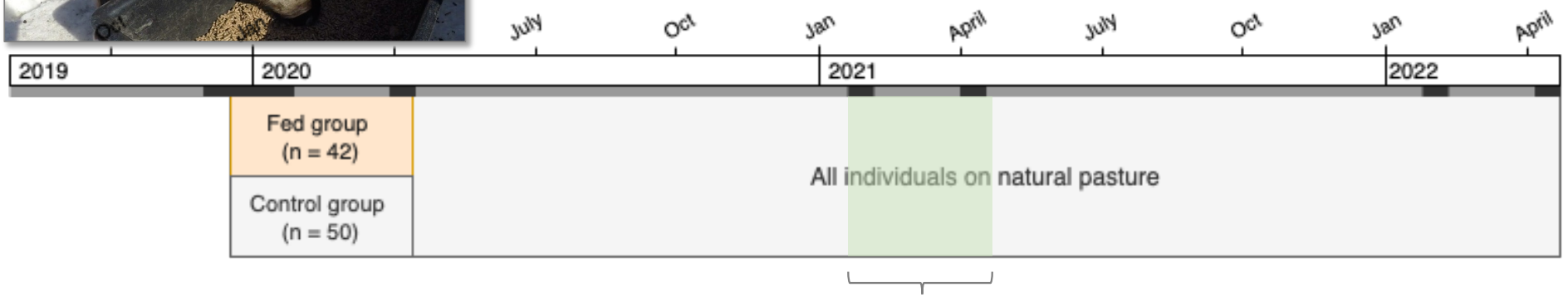
Application of resource selection functions on reindeer

– impact of winter feeding of calves on selection of seasonal home range

Heidi Rautiainen

Experimental design

Are calves that have been fed in enclosure (without their mothers) able to find forage themselves when they are free ranging again the upcoming winter?



Location data of two groups of reindeer between Feb – April 2021

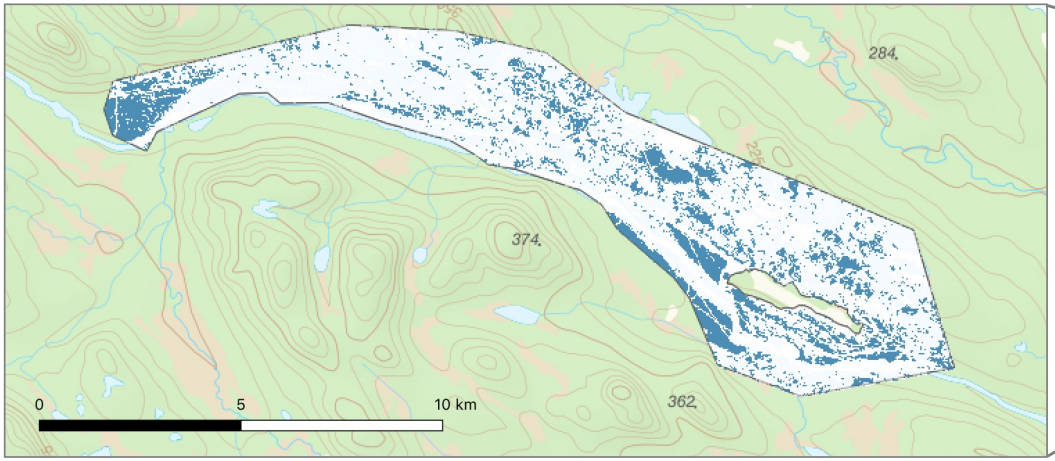
Outline

- Objectives and study area
- Variables and considerations
- Fitted model
- Interpretation

