# INFO ENTRY

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)
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* 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 | mod\_ds |
| question | Headers:  \*\*<font size="4"><span style="color:#2F5496">How does this relate to study design?</font></span>\*\*  \*\*<font size="4"><span style="color:#2F5496">How does that work?</font></span>\*\*  \*\*<font size="4"><span style="color:#2F5496">Why do we care?</font></span>\*\*  > \*\*Select “Unknown” if you’re not sure.\*\* |

## Assumptions, Pros, Cons – if modelling approach

|  |  |  |
| --- | --- | --- |
| Assumptions | Pros | Cons |
| - {{ mod\_ds\_assump\_01 }}  - {{ mod\_ds\_assump\_02 }}  - {{ mod\_ds\_assump\_03 }}  - {{ mod\_ds\_assump\_04 }}  - {{ mod\_ds\_assump\_05 }}  - {{ mod\_ds\_assump\_06 }}  - {{ mod\_ds\_assump\_07 }}  - {{ mod\_ds\_assump\_08 }}  - {{ mod\_ds\_assump\_09 }} | - {{ mod\_ds\_pro\_01 }}  - {{ mod\_ds\_pro\_02 }}  - {{ mod\_ds\_pro\_03 }}  - {{ mod\_ds\_pro\_04 }} | - {{ mod\_ds\_con\_01 }}  - {{ mod\_ds\_con\_02 }}  - {{ mod\_ds\_con\_03 }}  - {{ mod\_ds\_con\_04 }}  - {{ mod\_ds\_con\_05 }}  - {{ mod\_ds\_con\_06 }}  - {{ mod\_ds\_con\_07 }}  - {{ mod\_ds\_con\_08 } |

## Overview

This section will be available soon! In the meantime, check out the information in the other tabs!

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## Advanced

:::{note}

\*\*This content was adapted from\*\*: The Density Handbook, "[Using Camera Traps to Estimate Medium and Large Mammal Density: Comparison of Methods and Recommendations for Wildlife Managers](https://www.researchgate.net/publication/368601884\_Using\_Camera\_Traps\_to\_Estimate\_Medium\_and\_Large\_Mammal\_Density\_Comparison\_of\_Methods\_and\_Recommendations\_for\_Wildlife\_Managers)" (Clarke et al., 2024)

:::

Distance sampling (DS) theory was developed in the early 1990s to estimate density from line- or point-transect surveys, including aerial surveys (e.g., Alberta Environment and Parks 2016; {{ ref\_intext\_buckland\_et\_al\_1993 }}). The novelty of the DS approach is in its capacity to correct for imperfect detection (i.e., not observing animals that are present) by measuring the distance between survey lines or points and animals ({{ ref\_intext\_morin\_et\_al\_2022 }}). t ({{ ref\_intext\_buckland\_et\_al\_2015 }}; {{ ref\_intext\_gilbert\_et\_al\_2021 }}).

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\*\*Clarke et al. (2023) - Fig. 6\*\* An example detection function. The probability of detecting an animal decreases with increasing distance from the observer.

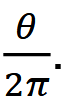
The DS model was adapted for use with camera trap data by Howe et al. (2017). Camera trap DS capitalizes on the similarities between camera trap surveys and human-observer point transect surveys – for example, both cameras and people tabulate the number of animals seen in a “snapshot” moment from a point in space ({{ ref\_intext\_buckland\_2006 }}). There are, however, important differences to account for. For one: in human-observer studies, a point is sampled for an instant, and only one or a few times total; a camera, in contrast, samples the same point for a long period of time ({{ ref\_intext\_palencia\_et\_al\_2021 }}). For another: human observers can pivot 360º around a point to count animals, while cameras are fixed in place and sample only a fraction of a circle ({{ ref\_intext\_howe\_et\_al\_2017 }}). Camera trap DS must therefore include inputs of time and viewshed angle. The equation derived by Howe et al. (2017) is:

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where \*𝑌\* is the number of detection events, 𝑤 is the truncation distance (i.e., the distance beyond which animal-camera distances are no longer considered), \*𝑒\* is the sampling effort, and \*𝑝\* is the probability of capturing an image of an animal within distance \*𝑤\* ({{ ref\_intext\_howe\_et\_al\_2017 }}).

