The influence of karst on biodiversity of the Northern Ecosystems.

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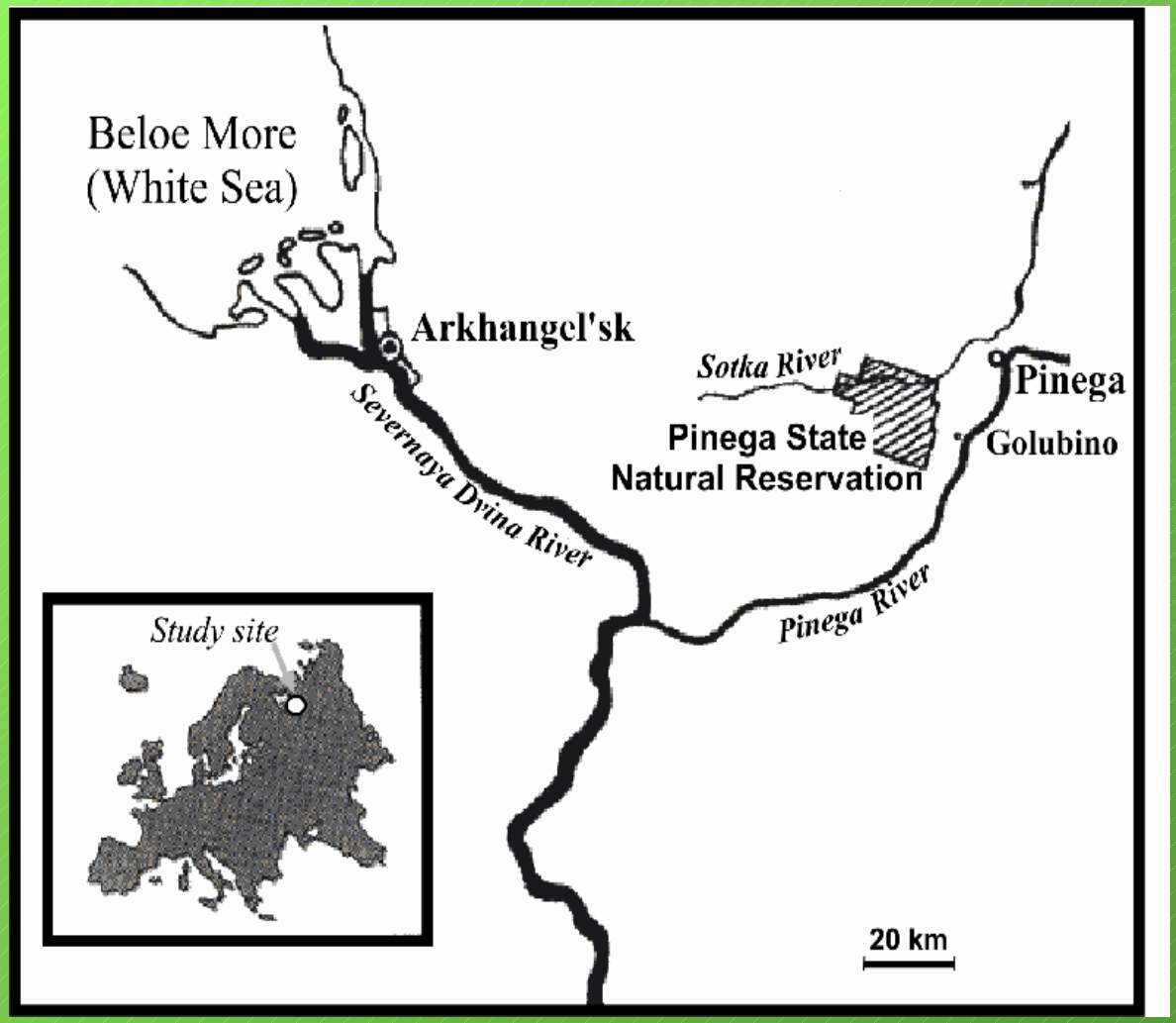
The character of landscapes can be greatly influenced by underlying soluble rocks and related karst processes.
This phenomenon has been studied within an area situated 200 km east and north-east of Arkhangelsk,
where karstified material influences taiga & forest-tundra landscapes.

