

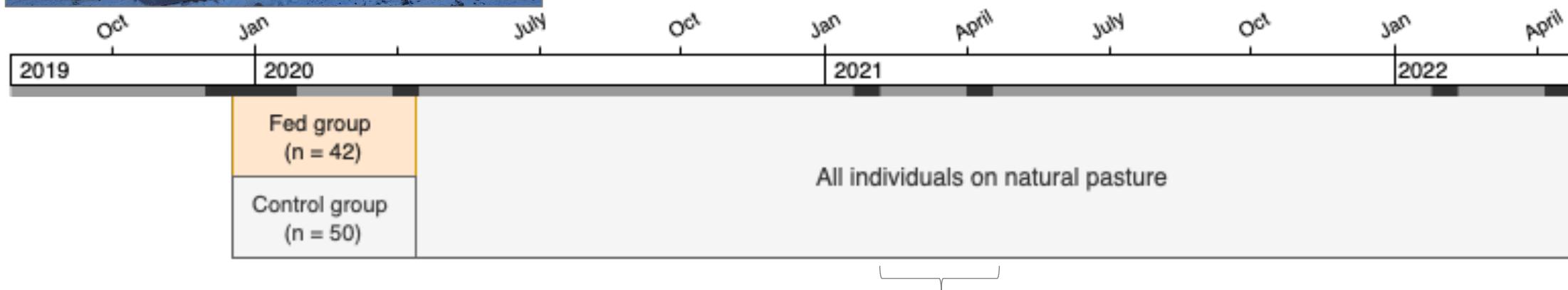
# Application of resource selection functions on reindeer

Impact of winter feeding of calves on selection of seasonal home range



# 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

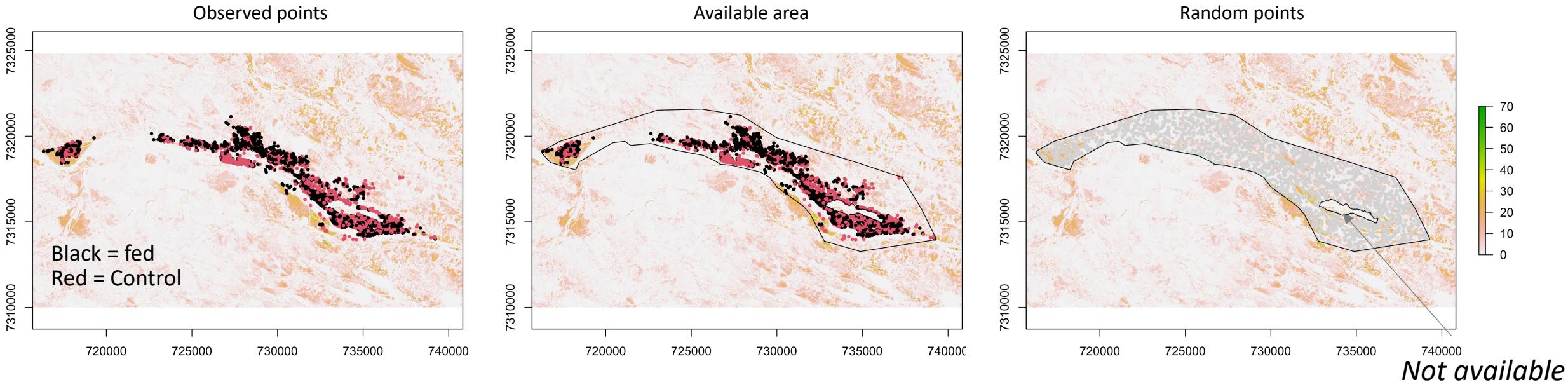
# Objectives

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



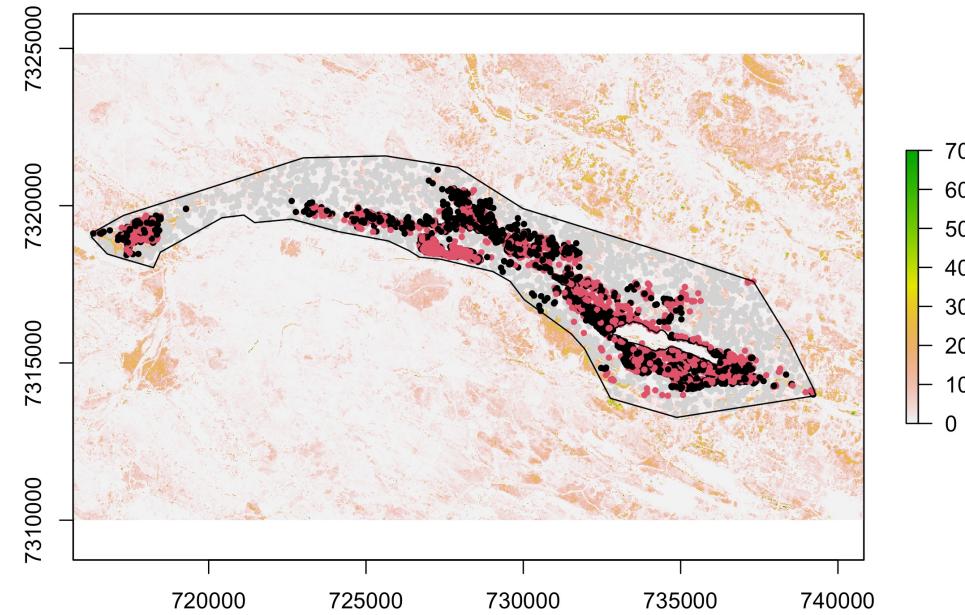
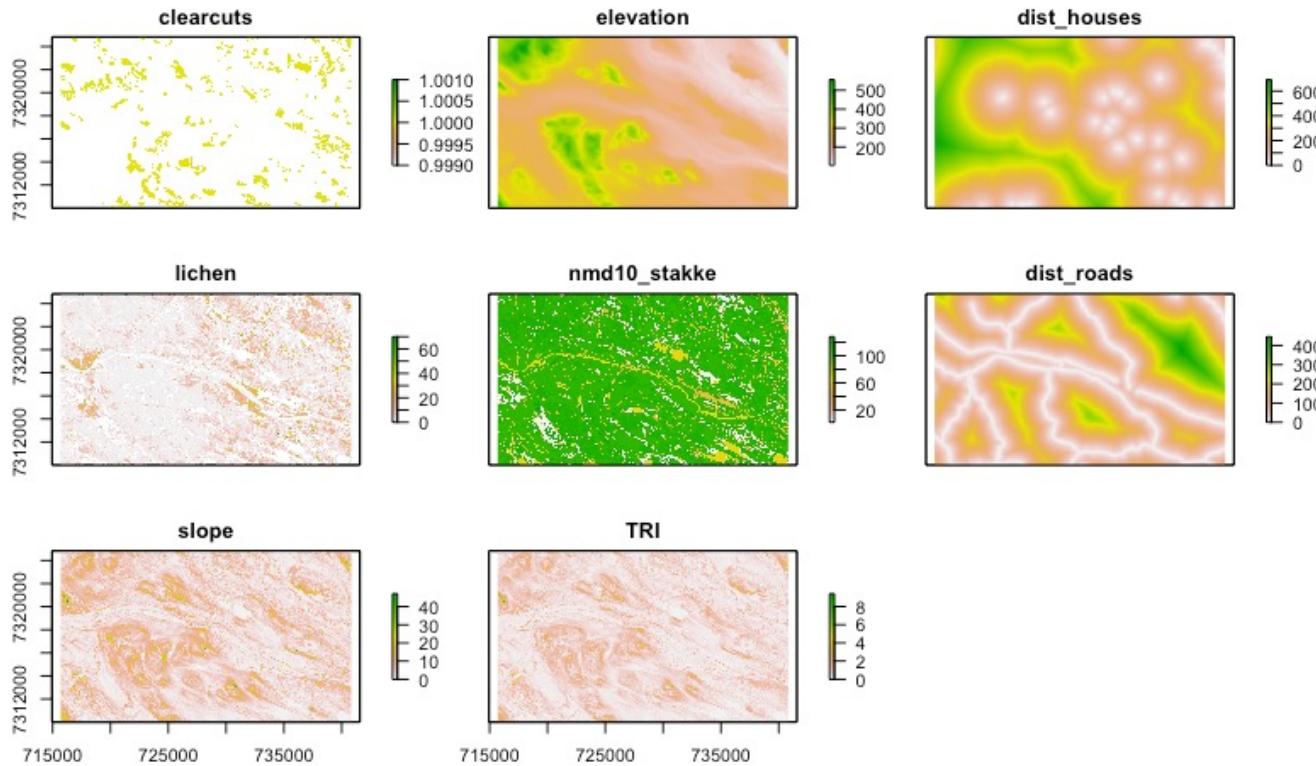
# RSF

- 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
