## INFO ENTRY - QUESTION INFO

ENTRY NOTES:

* green = does not need to be editted
* yellow = info for the inputter
* ref\_id = “refs\_glossary\_2024-08-09.xls > “references” tab
  + if the reference not present, either add it (if you’re confident that you can follow the format), or add a comment in this doc with the info and I will adjust
* **images – file name in** “refs\_glossary\_2024-08-09.xls > “references” tab
* Ignore everything in the “POPULATE MARKDOWN” section
* Size of columns in tables and text format do not matter; see note on bold and italize below
* Any content with “glue}`` prefix or surrounded by “{{ “ / “ }}” indicates where text will be inserted from the keys
* You may see “<br>” throughout, you can ignore these
* additional formatting notes (optional)
  + \*\***bold**\*\*
  + \**italics*\*
* **Topic Info**
  + If the topic is NOT related to a question, you can leave “question” as NULL
  + “question” here is more for your reference
* **Assumptions, Pros, Cons**
  + Only for modelling approaches; can ignore otherwise (leave table here)
  + [WILL BE HERE, BUT INSERTED DIRECTLY FROM CSV FILE (THUS NO INPUT NEEDED)]
* **Advanced**
  + If the topic doesn’t warrant inclusion, you can leave as NULL
* **Figures**
  + Placeholders here as “filename” can leave in if not <5 images
* **Video**
  + no “<” before the URL text and a “>” after URL in this case
  + ref\_id in this example is not correct, just for illustrative purposes
* **Analytical tools & resources**
  + The ref\_id should be included in the reference column (and the full text reference in the master reference file). If you aren’t sure if the reference is in the master doc, add the full text ref as a comment.
  + Please add a “<” before the URL text and a “>” after (e.g., <http://www.somesitelink.com>)
  + Type can be something similar to: Article, App/Program, R package
* **References / Glossary** 
  + items in-text above (IGNORE FOR NOW)
* **Notes**
  + (future ref / not included in markdown conversion)

## Topic Info

|  |  |
| --- | --- |
| **info\_id** | sp\_rarity |
| **question** | How rare or common is the Target Species?  describe rarity + Determine "cut-off" values or provide comparable species for users to base selection  Note about relating to site as well as species characteristics |

## 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, for a given species (or study area, depending on the scale of interest) {{ref\_intext\_kays\_et\_al\_2020}}.

While technically “how rare” a species is will be fairly dynamic from place to place (e.g., will depend on geographic range, habitat specificity, local abundance, etc.; {{ref\_intext\_crisfield\_et\_al\_2024}}), for the purposes of informing study design recommendations, the \*\*species rarity categories are defined as follows\*\*:

- \*\*Common\*\*: probability of occupancy > ~0.75-0.8 (> 0.75 [{{ref\_intext\_kinnaird\_obrien\_2012}}; {{ref\_intext\_kays\_et\_al\_2020}}]; > 0.8 [{{ref\_intext\_shannon\_et\_al\_2014}}; {{ref\_intext\_wearn\_gloverkapfer\_2017}}])

- \*\*Less common\*\*: 0.25-0.75

- \*\*Rare\*\*: probability of occupancy < 0.25 {{ref\_intext\_kays\_et\_al\_2020}}

- \*\*Very-rare\*\*: probability of occupancy < 0.001 ({{ref\_intext\_wearn\_gloverkapfer\_2017}}; {{ref\_intext\_rowcliffe\_et\_al\_2008}}; {{ref\_intext\_obrien\_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.

::: {note}

Species rarity can be generally thought of as a species characteristic, however, “not in the same sense that hair colour or wing venation… it’ an emergent trait of a species' population and its environment rather than a trait of an individual organism” {{ref\_intext\_kunin\_1997}}

:::

**\*\* [NEED]\*\*:**

- caveats, how to determine rarity

- Percentages for laymans terms

:::

## Advanced

Add some info here

## Figures

|  |  |  |  |
| --- | --- | --- | --- |
| **Image** | **file\_name** | **Caption (if applicable)** | **ref\_id** |
|  | figure1\_filename.png | figure1\_caption | figure1\_ref\_id |
|  | figure2\_filename.png | figure2\_caption | figure2\_ref\_id |
|  | figure3\_filename.png | figure4\_caption | figure3\_ref\_id |
|  | figure4\_filename.png | figure4\_caption | figure4\_ref\_id |
|  | figure5\_filename.png | figure5\_caption | figure5\_ref\_id |
|  | figure6\_filename.png | figure6\_caption | figure6\_ref\_id |

