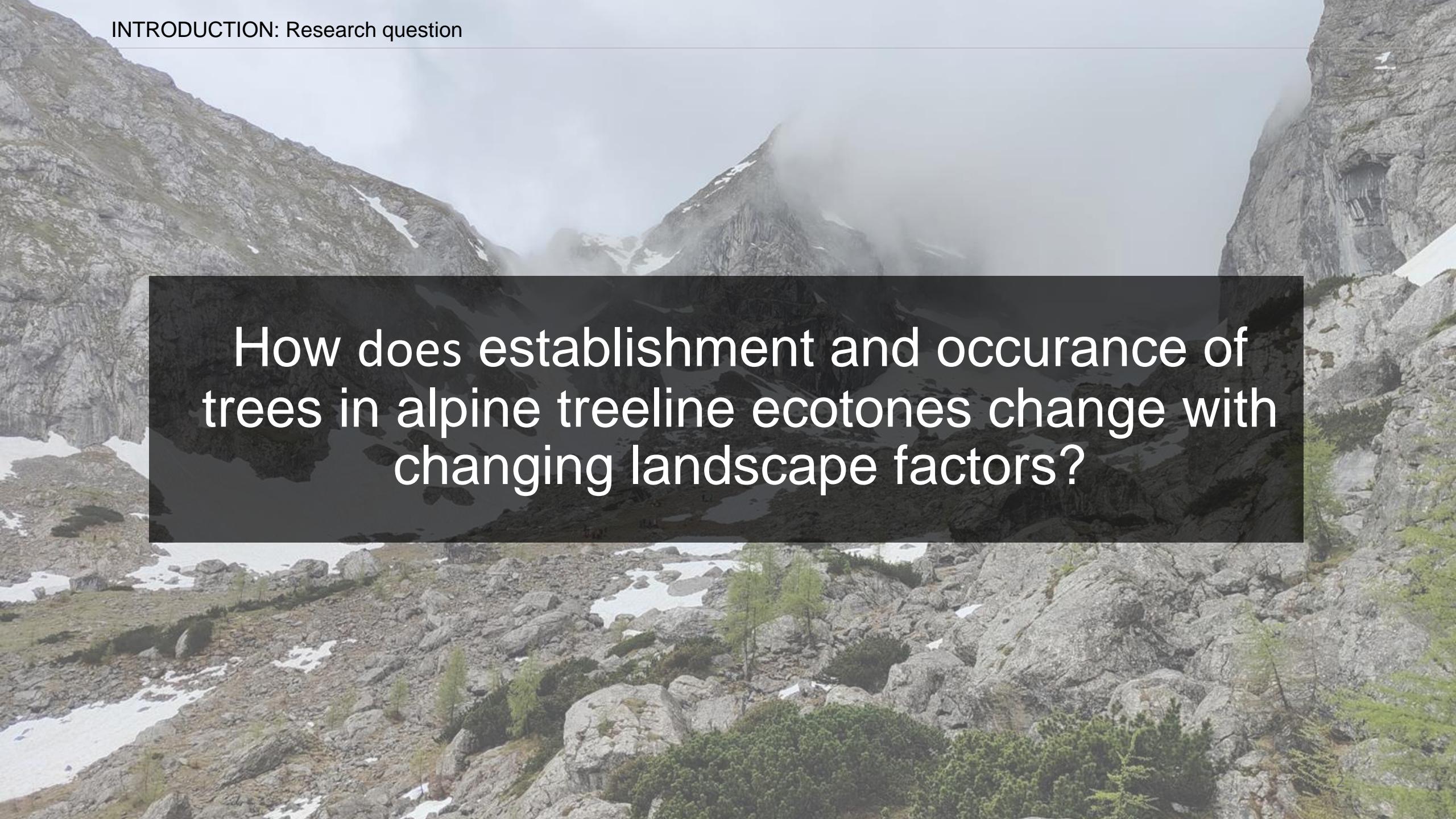


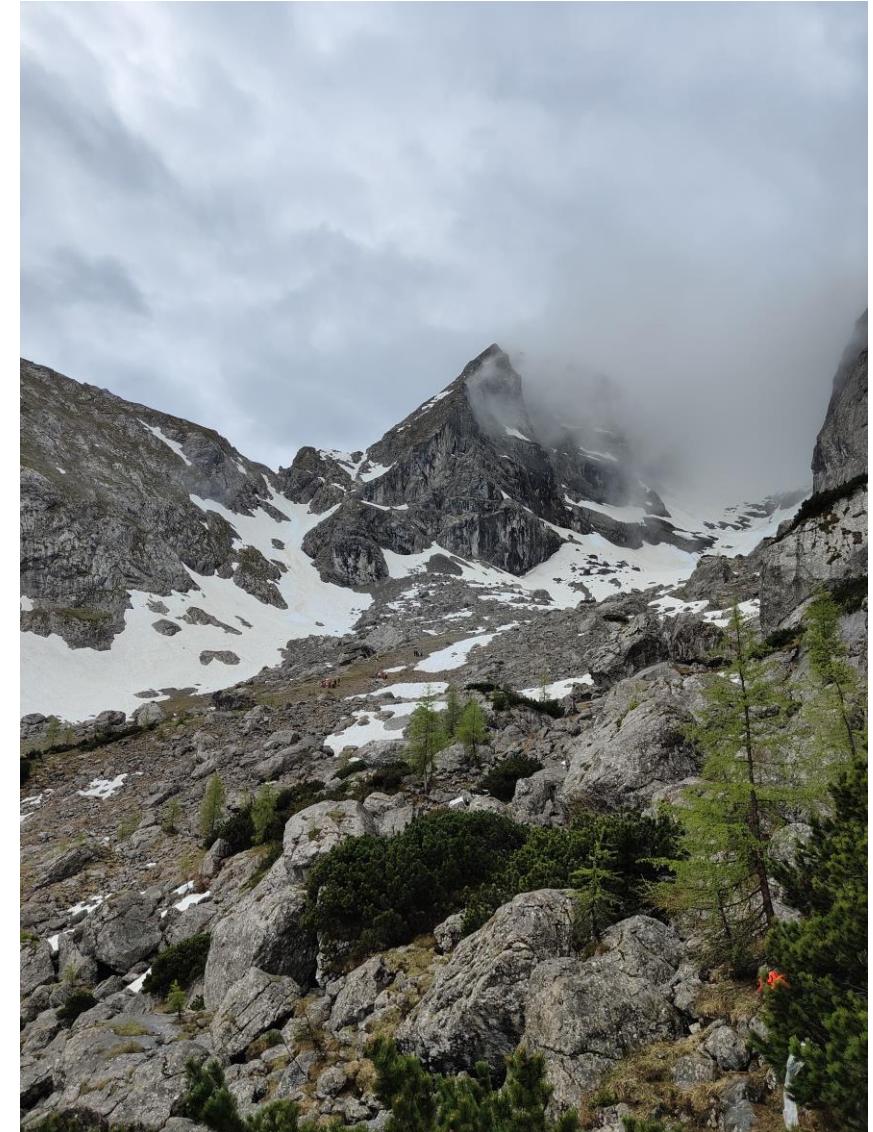
LANDSCAPE

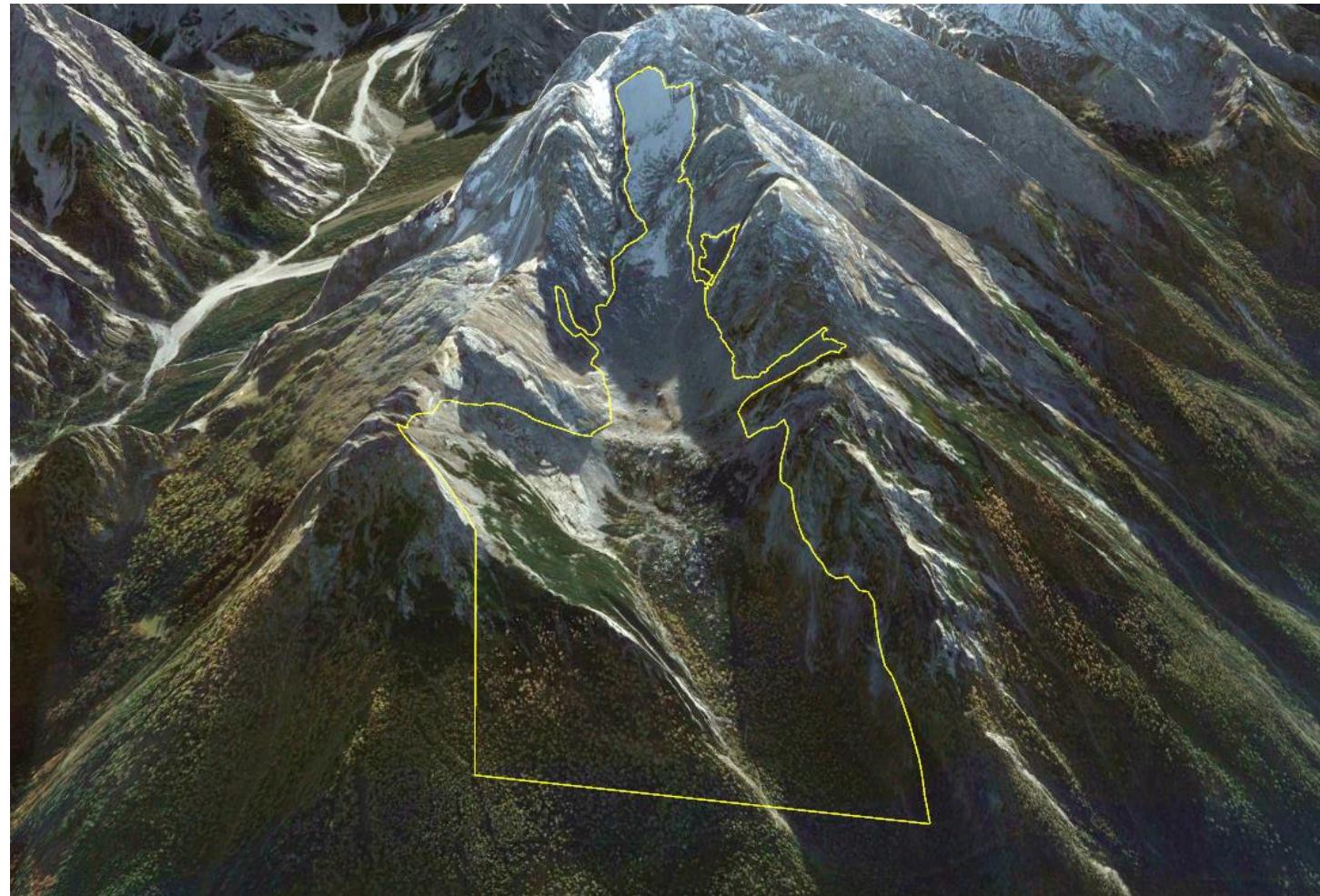


A wide-angle photograph of a mountainous landscape. In the foreground, there are rocky slopes with patches of snow and small green shrubs. The middle ground shows more rugged terrain with snow. In the background, several majestic mountains rise, their peaks partially obscured by thick, grey clouds. The overall scene is misty and atmospheric.

