

GLOBE Estonia Learning Expedition 2025

Effects of Human Activity on Podzolic Soil Horizons at Jõulumäe

Authors: Anette-Larissa Piir, Alexander Rootsmaa, **Esme Luise Kull**, Maksim Shirokikh,
Mia Konks, Riste Õue, Romer Ojaveer, **Thora Liisa Vildersen**

Supervisor: Vaike Rootsmaa

Estonia 2026

ABSTRACT

Jõulumäe is a locality in Häädemeeste parish, Pärnu County, Estonia, located near the coast of the Baltic Sea. The field expedition was conducted in the forested area of the Jõulumäe Recreational Sports Centre, a site used for cycling, skiing, camping, and other outdoor activities. Soil samples were collected from both forested and heavily trampled areas in order to compare the effects of human activity. In total, four samples were obtained: two from forest regimes and two from trampled regimes. The study focused on the impact of anthropogenic pressure on the organic and eluviated horizons of podzolic soils. Soil condition is critical for sustaining vegetation around the recreational centre and for supporting diverse invertebrate and microbial communities. A previous expedition took place at the same location in 2018; however, direct follow-up measurements were not possible because part of the original site had been replaced by an asphalt road. The area includes coastal dunes stabilized by vegetation, which plays an essential role in preventing wind erosion. Maintaining soil stability is therefore necessary for preserving dune ecosystems. This study contributes to broader environmental education and citizen science initiatives supported by the GLOBE Program.

Keywords: podzolic soils, visitor centers, coastal dunes, organic horizon, eluvial horizon, trampling.

Table of contents

ABSTRACT	2
Research Question and Hypotheses	4
Introduction	6
Materials and Methods	7
Results	12
Discussion	13
Conclusions	16
Bibliography	18
Appendices	20

Research Question and Hypotheses

Due to many visitors (Jõulumäe Tervisespordikeskus, 2025), the surface of Jõulumäe is often trampled on. The Jõulumäe Recreational Sports Center is a popular place for sports, recreation, holidays, training camps, and more. It accommodates approximately 200 people and has public trails. Therefore, the Center gets a lot of visitors annually and the surface is often trampled on.

Research question: How do human activities (Hiking, biking, skiing, orienting, disc golf, etc.) impact the organic and eluvial horizon?

Addressing this question is important to ensure safety (erosion control), biodiversity, clean water, and beautiful landscapes in the sporting grounds and visitor center. Organic and eluvial horizons are essential for erosion control, biodiversity, and water filtration (podzolic soils do not have good water filtering properties, and these horizons are important filters. If these horizons thinned, then water could not be filtered as needed, and could become polluted). “A thicker layer of soil is equivalent to a thicker filter, which is important to sustain good quality groundwater in these areas.” (Keesstra et al., 2012).

From the 2018 research: the study area soils do not have a humus horizon, right beneath the organic horizon is the eluvial horizon. The soils were with a sandy or sandy loam texture, and the pH of the soil was 4.1-5.2 (Summary of the 2018 field study is given in Appendix 11).

We proposed 2 hypotheses.

Hypothesis 1: The organic horizon is thicker in natural (less trampled) areas.

(Due to trampling, the vegetation is compacted.)

Hypothesis 2: The eluviated horizon’s thickness does not correlate with the regime. The eluvial horizon’s thickness is not greatly affected by trampling.

(The eluvial horizon being very old could mean that any short-term impact is irrelevant.)

We planned to collect samples from areas representing different land-use regimes (half-natural, trampled (a small trail), and natural). Because the original 2018 transect could not be replicated, we selected a nearby transect with similar environmental characteristics in order to enable comparison with the earlier study. From the samples, we measured soil horizon

thicknesses and other parameters (see Data Sheet 1) and drew conclusions based on the collected data.

Introduction

Podzolic soils occur on coastal dunes throughout Estonia, covering approximately 6.3% of the country's territory and 14.2% of forest soils (Leedu, 2016). Former sand dunes are now covered in pine forests, forming a structurally diverse coastal landscape valued for its ecological and recreational qualities. The area attracts visitors due to its scenic natural environment, varied terrain, and outdoor recreation opportunities supported by the Jõulumäe Recreational Sports Centre, which hosts numerous sporting events and attracts large numbers of visitors annually (Jõulumäe Tervisespordikeskus, 2025). Podzolic soils are particularly vulnerable to trampling because of their predominantly sandy composition (Leedu, 2016), making them sensitive to intensive recreational use. Soil degradation in such environments can reduce vegetation stability and increase erosion risk on dune landscapes. Therefore, understanding the condition and resilience of these soils is essential for maintaining ecosystem stability and supporting sustainable recreational land use.

In 2018, GLOBE students studied Jõulumäe soils (instructor Rootsmaa, V., previously unpublished data in Appendix 11). They analyzed 4 adjacent samples on a transect of 100 metres, and discovered that the humus horizon was absent from the surface. In the 7 years since the previous study (2018), there had been road construction and the previous transect has now been replaced by an asphalt road, and therefore, the 2018 data could not be renewed. Therefore, we researched a transect (100m) near the location of the previous study.

