# 01\_question-info-box DEMO

## 01\_question-info-box\_DEMO\_ ANNE

### 00\_notes-for-anne

* Only those assigned to you for the demo are here (first round, there are still LOTS to do)
* Eventually, we’ll need info for everything under “rec\_sample-design” and “mod\_approach”, but suggest we start with those in this table
* All **full text references** should now go in the ”06\_references.docx” file with the in-text citation left in the “references” box within the question. Could ignore for now, may be easier to address all at once. If you add a reference for something that’s not likely to be in the survey guidelines, perhaps add a comment with the full-text reference for now. No need to dig through survey guidelines though, if you’re not sure, can leave without or add comment with reference and I can address later.
* Don’t worry too much about formatting (styles, text size etc.) all will need to be converted to markdown anyways. EXCEPT, superscript should be formatted
* Some sections may not make sense for the topic (i.e., may not need images for some concepts), **just leave these blank or add “NA”**
* If you copy any text from the survey guidelines/metadata standards that contains links, **leave the links IN**

##### **Assignments -** [**01\_question-info-box DEMO**](https://docs.google.com/document/d/1DonTklgmf4FP56TuyIZzLsDmaZ5JghFh/edit#heading=h.gjdgxs)

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| --- | --- | --- | --- | --- |
| **info\_type** | **app\_page\_name** | **question\_code** | **who** | **status** |
| questions | 13.1\_sp\_info | i\_sp\_info | Anne |  |
| questions | 16.1\_sp\_occ\_restr | i\_sp\_occ\_restr | Anne |  |
| questions | 47.1\_cam\_independent | i\_cam\_independent | Anne |  |
| questions | 6.1\_cam\_strat\_covar | i\_cam\_strat\_covar | Anne |  |
|  |  |  | Anne |  |
| questions | 10.1\_sp\_asymptote | i\_sp\_asymptote | Cassie | In progress |
| questions | 17.2\_sp\_hr\_size | i\_sp\_hr\_size | Cassie | In progress |
| questions | 18.1\_sp\_size | i\_sp\_size | Cassie | In progress |
| questions | 19.1\_sp\_rarity | i\_sp\_rarity | Cassie | In progress |
| questions | 2.1\_objective | i\_objective | Cassie | In progress |
| questions | 20.1\_sp\_detprob\_cat | i\_sp\_detprob\_cat | Cassie | In progress |
| questions | 8.1\_surv\_dur\_min\_max | i\_surv\_dur\_min\_max | Not sure info box needed ? ANNE, THOUGHTS? |  |
| questions | 3.1\_num\_cams | i\_num\_cams | Not sure info box needed? ANNE, THOUGHTS? |  |

### (#i\_sp\_occ\_restr)=

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Question:** Is the distribution of the Target Species highly restricted? | | | | |
| **Overview** | | | | |
| **Advanced** | | | | |
| **Figures & Videos** | | | | |
| Image | | | File name | |
| Example…A sign with text on it  Description automatically generated | | | Mccomb-et-al\_2010\_Fig10.1.png | |
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| **Analytical tools & resources** | | | | |
| **Name** | **Link** | **Reference** | | **Additional\_info** |
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| **References** | | | | |

### (#i\_cam\_independent)=

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Question:** Will each camera location be treated as an independent sample? | | | | |
| **Overview** | | | | |
| **Advanced** | | | | |
| **Figures & Videos** | | | | |
| Image | | | File name | |
| Example…A sign with text on it  Description automatically generated | | | Mccomb-et-al\_2010\_Fig10.1.png | |
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| **Analytical tools & resources** | | | | |
| **Name** | **Link** | **Reference** | | **Additional\_info** |
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| **References** | | | | |

### (#i\_sp\_info)=

Related to recommendations in survey guidelines for species inventory

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Question:** How well is the biology about of the Target Species known? | | | | |
| **Overview** | | | | |
| **Advanced** | | | | |
| **Figures & Videos** | | | | |
| Image | | | File name | |
| Example…A sign with text on it  Description automatically generated | | | Mccomb-et-al\_2010\_Fig10.1.png | |
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| **Analytical tools & resources** | | | | |
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| **References** | | | | |