How does establishment and occurrence of trees in alpine treeline ecotones change with changing landscape factors?

- Establishment of trees is favoured by:
 - Lower slope angle
 - Higher surrounding tree cover
 - Higher exposure to solar radiation
 - Lower elevation

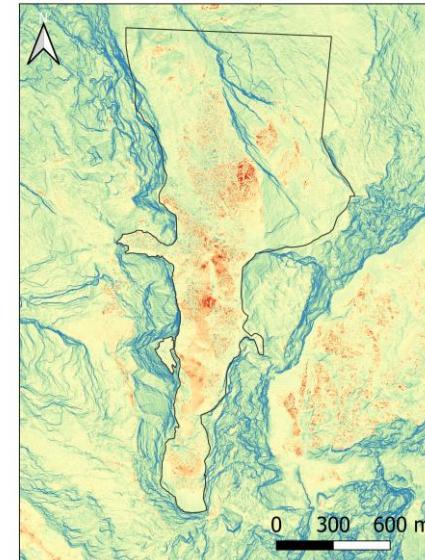
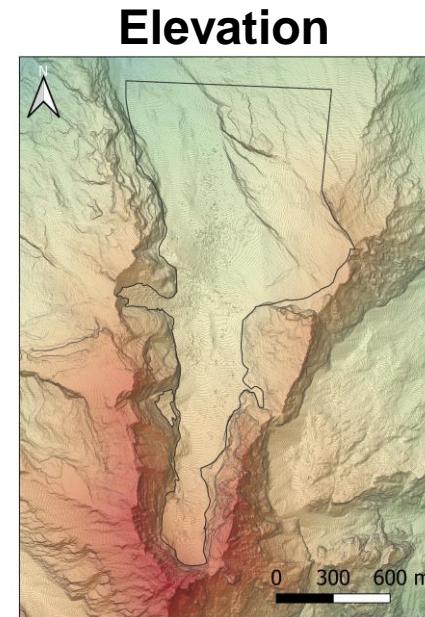
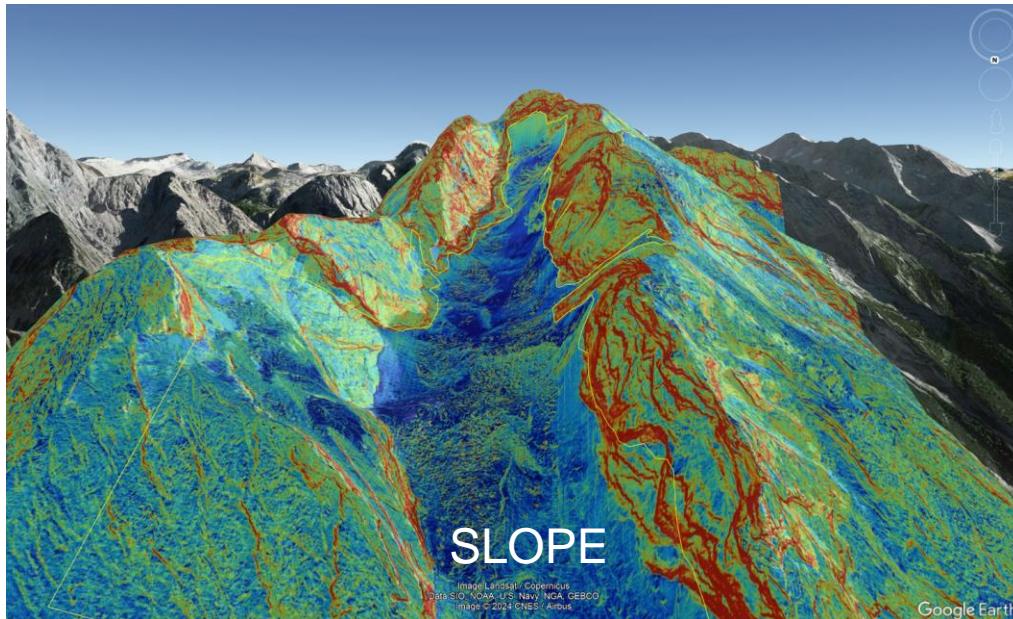
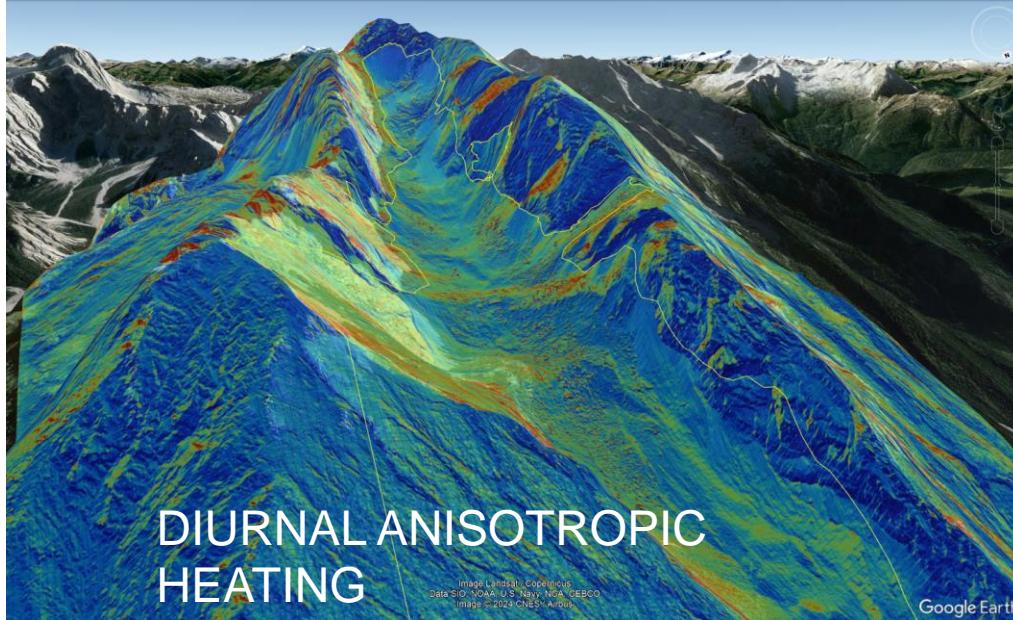




