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5 April 2024

MT5751 Assignment 4

Breaking the Ice: Spatial Capture-Recapture (SCR) for Snow Leopard Surveys in Karakoram

Overview

- Motivation
  - Snow Leopards and Existing Approaches
- Methods
  - Survey Strategies and Spatial Capture-Recapture (SCR)
- Results
- Discussion
  - Implications and Limitations

The Original Paper

scientific reports

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An empirical demonstration of the effect of study design on density estimations

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Motivations

- Snow leopards: sparce, high-interest, and individually-identifiable
  - Thus, low sample size and poor extensions of existing methods
  - Highly-mobile, yet genetically homogenous species
- Current understanding of effective SCR study designs for difficult terrains and elusive wildlife is limited
  - Large snow leopard range in remote areas begets investigating suitability of various sampling approaches and effect on estimates
- Most SCR analysis mainly estimates density and range
  - Based on “activity centres” and using spatial characteristics to parse out effects of detection ranges and probabilities from discrete traps
  - These may be better interpreted as maximum range estimates

Snow Leopards
Bharpu (L) and Baltoro (R)

Methods: Surveying

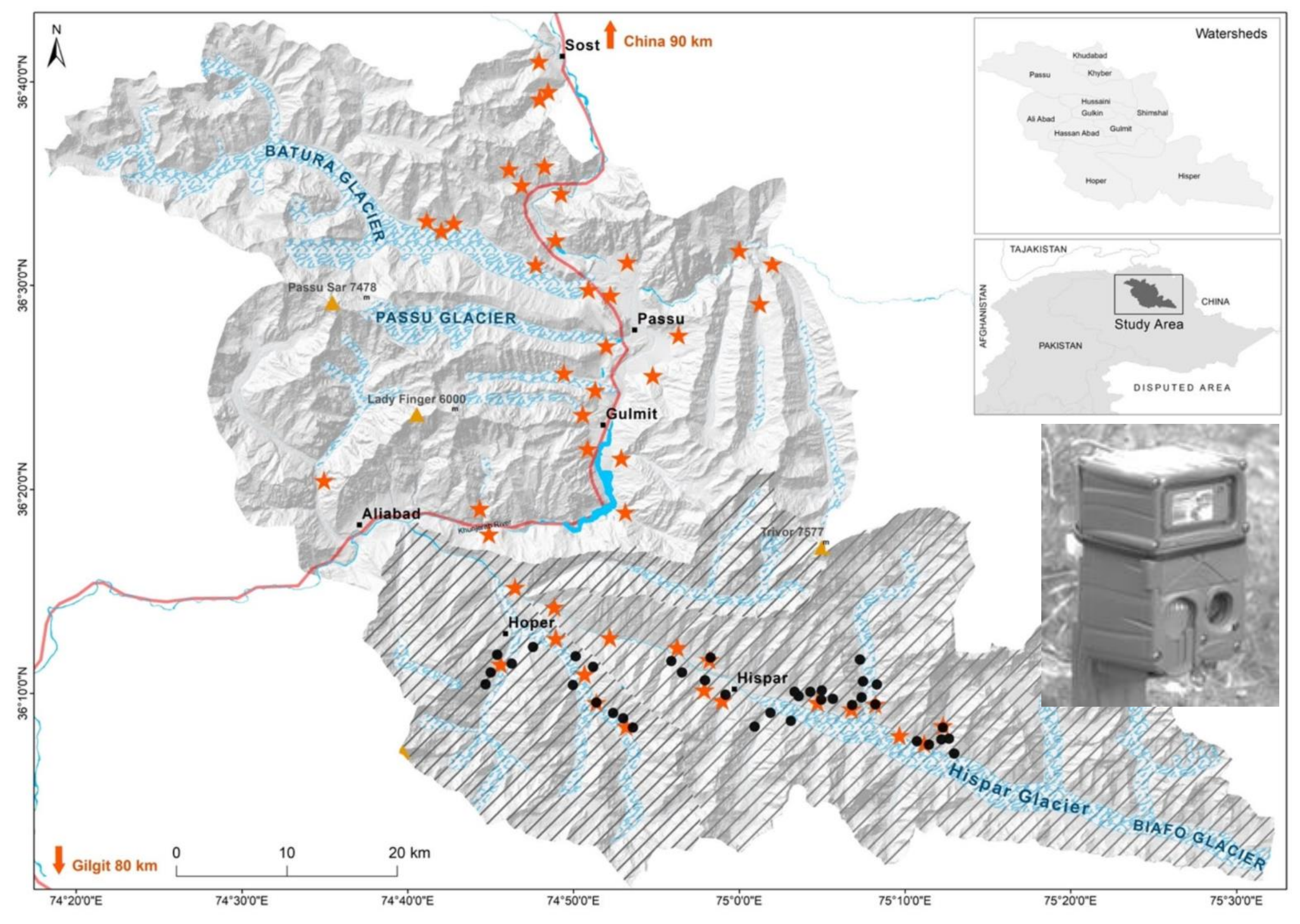


Figure 1: Map of the study area indicating the positions of cameras using circles for compact designs and stars for diffused designs.[9]

Survey 1 (Compact Design):

- ● : locations of compact cameras
- **Timeline**: March to May (2016)
- **Number:** 38 cameras
- **Spacing**: 1km^2
- **Area:** 253 km^2
- **Density:** 15 cameras per 100 km^2
- **Outcome:** 27 independent capture events, 4 unique individuals

Survey 2 (Diffuse Design):

- ★ : locations of diffused cameras
- **Timeline**: April to June (2018)
- **Number**: 44 camera traps
- **Spacing**: 5km^2
- **Area:** 2030 km^2
- **Density**: 2 cameras per 100 km^2
