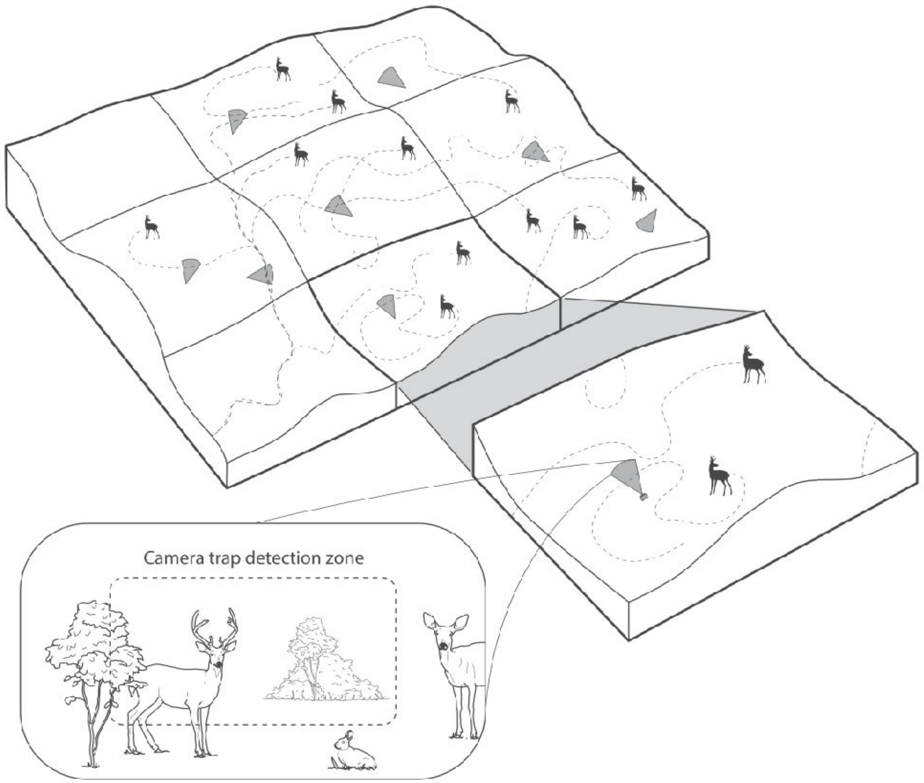
- what is it you would like to know, and why?
- how will you go about answering these questions?

- identify constraints on study, relevant scale of sampling, state variables will need to estimate
- think carefully about confounding variables and pseudo-replication

general considerations: **detection probability**

imperfect detection:
non-detection does not always mean animal not present

- variables affecting detection: species ecology, rainfall, habitat type, density, sampling design, camera type, time, species body mass, speed at which animal moves, animal density
- varies within and between species, across seasons, habitat, sites
- to reduce/account for non-detection:
  - increase trapping effort (number of camera traps or number of days)
  - incorporate in models



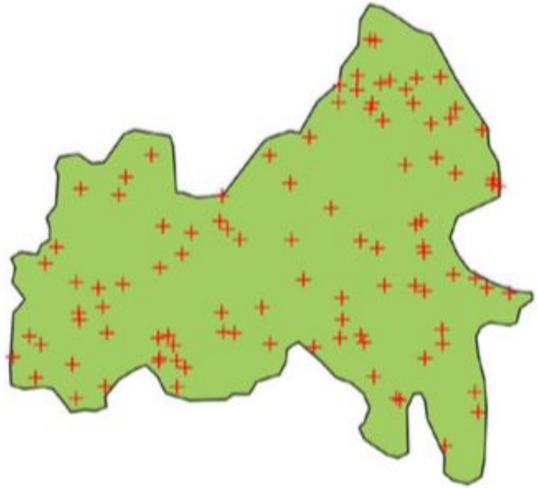
(Burton et al. 2015)

general considerations: **time**

- are you interested in capturing longitudinal changes?
  - capturing seasonal dynamics, monitoring results of interventions, etc.?
  - single time or repeated surveys?
  - how long to deploy?

general considerations: **space**

- sample representative areas
  - cannot draw inference on types of areas not included in sample
- sampling design depends on assumptions of statistics used
  - **simple random**



(Wearn & Glover-Kapfer 2017)

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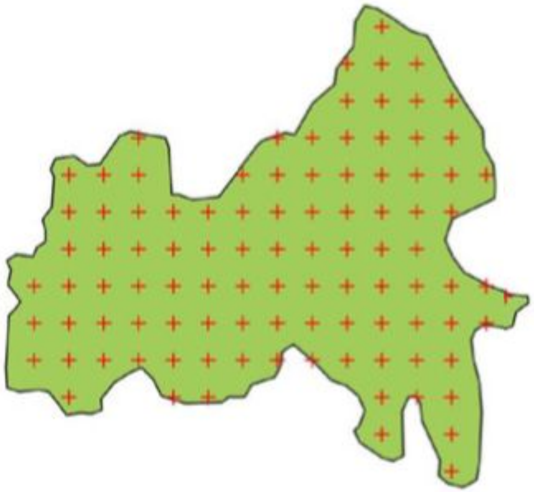
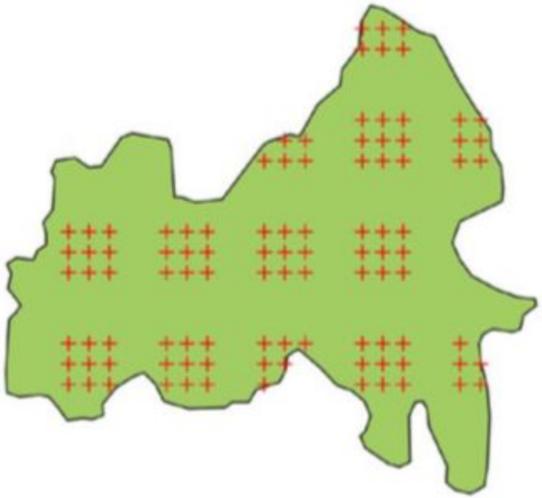


- **simple random**
- **systematic random**
  - more precise estimates of state variables because variance in detection and counts across sampling points will be lower

(Wearn & Glover-Kapfer 2017)

general considerations: **space**

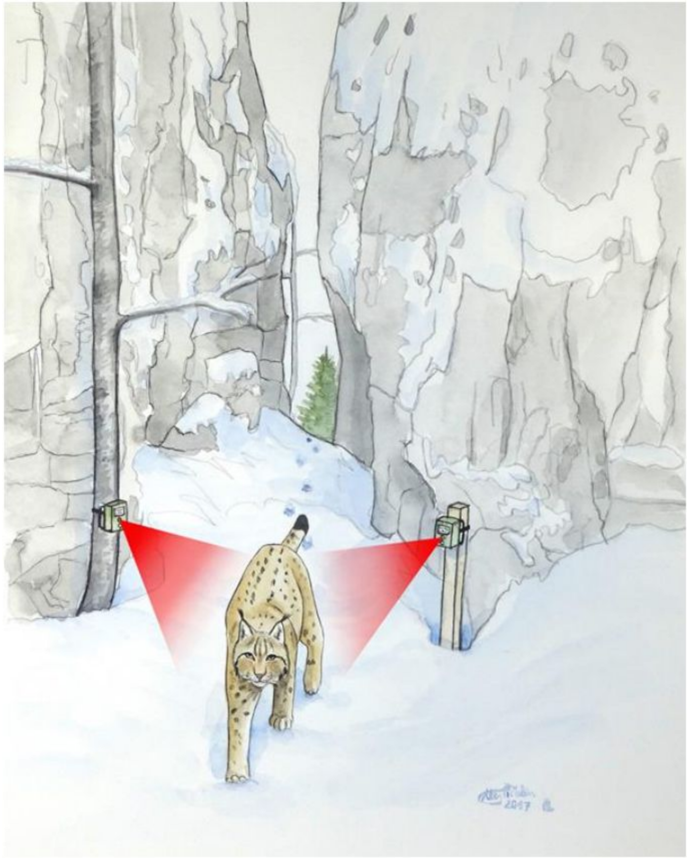
- sample representative areas
  - cannot draw inference on types of areas not included in sample
- sampling design depends on assumptions of statistics used
  - **simple random**
  - **systematic random**
  - **clustered random**
    - may be more where accessibility is difficult (multiple cams can be deployed quickly once a cluster as been reached)
    - will require more complicated analyses



(Wearn & Glover-Kapfer 2017)

general considerations: **paired cameras**

- image both sides of animal to recognize all marked individuals
- but sample **half** the locations single camera design can
  - single cams can also sometimes be effective for identifying individuals
  - new statistical methods can use data from just one side of each animal

