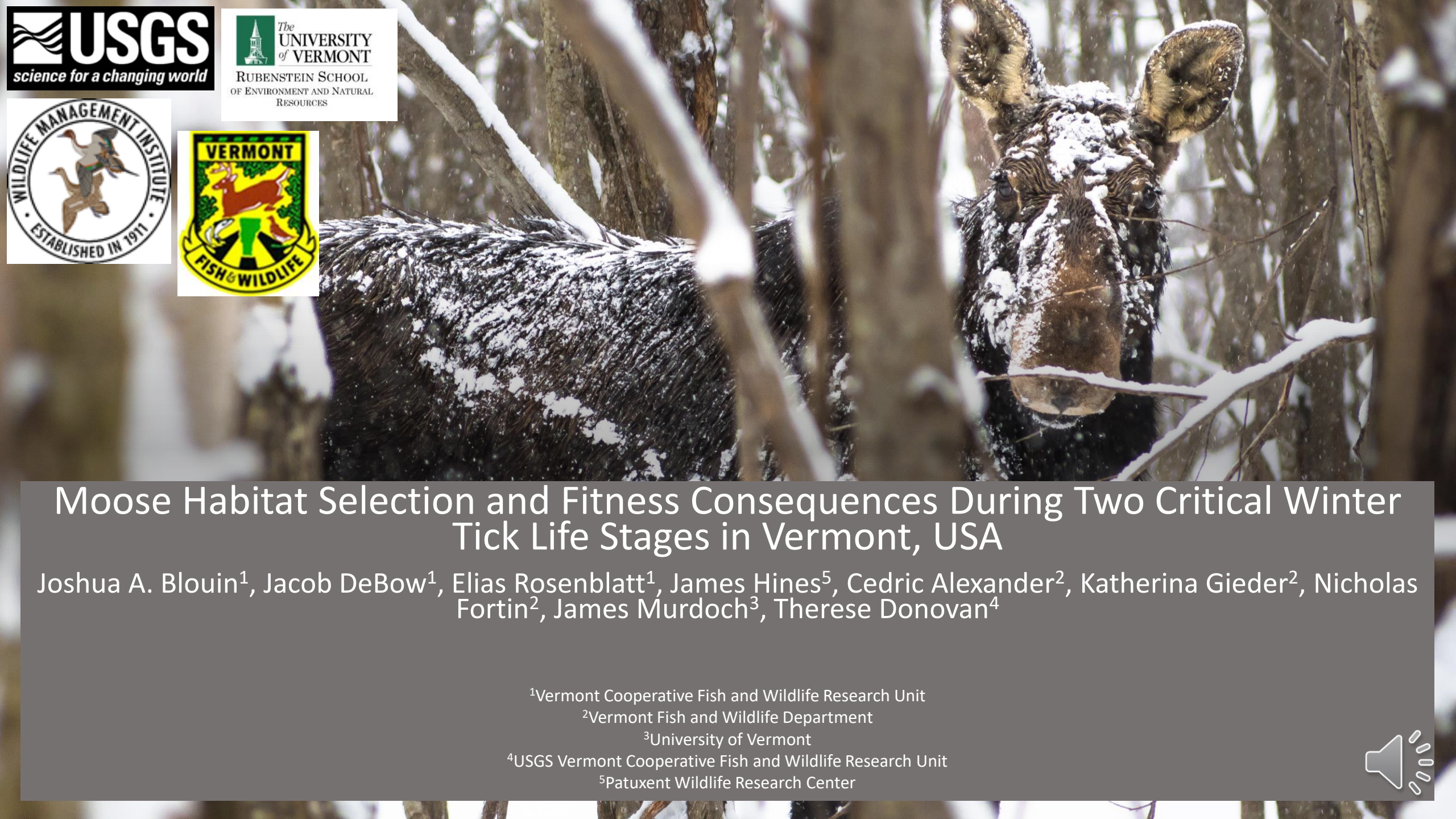

# Moose Habitat Selection and Fitness Consequences During Two Critical Winter Tick Life Stages in Vermont, USA


Joshua A. Blouin[1], Jacob DeBow[1], Elias Rosenblatt[1], James Hines[5], Cedric Alexander[2], Katherina Gieder[2], Nicholas Fortin[2], James Murdoch[3], Therese Donovan[4]

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# Winter Tick(Dermacentor albipictus)

Peak Fall Questing Period: (26 Sept. – 15 Nov.)

Peak Spring Drop-off Period: (16 March – 5 May)

# What we know about moose habitat selection during important winter tick life periods

- One important study in New England examined third-order (within home ranges) during the questing and drop-off periods (Healy et al 2018).

- Key findings: moose select the same habitats during both the questing and the drop-off periods, thus promoting the winter tick/moose cycle.

**SELECTIVE HABITAT USE BY MOOSE DURING CRITICAL PERIODS IN THE WINTER TICK LIFE CYCLE**

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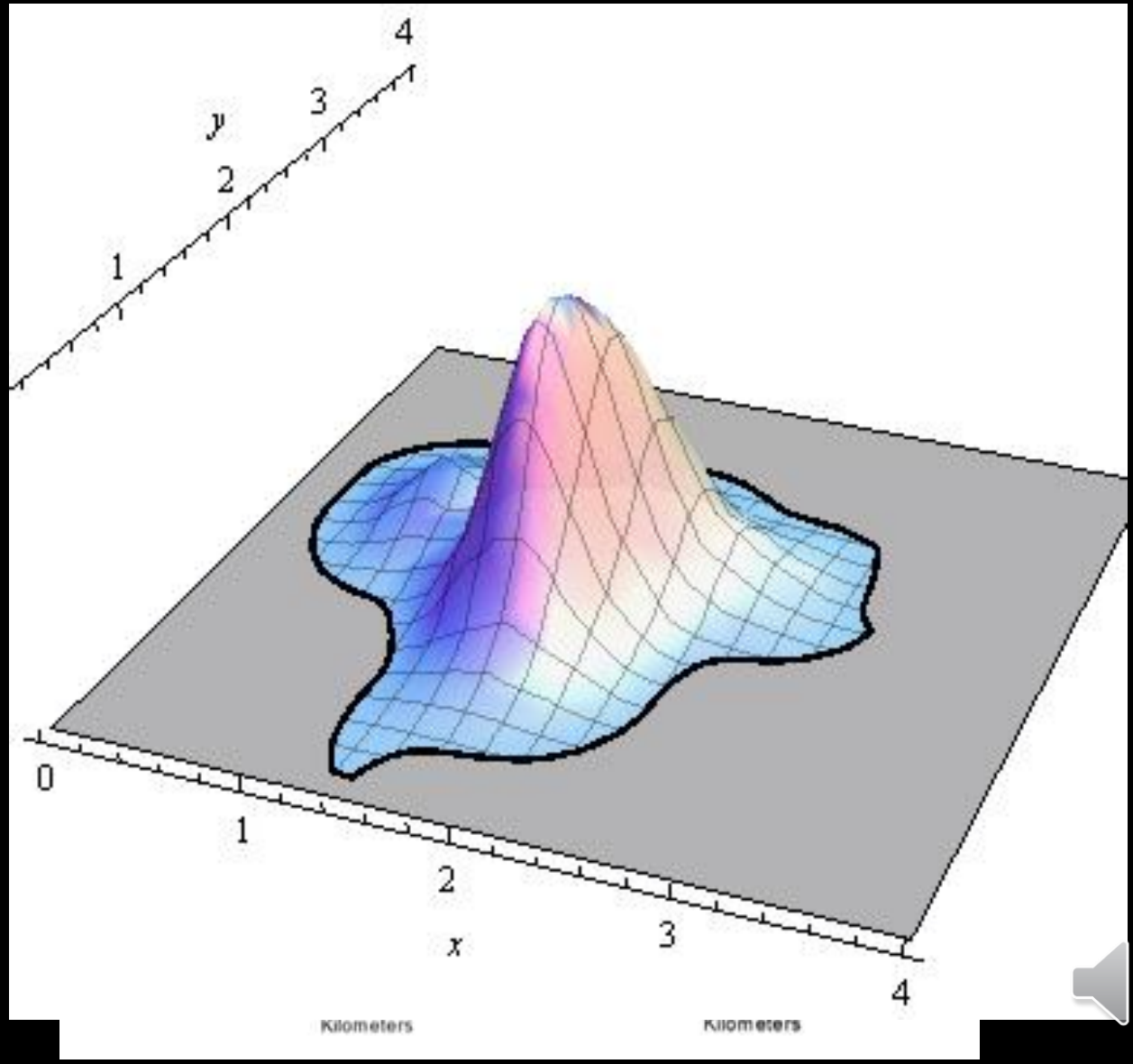
ABSTRACT: High calf mortality attributed to winter tick (*Dermacentor albipictus*) parasitism occurs in moose (*Alces alces*) populations along their southern range in the northeastern United States. We analyzed habitat use of cow and calf moose during the critical drop-off and questing periods in the winter tick life cycle to determine a potential relationship between tick density and habitat. We measured habitat use using geospatial analyses of locational data from > 200 radio-marked animals at 3 sites in New Hampshire and Maine. Moose selected for optimal habitat, defined as 4–16 year-old forest openings, regardless of season or site; this was the only land cover type used more than available (1.1–2.1X availability in home range, 1.2–3.1X availability in core range). Further, the proportional availability of optimal habitat within overlapping portions of seasonal home and core ranges exceeded the absolute proportion of optimal habitat within any one range. Temporal use of optimal habitat, which is available in relatively low proportion (15–20%) across the landscape, likely exceeds the geospatial estimates of use because moose spend 30–40% of daily activity foraging. We conclude that disproportionally abundant densities of winter ticks exist in this preferred cover type because of its selective use during the drop-off and questing periods of winter ticks.