### (#i\_cam\_strat\_covar)=

# Stratified habitat covariates

how this will impact site selection considerations

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| --- | --- | --- | --- | --- |
| **Question:** Do you plan to strategically place camera locations to include multiple habitats or otherwise differing categories (e.g., different land cover types, or near vs. far from a disturbance)  If so, how many covariates? (e.g., 5 different habitat types would be 5 covariates) | | | | |
| **Overview** | | | | |
| **Advanced** | | | | |
| **Figures & Videos** | | | | |
| Image | | | File name | |
| Example…A sign with text on it  Description automatically generated | | | Mccomb-et-al\_2010\_Fig10.1.png | |
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| **Analytical tools & resources** | | | | |
| **Name** | **Link** | **Reference** | | **Additional\_info** |
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|  |  |  | |  |
| **References** | | | | |

## 01\_question-info-box\_DEMO\_ CASS

### (i\_objective)=

### Objectives/State variable

|  |  |  |  |
| --- | --- | --- | --- |
| **def\_key** | **key** | **Objective** | Definition/Notes |
|  | **(#survey\_objectives)** | **Objective** | The specific objectives of the study, including the Target Species, the state variables (e.g., occupancy, density), and proposed modelling approach(es). Objectives should be specific, measurable, achievable, relevant, and time bound (i.e., SMART). |
|  | **(#state\_variable)** | **State variable** | A formal measure that summarizes the state of a community or population at a particular time (Wearn & Glover Kapfer, 2017), e.g., species richness or population abundance. |
| **d\_obj\_inventory** | **obj\_inventory** | **Species inventory** | a rapid assessment of species present in a given area at a given point in time; there is no attempt made to quantify aspects of communities or populations (Wearn & Glover-Kapfer, 2017). |
|  |  | Species diversity & richness - | Note that there are multiple “levels” to species richness (**α-richness [alpha], γ-richness (gamma), and** **β-diversity (beta)**); refer to (Models - Species diversity & richness)(#i\_mod\_divers\_rich) for more details. |
| d\_obj\_divers\_rich | obj\_divers\_rich | Species diversity & richness - Species diversity |  |
|  | obj\_divers\_rich | Species diversity & richness - Species richness | the number of species found in the community/area measured (Pyron, 2010) |
|  | obj\_divers\_rich | Species diversity & richness - **α-richness (alpha richness)** | species richness at the level of an individual camera location |
|  | obj\_divers\_rich | Species diversity & richness - **γ-richness (gamma richness)** | species richness across a whole study area |
|  | obj\_divers\_rich | Species diversity & richness - **β-diversity (betadiversity)** | the differences between the communities or, more formally, the variance among the communities |
| d\_obj\_occupancy | obj\_occupancy | Occupancy | the probability a site is occupied by the species {{McKenzie et al., 2002}}. Occupancy is also highly suitable for evaluating broad-scale patterns of species distribution {{Wearn & Glover-Kapfer, 2017}}. |
|  | obj\_rel\_abund | Relative abundance | Is an an indirect measure of abundance  Relative abundance can be evaluated via “indices”  When observational data is converted to a detection rate (i.e., the frequency [count] of independent detections of a species within a distinct time period). An index can be a count of animals or any sign that is expected to vary with population size (Caughley, 1977; O’Brien, 2010). |
|  | obj\_rel\_abund | Relative abundance - Intensity of use | “the expected number of use events of a specific resource unit during a unit of time” (i.e., “how frequently a particular resource unit is used”) (Keim et al., 2019).  “Intensity of use differs from probability of occupancy, selection or use, which can remain constant even when the intensity of use varies” (Keim, DeWitt, & Lele, 2011; Lele et al., 2013). |
|  | obj\_rel\_abund | Relative abundance - Probability of use | “the probability of at least one, use event of that resource unit during a unit of time” (i.e., “would a particular resource unit be used at least once) (Keim et al., 2019). |
|  | obj\_pop\_size | Population size | number of individuals in a population (irrelevant of area). |
|  | obj\_abundance | Absolute abundance | number of individuals in a population (Wearn & Glover-Kapfer, 2017; pg 64). |
|  | obj\_vital\_rate | Vital rates | (e.g., survival probabilities and recruitment rates) |
|  | obj\_density | Density | The number of individuals per unit area (Wearn & Glover-Kapfer, 2017). |
|  | obj\_behaviour | Behaviour | behaviour focused objectives vary greatly; they may be qualitative or quantitative (Wearn & Glover-Kapfer, 2017) (e.g., diel activity patterns, mating, boldness, predation, foraging, activity patterns, vigilance, parental care [Caravaggi et al. 2017; Wearn & Glover-Kapfer, 2017]). |

### (#i\_sp\_rarity)=

# Species rarity

describe rarity + Determine "cut-off" values or provide comparable species for users to base selection

