

# High Willow Shrubs in Yamal: Reasons of Their Wide Expansion and Methods of Biomass Assessment

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18 8'00

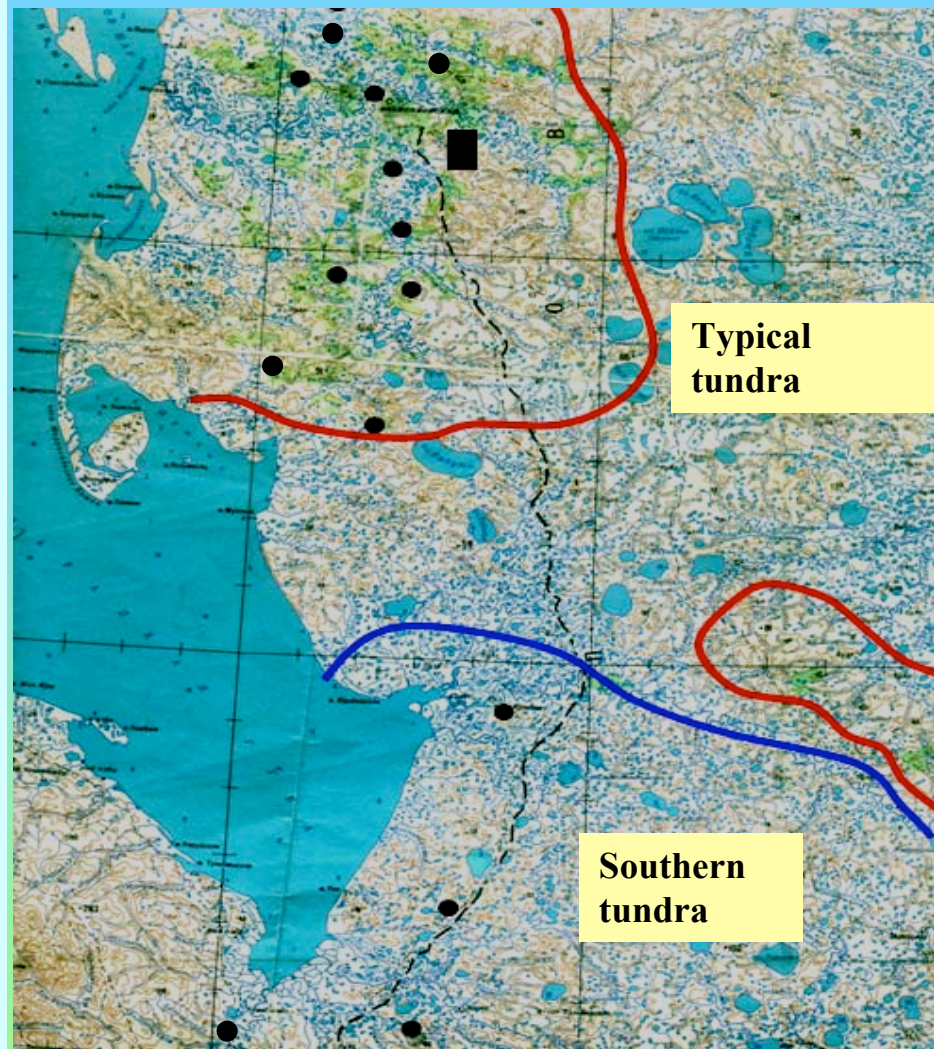


*High willow communities (>1 m) occupy the majority slopes in a typical tundra subzone of the Yamal Peninsula.*

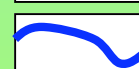
### Why?

In our opinion, distribution of highly productive willows are caused by active slope processes bringing to the surface marine saline deposits saved by permafrost. Areas of fine-grained marine sediments at the Yamal Peninsula have been found to the North of the Yuribey river valley where the Holocene thawing has never occurred.

Desalinization of marine sediments at landslide-affected slopes leads to active layer enrichment with water-soluble salts, which supply plants. This is main reason of biodiversity and bioproductivity increase.



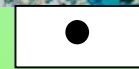
- area of high-willows tundra



- limit of typical to south tundra



- boundary of the frozen saline marine deposits (after Dubikov 2002, and Brushkov 1998)



- study site

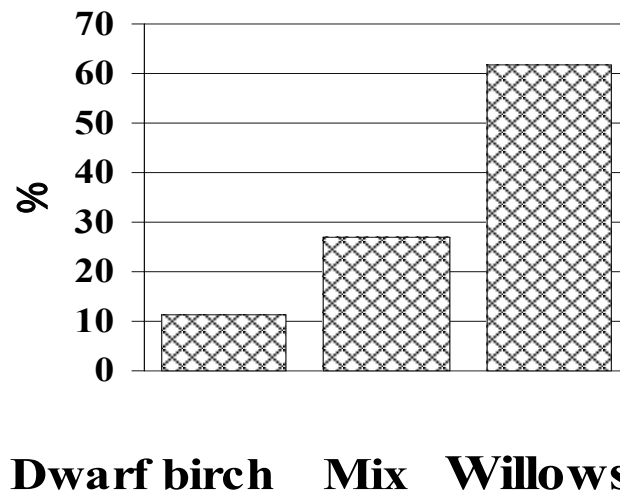


- polygon  
“Waskiny Dachy”

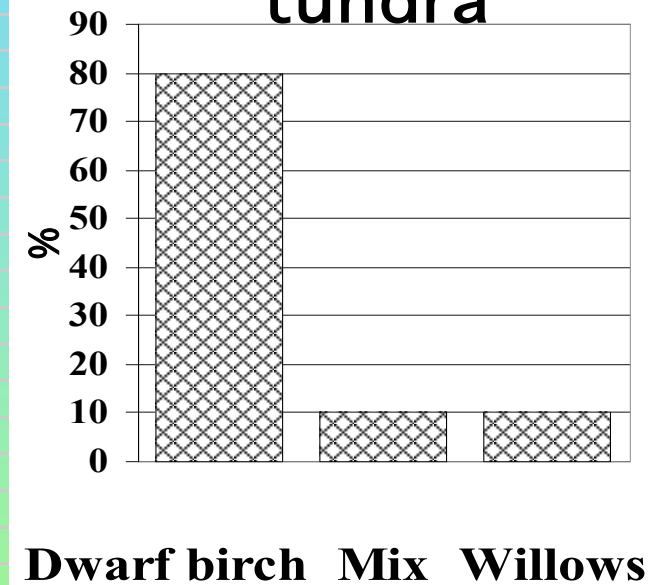
# Distribution of shrub communities in typical and southern tundra subzones

15 sites were investigated in Central Yamal, in typical tundra – 11 and in southern tundra – 4. Vegetation of the shrub-covered slopes was described along the transects with 25 m interval. The length of transects is 15 km in typical tundra and 4 km in southern tundra. There are 3 dominating groups in shrub layer: **willow**, **dwarf-birch-willow mix**, and **dwarf birch**.