\*\*To calculate sampling effort \*𝑒\*:\*\* let us first consider temporal effort. At a given camera, temporal effort is a function of the camera’s total sampling time \*𝐻\* and a predetermined interval \*𝑡\* units of time apart, at which the distance between camera and animal(s) is measured, such that temporal effort at the camera is \*𝐻\*/\*𝑡\* ({{ ref\_intext\_howe\_et\_al\_2017 }}). If that same camera has a viewshed angle of 𝜃 radians, the fraction of a circle it samples is 

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Taken together, sampling effort can therefore be expressed as:

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\*\*To estimate the probability of capturing an animal \*𝑝\*:\*\* practitioners must estimate the horizontal distance \*𝑟\* between a camera and the centre of every animal detected, at each snapshot moment \*𝑡\* intervals apart, for as long as animals are within the viewshed ({{ ref\_intext\_howe\_et\_al\_2017 }}). Howe et al. (2017) recommend a \*𝑡\* of 0.25 to 3 seconds; if the focal species is fast-moving or rare, and/or cameras have fast trigger speeds, practitioners should use a smaller \*𝑡\*. Measurements of \*𝑟\* can then be inputted into a detection function, \*𝑓\*(\*𝑟\*), which describes the probability an animal at distance \*𝑟\* is detected given 0 ≤ \*𝑟\* ≤ \*𝑤\* – producing an estimate of \*𝑝\* ({{ ref\_intext\_buckland\_et\_al\_2015 }}).

Options for measuring camera-animal distance \*𝑟\* include: 1) comparing images of animals to reference images of field crew or objects at known distances from the camera (manually or automated; {{ ref\_intext\_hauke\_et\_al\_2022 }}, {{ ref\_intext\_howe\_et\_al\_2017 }}); 2) placing permanent reference objects at known distances from the camera so they are visible in every capture ({{ ref\_intext\_palencia\_et\_al\_2021 }}); 3) physically measuring out camera-animal distances in the field, using animal images as references ({{ ref\_intext\_rowcliffe\_et\_al\_2011 }}); and 4) a recently-developed, fully-automated approach (<https://github.com/PJcs/DistanceEstimationTracking>[)](https://github.com/PJ-cs/DistanceEstimationTracking) which does not require reference images or objects ({{ ref\_intext\_johanns\_et\_al\_2022 }}).

If the species of interest is regularly and predictably inactive (e.g., rests at night), estimates of density must be corrected for activity level to minimize bias ({{ ref\_intext\_howe\_et\_al\_2017 }}; {{ ref\_intext\_palencia\_et\_al\_2021 }}). Practitioners may choose to set total sampling time \*𝐻\* as the time the study population was active and available for detection; another option is to correct density 𝐷\*\* for the proportion of time animals are active, such that:

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where \*𝐷<sub>𝐶</sub>\* is the corrected density estimate and 𝑎 is activity level ({{ ref\_intext\_howe\_et\_al\_2017 }}; {{ ref\_intext\_palencia\_et\_al\_2021 }}). Activity level is determined as per Rowcliffe et al. (2014).

## Simulations & Field Experiments

Howe et al. (2017) ran simulations of “complex” animal movement patterns (i.e., animals moved with variable speeds, meandered, and rested periodically), and found that, when periods of rest were excluded from analyses, the DS model produced unbiased and precise estimates of density (CV  0.10). When periods of rest were included, in contrast, DS performed poorly and inconsistently – whether animals rested within the viewshed or outside of the viewshed (i.e., were not detected). Animal activity patterns should therefore be considered when implementing the DS model; practitioners should have a strong understanding of when their species of interest is active versus inactive. Note that population and camera trap densities were both quite high in this simulation – 10 animals/km<sup>2</sup> and 6.25 camera traps/km<sup>2</sup> ({{ ref\_intext\_howe\_et\_al\_2017 }}).