ALCES VOL. 54: 85–100 (2018)

# The Hierarchical Manner of Habitat Selection

- First-order: a more coarse-scale examination of where a species selects their geographic range.
- Second-order: the home range of an individual within their geographical range.
- Third-order: more fine-scale examination of the habitat components *within* home ranges.

(Johnson 1980)



# The Big Picture

Analysis of habitat selection at more coarse scales (first and second-order selection) and how selection decisions ultimately affect fitness may provide important insights for the management of an iconic species in decline

# Objectives

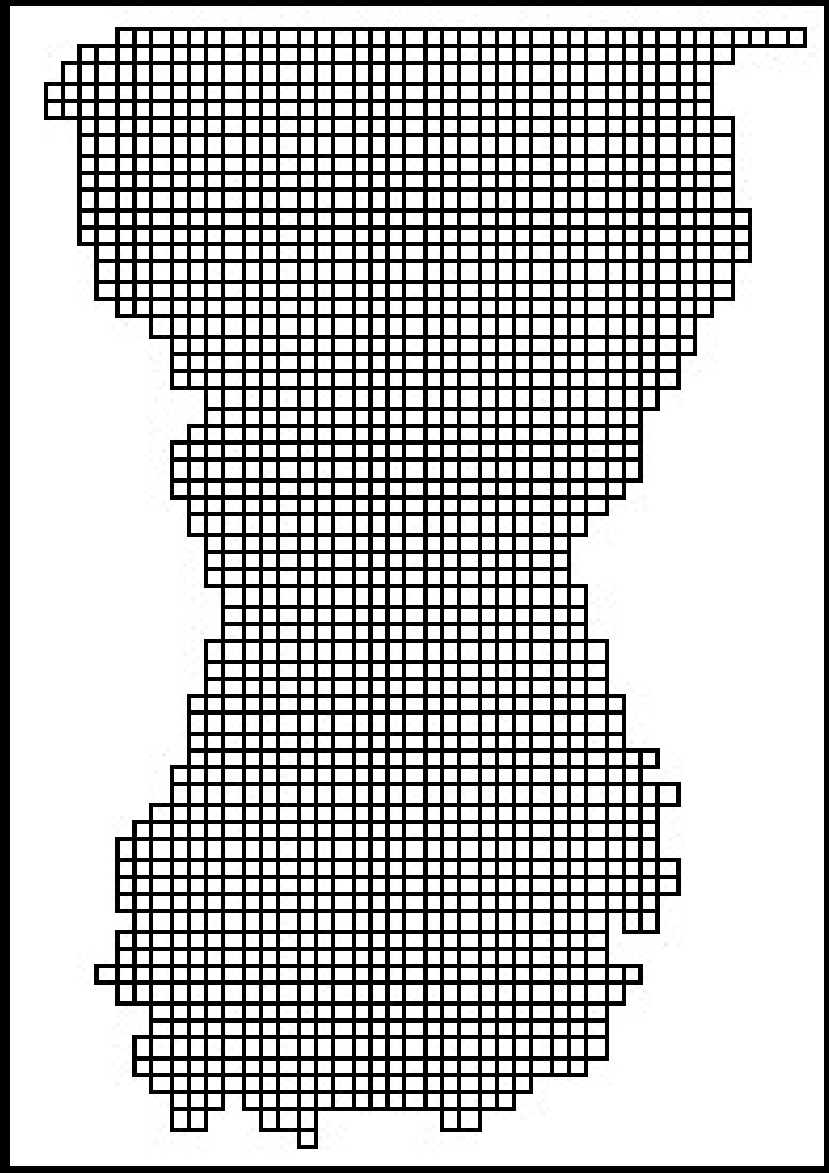
1) Investigate first-order habitat selection of adult female moose during each period using a multi-season occupancy framework; and
2) evaluate the fitness consequences of habitat selection by comparing fall questing resource selection for cows whose calves survived to age 1, versus those that did not.

**Objective 1: First-order habitat selection of adult female moose with dynamic occupancy analysis.**

*Site Description*

- We imposed a grid of 1693 patches, each 1km$^2$ to Identify “sites” or patches across the study area.

- We then filtered our GPS collar data by two primary periods (tick questing and drop-off) for all female moose captured during the study, resulting in 12,210 GPS locations of 74 moose.