## A. Typical tundra

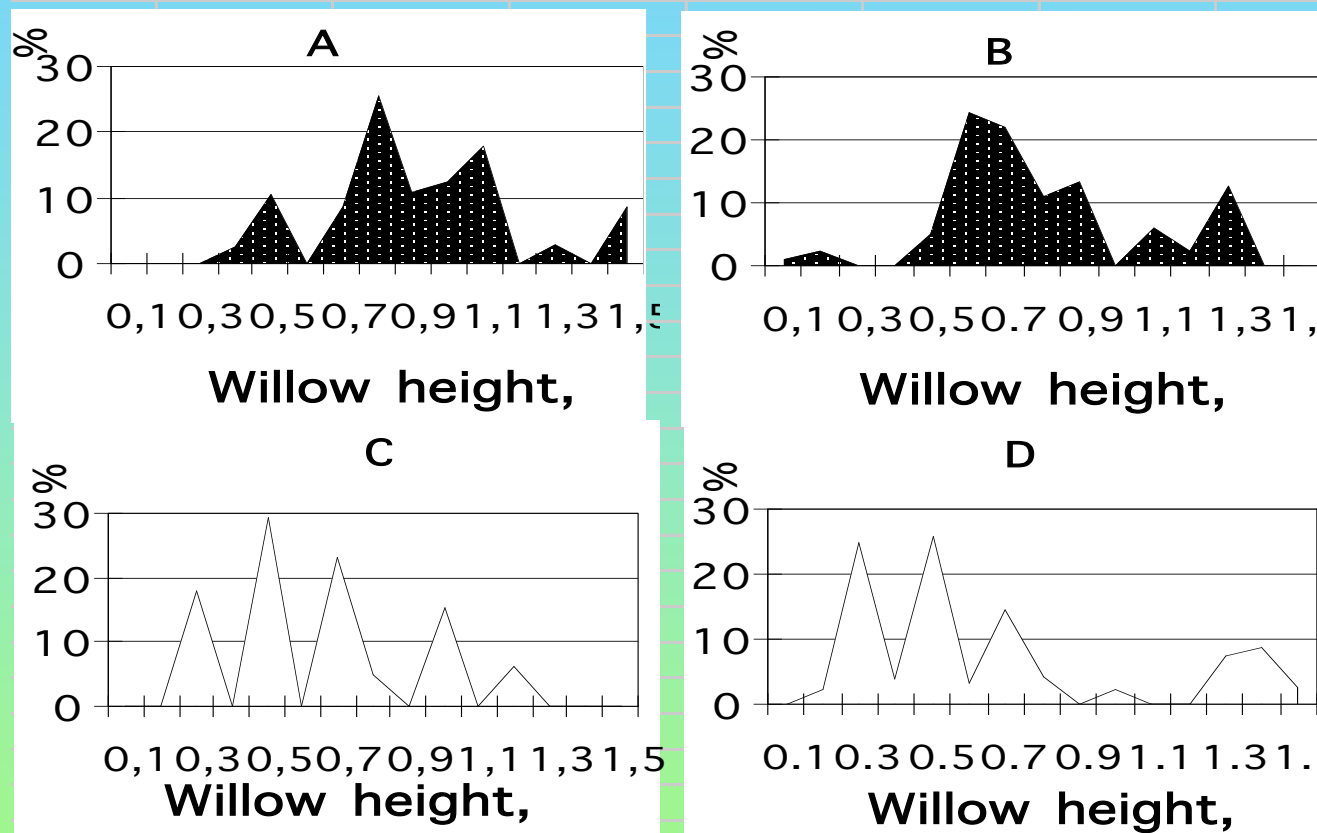


## B. Southern tundra



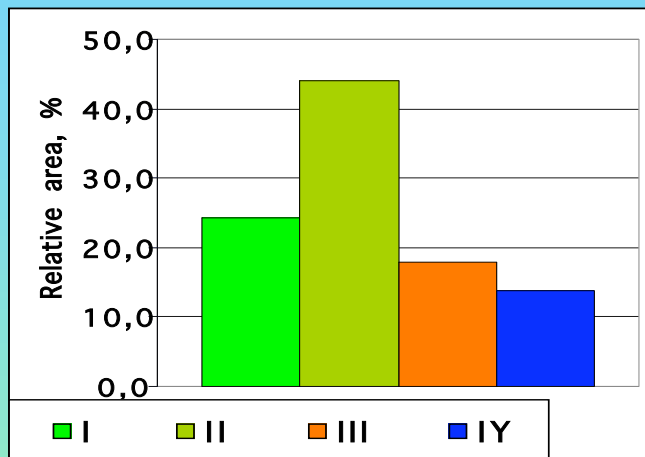
Willow communities on slopes in typical tundra (subzone D) are much wider distributed compare to southern tundra. Areas of high willow shrub tundra are correlated to the area of near-surface distribution of marine saline sediments.

# Willow Height in the typical tundra slopes at various aspects: A, eastern; B, southern; C, western; D, northern

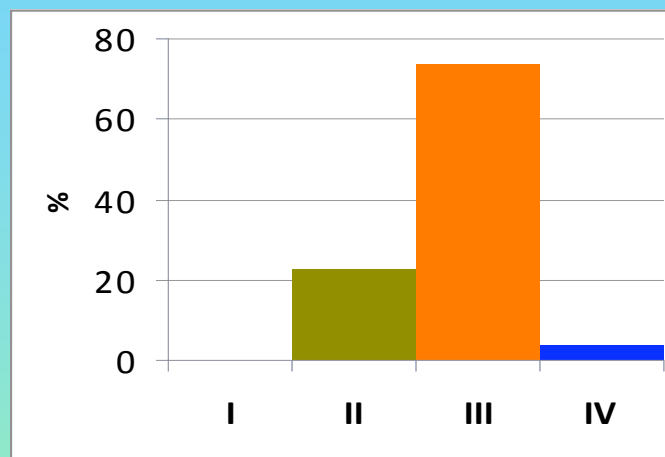


Minimum height is typical for northern slopes, and maximum – for eastern slopes.

# Distribution of Willow and Dwarf-Birch Shrub Thickets with different understory vegetation



*Salix glauca*



*Betula nana*

Distribution of *Salix glauca* and *Betula nana* thickets with different understory vegetation. Dwarf-birch tundra is characterized by thick moss cover. Willows dominate on surfaces with poorly developed moss (I-II).

**Thus, willows are typical for unstable (landslide-affected) slopes.**

## Understory vegetation groups:

**I –grasses** (*Poa alpigena subsp.colpodea*, *Puccinellia sibirica*, *Dupontia fischeri*, *Tripleurospermum hookeri*, *Ranunculus lapponicus*, *Trollius asiaticus*, *Valeriana capitata*, **moss coverage up to 30%**);

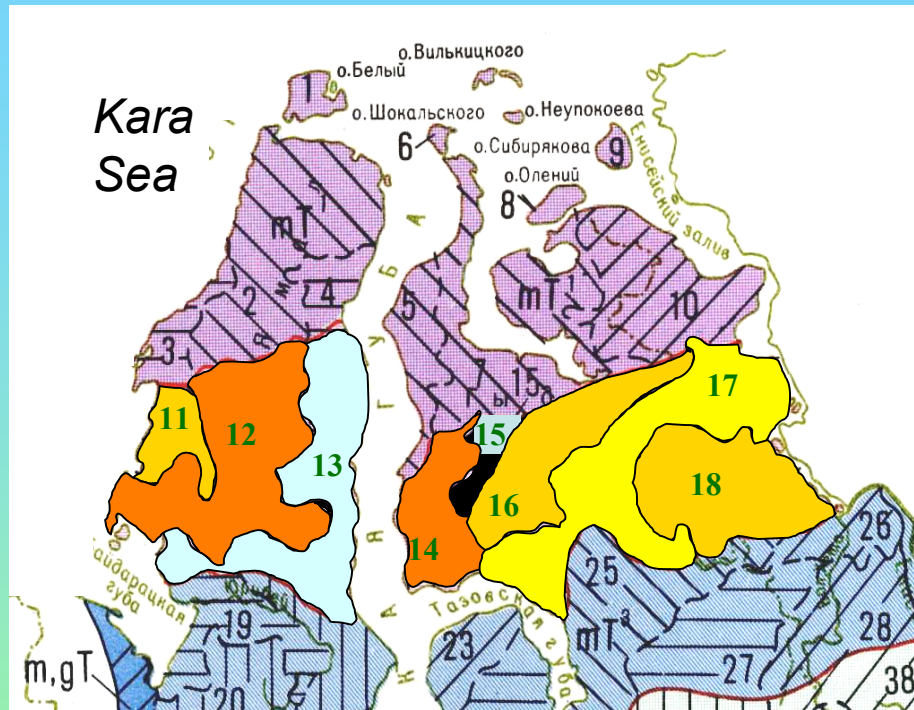
**II – moss/grasses** (*Carex concolor*, *C. arctisibirica*, *Calamagrostis holmii*, *Dechampsia borealis*, *Nardosmia frigida*, *Polemonium acutiflorum*, *Rubus arcticus*, *Equisetum arvense subsp.borealis*; **moss coverage 30-60%**; *Drepanocladus uncinatus*, *Polytrichum juniperinum*);

**III – mosses** (**moss coverage 80-100%**: *Dicranum elongatum*, *Hylocomium splendens*, *Aulacomnium turgidum*, *Ptilidium ciliare* etc.);

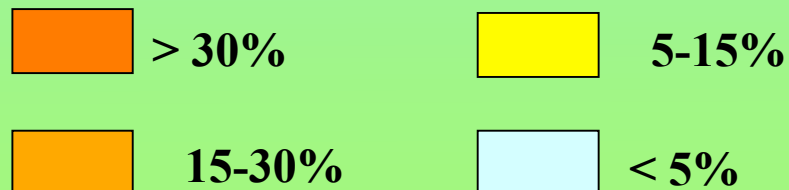
**IV – boggy moss/cotton-grass/sedges** (**moss coverage up to 100%**)