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Question:** How rare or common is the Target Species? | | | | |
| **Overview**  **\*\***Species rarity**\*\*** describes how many individuals present of the species, relative to the total number of individuals of all species (or how “represented” is the species when considering the total number of individuals of all species). Generally, species rarity can be thought of as the probability that the species occupies the site (or study area, depending on the scale of interest). [Note about relating to site as well as species characteristics]  **\*\*Species rarity categories are defined as follows\*\*:**   * **\*\*Common\*\*:**    + probability of occupancy > ~0.75-0.8 (> 0.75 [Kinnaird & O'Brien, 2011; Kays et al., 2020]; > 0.8 [Shannon et al., 2014; Wearn & Glover-Kapfer, 2017]) * **\*\*Less common\*\***: * **\*\*Rare\*\*:** probability of occupancy < 0.25 (Kays et al., 2020) * **\*\*Very-rare\*\***: probability of occupancy < 0.001 (Wearn & Glover-Kapfer, 2017; Rowcliffe et al., 2008; O'Brien, 2010) * **\*\*Unknown\*\*:** select this option if you’re not sure of the rarity of your Target Species (single or multiple species) * **\*\*Multiple\*\*:** select this option if your study includes multiple Target Species that vary in rarity. | | | | |
| **Advanced** | | | | |
| **Figures & Videos** | | | | |
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| **Analytical tools & resources** | | | | |
| **Name** | **Link** | | **Reference** | **Additional\_info** |
|  |  | |  |  |
|  |  | |  |  |
| **References**  (Chatterjee et al., 2021)  (Kinnaird & O’Brien, 2012)  (Kays et al., 2020)  (Shannon et al., 2014)  (Wearn & Glover-Kapfer, 2017)  (Rowcliffe et al., 2008)  (O'Brien, 2010) | | Glossary | | |

**notes**

* “low to moderate occupancy (ψ < 0.9)” ([Fuller et al., 2022, p. 14](about:blank)) ([pdf](about:blank))
* “Rarity is a species characteristic, but not in the same sense that hair colour or wing venation or other morphological traits are;it is an emergent trait of a species' population and its environment rather than a trait of an individual organism.” ([“The Biology of Rarity”, 1997, p. 3](zotero://select/library/items/GA55PMBU)) ([pdf](zotero://open-pdf/library/items/XPPSEZIT?page=16))

**Refs**

* Southwell, D. M., Einoder, L. D., Lahoz‐Monfort, J. J., Fisher, A., Gillespie, G. R., & Wintle, B. A. (2019). Spatially explicit power analysis for detecting occupancy trends for multiple species. *Ecological Applications*, *29*(6), e01950. <https://doi.org/10.1002/eap.1950>
* Wenger, S. J., & Freeman, M. C. (2008). Estimating Species Occurrence, Abundance, and Detection Probability Using Zero-Inflated Distributions. *Ecology*, *89*(10), 2953–2959. <https://doi.org/10.1890/07-1127.1>
* Chatterjee, N., Schuttler, T. G., Nigam, P., & Habib, B. (2021). Deciphering the rarity–detectability continuum: Optimizing survey design for terrestrial mammalian community.
* Kunin, W. E., & Gaston, K. J. (Eds.). (1997). *The Biology of Rarity*. Springer Netherlands. <https://doi.org/10.1007/978-94-011-5874-9>
* Flather, & Sieg. (2007). Species rarity: Definition, causes, and classification.
* Steenweg, R., Hebblewhite, M., Whittington, J., & Mckelvey, K. (2019). Species‐specific differences in detection and occupancy probabilities help drive ability to detect trends in occupancy. *Ecosphere*, *10*(4). <https://doi.org/10.1002/ecs2.2639>