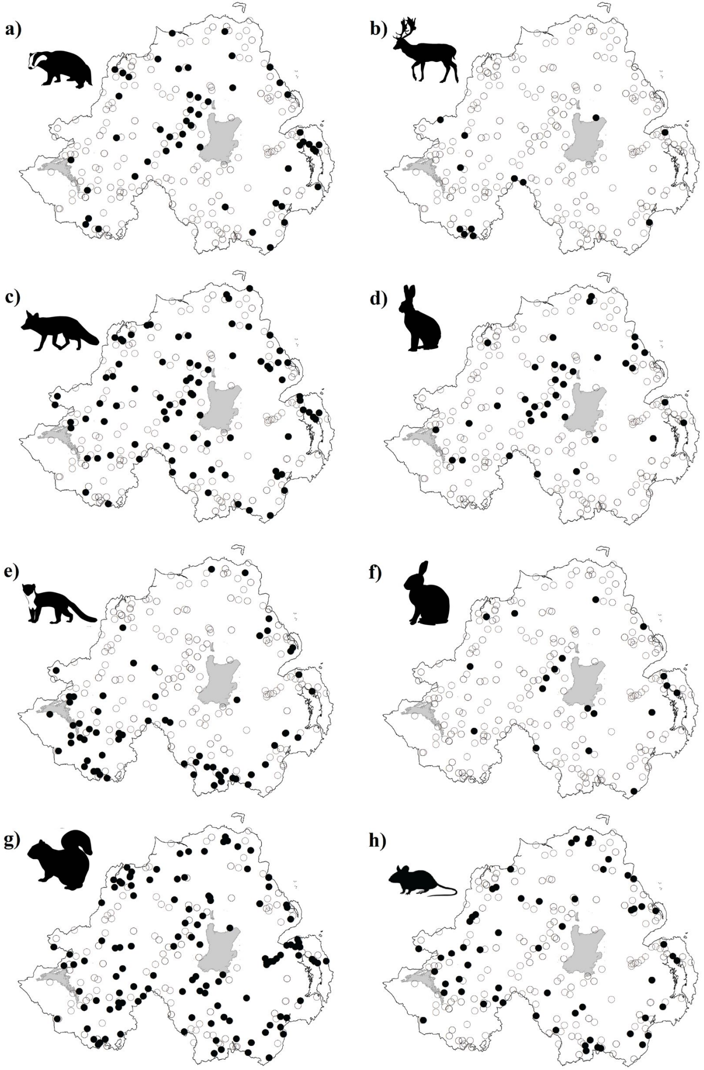


general considerations: **baiting**

- **purpose**: to attract animals to camera trap from surrounding area
  - increase detection rates
  - reduce survey effort
  - improve density estimates for **MARKED**
  - keep animal in front of camera for longer
- audible, visual, olfactory attractants
  - most effective depends on target species
  - natural bait preferred over artificial
- introduces massive bias

which species are present?

- detect species immigration, persistence, or local extinction
- record range extension
- record the presence of invasive species

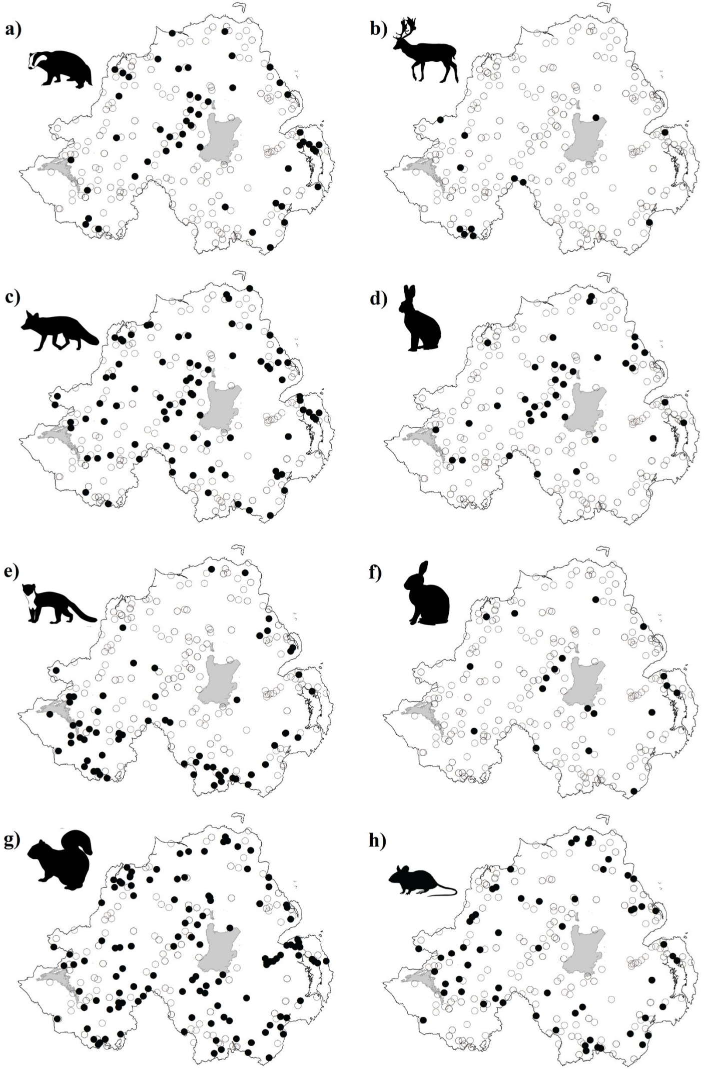


(figure: Caravaggi et al.

presence/absence

species inventories, community diversity

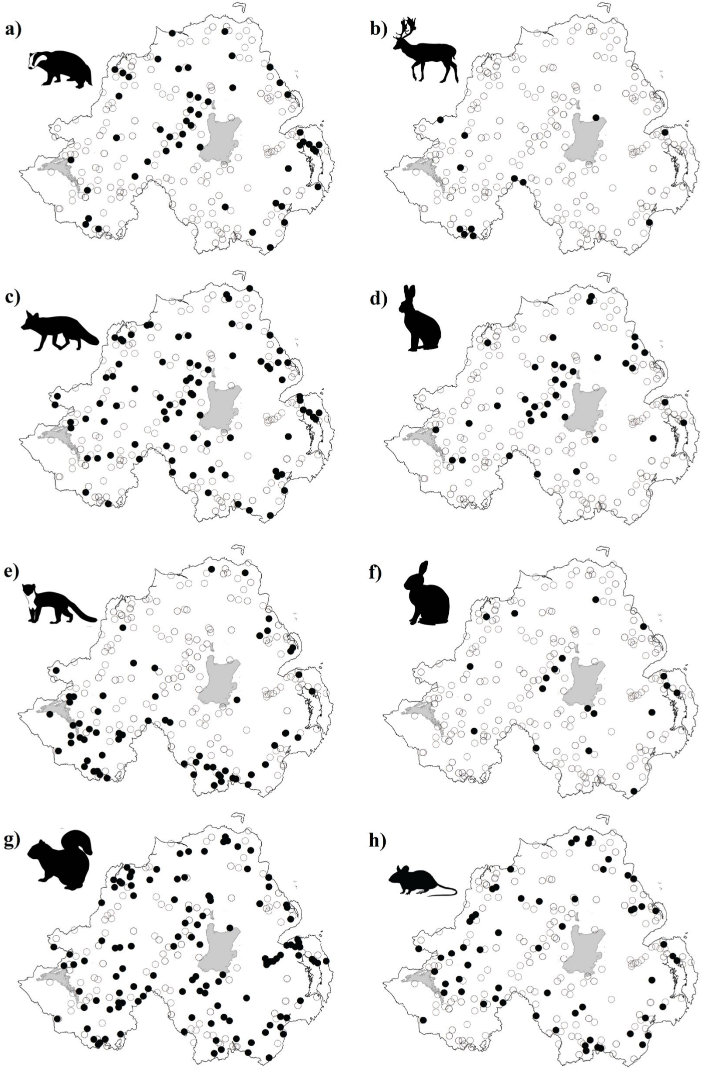
- attempt to discover what species present in a given area at a given point in time
- makes not attempt to quantify aspect of communities or populations
- no formal modelling process therefore no assumptions



presence/absence

camera placement: maximize detection probability of species of interest

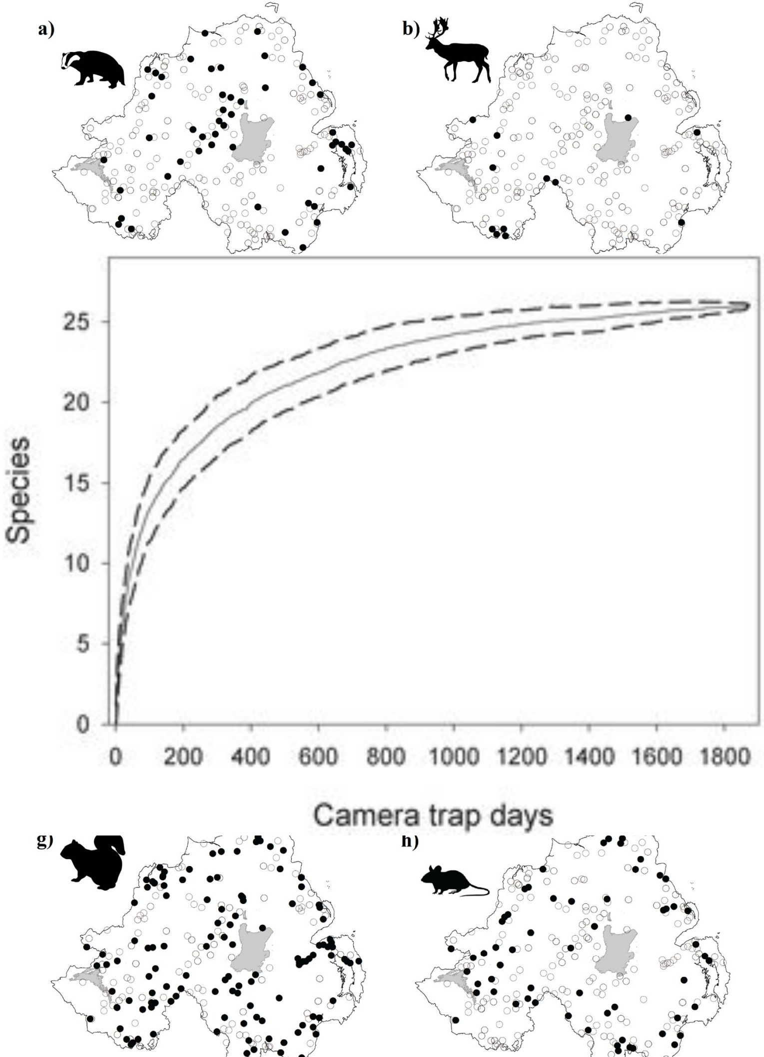
- ○ no statistical assumptions regarding spacing, detection, minimum sample size
- ○ requires knowledge of a species' ecology
- ■ when trying to detect >1 species, place at sites optimizing detection of all species
- ■ ideally, sampling design should be randomized and stratified
  - ● if time limited, targeted, non-random deployment often justified
- ○ no minimum number of locations



