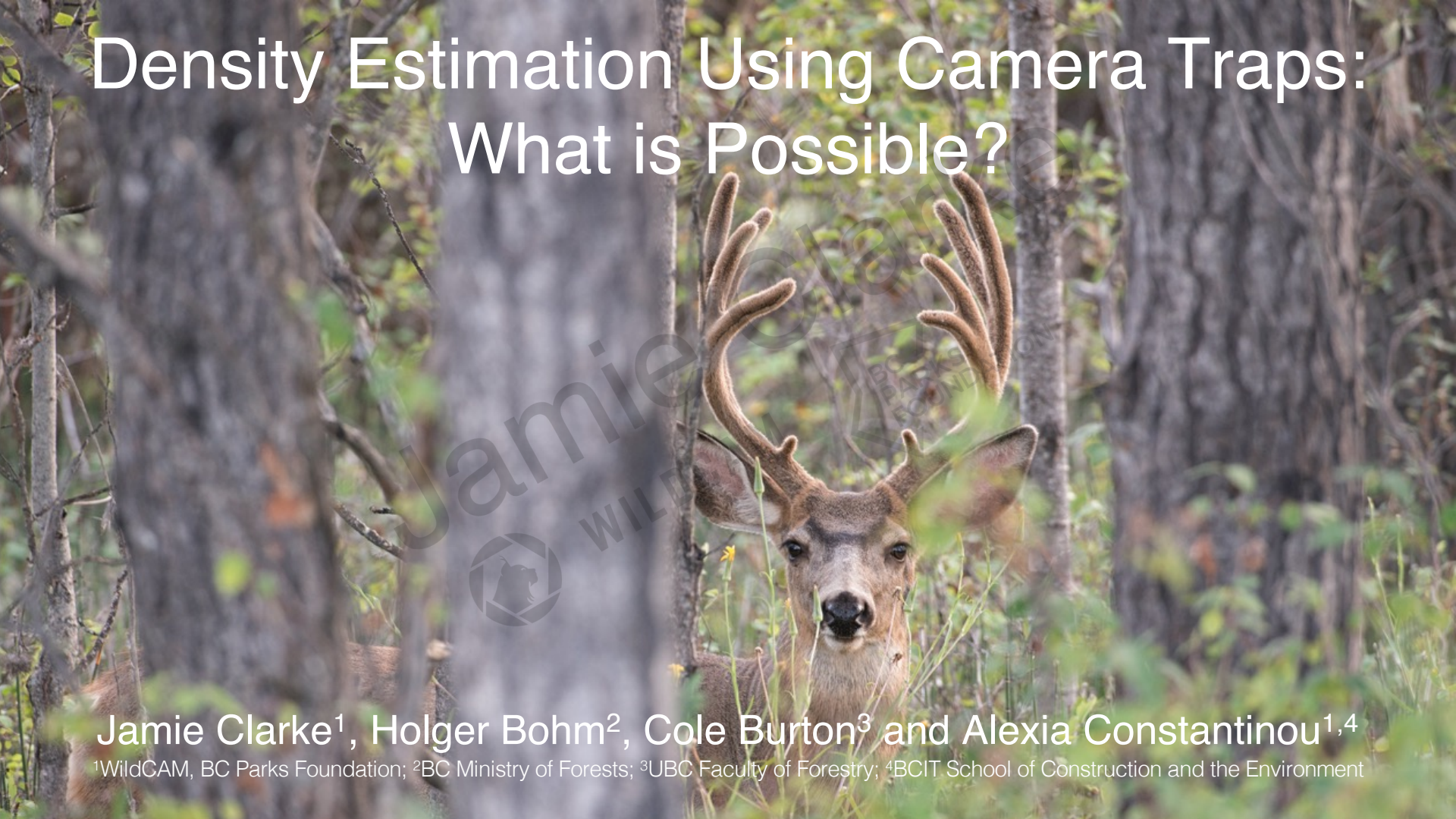
Density Estimation Using Camera Traps: What is Possible?

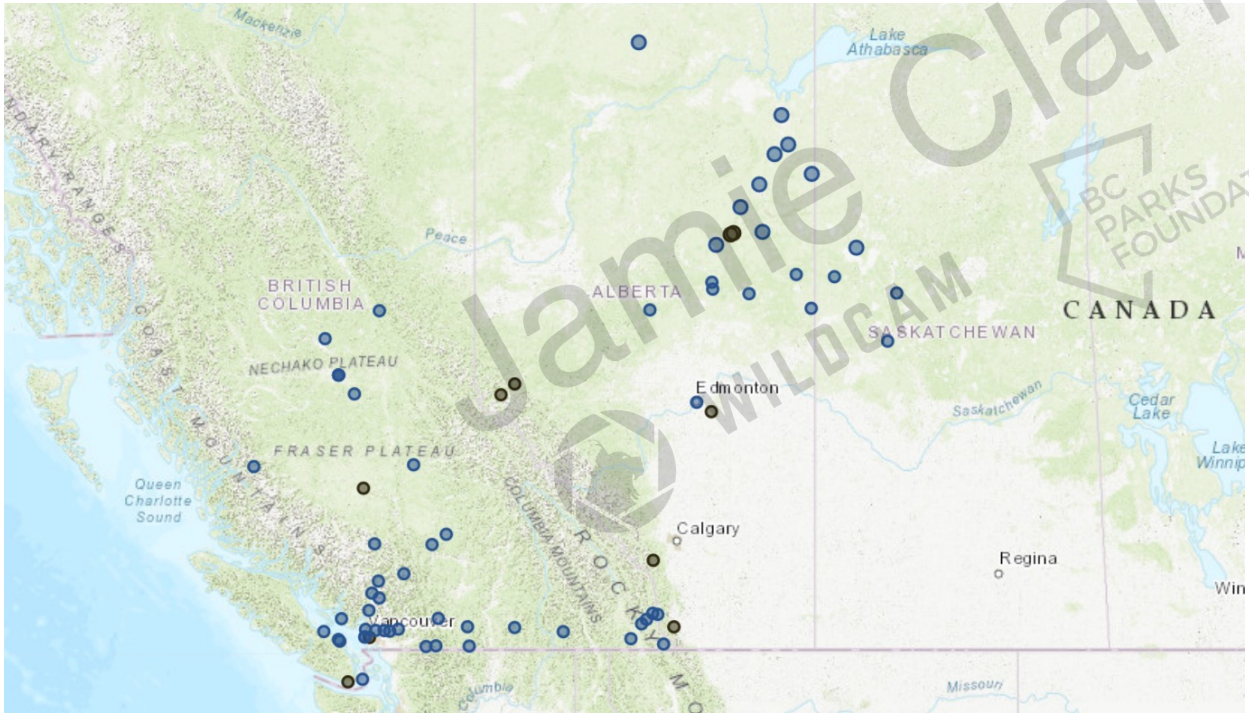


Jamie Clarke[1], Holger Bohm[2], Cole Burton[3] and Alexia Constantinou[1,4]

[1]WildCAM, BC Parks Foundation; [2]BC Ministry of Forests; [3]UBC Faculty of Forestry; [4]BCIT School of Construction and the Environment

This research took place on the traditional, ancestral, and unceded territories of the **Coast Salish Peoples** – the **Sḵwx̱wú7mesh** (Squamish), **Stó:lō** and **Səl̓ílwətaʔ/Selilwitulh** (Tsleil-Waututh) and **xʷməθkʷəy̓əm** (Musqueam) Nations – and the **sngaytskstx** (Sinixt) People.