### (#i\_sp\_detprob\_cat)=

# Detection probability

Describe detectability; define "detectability" options; incorporate interaction with lure? + ways to address + considerations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Question:** How detectable is Target Species?  Are all of the Target Species similarly detectable? (e.g., ) If all are similar, which best describes the Target Species detectability? | | | | |
| **Overview**  This question is asking about how easily you can detect the Target Species if it is present (i.e., “detectability”); simply put, how likely are you to detect an individual that is present.  **Detection probability (aka detectability) is defined as** the probability (likelihood) that an individual of the population of interest is included in the count at time or location *i*.  [insert info on how this relates to study design recommendations; ideally, modelled using project data]  Detection probability categories are defined as follows:   * **\*\*Low\*\*:**    + < 0.1 (Tobler & Powell, 2013)   + < 0.05 (Shannon et al., 2014)   + 0–0.37 (Chatterjee et al., 2021) * **\*\*Medium\*\*:**    + 0.37–0.67 (Chatterjee et al., 2021) * **\*\*High\*\*:**   + 0.67–1 (Chatterjee et al., 2021)   + > 0.5 (Mackenzie & Royle, 2005) * **\*\*Unknown\*\*:** select this option if you’re not sure of the detection probability of your Target Species (single or multiple species) * **\*\*Multiple\*\*:** select this option if your study include multiple Target Species.   ::: {note}  In order to determine the appropriate sampling design for your [Target Species](), we must consider detection probability.  Species are often detected "imperfectly," meaning that they are not always detected when they are present (i.e., imperfect detection, e.g., due to cover of vegetation, cryptic nature or small size) (MacKenzie et al., 2004). Imperfect detection results in “false absences” and may lead to incorrect conclusions from the data. Understanding and correcting for sources of “false absences” is often thought of in terms of probabilities. Detection probability is the probability (likelihood) that an individual from the population of interest is included in the count at time or location *i* (MacKenzie & Kendall, 2002). Detection probability can be influenced through multiple processes and at multiple scales.  For example:   * "Species living in groups have a higher chance of triggering the camera when they pass in front of the camera, and carnivores are known to cover a larger distance than species of other feeding guilds" (Garland, 1983) * Species vary in emissions of infrared radiation, which can inflate relative detection rates of warmer, larger species (Wearn & Glover-Kapfer, 2017).   [insert note about relating to site]  ::: | | | | |
| **Advanced**  Before study design choices are made, there is one critical concept to understand in remote camera research, which may impact study design choices at all levels of the data hierarchy. Reliable use of remote cameras to detect wildlife species hinges on the assumption that what is captured on the cameras accurately reflects what is present on the landscape. However, species are often detected "imperfectly," meaning that they are not always detected when they are present (i.e., imperfect detection, e.g., due to cover of vegetation, cryptic nature or small size) (MacKenzie et al., 2004). Imperfect detection can occur because the camera failed to capture an individual present at the site or because the animal was simply not present during the survey period (Martin et al., 2005).  Imperfect detection results in “false absences” and may lead to incorrect conclusions from the data. Understanding and correcting for sources of “false absences” is often thought of in terms of probabilities. Detection probability is the probability (likelihood) that an individual from the population of interest is included in the count at time or location i (MacKenzie & Kendall, 2002). Detection probability can be influenced through multiple processes and at multiple scales. Understanding the sources of “false absences” and factors that affect detection probabilities is an essential step when designing a study, deploying cameras and analyzing camera data.  The detection probability of an animal by a camera depends on **\*\*three conditional probabilities (Pr) of detection\*\*** that may operate alone or potentially in combination (Figure 1).  