presence/absence

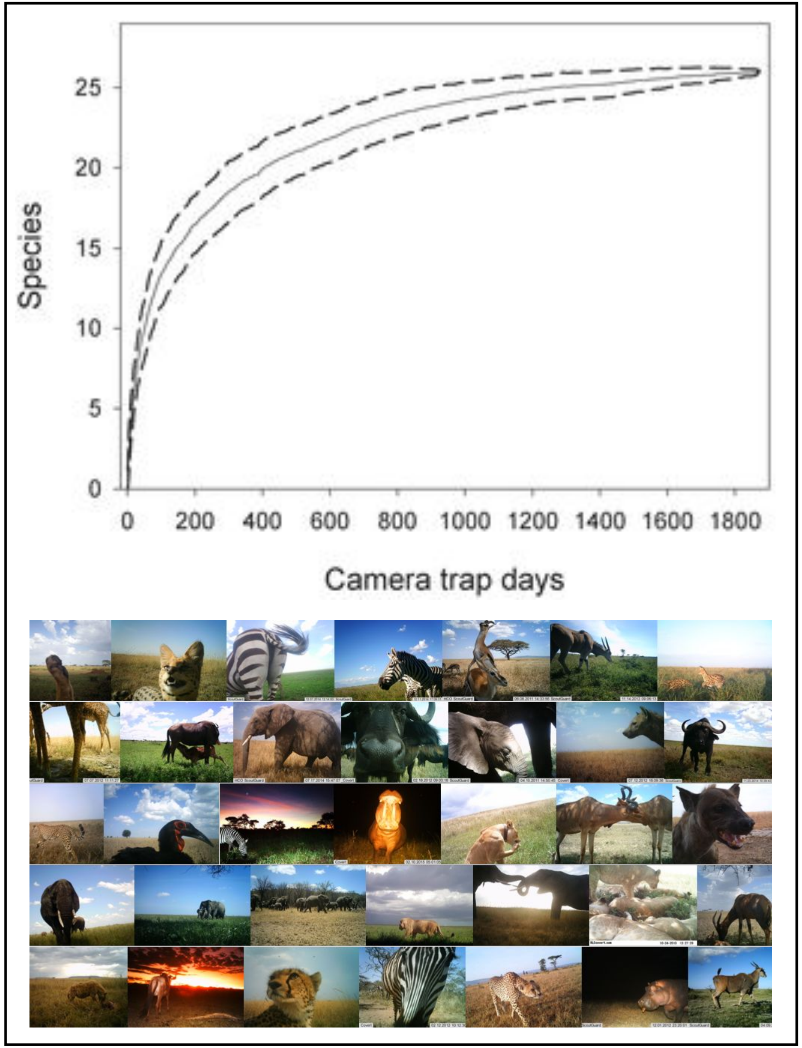
length deployment: flexibility on # days

- for broad-spectrum sampling:
    - sample shorter time and move cameras more frequently to maximize number of different microhabitats sampled
- for single-species sampling:
    - … and detection probability is high, deployment time can be short
    - … and detection probability is low, deploy longer
- **rarefied species accumulation curve** gives good indication of survey completeness



how diverse are ecological communities?

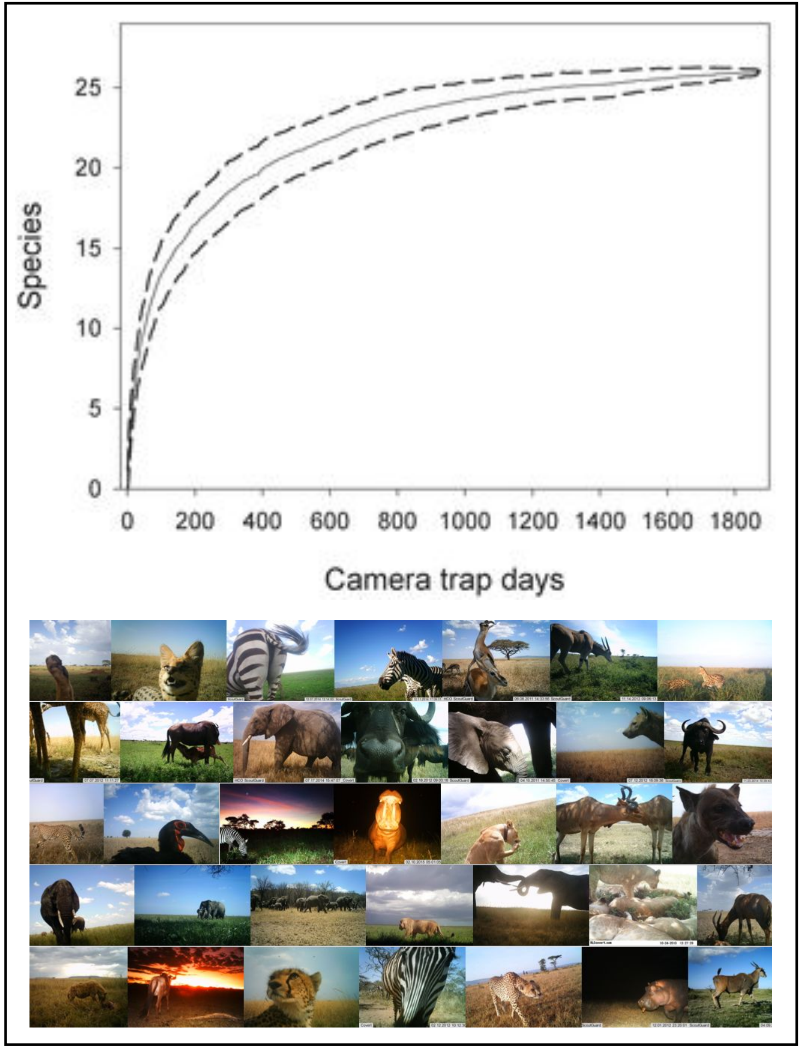
- quantify species richness
- across space:
    - how community composition varies between different areas
    - species turnover rates between adjacent sites
    - identify areas of conservation value
- comparisons through time:
    - effects of disturbance
    - monitoring & evaluation re: management



species richness

trap spacing and positioning

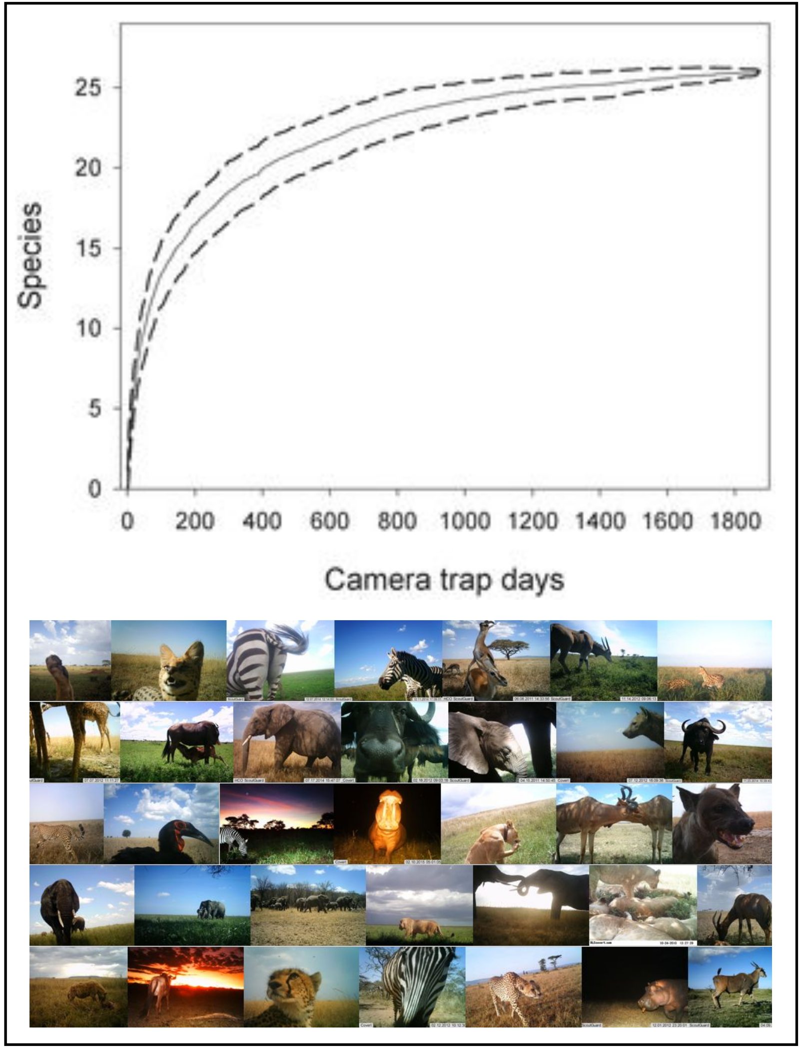
- randomized pattern (habitats and locations)
- far apart to ensure independence
  - cameras should not be sampling same animal community
  - inter-trap distance ≥ home range diameter of species with largest home range
  - rule of thumb: inter-trap distance of 1-2 km for large animals
- if increase sampling area, expect species richness to increase



species richness

trapping effort

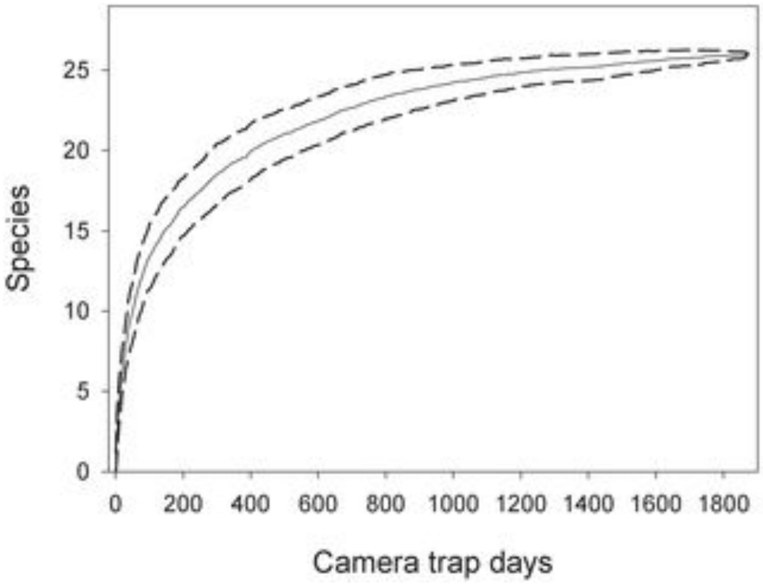
- when focus is rare species = conduct fewer surveys at more sampling points
- when focus is common species = sample fewer stations more intensely
- recording total species richness unlikely; some species will remain undetected
  - *observed* species richness likely always lower than *actual* species richness
  - rarefied species accumulation curve to see how complete survey is: when levels off, almost all species detected