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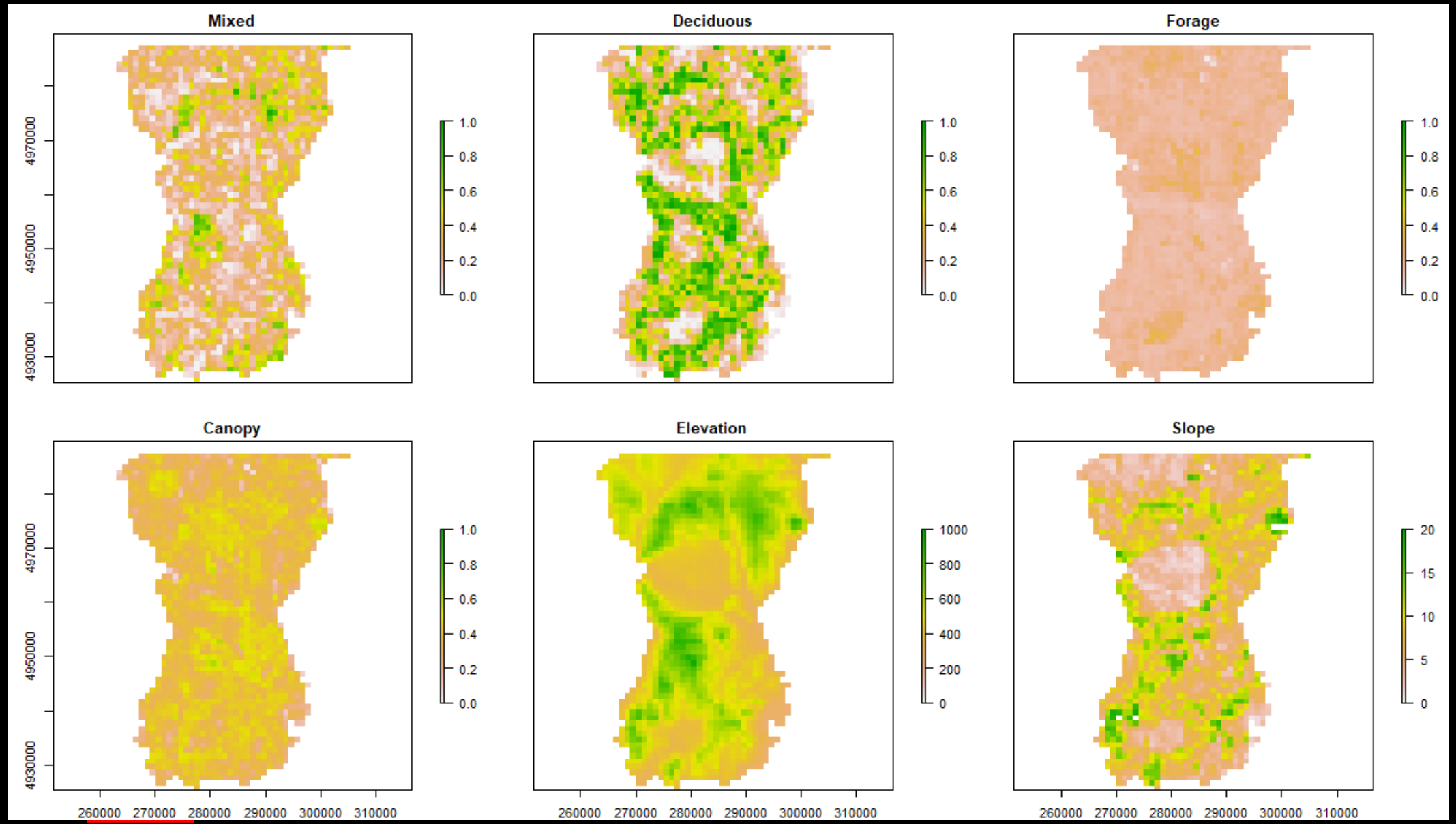
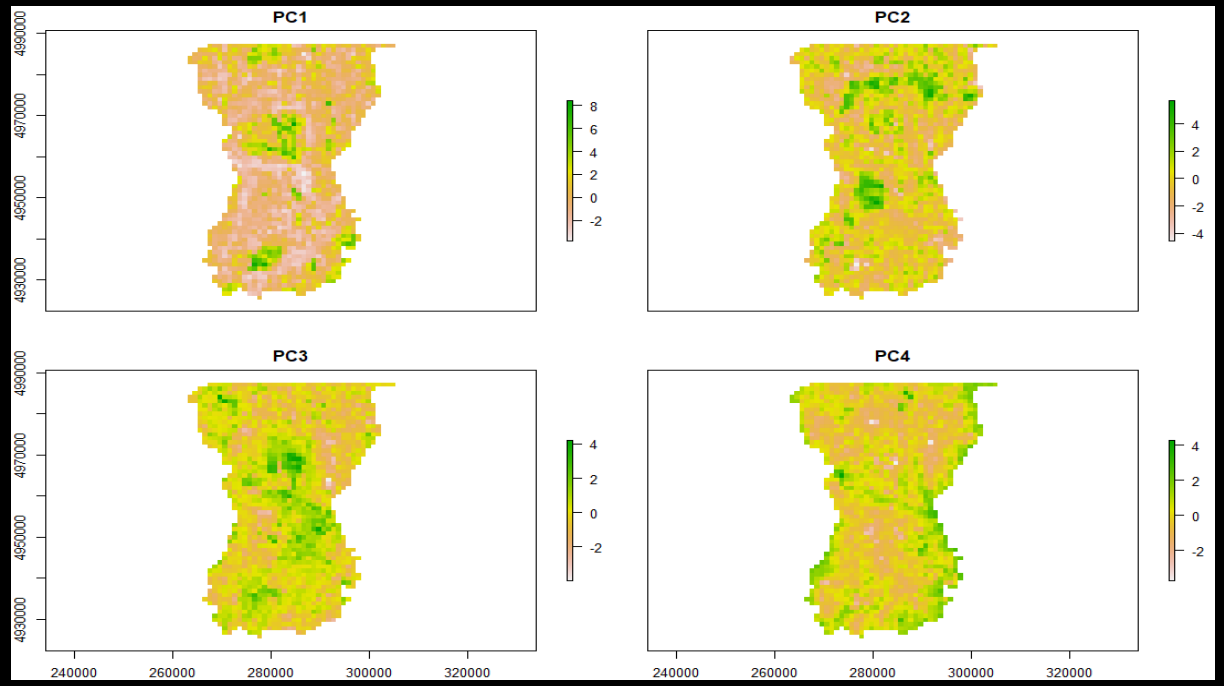
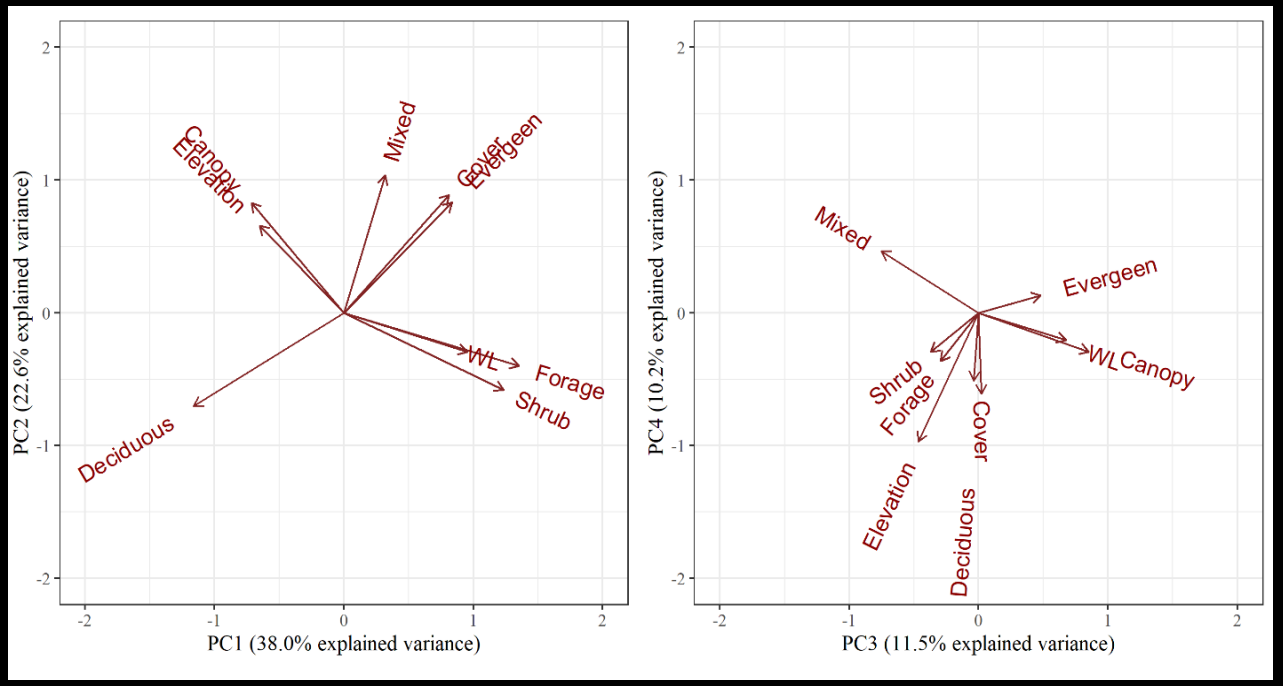
*Site Description*



