# 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)
  + [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

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| --- | --- |
| **info\_id** | mod\_sc |
| **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.\*\*  :::{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)  :::  \[in Clarke et al. 2023\]  {bdg-link-primary-line}`Spatial count<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_14\_mod\_sc.html>`  *2.1.2 Spatial Capture-Recapture* / *How the Model Works* in the SCR section --> {bdg-link-primary-line}`Spatial capture-recapture (SCR) / Spatially explicit capture recapture (SECR)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_11\_mod\_scr\_secr.html>`  *2.2.1 Spatial Count*--> {bdg-link-primary-line}`Spatial count<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_14\_mod\_sc.html>`  *2.3.1 Spatial Mark-Resigh*t--> {bdg-link-primary-line}`Spatial mark-resight<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_13\_mod\_smr.html>`  *2.3.2 Spatial Partial Identity Model*--> {bdg-link-primary-line}`Spatial Partial Identity Model (Categorical SPIM; catSPIM)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_15\_mod\_catspim.html>`and {bdg-link-primary-line}`Spatial Partial Identity Model (2-flank SPIM)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_16\_mod\_2flankspim.html>` |

## Assumptions, Pros, Cons – if modelling approach

|  |  |  |
| --- | --- | --- |
| **Assumptions** | **Pros** | **Cons** |
| - {{ mod\_sc\_assump\_01 }}  - {{ mod\_sc\_assump\_02 }}  - {{ mod\_sc\_assump\_03 }}  - {{ mod\_sc\_assump\_04 }}  - {{ mod\_sc\_assump\_05 }}  - {{ mod\_sc\_assump\_06 }} | - {{ mod\_sc\_pro\_01 }} | - {{ mod\_sc\_con\_01 }}  - {{ mod\_sc\_con\_02 }}  - {{ mod\_sc\_con\_03 }}  - {{ mod\_sc\_con\_04 }}  - {{ mod\_sc\_con\_05 }}  - {{ mod\_sc\_con\_06 }}  - {{ mod\_sc\_con\_07 }} |

## 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)

:::

A spatial count (SC) model is essentially a spatial capture-recapture (SCR; see {bdg-link-primary-line}`Spatial capture-recapture (SCR) / Spatially explicit capture recapture (SECR)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_11\_mod\_scr\_secr.html>`) model with an extension to account for unmarked animals’ unknown identities ({{ ref\_intext\_royle\_et\_al\_2014 }}). SC, then, is formulated in much the same way as SCR: populations are treated as collections of individual activity (or home range) centres, and spatial detection data is used to infer the number and locations of these activity centres (see {bdg-link-primary-line}`Spatial capture-recapture (SCR) / Spatially explicit capture recapture (SECR)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_11\_mod\_scr\_secr.html>`). Instead of identifying animals and constructing individual detection histories (i.e., each individual’s spatial pattern of detections), however, SC uses trap-specific counts (i.e., the tally of animal detections at each trap of known location) and the correlation structure among trapspecific counts to estimate the number and location of activity centres ({{ ref\_intext\_royle\_et\_al\_2014 }}, {{ ref\_intext\_sun\_et\_al\_2022 }}).

Like SCR, an SC model is composed of a spatial process model and an observation model. The spatial process model, which describes how activity centres are distributed across the landscape, is a homogeneous point-process model – a completely random pattern of points in space (Baddeley, no date; {{ ref\_intext\_royle\_2016 }}). The observation model, which describes where individuals are detected on the landscape, is constructed as if we know each individual’s detection history and the size of the population ({{ ref\_intext\_chandler\_royle\_2013 }}). As Royle et al. (2014) put it: “[SC] is formulated in terms of the data we wish we had, i.e., the typical [detection] history data observed in [SCR] studies of marked animals.” We can construct an SC model in this way because trap-specific counts of animals arise from those animals’ detection histories; in other words, counts are a simplified version of the data that would have been collected, had individuals been identifiable ({{ ref\_intext\_chandler\_royle\_2013 }}, {{ ref\_intext\_sun\_et\_al\_2022 }}).