Identification of homogeneous areas based on:

- 1. Topography** (topography inherently reflects vegetation)

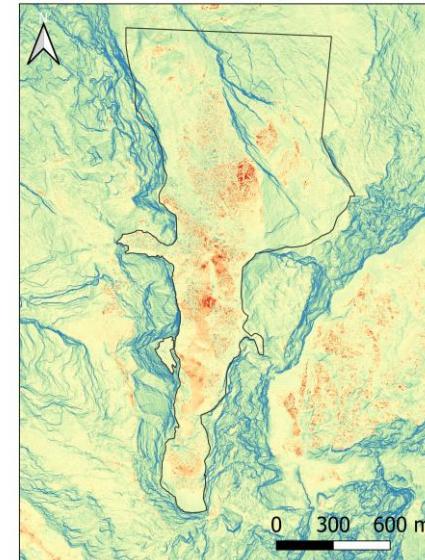
TOPOGRAPHY: Definition of Topographic Indices



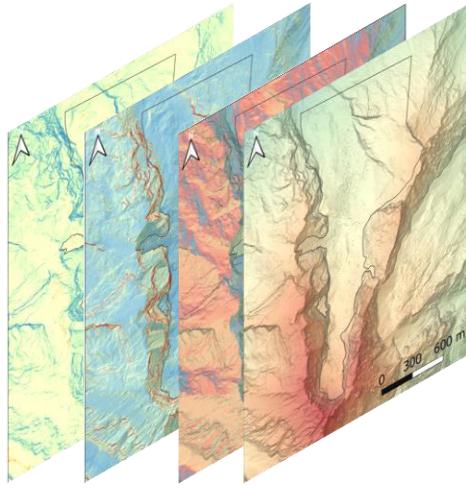
Elevation



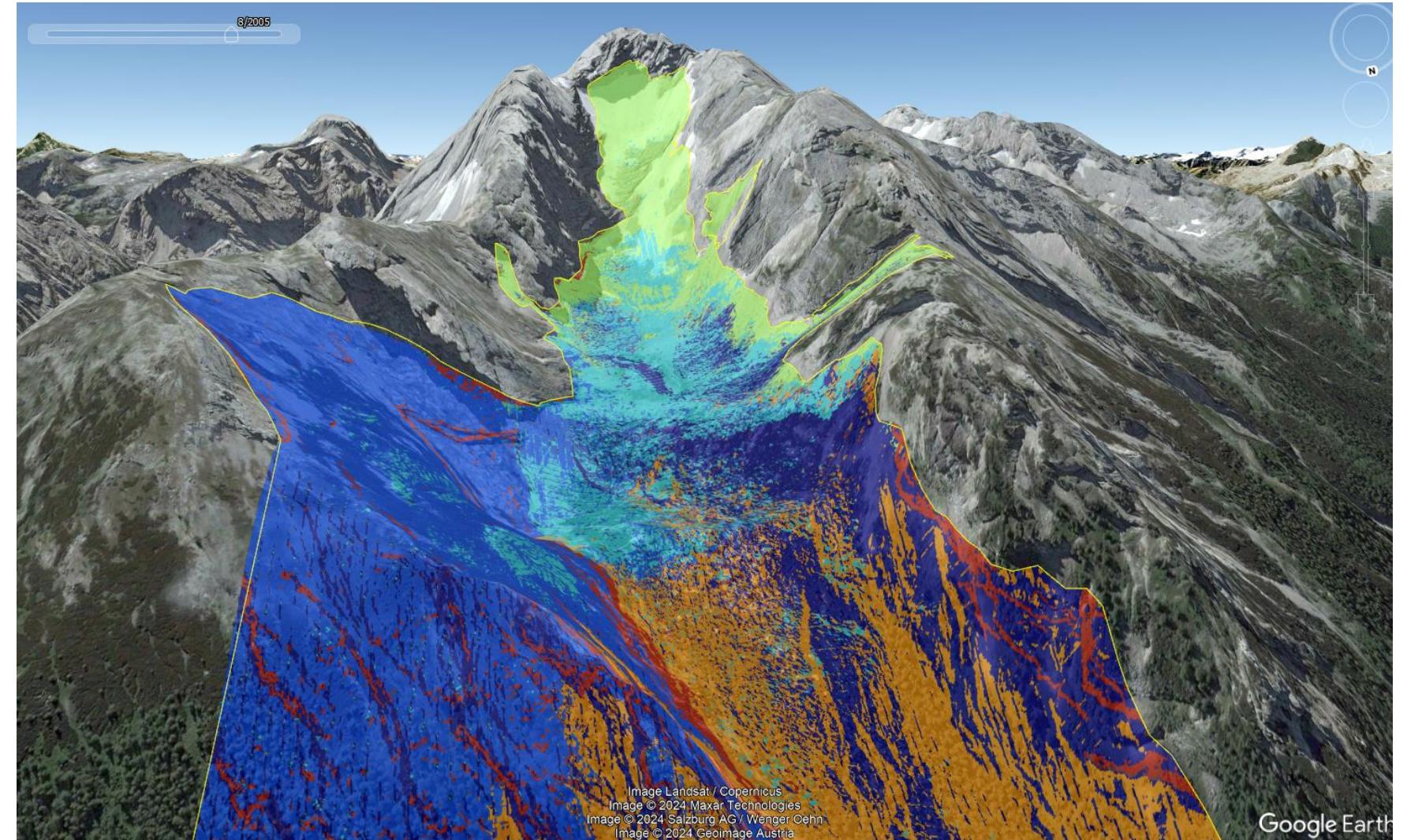
TRI



Aspect

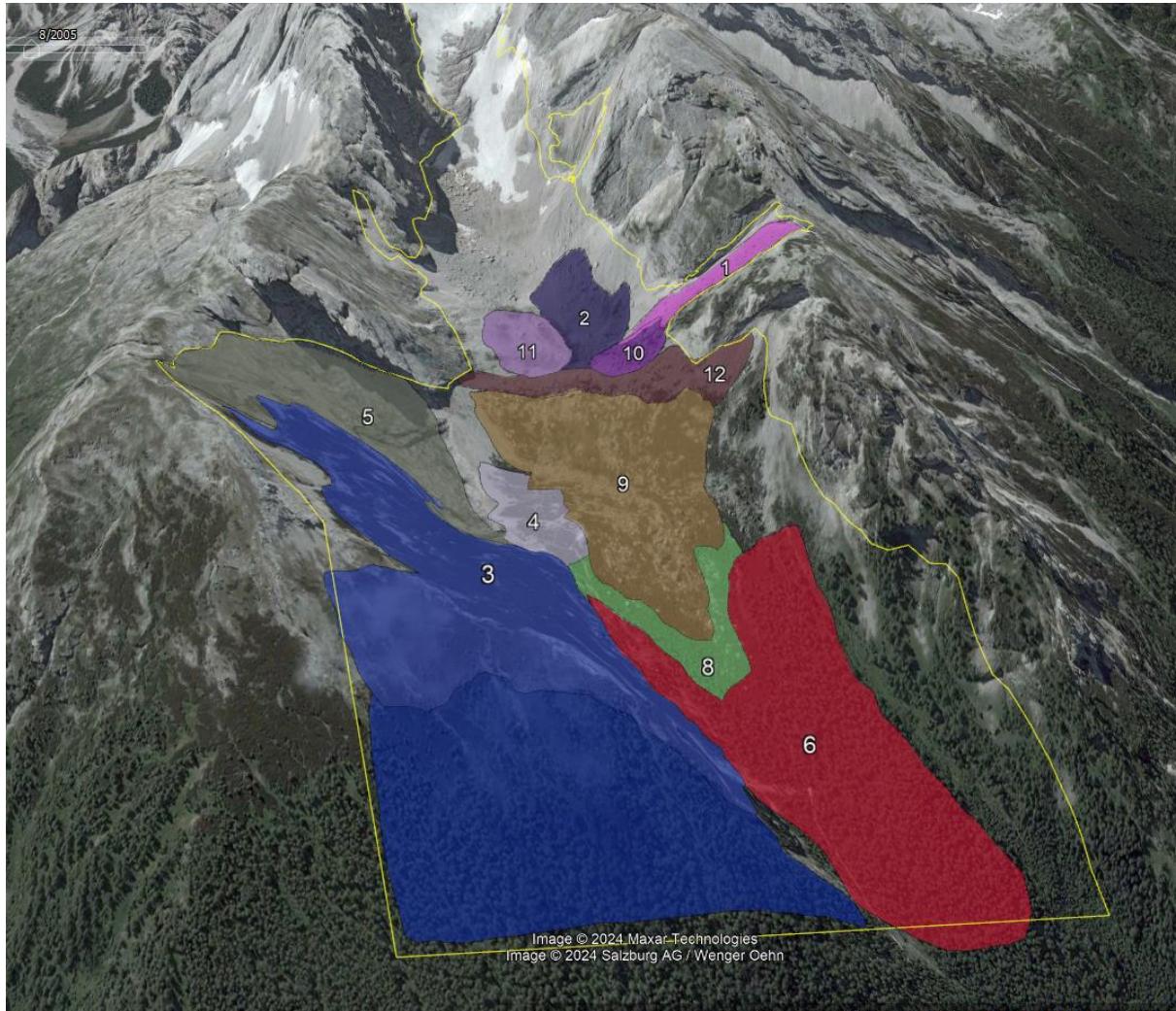


PCA of Topographic Variables and K-means Clustering to Obtain 'Homogeneous Groups' from a Topographic Perspective