- **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:scale(terrain) + group:log(dist_houses + 1) +  
  
log(dist_houses + 1) + (1 | id) + (0 + log/lichen + 1) | id) +  
(0 + scale(elevation) | id) + (0 + scale(terrain) | id) +  
(0 + log(dist_houses + 1) | id)), # allow for individual  
# variation  
family=binomial,  
weights=weight,  
data = data_ready_rsf,  
doFit=FALSE) # weight = 1000  
  
TMB3$parameters$theta[1] <- log(10)  
lth <- length(TMB3$parameters$theta)  
TMB3$mapArg <- list(theta=factor(c(NA,1:(lth-1))))  
TMBfit3 <- glmmTMB::fittMB(TMB3)  
summary(TMBfit3) # fixed intercept  
# variance set to 100
```

# Model output

Random effects:

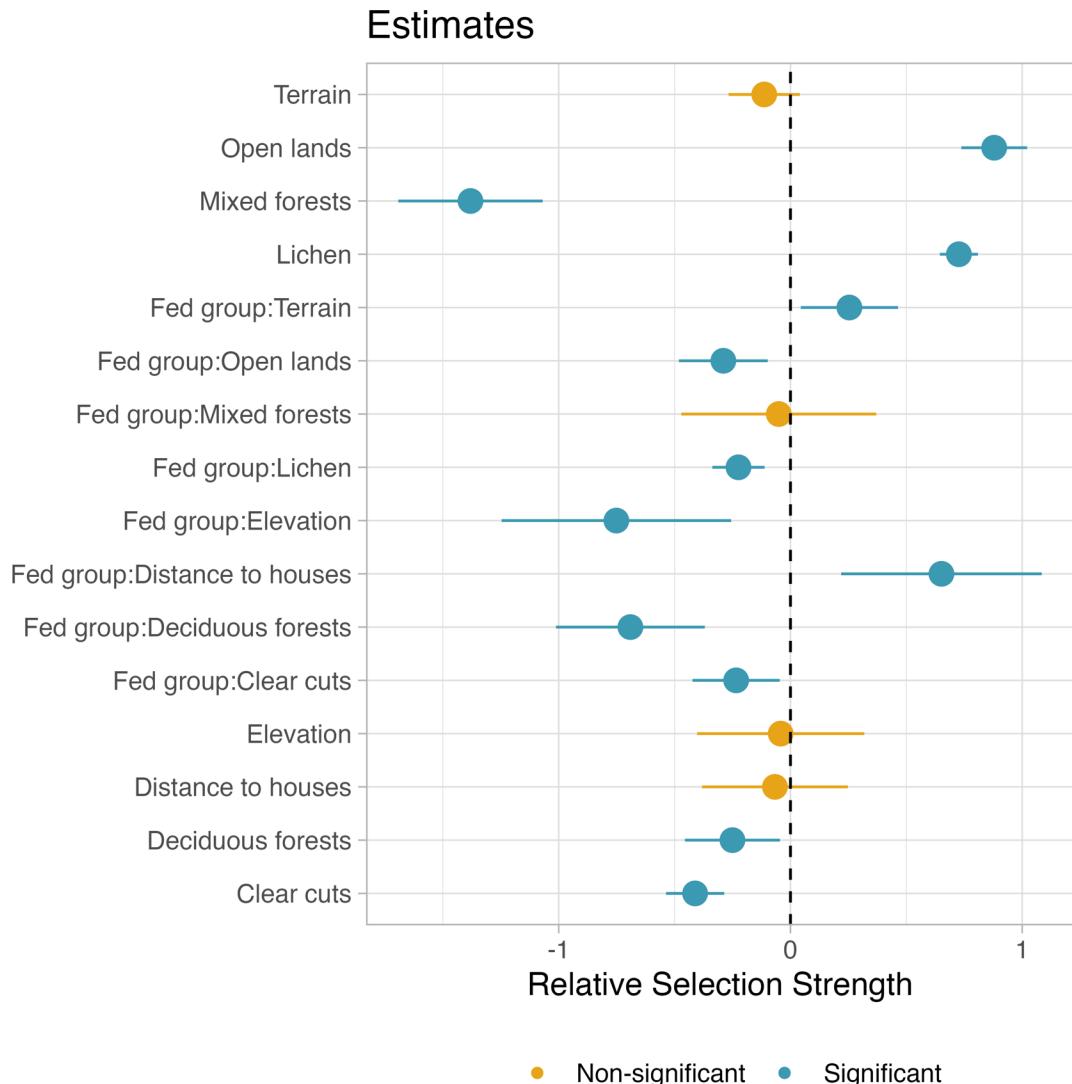
Conditional model:

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 **	



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

# Interpretation

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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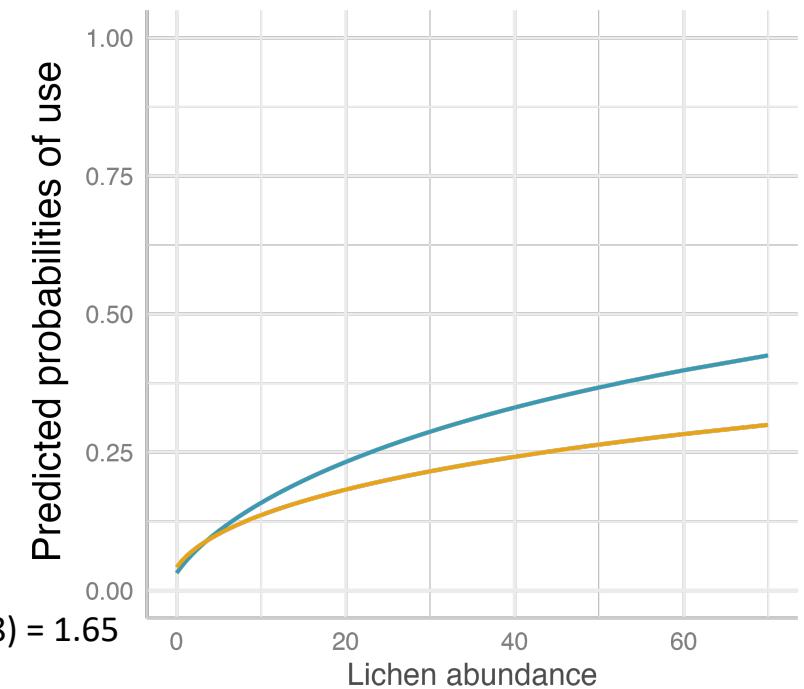
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**Control**