- **Outcome:** 21 independent capture events, and 9 unique individuals

Methods: State Model

- SCR uses hierarchical modelling to separate out two processes:
  - The latent state model: what drives ecological “truth”
  - The observation model: accounting for imperfect observations
- SCR is primarily used to estimate animal density D (also activity centres, but those closely link to the observation model)
- This work focusses more on the observation process, so D is linearly modelled using a single covariate for survey type (session)
- **Crucial assumption**: underlying snow leopard density does not change between sessions, so all differences must be due to survey design

Methods: Observation Model

- Camera traps: multiple individuals at multiple sites and number of detections (count detectors)
- We're primarily interested in detections $y_{ij(k)g}$ as either 0 (undetected) or 1 (detected), across
  - $i = 1,2,\dots,13$ individuals; $j = 1,2,\dots,82$ camera traps; $g = 1,2$ sessions (here identical to occasions k)
- y are counts, so $y_{ijg}|s_i \sim Poisson(\lambda_{ijg})$, where
  - s_i: the activity centre for individual i, and
  - λ_{ijg}: expected detections for individual i, trap j, and session g, and
  - Detection probability $p_{ijg} = 1 - \exp(-\lambda_{ijg})$
- The core of SCR is estimating λ_{ijg} using a detection function

Methods: Observation Model

- The core of SCR is estimating λ_{ijg} using a detection function:
  - $\lambda_{ijg} = \lambda_0 \times e^{\left(-\frac{distance\left(s_i, x_j\right)^2}{2\sigma^2}\right)}$, where
  - λ_0: expected detections for individual with centre s_i at trap j
  - σ: half-normal detection parameter, representing detection range
- λ_0 is estimated using a Poisson GLM with an offset
  - $\log(\lambda_0) = \alpha + \log(operating\ days)$, where
  - α is a constant per-day encounter rate
- $Poisson(\lambda_{ijg})$ multiplicatively summed (assuming independence) across all traps j and sessions g to estimate a likelihood