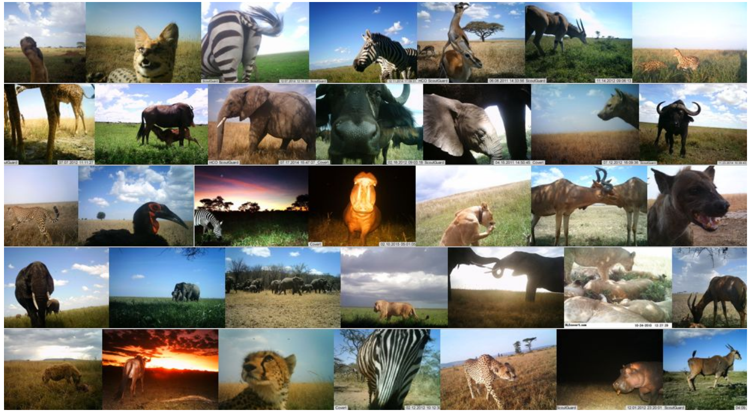


species richness

trapping effort

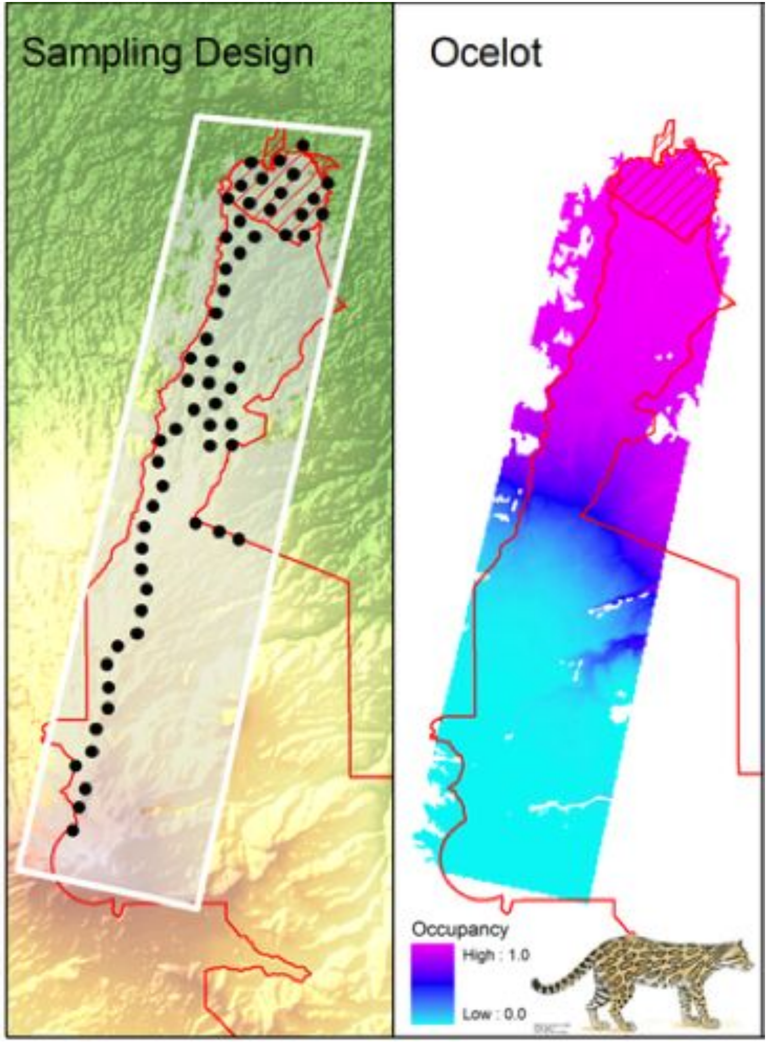
- number of sampling locations depends on:
  - size of study area
  - layout of cameras
  - number of trap days sampled
  - rule-of-thumb: 20-50 sites per stratum
- length of study
  - animal abundance
  - community evenness
  - rule-of-thumb: at least 30 days per location or at least 1,000 camera trap-days overall





how are species distributed across space?

- occupancy
- ecological or anthropogenic features that shape distribution
  - habitat, disturbance, competition, resource abundance, predators
  - facilitates coexistence?
- changes through time

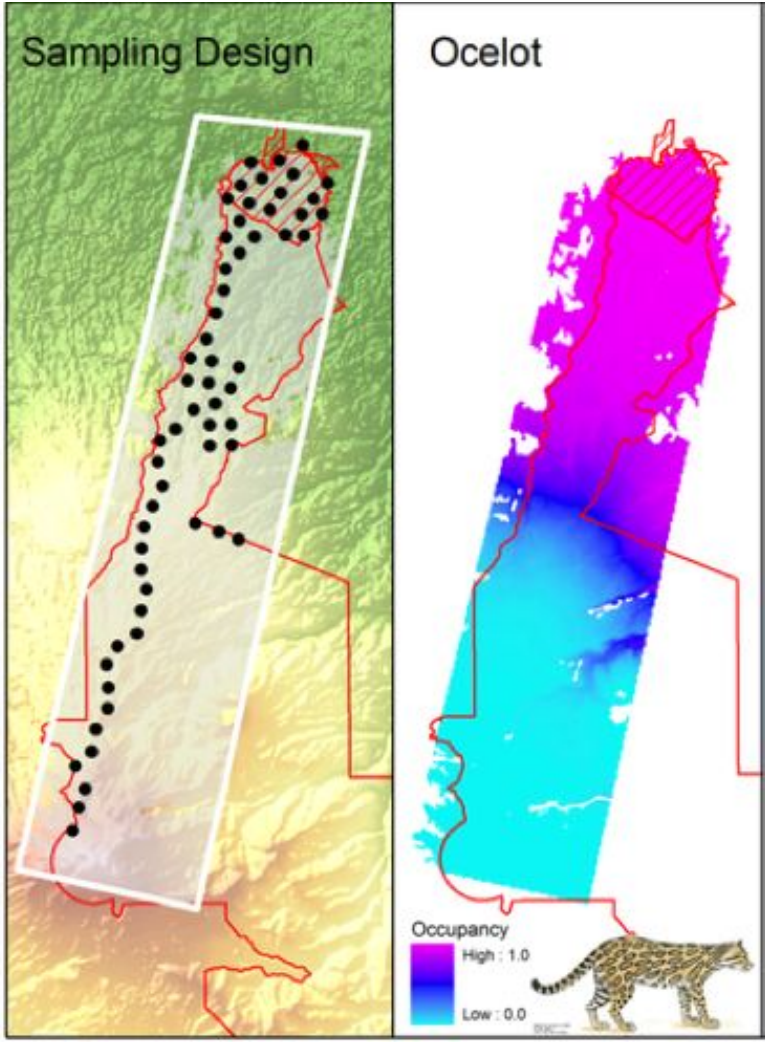


(figure: Ahumada et al.

distribution (occupancy)

occupancy modelling

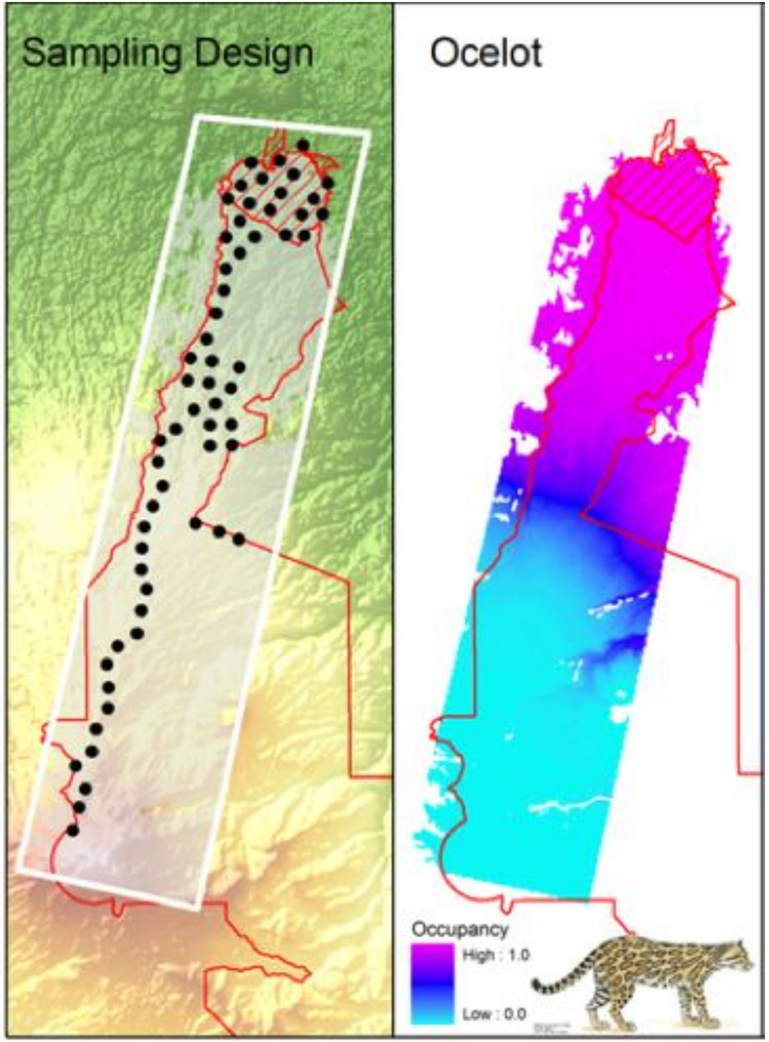
- **probability** of where will find a species across a landscape
  - habitat or community features contribute to likelihood animal will be there
  - can account for factors contributing to **imperfect detection**