Detection probability can be affected by species-specific characteristics, Camera Model specifications and set-up, and environmental variables (Hofmeester et al., 2019). For example, **species-specific characteristics** (individuals or populations), such as body size (e.g., O’Brien et al., 2011), behaviour (e.g., Caravaggi et al., 2020; Rowcliffe et al., 2011), and rarity can influence detection probability, with larger, bolder and more common species generally having higher detection rates. Camera Model **\*\*specifications and set-up\*\***, such as the Trigger Sensitivity, Camera Height, or angle may affect detection probability in that smaller species might not be detected or identifiable if the Trigger Sensitivity is low, or the Camera Height or angle is too high. The Camera Direction could impact the probability of an animal triggering a camera if it is directed towards an object that impedes the Field of View (FOV) or image quality (e.g. due to sun glare). Environmental factors (e.g., vegetation cover, snow depth) may affect detection probability and occurrence (e.g., Becker et al., 2022; Hofmeester et al., 2019; Iknayan et al., 2014; Steenweg et al., 2019). For example, a low number of detections in a densely vegetated site might be because of poor camera visibility or avoidance of this habitat by the species of interest.  Hofmeester et al. (2019) suggested there are **\*\*six scales (orders) that may impact detection probability\*\*** and that should be considered within an explicit time period (adapted from Hofmeester et al. [2019]; Figure 2):   1. **\*\*Distribution range\*\*** (1st order; i.e., the physical or geographical range of a species) 2. **\*\*Landscape\*\*** (2nd order; i.e., the location of an individual’s home range within the geographic range) 3. **\*\*Habitat patch\*\*** (3rd order; i.e., usage of habitat components within an individual’s home range) 4. **\*\*Microsite\*\*** (4th order; usage of microhabitats such as food items/feeding patches/nest sites/movement trails, etc. within a habitat) 5. **\*\*Camera specification / set-up\*\*** (5th order; i.e., factors that affect the probability that an animal [triggers](#bookmark=id.2u6wntf) the camera if present) 6. **\*\*Image\*\*** (6th order; i.e., factors that affect correct identification of animals or individuals)   Unmeasured variation in detection probability can result in the inability to differentiate the effects of detection probability vs. habitat preference (Jennelle et al., 2002) and, in turn, cause erroneous estimates of occurrence and abundance (Burton et al., 2015; Dénes et al., 2015; Kays et al., 2021).  Factors that influence detection probability at the microsite and camera specification / set-up scales are likely to result in the largest biases and thus warrant the most consideration (see Hofmeester et al. [2019] for details). Therefore, it is particularly important to consider how to place cameras to avoid such biases. Deploying cameras in a consistent fashion (e.g., carefully ensuring that cameras are always set at the same Camera Height, orientation (direction), and angle) is essential. | | | | |
| **Figures & Videos** | | | | |
| A screenshot of a computer  Description automatically generated  ```{figure} ../03\_images/03\_image\_files/survey\_guidelines/Detection-probability-2023-05-04.png  :align: center  ```  **Figure 1.** Three conditional probabilities (Pr) of detection that may impact the detection probability of an animal (or species) by a camera (adapted from Moeller et al. [2023], Hofmeester et al. [2019], and Findlay et al. [2020]). | | | A screenshot of a computer  Description automatically generated  ```{figure} ../03\_images/03\_image\_files/survey\_guidelines/DetectionProb\_Hofmeester-et-al\_2019\_Fig1.png  :align: center  ```  **Figure 2.** Spatial scales (1-6) and processes that determine the detection probability (Hofmeester et al., 2019; abbreviated figure caption). | |
| A diagram of a diagram  Description automatically generated  ```{figure} ../03\_images/03\_image\_files/Tourani-et-al\_2020\_Fig1.png  :align: center  ``` | | | A chart with yellow and green squares  Description automatically generated ```{figure} ../03\_images/03\_image\_files/Iknayan-et-al\_2014\_Fig2.png  :align: center  ``` | |
| **Analytical tools & resources** | | | | |
| **Name** | **Link** | **Reference** | | **Additional\_info** |
| psolymos/detect: R package for analyzing wildlife data with detection error | https://github.com/psolymos/detect  https://peter.solymos.org/detect/ |  | |  |
|  |  |  | |  |
| **References**  (Alberta Remote Camera Steering Committee (RCSC) et al., 2023)  (Chatterjee et al., 2021)  (Mackenzie & Royle, 2005)  (Shannon et al., 2014)  (Tobler & Powell, 2013) | | | | |