K-means cluster

TOPOGRAPHY: Delineation of the Clusters Under Investigation



12 clusters delineated based on **topography** and **dominant vegetation**

2



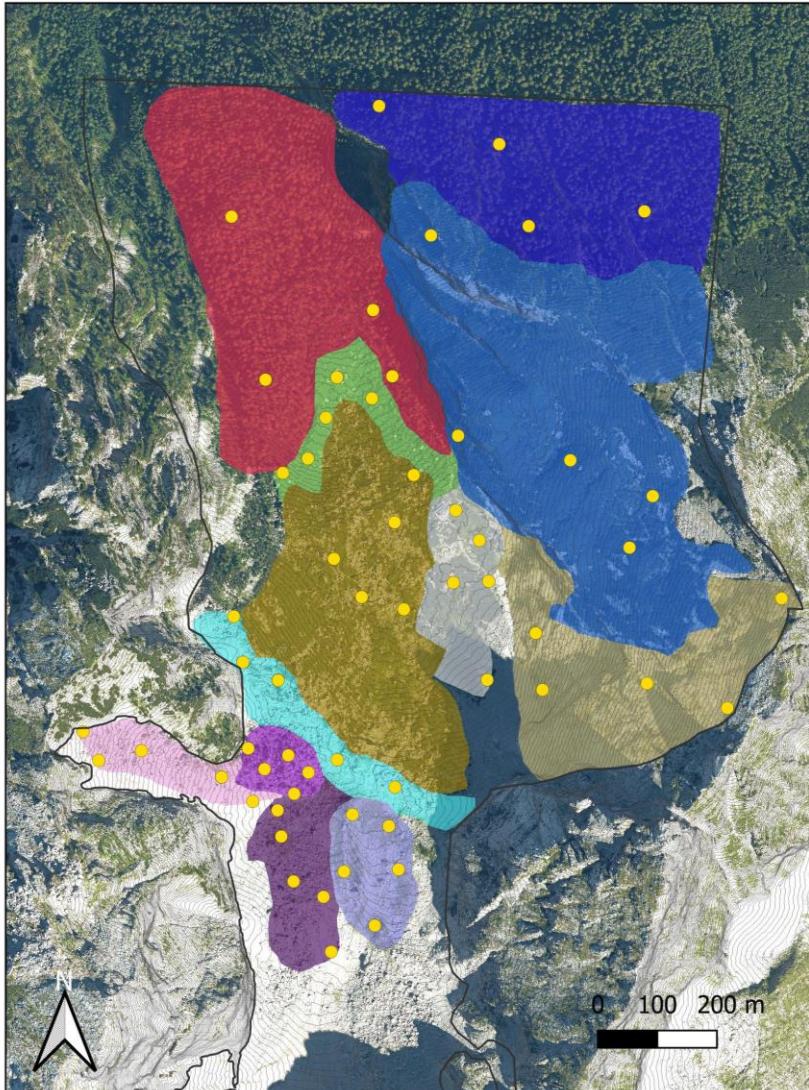
9



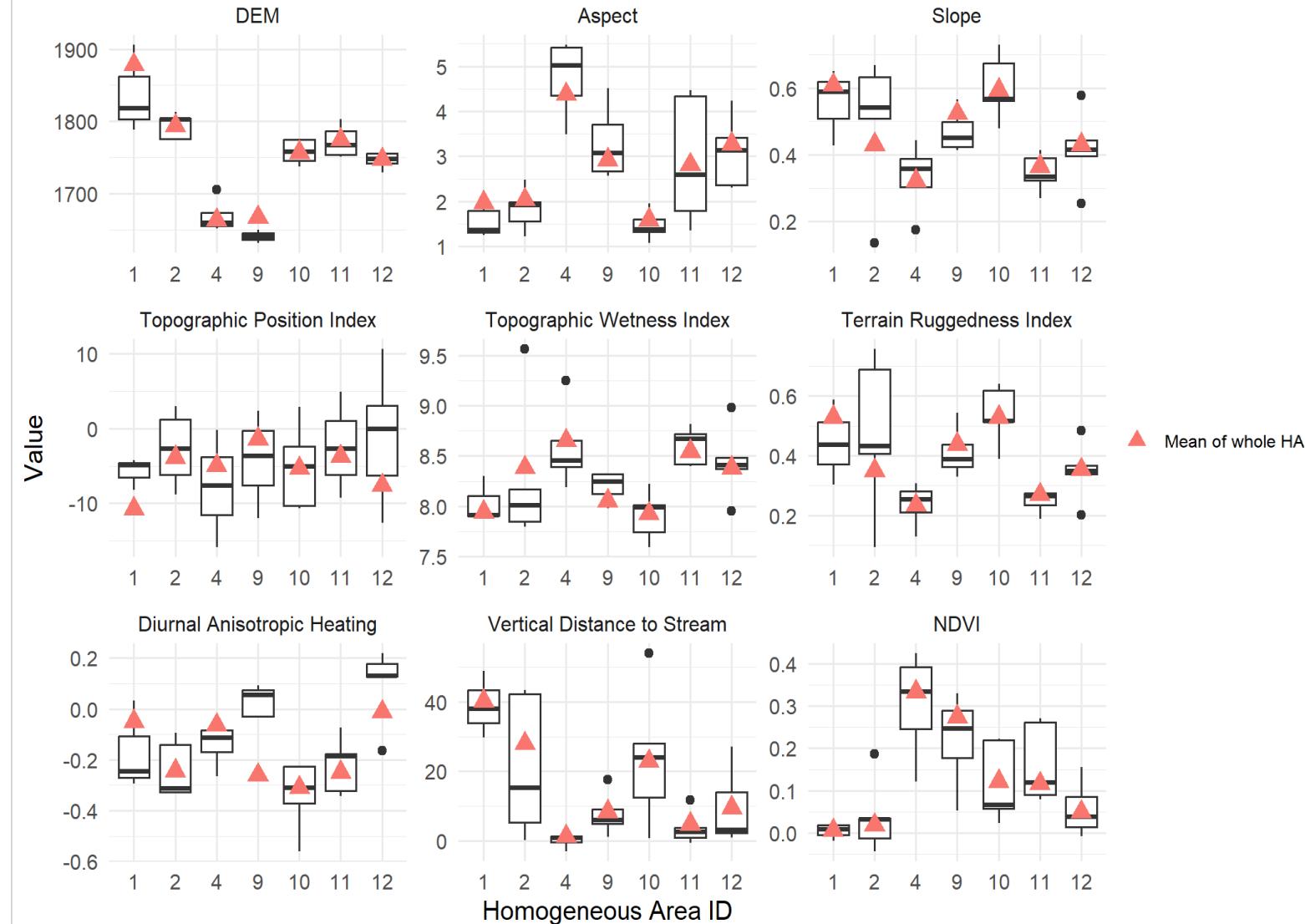
1



5 Random Points per Cluster



Descriptive variables of Plots within each Homogeneous Area (HA)



MATERIALS

Measuring Tapes



Two pre-measured tapes for accurate area determination. The ropes were laid out so that their vertices pointed towards the cardinal directions, allowing us to determine the circle's area using a compass for precise orientation.