What is WildCAM?



WILDCAM

is a **network of camera trappers**, for camera trappers, that supports effective wildlife stewardship by fostering **coordination + collaboration** and sharing **best practices**

Who is WildCAM?

Our Advisory Committee:

- Dr. Cole Burton, University of British Columbia
- Dr. Jason Fisher, University of Victoria
- Dr. Joanna Burgar, BC Ministry of Water, Land and Resource Stewardship
- Dr. Dan Farr, Alberta Resource Stewardship Division
- Dr. Anne Hubbs, Alberta Environment and Parks
- Dr. Kaitlyn Gaynor, University of British Columbia
- Dr. Tyler Muhly, Ministry of Forests
- Melanie Percy, BC Parks

BRITISH COLUMBIA
Ministry of Forests, Lands, Natural Resource Operations and Rural Development

WildCo

BC PARKS FOUNDATION

WildCAM + the BC Parks Foundation

WildCAM is administered by the

BC PARKS FOUNDATION

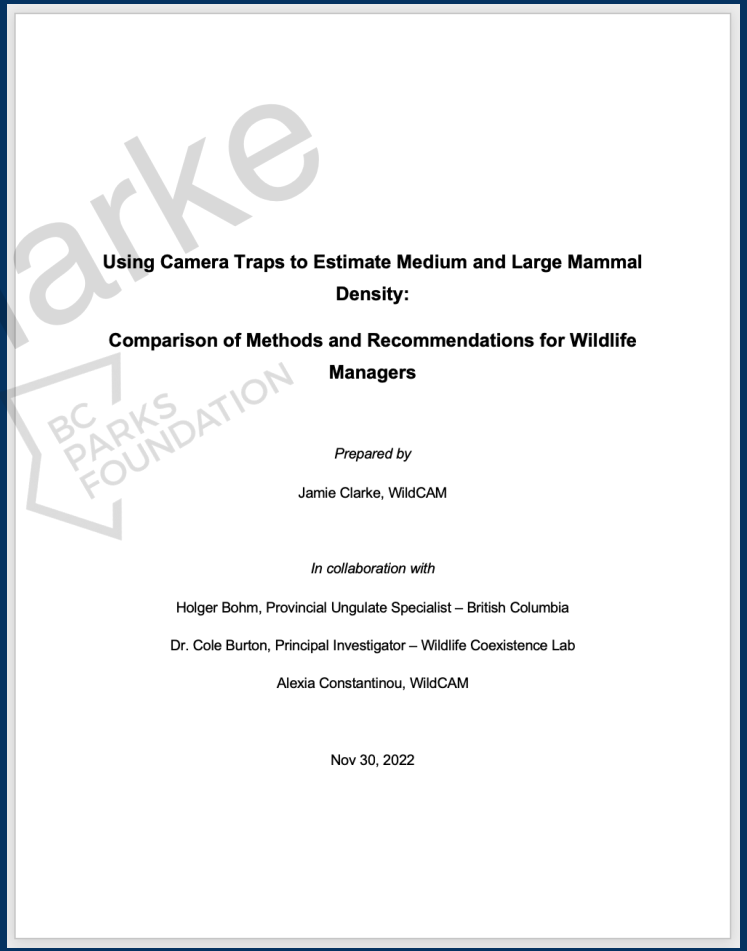
– which **protects, enhances and sustains BC's parks**, while inspiring and connecting people to them

WildCAM Coordinator

Jamie Clarke

So You Know…

Material covered today is also available in the handbook



Using Camera Traps to Estimate Medium and Large Mammal Density:

Comparison of Methods and Recommendations for Wildlife Managers

Prepared by

Jamie Clarke, WildCAM

In collaboration with

Holger Bohm, Provincial Ungulate Specialist – British Columbia

Dr. Cole Burton, Principal Investigator – Wildlife Coexistence Lab

Alexia Constantinou, WildCAM

Nov 30, 2022

1 Background

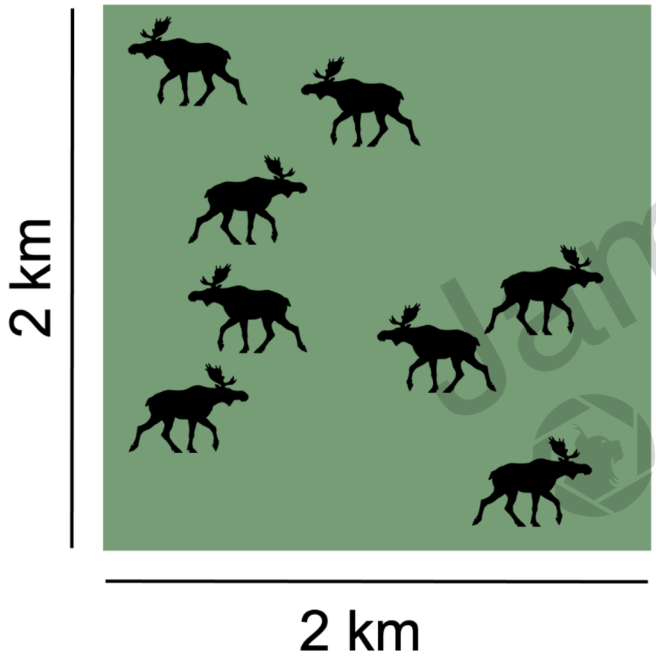
What is Density?

$$\frac{\#\ animals}{area}$$

$\#\ animals \longrightarrow$ population size

$area \longrightarrow$ total area sampled

What is Density?



=

$$\frac{\text{moose}}{\text{km}^2}$$

Why is Density Useful?

monitor → populations trends: increases? declines?
(Morin et al. 2022)

manage → # animals that can be sustainably hunted?
(2020-2022 Hunting and Trapping Regulations Synopsis)

assess → impacts of management actions?
(Sun et al. 2022)