Objectives

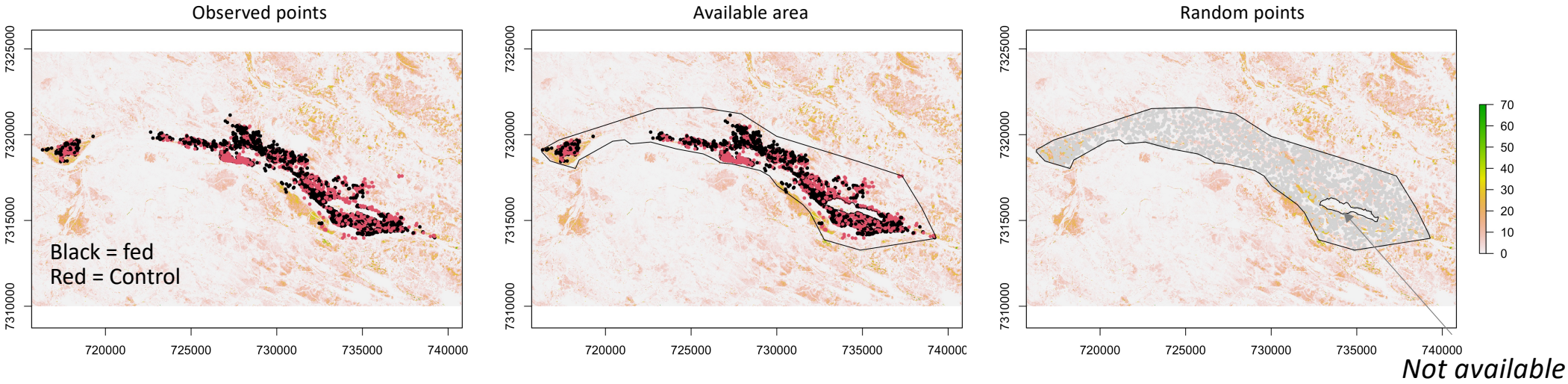
- Comparing habitat selection between two groups of reindeer
- Understand what habitat covariates reindeer are selecting (or avoiding) and if preference/avoidance differs between groups
- Lichen important (and focus here)
- **Second order selection** i.e., selection of home range of an individual or social group (from the physical or geographical range)