distribution (occupancy)

assumptions

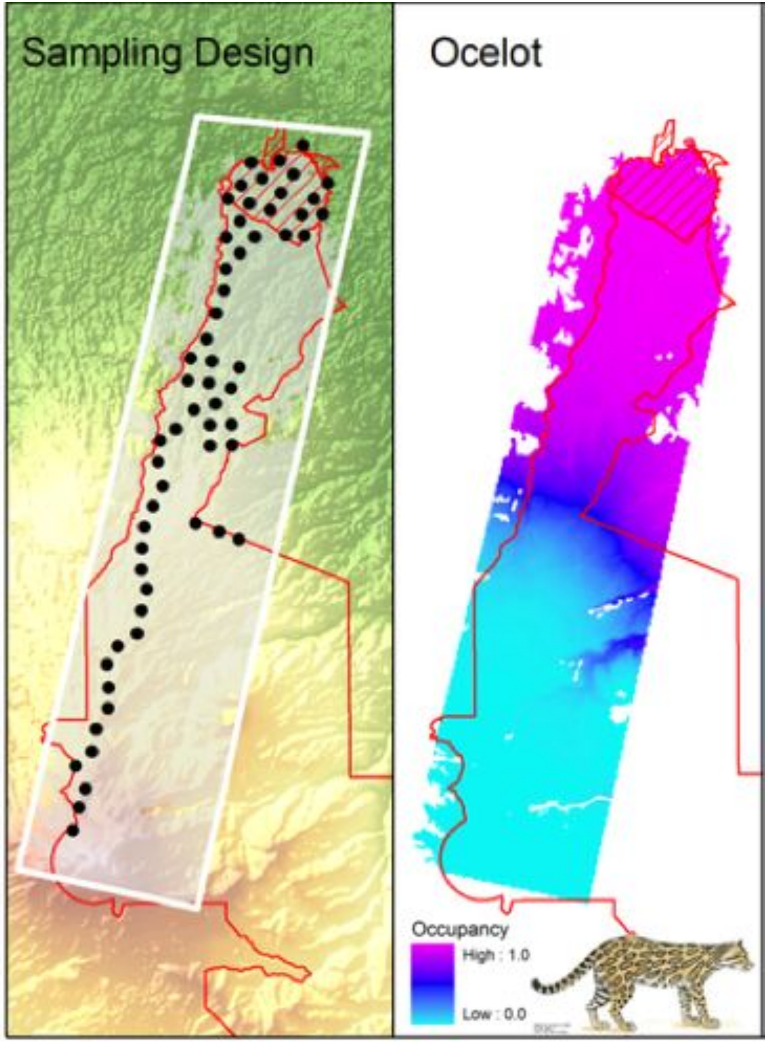
1. occupancy of site remains same over survey period
2. probability of occupancy and detection are constant across sites or can be modelled using covariates
3. all species are correctly identified
4. detections at each location are independent
   - detection of species at one site cannot influence detection of species at another
   - if individual recorded at one site, it does not get recorded at different site



distribution (occupancy)

trap spacing and positioning

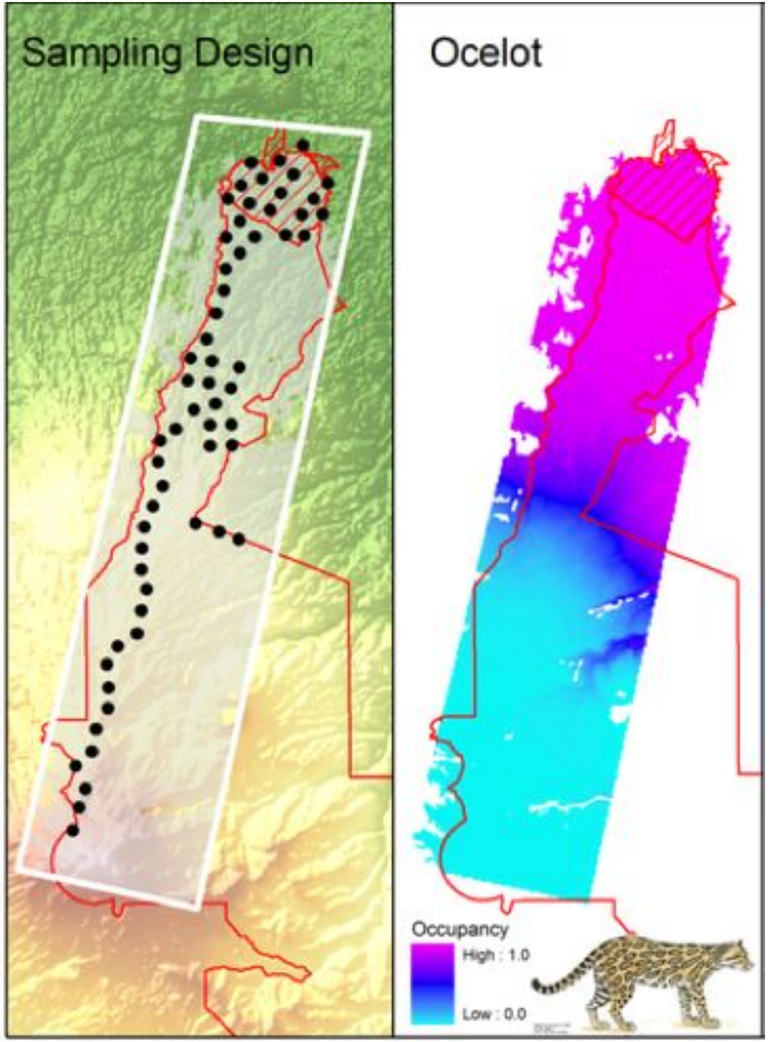
- ideally, regular square grid
- traps spaced to ensure site independence
  - distance between traps > diameter of species' home range BUT not so large that home range falls completely between camera locations
  - rule-of-thumb: at least 1 km between cameras



distribution (occupancy)

trapping effort

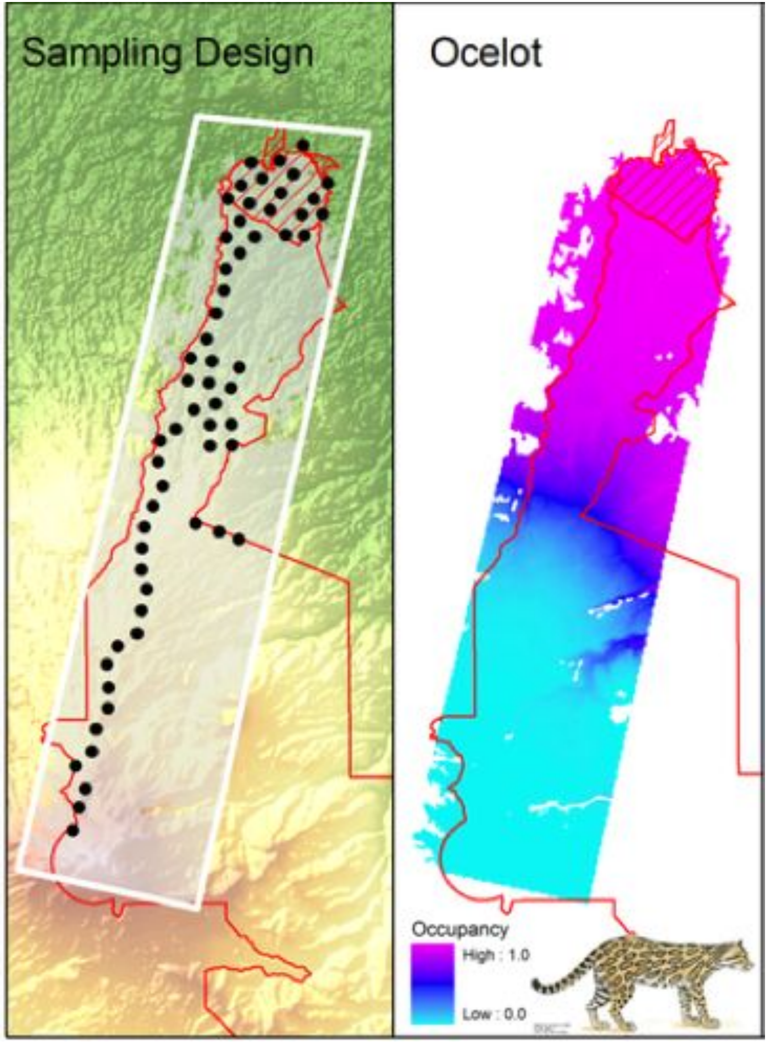
- ideally survey the entire study area at once
- lower the detection probability = larger trapping effort
    - increase effort either by sampling for a longer period or at more locations
- for rare species, survey more sampling units less intensively
- for common species, survey fewer sampling units more intensively
- more effort needed if covariates included in modelling



distribution (occupancy)