**notes**

* It is important to understand and account for factors that affect detectability since unmeasured variation in detectability can result in the inability to differentiate the effects of detectability vs. preference (Jennelle et al., 2002).
* **MEEK -** The relationship between the target animals and the camera trap model or study design used is particularly important because design features of a camera, and the way in which it is deployed, may affect the ability to detect target species (Harmsen et al. 2009).
* Unmeasured variation in detectability can cause large errors in estimates of both occurrence and abundance (Burton et al. 2015; Dénes et al. 2015; Kays et al. 2021).

### (#i\_sp\_asymptote)=

# Species-accumulation asymptote

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Question:** Do you wish to sample long enough to reach the species-accumulation asymptote? | | | | |
| **Overview**  This question is related to the state variable “Species Diversity & Richess”  A “species accumulation curve.... gives the expected number of observed species as a function of sampling effort” {{ intext\_deng-et-al\_2015 }}.  Species accumulation curves are used “to assess and compare diversity across populations or to evaluate the benefits of additional sampling” {{ intext\_van-dooren\_2016 }}. The species-accumulation asymptote refers to the point on the curve where you’ve sampled long enough to observe \**most*\*of the species present.  In other words, a species accumulation curve shows you the relationship between the sampling duration and the number of species detected (i.e., how you might expect to “accumulate” new species as time goes on). Consider the figure below. You can see that as the “number of records” (on the x-axis) increases, at first (where the line is the steepest), you detect new species quickly. This is because many species that are easy to detect and/or common, and thus you’re more likely to encounter them in a shorter amount of time. Yet as time goes on (you collect more samples), the rate at which you detect new species starts to slow down (fewer and fewer new species over the same amount of time that passes / # samples are collected); this is because, in general, rare species will occur much less often, and thus more time is needed to allow them all a chance to visit the camera location. Therefore, the curve starts to level off as after you’ve detected most (or all) of the easily detectable/common species and are slowly detecting those that are less detectable and/or less common. As this line flattens out, eventually, barely any new species are detected, if any are at all.  Whether you choose to sample long enough to reach the species-accumulation asymptote will depend on your modelling approach, since it not always necessary; some non-parametric methods are thought to estimate asymptotic richness fairly well “even when extrapolating to double or triple the size of the sample” {{ intext\_colwell-et-al\_2012; intext\_wearn-et-al\_2017}}.  \*\*If you’re not sure, select the conservative answer of “Yes”\*\* | | | | |
| **Advanced**  **[NULL?]** | | | | |
| **Figures & Videos** | | | | |
| ```{figure} ../03\_images/03\_image\_files/Gotelli-and-Colwell\_2011\_Fig4.1.png  :align: center  ```  \*\*(Gotelli and Colwell 2011)\*\* | | | ```{figure} ../03\_images/03\_image\_files/VanDooren\_2016\_Fig1.png  :align: center  ```  \*\*\*(Van Dooren, 2016)\*\*\* | |
| Video: Species Accumulation Curves (11 minutes)  <iframe width="560" height="315" src="https://www.youtube.com/embed/Jj7LYrU\_6RA?si=odfIIBoC2w9h3\_CU" title="YouTube video player" frameborder="0" allow="accelerometer; autoplay; clipboard-write; encrypted-media; gyroscope; picture-in-picture; web-share" referrerpolicy="strict-origin-when-cross-origin" allowfullscreen></iframe> | | | https://chao.shinyapps.io/iNEXTOnline/ | |
| **Analytical tools & resources** | | | | |
| **Name** | **Link** | **Note** | | **Reference** |
| Species Accumulation Curves | <https://www.pisces-conservation.com/sdrhelp/index.html?specaccum.html> |  | |  |
| iNext Online | <https://chao.shinyapps.io/iNEXTOnline/  <https://www.youtube.com/watch?v=h3MLWK9IJ4A> | Software for interpolation and extrapolation of species diversity  Rarefied Species Accumulation Curves (the simple way) tutorial | |  |
| Species Accumulation Curves with vegan, BiodiversityR and ggplot2 | <https://rpubs.com/Roeland-KINDT/694021> |  | | Roeland Kindt, R. (2020). Species Accumulation Curves with vegan, BiodiversityR and ggplot2. https://rpubs.com/Roeland-KINDT/694021 |
| **References**  {{ gotelli-colwell\_2011 }}  {{ deng-et-al\_2015 }}  {{ rovero-et-al\_2010 }}  {{ si-et-al\_2014 }}  {{ van dooren\_2016 }}  {{roeland, 2020}} | | | | |

**Notes**

The species accumulation curve of a population gives the expected number of observed species as a function of sampling effort (Deng, Daley, and Smith 2015)

The few species-accumulation curves for camera trap data that have been published seem to level off between 20 and 100 locations (Ahumada et al. 2011; Li et al. 2012; Wearn et al. 2016). Helpfully, it may not always be necessary to sample until species-accumulation curves have begun to reach their asymptote. Non-parametric methods of estimating asymptotic richness are thought to yield good results even when extrapolating to double or triple the size of the sample

Robero & Tobler, 2010) “Species accumulation curves have been widely used to visually assess the completeness of an inventory and to compare diversity between surveys with different sampling effort (Colwell & Coddington, 1994; Krebs, 1999; Gotelli & Colwell, 2001). They plot the cumulative number of species detected against the survey effort and reach an asymptote when all species have been recorded. Raw species accumulation curves have a stepped shape that makes it hard to detect an asymptote (Fig. 4). This problem is solved by rarefied species accumulation curves which smooth the curve by randomly re-sampling the data and calculating the average number of species expected to be found at a given sampling intensity (Gotelli & Colwell, 2001). While species accumulation curves can be used to compare diversity between different samples, the shape of the curve can vary with the relative abundance of different species (Thompson & Withers, 2003). Communities with a high proportion of abundant species have a steeper initial slope than communities with a high proportion of rare species.