$$\exp(0.72683) = 2.06$$

**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

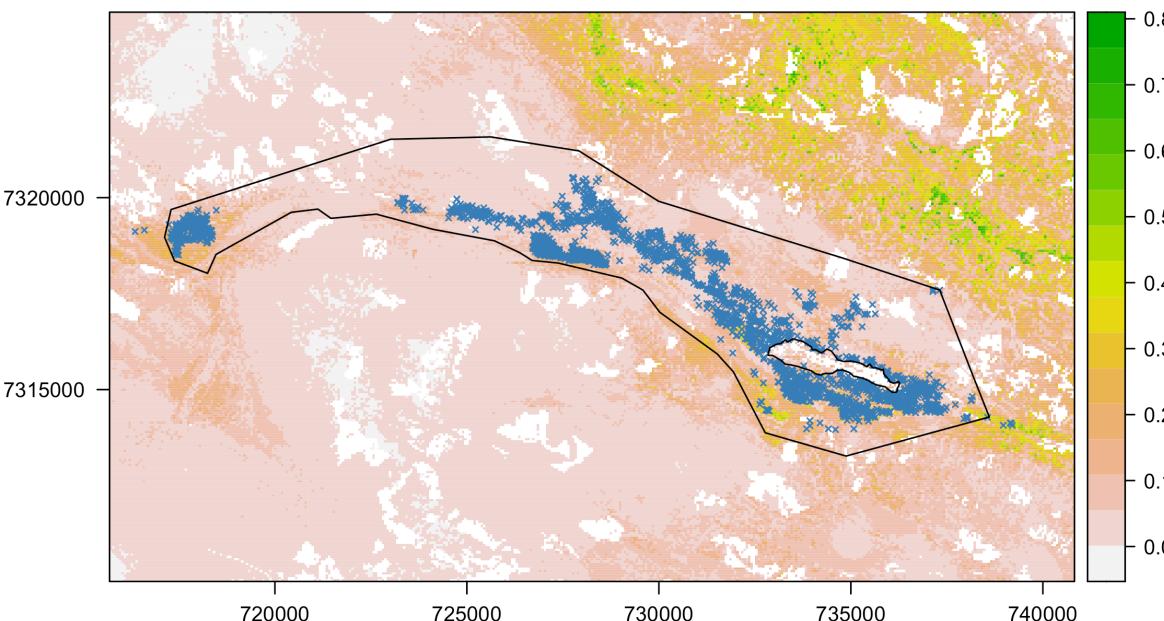
**May be expressed as:**

$1/\exp(-0.22439) = 1.25$  (fed group 1.25 times more likely to select lower lichen abundance)

# Prediction plots (fed)

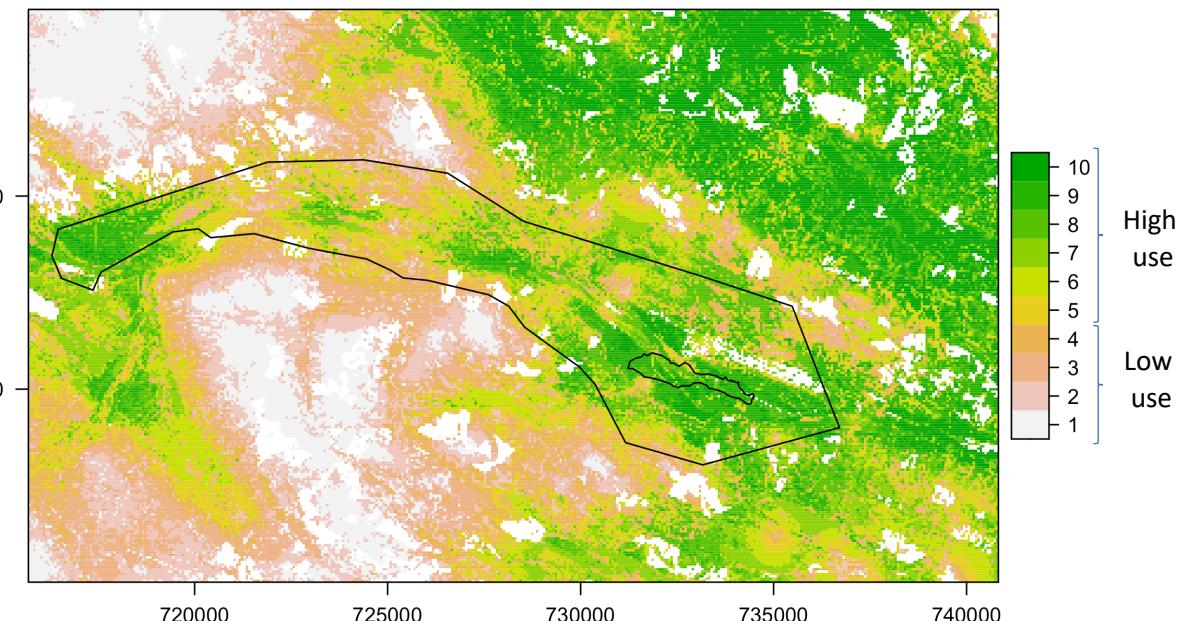
Relative probability of selection

Predicted (continuous)



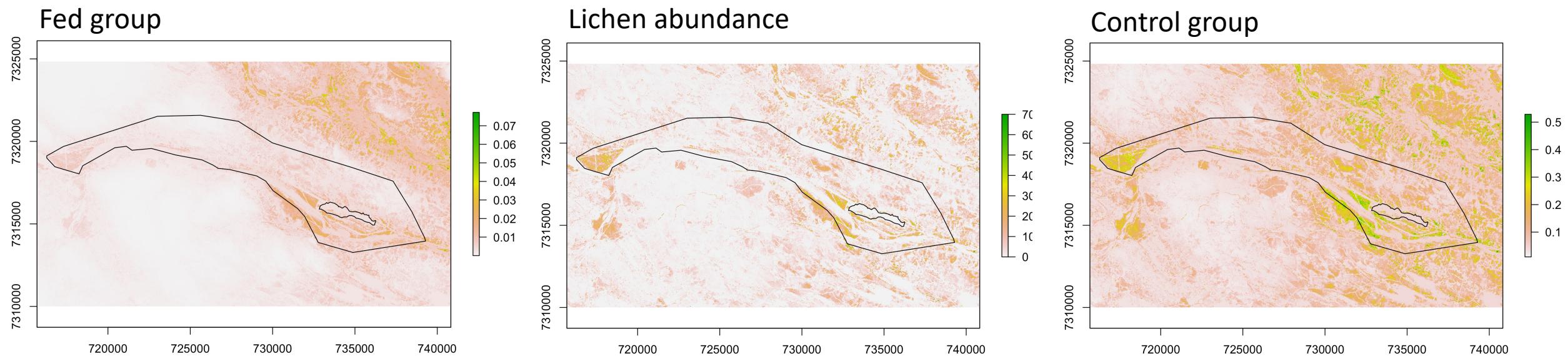
- Unique value for each pixel i.e., difficult to interpret as more weight to maximum probability predictions (upper right)