# Landslide slopes in the typical (subarctic) tundra

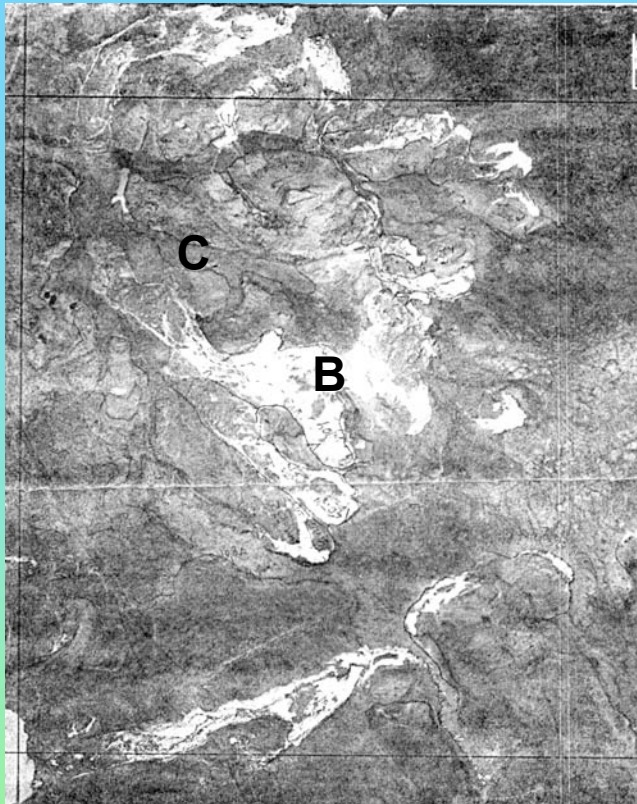


**Fraction of the landslide slopes in the Regions:**



<i>Regions</i>	<i>Area of the Regions, км²</i>	<i>Fraction of regions in the zone, %</i>	<i>Fraction of landslide slopes in the Regions, %</i>	<i>Fraction of landslide slopes in the zone, %</i>
11	4946	4,94	20,28	1,00
12	19337	19,31	30,19	5,83
13	18103	18,07	1,83	0,33
14	8767	8,75	31,92	2,79
15	3063	3,06	0,46	0,01
16	13500	13,48	15,92	2,15
17	20764	20,73	9,54	1,98
18	11677	11,66	19,11	2,23
<b>Total</b>	<b>100161</b>	<b>100,00</b>	<b>-</b>	<b>16,32</b>

# Landslide-affected slopes, shown on the slides and maps

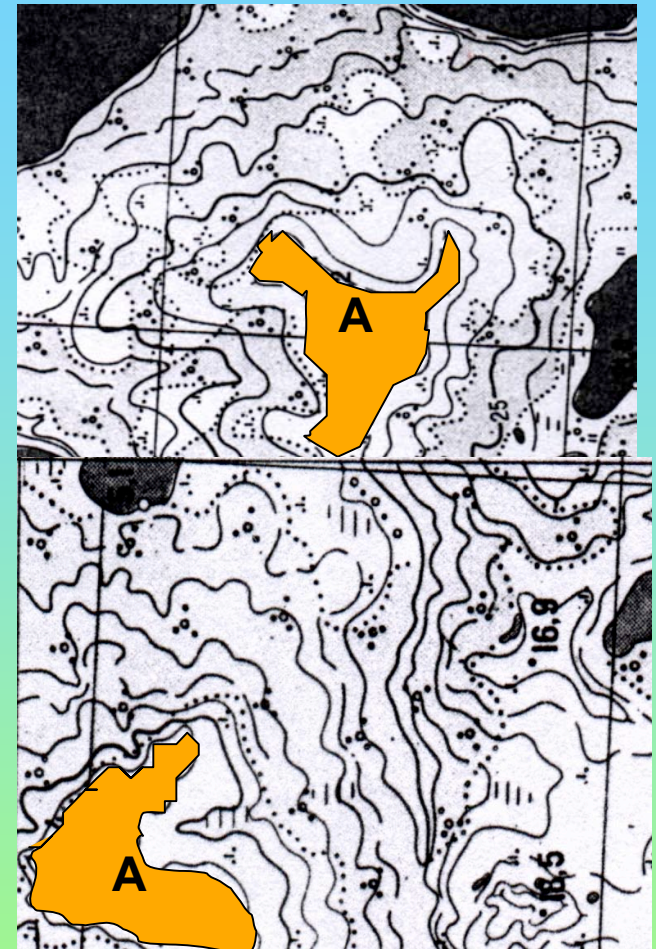


Landslide-affected slopes have a specific set of morphological elements:

(A) tops of the hills and stable slopes (not affected by landslides, i.e. '*natural background*');

(B) cirque-shaped depression (*shearing planes*, i.e. denudation zone);

(C) hummocky scarp and terraces (*landslide bodies*, i.e. accumulation zone).

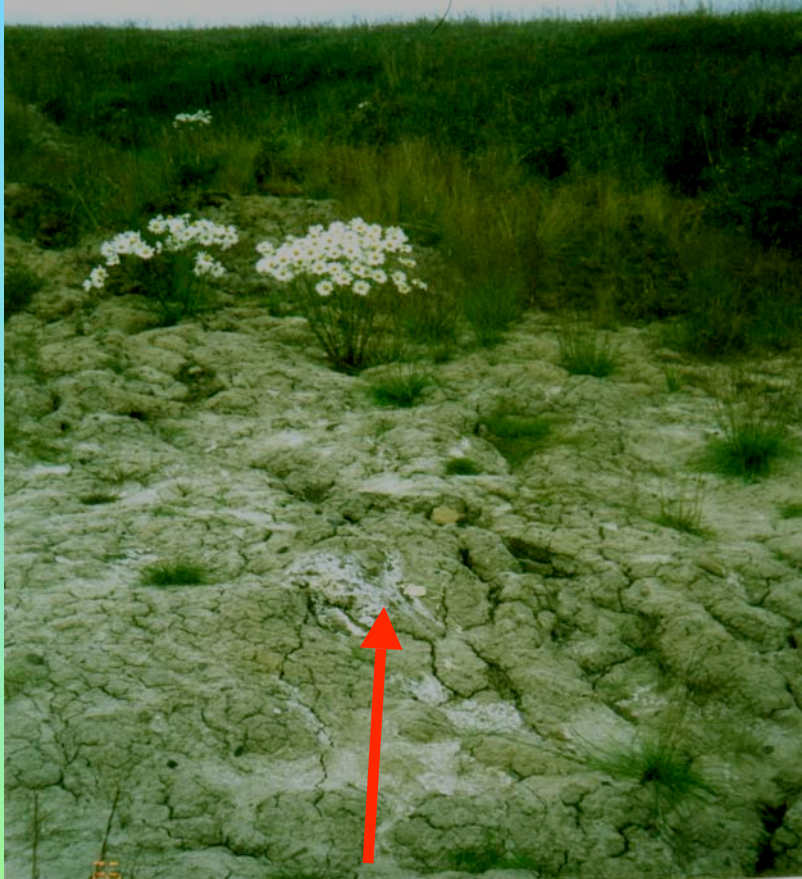


Cryogenic landslides are cyclic in time in various parts of the landslide-affected slope. As a result of the process, the slopes represent a landslide system of various ages.