## Video

|  |  |  |
| --- | --- | --- |
| **caption** | **URL (no < / > before/after URL** | **ref\_id** |
| Species accumulation and rarefaction curves | https://www.youtube.com/embed/4gcmAUpo9TU?si=\_S-JYDDskR8QbHs5 | vid1\_ref\_id |
| vid2\_caption | vid2\_url | vid2\_ref\_id |
| vid3\_caption | vid3\_url | vid3\_ref\_id |
| vid4\_caption | vid4\_url | vid4\_ref\_id |
| vid5\_caption | vid5\_url | vid5\_ref\_id |
| vid6\_caption | vid6\_url | vid6\_ref\_id |

## Analytical tools & resources

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| **Type** | **Name** | **Note** | **URL** | **ref\_id** |
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| resource15\_type | resource15\_name | resource15\_note | resource15\_url | resource15\_ref\_id |

## References / Glossary

|  |  |
| --- | --- |
| **ref\_id** | **glossary\_keys** |
| {{ ref\_bib\_chatterjee\_et\_al\_2021 }}  {{ ref\_bib\_kinnaird\_obrien\_2012 }}  {{ ref\_bib\_kays\_et\_al\_2020 }}  {{ ref\_bib\_shannon\_et\_al\_2014 }}  {{ ref\_bib\_wearn\_gloverkapfer\_2017 }}  {{ ref\_bib\_rowcliffe\_et\_al\_2008)  {{ ref\_bib\_southwell\_et\_al\_2019 }}  {{ ref\_bib\_flather\_sieg\_2007 }}  {{ ref\_bib\_kunin\_1997 }} | keys\_here |

## Notes

(future ref / not included in markdown conversion)

* “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))
* The difficulties with estimating occupancy for very rare species are compounded by the fact that there is often a positive correlation between occupancy and detectability (e.g. Shannon et al. 2014), meaning that many rare species also have low detection probabilities. When this is the case, for example if detection probability is < 0.05, it may be very difficult to obtain any occupancy estimate at all (O’Brien 2010; Shannon et al. 2014), or it may erroneously be estimated as 1 (a “boundary effect”; Guillera-Arroita et al. 2010). When this is the case, another option is to employ hierarchical multi-species occupancy models, in which occupancy and detection probability parameters for rare species are estimated by “borrowing strength” from information on more common species (e.g. Tobler et al. 2015; Wearn et al. 2017).
* For species which are especially elusive and difficult to detect (with detection probabilities < 0.05), 80-100 days of sampling may be required (Shannon et al. 2014).
* ψ (occupancy): the expected probability that a given camera site is occupied, for a given species (Kays et al., 2020)
* The three-dimensional rarity typology proposed by Rabinowitz in 1981, based on geographic range, habitat specificity, and local abundance, is among the most widely used frameworks for describing rarity in ecological and conservation research.

<https://www.researchgate.net/publication/236965289_Species_rarity_definition_causes_and_classification#:~:text=Rarity%20is%20a%20relative%20concept,of%20other%20organisms%20of%20comparable>

# POPULATE MARKDOWN

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(i\_mod\_divers\_rich)=

# {{ name\_mod\_divers\_rich }}

### :::::::::{div} full-width

### ::::::{dropdown} Assumptions, Pros, Cons

:::::{dropdown} Species richness (Alpha diversity)

::::{grid}

:::{grid-item-card} Assumptions

- {{ mod\_divers\_rich\_alpha\_assump\_01 }}

- {{ mod\_divers\_rich\_alpha\_assump\_02 }}

- {{ mod\_divers\_rich\_alpha\_assump\_03 }}

- {{ mod\_divers\_rich\_alpha\_assump\_04 }}

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:::{grid-item-card} Pros

- {{ mod\_divers\_rich\_alpha\_pro\_01 }}

- {{ mod\_divers\_rich\_alpha\_pro\_02 }}

- {{ mod\_divers\_rich\_alpha\_pro\_03 }}

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:::{grid-item-card} Cons

- {{ mod\_divers\_rich\_alpha\_con\_01 }}

- {{ mod\_divers\_rich\_alpha\_con\_02 }}

- {{ mod\_divers\_rich\_alpha\_con\_03 }}

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:::::{dropdown} Species diversity (Beta diversity)

::::{grid}

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- {{ mod\_divers\_rich\_beta\_assump\_03 }}

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:::{grid-item-card} Pros

- {{ mod\_divers\_rich\_beta\_pro\_01 }}

- {{ mod\_divers\_rich\_beta\_pro\_02 }}

- {{ mod\_divers\_rich\_beta\_pro\_03 }}

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:::{grid-item-card} Cons

- {{ mod\_divers\_rich\_beta\_con\_01 }}

- {{ mod\_divers\_rich\_beta\_con\_02 }}

- {{ mod\_divers\_rich\_beta\_con\_03 }}

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:::::{dropdown} Species diversity (Gamma diversity)

::::{grid}

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- {{ mod\_divers\_rich\_gamma\_assump\_03 }}