The thickness of these topmost soil layers (horizons) impacts the soil's properties, such as resistance to erosion - consistency, biodiversity in the soil, water conservation, etc., however, the trampling causes damage to the upper horizons, causing problems such as erosion, reduced biodiversity and deterioration of the soil's water-filtering abilities – which podzolic soils are already poor at. Erosion is the wearing of the hilltop material (due to weathering, trampling) and its accumulation to the foot of the hill or other depressions. These problems are detrimental to the environment – trampling can lead to a decline in the biological diversity and soil fertility, which also impacts local people (visitors and locals). This must be acknowledged globally, for podzolic soils cover 14% of Europe and are the dominant soil type in northern latitudes (The Soil of Europe 2025, page 32). These soils also cover approximately 4% of Earth's (nonpolar) land (Podzols 2025). When running a sports centre, it is important to consider the ecological impact it could have on the environment.

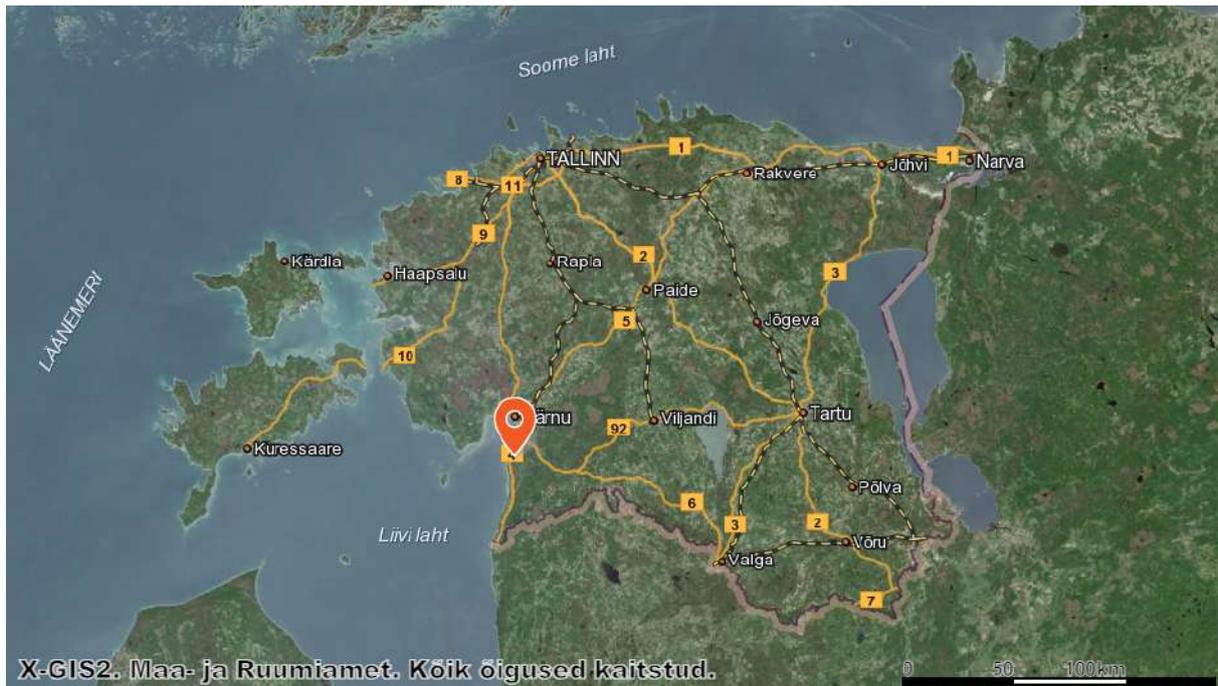


Figure 1. We did our research on 17 August 2025 in Jõulumäe (Marked on the map of Estonia). Basemap: Estonian Land Board X-GIS2 Portal.

Materials and Methods

To answer our research question and compile a general overview of Jõulumäe podzolic soils, the organic and eluvial horizons, we measured a 100 meters transect (Figure 2), near the location of the 2018 transect. Four adjacent samples were taken from the soil: the first site was at 0 metres, the second was at 34m, the third was at 70m and the fourth was at 100 metres. The profile of the transect is on the following graph below (Figure 3).

Sample 1: The first site was inside a small pine grove, in a small depression (sample 1 altitude ~12 metres). The regime: occasional hikers, walkers passing over the area, holiday homes were about 50 metres from our testing site. Ground coverage: moss, some blueberry bushes, pines and barren sand. We excavated with a spade.

Sample 2: The second site was located by the foot of the hill (sample 2 altitude ~12 metres), in a pine forest area - the sample representing the most natural conditions of the four sites (photos in Appendix), many different species of plants, no trail, bugs, etc.

Sample 3: The third site was on the hillside (sample 3 altitude ~17 metres), with a heavy trampling regime (right next to a bicycle cross track). From our small (85 cm deep) borehole sample we could see the artificial road coverage.

Sample 4: The fourth site was located on the crest of the hill (sample 4 altitude ~18.5 metres), the regime was trampled (though less trampled than site 3) – half-natural, a small trail. Covering the ground were only pine needles and occasional moss (otherwise it was barren). This is probably also due to the location of the site (on the crest of the hill). Photos of the ground in each of the four locations are in the Appendix.)

To gather the data we used GLOBE protocol (Altin et al., 2021, p. 106–111).