Results

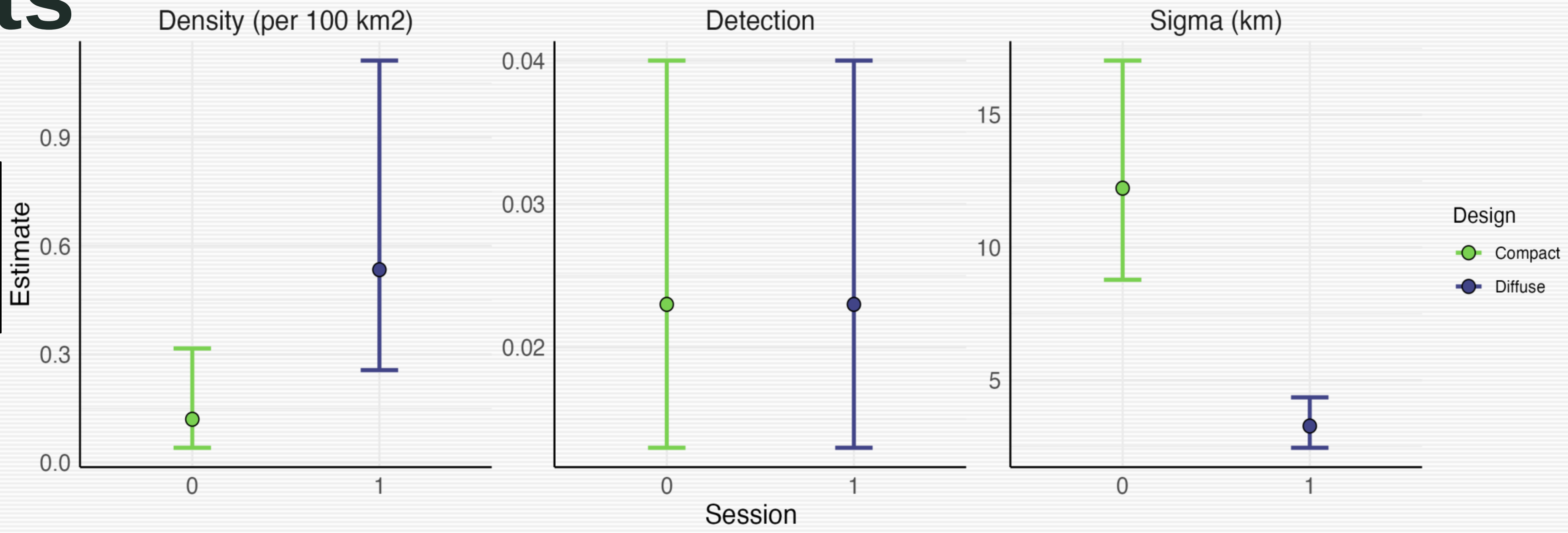


Figure 2: Effect of design on SCR parameter estimates. Bars indicate 95% confidence intervals.[9]

Model	Session	D	N	λ_0	σ
m5	Compact	0.11 (0.06)	6.95 (3.60)	0.023 (0.006)	12.23 (2.07)
	Diffuse	0.53 (0.20)	32.42 (12.14)		3.27 (0.50)
m7	Compact	0.11 (0.06)	6.82 (3.50)	0.032 (0.014)	11.94 (1.76)
	Diffuse	0.55 (0.21)	33.16 (12.75)	0.017 (0.007)	3.58 (0.66)
m3	Compact	0.25 (0.08)	15.50 (4.66)	0.023 (0.006)	10.99 (2.00)
	Diffuse				3.62 (0.56)

Table 1: Parameter estimates of SCR. D density/100 km2 , N population, 0 detection probability, σ spatial scale parameter.[9]