To relate trap-specific counts to detection histories, we use the equation:

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where \*n<sub>𝑗𝑘</sub>\* is the count of animals at sampling location \*𝑗\* and during sampling period \*𝑘\*; \*𝑁\* is population size; and \*𝑦<sub>𝑖𝑗𝑘</sub>\* is individual 𝑖's detection history at sampling location \*𝑗\* and during sampling period \*𝑘\* ({{ ref\_intext\_royle\_et\_al\_2014 }}). So, the trap- and period-specific count \*n<sub>𝑗𝑘</sub>\*

– the information we gather for SC – is the same as the sum of every individual’s encounter history at that trap – the information we gather for SCR ({{ ref\_intext\_royle\_et\_al\_2014 }}).

To approximate population size, we take a data augmentation approach. Population size \*𝑁\* is treated as a subset of some larger, hypothetical population of size \*𝑀\* (the “augmented” population; {{ ref\_intext\_royle\_dorazio\_2012 }}), such that:

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where \*𝑀\* ≫ \*𝑁\* and \*𝜔<sub>𝑖</sub>\* is the probability of existence of individual \*𝑖\* within population \*𝑁\* ({{ ref\_intext\_chandler\_royle\_2013 }}, {{ ref\_intext\_sun\_et\_al\_2022 }}). \*𝜔<sub>𝑖</sub>\* is Bernoulli distributed – an animal can be present (i.e., \*𝜔<sub>𝑖</sub>\* = 1) or absent (i.e., \*𝜔<sub>𝑖</sub>\* = 0) – and depends on the number of detections at traps and the distance between traps and individuals’ activity centres ({{ ref\_intext\_chandler\_royle\_2013 }}, {{ ref\_intext\_sun\_et\_al\_2022 }}).

Note that, for SC, a “trap” is simply a tool or method for collecting count data. Trap types include hair snags, track plates, acoustic recording devices, human point-count observers and camera traps ({{ ref\_intext\_chandler\_royle\_2013 }}, {{ ref\_intext\_royle\_et\_al\_2014 }}). We will refer to camera traps for the remainder of this section.

The aim of SC sampling design is to infer the number and location of activity centres by inducing correlation (i.e., linear relation) between the number and location of detections ({{ ref\_intext\_burgar\_et\_al\_2019 }}, {{ ref\_intext\_chandler\_royle\_2013 }}, {{ ref\_intext\_sollmann\_2018 }}, {{ ref\_intext\_sun\_et\_al\_2022 }}). To this end, camera traps must be deployed close enough together that individuals will be detected at multiple locations ({{ ref\_intext\_chandler\_royle\_2013 }}). Grid or clustered designs may be best ({{ ref\_intext\_burgar\_et\_al\_2019 }}, {{ ref\_intext\_clarke\_2019 }}, {{ ref\_intext\_sun\_et\_al\_2014 }}).

**## Simulations and Field Experiments**

The relatively few studies that have tested SC models suggest that they tend to produce fairly accurate but imprecise density estimates.

- A study on fishers showed that, compared to genetic SCR, SC underestimated density and estimates were less precise ({{ ref\_intext\_burgar\_et\_al\_2018 }}).

- Evans and Rittenhouse (2018) found that SC yielded accurate but less precise estimates of black bear density than camera trap SCR.

- Another study compared estimates of caribou density from SC with estimates from the spatial partial identity model (SPIM; see {bdg-link-primary-line}`Spatial Partial Identity Model (Categorical SPIM; catSPIM)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_15\_mod\_catspim.html>`and {bdg-link-primary-line}`Spatial Partial Identity Model (2-flank SPIM)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_16\_mod\_2flankspim.html>`). In this system, SC likely underestimated density compared with SPIM – perhaps because the model interpreted captures of many individuals as recaptures of a few individuals – and was less precise and more variable year-toyear ({{ ref\_intext\_sun\_et\_al\_2022 }}).

- SC was used to estimate the densities of caribou, moose, wolf, coyote and black bear populations in the oil sands region of Alberta ({{ ref\_intext\_burgar\_et\_al\_2019 }}). Estimates for all species were imprecise; some had confidence intervals with upper and lower bounds that differed more than 10-fold. The authors note, however, that other density estimation methods used in the region (e.g., aerial surveys) are not more precise than SC ({{ ref\_intext\_burgar\_et\_al\_2019 }}). The researchers also simulated their data, finding that SC tended to underestimate density when the number of captures and spatial recaptures (i.e., spatially-correlated detections between cameras) were low.