(Si et al., 2014) - Species accumulation curve: “the relationship of the number of species and the sampling effort, which may depend on the time or area sampled. One expects curves to approach an asymptote, and thus give a judgment of sampling adequacy (Daubenmire, 1968). In long-term monitoring projects, sampling over gradients in time is logically similar to sampling over gradients in space (Colwell & Coddington, 1994).

https://www.pisces-conservation.com/sdrhelp/index.html?specaccum.htm

### (#i\_sp\_low\_density)=

# Does the Target Species occur in low density?

Provide guideline of what constitutes "low density" (e.g. < x/ km2)? scale - in the area of interest? The difference between this question nd "how rare or common..." may not be readily apparent

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| **Question:** Does the Target Species occur in low density? | | | | |
| **Overview** | | | | |
| **Advanced** | | | | |
| **Figures & Videos** | | | | |
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| **Analytical tools & resources** | | | | |
| **Name** | **Link** | **Reference** | | **Additional\_info** |
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| **References** | | | | |

**notes**

* “low density populations (6 or 16.5 bears/100 km2)” ([Fuller et al., 2022, p. 14](about:blank)) ([pdf](about:blank))

### (#i\_sp\_hr\_size)=

# Home range data

Home range data - importance for site selection

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| **Question:** Is home range size information available for your Target Species (can be taken from the literature)? If so, enter the home range diameter (in metres) | | | | |
| **Overview**  Check the linked table from "HomeRange: A global database of mammalian home ranges" (Broekman et al., 2022) or see if you can find similar information on home range sizes online or elsewhere.  Home range size information should, ideally, be chosen to reflect the conditions of your study (as closely as possible). For example, using data on home range size from a study that only reported home range size for one season (e.g., summer home range size) might bias placement if your study aims to evaluate occupancy over the entire year of a species whose movement highly varies between seasons (e.g., moves more in summer).  ::: {note}  The size of species’ home has implicatons for many modelling approaches.  For example, home range size “has implications for the interpretation of occupancy. If animals range over a much larger area than a single site, then a) they may conceivably be unavailable for capture during a sampling occasion, and b) the “occupancy” of a site is more related to the ranging patterns and habitat preferences of an individual, rather than the coarse-scale distribution of a species” (Wearn & Glover-Kapfer, 2017).  ::: | | | | |
| **Advanced** | | | | |
| **Figures & Videos** | | | | |
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| **Analytical tools & resources** | | | | |
| **Name** | **Link** | **Reference** | | **Additional\_info** |
| HomeRange: A global database of mammalian home ranges | <https://onlinelibrary.wiley.com/doi/epdf/10.1111/geb.13625>  <<https://github.com/SHoeks/HomeRange>>  <https://shoeks.github.io/HomeRange/> |  | | HomeRange, a global database with 75,611 home- range values across 960 different species of mammals, including terrestrial, aquatic and aerial species |
|  |  |  | |  |
| **References** | | Glossary | | |

**notes**

* “Home range size is used as a means to control spacing between detectors when point sampling, but it is not related to the occupancy-abundance relationship and the potential for bias in estimates of occupancy. Rather, the importance of home range size to control spacing is related to bias in the standard errors if the independence of occupancy status assumption (e.g., sites are closed to changes in the state of occupancy for the duration of sampling) is violated. Investigators choose grain size, yet many studies fail to report justification for the selected grain size (Devarajan et al., 2020), and frequently use grid cell size to space traps/detectors under aerial sampling in discrete space and point sampling in continuous space. A final concern related to the site grainsize and assumptionthat the occupancy states across sites are independent relates to spatial correlation in the occupancy process. If individual home ranges overlap more than one point detector (e.g., point sampling of use), there is potential for spatial correlation in neighboring site occupancy states that could lead to false positives in testing hypotheses about ψ, as for example,in incorrectly concluding that occupancy changed (increased or decreased) over time. The outcome of spatial correlation in the occupancy process is that measures of precision will be overestimated (MacKenzie et al., 2017). To our knowledge, these types of false positive errors have not been formally investigated in occupancy models. The choice of grain is therefore an important consideration in occupancy studies since that choice will affect model assumptions and interpretation and is dependent on whether the study involves areal or point sampling (Efford and Dawson, 2012). Finally, point sampling in continuous space may result in unmodeled site-level heterogeneity in detection, resulting in underestimates in both ψ in occupancy models and site-level abundance in Royle-Nichols models (Efford and Dawson, 2012). This form of heterogeneity may arise because the probability of detecting an individual should increase with increasing overlap of its home range and a detector, and the number of individuals varies among occupied sites; the probability of detecting the species given presence may therefore be heterogeneous due to both variation in home-range overlap with sites and abundance at sites, while Royle-Nichols models only account for variation in abundance across sites..” ([Fuller et al., 2022, p. 4](about:blank)) ([pdf](about:blank))

### (#i\_sp\_size)=

# Target Species; Body size

Discuss influence of body size on design choices + Include mention of potential season effects on movement / HR + motility; movement; home range size