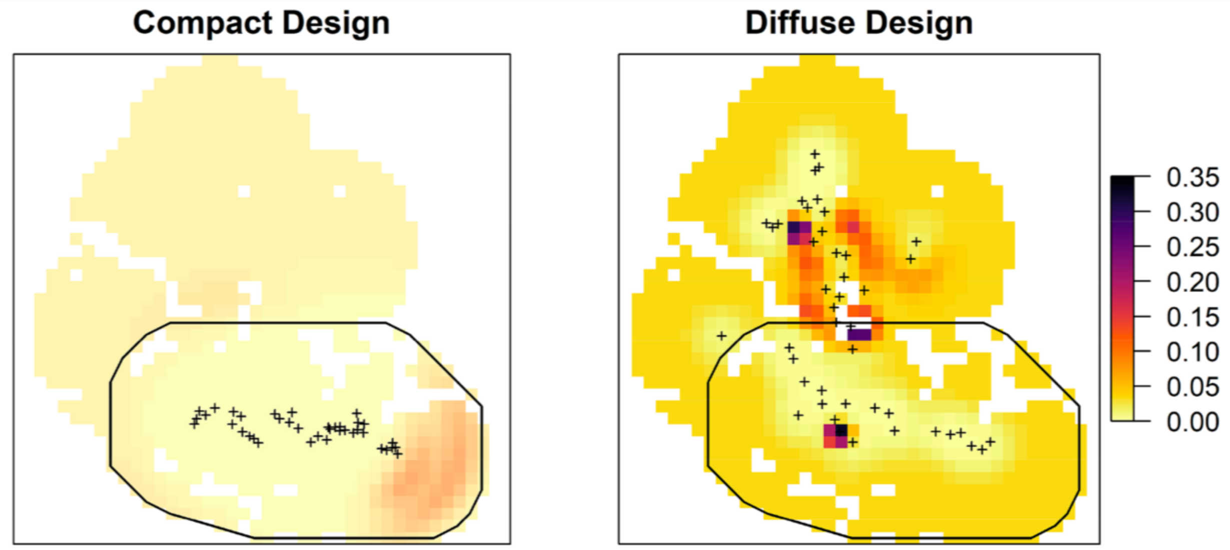


Figure 3: Spatial snow leopard density estimates (per 100 km^2) with trap locations as black crosses. Black polygon marks dense survey camera trapping area[9]

Results

- No benefit to changing λ_0 between sessions (similar densities and other parameter estimates)
- Different estimates due to markedly different detection range σ
  - Compact design suggests wide detection with high uncertainty
  - Diffuse design posits more precise, conservative detection
- Lower detection range leads to more spatial precision in predictions and higher estimated density
  - Overall lower density for compact design and different high-density areas
    - Diffuse design: Hunza River valley around more settled areas
    - Compact design: Biafo Glacier away from roads and villages