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:::{grid-item-card} Pros

- {{ mod\_divers\_rich\_gamma\_pro\_01 }}

- {{ mod\_divers\_rich\_gamma\_pro\_02 }}

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- {{ mod\_divers\_rich\_gamma\_con\_01 }}

- {{ mod\_divers\_rich\_gamma\_con\_02 }}

- {{ mod\_divers\_rich\_gamma\_con\_03 }}

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### ::::::

### :::::::{tab-set}

#### ::::::{tab-item} Overview

\*\*{{ term\_mod\_divers\_rich }}\*\*: {{ term\_def\_mod\_divers\_rich }}

<br>

“Species richness is simply the number of species in an area ({{ ref\_intext\_wearn\_gloverkapfer\_2017 }})

Species diversity is more complex, and includes a measure of the number of species in a community, and a measure of the abundance of each species. Species diversity is usually described by an index, such as Shannon's Index H'.” {{ ref\_intext\_pyron\_2010 }}

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#### ::::::

#### ::::::{tab-item} Advanced

Parameters**:**

- \*\*α-richness (alpha richness)\*\*: species richness at the level of an individual camera location {{ ref\_intext\_wearn\_gloverkapfer\_2019 }}

- \*\*γ-richness (gamma richness)\*\*: species richness across a whole study area {{ ref\_intext\_wearn\_gloverkapfer\_2019 }}

- \*\*β-diversity (betadiversity)\*\*: the differences between the communities or, more formally, the variance among the communities {{ ref\_intext\_wearn\_gloverkapfer\_2019 }}

<br>

\*\*Observed \*vs\* estimated species richness\*\* (from {{ ref\_intext\_wearn\_gloverkapfer\_2019 }}):

- \*\*Observed species richness\*\*: the sum of the number of species seen (e.g. {{ ref\_intext\_kitamura\_et\_al\_2010 }}; {{ ref\_intext\_pettorelli\_et\_al\_2010 }}; {{ ref\_intext\_ahumada\_et\_al\_2011 }}; {{ ref\_intext\_samejima\_et\_al\_2012 }})

- Observed species richness will not, in general, be a reliable index of actual species richness because, even if sampling effort is strictly controlled, the detectability of species will vary across samples

- \*\*Estimated species richness\*\*: when the “sum of the number of species seen” is adjusted based on corrections for “imperfect detection” (i.e. the fact that some species in a given sample may have been missed)

- (e.g. {{ ref\_intext\_tobler\_et\_al\_2008 }}; {{ ref\_intext\_kinnaird-&-obrien-2012 }}; {{ ref\_intext\_brodie\_et\_al\_2015 }}; {{ ref\_intext\_yue\_et\_al\_2015 }}; {{ ref\_intext\_wearn\_et\_al\_2016 }})

- The \*\*two principal ways of estimating species richness from remote camera data \*\* are (from {{ ref\_intext\_wearn\_gloverkapfer\_2019 }}):<br>

- non-parametric estimators ({{ ref\_intext\_gotelli\_chao\_2013 }}), which use information about the rarest species in the sample to provide a minimum estimate of the number of true species (e.g. {{ ref\_intext\_tobler\_et\_al\_2008 }}),

- or 2) occupancy models ({{ ref\_intext\_mackenzie\_et\_al\_2006 }})

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#### ::::::{tab-item} Visual resources