Study area



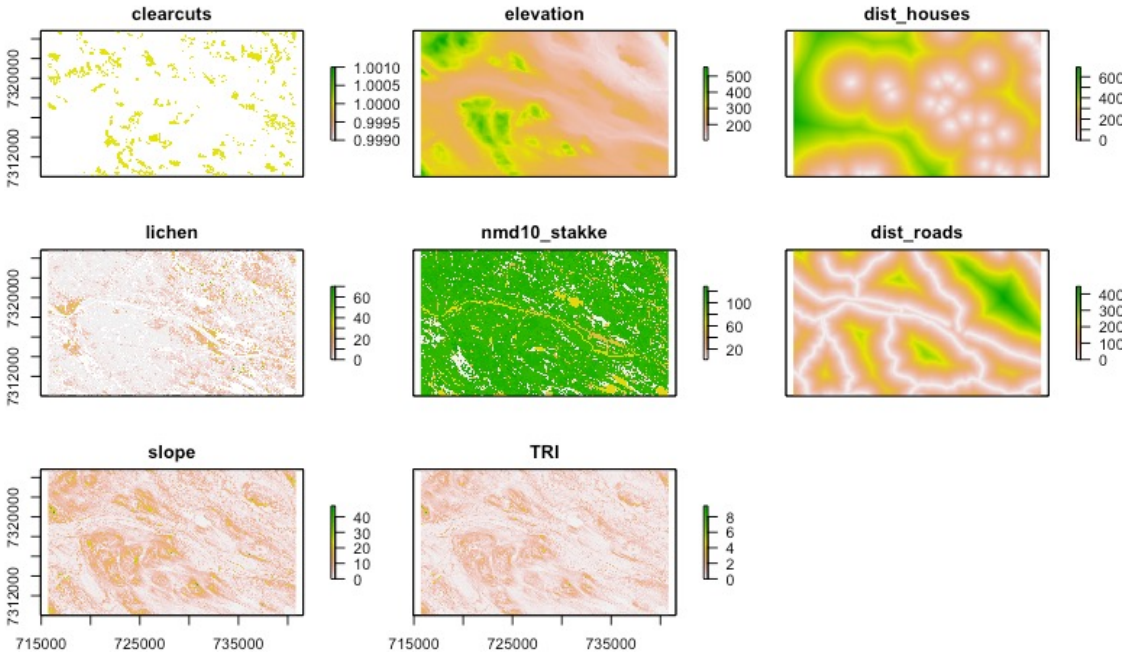
RSF

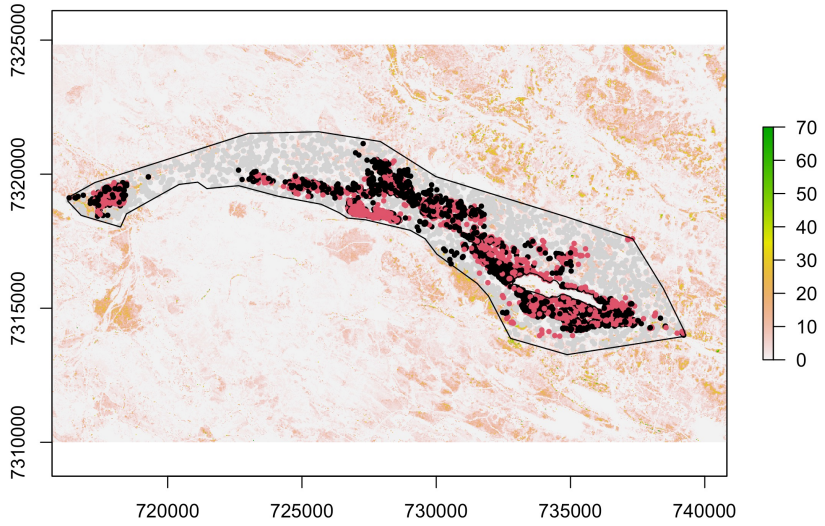
- Find used locations (observed positions)
- Define availability
- Sample available locations (random points)
- Extract environmental covariates for both observed and random



Extract covariates for each position

Black = fed
Red = Control





RSF cont.

- Find used locations (observed positions)
- Define availability
- Sample available locations (random points)
- Extract environmental covariates for both observed and random
- Perform logistic regression on the used vs. available design with covariates as explanatory factors
- Assuming that some resources are actively selected over other resources, the RSF attempts to quantify that selection of home range for (or avoidance of) each group
- Make predictions on where we would expect groups to be based on their previous locations

Considerations

- **Covariates**: Consider (measurable) contributors to reindeer movement pattern
- **Individual or population**: Predictions for a population or an individual? For population; a random effect (individual ID) may offer insight into the differences among individuals within the population.
- **Resolution**: the resolution of the location (presence) points and the scale of the predictor variables. Different scales may reveal different patterns of preference.
- **Defining available area –** how? Here 100% MCP See Beyer et al. (2010)
- **Factors affecting animal preferences**: shifts in preferences across seasons, individuals of different ages, or pregnant females?

Final fitted model

```
TMB3<- glmmTMB(obs ~ landclass + group + log(lichen + 1) + scale(elevation) +  scale(terrain) +     # main effects

                     landclass:group + group:log(lichen + 1) + group:scale(elevation) +            # group comparisons
                     group:scale(terrain) +  group:log(dist_houses + 1) +


                     log(dist_houses + 1) + (1 | id) + (0 + log(lichen +  1) | id) +               # allow for individual
                     (0 + scale(elevation) | id) + (0 + scale(terrain) |  id) +                    # variation
                     (0 + log(dist_houses + 1) | id))),

               family=binomial,
               weights=weight,                                                                     # weight = 1000
               data =  data_ready_rsf,
               doFit=FALSE)

TMB3$parameters$theta[1] <- log(10)                                                                # fixed intercept
lth <- length(TMB3$parameters$theta)                                                               # variance set to 100
TMB3$mapArg <- list(theta=factor(c(NA,1:(lth-1))))
TMBfit3 <- glmmTMB::fitTMB(TMB3)
summary(TMBfit3)
```

Muff S, Signer J, Fieberg J (2020)