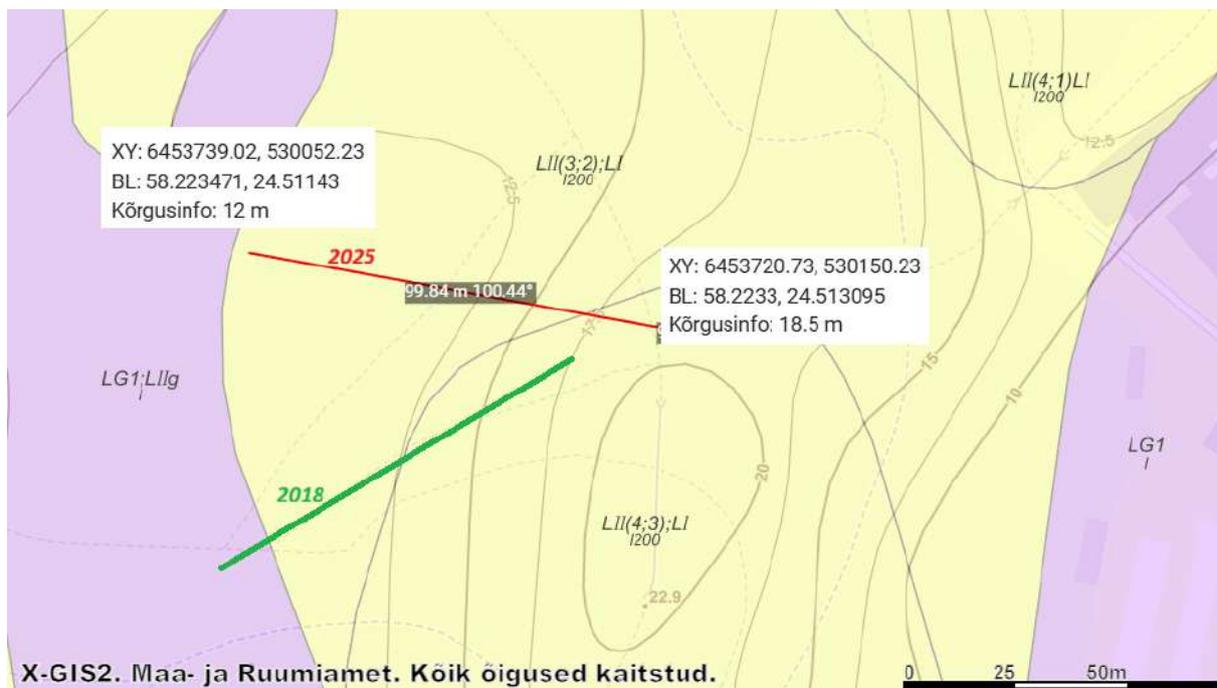


Figure 2. The 100m transect of our study (2025 in red) and the prior study in the same area (2018 in green). Basemap: Estonian Land Board X-GIS2 Portal.

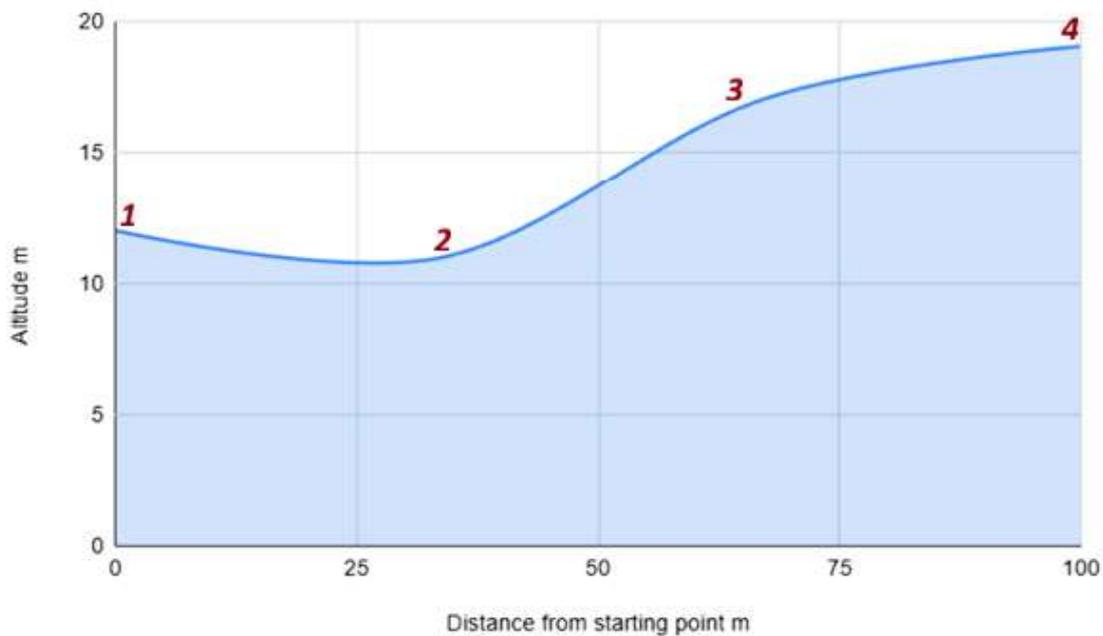


Figure 3. Transect profile, sample locations 1-4.