In northwestern Africa, camera trap DS produced higher estimates of duiker density than line-transect surveys – a method generally thought to underestimate the densities of forest-dwelling ungulates ({{ ref\_intext\_howe\_et\_al\_2017 }}). The researchers collected video data.

Another study in northwestern Africa found that the DS model performed variably for different species ({{ ref\_intext\_cappelle\_et\_al\_2021 }}). DS density estimates of a common ungulate – duiker – were comparable to previous estimates (line-transect surveys and Howe et al.’s (2017) camera trap DS study), and similarly precise. For semi-arboreal chimpanzees, DS-derived density estimates were biased low and depended greatly on measures of activity level (i.e., the proportion of the day chimpanzees were on the ground and available for detection). Compared with other studies:

- DS performed inferiorly to spatial capture-recapture (SCR; see section *2.1.2 Spatial Capture Recapture*) with individual identification ({{ ref\_intext\_despres\_einspenner\_et\_al\_2017 }}, {{ ref\_intext\_cappelle\_et\_al\_2019 }}).

- DS estimates were, however, comparable to labour-intensive line-transect nest surveys.

The DS model performed inconsistently for rare species in this system, producing reasonable estimates of leopard density but questionable estimates of elephant density.

DS-derived leopard density was similar to a previous study combining collar, camera and track data ({{ ref\_intext\_cappelle\_et\_al\_2021 }}, {{ ref\_intext\_jenny\_1996 }}). DS-derived elephant density was nearly double that from previous line-transect surveys and extremely imprecise (0.60 < CV < 2.00; {{ ref\_intext\_cappelle\_et\_al\_2021 }}). As per Howe et al. (2017), videos were also used for this study.

Palencia et al. (2021) used DS to estimate the densities of red deer and boar. They found that the model performed similarly to the random encounter model (REM; see \**2.2.3 Random Encounter Model*\*) and the random encounter and staying time model (REST; see *2.2.4 Random Encounter and Staying Time*) for both species. Compared to independent density estimates (line-transect distance sampling for red deer, drive counts for boar): DS yielded a comparable density for deer but underestimated density for boar, perhaps due to slow camera recovery times ({{ ref\_intext\_palencia\_et\_al\_2021 }}). Precision of camera trap DS was quite low, with an average CV of 0.42. Still images were used.

Bessone et al. (2020) used camera trap DS to estimate the densities of 14 vertebrate species, finding that low population density and reactivity to cameras were major sources of bias, and that the model applied best to evenly-distributed (versus clumpilydistributed) populations. Precision was highest for common, high-density species, but satisfactory (i.e., CV < 0.35) for rare-but-widely-distributed species.

Finally, another density methods comparison study showed that camera trap DS was more precise than genetic mark-recapture, live capture-recapture, REM, and spatial count (SC; see section \**2.2.1 Spatial Count*\*) for pine marten (CV = 0.34; {{ ref\_intext\_twining\_et\_al\_2022 }}). While all methods produced densities within accepted ranges, DS tended to underestimate density ({{ ref\_intext\_twining\_et\_al\_2022 }}).

## Figures

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| --- | --- | --- | --- |
| Image | file\_name | Caption (if applicable) | ref\_id |
| A graph of a number of data  Description automatically generated | clarke\_et\_al\_2023\_fig6\_clipped.png | \*\*Clarke et al. (2023) - Fig. 6\*\* An example detection function. The probability of detecting an animal decreases with increasing distance from the observer. | clarke\_et\_al\_2023 |
|  | clarke\_et\_al\_2023\_eqn\_ds1.png | figure2\_caption | clarke\_et\_al\_2023 |
|  | clarke\_et\_al\_2023\_eqn\_ds2.png | figure3\_caption | clarke\_et\_al\_2023 |
|  | clarke\_et\_al\_2023\_eqn\_ds3.png | figure4\_caption | clarke\_et\_al\_2023 |
| A black and white image of a mathematical equation  Description automatically generated | clarke\_et\_al\_2023\_eqn\_ds4.png | figure5\_caption | figure5\_ref\_id |
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\*\*Gotelli & Colwell (2011) - Fig. 4.1\*\* Species accumulation and rarefaction curves.