Model output

```
Random effects:

Conditional model:
 Groups Name                 Variance  Std.Dev.
 id     (Intercept)          100.00000 10.0000
 id.1   log(lichen + 1)        0.01649  0.1284
 id.2   scale(elevation)       0.44325  0.6658
 id.3   scale(terrain)         0.07490  0.2737
 id.4   log(dist_houses + 1)   0.33171  0.5759
Number of obs: 65032, groups:  id, 30

Conditional model:
                                  Estimate Std. Error z value Pr(>|z|)
(Intercept)                       -9.87312    2.68286  -3.680 0.000233 ***
landclassopen lands                0.87915    0.07096  12.389  < 2e-16 ***
landclassMixed forests            -1.38080    0.15585  -8.860  < 2e-16 ***
landclassclearcuts                -0.41147    0.06272  -6.560 5.37e-11 ***
landclassDeciduous forests        -0.25040    0.10249  -2.443 0.014561 *
groupFed1                         -4.32654    3.67673  -1.177 0.239301
log(lichen + 1)                    0.72683    0.04110  17.686  < 2e-16 ***
scale(elevation)                  -0.04207    0.18039  -0.233 0.815575
scale(terrain)                    -0.11318    0.07689  -1.472 0.141022
log(dist_houses + 1)              -0.06703    0.15738  -0.426 0.670163
landclassopen lands:groupFed1     -0.28961    0.09590  -3.020 0.002528 **
landclassMixed forests:groupFed1  -0.05041    0.21032  -0.240 0.810578
landclassclearcuts:groupFed1      -0.23438    0.09407  -2.491 0.012725 *
landclassDeciduous forests:groupFed1 -0.69061  0.16059  -4.300 1.70e-05 ***
groupFed1:log(lichen + 1)         -0.22439    0.05639  -3.979 6.91e-05 ***
groupFed1:scale(elevation)        -0.75118    0.24761  -3.034 0.002415 **
groupFed1:scale(terrain)           0.25429    0.10484   2.425 0.015288 *
groupFed1:log(dist_houses + 1)     0.65153    0.21636   3.011 0.002601 **
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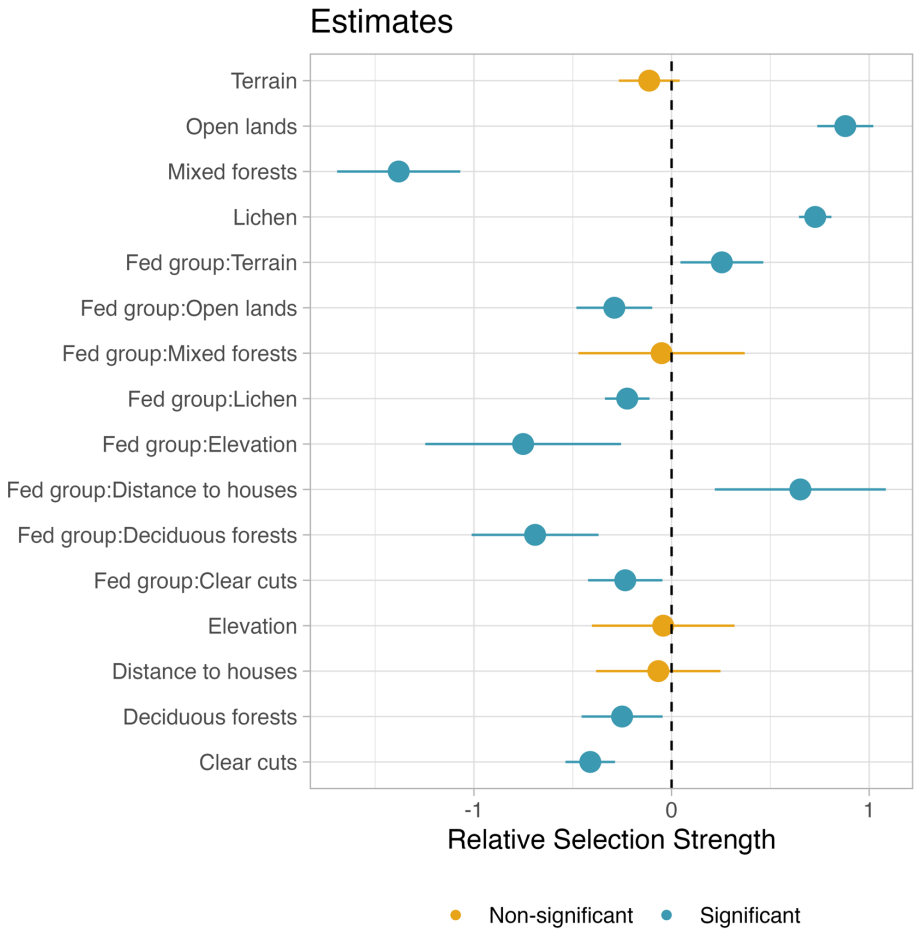

Interpretation: continuous predictors

```
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Interpretation: continuous predictors

Continuous predictors (example)

Here, two locations in the same land coniferous forest (reference category) and same elevation, terrain etc, but differing by one unit in `lichen` (log scale since I have transformed it) and elevation is scaled:

Location s1: Lichen = 2, elevation = 1, land cover = coniferous forest (reference) and here, everything else = 0
Location s2: Lichen = 1, elevation = 1 , land cover = coniferous forest (reference) and here, everything else = 0

$$\frac{\text{Relative use (s1)}}{\text{Relative use (s2)}} = \frac{e^{(2\times\beta_{lichen}+1\times\beta_{elevation}+\ \ldots\ +0\times\beta_{terrain}+0\times\beta_{openlands})}}{e^{(1\times\beta_{lichen}+1\times\beta_{elevation}+\ \ldots\ +0\times\beta_{terrain}+0\times\beta_{openlands})}}$$

$$= \frac{e^{(2\times 0.73+1\times(-0.04)+\ \ldots\ +0\times\beta_{terrain}+0\times\beta_{openlands})}}{e^{(1\times 0.73+1\times(-0.04)+\ \ldots\ +0\times\beta_{terrain}+0\times\beta_{openlands})}} = \frac{4.28}{2.07} = 2.068513$$

See Fieberg J, Signer J, Smith B, Avgar T (2021)

Note:
Log lichen 2 ≈ lichen 6.3
Log lichen 1 ≈ lichen 1.7

Interpretation : continuous predictors

```
Random effects:

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```

Same as:
$e^{(\beta_{lichen})}$ = exp(0.72683) = 2.068513

Interpretation: For one (log unit) increase in lichen, the control group is 2.06 times more likely to be observed at higher lichen abundance

In other words: If the control animals were to be presented with the two hypothetical locations, the model suggests they would be 2.06 times more likely to choose the one with higher lichen abundance

$e^{(\beta_{lichen})}$ quantifies the relative intensity of use of two locations that differ by 1 log-unit of lichen but are otherwise equivalent (i.e., they are equally available and have same values of all other covariates)

For scaled variables: comparison of 1 SD unit

Interpretation

```
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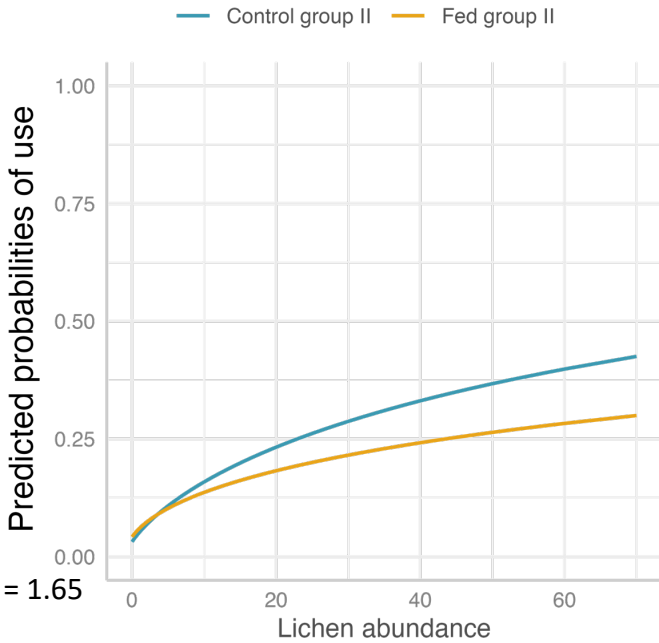


Control
exp(0.72683) = 2.06

Fed
exp(0.72683-0.22438) = 1.65

Odds ratio fed over control
exp(-0.22439) = 0.80

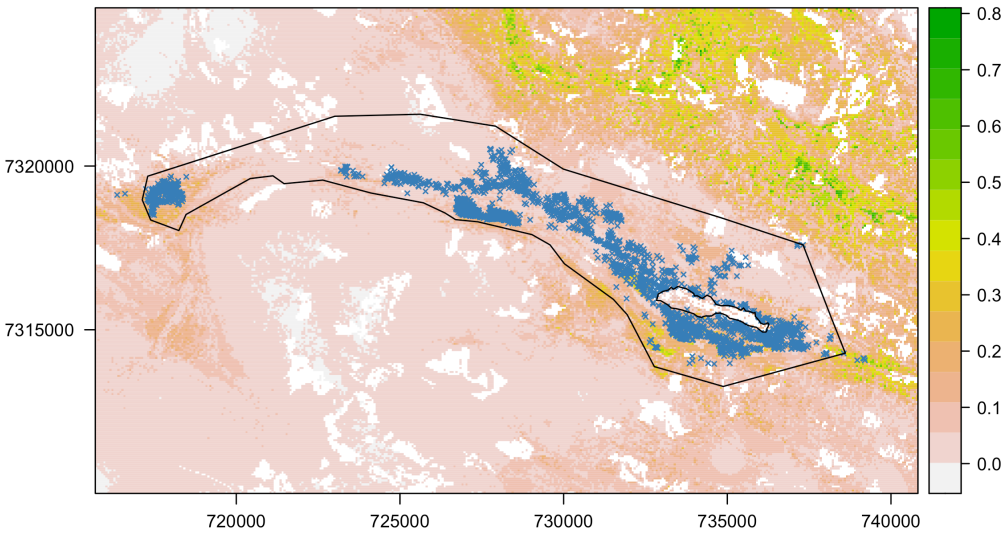
Interpretation: For one unit increase in lichen abundance, the fed group is 0.80 times less likely to choose areas with higher lichen abundance than the control group