The aims of the work:

1. **Detailed description of the functional regimes of natural complexes (geological, pedological, biological, etc.) and the comparison of glacial and karst landscapes.**

2. **To investigate: How can karst processes influence on natural possesses in a northern climatic zone (Northern taiga and South tundra).**

The area of works



Northern latitude 64^0

Post glacial relief

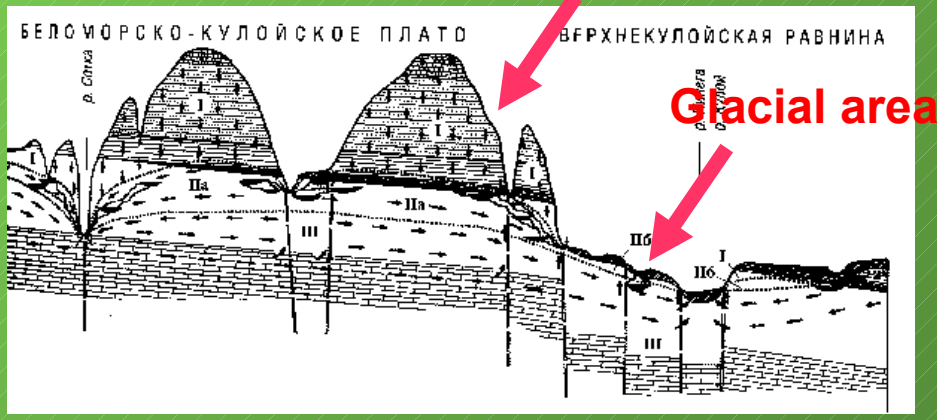
Temperate humid climate

Annual temp. 0,2 ^{0}C

Annual precipitation 652 mm

The natural zone – Northern Taiga (mainly spruce forest and Sphagnum peat bogs)

The taiga zone in the Russian European North is a territory with predominant swamped glacial plains. Such landscapes are formed in cold & humid climates combined with poor drainage.



However, there is another type of landscape that has developed over gypsum & limestone rocks covered by a thin layer of moraine or outcropping to the surface. Here, instead of typical spruce woods, there are low-productive larch woods, natural meadows,

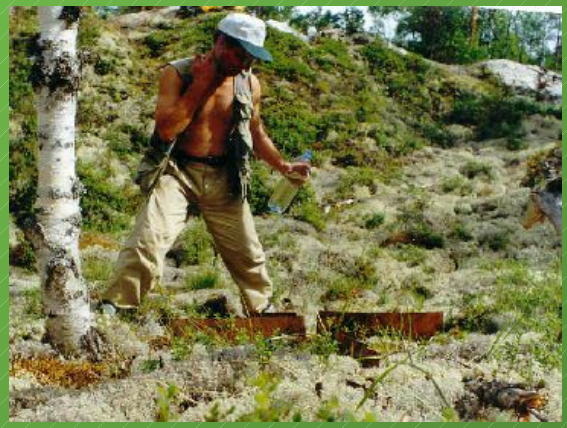
and open woodlands with plant species atypical of northern habitats.

Bogs occur rarely, but so-called "disappearing" lakes, caves, and other karst forms are common.

The dynamic processes involved in such landscapes were monitored on 2 sites using a three-dimensional approach. Thus, the characteristics of environment (i.e. temperature, moisture, concentration of nutrients in soil solution, etc.) and life indices (i.e. microbiological activity, bird occurrence and frequency, plant community characteristics, etc.) were measured together with their principal quantitative & qualitative differences in conditions of karst & moraine landscapes.

The measurement of an annual growth.