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The jagged line is the species accumulation curve for one of many possible orderings of 121 soil seedbank samples, yielding a total of 952 ......

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## Video

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## Analytical tools & resources

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| resource1\_type | Distance Sampling: Estimating Abundance of Biological Populations (1993) | resource1\_note | https://distancesampling.org/downloads/distancebook1993/index.html | resource1\_ref\_id |
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## References / Glossary

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## Notes

# Markdown

## File from = 00\_00\_template-master\_2024-09-29.docx

**POPULATE MARKDOWN \_2024-09-28** - MODS

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

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::::{grid-item-card} Assumptions

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::::{grid-item-card} Pros

- {{ mod\_occupancy\_pro\_01 }}

- {{ mod\_occupancy\_pro\_02 }}

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- {{ mod\_occupancy\_con\_01 }}

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

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::::::{tab-item} In-depth

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\*\*This content was adapted from\*\*: The Density Handbook, "[Using Camera Traps to Estimate Medium and Large Mammal Density: Comparison of Methods and Recommendations for Wildlife Managers](https://www.researchgate.net/publication/368601884\_Using\_Camera\_Traps\_to\_Estimate\_Medium\_and\_Large\_Mammal\_Density\_Comparison\_of\_Methods\_and\_Recommendations\_for\_Wildlife\_Managers)" (Clarke et al.. 2024)

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Occupancy models describe spatial patterns of animal occurrence ({{ ref\_intext\_sollmann\_2018 }}) and have been proposed as a proxy for abundance ({{ ref\_intext\_noon\_et\_al\_2012 }}). They ask: what proportion of a study area is inhabited by a population – that is, at how many camera sites do one or more individuals of a species occur ({{ ref\_intext\_mackenzie\_et\_al\_2017 }})? The basic equation for occupancy is:

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where \*𝜓\* is the probability a site is occupied, \*𝑥̂\* is the estimated number of occupied sites (i.e., the count of sites where animals were detected, corrected for detection probability) and 𝑠 is the total number of sites surveyed ({{ ref\_intext\_mackenzie\_et\_al\_2017 }}). Unlike simple measures of presence-absence, occupancy models account for imperfect detection ({{ ref\_intext\_sollmann\_2018 }}). They attempt to differentiate between absence – animals truly not present – and nondetection – animals present but not detected – by repeatedly sampling sites over time. The central assumption of basic occupancy models is that repeated samples occur during a period in which the site is closed to changes in occupancy (i.e., occupancy status – present or absent – does not change during the sampling period). Thus if a species is detected during one of three sampling occasions, it is assumed that it was present during all three occasions but undetected during two.

In theory, occupancy and abundance share a predictable relationship. As population size increases, the number of sites occupied by members of that population should also increase (until all sites are occupied); likewise, a decrease in population size should lead to a decrease in the number of sites used ({{ ref\_intext\_gaston\_et\_al\_2000 }}; {{ ref\_intext\_royle\_dorazio\_2008 }}). This is called an occupancy-abundance relationship, and – because of it – occupancy can be used as an index of abundance.

Advantages of occupancy as an index of abundance include:

- Occupancy studies may be easier to implement than some abundance or density estimators ({{ ref\_intext\_noon\_et\_al\_2012 }}; {{ ref\_intext\_sollmann\_2018 }}).

- Occupancy-abundance relationships appear to be robust to territoriality, group travelling behaviour and other biological traits (

{{ ref\_intext\_steenweg\_et\_al\_2018 }}).

- Occupancy can be modelled as a function of site- and sampling-specific covariates to better understand which factors predict animal occurrence ({{ ref\_intext\_sollmann\_2018 }}).

However, many researchers have cautioned against the use occupancy as an index. As with relative abundance (RA; see above), there is no consistent, long-term relationship between occupancy and abundance ({{ ref\_intext\_efford\_dawson\_2012 }}). Occupancy can change with abundance, but also with survey duration, species home range size, animal movement, etc., muddling occupancy-abundance relationships and thus inferences about population size ({{ ref\_intext\_neilson\_et\_al\_2018 }}; {{ ref\_intext\_steenweg\_et\_al\_2018 }}). While occupancy is a powerful stand-alone metric, Sollmann (2018) says it should not be “misinterpreted” as an index of abundance.