# The young landslides, formed 10 to 30 years ago

## B1. The young shearing planes (1989-1990)



## C1. The young landslide body



The salted marine sediments, which outcropped due to landslide event



**The old  
landslides,  
formed up to  
300 years ago**



**B2 – meadow  
sedge/grass  
communities with  
active willow  
restoration**



**The ancient landslides,  
formed 300 to more than  
2,000 years ago (B3, C3).**

**High willow communities occupy the  
majority ancient landslide slopes**

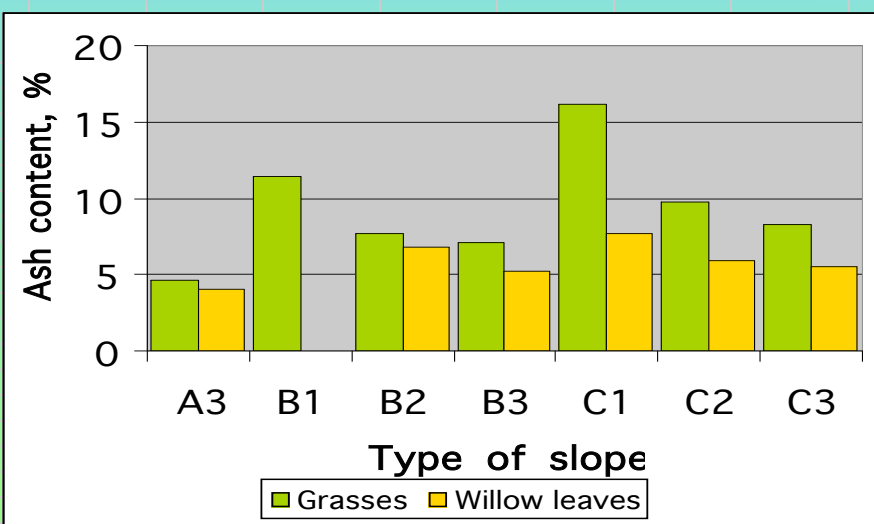
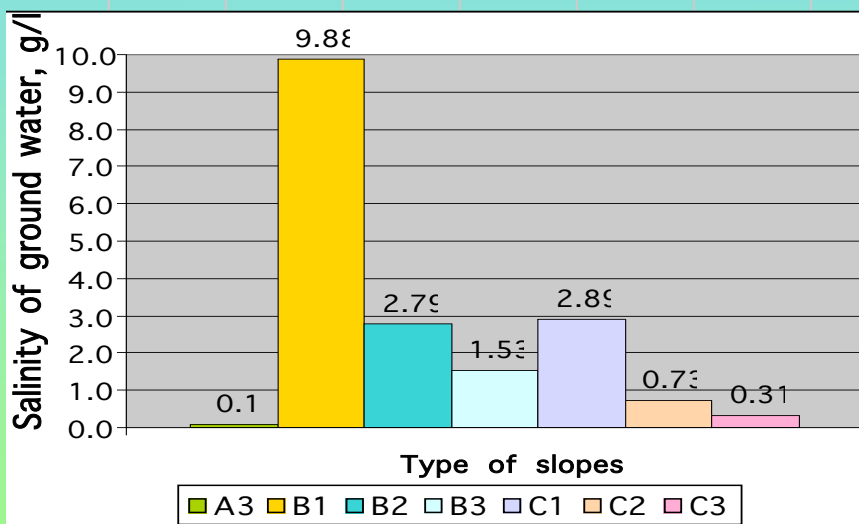
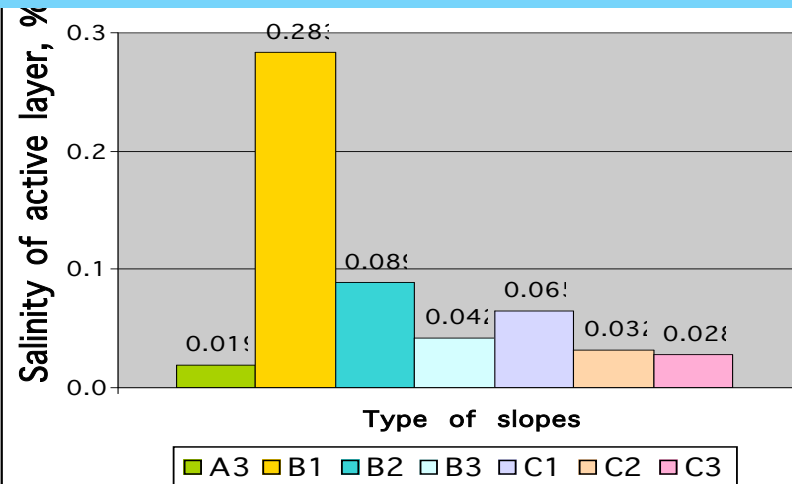
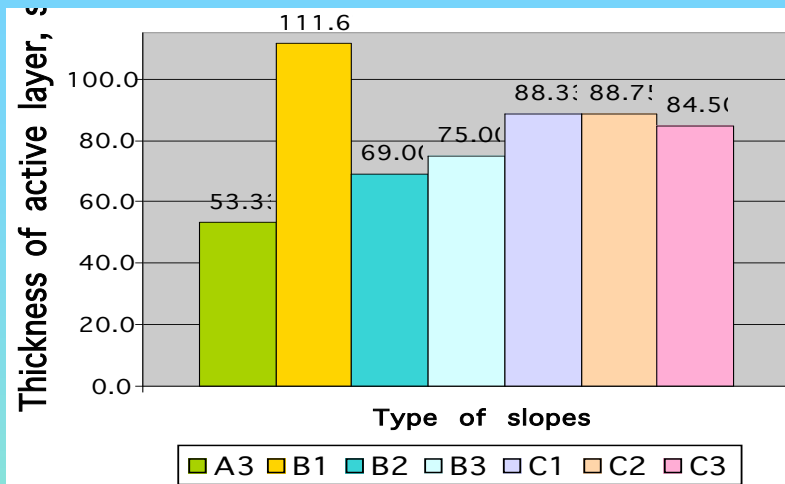


**Willow associations are dense on the  
ancient landslide bodies and are sparse  
on the shearing planes of the same age**



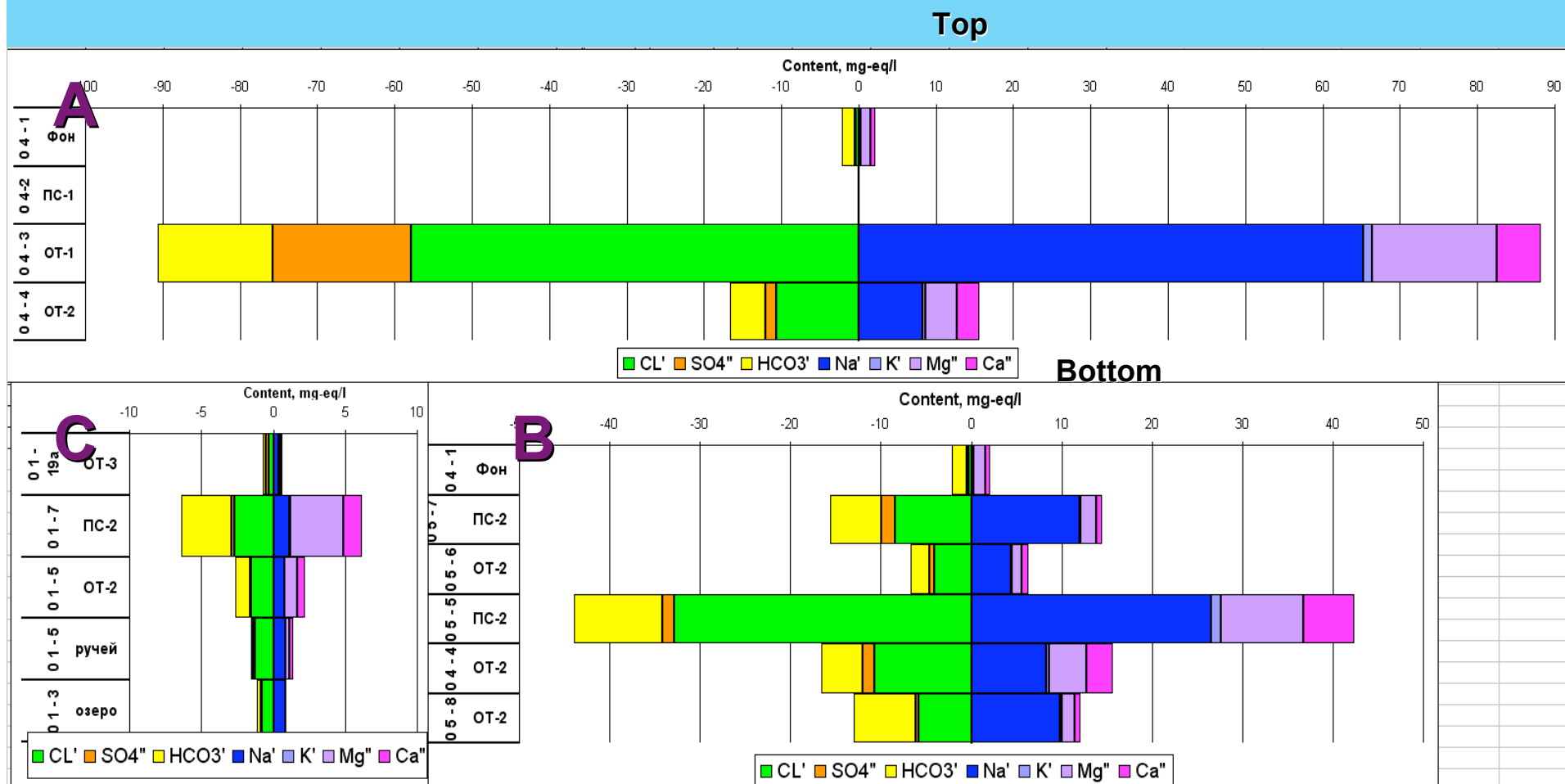


# Biogeochemical features of landslide-affected slopes



The ash content, thickness of active layer and salinity of soils and soil water is controlled by the relative age of landslide events and decreases from modern landslides (B1, C1) to old landslides (B2, C2) and to ancient landslides (B3, C3) and, finally to stable slopes (A3).

