

Soil development as limiting factor for shrub expansion in southwestern Greenland



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Introduction

Southern Greenland currently experiences an increase in summer temperatures and a prolonged growing season (Masson-Delmotte et al. 2012), resulting in an increased shrub cover at the boreal – tundra border ecotone (Normand et al. 2013).

These findings suggest the beginning of a greener Greenland, in which tundra vegetation is transformed to a boreal woody flora. However, vegetation at borderline ecotones is influenced by further ecologic factors than just temperature.

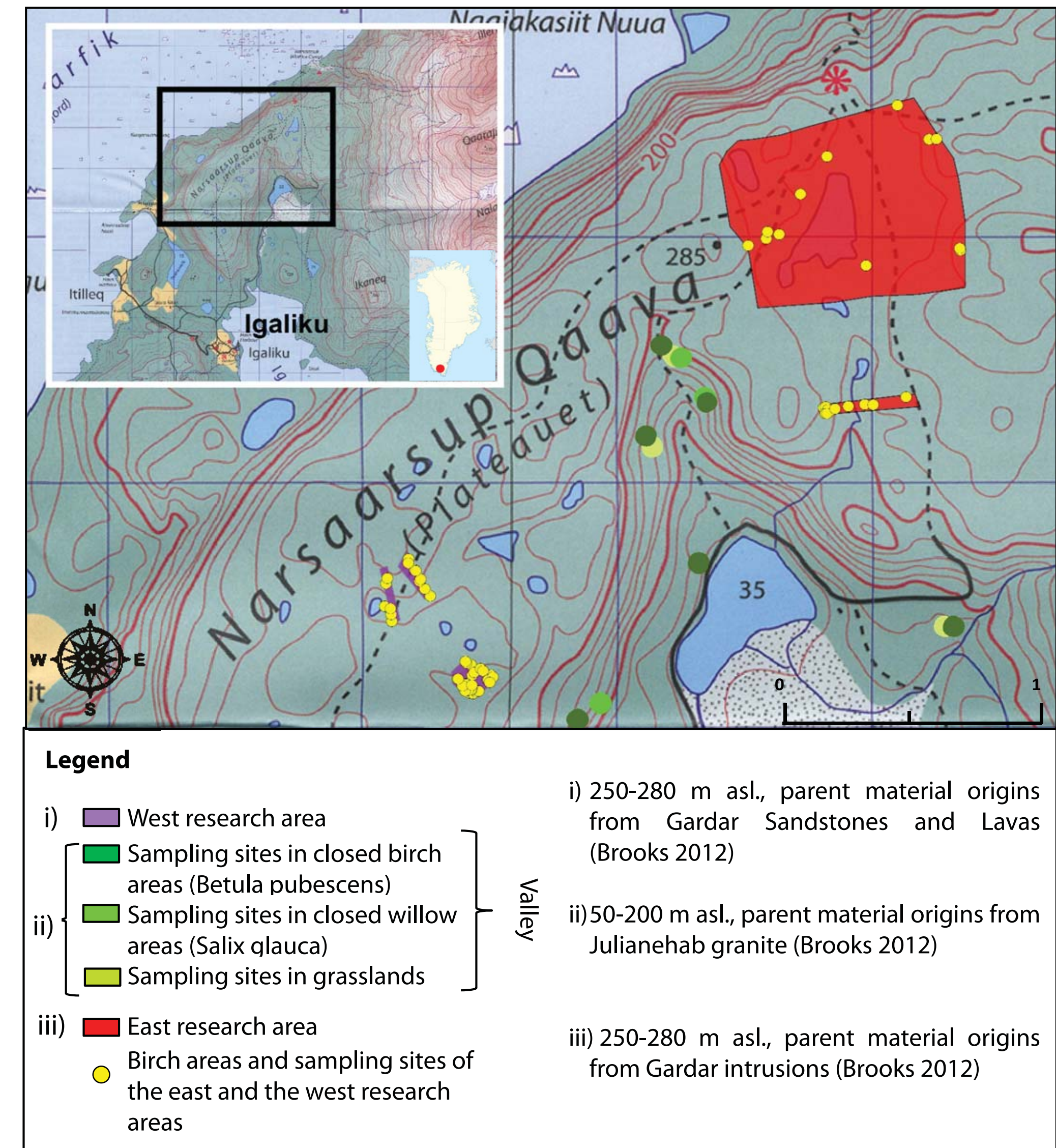


Figure 1: Research areas.

In this study, the ecologic conditions and the extent of birch vegetation at a selection of sites along an elevation gradient near Igaliku in southern Greenland were examined to **identify potential factors, which limit the expansion of woody vegetation apart from temperature.**

We assume that **water and soil availability will partly regulate the response of high latitude ecosystems to climate warming.**

Methods

The extent of shrubs (area, max. height and max. diameter at 50 cm) and the topographic parameters (slope angle, -exposition, -position and -form) were mapped for all sampling sites. Minimal age of shrubs was determined by tree ring analysis.