Dendrometer Caliper



A small-sized caliper used for measuring the diameter at the base of the individuals, just before the first branching.

Meter Stick



Used for accurately measuring the height of each individual from the base to the topmost point.

Individual Identification

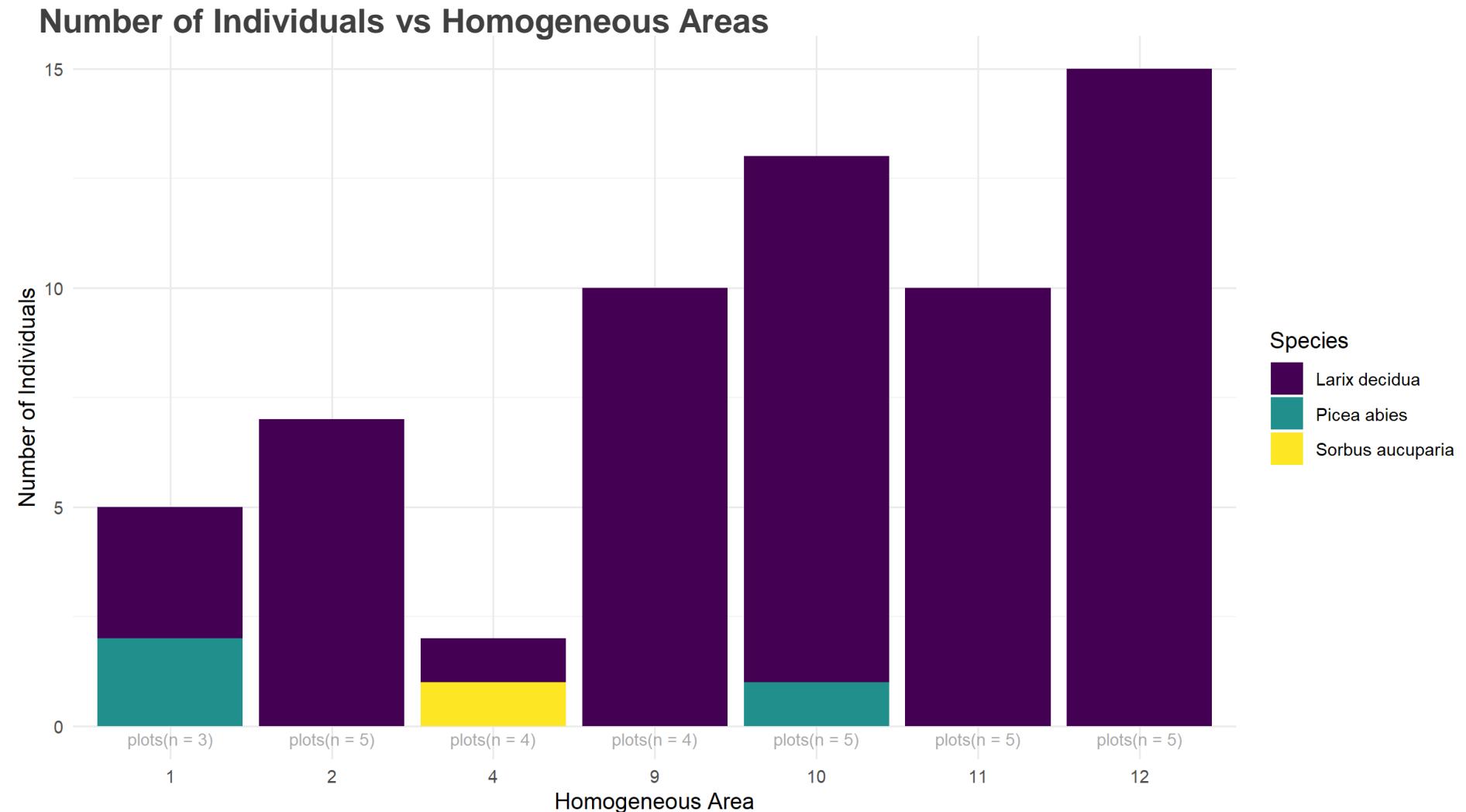
Each individual was carefully identified by species. The identification process included examining specific characteristics such as leaf shape, bark texture, and overall growth form to ensure accurate classification.