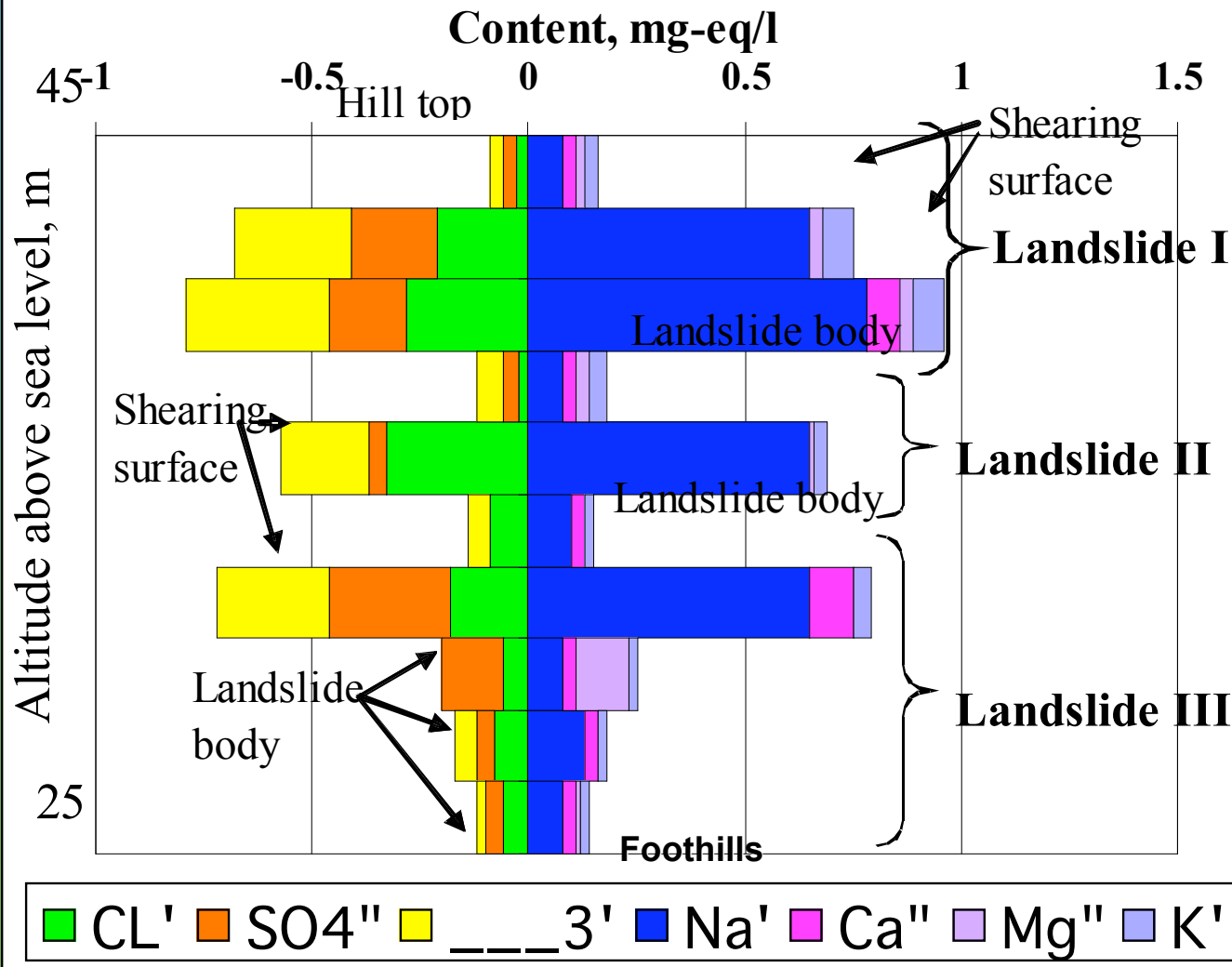
# Chemical composition of soil water on young (A), old (B) and ancient (C) landslide slopes



Similar to the abovementioned pattern was found in distribution of ions in soil water – decrease in direction from young to ancient landslides. Shearing surfaces of landslides are always more saline than landslides bodies.



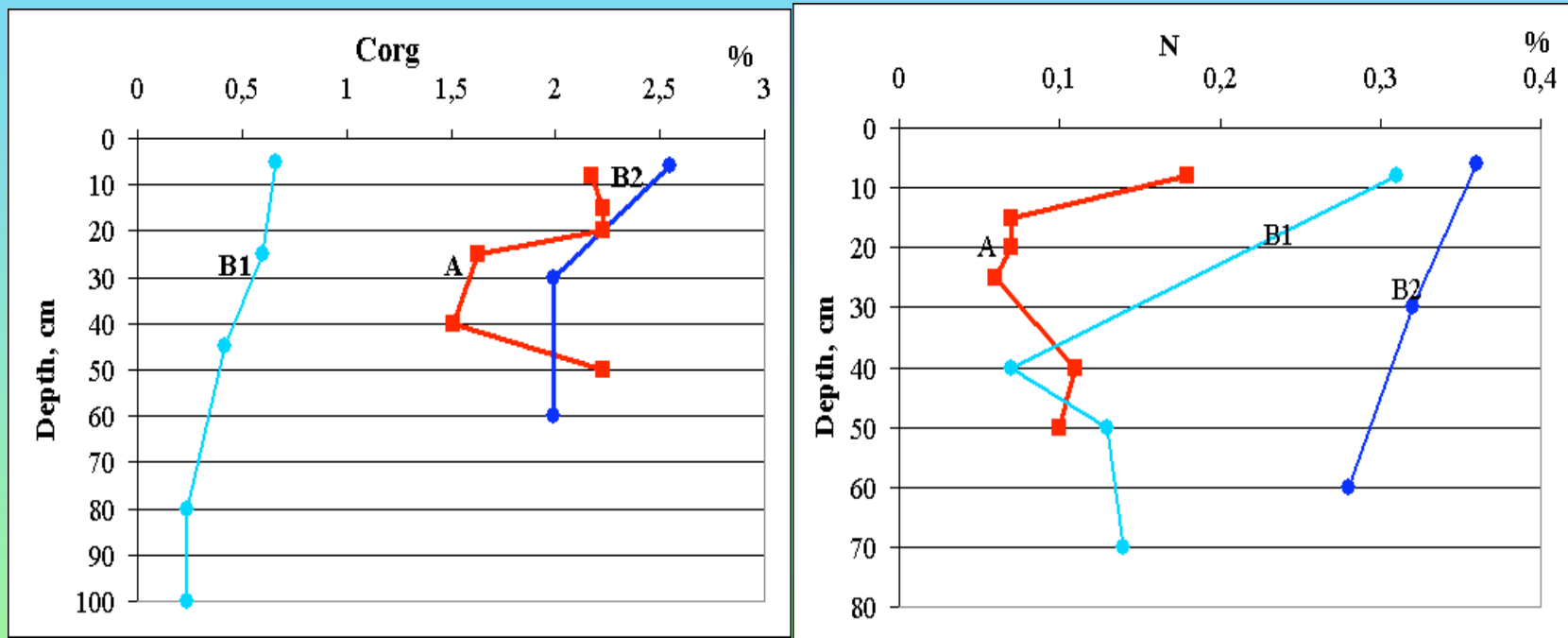
## Chemical composition of soils (at the depth of 40-50 cm) on old landslide slope



The same pattern was observed in soil chemical composition.

3 old landslides occur on 800 m long slope. Ion concentration is laterally variable with maximum at shearing surfaces. Ion concentration on hill tops is much lower than on old landslide-affected slope.