Soil samples were taken by soil corer for 0-10 cm and analyzed for soil nutrients, pH, soil moisture and earth fine fraction.

Results

Table 1: Vegetation appearance and extent on the research areas.

	West	Valley	East
Research area [ha]	3.14	0.12	65.48
Birch area (>1m) [m ²]	236.41	600	564.28
Proportion of birch area in research area [%]	0.75	50	0.08
Mean extent of birch areas (>1m) [m ²]	13.9	100	37.6
Mean height of birches (>1m) [m]	1.1	1.97	1.2
Mean basal diameter at 50 cm of birches (>1m) [cm]	2.96	2.98	2.89

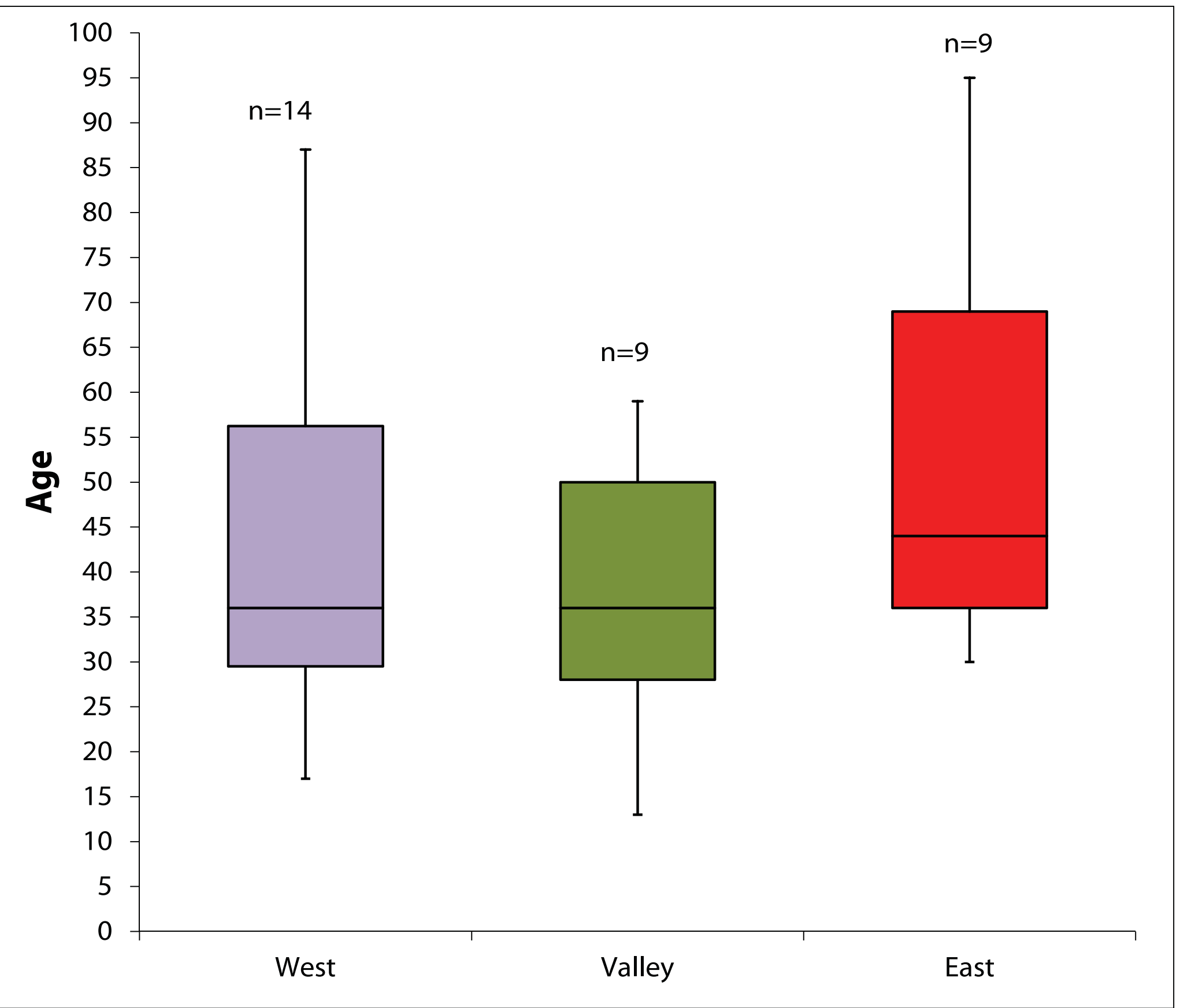


Figure 2: Age of birches on the sampling sites determined by tree ring analysis.

Results (cont.)

The appearance and the extent of birches differ at the three research areas (Tab. 2) even if birches along the elevation gradient have a similar age (Fig. 2 and Fig. 3).