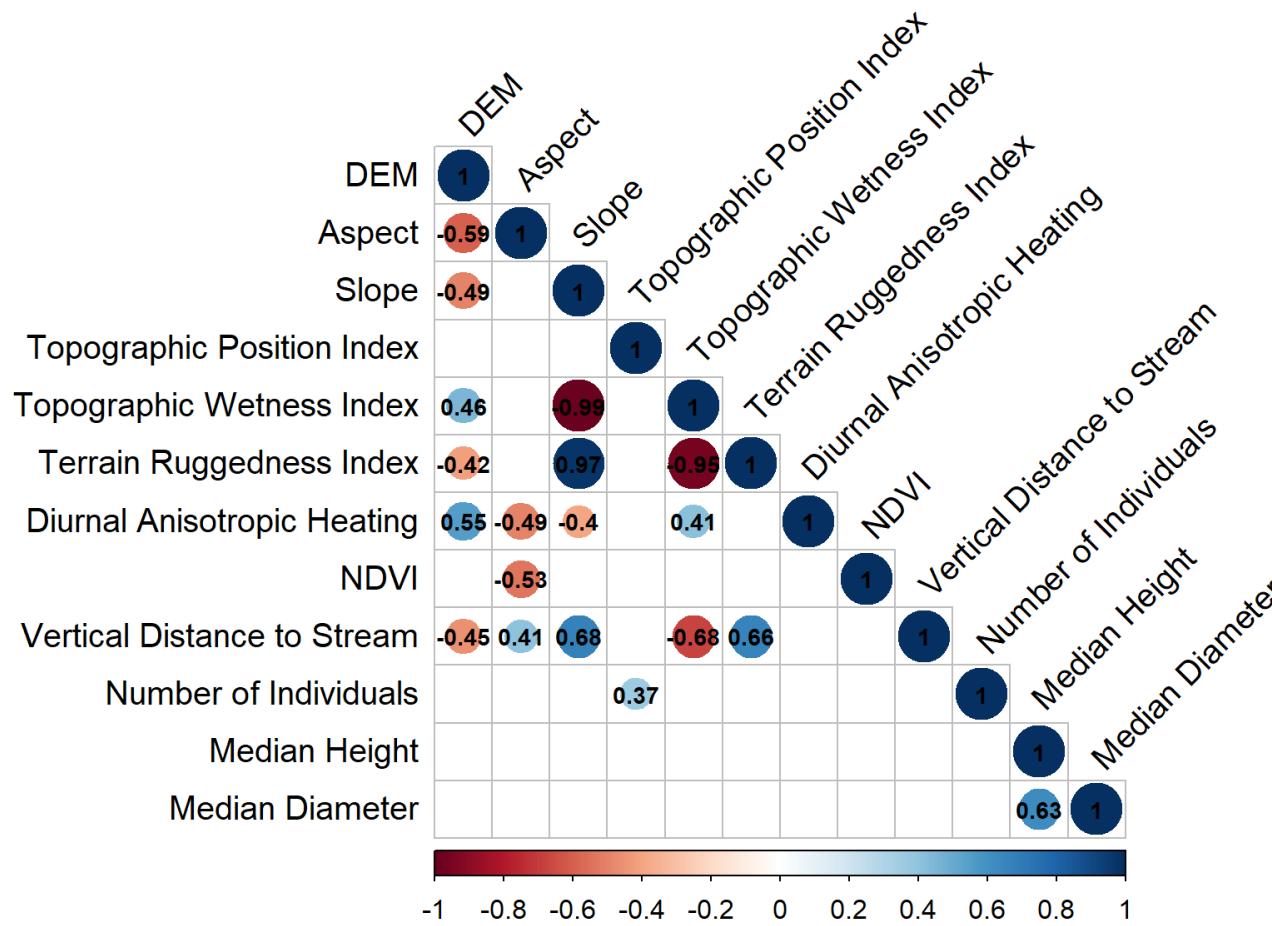
Data Collection

The data was recorded in a field notebook and subsequently transferred to a computer for analysis.

- Mostly *Larix decidua*
- Smallest amount of individuals in area 4
- Highest amount individuals in area 12
- No significant differences