## Corg and N vertical distribution in soils of stable surfaces (A), young (B1) and old (B2) landslide shearing planes



**Total Nitrogen on landslide slopes is much higher than on stable surfaces. Amount of organic C decreases on young shearing planes where mineral grounds are exposed and all organic matter displaces by landslide event.**



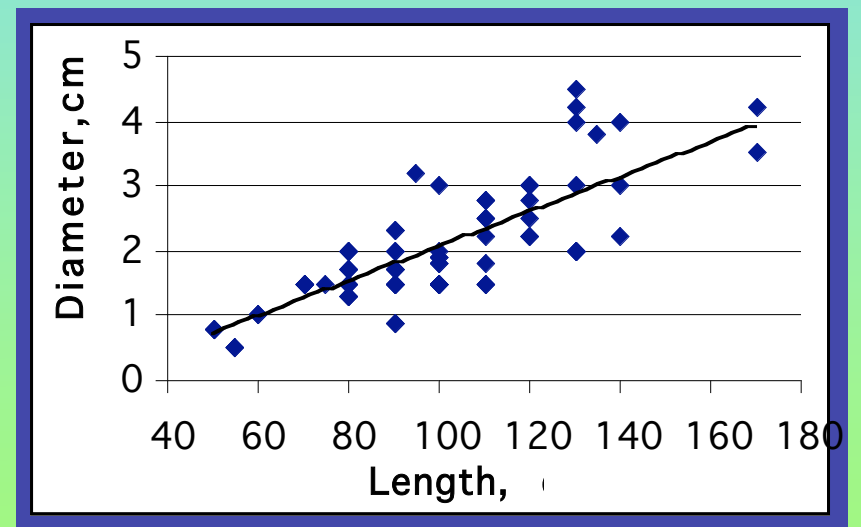
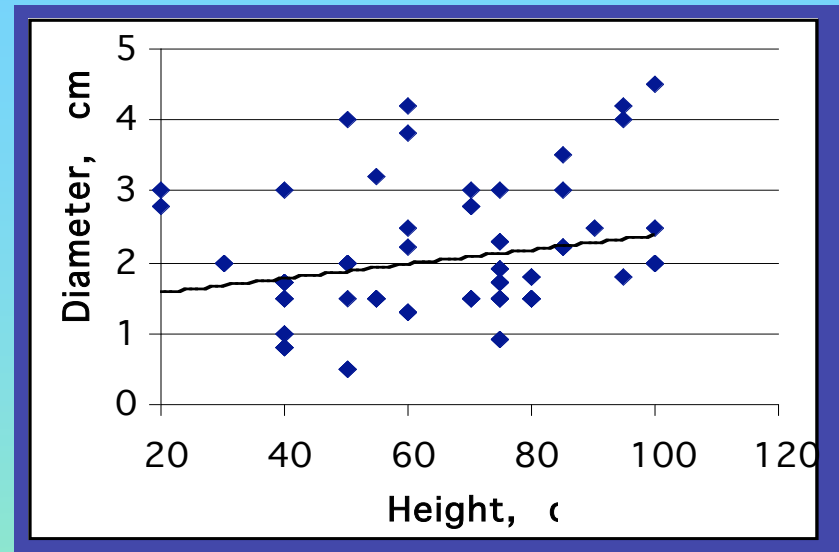
# *Methods of Willow-Shrub Biomass Assessment*

**Due to high willow density, techniques developed for forest and desert areas cannot be applied in the tundra regions of Yamal.**

**The above-surface phytomass is determined using original method of “model trunk”. The number of trunks in the test plot of nine square meters has been counted. Diameter, length and height of each of them have been measured.**

**The hemiprostrate growth of willow causes weak correlation between diameter and height of the shrub.**

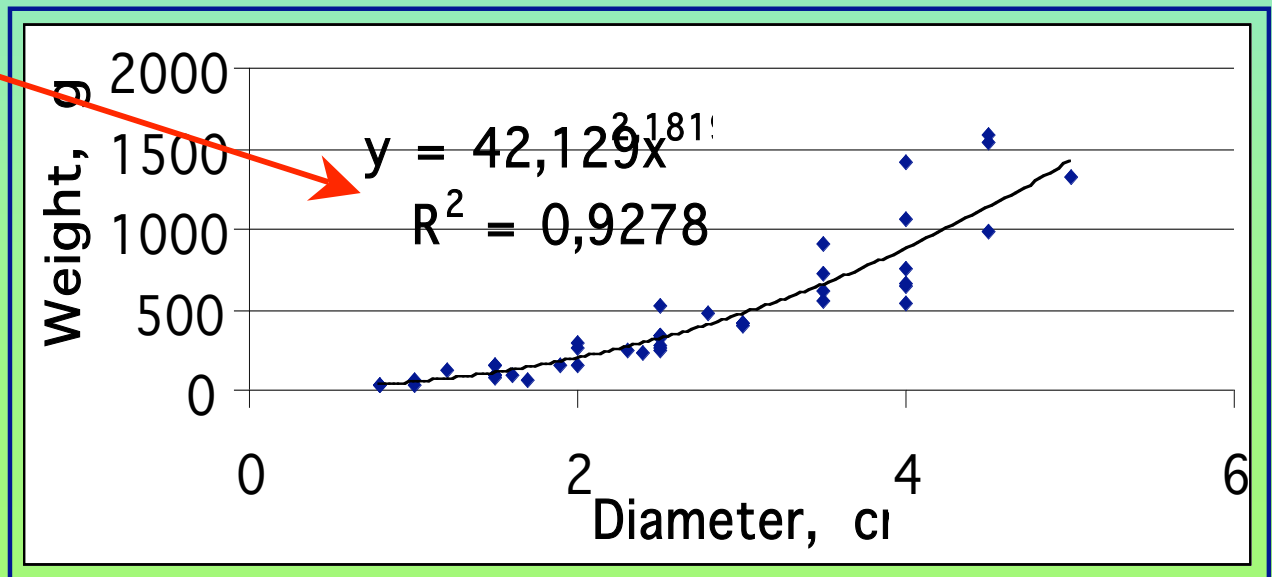
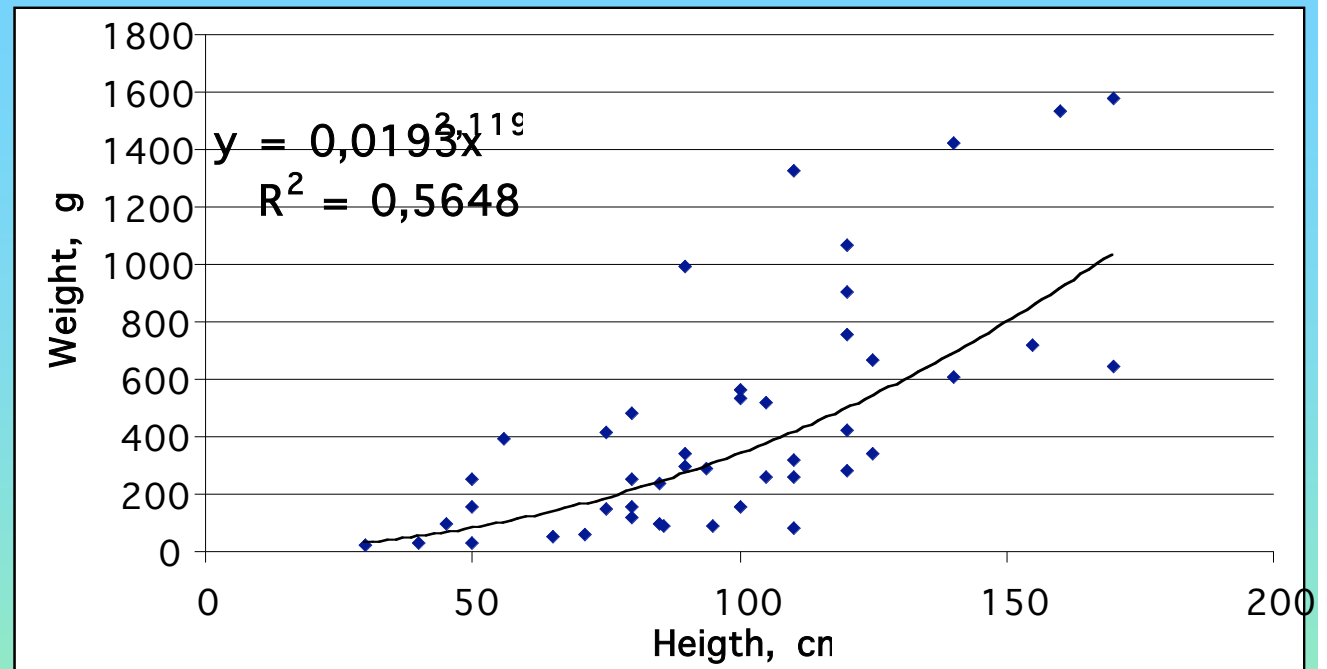
**Correlation is much better between the length of the trunk and its diameter.**



Several model trunks from each plots were chosen and weighted.

