## Topic Info

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| --- | --- |
| **info\_id** | mod\_tifc |
| **question** | NULL |

## Assumptions, Pros, Cons – if modelling approach

|  |  |  |
| --- | --- | --- |
| **Assumptions** | **Pros** | **Cons** |
| - {{ mod\_tifc\_assump\_01 }}  - {{ mod\_tifc\_assump\_02 }}  - {{ mod\_tifc\_assump\_03 }} | - {{ mod\_tifc\_pro\_01 }}  - {{ mod\_tifc\_pro\_02 }}  - {{ mod\_tifc\_pro\_03 }} | - {{ mod\_tifc\_con\_01 }}  - {{ mod\_tifc\_con\_02 }} |

## 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)

:::

The time in front of the camera (TIFC) model is based on quadrat sampling. Typically, quadrats are used to sample slow- or non-moving organisms at a moment in time; as a simple example, a researcher lays a quadrat on the ground, counts the number of mussels in it and divides the count by the quadrat area. TIFC treats the camera viewshed like a vertical quadrat ({{ ref\_intext\_becker\_et\_al\_2022 }}; {{ ref\_intext\_dickie\_2022 }}). Unlike a conventional quadrat, however, the camera viewshed samples highly mobile organisms in a relatively small sliver of space and over long periods time ({{ ref\_intext\_becker\_et\_al\_2022 }}; {{ ref\_intext\_dickie\_2022 }}). The count of animals in the camera viewshed “quadrat,” then, can be thought of in “animal time” and the area covered by the quadrat in “area-time,” such that: </p><br>

```{figure} ../03\_images/03\_image\_files/clarke\_et\_al\_2023\_eqn\_tifc1.png

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**\*\*Clarke et al. (2023) - Fig. 8\*\*** A) Still from 中島啓裕’s (2021) video series. Example of overlaying a video recording of an animal on a reference image of the focal area (faint triangle) to determine staying time \*T\*. B) Still from Appendix S2 from Palencia et al. (2021). Example of superimposing the focal area on an image capture.

where the numerator, animal-time, is the number of animals \*N\* multiplied by the time those animals spend in the viewshed \*T<sub>O</sub>\*, summed over all detections; and the denominator, area-time, is the area of the viewshed \*A<sub>V</sub>\* multiplied by the total camera operating time \*T<sub>O</sub>\* ({{ ref\_intext\_becker\_et\_al\_2022 }}). Using this equation, density must be calculated for each species at each camera station, then averaged across the camera network.

To calculate \*A<sub>V</sub>\*: in the field, markers (e.g., poles) must be placed at known distances from the camera to divide the viewshed into distance bins; during analysis, the proportion of detections in each bin is determined ({{ ref\_intext\_becker\_et\_al\_2022 }}). The camera angle of view – which varies with make and model – is also needed to solve for \*A<sub>V</sub>\*. In most cases, \*T<sub>O</sub>\* will be the time from initial camera deployment to final camera collection ({{ ref\_intext\_becker\_et\_al\_2022 }}). In case of displacement, damage or failure, cameras should be programmed to take time-lapse images, so end-of-operation time can be traced back to a specific day or hour ({{ ref\_intext\_becker\_et\_al\_2022 }}).</p></br>

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**\*\*Clarke et al. (2023) - Fig. 9\*\*** Examples of behaviours that increase time in the viewshed (\*𝑇~𝑣~\*). A) A mule deer inspects a camera trap. &copy Cole Burton, Wildlife Coexistence Lab. B) A black bear pulls on the lock securing a camera trap to a tree. &copy Michael Procko, Wildlife Coexistence Lab.

<br>

## Simulations and Field Experiments (Clarke et al., 2023)

</p>The TIFC model has been field-tested on several different species. For moose, TIFC produced similar density estimates as aerial distance sampling (DS) after TIFC-derived estimates were corrected for the time animals spent investigating equipment (camera and 5 m pole; {{ ref\_intext\_becker\_et\_al\_2022 }})). This study used image data collected in Alberta at 2,990 camera stations over the course of 6 years; despite the large sample size and long study duration, estimates were not very precise.<br>

<br>

A study of five ungulate species (moose, bison, elk, mule and white-tailed deer) in two enclosed parks in Alberta found that TIFC- and aerial survey-derived density estimates were similar for moose and bison, but that TIFC significantly overestimated elk density compared with aerial surveys ({{ ref\_intext\_foca\_2021 }}). Two potential reasons for the discrepancy in elk density are: 1) that aerial surveys underestimated density, since elk in the study area occupy forested habitats, do not form large herds during the survey period, and estimates were not corrected for sightability; and 2) cameras may have been disproportionately set in areas elk prefer ({{ ref\_intext\_foca\_2021 }}). Group travelling behaviour may also have affected elk TIFC estimates, since detection probability and time in the viewshed (\*T<sub>V</sub>\*) can change with group size ({{ ref\_intext\_foca\_2021 }}). Estimates of mule and white-tailed deer densities could not be compared with aerial survey results, since deer are not surveyed by air in this area. Foca’s (2021) TIFC analyses produced the first density estimates for deer in both parks.<br>

<br>

In Uganda, TIFC-derived estimates of antelope were comparable to results from camera trap spatial capture-recapture (SCR; {{ ref\_intext\_brownlee\_et\_al\_2022 }}; {{ ref\_intext\_warbington\_boyce\_2020 }}). The model performed inconsistently for black bears, caribou, white-tailed deer and other species, however, compared to camera-based spatial count (SC), DNA markre capture and aerial survey methods (Fisher et al. in review).</p><br>

## Figures

|  |  |  |  |
| --- | --- | --- | --- |
| **Image** | **file\_name** | **Caption (if applicable)** | **ref\_id** |