Despite its widespread use, occupancy may be particularly problematic for camera trap studies due to the violation of the closure assumption. Burton et al. (2015) highlighted that many camera trap studies using occupancy do not explicitly define the “site,” although is often implicitly given as some larger area around a camera trap. Since camera trap studies typically target mammal species with relatively large home ranges, the site closure assumption is almost certainly violated in most cases. Many camera trappers therefore assume that “occupancy” is in fact “use” of a site (i.e., the site is not closed), and that detection probability also includes availability for detection. Mackenzie et al. (2017) suggested that estimates should be unbiased if movements in and out of a site are random, but this assumption is rarely tested. And where occupancy estimates have been tested using realistic mammal movements, they have generally performed poorly ({{ ref\_intext\_neilson\_et\_al\_2018 }}; {{ ref\_intext\_stewart\_et\_al\_2018 }}).

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

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\*\*Murray et al. (2021) - Fig. 1\*\* Schematic of our multi- state occupancy model to estimate the occurrence of coyotes and mange.

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We used images of coyotes collected along transects following an urban gradient in the Chicago metro area in a standard single-species multi-season model with a stacked design. Following the coyote occupancy model, our mange model estimates the distribution of coyote with sarcoptic mange conditional on the distribution of coyote, mangy or otherwise, using by-image variation in the presence of mange signs and the quality of the image.

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\*\*Southwell et al. (2019) - Fig. 1.\*\* Structure of the spatially explicit power analysis framework for multiple species in dynamic landscapes.

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\*\*Chatterjee et al. (2021) - Table 2.\*\* Broad classifications of mammals based on occupancy and detection probabilities.

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figure8\_caption

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figure9\_caption

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figure10\_caption

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figure11\_caption

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figure12\_caption

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::::{grid-item-card} {{ ref\_intext\_cove\_2020a }}

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Occupancy Modeling Video 1 -- Sampling Techniques for Mammals

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::::{grid-item-card} {{ ref\_intext\_cove\_2020b }}

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Occupancy Modeling Video 2 -- Introductory Statistical Review

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::::{grid-item-card} {{ ref\_intext\_cove\_2020c }}

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Occupancy Modeling Video 3 -- What are Occupancy Models and What are the Applications?

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::::{grid-item-card} {{ ref\_intext\_cove\_2020d }}

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Occupancy Modeling Video 4 -- How to Run and Interpret the Models in PRESENCE

::::

::::{grid-item-card} {{ ref\_intext\_proteus\_2018 }}

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style="position:absolute;top:0;left:0;width:100%;height:100%;"></iframe>

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Occupancy modelling - more than species presence/absence! (Darryl MacKenzie)

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::::{grid-item-card} {{ ref\_intext\_proteus\_2019a }}

<div>

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<iframe src="https://www.youtube.com/embed/zKQFY8W4ceU?si=ibziVu2KyWro5IUx" frameborder="0" allowfullscreen

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Occupancy modelling - the difference between probability and proportion of units occupied

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

Check back in the future!

<!--::::{dropdown}-->

:::::{card} shiny\_name

shiny\_caption

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frameborder="0"

allow="accelerometer; autoplay; clipboard-write; encrypted-media; gyroscope; picture-in-picture"

allowfullscreen>

</iframe>

<!--

:::::

::::{dropdown} Bias in single-season occupancy models

Compute the relative bias (in %) in the maximum-likelihood estimator of the occupancy probability ψ in a single-season (aka static) occupancy model with constant parameters fitted with the package 'unmarked'.