List of tools/materials we used:

- Tape measure (100m - to measure out the transect)
- Tape measure (8m - to measure the upper and lower boundaries and thickness of each horizon)
- Big shovel (to dig a sample hole - sample 1)
- Small shovel (to move the soil for studies)
- Universal indicator (for measuring soil pH)
- Spoon (for lifting soil to plastic cups, mixing substances)
- Distilled water (for cleaning pH equipment)
- Soil drill (to drill sample holes - sample 2, 3, and 4)
- Soil thermometers (2 pcs) (to measure the temperature of soil 5 cm and 10 cm below the ground surface)
- GLOBE soil color book (to determine the color of soil - primary and secondary color)
- Plastic cups (to do pH tests - mix soil and distilled water, then measure pH with pH paper.)
- Water (to moisturize soil for texture testing)

- Flags (to mark sample holes on the transect - samples 1, 2, 3, and 4)
- Plastic bag that we put the soil on after digging and drilling
- Vinegar (to determine free carbonates in the soil - vinegar reacts with the carbonates, and releases CO₂ - the surface bubbles)
- Plastic cup to determine the carbonates
- GLOBE pedosphere 1. data sheet (for gathering data)
- Digital thermometer (to measure air temperature)
- Camera microscope (to make pictures of the grains of different horizons)
- Gloves (for protection)
- Pen (to mark data on the data sheet)
- Markers (to mark soil horizons - from 0 to -100: artificial soil (the road coverage) (Ty) (Leedu & Astover 2021), organic (O), humus (A), eluviated (E), illuviated (B), parent material (C1 and C2) (Astover et al., 2013, p. 22-25).



Figure 4. Our tools. Photographer: *Riin Värton*

How did we analyze our data?

Data was written on protocol sheets (Appendix 7, Appendix 8, protocol sheets 1 and 2), and after that we made graphs of the transect, altitudes, and our samples (horizon thicknesses).

Results

Both hypotheses were incorrect. The first hypothesis was rejected because the organic horizon (O-horizon) was nearly indistinguishable between the natural and trampled areas (Figure 5). More precisely, the thickness of the organic horizon was approximately 4–5 cm in samples 1–4. It is also relevant to note that vegetation was quite similar across all four sites (see photos in the Appendices). In sample 3, there is a layer of artificial surface coverage from the bicycle cross track, but beneath it there is still a 4–5 cm organic layer. Sample 4 has a slightly thinner O-horizon, likely due to its position on the crest of the hill. A prior GLOBE study conducted in Taevaskoja found that erosion is greater at hilltops, leading to thinner upper horizons (Ületoa et al., 2024). Because all samples had similar O-horizon thicknesses, the first hypothesis is not supported.

The second hypothesis was also incorrect because the eluviated horizon (E-horizon) was noticeably thicker in forest regimes than in trampled areas. Samples 1 and 2 (half-natural/forest regimes) had a 15–20 cm thick eluviated horizon, while samples 3 and 4 (trampled regime) had E-horizon thicknesses of 15 cm and 4 cm, respectively. The maximum thickness of the eluviated horizon was observed in sample 2, which represented the most natural regime. Sample 4 had the thinnest E-horizon (only 4 cm), although this may have been influenced by erosion at the hilltop. Based on the sites explored along the transect, it can be concluded that land-use regime influences the thickness of the eluvial horizon to some degree. However, the effect of erosion on horizon thickness must also be considered (Ületoa et al., 2024).

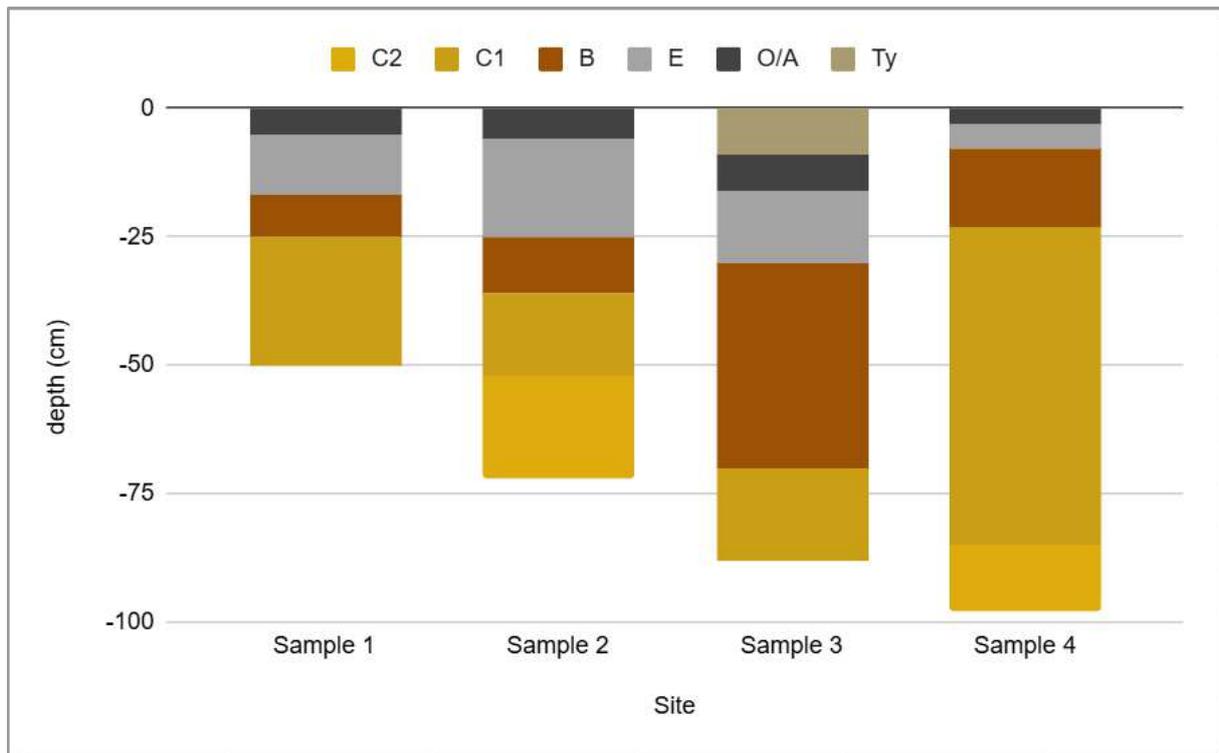


Figure 5. Soil profiles of the four study sites.