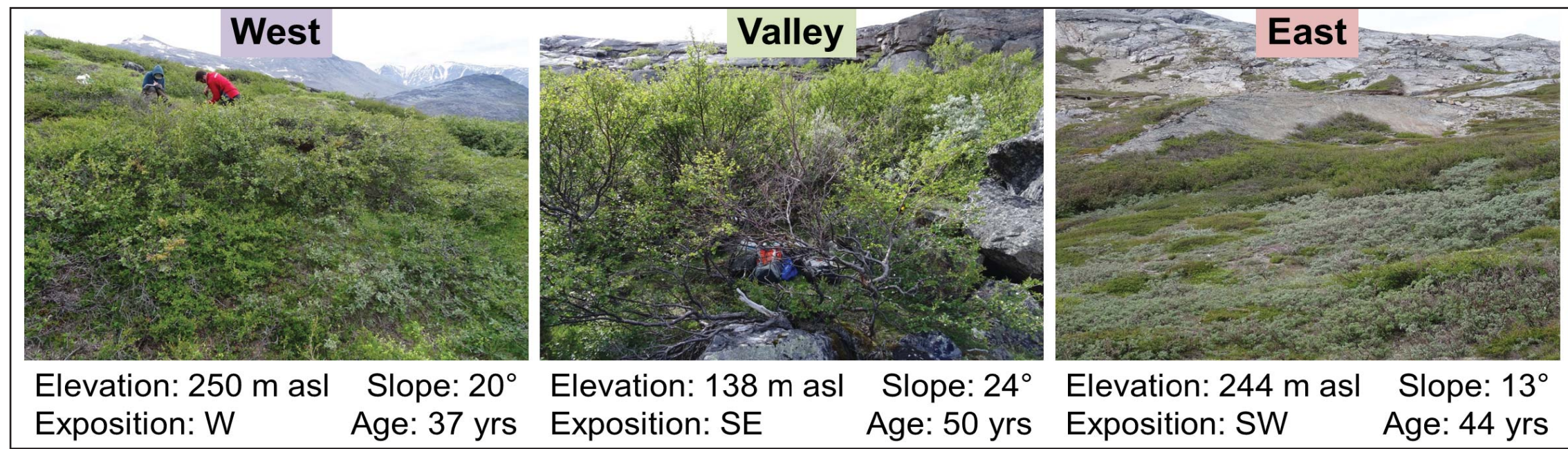


Figure 3: Examples of sampling sites for the different research areas with similar birch age.

Table 2: Means of soil parameters and their standard deviations for the different birch sampling sites and their reference sites.

	West		Valley			East	
	Reference site	Birch site	Reference site	Birch site	Willow site	Reference site	Birch site
pH [-]	4.9 ± 0.2	4.7 ± 0.3	5.3 ± 0.4	5.3 ± 0.2	no data	5.3 ± 0.2	4.8 ± 0.2
Soil moisture [%]	52 ± 12	37 ± 10	28 ± 8	33 ± 8	42 ± 5	12 ± 5	20 ± 7
Fraction of fine earth <2 mm [%]	96 ± 2	93 ± 9	93 ± 4	94 ± 3	99 ± 0.4	63 ± 17	77 ± 14
Soil nitrogen [t ha ⁻¹] 0-10 cm	4.5 ± 1.2	3.0 ± 0.9	2.8 ± 0.8	2.8 ± 0.4	4.5 ± 0.6	2.2 ± 0.6	2.8 ± 0.7
Soil carbon [t ha ⁻¹] 0-10 cm	52.4 ± 10.3	38.8 ± 10.3	43.8 ± 11.9	46.1 ± 5.7	58.5 ± 2.7	24.5 ± 8.3	39.0 ± 8.0
Soil potassium [kg ha ⁻¹] 0-10 cm	14.7 ± 2.3	8.4 ± 1.1	43.0	24.5 ± 12.4	no data	16.1 ± 12.1	14.8 ± 5.8
Soil phosphate [kg ha ⁻¹] 0-10 cm	0.0 ± 0.0	0.5 ± 0.7	0.7 ± 1.2	2.0 ± 2.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 1.0

Conclusion

The presented study did not find an altitudinal gradient in birch age. The results infer that the expansion of birches at the eastern research area is limited due to the **low amount of fine earth** leading to a **reduced ability of soils to store water** (Tab. 2). Minimal soil moisture is guaranteed on straight and concave slopes. At the western research area birch extent could be limited **by stagnant water**, as reference sites show the highest amount of soil moisture (Tab. 2). Adequate soil moisture is assured on straight and convex slopes.

Due to the soil and water conditions, a high proportion of areas is not suitable for a woody flora, despite the increase in summer temperatures and the prolonged growing season.



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D | Departement
U | W Umweltwissenschaften

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