May be expressed as:
1/exp(-0.22439) = 1.25 (fed group 1.25 times more likely to select lower lichen abundance)

Prediction plots (fed)

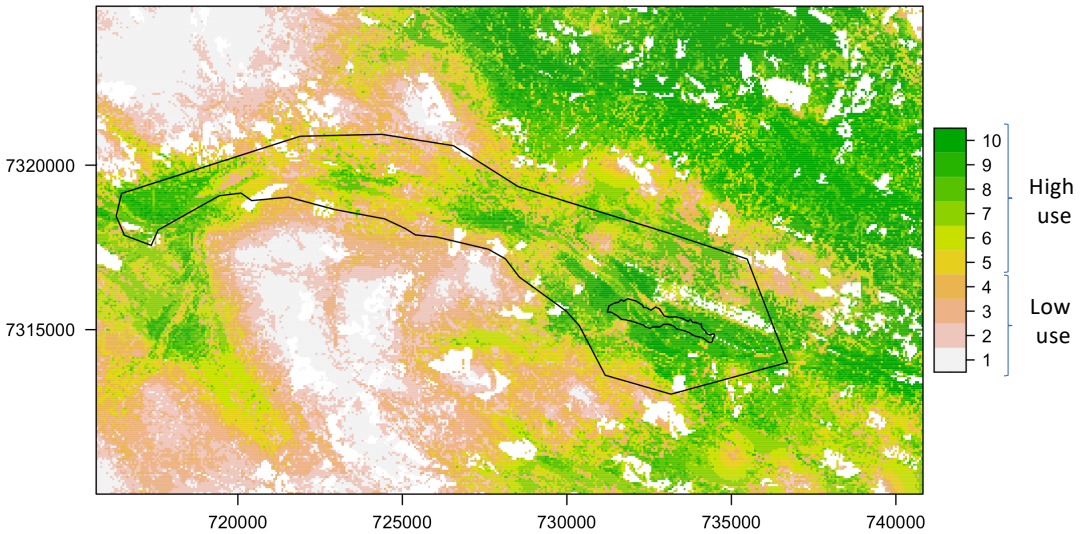
Relative probability of selection

Predicted (continuous)



- Unique value for each pixel i.e., difficult to interpret as more weight to maximum probability predictions (upper right)

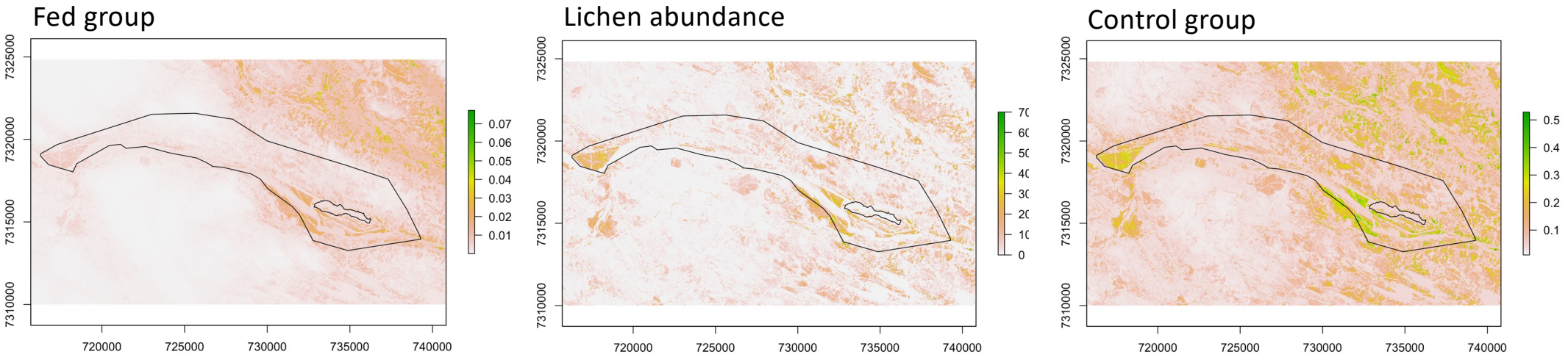
Predicted (binned/reclassified RSF scores)