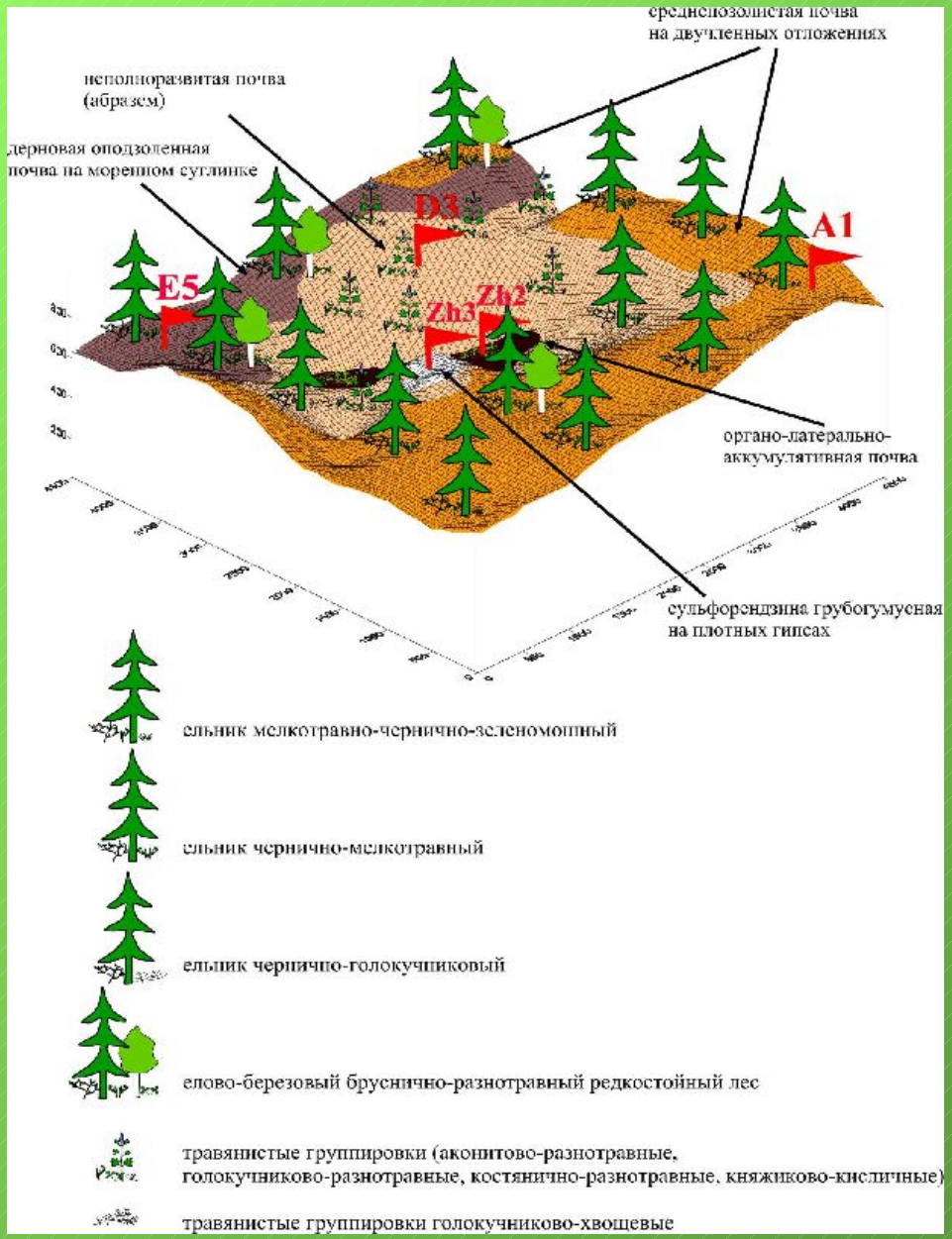
The measurement of soil microbiological activity.