# Objective 1: First-order habitat selection of adult female moose with dynamic occupancy analysis.

*Site Description*



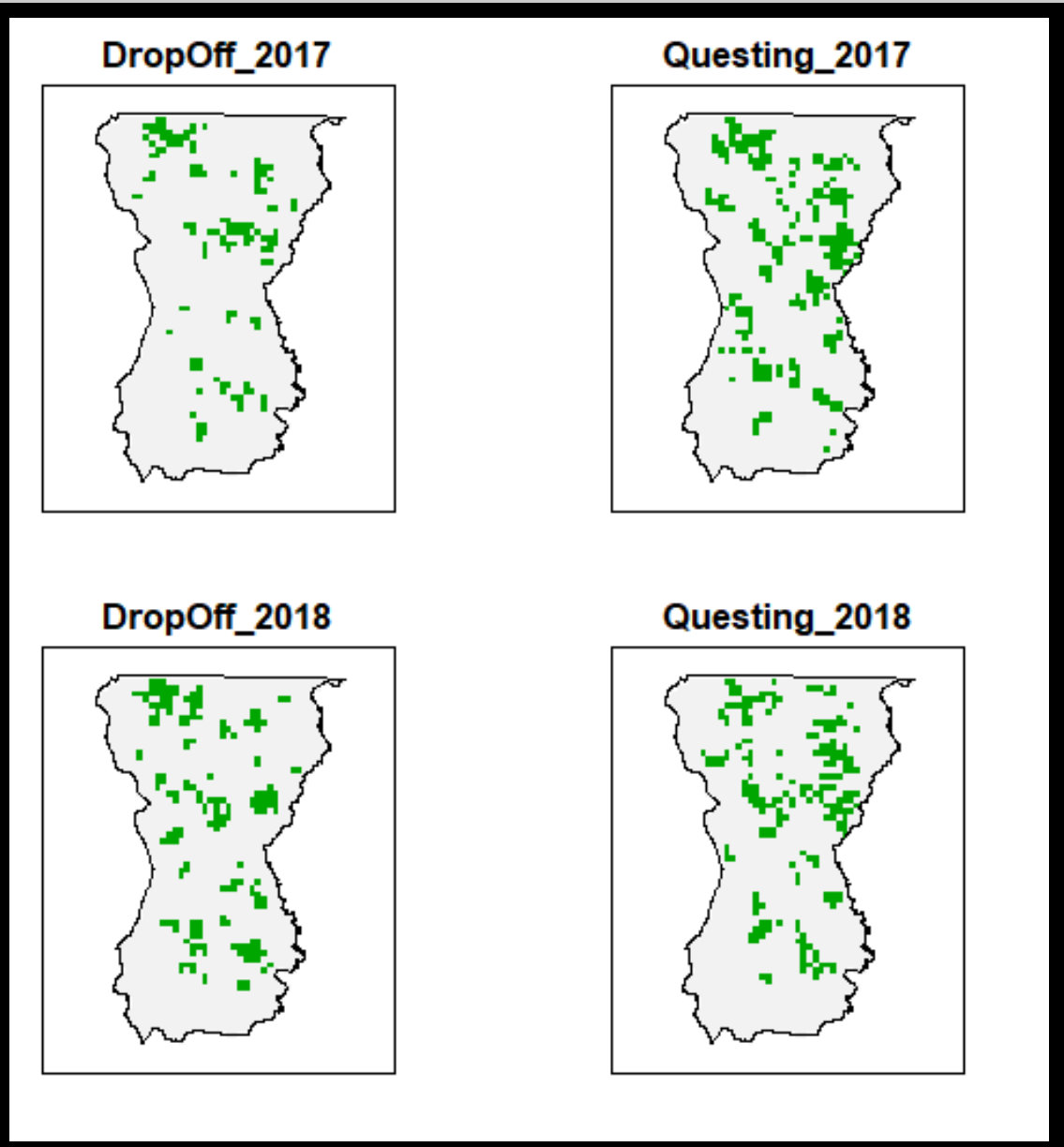



**Objective 1: First-order habitat selection of adult female moose with dynamic occupancy analysis.**

*Distribution of moose across patches*

*Encounter Histories*

- We created an encounter history for each peak 50-day period (tick questing or drop-off)
- 1693 patches across the study area, green patches were occupied, white patches were areas where moose were undetected.
- EH show changes in occupancy patterns

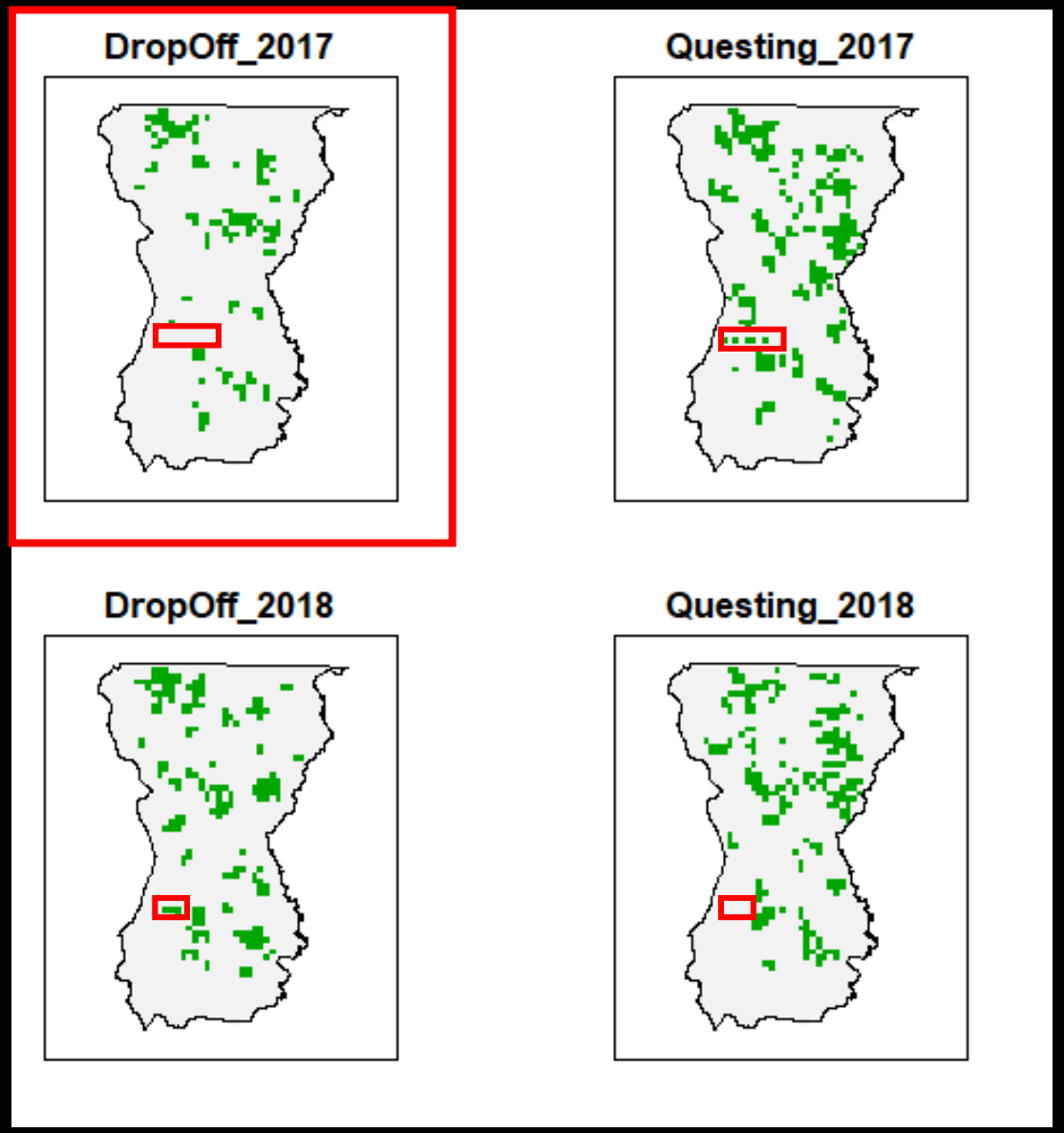


**Objective 1: First-order habitat selection of adult female moose with dynamic occupancy analysis.**

*Distribution of moose across patches*

*Encounter Histories*

- Multi-season Occupancy Model is concerned with 4 parameters:
  - The initial probability that moose occupy a patch (psi)
  - Colonization of patches over time (gamma)
  - Extinction of patches over time (epsilon)