Estimates of Density are Critical for Wildlife Stewardship

standardized comparisons across…

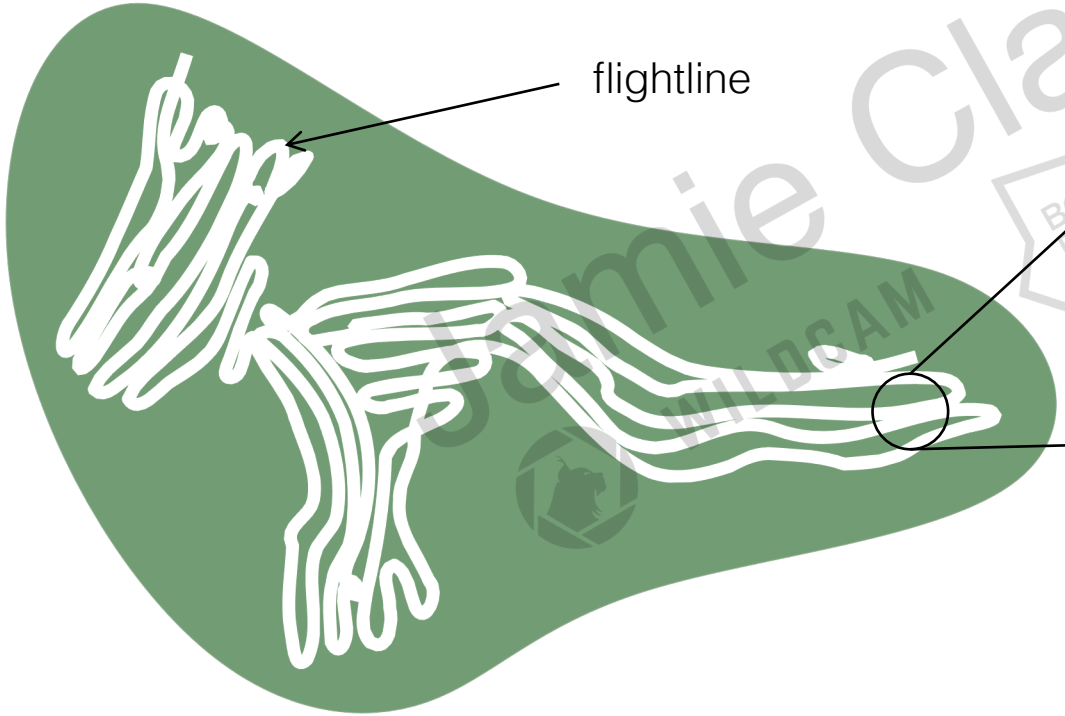
(Morin et al. 2022)

space  vs 

species  vs 

time t_1 vs t_2

In BC: Often Estimate Density via Aerial Survey



© Parks Canada

aerial surveys sample large swaths of land over short periods of time

© fRI Research

© fRI Research

Aerial Surveys Are…

Expensive

- flown infrequently
- few wildlife management units surveyed/year (Boyce et al. 2012)

→ sporadic, spotty coverage

Dangerous

- injury + death to biologists
- disturbance to wildlife
  (Côté et al. 2013, Crupi et al. 2020, Frid 2003)

→ most dangerous part of a wildlife biologist's job
(Sasse 2003)

Limited in Scope

- big animals
- open, snowy areas
  (BC Ministry of SRM 2002)
- poor density estimate
  (Davis et al. 2022)

→ species-, landscape- and season-limited

Motivation

Motivation

Is there a better way to estimate density?

Motivation

Is there a better way to estimate density?

Are camera traps better than aerial surveys?

Motivation

Is there a better way to estimate density?

Are camera traps better than aerial surveys?

first: we need to know…

Motivation

is there a better way to estimate density?

are camera traps better than aerial surveys?

first: we need to know…

How can you estimate population density using camera traps?

Problem

Information about camera trap density models is all over the place – hundreds of peer-reviewed papers, grey literature, reports…

② Context

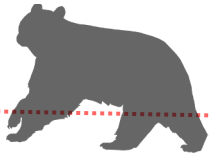
How Do Camera Traps Work?

How Do Camera Traps Work?

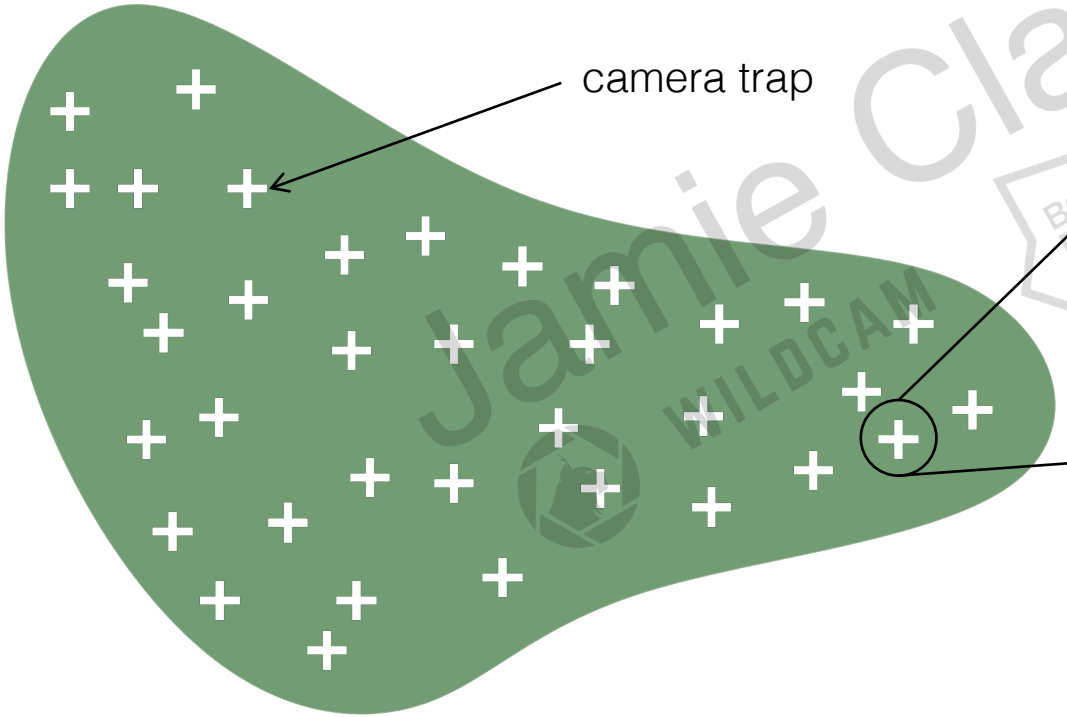
© WildCo Lab

temperature difference + movement = trigger

motion sensor



How Do Camera Traps Sample the Landscape?



© Alexia Constantinou

cameras sample tiny slivers of space for long stretches of time

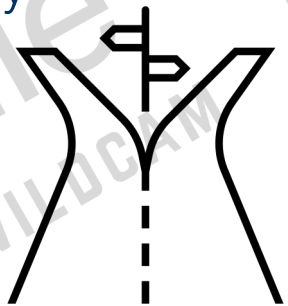
③ Camera Trap Density Models

Can use **indices of density**
(relative abundance, occupancy)

Use **density models**
(our focus today)

No – don't need to know absolute density

Yes – need to know absolute density

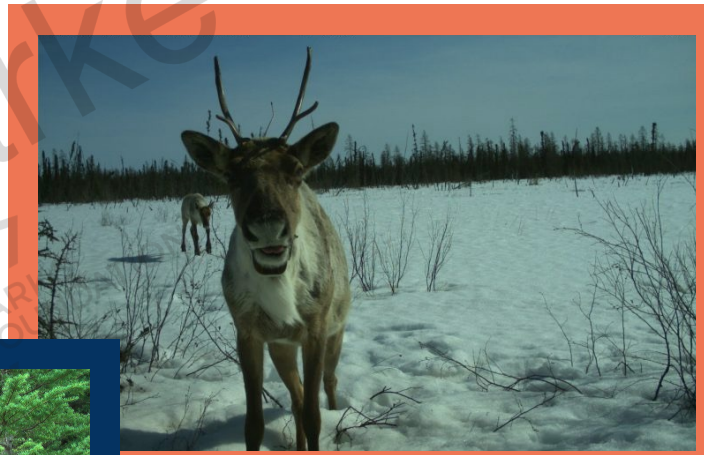


First we need to ask:
are density estimates needed?