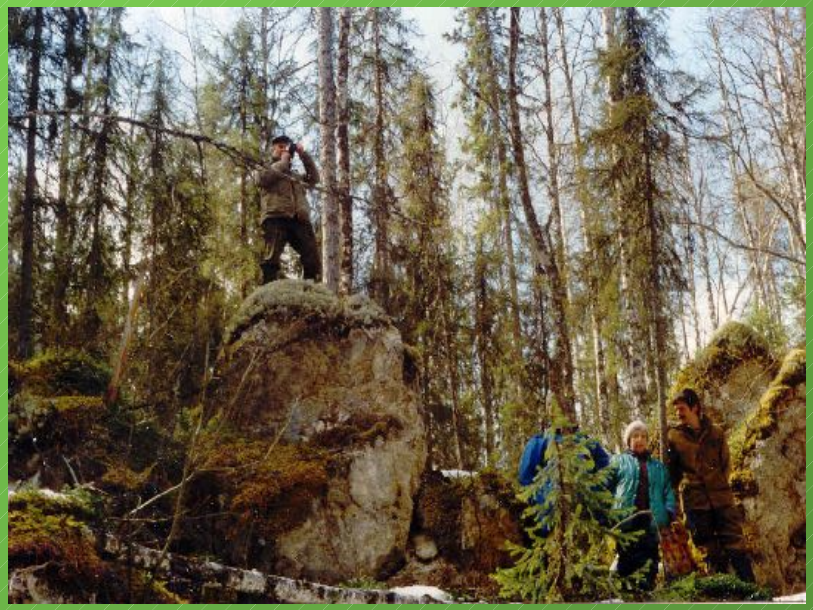


The trap for insects.

The soil temperature monitoring

Karst area



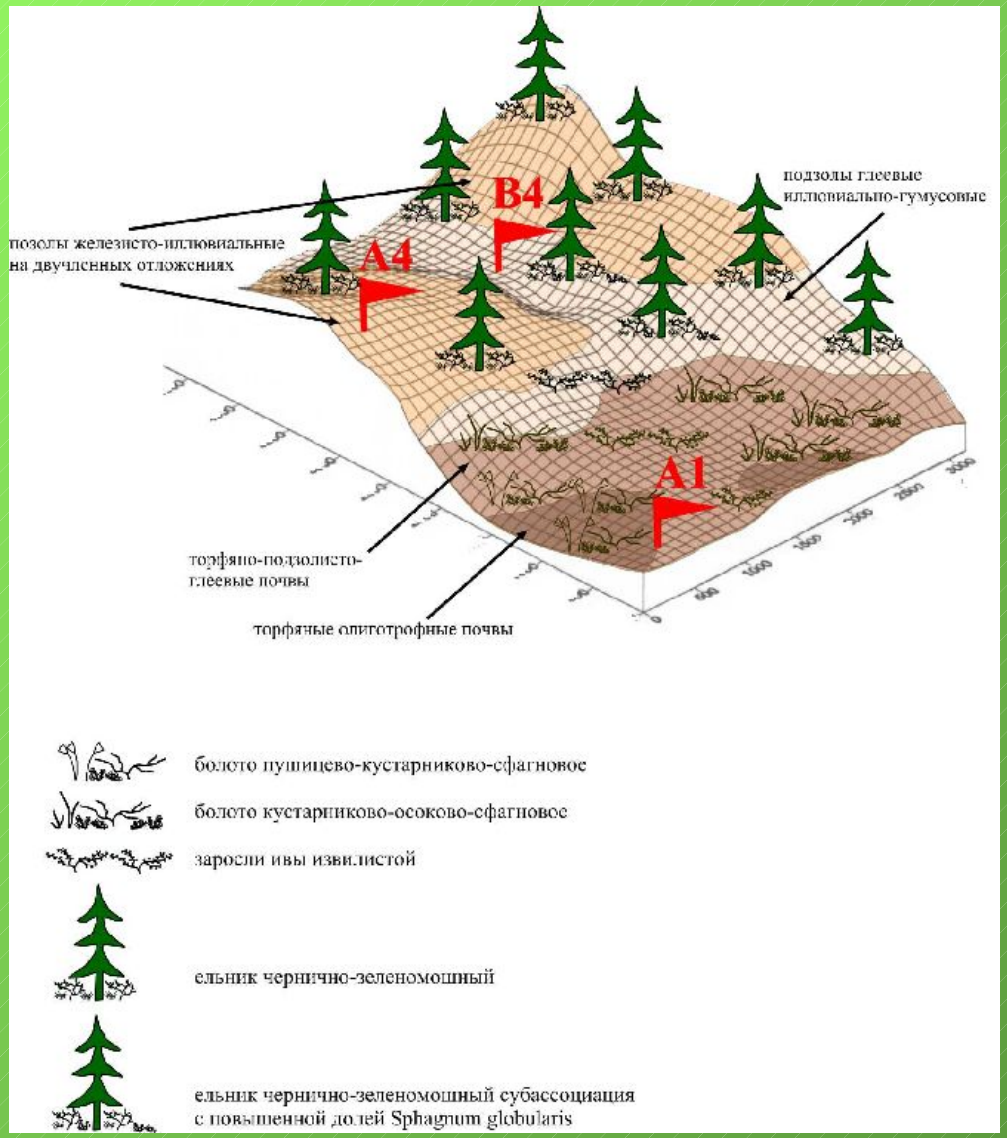


Soils: Gypsiric Leptosold, Histosols (in karst sink-holes), Unbric Regisols.