- RSF values split into (10) quantiles (bins) to get a discrete scale

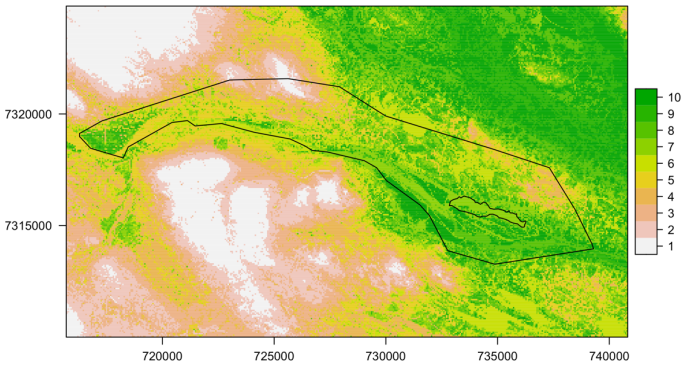
Boyce MS, Vernier PR, Nielsen SE, Schmiegelow FKA (2002)
Reviewed in: Morris LR, Proffitt KM, Blackburn JK (2016)

Predictions and lichen map

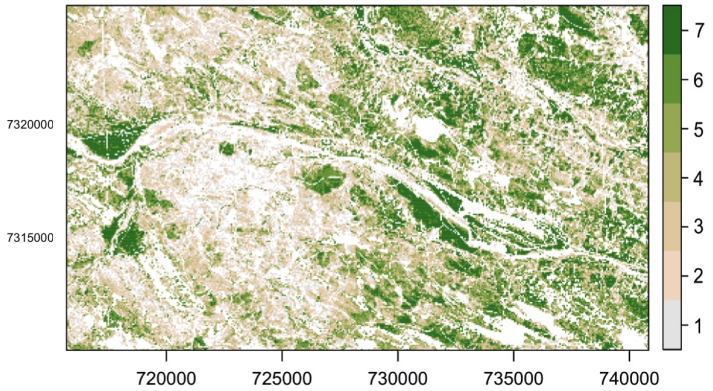


Predictions and lichen map

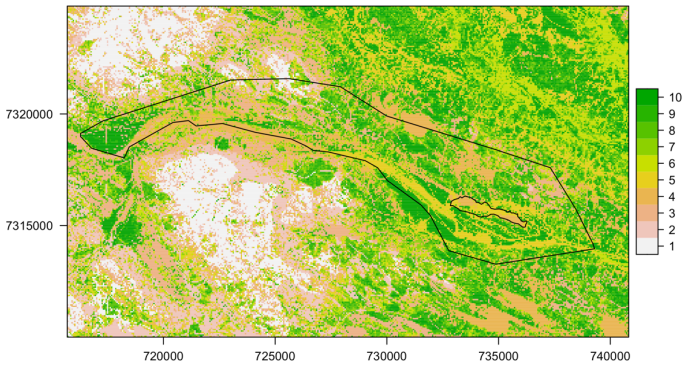
Fed group



Lichen abundance



Control group



Interpretation: categorical predictors

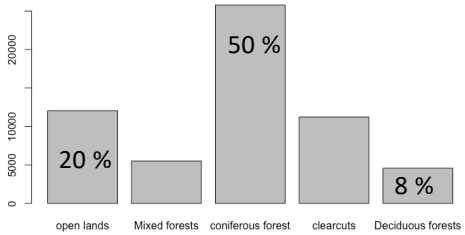
Land cover class

	0	1
open lands	12045	1287
Mixed forests	5511	98
coniferous forest	25779	3724
clearcuts	11227	604
Deciduous forests	4575	182