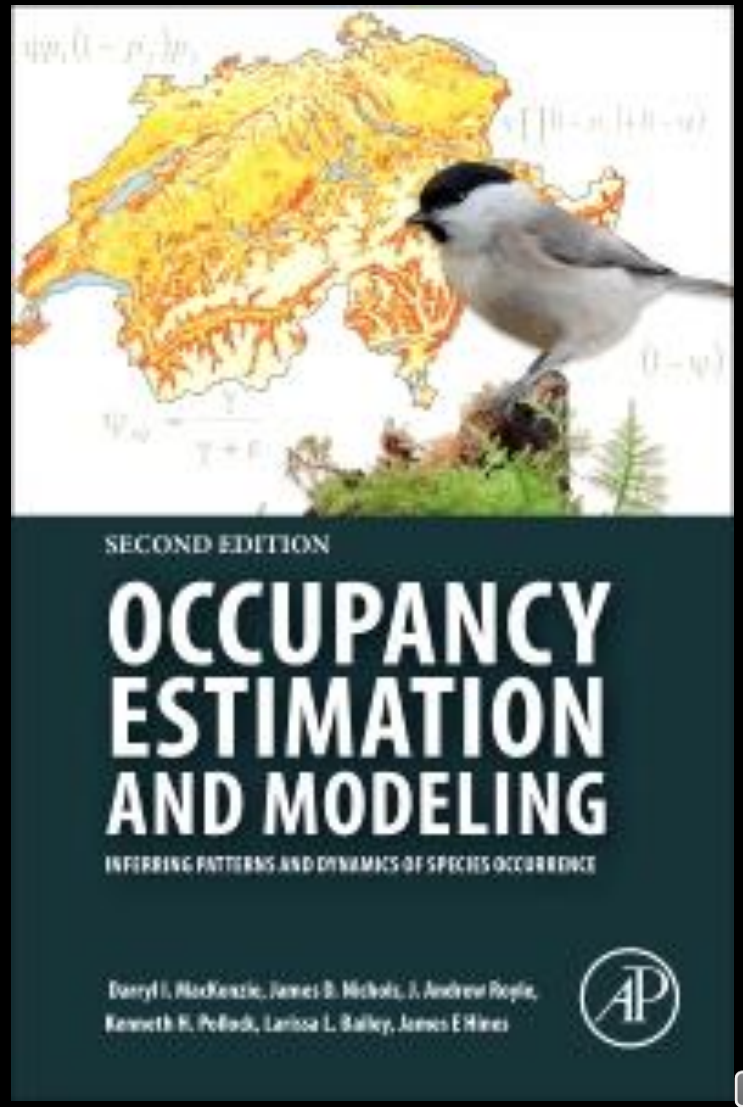


**Objective 1: First-order habitat selection of adult female moose with dynamic occupancy analysis.**
*Distribution of moose across patches*
*Encounter Histories*

Using *Rpresence* (Hines 2006), we evaluated changes in occupancy patterns across patches and through time.

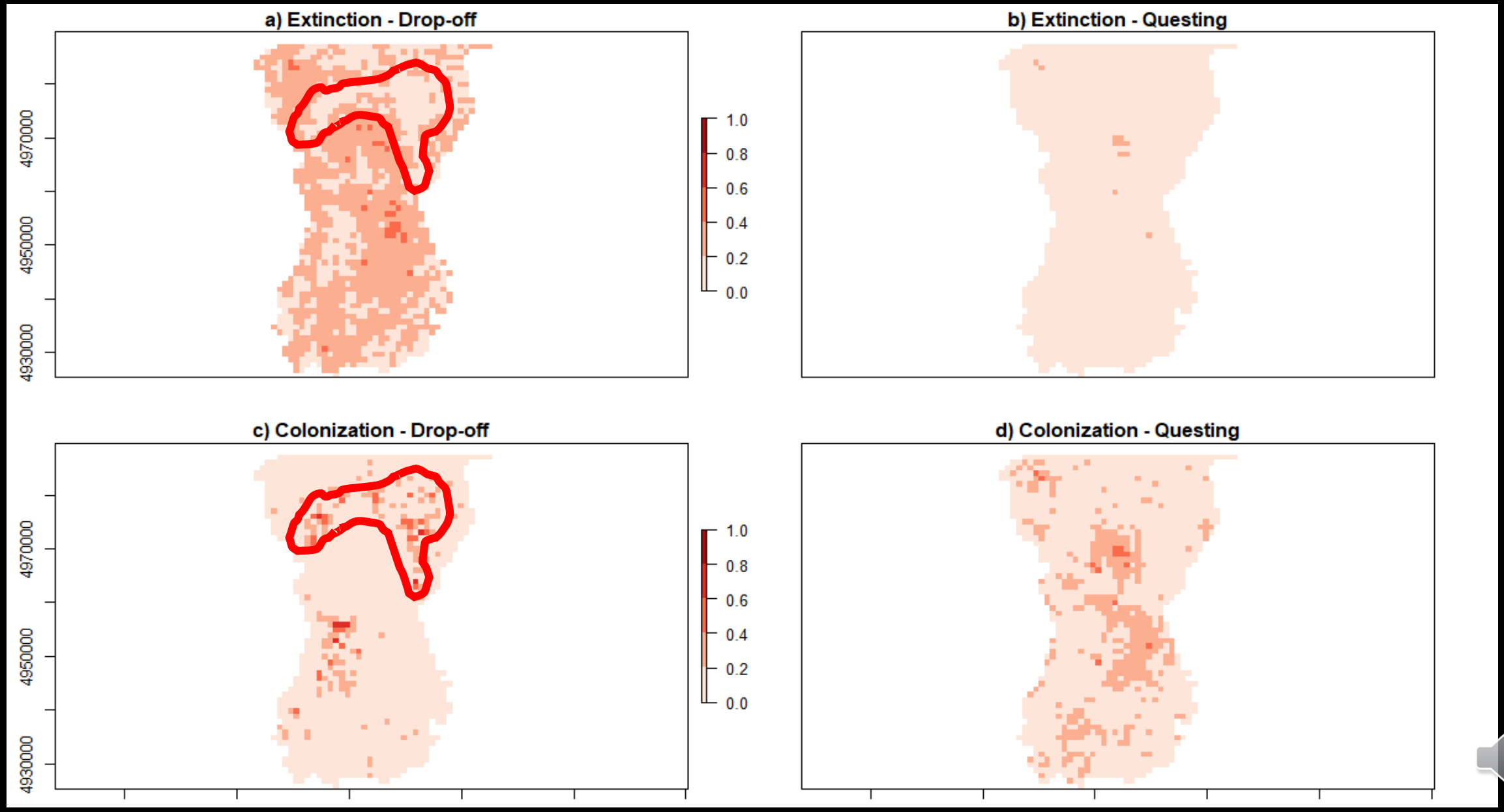
We created a model set of 24 models, representing alternative hypotheses that explain changing occupancy patterns.

Extinction and colonization probabilities for the top model were a function of the interaction between PC1 and season, PC2 and season, PC3 and season, and year.