Vegetation: Spruce (*Picea obovata, Larex sibirica*) forest with ground cover of *Vaccinium myrtallis* and *Trientalis eurropaca*, and grass accosiations in sink-holes

Bedrocks: hard gypsum covered by loamy morine in part.

Glacial area



Soils: Gley-Histic Albeluvisiols, Histosols (in depressions)

Vegetation: Pine-birch (*Betula nana*)-Spruce (*Picea abies, P. obovata*) forest with shrubs and green mosses gound cover

Bedrocks: loamy morine

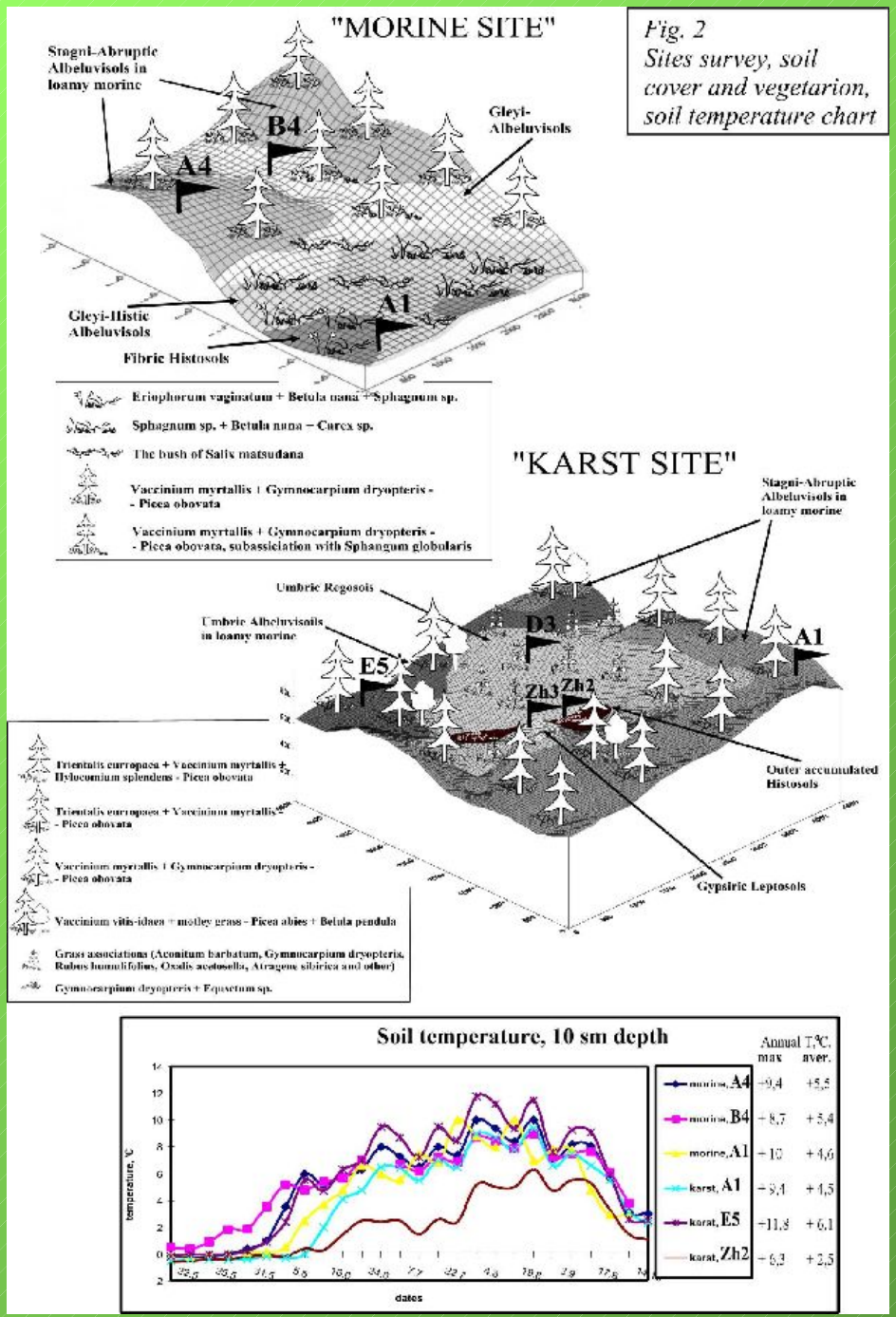


Fig. 2
Sites survey, soil cover and vegetarion, soil temperature chart

Soil temperature conditions

The comparison of the temperature condition during a year shows that karst site has more contrast changes in temperatures in the different soils distributed within the sit

The soil in karst sink-hole was heated in the depth 10 sm up to +2^{0}C only in the end of Jul

Average temperatures of the vegetation (May-October) period, depth 10 sm:

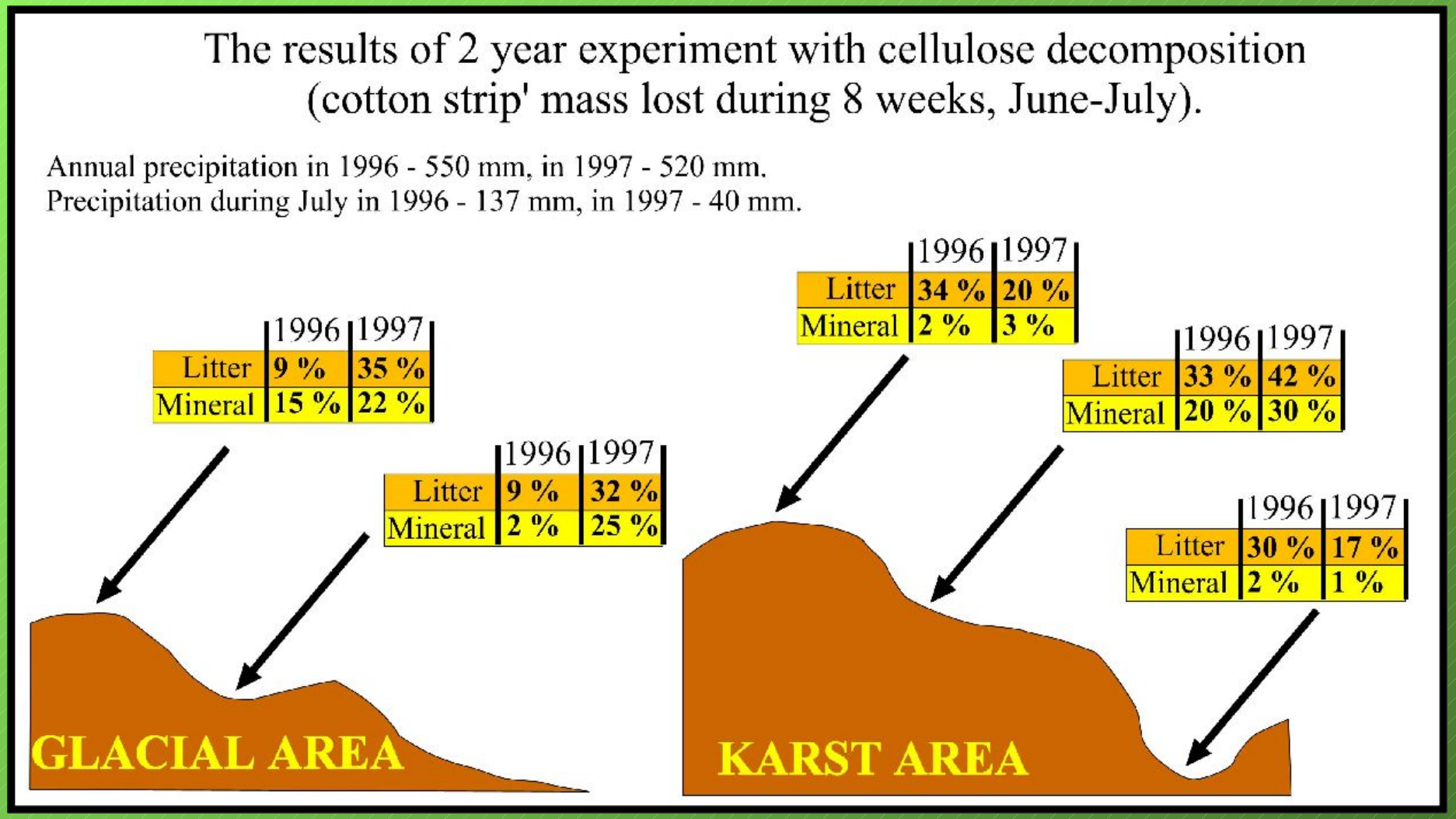
Glacial landscape, local top +5,5 ^{0}C

Glacial landscape, local bottom +4,6 ^{0}C

Karst landscape, local top +6,1 ^{0}C

Karst landscape, local bottom +2,5 ^{0}C

The inflience of warm and moisture on microbial activity: cellulose decomposition



Phonological observations

Species	Phase	"morine", slope	"morine", bog	"karst", slope	"karst", Sink-hole
Vaccinium myrtallus	Spreading of leaves	29 May	29 May	28 May	-
	Mass florescence	**13 June**	**20 June**	**12 June**	-
	Drupe bletting	5 August	1 August	1 August	-
Picea obovata	Growth of sprouts	**13 June**	**-**	**13 June**	-
Betula pendula	Spreading of leaves	**27 May**	**-**	**29 May**	-
Oxalis acetosella	Beginning of vegetation	-	-	29 May	6 June
	Beginning of florescence	-	-	5 June	13 June
	Mass florescence	-	-	13 June	20 June
Orobus vernus	Beginning of vegetation	-	-	25 May	6 June
	Budding	-	-	28 May	13 June
Geranium sylvaticum	Mass florescence	**2 July**	**-**	**4 July**	**25 July**
Aconutum barbatum	Mass florescence	-	-	16 July	25 July

Total number of invertebrates entrapped during June–September 1996

Systematic groups	Spruce forest on karst	Spruce forest on glacial
Lumbricidae (Oligochaeta)	5	1
Phalangidae (Arachnida)	70	10
Aranei (Arachnida)	51	42
Julidae (Diplopoda)	4	2
Carabidae (Coleoptera)	147	38
Staphylinidae (Coleoptera)	45	25
Curculionidae (Coleoptera)	10	16
Formicidae (Hymenoptera)	189	133

Cold microclimate in karst sink-holes and at entrances of caves allows to habiate some arctic-alpine species

At karst area there are some atypical plant species, such as

relic arctic-alpine ones: *Arctous alpina, Dryas octopetala, Pinguicula alpine*;