Discussion

During the research we had multiple factors: the regime (trampled/natural) and erosion (the slope angle of the hillside). The research from Taevaskoja showed that the top of the mountain has thinner horizons (sample 4) and at the foot of the mountain, there are thicker horizons (samples 1 and 2). However, the erosion might be greater in Taevaskoja compared to Jõulumäe. The effect of erosion is still unknown.

We see two possible scenarios, that would explain the results of our experiments.

Scenario 1: Erosion had a marginal effect and did not significantly affect our results.

According to this scenario, we found that the podzolic soil's organic horizon's thickness is not greatly affected by the regime. Whether there are many people trampling over the soil or only a few, the organic horizon will probably be with a similar thickness in a similar location – trampling does not have a large effect on the thickness of the O-horizon.

Podzolic soil's eluviated horizon is influenced by the regime – trampling can lead to the decrease of the eluviated horizon's thickness.

The organic horizon of the podzolic soils is most fertile (Soil Science Society of America, n.d.), and within this conclusion, it is good news that the O-horizon is not greatly affected by the trampling.

Scenario 2: Erosion (the wearing of the hilltop material (due to weathering, trampling) and its accumulation to the foot of the hill/other depressions) caused our results to differ from results that would have been gathered from an even surface. Therefore, we can analyze the data considering the effect of erosion.

In this case, the first hypothesis would be incorrect - the O-horizons were with the same thickness, no matter the location (except the fourth sample on the crest of the hill, with a slightly smaller thickness of the O-horizon - caused by erosion). New organic material still gathers and keeps the horizon with similar thickness (in every location there were pine trees - pine needles are a source of organic material). From the data it can be concluded, that trampling does not affect the thickness of the O-horizon greatly.

Our second hypothesis - the thickness of the eluvial horizon does not correlate with the regime - could be true, assuming the wearing of the hilltop. The two samples 1 and 2 (natural regime) had a noticeably thicker E-horizon, but were also located in a small depression (sample 1) and by the foot of the hill (sample 2), which (according to the Ületoa et al., 2024.) would mean thicker O-, E-, B- and C-horizons compared to samples (samples 3 and 4) that were on a slope and on the crest of the hill.

A follow-up study should be made on a flat surface (lessening the factor of erosion) to gather new data and to determine the effect of trampling on the organic and eluvial horizons. How do the results relate to our previous (background) information and literature?

Few studies have examined the specific impact of human activity on podzolic soils at Jõulumäe or at comparable recreational and sports centres, which limits direct comparison with previous research. However, earlier work has shown that podzolic soils are highly susceptible to trampling, a pattern that is consistent with our findings. Intensive land use can damage the vegetation cover that stabilizes aeolian sands, increasing landscape vulnerability. As noted by Ratas and Rivis (2003), the destruction of plant cover in coastal dune systems allows strong winds to mobilize sand. Trampling and related recreational pressures may therefore weaken vegetation, loosen soil structure, and accelerate both wind and water erosion, potentially contributing to the gradual degradation of dune landscapes.

This study is relevant because soil condition is a key determinant of ecosystem stability, biodiversity, and environmental safety. Soil erosion represents a significant risk, particularly in intensively used landscapes, as it degrades soil structure, reduces fertility, and increases landscape vulnerability. The integrity of organic and eluvial horizons is especially important because these layers host diverse biological communities that depend on stable soil conditions. Soil quality also regulates critical hydrological functions, including water filtration and nutrient retention, as well as water storage capacity. These functions are particularly significant in podzolic soils, which exhibit low drought resistance and limited moisture buffering ability. The ecological well-being of soil directly influences the survival and activity of soil microorganisms, which in turn support nutrient cycling and ecosystem functioning. Our observations indicate that erosion processes can be effectively mitigated even in heavily used areas through appropriate land management, emphasizing the importance of sustainable soil stewardship.

Conclusions

For more accurate results, a larger number of samples would be preferable; this should be a priority for future research on the topic, including sampling across more varied sites to improve general understanding. Our results, together with findings from other studies, highlight the importance of land-use regulation in preventing declines in soil fertility and biodiversity, maintaining water filtration and retention capacity, and reducing erosion.

a. What did we learn?

As in the 2018 study, the 2025 measurements showed that both the litter and eluviated horizons were thinnest at the top of the hill. Vegetation cover was more limited at the hilltop; however, a litter layer was still present because pine needles form the primary component of the organic horizon. This litter cover reduces the impact of trampling, while the asphalt path constructed in the landscape helps limit foot traffic in adjacent areas. Together, these factors contribute to mitigating soil disturbance despite intensive recreational use.

b. What do our results mean in a global context? Local?