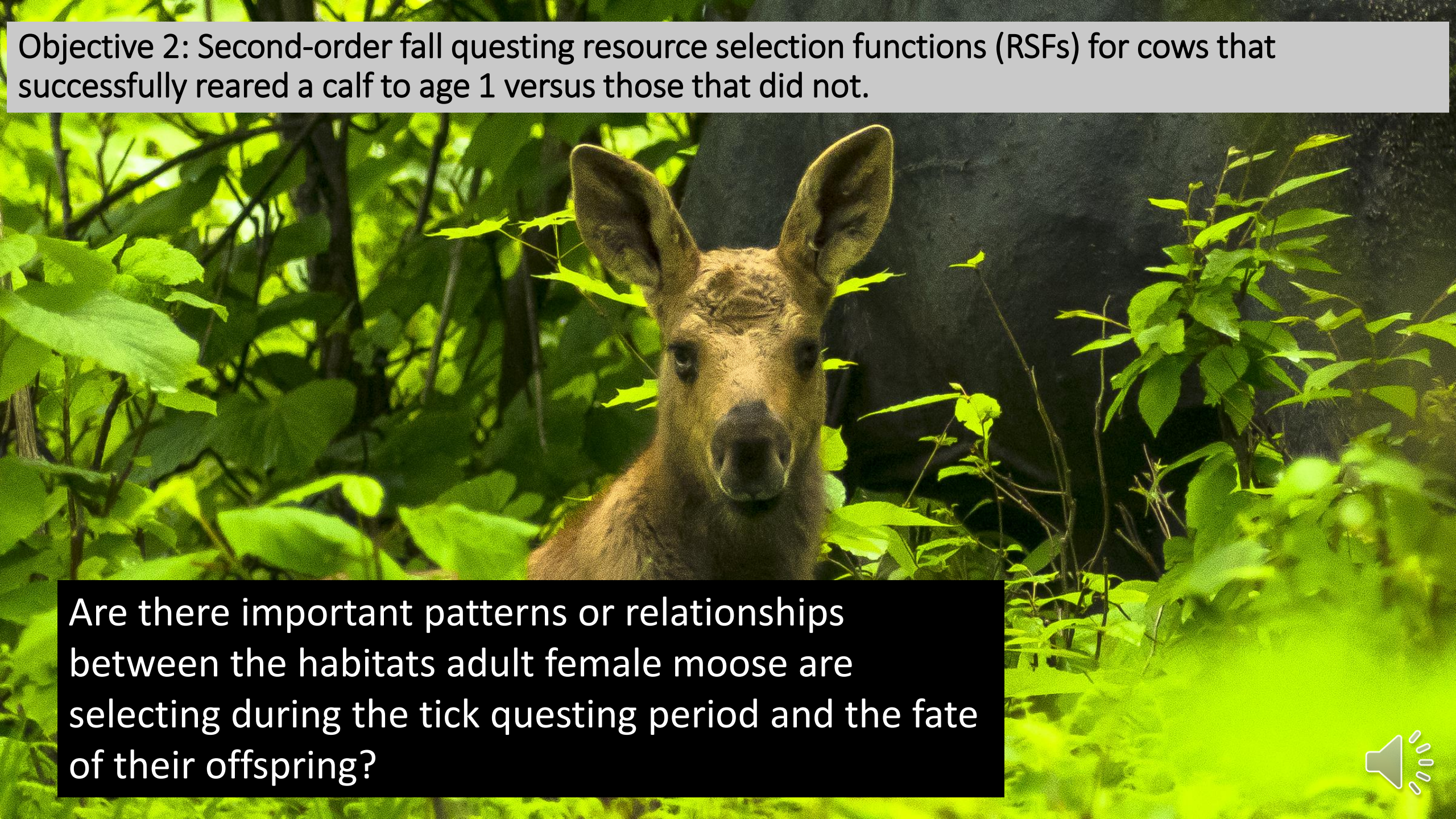


**Objective 1: First-order habitat selection of adult female moose with dynamic occupancy analysis.**

*Key Results*



Objective 2: Second-order fall questing resource selection functions (RSFs) for cows that successfully reared a calf to age 1 versus those that did not.



Are there important patterns or relationships between the habitats adult female moose are selecting during the tick questing period and the fate of their offspring?

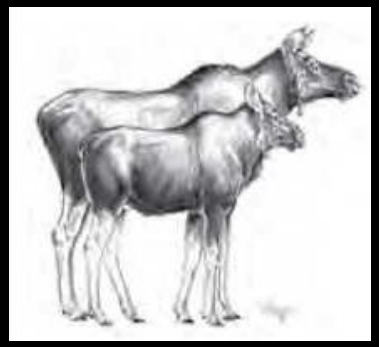
# Objective 2: Second-order fall questing resource selection functions (RSFs) for cows that successfully reared a calf to age 1 versus those that did not.

*Methods*

Adult Females collared in January

Calf is born in May and cow/calf observed through the summer

Following January, capture crew targets collared cows with known calves (n = 10)



Examine where cow/calf pairs were during the fall tick questing period

Fate = dead (n = 5)

Fate = live (n = 5)

Objective 2: Second-order fall questing resource selection functions (RSFs) for cows that successfully reared a calf to age 1 versus those that did not.

*Methods*

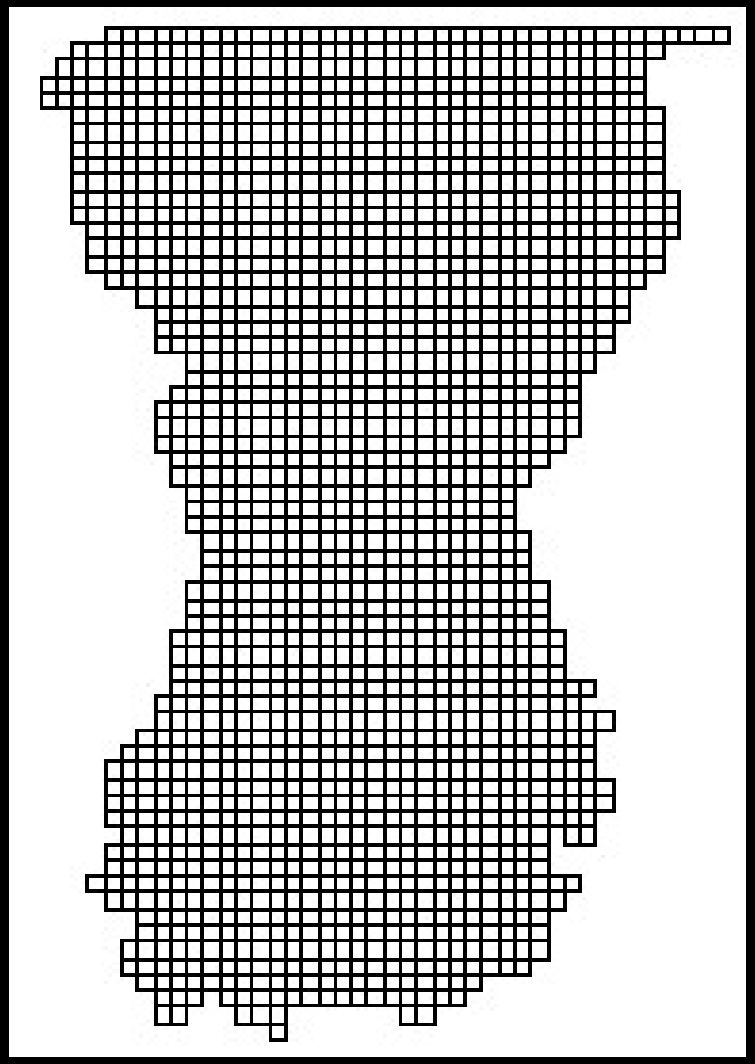
- Two RSFs were estimated:
  - One for adult females that successfully reared offspring to age 1
  - One for those whose calves perished prior to age 1 (due to heavy tick infestations).

Objective 2: Second-order fall questing resource selection functions (RSFs) for cows that successfully reared a calf to age 1 versus those that did not.