boreal Siberian: *Atragene sibirica, Diplazium sibirica*;

nemoral: *Stellaria nemoralus, Paeonia anomata*;

endemic: *Gypsophyla uralensis subsp. pinegensis, Thymus talievii* and others.

Heat keeping inside caves allow to *wait for the end of a winter season.*

The population of flyes *Helomisa serrata* habitate in karstcaves during a winter. The freezing of ice masses is weak generator of a heat in a cave.
Flyes are active on a ice at 0 to -2 ^{0}C.

General biodiversity in study area (the territory of Pinezhsky Natural Reservation)

Karst landscapes increase the biodiversity of **vascular plants.** **80%** of plant species occurring on the reserve are found within such landscapes, whereas glacial landscapes can support only **20% of species**. This is associated with the appearance and continuous growth of rare and relict species and also with an increase in the proportion of secondary forests as part of the total vegetation cover of karst landscapes.

For the **bryoflora** of karst areas, the total number of species reaches **127** (as compared to **107** in glacial landscapes). The share of sphagnum species is slightly less.

For the **lichenoflora**, the number of species that **grow on bare rocks is doubled (43 species)**. The share of **epiphytic lichens** also extends up to **72** species (as compared to **64** in glacial landscapes), which is connected with the appearance of open woodlands and better supply of sunlight.

Fishes increase their biomass in karst lakes with their high concentration of salts. Most likely, this is due to the increase in the biomass of crustaceans *Amphipoda* in calcium-rich karst lakes; the presence of calcium facilitates the growth of their chitin cover.