Soil erosion is a globally significant environmental problem; however, at Jõulumäe it has been effectively managed and kept under control.

c. What would we do differently next time? What to improve?

Future research should focus on comparing soil conditions at sites located at the same elevation rather than along a slope. This would help isolate the effects of human activity from natural topographic variation, as slope position influences erosion, moisture distribution, and horizon development. Studying areas with comparable elevation and geomorphological conditions would allow for more controlled comparisons and improve the reliability of conclusions about trampling and land-use impacts. Repeated long-term monitoring at such standardized locations would also strengthen temporal comparisons with earlier studies.

In both studies (2018 and 2025), organic and eluviated horizon samples taken from the crest of the hill were considerably thinner than those taken from the foot of the hill.

Vegetation was sparser on the crest; however, the organic horizon still formed, as pine needles are the main component of the litter layer. This reduces the influence of trampling, and the nearby asphalt road helps concentrate foot traffic, thereby limiting disturbance in

surrounding areas. Soil erosion is a significant environmental problem, but at Jõulumäe the situation appears to be under control.

Bibliography

Altin, L., Kikas, Ü., Sepp, M., Kamenik, J., Jõgis, A., Laarmaa, R., Henno, I., Univer, M. J., Altin, E., Rootsmaa, V., Pärn, J., & Raudsepp, J. (2021). *Maa kui süsteem: GLOBE 25 õppekogumik*. Sulemees.

Astover, A., Reintam, E., Leedu, E., & Kõlli, R. (2013). *Muldade väliuurimine*. Eesti Maaülikool.

https://s3web.emu.ee/emuweb/emuweb/s3fs-public/2025-02/Muldade_valiuurimine_veeb%20%281%29_0.pdf

European Commission, Joint Research Centre. (2010). *The soil atlas of Europe* (p. 32). https://esdac.jrc.ec.europa.eu/projects/Soil_Atlas/Editors_download/pdfs/pdf24-37.pdf

Jõulumäe Tervisespordikeskus. (n.d.). <https://joulumae.ee/>

Keesstra, S. D., Geissen, V., Mosse, K., Piirani, S., Escudero, E., Leistra, M., & van Schaik, L. (2012). Soil as a filter for groundwater quality. *Current Opinion in Environmental Sustainability*, 4(5), 507–516.

<https://www.sciencedirect.com/science/article/abs/pii/S1877343512001431>

Leedu, E., & Astover, A. (2021). *Tehismuld (Technosol)*. Eesti Maaülikool. <https://dspace.emu.ee/server/api/core/bitstreams/11637e90-13cd-4140-8708-ae818e253ae2/content>

Leedu, E., Penu, P., & Kikas, T. (2016). *Aasta muld 2017: Leedemuld*. Eesti Maaülikool.

Maa- ja Ruumiameti geoportaal. (n.d.). <https://geoportaal.maaamet.ee/>

Ratas, U., & Ravis, R. (2003). Coastal dune landscape of Estonia. *Forestry Studies*, 39.

Sepp, M., & Pae, T. (2023). Häädemeeste, kihelkond luidete peal. *Eesti Loodus*, 68–73. <https://www.loodusajakiri.ee/eesti-kihelkonnad-haademeeste-kihelkond-luidete-peal/>

Soil Science Society of America. (n.d.). *Erosion*. Soils4Teachers. <https://www.soils4teachers.org/erosion>

The University of British Columbia. (n.d.). *Podzols: Map of podzolic soil coverage of the Earth*.

<https://luitool.soilweb.ca/podzols/>

University of Georgia. (n.d.). *Munsell soil color chart*.

<https://soils.uga.edu/files/2016/08/Munsell.pdf>

Ületoa, A., Linnus, R., Mattisen, M., Ilp, M., Riigor, K., Varusk, E., & Oja, S. (2024). *Exploring the Suur Taevaskoda sandstone outcrop: GLOBE regional learning expedition*.

The GLOBE Program.

Appendices

Appendix 1. Soil map (Estonian Land Board)



Appendix 2. Sample 3



Appendix 3. Location 1



Appendix 4. Location 2



Appendix 5. Location 3



Appendix 6. Location 4



Appendix 7. Protocol sheet 1

H. Kall

Mulla kirjeldamise uurimiskoha defineerimine ja mullaprofili (horisontide) kirjeldamine
(Pedosphere, Soil characterization)

Andmeleht 1

Rühma nimi: URAAN

Asukoht: Jõulumäe kõrgem tüüp (märrimets)

Uurimiskoha nimi:

Koordinaadid: 58,22348°N 24,51320°E

Kõrgus merepinnast: 19 m

Asukoha määramise viis: GPS / muu

Kuupäev ja kellaaeg: Aasta 2025 Kuu: 08 Päev: 17 Kellaaeg (UT): 16:20

Kommentaariid:

Nõlva kalle: — °

Ilmakaar (mis suunas nõlv tõuseb?): —

Proovivõtumeetod:

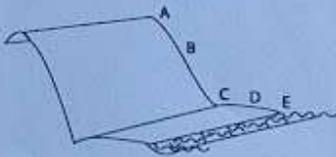
- sügavkaeve
- puuriga võetud
- poolkaeve
- muu avatud profiil
- erosioon

Maakasutus (land use):

- linn/asula
- põllumajandus
- puhkemajandus
- mets
- muu —

Asend pinnavormil (landscape position):

- A künka lagi
- B nõlv
- C jalam
- D tasane ala
- E veekogu kallas (vt joonist)



Joonis. Mullakaeve asend pinnavormil.