| A mathematical equation with black text  Description automatically generated | clarke\_et\_al\_2023\_eqn\_tifc1.png | **\*\*Clarke et al. (2023) - Fig. 8\*\*** A) Still from 中島啓裕’s (2021) video series. Example of overlaying a video recording of an animal on a reference image of the focal area (faint triangle) to determine staying time \*T\*. B) Still from Appendix S2 from Palencia et al. (2021). Example of superimposing the focal area on an image capture. | clarke\_et\_al\_2023 |
| A black bear in the woods  Description automatically generated | clarke\_et\_al\_2023\_fig9\_clipped.png | \*\*Clarke et al. (2023) - Fig. 9\*\* Examples of behaviours that increase time in the viewshed (\*𝑇~𝑣~\*). A) A mule deer inspects a camera trap. &copy Cole Burton, Wildlife Coexistence Lab. B) A black bear pulls on the lock securing a camera trap to a tree. &copy Michael Procko, Wildlife Coexistence Lab. | clarke\_et\_al\_2023 |
|  | becker\_2024\_slide8.png | [  FROM MARCUS PPT SLIDE 8; NEED PERMISSION | becker\_2024 |
|  | becker\_2024\_slide9a.png | FROM MARCUS PPT SLIDE 8; NEED PERMISSION | becker\_2024 |
|  | becker\_2024\_slide12.png | FROM MARCUS PPT SLIDE 8; NEED PERMISSION | becker\_2024 |
|  | figure6\_filename.png | figure6\_caption | figure6\_ref\_id |

## Video

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| --- | --- | --- |
| **caption** | **URL (no < / > before/after URL** | **ref\_id** |
| How to estimate density using TIFC;  Video clip from presentation titled “Comparisons between moose densities with aerial surveys and integrated camera projects”  FROM MARCUS PPT; NEED PERMISSION | https://drive.google.com/file/d/1IdxQScbzkHd2griu-dEYM4FTFjaXalKe/preview | becker\_2024 |
| 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 |

## Shiny

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## Analytical tools & resources

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| --- | --- | --- | --- | --- |
| **Type** | **Name** | **Note** | **URL** | **ref\_id** |
| Tutorial | Estimating animal density using TIFC (Time In Front of Camera) | Created by author of TIFC method. | <https://github.com/mabecker89/tifc-method> | becker\_et\_al\_2021 |
| R package | abmi.camera.extras |  | <https://mabecker89.github.io/abmi.camera.extras> | becker\_et\_al\_2020 |
| Tutorial | abmi.camera.extras: Animal Density from Camera Data |  | Main resource page <https://mabecker89.github.io/abmi.camera.extras/index.html> includes:<br>- [Overview]<https://mabecker89.github.io/abmi.camera.extras/articles/overview.html><br>- [Probabilistic gaps]<https://mabecker89.github.io/abmi.camera.extras/articles/gaps.html><br>- [Time in the camera field of view]<https://mabecker89.github.io/abmi.camera.extras/articles/fov.html><br>- [Effective detection distance]<https://mabecker89.github.io/abmi.camera.extras/articles/edd.html><br>- [Density at individual deployments]<https://mabecker89.github.io/abmi.camera.extras/articles/dep-density.html>- [Lure adjustments]<https://mabecker89.github.io/abmi.camera.extras/articles/lure.html><br>- [Density in an area of interest (AOI)]<https://mabecker89.github.io/abmi.camera.extras/articles/aoi-density.html><br>- [Important assumptions]<https://mabecker89.github.io/abmi.camera.extras/articles/assumptions.html> | becker\_et\_al\_2020 |
| resource4\_type | resource4\_name | resource4\_note | resource4\_url | resource4\_ref\_id |
| resource5\_type | resource5\_name | resource5\_note | resource5\_url | resource5\_ref\_id |
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| resource15\_type | resource15\_name | resource15\_note | resource15\_url | resource15\_ref\_id |

## References / Glossary

|  |  |
| --- | --- |
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| {{ ref\_bib\_becker\_et\_al\_2022 }}  {{ ref\_bib\_becker\_2024 }}  {{ ref\_bib\_clarke\_et\_al\_2023 }}  {{ ref\_bib\_dickie\_2022 }}  {{ ref\_bib\_foca\_2021 }}  {{ ref\_bib\_palencia\_et\_al\_2022 }}  {{ ref\_bib\_warbington\_boyce\_2020 }} |  |

## Notes

# Markdown

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

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jupytext\_version: 1.16.4 <!-- 6.5.4-->

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

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

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- {{ 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 }}

- {{ mod\_occupancy\_pro\_04 }}

- {{ mod\_occupancy\_pro\_05 }}

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::::{grid-item-card} Cons

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

- {{ mod\_occupancy\_con\_02 }}

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

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

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

:::{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)

:::

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.

:::{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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\*\*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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Occupancy Modeling Video 1 -- Sampling Techniques for Mammals

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Occupancy Modeling Video 2 -- Introductory Statistical Review

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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

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

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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!

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shiny\_caption

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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 }}

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

{{ 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 }}

{{ ref\_bib\_guillera\_arroita\_et\_al\_2012 }}

{{ 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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