Significant ($p < 0.05$) Spearman Pairwise Correlation Between Variables



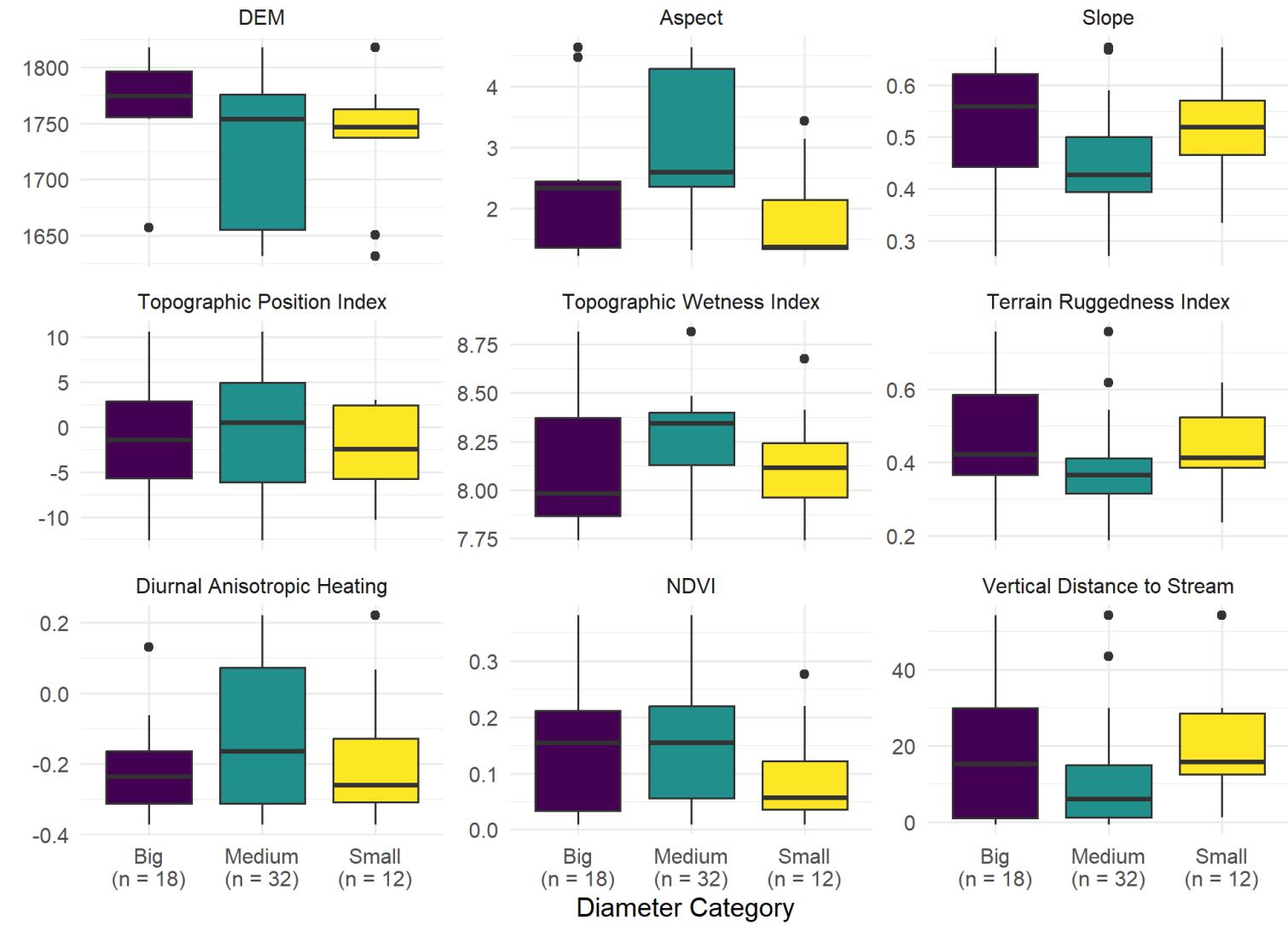
- Positive correlation between TPI and number of individuals
- Plots which are higher than their surroundings tend to have a higher amount of individuals
- No other noteworthy correlations

We could not confirm these hypotheses :

Lower slope angle, higher exposure to solar radiation and lower elevation did not favour the number of trees.

- small: ≤ 1 cm
medium: $1 < - \leq 3$ cm
big: > 3 cm
- Diameter as indicator for age
- No significant differences in the variables between the diameter categories

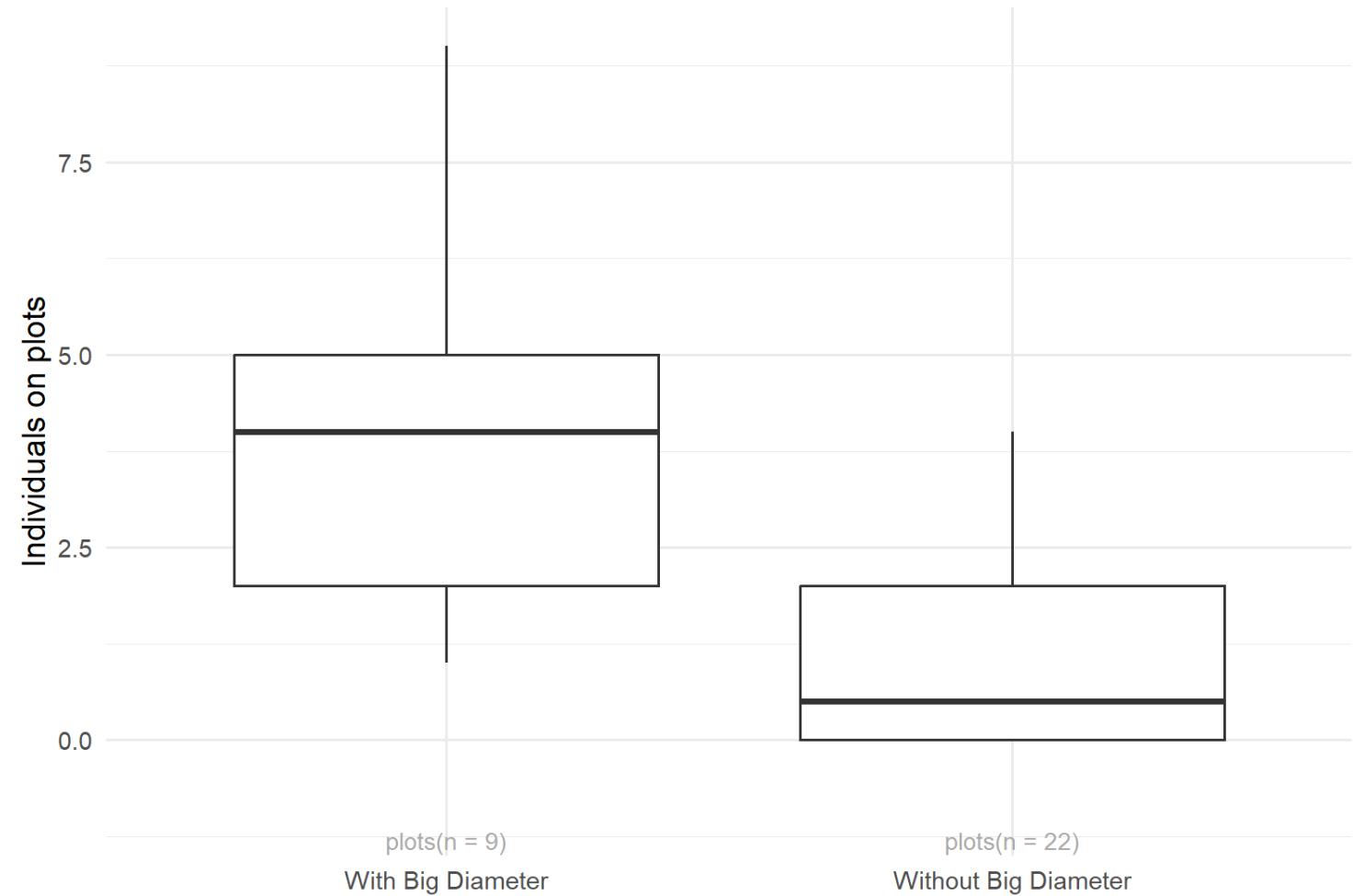
Boxplots of Variables Grouped by Diameter Category



- Comparison of the number of individuals on plots with and without individuals having a diameter greater than 3 cm

Do older trees promote the occurrence of individuals, or are older trees simply found in locations with favorable conditions for individuals?