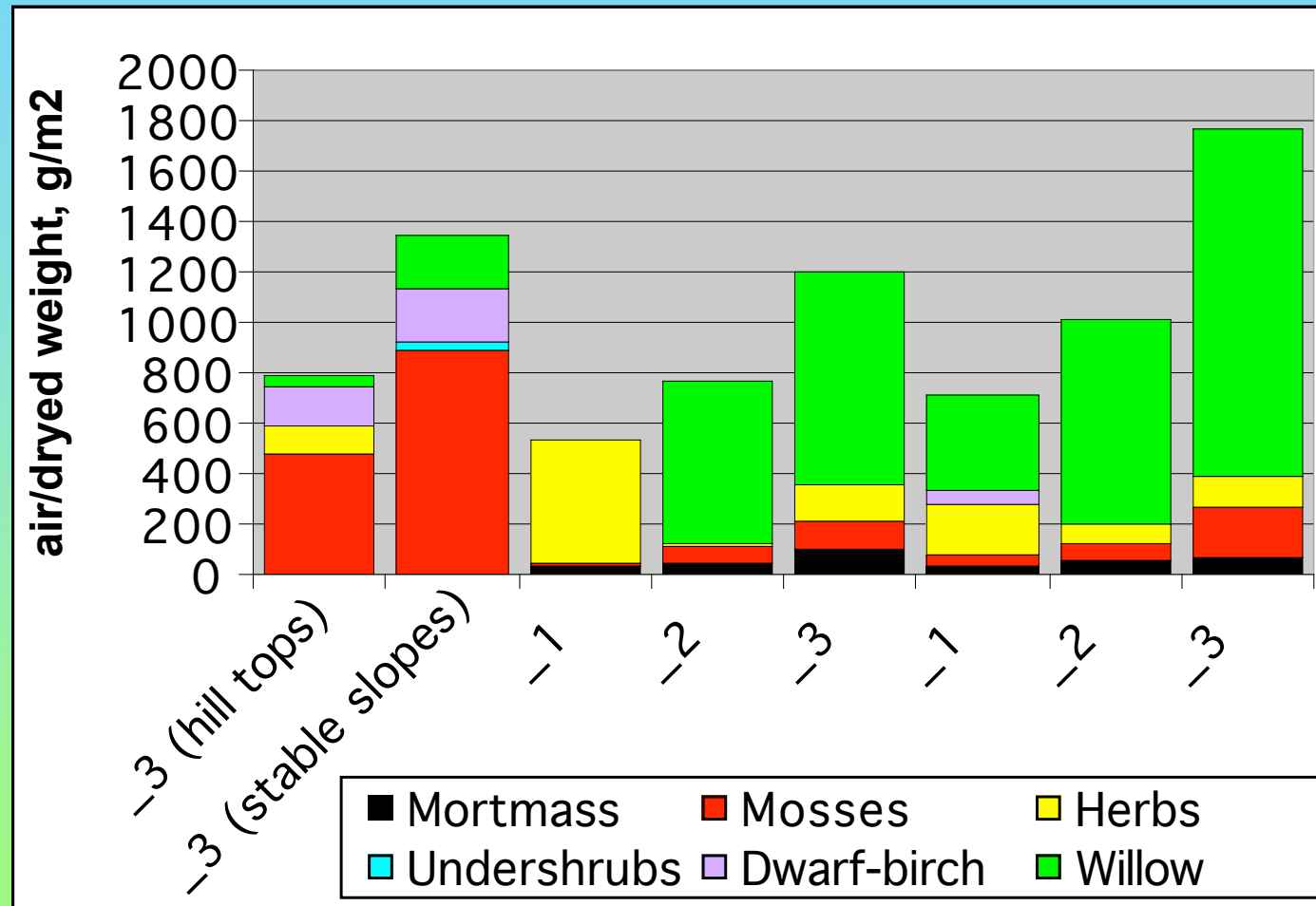
Correlation of weight and height is also bad due to hemiprostrate growth of willow.

Correlation between trunk weight and diameter has turned out to be the most authentic, and mathematical function for this dependence has been determined with 0.93 probability confidence. This function has been used for estimation of high willow phytomass in Yamal region.