Maakate (cover type):

- paljas muld (Bare Soil)
- kaljud (Rocks)
- rohi (Grass)
- põõsad (Shrubs)
- puud (Trees)
- muu (Other)

Lähtekivim (parent material):

- aluspõhi
- turvas
- tehismaterjal
- meresetted
- järvesetted
- vooluveesetted
- mandrijääsetted (moreen)
- nõlvasetted
- ei tea
- muu tundmatud (levitud)

Appendix 8. Protocol sheet 2

4 kaev

Mullaprofili (horisontide) kirjeldamine

Horisondi nr/nimi	1	2	3	4	5
Ülemine piir (cm)	0	3	8	23	85
Alumine piir (cm)	3	8	23	85	98+
Horisondi tüsedus (cm)	3	5	15	62	13+
Niiskus (kuiv, niiske, märg)	niiske	-	-	-	-
Struktuur (tompjas, teraline, plaatjas, sammasjas, prismataoline, struktuuritu)	-	teraline	-	-	-
Värvuse kood (primaarne/sekundaarne)	2,5YR 8/2	2,5YR 8/1	2,5YR 8/2	10YR 8/6	10YR 8/6
Konsistents (lahtine, rabe, kõva, väga kõva)	-	lahtine	-	-	-
Lõimis (liiv, saviliiv, liivsavi, savi)	-	liiv	-	-	-
Kivisus (kivid puuduvad, vähe, palju)	puuduvad	-	-	-	-
Juuresus (puuduvad, vähe, palju)	puuduvad	-	-	-	-
Vabad karbonaadid (puudub, nõrk, tugev)	puudub	-	-	-	-

Tehke mulla profilist foto ning ümbritsevast maastikust 6 fotot:

põhikmakaartest + taevavaade + maapind

Foto number:

põhi 19

lõuna 20

ida 21

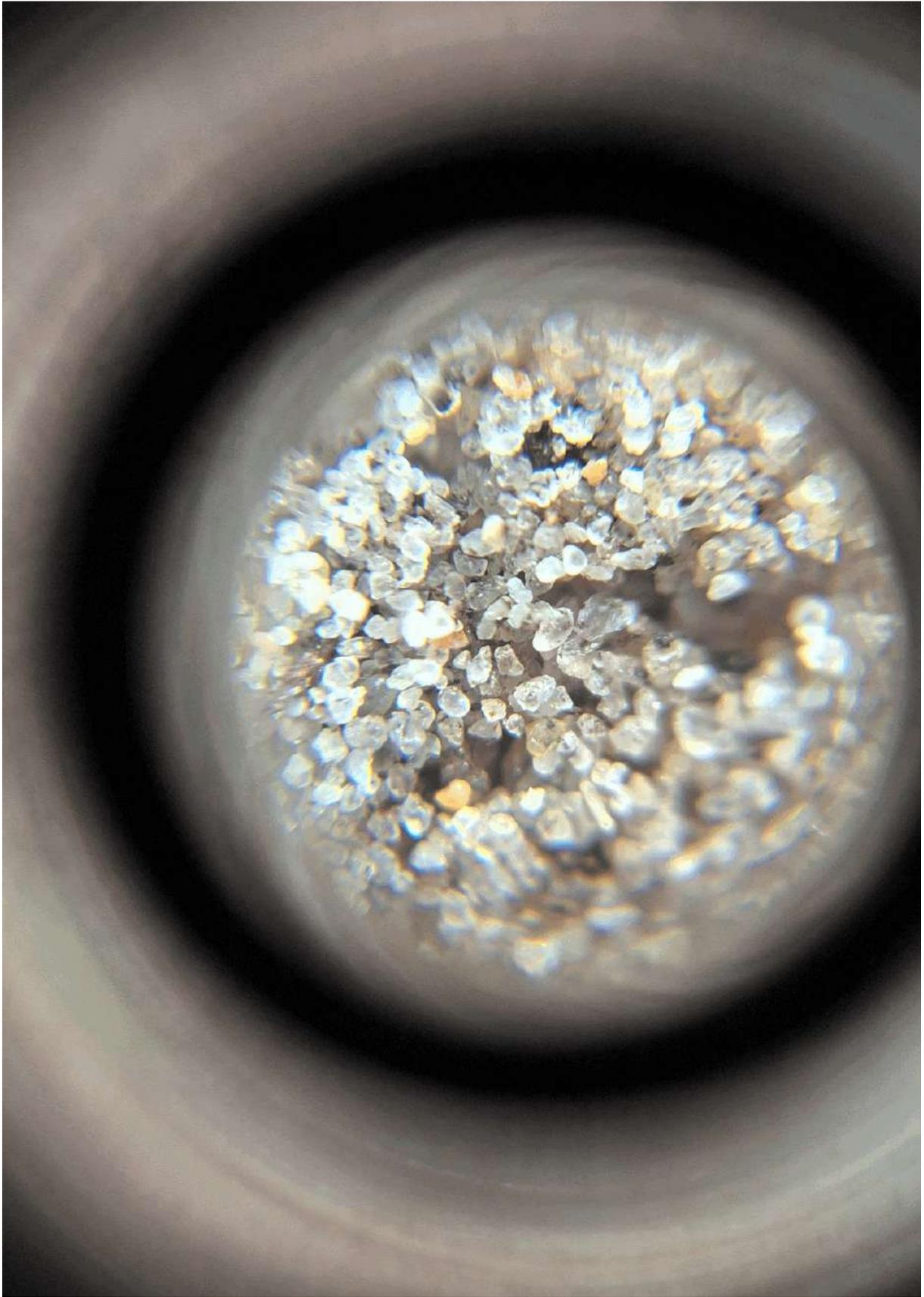
lääs 22

taevavaade 23

maapind 24

P4	1 5/4	2 5/4	3 5/4	4 5/4	5 5/4
----	----------	----------	----------	----------	----------

Appendix 9. Grains of sand (eluvial horizon) (camera microscope). *Author: Thora Liisa
Vildersen*



Appendix 10. Our team photo

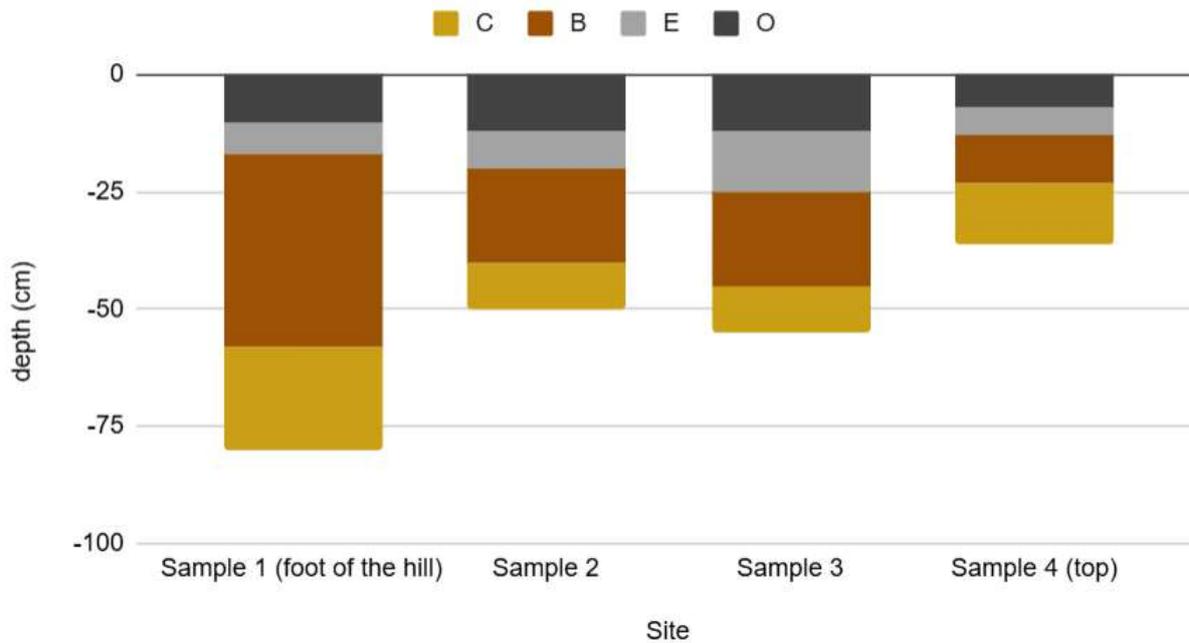


Appendix 11. Summary table, soil profiles, and summary of the 2018 fieldwork conducted at the same location.

Kaeved	1.1 O	1.2 E	1.3 B	1.4 C	2.1 O	2.2 E	2.3 B	2.4 C	3.1 O	3.2 E	3.3 B	3.4 C	4.1 O	4.2 E	4.3 B	4.4 C
Kaugus (m)	0				14				43				100			
Tüsedus (cm)	7	6	10	>13	14	13	20	>10	12	8	20	>10	10	7	41	>22
pH	-	-	-	-	4.1	4.2	4.5	5.1	-	-	-	-	4.2	4.6	4.9	5.2
Lõimis	Sidus liiv või saviliiv kõikides E, B ja C horisontides.															
Värvus	7.5 YR 2.5 /3	10 YR 6/1	10 YR 4/6	10 YR 8/6	7.5 YR 2.5/ 3	N5/	2.5 Y 8/6	2.5 Y 7/8	10 YR 3/4	7.5 R 4/1	10 YR 7/6	10 YR 7/8	7.5 YR 7/2	7.5 R 5/1	5 YR 5/8	10 YR 7/4
Temp.	17.5	17.2	-	17.2	16.9	15.2	-	14.7	17.2	16.8	-	16.5	15.9	15.3	-	13.9

Appendix 12. Soil profiles of the four study sites (2018)

2018



Appendix 13. Summary of the 2018 field study.

- The humus horizon was absent.
- The litter layer was immediately followed by the leaf horizon.
- The soil texture was cohesive sand or sandy loam in all E, B, and C horizons.
- The litter horizon was the most acidic (pH 4.1–4.2).
- Acidity decreased with depth.
- The thickness of soil horizons varied across different parts of the slope.
- The middle section of the slope consisted of moderately podzolized soil, while the upper and lower sections had weakly podzolized soil.
- The illuvial horizon was locally absent or extended deep in streaks.
- The parent material of the C horizon is aeolian sand.