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| **Question:** What is the approximate size of the Target Species? | | | | |
| **Overview**  Here are a few examples of comparable species for each body size options:   * \*\***Small**\*\*: rodents and similarly sized species in the “Mustelidae” family [i.e., weasels, badgers, otters, martens, wolverine, etc.]) * \*\***Medium**\*\*: small and mid-sized species, ~< 33 lbs (or 15 kilograms), such as meso-carnivores (i.e., Red, fox, Coyote) {{Roemer et al., 2009}} * \*\***Large**\*\*: bears or ungulates (i.e., large mammals with hooves, such as White-tailed deer, Elk, Moose, etc) * \*\***Multiple**\*\* - \*select this option if your study includes multiple Target Species that vary in body size.\*   **Why does this matter?**    ```{figure} ../03\_images/03\_image\_files/Kays-et-al\_2021\_Fig6.png  :align: center  ``` | | | | |
| **Advanced** | | | | |
| **Figures & Videos** | | | | |
| ```{figure} ../03\_images/03\_image\_files/kays-et-al\_2021\_fig6.png  :align: center  ``` | | | ```{figure} ../03\_images/03\_image\_files/Anile\_Devillard\_2016\_Fig2.jpg  :align: center  ``` | |
| ```{figure} ../03\_images/03\_image\_files/Anile\_Devillard\_2016\_Fig3.jpg  :align: center  ``` | | | ```{figure} ../03\_images/03\_image\_files/BodySize\_Movement.png  :align: center  ``` | |
| ```{figure} ../03\_images/03\_image\_files/Anile\_Devillard\_2016\_Fig3.jpg  :align: center  ```  Fisher-et-al\_2011\_Fig6.png | | | Fisher-et-al\_2011\_Fig6.png | |
| **Analytical tools & resources** | | | | |
| **Name** | **Link** | | **Reference** | **Additional\_info** |
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| **References**  {{Chatterhee et al., 2021}}  {{Fisher et al., 2011}}  {{Roemer et al., 2009}}  {{**LaBarbera et al., 1989}}** | | Glossary | | |
| Not used   * Very small species (< 100 g) are sometimes detected by higherend camera traps on the market today (e.g. Fig 4-3), but detections will only be reliable at distances less than 2 m from the camera ({{Rowcliffe et al. 2011}}) * There is also some evidence that detection angles are smaller for species which move at faster speeds ({{Rowcliffe et al. 2011}}. * Small species which routinely move at fast speeds, such as stoats and weasels, are likely to have especially small detection zones ({{Glen et al. 2013}}). | |  | | |

**Why does this matter?**

Body size should be considered for a few reasons, such as:

* Effects on the detection process:
* Larger species may require lower sampling effort than smaller species; this is because larger species are more likely to trigger the camera (and thus generally have a higher detection probability) ({{Chatterhee et al., 2021}}; {{Chatterhee et al., 2021}})
* Body size affects how easy it is to detect an individual moving through the camera’s detection zone ([detectability]()); larger species can be detected farther away or occur at wider angles ({{Rowcliffe et al. 2011}}; {{Hofmeester et al. 2017}}).
* Dispersal ability / Home range size
* When thinking beyond the camera's FOV, larger species generally also have larger home ranges {{Garland, 1983}} and daily movement distances, making them more likely to be detected at multiple cameras {{Chatterhee et al., 2021}}.
* Species with higher dispersal ability (i.e., able to travel further distances) are also more likely to be absent during the survey (and therefore, may generally occur at a camera location, but weren’t detected when you were sampling)

dispersal distance of mammals is proportional to home range size

* Detection process –
  + Body size affects the detection process (O’Brien et al., 2011) and has been shown to bias estimates from relative abundance indices (Anile et al., 2016).
* Dispersal ability -
  + “All other things being equal, larger species might be more easily trapped as they move more slowly than smaller species, or because their population density is higher (see Bengsen et al., 2011 and Rowcliffe & Carbone, 2008; Rowcliffe et al., 2008 on the importance of population density on trapping rates).”
* “While occupancy was positively correlated with body size, detection probability was not significantly correlated with body size (r = 0.17, P = 0.49).” (Chatterhee et al., 2021)

**Refs**

* Ofstad, E. G., Herfindal, I., Solberg, E. J., & Sæther, B.-E. (2016). Home ranges, habitat and body mass: Simple correlates of home range size in ungulates. *Proceedings of the Royal Society B: Biological Sciences*, *283*(1845), 20161234. <https://doi.org/10.1098/rspb.2016.1234>
* LaBarbera, M. (n.d.). Analyzing Body Size as a Factor in Ecology and Evolution.