Different Kinds of Camera Trap Density Models

marked models

unmarked models



partially-marked models

So You Know…

- there is ongoing work to **evaluate** these models
- some of this work is highlighted in the **handbook**

Today: going over *how* models work

Marked Models

Animals have unique natural or artificial marks = unique identities

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Capture-Recapture

(Karanth and Nichols 1998, Otis et al. 1978)

Data Needed:

- ▢ individual detection histories

sampling occasion

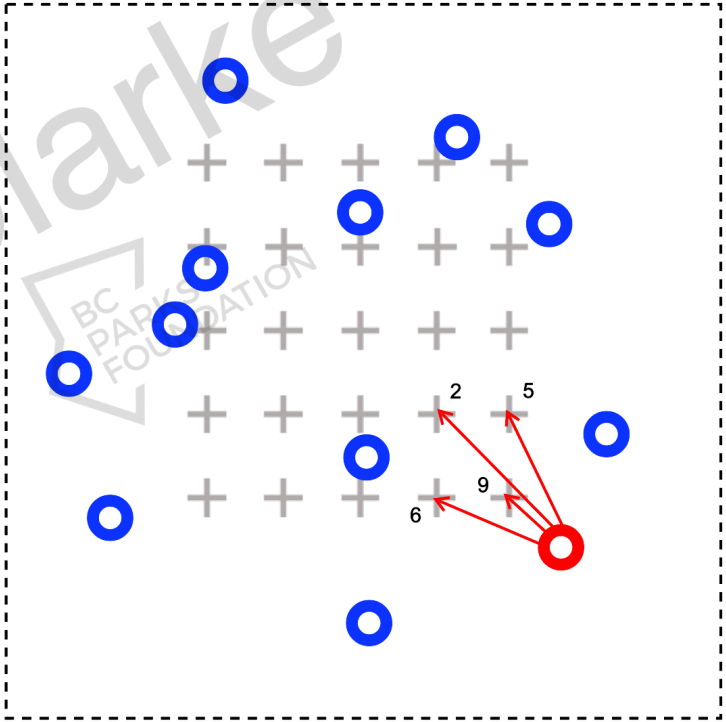
individual	1	2	3	…	$k = K$
1	0	0	1	…	0
2	0	0	1	…	1
3	0	0	1	…	0
…	…	…	…	…	…
$n+1$	0	0	0	…	0
$n+2$	0	0	0	…	0
…	…	…	…	…	…
N	0	0	0	0	0

Spatial Capture-Recapture

(Borchers and Efford 2008, Royle and Yound 2008)

Data Needed:

- ☐ individual detection histories
- ☐ camera trap coordinates



Unmarked Models

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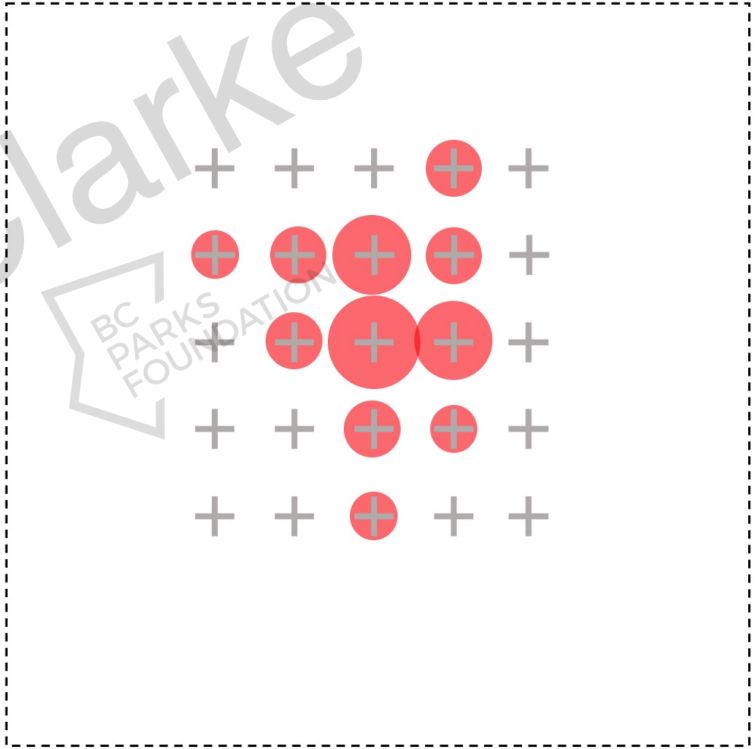
Animals do not have unique marks = cannot be individually identified

Spatial Count

(Chandler and Royle 2013)

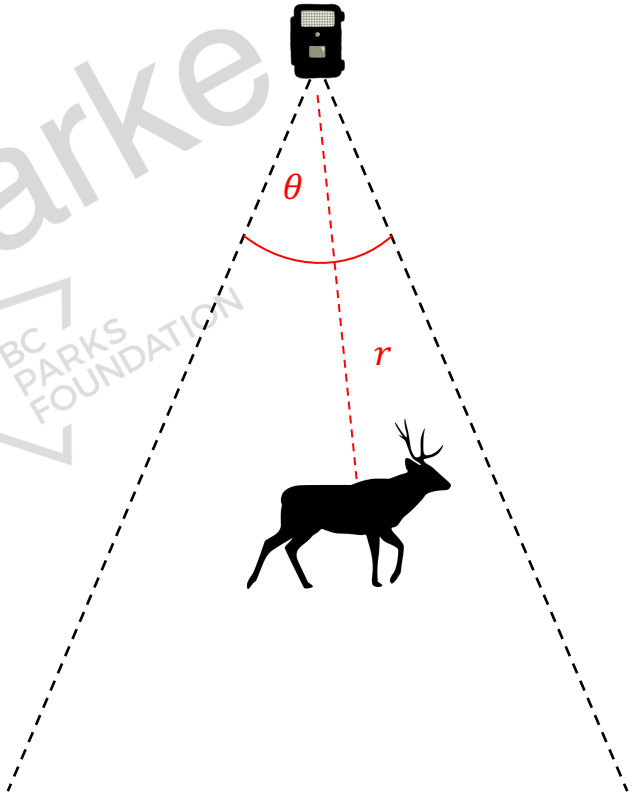


Data Needed:

- ☐ camera-specific counts of animals
- ☐ camera trap coordinates

Distance Sampling

(Howe et al. 2017)



Data Needed:

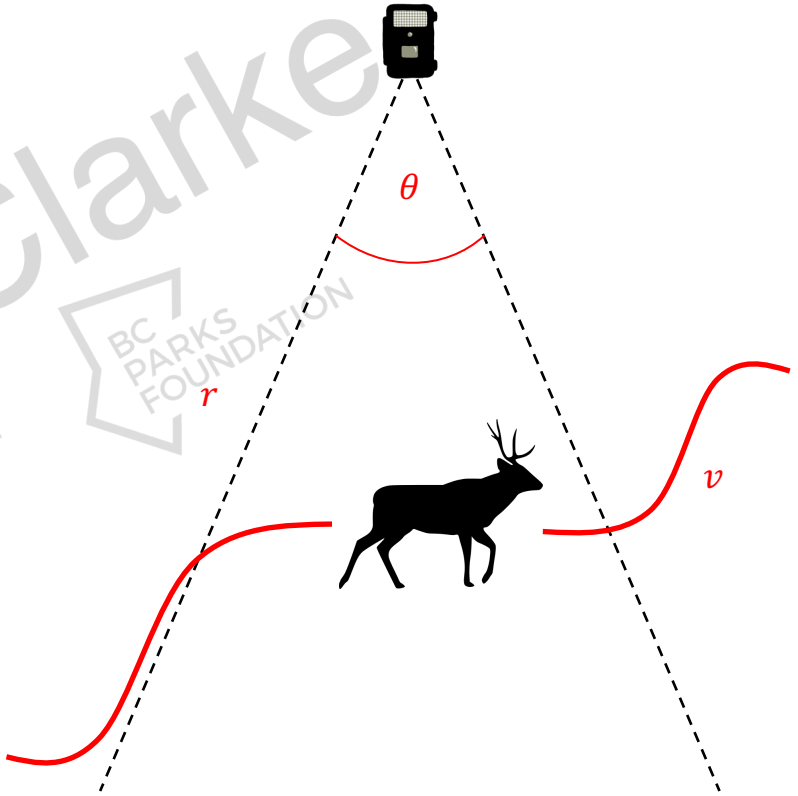
- ☐ number of detections
- ☐ viewshed angle
- ☐ distance between camera and animals' centre

Random Encounter Model

(Rowcliffe et al. 2008)

Data Needed:

- ☐ number of images per unit time
- ☐ animal movement speed
- ☐ radius and angle of detection zone
- ☐ average group size

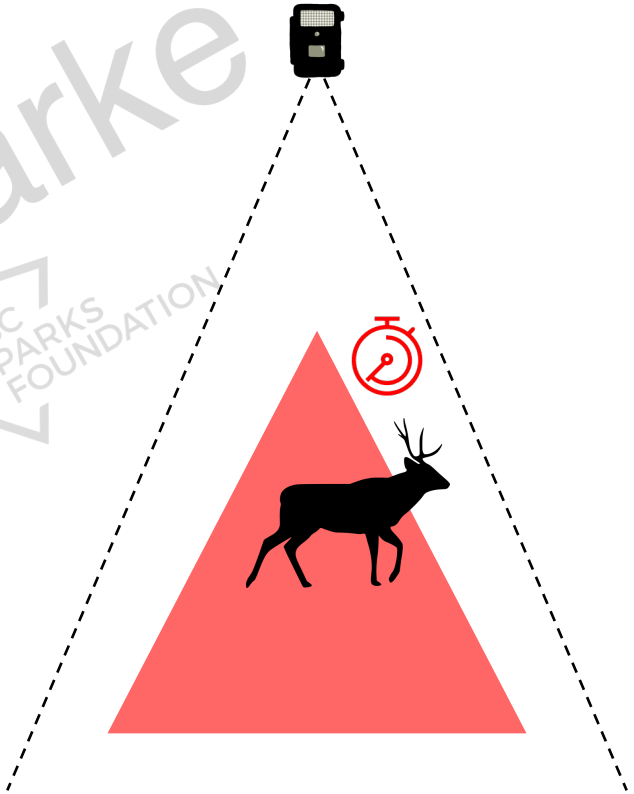


Random Encounter and Staying Time

(Nakashima et al. 2018)

Data Needed:

- ☐ number of detections
- ☐ camera focal area
- ☐ time individuals spend in focal area
- ☐ total sampling time
- ☐ proportion of time animals spend active

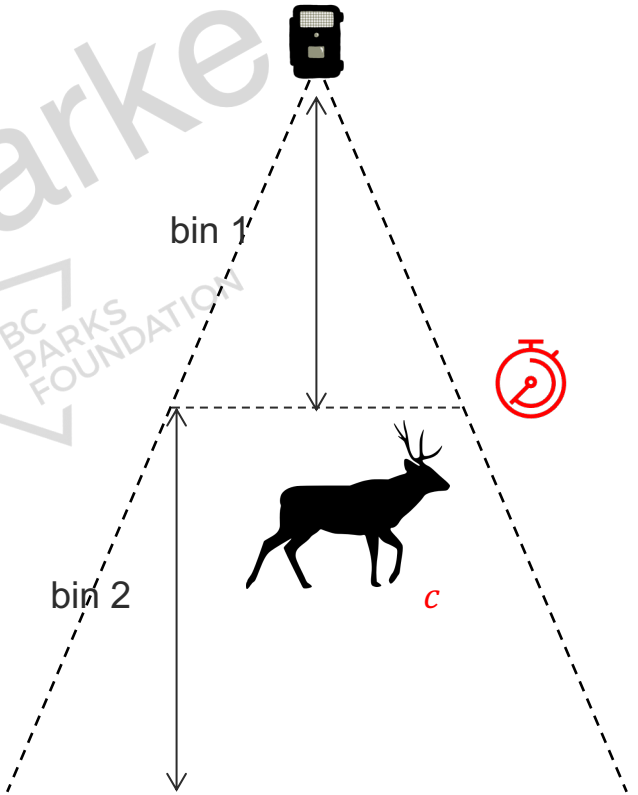


Time in Front of the Camera

(Becker et al. 2022)

Data Needed:

- ☐ counts of individuals in images
- ☐ time individuals spend in viewshed
- ☐ viewshed divided into distance bins
- ☐ total camera operating time

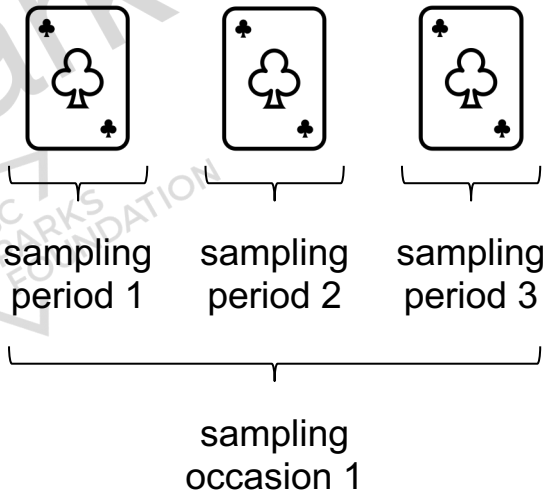


Time-to-Event

(Moeller et al. 2018)

Data Needed:

- ☐ time until individual(s) detected
- ☐ animal movement speed
- ☐ viewshed area



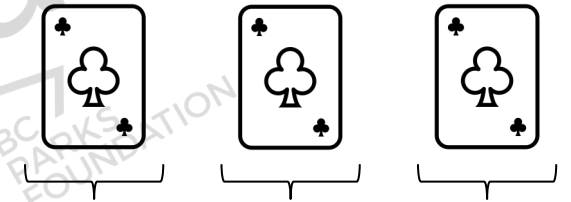
how much time until  drawn?