Individuals on plots with/without Individuals with big diameter
Mann-Whitney U test p-value = 0.002



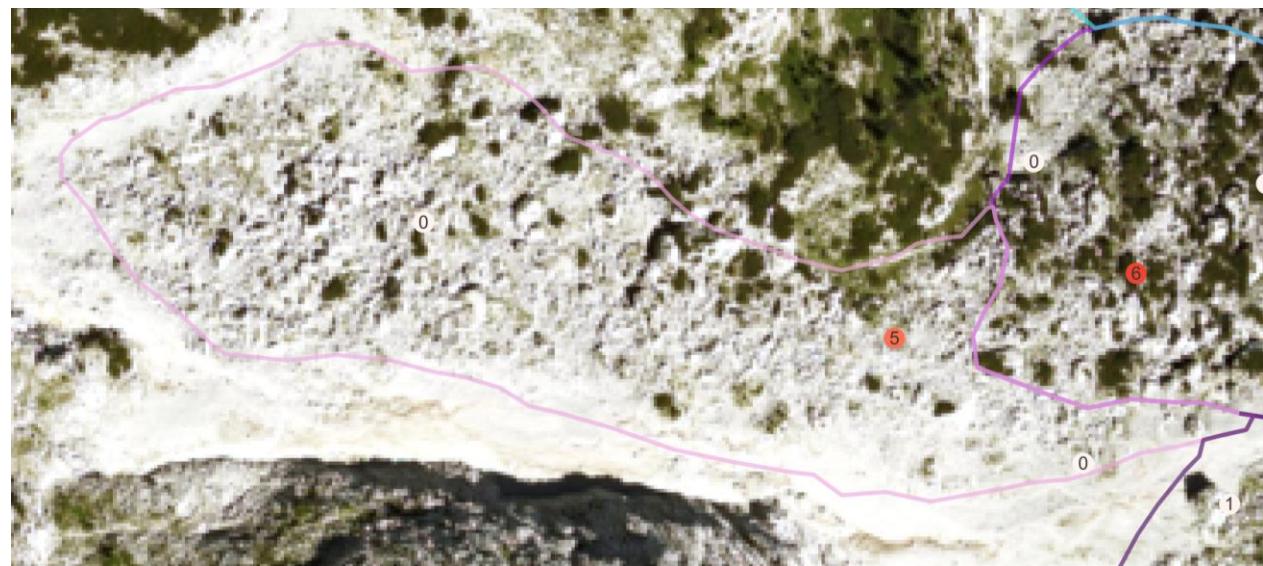
DATA ANALYSIS: Map of Plots and Number of Seedlings

Although only some statistically significant relationships were found, observable patterns can still be identified.



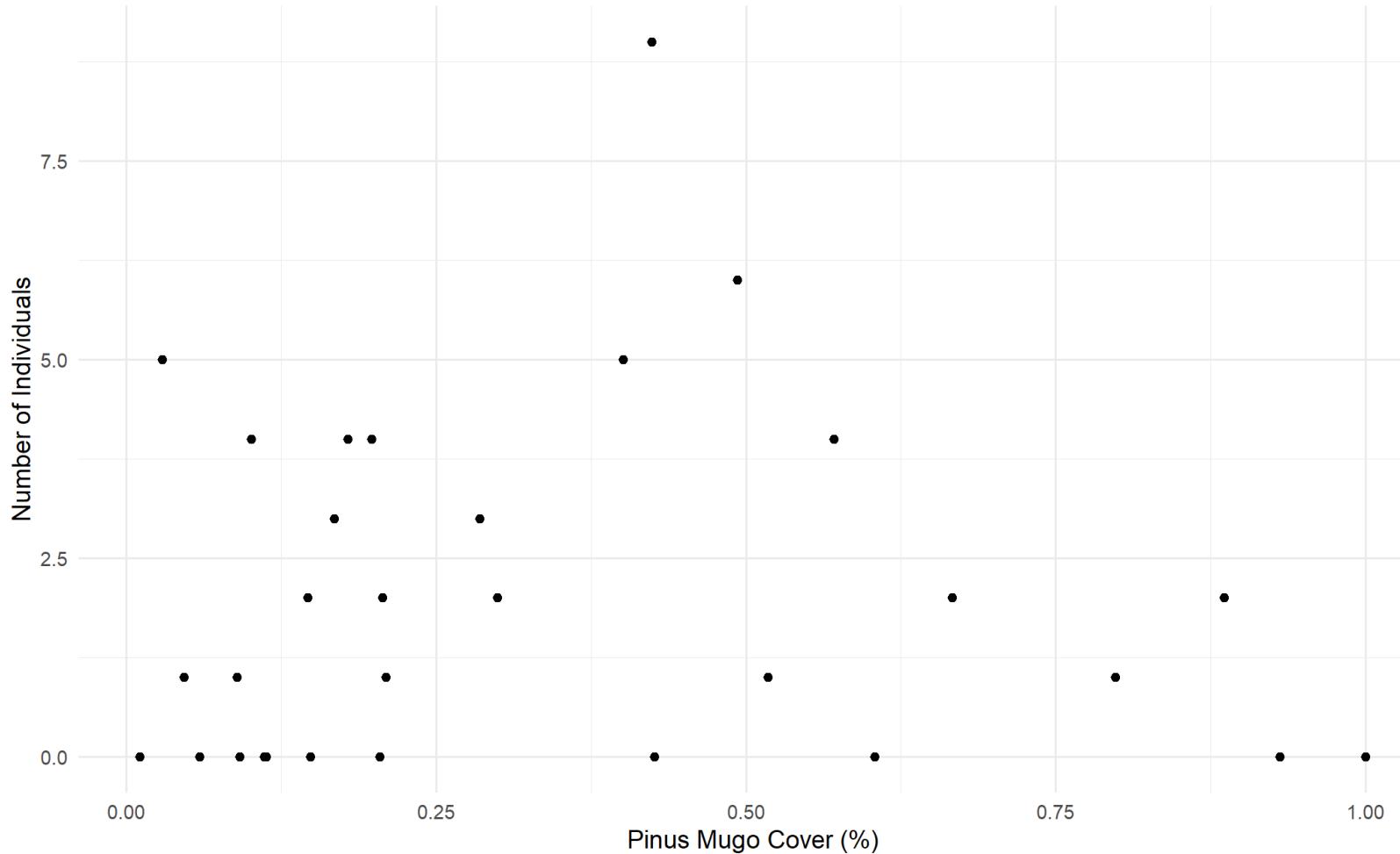
DATA ANALYSIS: Observations

- Low number of individuals in dense *Pinus mugo*
- No individuals on debris ramp



DATA ANALYSIS: Number of Individuals and Pinus mugo

Number of Individuals vs Pinus Mugo Plant Cover



- Classified with unsupervised classification
- Visually tested
- High plant cover of *Pinus mugo* resulted in lower amounts of individuals
- Not significant

DATA ANALYSIS: Observations



- Rock fields with Soil in between rocks resulted in highest numbers of Individuals

- Were the homogeneous areas chosen in a way representative of all included factors?
- Randomizing all plot locations may have made up for a few flaws:
 - 1: Necessary exclusion of certain plots in response to inaccessible terrain
 - 2: Snow covered grounds greatly affected tree occurrence
- A greater number of replicates would plausibly increase the chance of yielding significant results



- Correlations between establishment of *Pinus mugo* and decreased plant diversity
- *Pinus mugo* habitats are often drier and more shaded than other alpine habitats
- *Pinus mugo*'s negative effect on establishment of other species – likely by consequential light condition changes



Zeidler, M., Hertlová, B., Banaš, M. & Zahradník, D. (2018) 'Vegetation shift after a clear-cut of non-native dwarf pine (*Pinus mugo*)', *Biologia*, 73, pp. 113-119.

Zeidler, M., Duchoslav, M., Banaš, M. & Lešková, M. (2012) 'Impacts of introduced dwarf pine (*Pinus mugo*) on the diversity and composition of alpine vegetation', *Community Ecology*, 13, pp. 213-220.

- Greater number of replicates
- Competition from *Pinus mugo* as a controlling factor?
- More extensive studies on alpine tree species establishment with respect to a variety of landscape factors and specifically their interactions is of interest for future research