# Aboveground biomass at landslide-affected slopes and 'natural background' surfaces

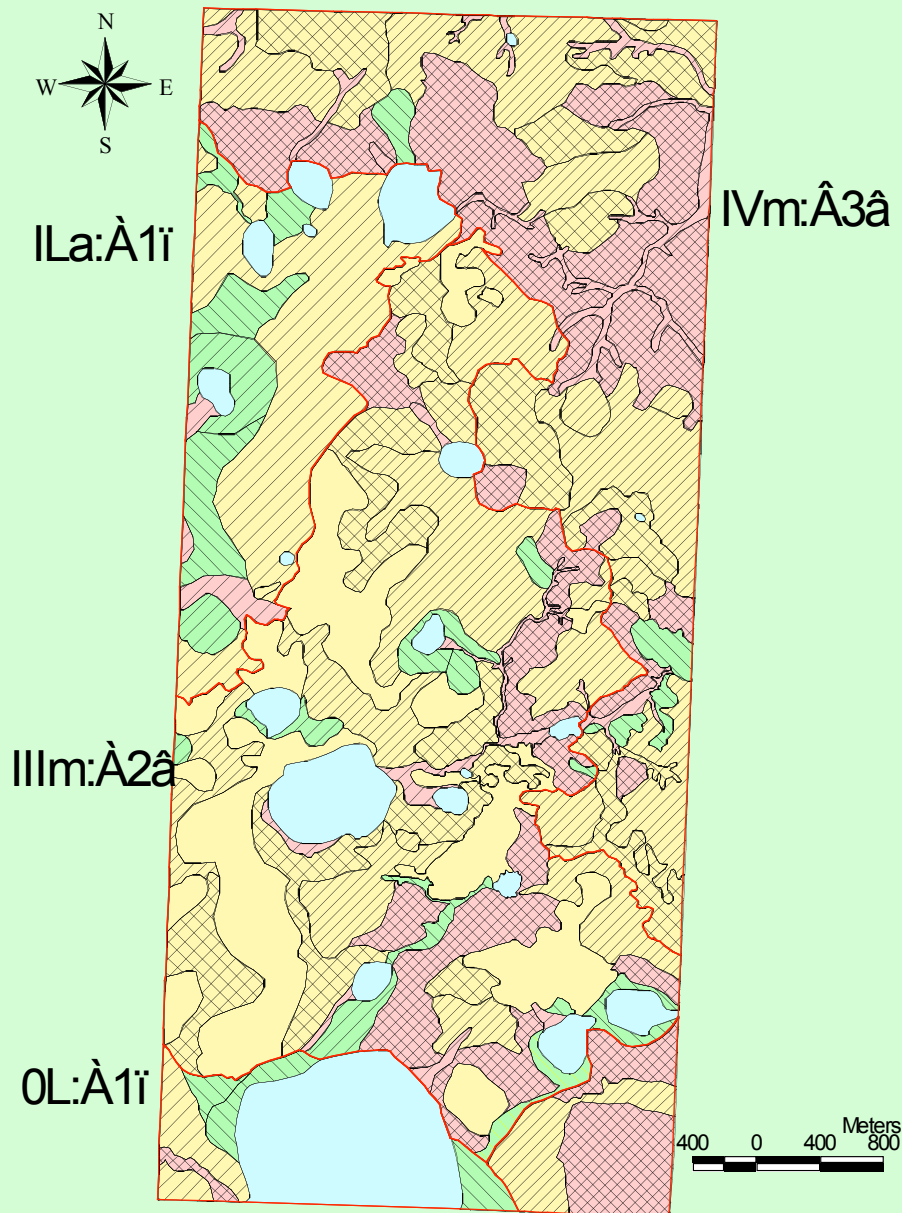


N. Ukraintseva et al., 2003

# Polygon "Waskiny Dachy". Map of the aboveground Biomass and its Composition

Authors: N. Ukraintseva, N. Smetanin

**This map shows both total biomass  
and its composition**



## Aboveground Biomass, g/m<sup>2</sup>

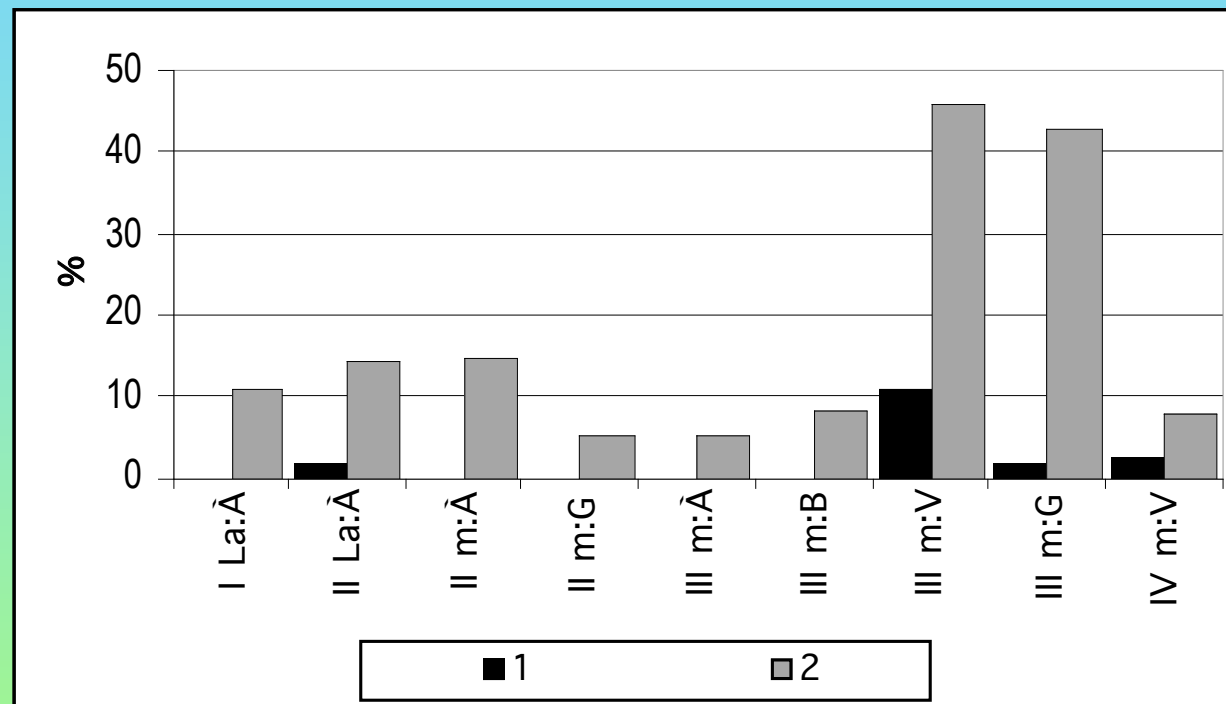
	100-250
	250-700
	500-800
	700-1000
	1000-1300
	600-1600

## Biomass composition

	- grasses up to 50%
	- mosses up to 50%
	- shrubs up to 50%
	- landscape Index
	-landscapes and geosystems boundary
	- lakes

# Distribution of the andslide-affected slopes in landscapes of the Bovanenkovsky gas field

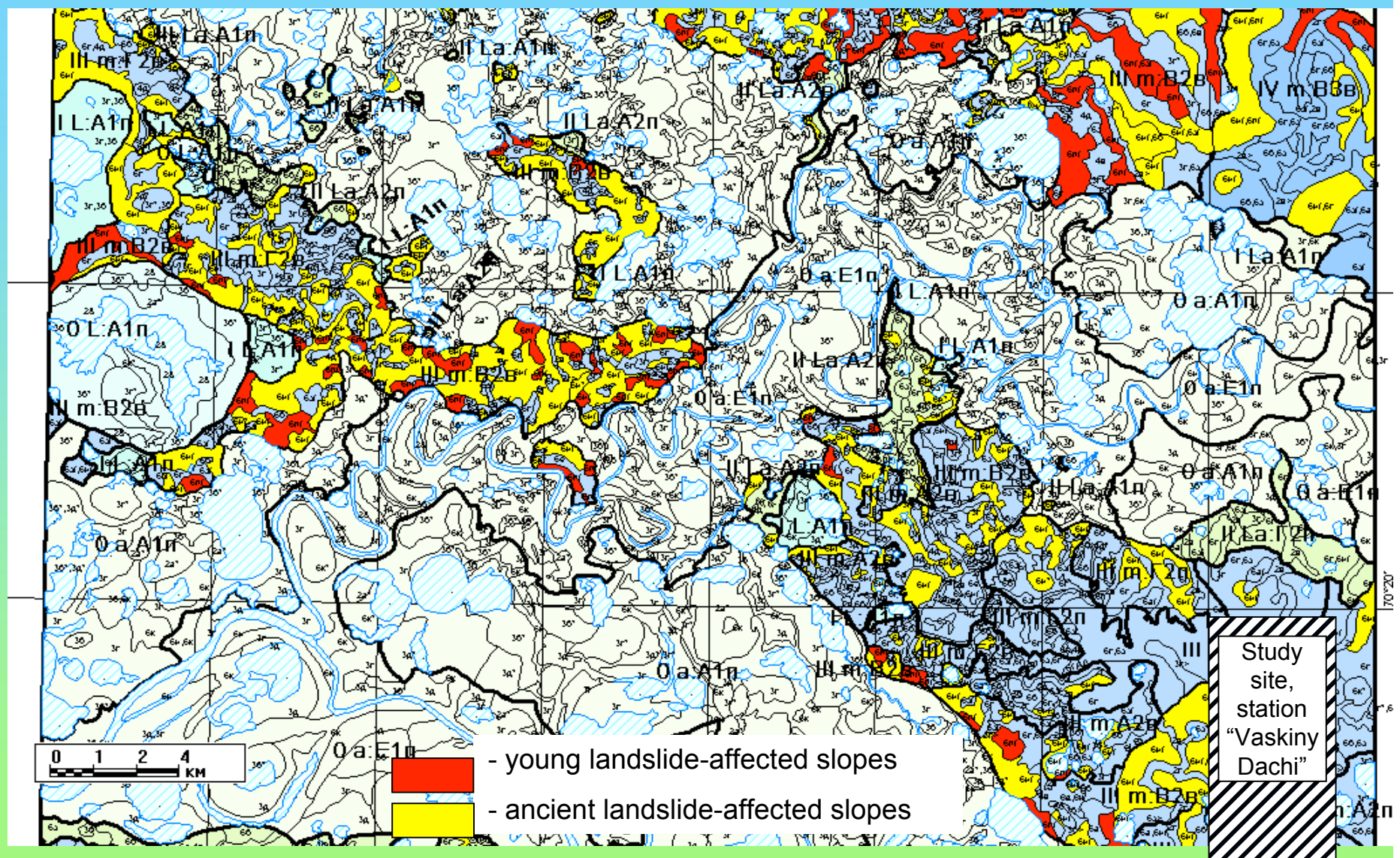
1 - young slopes; 2 - old and ancient slopes.



1) The maximum distribution of landslide slopes is characteristic for large-hill thermodenudation areas of III marine plain (III m:V - about 47 %).

2) The fraction of young landslides from the total area of landslide slopes for all districts does not exceed 20-30 % that indicates **some attenuation of process**





# CONCLUSIONS

1. Unusually high willows occur in typical tundra on the hill slopes, while to the south of it in southern tundra slopes are covered with dwarf birch communities.
2. The presence of such unusually high willows in typical tundra is caused by the geochemical properties of soils and soil water.
3. Geochemical properties of soils are formed due to active slope processes, mainly active-layer detachment slides, bringing to the surface saline marine sediments, saved by permafrost.
4. The area of saline deposits distribution at Yamal Peninsula is found to the north of the of the Yuribey river valley where the Holocene thawing has never occurred.
5. Biogeochemical features of landslide-affected slopes are controlled by the relative age of landslide events and decreases mainly in a row: modern landslides - old landslides - ancient landslides - stable slopes.
6. Willow-Shrub-Biomass was determined using original method of “model trunk”. The aboveground biomass of the ancient landslides is also higher than that of the stable surfaces –about 1700 g/m<sup>2</sup> compared to 800 g/m<sup>2</sup>.
7. Replacement of high willow shrubs by typical zonal vegetation with thick lichen-moss-litter layer indicates the final stage of the landslide process.



A photograph of a grassy hillside under a blue sky. A path of light-colored rocks or sand leads up the slope. The hillside is covered with tall, dry grass and patches of green grass. Numerous white daisies with yellow centers are scattered across the path and the surrounding vegetation. In the background, the hill rises further, showing more vegetation and some rocky outcrops.

**Thank you  
for your Attention !**

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