{{ ref\_bib\_gimenez\_2020a }}

<iframe https://ecologicalstatistics.shinyapps.io/bias\_occupancy/

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allowfullscreen>

</iframe>

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

| Type | Name | Note | URL |Reference |

|:----------------|:-------------------------------|:----------------------------------------------------------------|:----------------------|:----------------------------------------|

| rJAGS/R code | mfidino/multi-state-occupancy-models | | <https://github.com/mfidino/multi-state-occupancy-models> | {{ ref\_bib\_fidino\_2021a }} |

| JAGS/R code | A gentle **introduction to an integrated occupancy model that combines presence-only and detection/non-detection data, and how to fit it in**JAGS**; <br>**integrated-occupancy-model” | | <https://masonfidino.com/bayesian\_integrated\_model/>;<br><https://github.com/mfidino/integrated-occupancy-model> | {{ ref\_bib\_fidino\_2021b }}; {{ ref\_bib\_fidino\_2021c }} |

| JAGS code/Tutorial | So, **you don't have enough data to fit a dynamic occupancy model? An introduction to auto-logistic occupancy models; <br>**auto-logistic-occupancy |

| <https://masonfidino.com/autologistic\_occupancy\_model/>;<br><https://github.com/mfidino/auto-logistic-occupancy> | {{ ref\_bib\_fidino\_2021d }}; {{ ref\_bib\_fidino\_2021e }} |

| R package | Package “autoOcc” | An R package for fitting autologistic occupancy models | <https://github.com/mfidino/autoOcc> | {{ ref\_bib\_fidino\_2023 }} |

| R code | mfidino/periodicity | Using Fourier series to predict periodic patterns in dynamic occupancy models | <https://github.com/mfidino/periodicity> | {{ ref\_bib\_fidino\_magle\_2017 }} |

| resource13\_type | Bias in **occupancy estimate for a static model** |

| < > | {{ ref\_bib\_resource6\_ref\_id }} |

| R code/Tutorial | “An Introduction to Camera Trap Data Management and Analysis in R > Chapter 11 Occupancy” | | <https://bookdown.org/c\_w\_beirne/wildCo-Data-Analysis/occupancy.html> | {{ ref\_bib\_wildco\_lab\_2021c }} |

| Program | Program “PRESENCE” | "Relatively simple, but comprehensive, software dedicated to occupancy estimation. Linux version available. Can also be used for occupancy-based species richness estimation." (Wearn & Glover-Kapfer, 2017) | \*\*Software\*\*: <www.mbr-pwrc.usgs.gov/ software/presence.html>;<br>\*\*Help forum\*\*: <www.phidot.org>| {{ ref\_bib\_hines\_2006}} |

| R package | Package “RPresence” | “The R counterpart to Presence. Cross-platform (Windows, Mac and Linux)." (Wearn & Glover-Kapfer, 2017) | <https://www.mbr-pwrc.usgs.gov/software/presence.shtml> | {{ ref\_bib\_hines\_2006 }} |

| R package | R package "unmarked” | "Implements a wide variety of occupancy and count-based abundance models (the latter are mostly not appropriate for camera-trapping). Actively being developed and supported by a community of users. Cross-platform (Windows, Mac and Linux)." (Wearn & Glover-Kapfer, 2017) | <https://cran.r-project.org/web/packages/unmarked/index.html>;<br><https://groups.google.com/d/forum/unmarked,>;<br>https://hmecology.github.io/unmarked> | {{ ref\_bib\_kellner\_et\_al\_2023 }}; {{ ref\_bib\_fiske\_chandler\_2011 }} |

| R code/Tutorial | Multi-season Occupancy Models | | <https://darinjmcneil.weebly.com/multi-season-occupancy.html> | {{ ref\_bib\_mcneil\_nd }} |

| R package | Package “detect” | R package for analyzing wildlife data with detection error | <https://github.com/psolymos/detect> | {{ ref\_bib\_solymos\_2023 }} |

| Spreadsheet | OccPower.xlsx | Spreadsheet to compute power to detect difference in 2 independent occupancy estimates using asymptotic approximations described in Guillera-Arroita et. al. (2012). | [Download the XLS](../09\_downloads/OccPower.xlsx) | {{ ref\_bib\_guillera\_arroita\_et\_al\_2012 }} |

| Tutorial | occupancyTuts: Occupancy modelling tutorials with RPresence | Occupancy modelling tutorials with RPresence | <https://doi.org/10.1111/2041-210X.14285> | {{ ref\_bib\_donovan\_et\_al\_2024 }} |

| R code/Tutorial | Implicit dynamics occupancy models in R | Implicit dynamics occupancy models with the R package RPresence. These models estimate occupancy probability when it changes through time without estimating colonization and extinction parameters.<br>