Space-to-Event

(Moeller et al. 2018)

Data Needed:

- ☐ number of cameras until individual(s) detected
- ☐ viewshed area



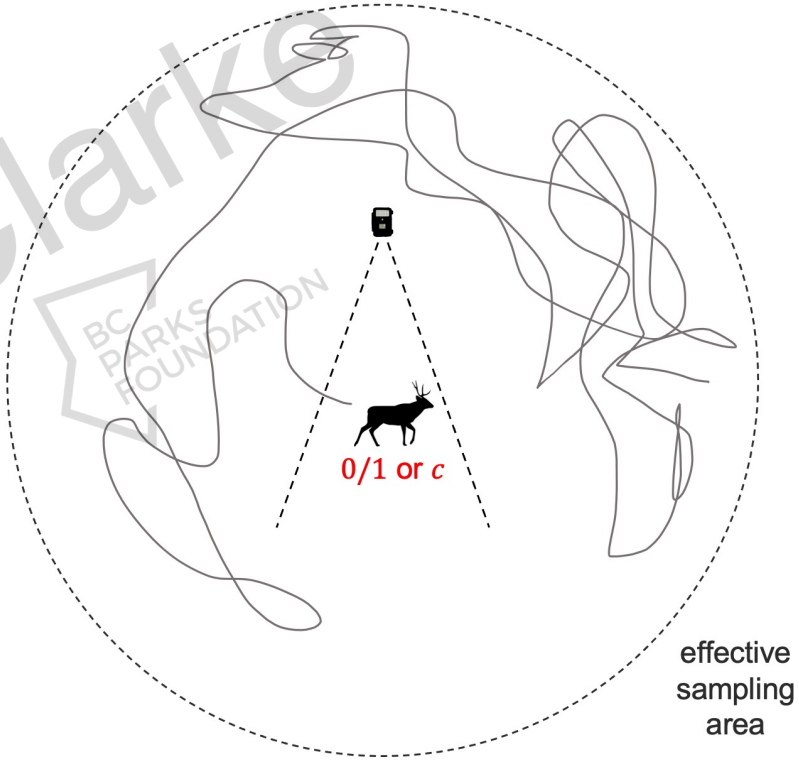
how much area until  drawn?

Site-Structured Models: Royle-Nichols + N-Mixture

(Royle and Nichols 2003, Royle 2004)

Data Needed:

- ☐ detections + non-detections *or* counts of animals during each survey occasion



Partially-Marked Models

Subset of marked animals in a population = populations are partially-marked

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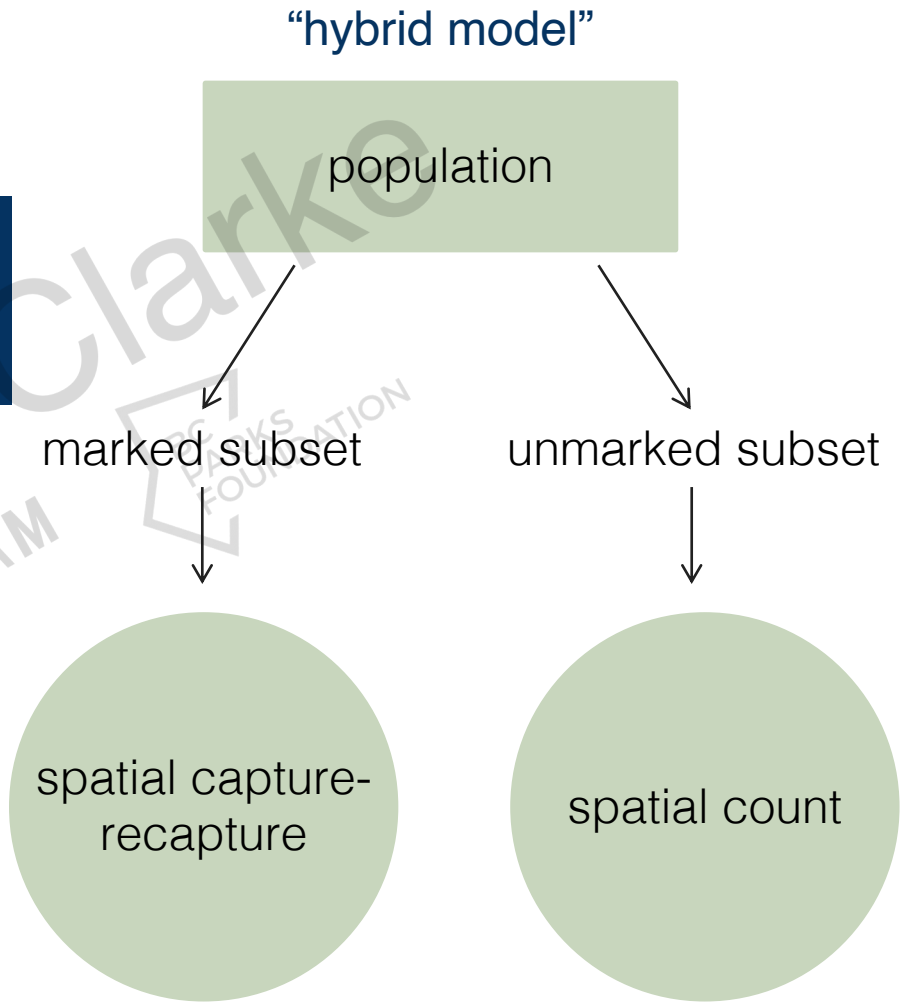
Spatial Mark-Resight

(Chandler and Royle 2013, Sollmann et al. 2013)



Data Needed:

- ☐ individual detection histories
- ☐ camera-specific counts of animals
- ☐ camera trap coordinates

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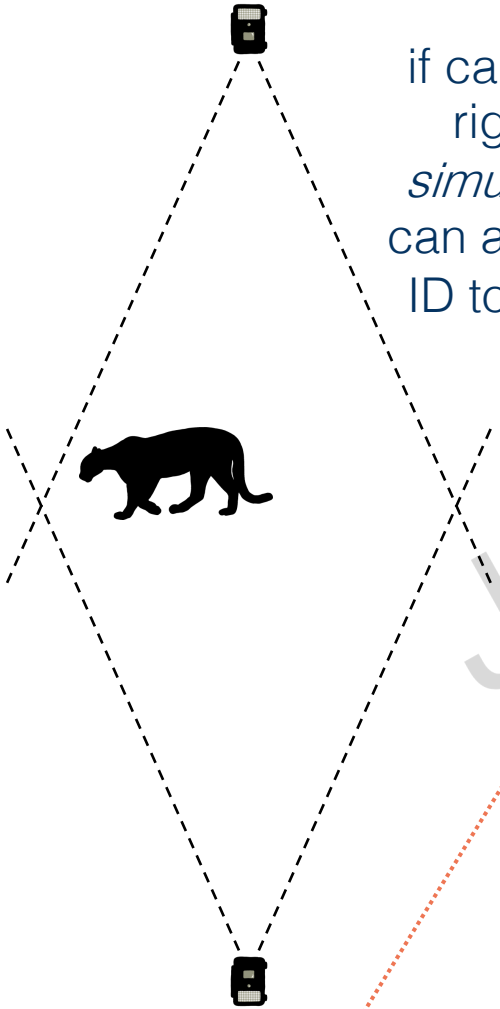
Image sets are partially-identifying



if capture left + right flanks *simultaneously*: can assign same ID to each side

vs

if capture left + right sides *separately* : can erroneously assign different IDs to left + right flanks