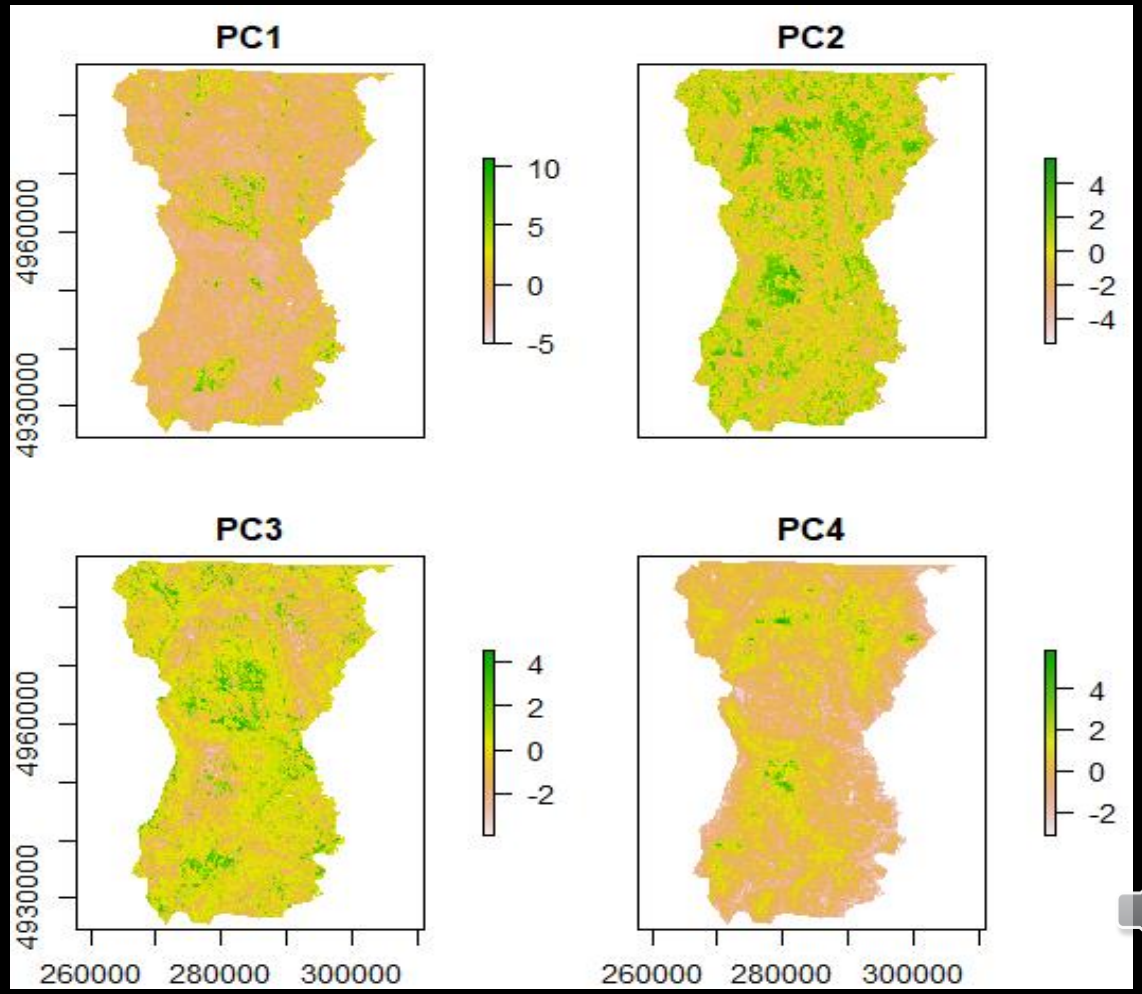
*Methods*

*Site description*

Gridded landscape (200m$^2$)



Like objective 1, we performed a PCA to account for complexities and collinearity between habitat variables.

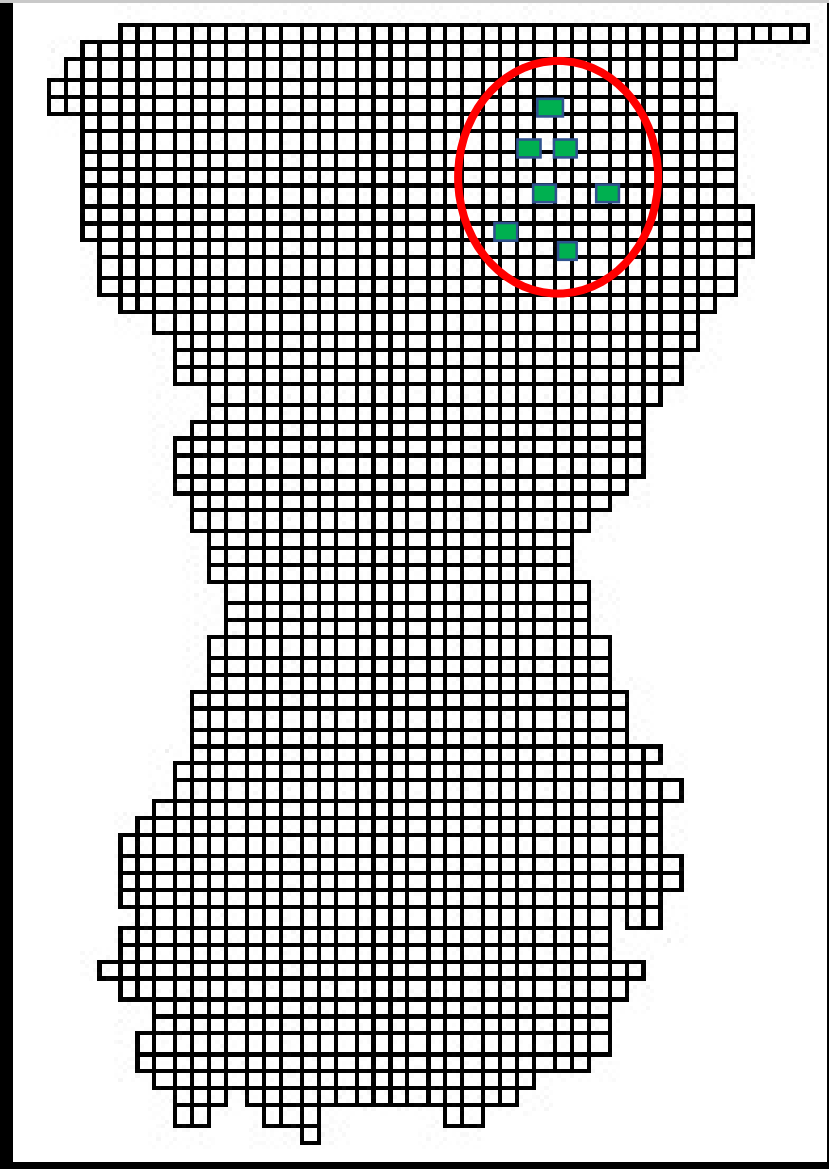


Objective 2: Second-order fall questing resource selection functions (RSFs) for cows that successfully reared a calf to age 1 versus those that did not.

*Resource Selection Functions (RSFs)*

- RSF: Any function proportional to the probability of selection of a resource unit.