Predicted (binned/reclassified RSF scores)



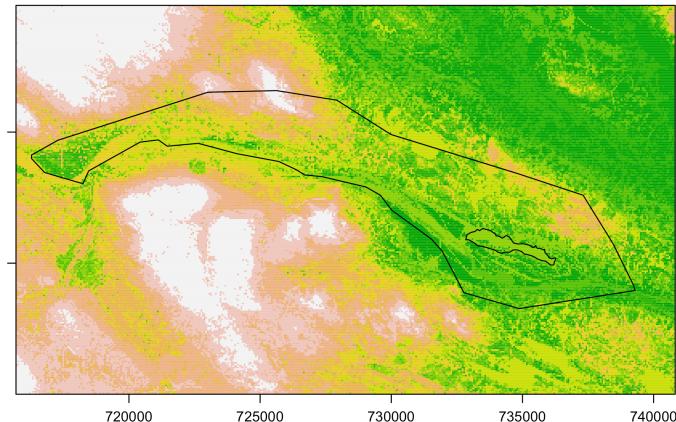
- RSF values split into (10) quantiles (bins) to get a discrete scale

# Predictions and lichen map

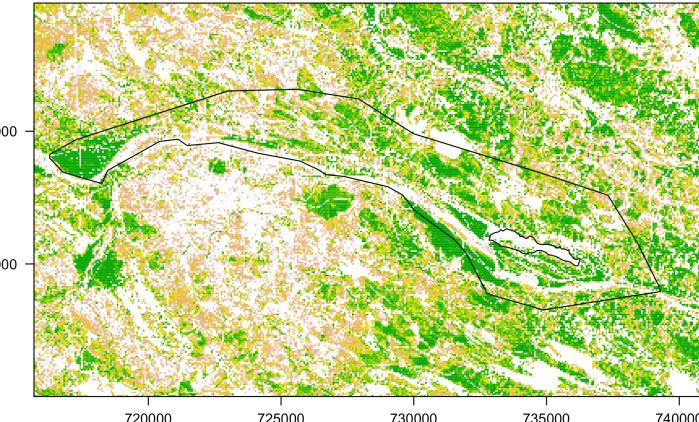


# Predictions and lichen map

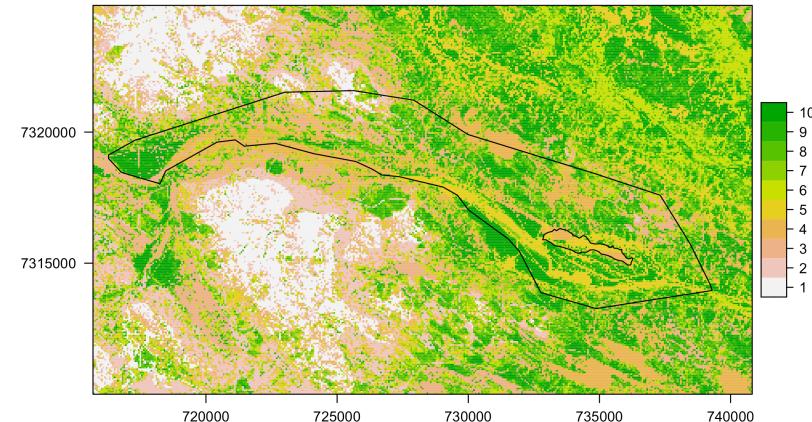
Fed group



Lichen abundance



Control group



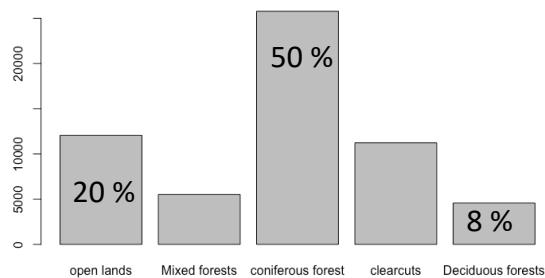
# Interpretation

## Categorical predictors

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

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

...but they are not:



(Naïve) correction for differences in availability:

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

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

# References

- Boyce MS, Vernier PR, Nielsen SE, Schmiegelow FKA (2002) Evaluating resource selection functions. Ecological Modelling 157:281-300. DOI: 10.1016/S0304-3800(02)00200-4
- Morris LR, Proffitt KM, Blackburn JK (2016) Mapping Resource Selection Functions in Wildlife Studies: Concerns and Recommendations. Appl Geogr 76:173-183. DOI: 10.1016/j.apgeog.2016.09.025
- Muff S, Signer J, Fieberg J (2020) Accounting for individual-specific variation in habitat-selection studies: Efficient estimation of mixed-effects models using Bayesian or frequentist computation. J Anim Ecol 89:80-92. DOI: 10.1111/1365-2656.13087
- Fieberg J, Signer J, Smith B, Avgar T (2021) A 'How to' guide for interpreting parameters in habitat-selection analyses. J Anim Ecol 90:1027-1043. DOI: 10.1111/1365-2656.13441