- Risk for misleading results: High (or low) levels of use may be associated with negative (or positive) coefficients simply based on ratio available:random points

Assumption: both land cover classes are equally available within the MCP

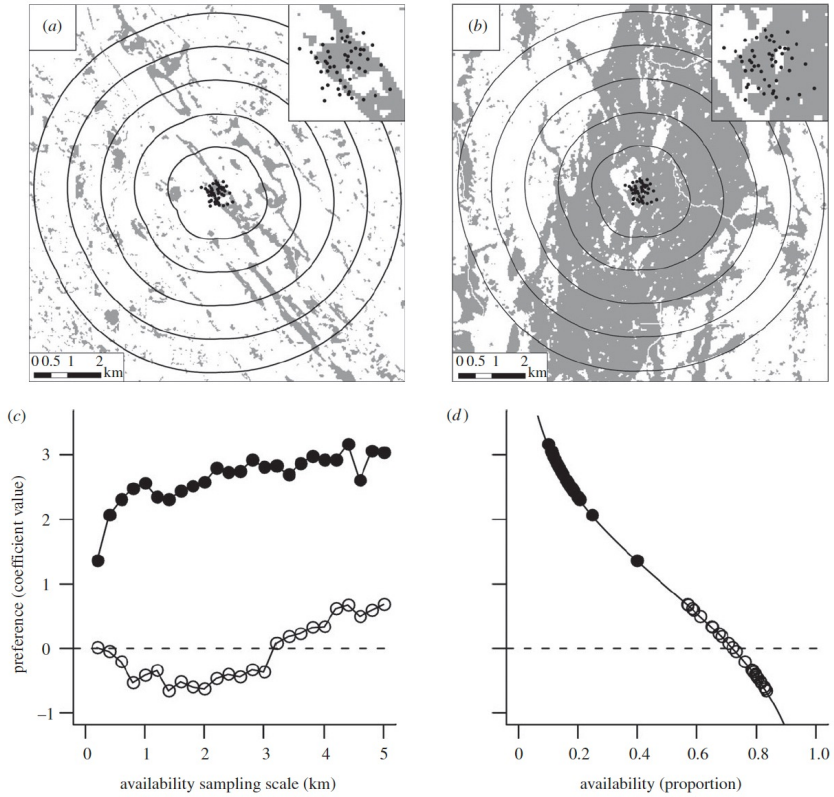
…but they are not:



See Fieberg J, Signer J, Smith B, Avgar T (2021)
Beyer et al. (2010)

Sample of availability, considerations

Different availability areas in different relative availabilities landcover



C: Preference changes with scale only because the relative availability of the vegetation types changes in a and b

D: As availability increases, the coefficient decreases for a given sample of use (size of the area)

Beyer et al. (2010)

Interpretation: categorical predictors

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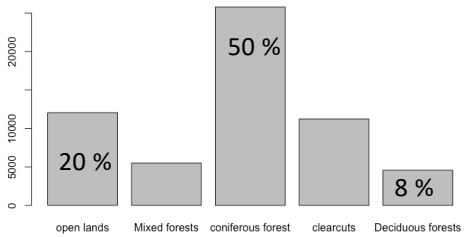

(Naïve) correction for differences in availability:

$$\exp(\beta_{open\ lands}) \times \frac{available\ locations_{open\ lands}}{available\ locations_{reference\ category}}.$$

$$= 0.87915 \times \frac{12045}{25779} = 1.125514$$

See Fieberg J, Signer J, Smith B, Avgar T (2021)
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```

Interpretation: categorical predictors

Control

$$e^{(\beta_{open\ lands})} \times \frac{available\ locations_{open\ lands}}{available\ locations_{reference\ category}}. = 1.125514$$

Fed

$$\exp\left(\beta_{open\ lands} + \beta_{open\ lands:Fed}\right) \times \frac{available\ locations_{open\ lands}}{available\ locations_{reference\ category}}. =$$

$$\exp(0.87915\text{-}0.28961) \times \frac{available\ locations_{open\ lands}}{available\ locations_{reference\ category}}. = 0.8425178$$

Fed over control relative to reference category

$$0.8425178 / 1.125514 = 0.7485627$$

See Fieberg J, Signer J, Smith B, Avgar T (2021)
Beyer et al. (2010)

References

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