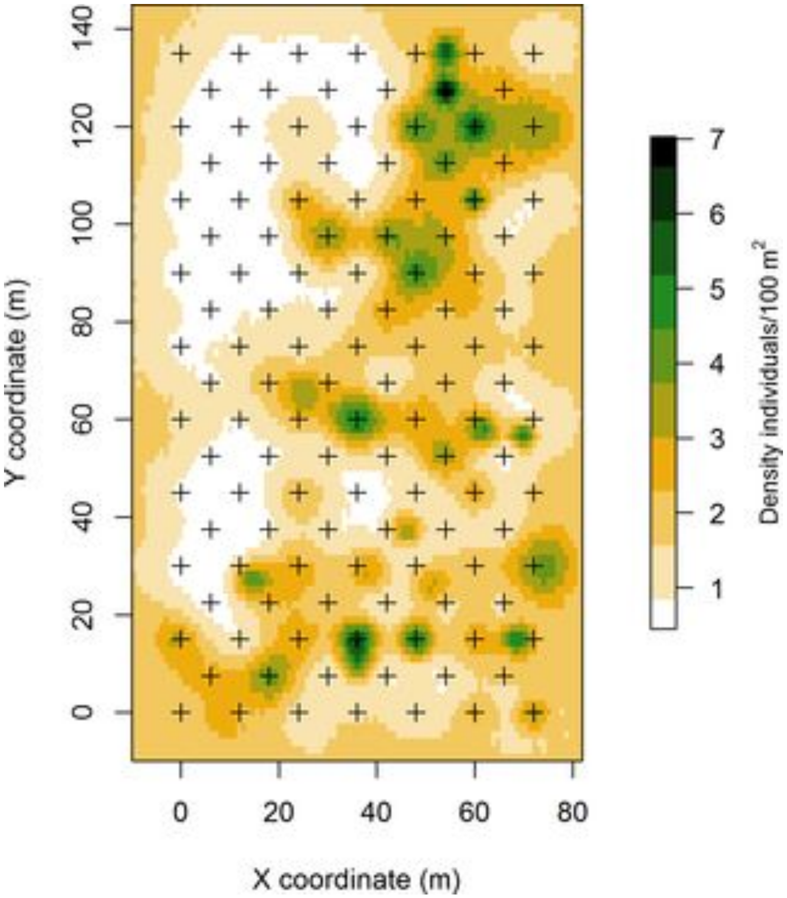
trapping effort

- number of sampling locations depends on:
  - how patchy occurrence of species is
  - more covariates, more sites
  - rule-of-thumb: at least 30-60 sites for reasonably precise estimates
- length of study: at least two weeks and likely >30 days
  - for elusive species, 80-100 days
  - for smaller-bodied species, 30 days
  - for most medium- to large-bodied species, 40-60 days but possibly up to 2-3 months
  - sampling done in minimum time possible to satisfying assumption that sites closed to changes in occupancy



how abundant is a species?

- relative or absolute
  - “marked” (individually-identifiable) vs. “un-marked” individuals
- abundance or density
- evaluate patterns over space
- monitor trends over time

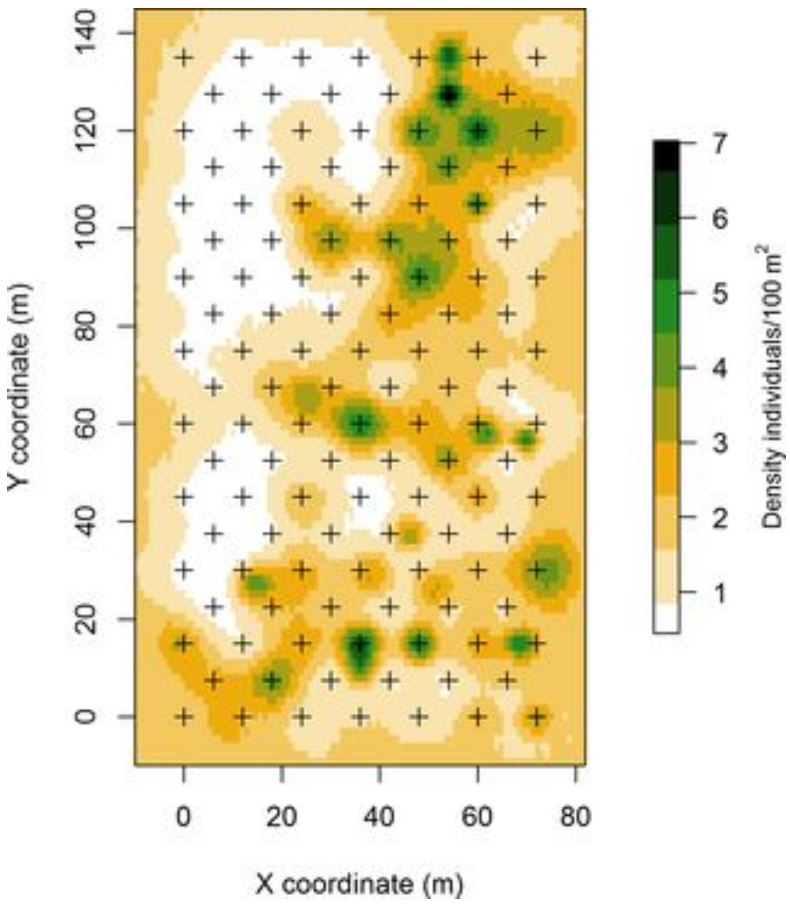


(figure: Romairone et al.

abundance/density

marked vs. unmarked species

- unmarked = cannot be individually identified
  - difficult to tell if estimates result from sampling issues or reflect true underlying abundance
  - **relative abundance indices (RAIs)**: relative abundance
  - other methods being developed
- marked = can identify individuals
  - can calculate abundance directly
  - **spatially-explicit capture-recapture (SECR) models**



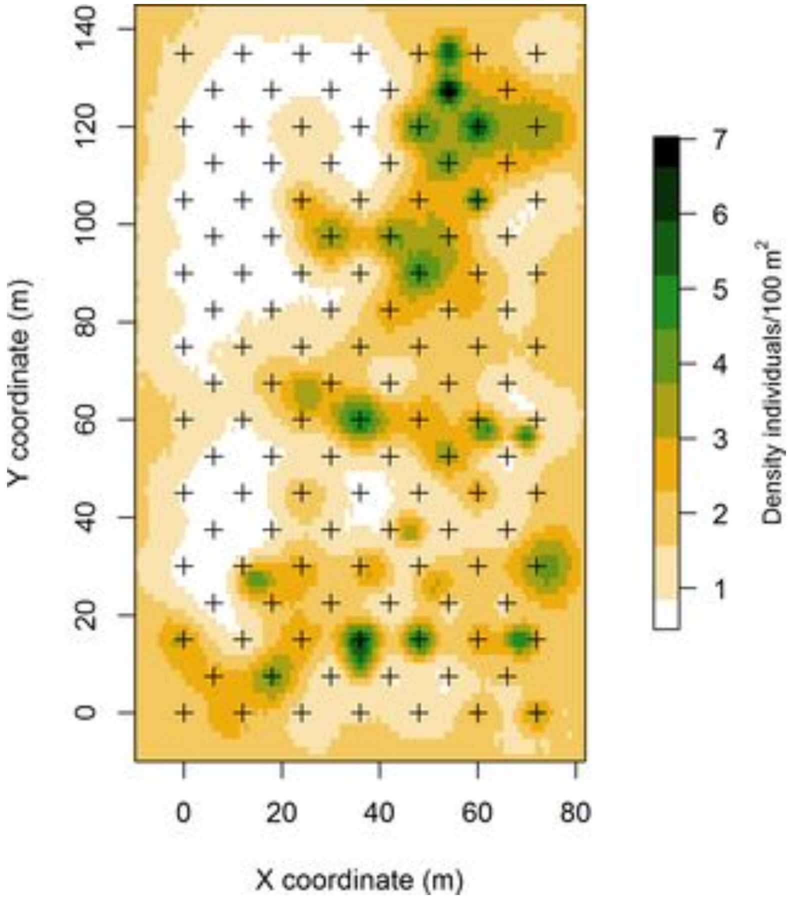
RAIs
relative abundance index

assumptions

1. standardized sampling design

trap spacing and positioning

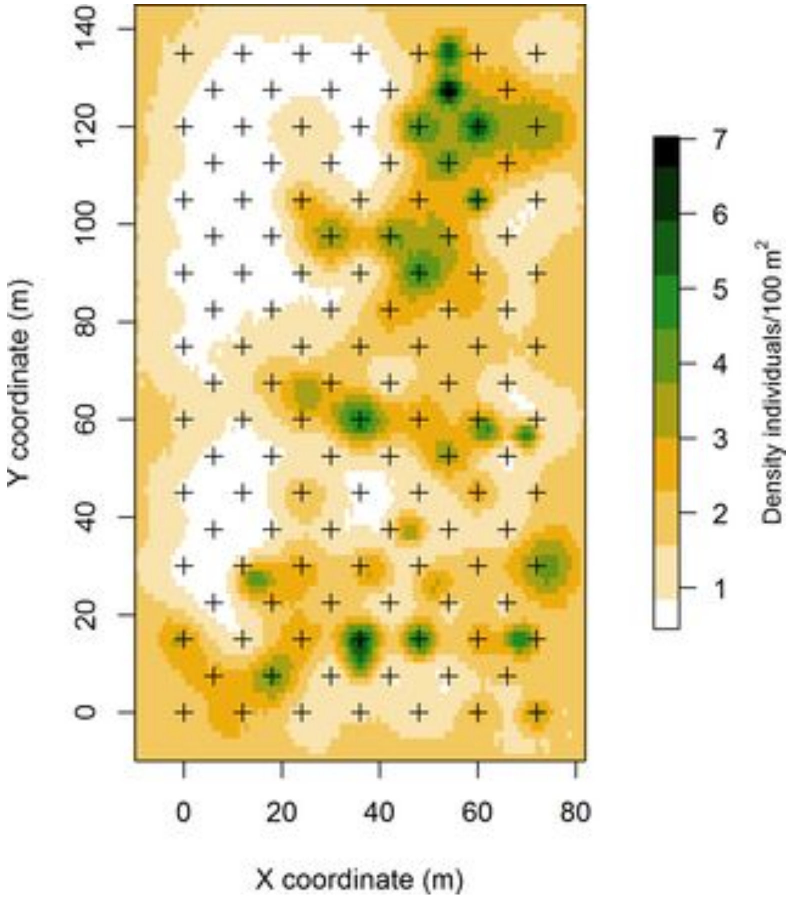
- randomization (systematic or simple)
- inter-trap distance should be large enough for independence (typically 1-2 km)