##### :::::{grid} 3

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###### ::::{grid-item-card} {{ ref\_intext\_pyron\_2010 }}

```{figure} ../03\_images/03\_image\_files/pyron\_2010\_fig1.png

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\*\*Pyron (2010) - Figure 1\*\*: Species evenness and species richness for animalcule communities

<!-- Both communities contain five species of animalcules. Species richness is the same. The community on the left is dominated by one of the species. The community on the right has equal proportions of each species. Evenness is higher when species are present in similar proportions. Thus the community on the left has higher species diversity, because evenness is higher. -->

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###### ::::{grid-item-card} {{ ref\_intext\_gotelli\_colwell\_2011 }}

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\*\*Vandooren (2016) – Figure 1\*\*: Species accumulation curves. Species richness is the asymptote of a species accumulation curve, which expresses the dependence on sampling effort of the number of species sampled from an assemblage….

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##### :::::{grid} 3

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###### ::::{grid-item-card} {{ ref\_intext\_molloy\_2018 }}

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\*\*Loreau et al. (2010) – Figure 4.\*\* Species accumulation and rarefaction curves. Species accumulation curves show the number of species obtained by successively censusing either individual organisms (individual-based accumulation curves) or samples (sample-based accumulation curves). Smoothed species rarefaction curves represent the statistical expectation of the corresponding accumulation curves. Credit: Rob Colwell, after Gotelli and Colwell (2001)

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###### ::::{grid-item-card} {{ ref\_intext\_loreau\_2010 }}

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\*\*Loreau et al. (2010) – Figure 3.\*\* The various levels of organisation and components that define the multiple facets

of biodiversity

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Abundance, species richness, and diversity

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Species accumulation and rarefaction curves

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Using vegan to calculate alpha diversity metrics within the tidyverse in R (CC196)

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Species abundance tools in Genstat

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Species Diversity and Species Richness

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Field Ecology - Diversity Metrics in R

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#### ::::::{tab-item} Shiny apps/Widgets

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\*\* iNEXTOnline \*\*

shiny\_caption

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#### ::::::{tab-item} Analytical tools & resources

**Error! Not a valid filename.**

| R package | Chapter 9 Community composition | \- | <https://bookdown.org/c\_w\_beirne/wildCo-Data-Analysis/composition.html#estimated-richnes> | {{ ref\_bib\_wildco\_lab\_2021b }} |

| R package | R package “vegan | \- | <https://cran.r-project.org/web/packages/vegan/index.html> | {{ ref\_bib\_oksanen\_et\_al\_2024 }} |

| Program | EstimateS | Dedicated software for estimating diversity, using asymptotic or rarefaction methods. Mac version available | <https://www.robertkcolwell.org/pages/1407> | {{ ref\_bib\_colwell\_2022 }} |

| R package | Package ‘iNEXT’ - Interpolation and Extrapolation for Species Diversity | The iNext package (INterpolation and EXTrapolation of species richness) - is both easy to use and rapid to compute. It also comes with a wealth of plotting functions - see the iNext Quick Introduction for a great walk through tutorial. Its core functionality is based on: Chao, Anne, et al. “Rarefaction and extrapolation with Hill numbers: a framework for sampling and estimation in species diversity studies.” Ecological monographs 84.1 (2014): 45-67. | <https://cran.r-project.org/web/packages/iNEXT/iNEXT.pdf> | {{ ref\_bib\_hsieh\_et\_al\_2015 }} |

| Exercise/Tutorial | 2.2: Measuring Species Diversity | Easy to interpet explanation of species richness vs evenness, species area curves, rarefaction, and how to calculate diversity | <https://bio.libretexts.org/Courses/University\_of\_California\_Davis/BIS\_2B%3A\_Introduction\_to\_Biology\_-\_Ecology\_and\_Evolution/02%3A\_Biodiversity/2.02%3A\_Measuring\_Species\_Diversity> | {{ ref\_bib\_gerhartbarley\_nd }} |

| R package / Tutorial | Species Accumulation Curves with vegan, BiodiversityR and ggplot2 | Software for interpolation and extrapolation of species diversityRarefied Species Accumulation Curves (the simple way) | <https://rpubs.com/Roeland-KINDT/694021> | {{ ref\_bib\_resource6\_ref\_id }} |

| resource7\_type | resource7\_name | resource7\_note | resource7\_note | {{ ref\_bib\_resource7\_ref\_id }} |

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#### ::::::{tab-item} References

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{{ ref\_bib\_ahumada\_et\_al\_2011 }}

{{ ref\_bib\_baylor\_tutoring\_center\_2021 }}

{{ ref\_bib\_brodie\_et\_al\_2015 }}

{{ chao\_et\_al\_2016 }}

{{ chao\_et\_al\_2014 }}

{{ ref\_bib\_colwell\_2022 }}

{{ ref\_bib\_gerhartbarley\_nd }}

{{ ref\_bib\_gotelli\_colwell\_2001 }}

{{ ref\_bib\_gotelli\_colwell\_2010 }}

{{ ref\_bib\_hsieh\_et\_al\_2015 }}

{{ ref\_bib\_iknayan\_et\_al\_2014 }}

{{ ref\_bib\_kinnaird\_obrien\_2012 }}

{{ ref\_bib\_kitamura\_et\_al\_2010 }}

{{ ref\_bib\_mackenzie\_et\_al\_2006 }}

{{ ref\_bib\_mecks100\_2018 }}

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{{ ref\_bib\_pettorelli\_et\_al\_2010 }}

{{ ref\_bib\_project\_dragonfly\_2019 }}

{{ ref\_bib\_pyron\_2010 }}

{{ ref\_bib\_riffomonas\_project\_2022 }}

{{ ref\_bib\_samejima\_et\_al\_2012 }}

{{ ref\_bib\_styring\_2020 }}

{{ ref\_bib\_tobler\_et\_al\_2008 }}

{{ ref\_bib\_vsn\_international\_2022 }}

{{ ref\_bib\_wearn\_et\_al\_2016 }}

{{ ref\_bib\_wildco\_lab\_2021b }}

{{ ref\_bib\_yue\_et\_al\_2015 }}

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