### (#i\_mod\_tifc)=

### Time in front of the camera (TIFC)

ensure concepts of "Detection distance", "Effective detection distance" - have defs below

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| **Time in front of the camera (TIFC) (Huggard, 2018; Warbington & Boyce, 2020; tested in Becker et al., 2022):** A method used to estimate density that treats camera image data as quadrat samples (Becker et al., 2022). | | | | | |
| Overview - How the Model Works | | | | | |
| Advanced - How the Model Works (Clarke et al., 2023)  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 (Becker et al. 2022, 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 (Becker et al. 2022, 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:  A mathematical equation with black text  Description automatically generated  ```{figure} ./images/Clarke-et-al\_2023\_eqn\_tifc1.png  :align: center  ```  where the numerator, animal-time, is the number of animals N multiplied by the time those animals spend in the viewshed TV, summed over all detections; and the denominator, area-time, is the area of the viewshed AV multiplied by the total camera operating time TO (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 AV: 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 (Becker et al. 2022). The camera angle of view – which varies with make and model – is also needed to solve for AV. In most cases, TO will be the time from initial camera deployment to final camera collection (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 (Becker et al. 2022). | | | | | |
| A black bear in the woods  Description automatically generated  ```{figure} ./images/Clarke-et-al\_2023\_Fig9\_clipped.png  :align: center  ```  **Figure 9.** Examples of behaviours that increase time in the viewshed (𝑇𝑣). A) A mule deer inspects a camera trap. © Cole Burton, Wildlife Coexistence Lab. B) A black bear pulls on the lock securing a camera trap to a tree. © Michael Procko, Wildlife Coexistence Lab. | | | | | |
| Assumptions (RCSC et al., 2023) | | Pros (RCSC et al., 2023) | | Cons (RCSC et al., 2023) | |
| * Camera locations are randomly placed or representative relative to animal movement (Becker et al., 2022) * Movement is unaffected by the cameras (Becker et al., 2022) * Reliable detection of animals in part of the camera’s FOV (at least) (Becker et al., 2022) | | * Does not require individual identification (Warbington & Boyce, 2020) * Makes no assumption about home range (Warbington & Boyce, 2020) * Comparable to estimates from SECR (Warbington & Boyce, 2020) | | * Requires careful calculation of the effective area of detection (Warbington & Boyce, 2020) * A high level of measurement error (Becker et al., 2022) | |
| Simulations and Field Experiments (Clarke et al., 2023)  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; 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.  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 (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 (Foca 2021). Group travelling behaviour may also have affected elk TIFC estimates, since detection probability and time in the viewshed (TV) can change with group size (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.  In Uganda, TIFC-derived estimates of antelope were comparable to results from camera trap spatial capture-recapture (SCR; Brownlee et al. 2022, Warbington and 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). | | | | | |
| Figures & Videos | | | | | |
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| Analytical tools & resources | | | | | |
| Name | Link | | Reference | | Additional\_info |
| Estimating animal density using TIFC (Time In Front of Camera) | https://github.com/mabecker89/tifc-method | |  | |  |
| Calculate total time in front of camera by series | <https://mabecker89.github.io/abmi.camera.extras/articles/fov.html> | |  | |  |
| References Alberta Remote Camera Steering Committee (RCSC), Stevenson, C., Hubbs, A., & Wildlife Cameras for Adaptive Management (WildCAM). 2023. Remote Camera Survey Guidelines: Guidelines for Western Canada. Edmonton, Alberta. https://ab-rcsc.github.io/RCSC-WildCAM\_Remote-Camera-Survey-Guidelines-and-Metadata-Standards/1\_survey-guidelines/1\_0.1\_Citation-and-Info.html  Becker, M., Huggard, D. J., Dickie, M., Warbington, C., Schieck, J., Herdman, E., Serrouya, R., & Boutin, S. (2022). Applying and Testing a Novel Method to Estimate Animal Density from Motion-Triggered Cameras. Ecosphere, 13(4), 1-14. <https://doi.org/10.1002/ecs2.4005>  Clarke, J., Bohm, H., Burton, C., & Constantinou, A. (2023). Using Camera Traps to Estimate Medium and Large Mammal Density: Comparison of Methods and Recommendations for Wildlife Managers. <https://doi.org/10.13140/RG.2.2.18364.72320>  Warbington, C. H., & Boyce, M. S. (2020). Population density of sitatunga in riverine wetland habitats. Global Ecology and Conservation, 24. <https://doi.org/10.1016/j.gecco.2020.e01212> | | | | | |

notes

* **Effective detection distance:** The distance from a camera that would give the same number of detections if all animals up to that distance are perfectly detected, and no animals that are farther away are detected; Buckland, 1987, Becker et al., 2022).
* **Detection distance:** "The maximum distance that a sensor can detect a target" (Wearn and Glover-Kapfer, 2017).

### (#i\_app\_tifc)=

### TIFC app

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| Overview - How the app works | | | |
| Advanced - How the app works(?) | | | |
| **Figures & Videos** (if needed/not already in approach) | | | |
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| **Analytical tools & resources** (if needed/not already in approach) | | | |
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| References | | | |

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