RAIs
relative abundance index

trapping effort

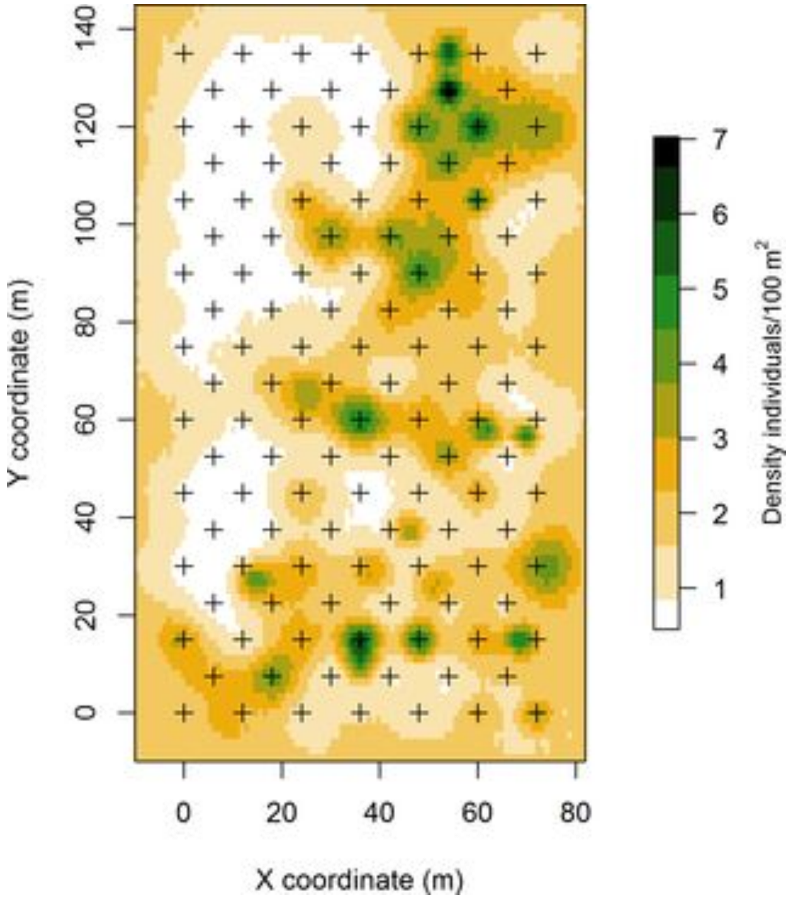
- number of sampling locations depends on how patchy species is
  - more locations increases precision
  - rule-of-thumb: ideally >50 locations
- length of study: no minimum, but precision will increase with effort
  - no formal closure assumptions; trapping rate reflective of average abundance for period over which calculated
  - rule-of-thumb: at least 30 nights or 20 captures



SECR models

spatially-explicit capture-recapture

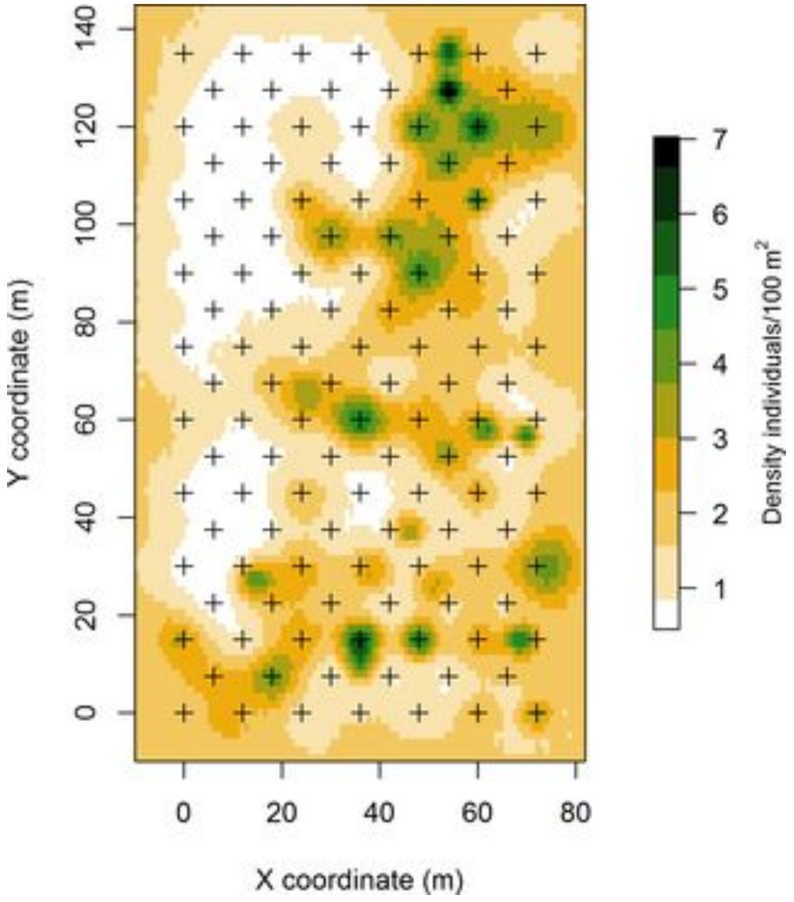
- calculating “true” underlying abundance
- relies on **repeated sampling** of animals across multiple spatial locations
- relies on **individual identification** of animals
    - e.g., spots, stripes, scars, collars, tags



SECR models
spatially-explicit capture-recapture

assumptions

1. population closure
2. individuals remain equally recognizable across captures
3. variation in detection probability can be modelled
4. every animal has some possibility of being detected
5. captures of different individuals are independent
6. no behavioral response to being photographed
7. sampling observations are independent
8. animal ranges are stable throughout trapping session
9. trap placement is random with respect to distribution of animal home ranges

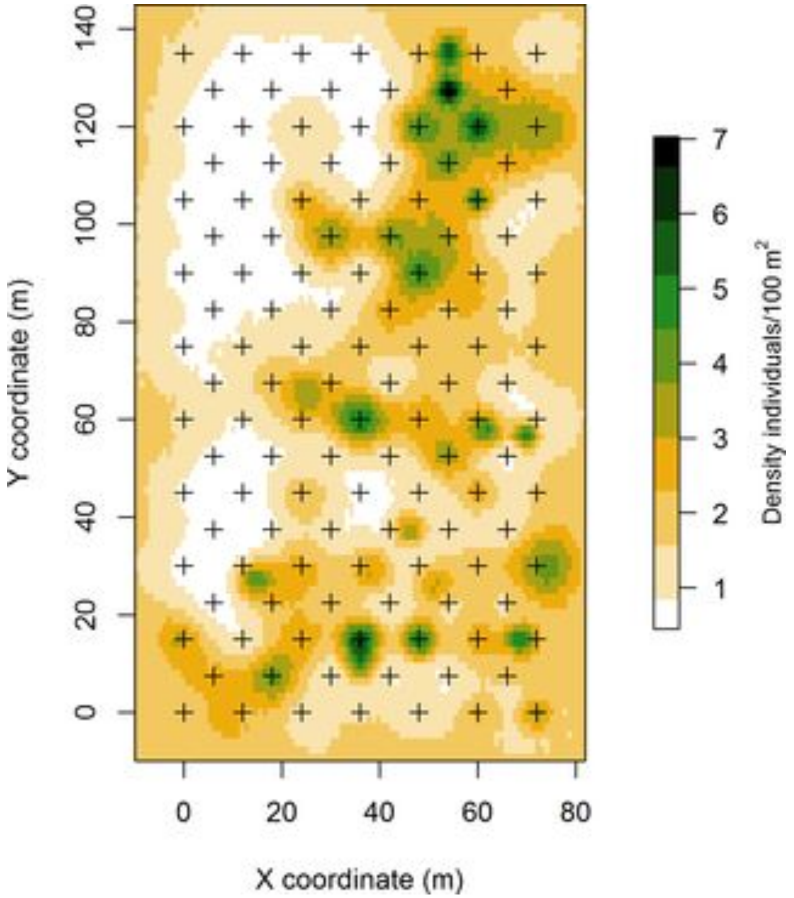


SECR models

spatially-explicit capture-recapture

trap spacing and positioning

- want multiple traps (≥ 2) per home range
  - aim for inter-trap distance of 1/3 of home-range radius or 4-7 cameras per home range
- can be placed in any configuration
  - still preferential to randomize placement or place across a range of microhabitats
- paired traps to capture both sides individual
- shape of grid: low surface-to-area ratio to minimize ”edge effects”