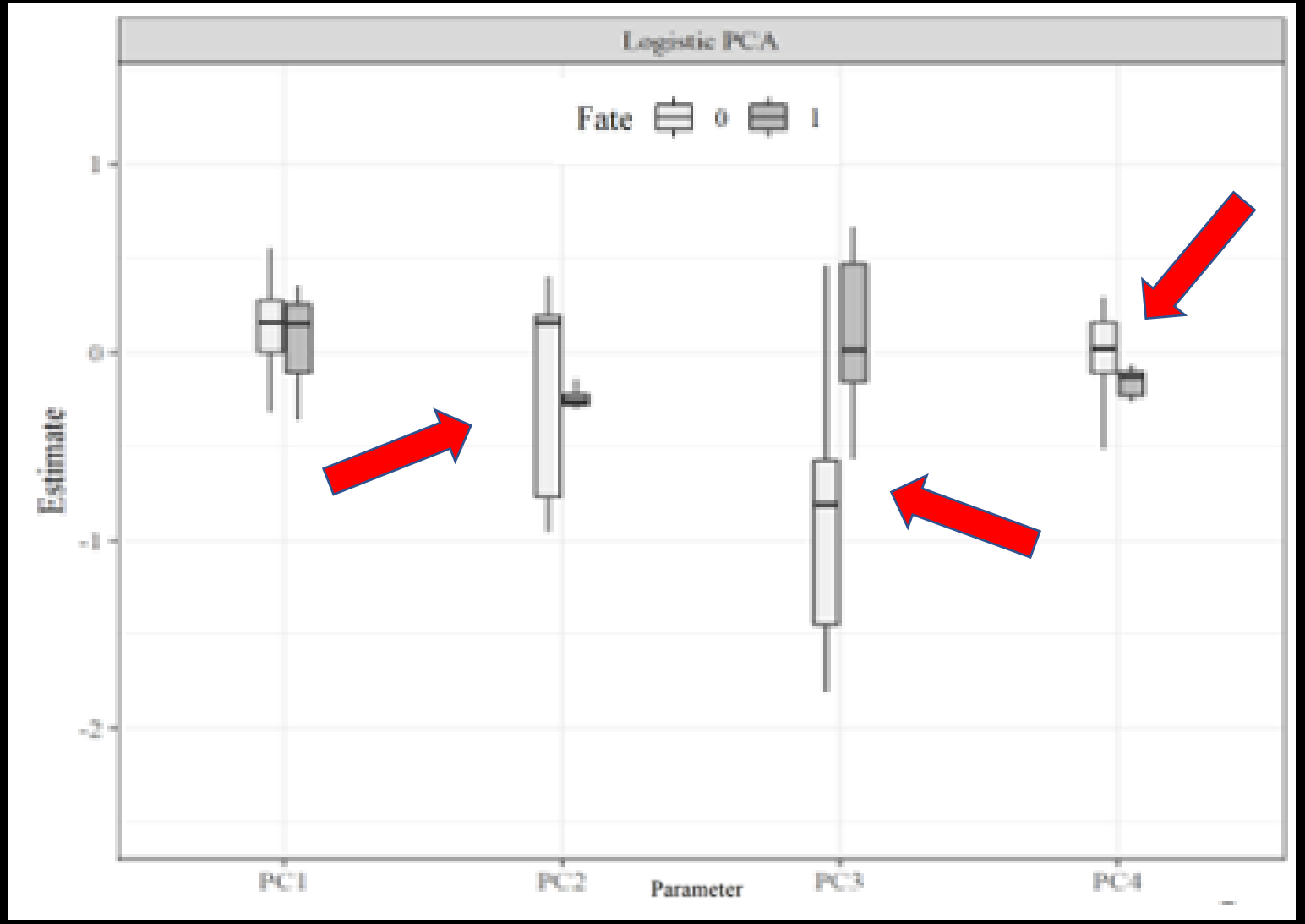
- Estimating RSF as:
  "used vs unused ~ PC1 + PC2 + PC3 + PC4"



Objective 2: Second-order fall questing resource selection functions (RSFs) for cows that successfully reared a calf to age 1 versus those that did not.

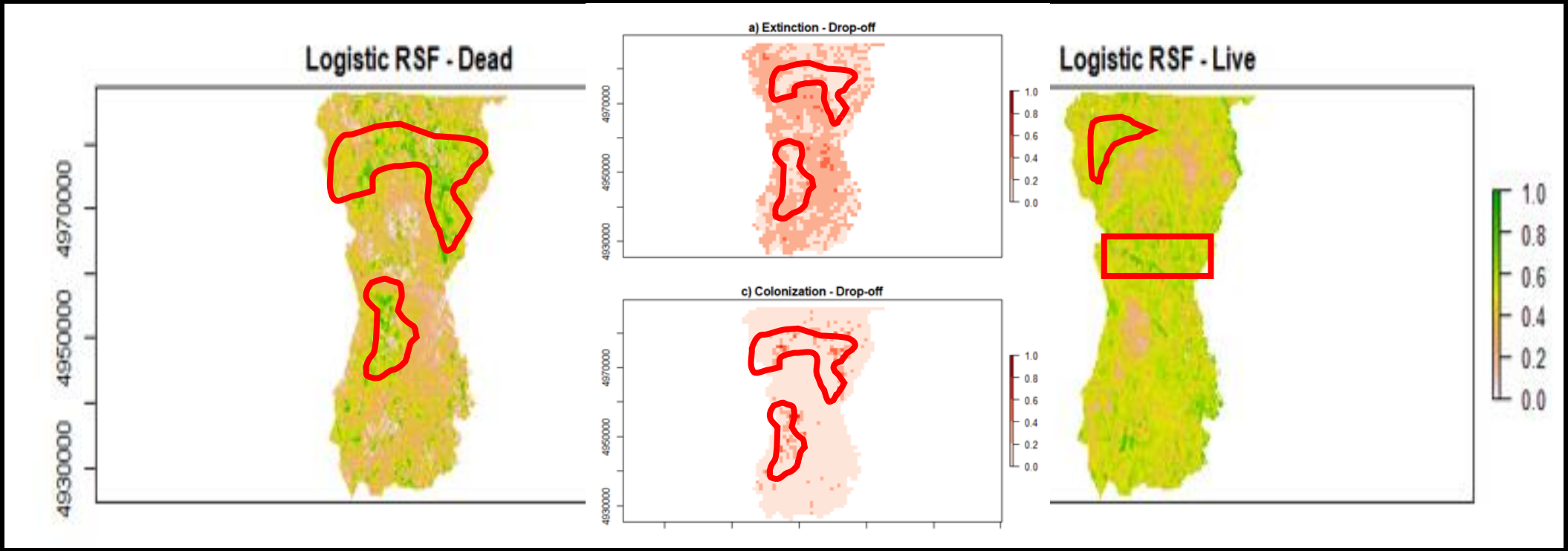
*Key Results*

- RSFs indicated differences in habitat selection between female moose whose calves survived vs died.



Objective 2: Second-order fall questing resource selection functions (RSFs) for cows that successfully reared a calf to age 1 versus those that did not.

*Key Results*




Females with calves that died

- Higher proportions of young (shrub/forage) mixed forest at higher elevations (areas with the highest probability of occupancy during the spring drop-off period).

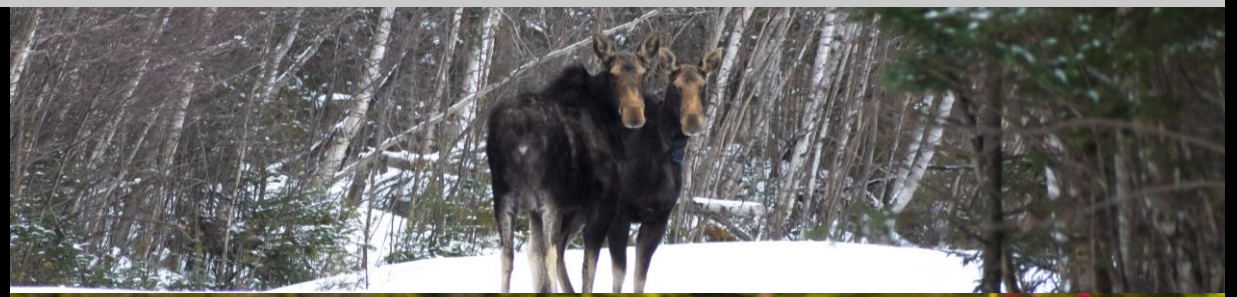
Females with calves that survived

- Adequate young (shrub/forage) deciduous habitats, while also selecting habitats with higher proportions of mature (canopy) evergreen forests and wetlands at lower elevations, i.e., their second-order selection patterns deviated from the occupancy analysis.

# Conclusions

- These results show the fitness consequences of habitat selection decisions made by females during the questing period.

- May inform more direct management strategies (i.e. hunter harvest), indirect (i.e. conservation, modification, or formation of certain habitats), and direct approaches to manage winter ticks (i.e. naturally occurring fungus applications).



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