# 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
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* 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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| **question** | NULL |

## Assumptions, Pros, Cons – if modelling approach

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| **Assumptions** | **Pros** | **Cons** |
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## Overview

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## Advanced

Of all the modelling frameworks discussed in this document, capture-recapture (CR) also called capture-mark-recapture or mark-recapture – is perhaps the most wellknown. Since the 19th century, CR has been used to measure population size by capturing, marking, releasing and recapturing individuals ({{ ref\_intext\_lecren\_1965 }}, {{ ref\_intext\_otis\_et\_al\_1978 }}). For species or populations that are challenging to physically trap and mark, CR can also be applied to DNA, acoustic and camera trap data ({{ ref\_intext\_royle\_et\_al\_2014 }}). Here, we will discuss camera trap CR.

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\*\*Clarke et al. (2023) – Fig. 3\*\* Adapted from Royle (2020). A detection history matrix for an example population. For each individual (1 through \*𝑛\*) during each sampling occasion (1 through \*𝐾\*), a value of 1 is assigned if that individual was detected at a camera trap and a value of 0 is assigned if it was not detected at a camera trap. Note that we do not detect individuals \*𝑛\* + 1, \*𝑛\* + 2…\*𝑁\* (0s for every sampling occasion), but they are still present and able to be detected.

To estimate density using camera trap CR, we must first estimate population size \*𝑁\*. CR models use individuals’ detection histories – that is, the record of when each individual was photographed or not photographed (i.e., (re)captured or not (re)captured) – to solve for \*𝑁\* (Figure 3; Royle, 2020). Population-level detection histories look like a matrix of 1s and 0s, where 1s signify that an individual was captured during a given sampling occasion \*𝑘\*, and 0s signify that the individual was not captured during that occasion ({{ ref\_intext\_royle\_2020 }}, {{ ref\_intext\_royle\_et\_al\_2014 }}). The number of individuals photographed at least once over the course of the study (i.e., the count of animals captured) is \*𝑛\*.

Importantly, the count of animals is not the same as the size of the population (i.e., \*𝑛\* ≠ \*𝑁\*). Some individuals will never be photographed during a study, even though they are present and able to be detected (i.e., they are in \*𝑁\* but not in \*𝑛\*; {{ ref\_intext\_royle\_2020 }}). Using the matrix of detection histories, we must therefore calculate the likelihood animals will be detected by an array of camera traps – that is, detection probability \*p\* ({{ ref\_intext\_royle\_2020 }}).

Taking this information together, we can calculate population size \*𝑁\* as:

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which is often referred to as the canonical estimator of population size ({{ ref\_intext\_royle\_2020 }}). Population size \*𝑁\* can then be divided by an estimate of the area of the sampling frame \*𝐴\* to obtain density.

CR models have important limitations – notably that they do not consider the spatial configuration of camera traps or the spatial pattern of animal detections. This gives rise to two major issues:

1. The sampling frame \*𝐴\* is not known ({{ ref\_intext\_chandler\_royle\_2013 }}). In other words: the true area animals occupy is never measured, only approximated using adhoc approaches (e.g., using a buffer strip around the trap array; {{ ref\_intext\_rich\_et\_al\_2014 }}, {{ ref\_intext\_sollmann\_ 2018 }}). Consequently, density cannot be calculated explicitly ({{ ref\_intext\_chandler\_royle\_2013 }}), and CR-derived density estimates are somewhat arbitrary and difficult to compare across studies ({{ ref\_intext\_green\_et\_al\_2020 }}, {{ ref\_intext\_royle\_et\_al\_2014 }}, {{ ref\_intext\_sollmann\_ 2018 }}).

2. Detection probability is assumed to be the same across all individuals and sampling occasions, even though the likelihood a given individual is detected at a given camera trap will change with its proximity to that trap. An animal that occupies territory far away from a trap is less likely to be detected there than one that lives nearby, for example ({{ ref\_intext\_morin\_et\_al\_2022 }}).

The standard CR model has largely been phased out with the advent of spatially-explicit CR models (see \**2.1.2 Spatial Capture-Recapture*\* [of [Clarke et al. 2023](https://www.researchgate.net/publication/368601884\_Using\_Camera\_Traps\_to\_Estimate\_Medium\_and\_Large\_Mammal\_Density\_Comparison\_of\_Methods\_and\_Recommendations\_for\_Wildlife\_Managers); {{ ref\_intext\_burton\_et\_al\_2015 }}, {{ ref\_intext\_sollmann\_ 2018 }}), which address the shortcomings of CR and have been shown to produce more accurate density estimates (e.g., {{ ref\_intext\_blanc\_et\_al\_2013 }}, {{ ref\_intext\_obbard\_et\_al\_2010 }}, {{ ref\_intext\_sollmann\_et\_al\_2011 }}).

## Figures

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| **Image** | **file\_name** | **Caption (if applicable)** | **ref\_id** |
| A black background with a white arrow  Description automatically generated | clarke\_et\_al\_2023\_fig11\_clipped.png | \*\*Clarke et al. (2023) – **Fig. 3\*\*** Adapted from Royle (2020). A detection history matrix for an example population. For each individual (1 through \*𝑛\*) during each sampling occasion (1 through \*𝐾\*), a value of 1 is assigned if that individual was detected at a camera trap and a value of 0 is assigned if it was not detected at a camera trap. Note that we do not detect individuals \*𝑛\* + 1, \*𝑛\* + 2…\*𝑁\* (0s for every sampling occasion), but they are still present and able to be detected. | clarke\_et\_al\_2023 |
| A number of letters and numbers  Description automatically generated with medium confidence | clarke\_et\_al\_2023\_eqn\_cr1.png | figure2\_caption | fclarke\_et\_al\_2023 |
|  | figure3\_filename.png | figure4\_caption | figure3\_ref\_id |
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## Video

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## Analytical tools & resources

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CAPTURE

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## References / Glossary

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| {{ ref\_bib\_blanc\_et\_al\_2013 }}  {{ ref\_bib\_burton\_et\_al\_2015 }}  {{ ref\_bib\_chandler\_royle\_2013 }}  {{ ref\_bib\_green\_et\_al\_2020 }}  ({{ ref\_bib\_lecren\_1965 }}  {{ ref\_bib\_obbard\_et\_al\_2010 }}  {{ ref\_bib\_otis\_et\_al\_1978 }}  {{ ref\_bib\_morin\_et\_al\_2022 }}  {{ ref\_bib\_rich\_et\_al\_2014 }}  {{ ref\_bib\_royle\_et\_al\_2014 }}  {{ ref\_bib\_royle\_2020 }}  {{ ref\_bib\_sollmann\_et\_al\_2018 }}  {{ ref\_bib\_sollmann\_et\_al\_2011 }} | keys\_here |

## Notes