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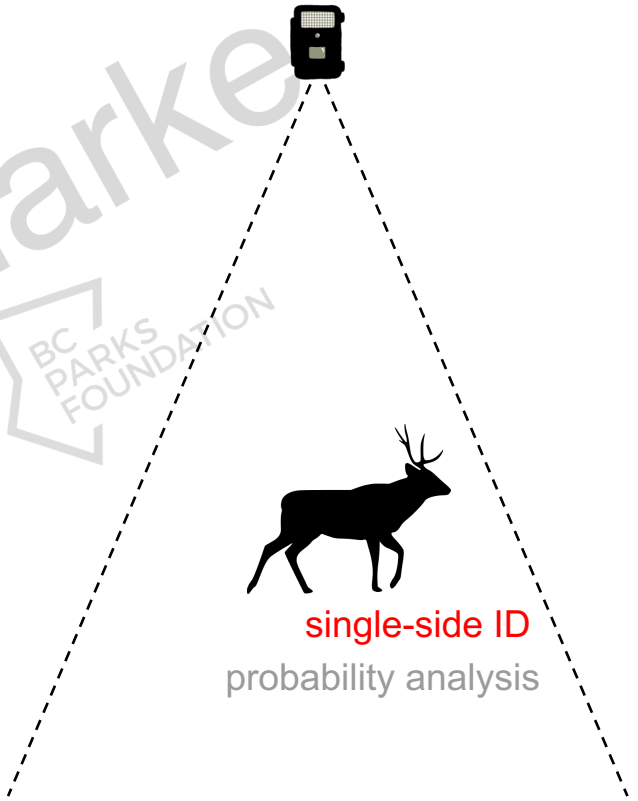
2-Flank Spatial Partial Identity Model

(Augustine et al. 2018)

Data Needed:

- ☐ individual detection histories
- ☐ camera trap coordinates



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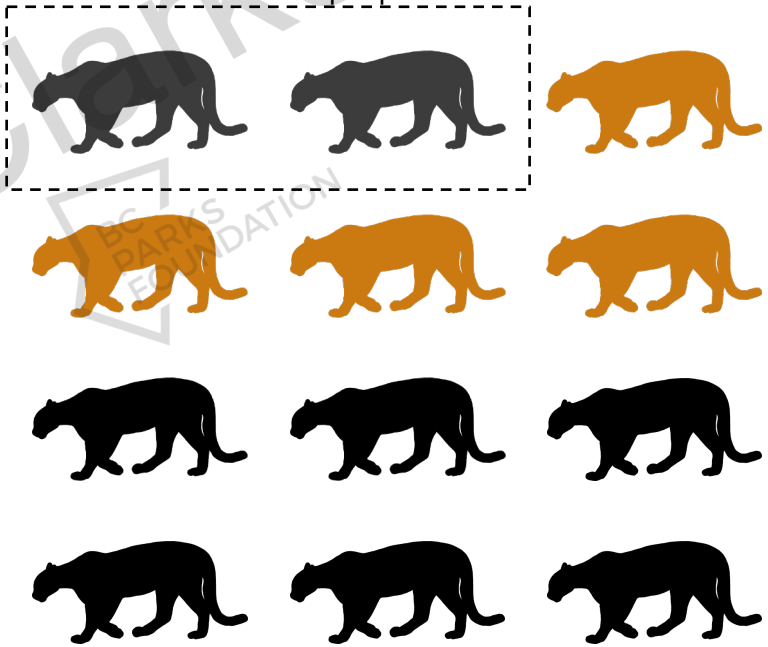
Individual animals have sets of partially-identifying traits = individuals are partially-marked

Categorical Spatial Partial Identity Model

(Augustine et al. 2019)

perform spatial count on small subsets of population



Data Needed:

- ☐ camera-specific counts of animals
- ☐ camera trap coordinates
- ☐ categorical identifiers

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Animals partially-identified using suites of categorical traits

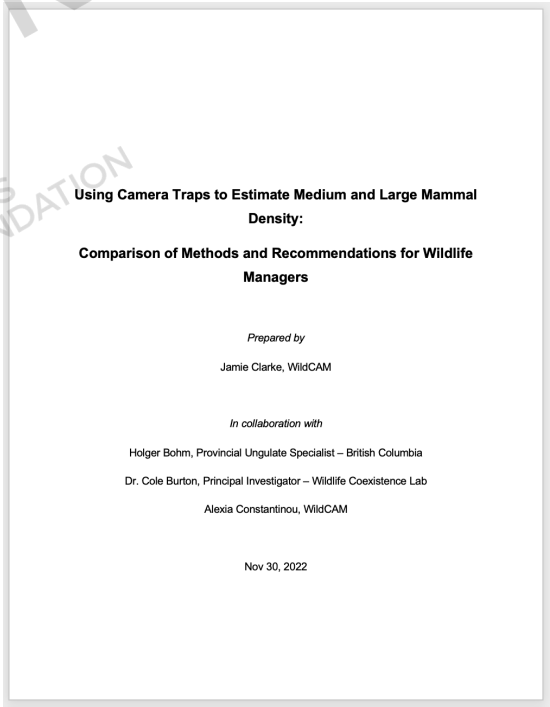
full categorical identity:

♀, adult, collar, 2 antler points

④ Outcomes

Wrote a Handbook That…

- summarizes + explains *how models work*
- lists model *assumptions* + effects of violations
- lists *advantages* + *limitations*
- discusses *simulations* + *empirical tests*
- gathers all this info in 1 place!



Using Camera Traps to Estimate Medium and Large Mammal Density:

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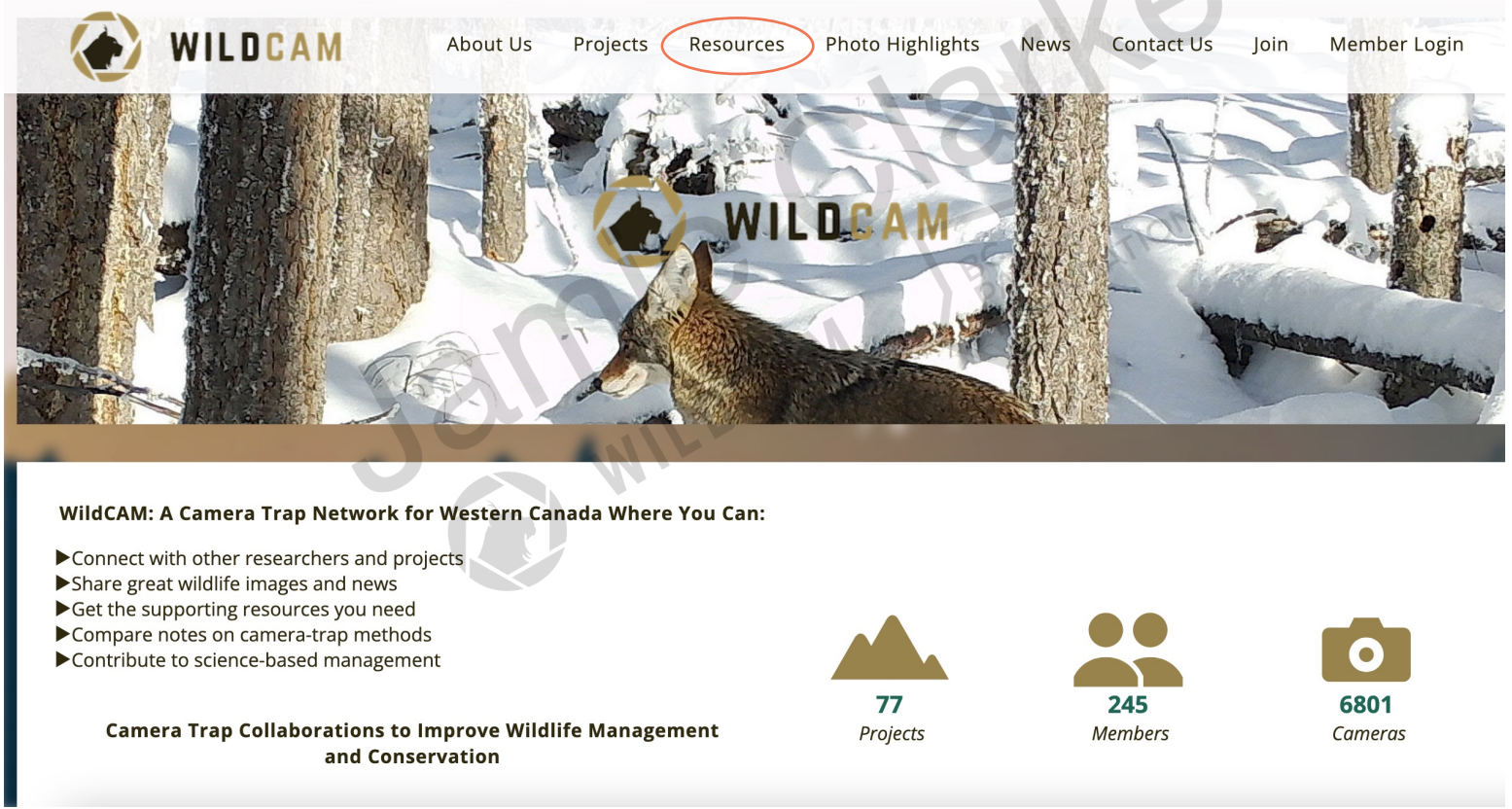
Nov 30, 2022

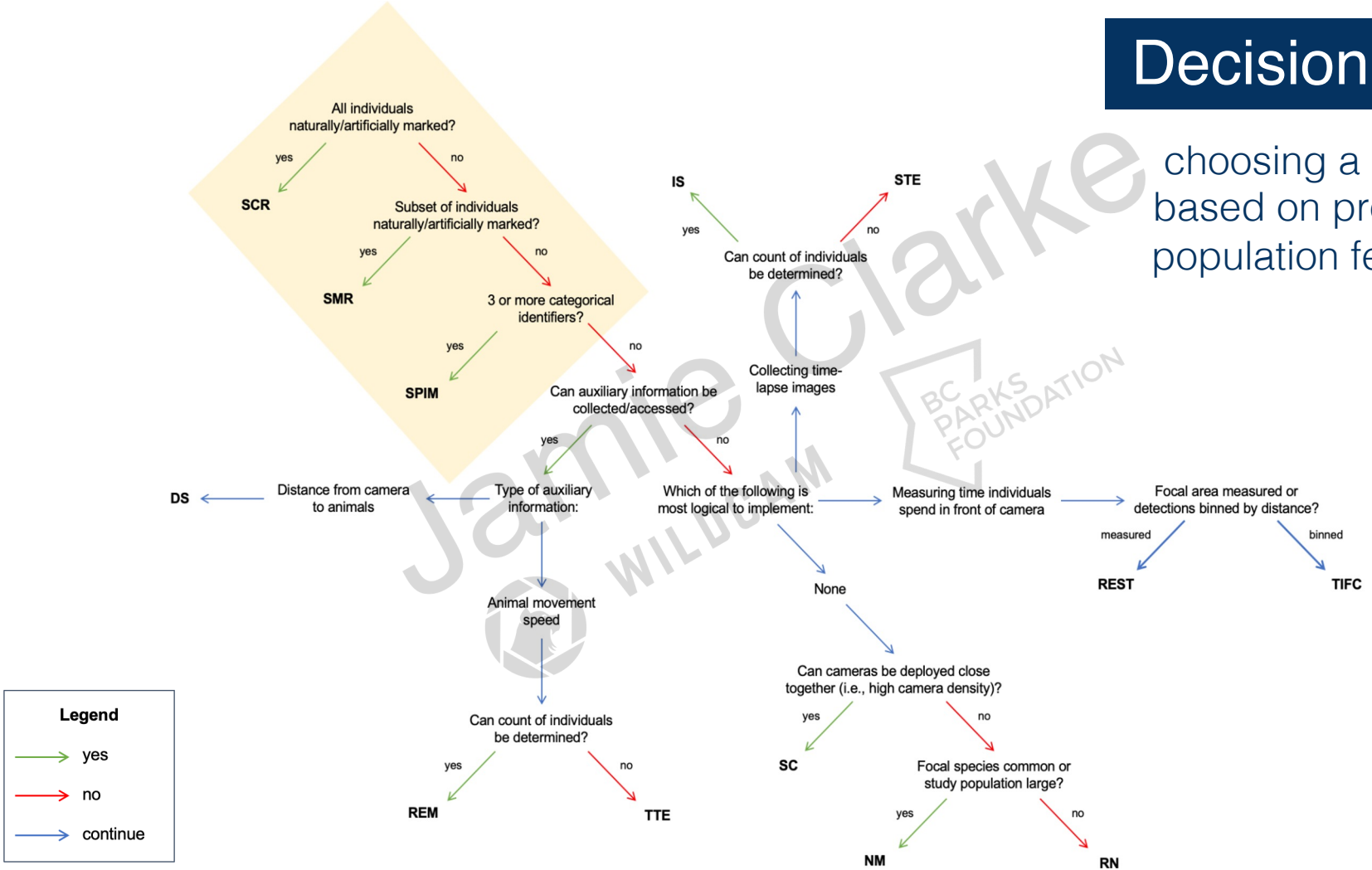
Handbook Will Be Available to Read at:

www.wildcams.ca



Decision Tree

choosing a model based on project + population features



⑤ Next Steps

We Know What's Possible – Now, *What's Best*?

Proposed *field-testing* select camera trap models on ungulates in BC + *comparing* to concurrent aerial surveys

How *accurate*, *precise* + *consistent* are camera trap vs aerial survey-derived density estimates?

How *robust* are camera trap density models to *assumption violations*? Different *sampling designs*?

We Know What's Possible – Now, *What's Best*?

Proposed *field-testing* select camera trap models on ungulates in BC + *comparing* to concurrent aerial surveys

How *accurate*, *precise* + *consistent* are camera trap vs aerial survey-derived density estimates?

How *robust* are camera trap density models to *assumption violations*? Different *sampling designs*?

make guidelines for practitioners

We gratefully acknowledge the financial support of the **Province of British Columbia** through the **Ministry of Forests, Lands, Natural Resource Operations and Rural Development**.

Questions?

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