The code and sample data from this tutorial are available on GitHub; < https://github.com/jamesepaterson/occupancyworkshop>. | <https://jamesepaterson.github.io/jamespatersonblog/2024-06-02\_implicitdynamicsoccupancy.html> | {{ ref\_bib\_paterson\_2024 }} |

| resource16\_type | Using the mgcvmgcv package **to create a generalized additive occupancy model in**R | resource16\_note | <https:**//masonfidino.com/generalized\_additive\_occupancy\_model>** | {{ ref\_bib\_resource16\_ref\_id }} |

| resource17\_type | Bias in single-season occupancy models | "Compute the relative bias (in %) in the maximum-likelihood estimator of the occupancy probability ψ in a single-season (aka static) occupancy model with constant parameters fitted with the package 'unmarked'." | \*\*Repo\*\*: <https://github.com/oliviergimenez/bias\_occupancy\_flexdashboard><br>\*\*App\*\*: <https://ecologicalstatistics.shinyapps.io/bias\_occupancy> | {{ ref\_bib\_gimenez\_2020a }} |

| R code | Bias in occupancy estimate for a static model | "R code to calculate bias in occupancy estimate as a function of the detection probability given various levels of occupancy probability, various number of sites and surveys." | <https://github.com/oliviergimenez/bias\_occupancy>| {{ ref\_bib\_gimenez\_2020b}} |

| resource19\_type | resource19\_name | resource19\_note | resource19\_url | {{ ref\_bib\_resource19\_ref\_id }} |

| resource20\_type | resource20\_name | resource20\_note | resource20\_url | {{ ref\_bib\_resource20\_ref\_id }} |

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

{{ ref\_bib\_cove\_2020a }}

{{ ref\_bib\_cove\_2020b }}

{{ ref\_bib\_cove\_2020c }}

{{ ref\_bib\_cove\_2020d }}

{{ ref\_bib\_donovan\_et\_al\_2024 }}

{{ ref\_bib\_efford\_dawson\_2012 }}

{{ ref\_bib\_fidino\_2021d }}

{{ ref\_bib\_fidino\_2021a }}

{{ ref\_bib\_fidino\_2021b }}

{{ ref\_bib\_fidino\_2021c }}

{{ ref\_bib\_fidino\_2021e }}

{{ ref\_bib\_fidino\_2023 }}

{{ ref\_bib\_fidino\_magle\_2017 }}

{{ ref\_bib\_fiske\_chandler\_2011 }}

{{ ref\_bib\_gaston\_et\_al\_2000 }}

{{ ref\_bib\_gimenez\_2020a }}

{{ ref\_bib\_gimenez\_2020b }}

{{ ref\_bib\_gimenez\_2023 }}

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{{ ref\_bib\_hines\_2006 }}

{{ ref\_bib\_kellner\_et\_al\_2023 }}

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{{ ref\_bib\_mcneil\_nd }}

{{ ref\_bib\_murray\_et\_al\_2021 }}

{{ ref\_bib\_neilson\_et\_al\_2018 }}

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

{{ ref\_bib\_paterson\_2024 }}

{{ ref\_bib\_proteus\_2018 }}

{{ ref\_bib\_proteus\_2019a }}

{{ ref\_bib\_proteus\_2019b }}

{{ ref\_bib\_royle\_dorazio\_2008 }}

{{ ref\_bib\_sollmann\_2018 }}

{{ ref\_bib\_solymos\_2023 }}

{{ ref\_bib\_southwell\_et\_al\_2019 }}

{{ ref\_bib\_steenweg\_et\_al\_2018 }}

{{ ref\_bib\_stewart\_et\_al\_2018 }}

{{ ref\_bib\_weecology\_2020 }}

{{ ref\_bib\_wildco\_lab\_2021c }}

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