**Box 1.** The unmarked models that follow estimate density within the collective viewshed area (i.e., the combined fields-of-view of all cameras in a network) and assume that this estimate applies to the larger study area ({{ ref\_intext\_gilbert\_et\_al\_2021 }}). This is in contrast to spatial capture-recapture (SCR; see {bdg-link-primary-line}`Spatial capture-recapture (SCR) / Spatially explicit capture recapture (SECR)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_11\_mod\_scr\_secr.html>`) models and derivatives – including spatial count (SC; see {bdg-link-primary-line}`Spatial count<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_14\_mod\_sc.html>`), spatial mark-resight (SMR; see {bdg-link-primary-line}`Spatial mark-resight<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_13\_mod\_smr.html>`) and the spatial partial identity model (SPIM; see {bdg-link-primary-line}`Spatial Partial Identity Model (Categorical SPIM; catSPIM)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_15\_mod\_catspim.html>`and {bdg-link-primary-line}`Spatial Partial Identity Model (2-flank SPIM)<https://ab-rcsc.github.io/rc-decision-support-tool\_concept-library/02\_dialog-boxes/03\_16\_mod\_2flankspim.html>`) – which estimate density over a defined area.

## Figures

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| **Image** | **file\_name** | **Caption (if applicable)** | **ref\_id** |
| A black and white math equation  Description automatically generated | clarke\_et\_al\_2023\_eqn\_sc1.png | figure1\_caption | figure1\_ref\_id |
| A black and white math formula  Description automatically generated with medium confidence | clarke\_et\_al\_2023\_eqn\_sc2.png | figure2\_caption | figure2\_ref\_id |
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Shorten long captions (example)

\*\*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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SC models with the ‘nimble’ package (de Valpine\_et\_al\_2017

## References / Glossary

|  |  |
| --- | --- |
| **ref\_id** |  |
| {{ ref\_bib\_burgar\_et\_al\_2018 }}  {{ ref\_bib\_burgar\_et\_al\_2019 }}  {{ ref\_bib\_chandler\_royle\_2013 }}  {{ ref\_bib\_clarke\_2019 }}  {{ ref\_bib\_clarke\_et\_al\_2023 }}  {{ ref\_bib\_evans\_rittenhouse\_2018 }}  {{ ref\_bib\_gilbert\_et\_al\_2021 }}  {{ ref\_bib\_royle\_2016 }}  {{ ref\_bib\_royle\_dorazio\_2012 }}  {{ ref\_bib\_royle\_et\_al\_2014 }}  {{ ref\_bib\_sun\_et\_al\_2014 }}  {{ ref\_bib\_sun\_et\_al\_2022 }}  {{ ref\_bib\_sollmann\_2018 }}  {{ ref\_bib\_gilbert\_et\_al\_2021 }} |  |

## Notes

# Markdown

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

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

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\*\*{{ term\_mod\_occupancy }}\*\*: {{ term\_def\_mod\_occupancy }}

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

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

- {{ mod\_occupancy\_assump\_01 }}

- {{ mod\_occupancy\_assump\_02 }}

- {{ mod\_occupancy\_assump\_03 }}

- {{ mod\_occupancy\_assump\_04 }}

- {{ mod\_occupancy\_assump\_05 }}

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

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

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

- {{ mod\_occupancy\_pro\_03 }}

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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:

```{figure} ../03\_images/03\_image\_files/clarke\_et\_al\_2023\_eqn\_occupancy1.png

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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

:::::{grid} 3

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::::{grid-item-card} {{ ref\_intext\_murray\_et\_al\_2021 }}

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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.

:::{dropdown}

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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::::{grid-item-card} {{ ref\_intext\_southwell\_et\_al\_2019 }}

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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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::::{grid-item-card} {{ ref\_intext\_clarke\_et\_al\_2023 }}

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

::::

::::{grid-item-card} {{ ref\_intext\_figure5\_ref\_id }}

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figure5\_caption

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figure6\_caption

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figure7\_caption

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

::::

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

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

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

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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"

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allowfullscreen>

</iframe>

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:::::

::::{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 }}

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{{ 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 }}

{{ ref\_bib\_mackenzie\_et\_al\_2017 }}

{{ 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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