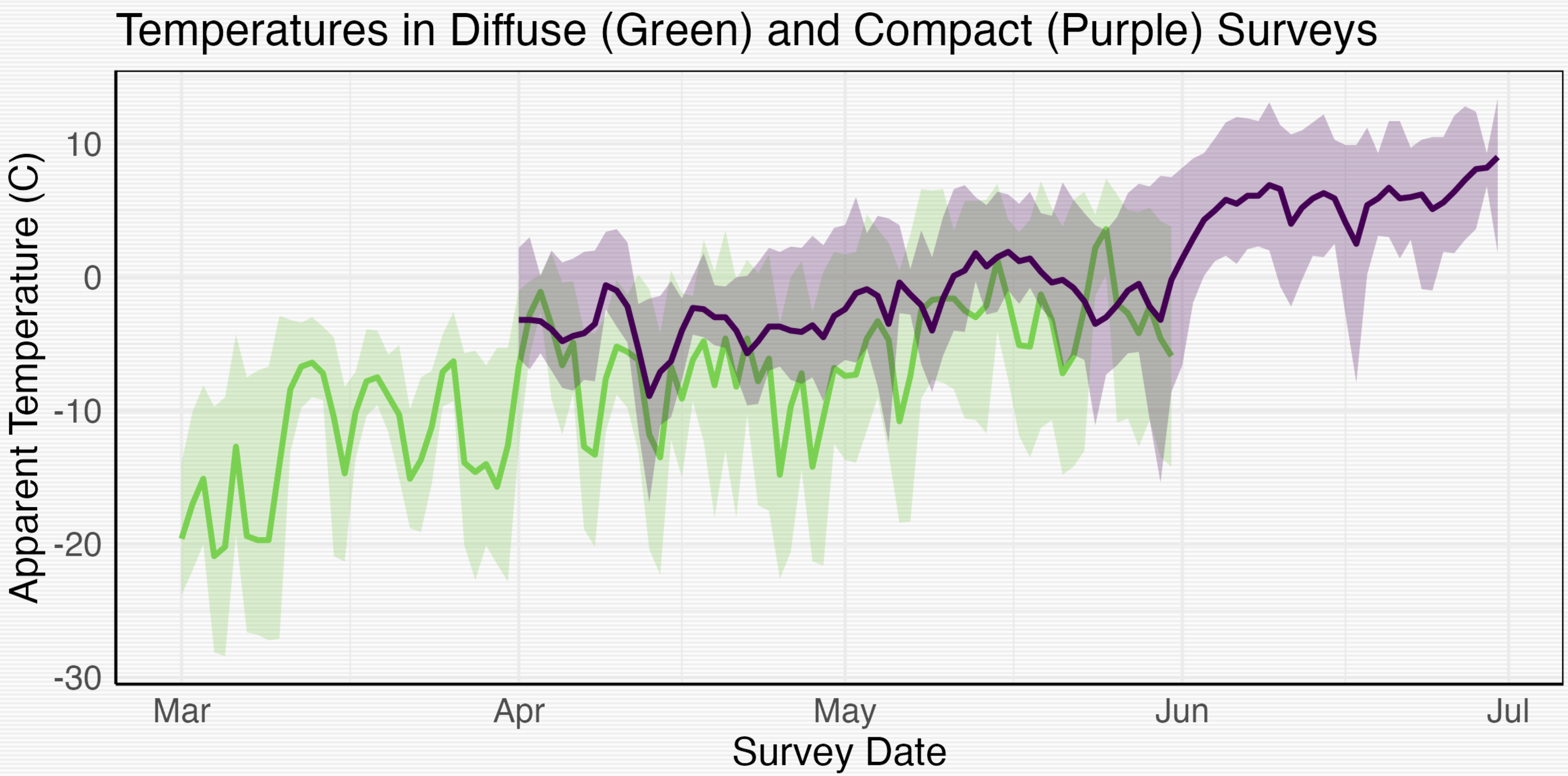
Discussion

- Authors recognise that given the sample size, both surveys are “at the limit of acceptability” for SCR
- Clear differences in survey design on results: data collection can have a major impact on estimates
  - More work needed on maximum movement distances for snow leopards (a common rule of thumb; still no estimates)
- Possible overestimation of movement in small study areas
- Clear topographic differences in animal movement: non-circular ranges like under flat, homogenous topography
  - Density surface estimation may provide an interesting extension when more data becomes available

Discussion

- Actual analysis is limited by assumptions and separability
  - p_0 (thus also λ_0) and σ react poorly to using the same covariates
  - Using a single covariate (survey type) prevents any inference or separation based on specific causes of cross-survey differences
  - Short survey time (3 months, 2 times) prevents estimates about migration and testing assumptions like closure
- Some possible covariates that may challenge equal encounter rate and density:
  - Road density per 100 km^2 (0.0061, compact and 0.0265, diffuse)
  - Weather (precipitation, temperature) and local topography
  - Behaviour: leopards may become trap-happy after exposure to baited camera traps with castor oil during initial 2016 diffuse survey

Discussion



Temperatures in Diffuse (Green) and Compact (Purple) Surveys
Apparent Temperature (C)
10
0
-10
-20
-30
Mar
Apr
May
Jun
Jul
Survey Date

Questions?

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