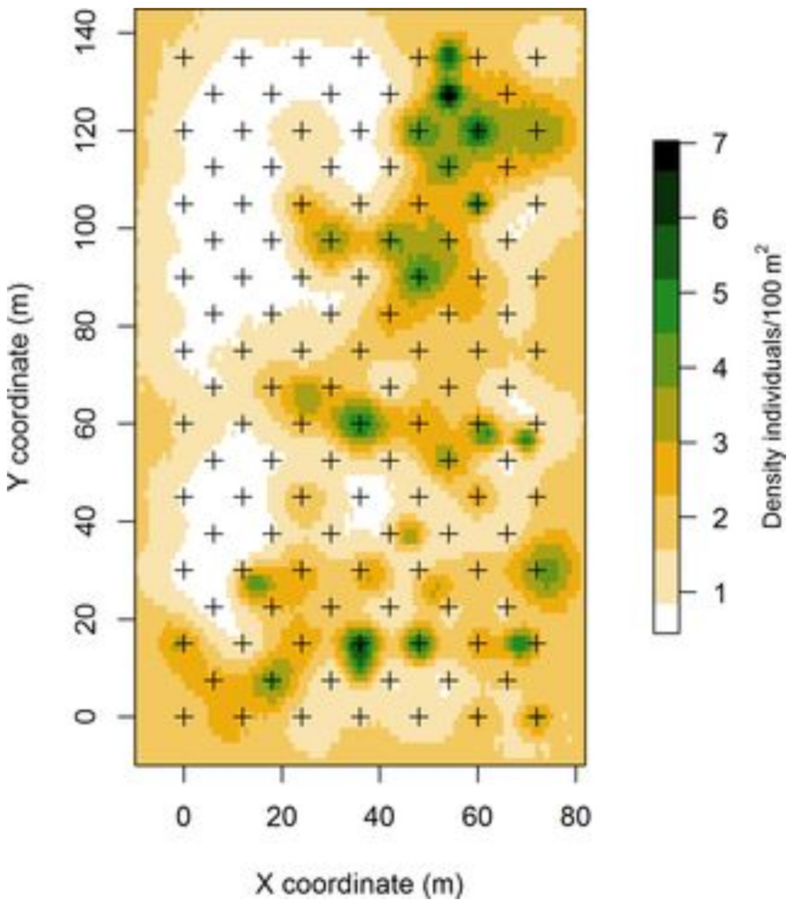


SECR models

spatially-explicit capture-recapture

trapping effort

- number of sampling locations
  - encompass ranges of 5-10 individuals **minimum**
  - ideally, expose 10-30 individuals to sampling
  - recommend ~4 cameras per home range, so 40-120 camera locations total
  - low capture probabilities = more locations needed
- length of study
  - at least 1,200 trap nights
  - period of study should be short as possible to satisfy assumptions of closure



questions relating to animal behavior

- activity patterns
- foraging ecology
- intra-specific interactions
  - social systems
- inter-specific interactions
  - niche partitioning
  - competition, predation, mutualisms
- wildlife-human interactions

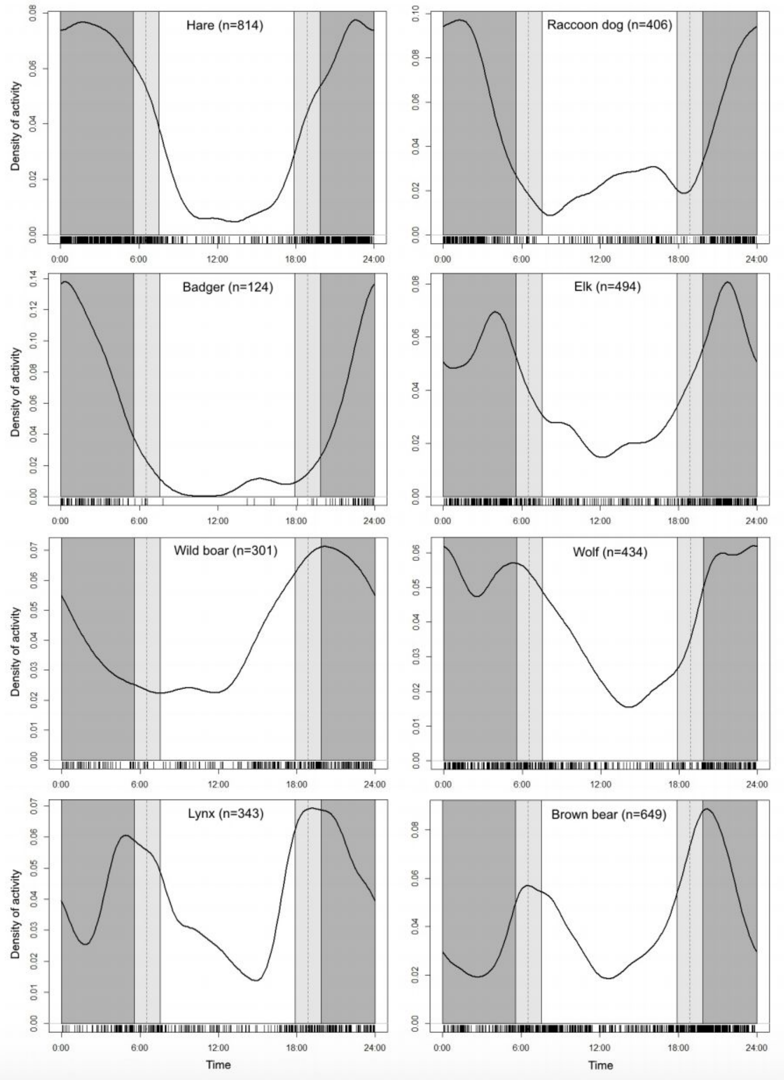
behavior

wide range of study topics:

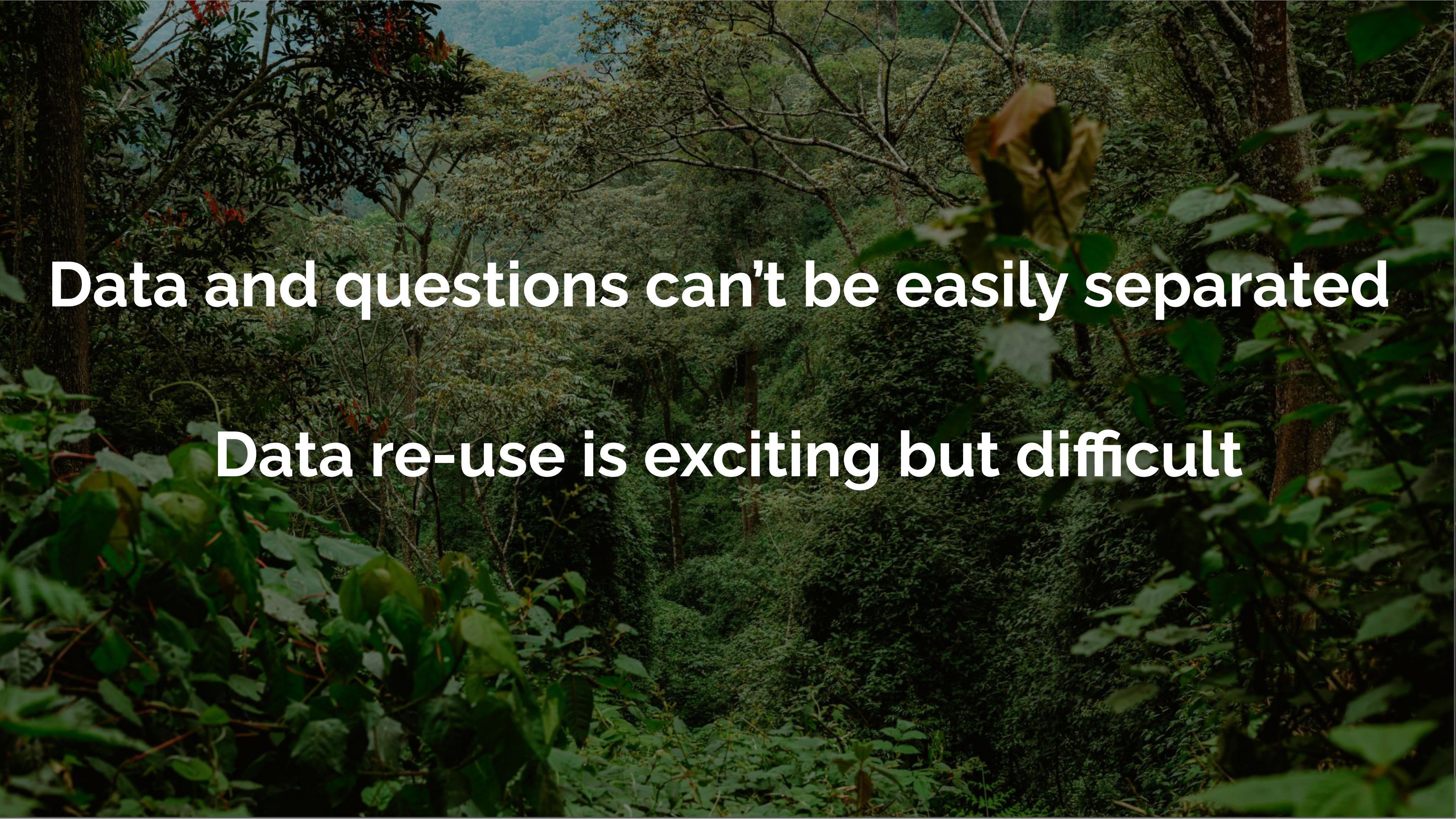
- predation, foraging, mating, parental care, inter-species interactions, human-wildlife conflict, etc.
- some qualitative and some quantitative
- focus of study could be on one particular species or one location

temporal activity

- preferably random sampling across area of interest
- at least 100 samples to characterize patterns with any degree of precision



(figure: Ogurtsov et al.


Data and questions can't be easily separated
Data re-use is exciting but difficult