Amphibians and reptiles increase their numbers in karst areas due to the appearance of meadows and secondary forests.

Birds are influenced by karst in two ways. Firstly, the number of species living in water-bog habitats is decreased. Secondly, the total frequency of bird occurrence is higher in karst areas, together with the appearance of specific alpine species (*Motacilla cinerea, Mergus merganser, Cinclus cinclus*).

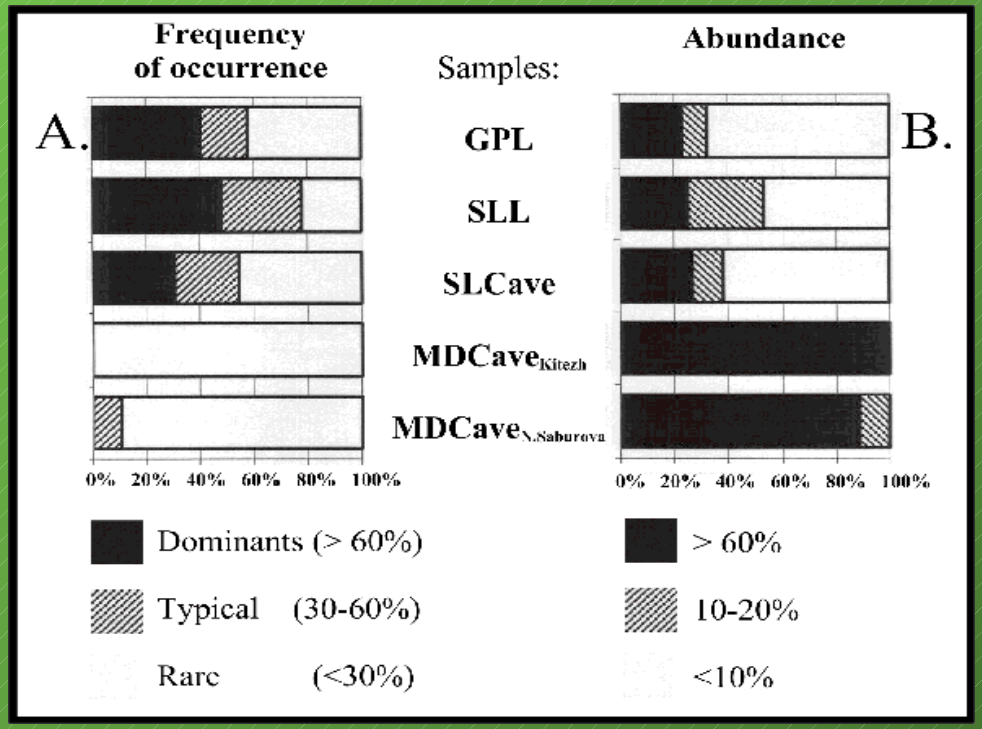
Small mammals. Mice-like rodents increase in numbers within meadow phytocenoses. Some species totally disappear in karst areas (*Castor fiber*, *Ondatra Zibetica, Sciurus vulgaris*), while others significantly increase in number due to a richer supply of their specific food sources or shelters (*Eutamias sibiricus, Lutra lutra, Musteia erminea, Vespertilio nilssonii*). Certain species are not specifically influenced by karst (*Lutreola vision, Lepus timigus, Mustela martes*).

Large mammals. Moose increase in numbers in karst areas due to a better nutrition base (meadows and smaller trees). Bear (*Ursus arctos*) prefer karst areas, because of the ease of finding shelter (although dens are rarely be found in caves, bears often make their dens among fallen trees and branches in large karst depressions). The frequency of foxes (*Vulpes vulpes*) decreases in karst landscapes. The influence of karst on large predators (*Canis lupus, Lynx lynx, Gulo gulo*) has not been revealed.

Some features of microbocoenosises in caves

Cave microbial communities were overall quite similar to those from surface soil horizons located over the caves, with some substantial structural and functional differences, including: replacement of dominant species and the appearance of new, rare species; the prevailing growth of oligotrophic and psychrotolerant forms; the changes in kinetic growth parameters, and probably also the changes in the strategy of organic substances consumption under other microclimatic conditions.

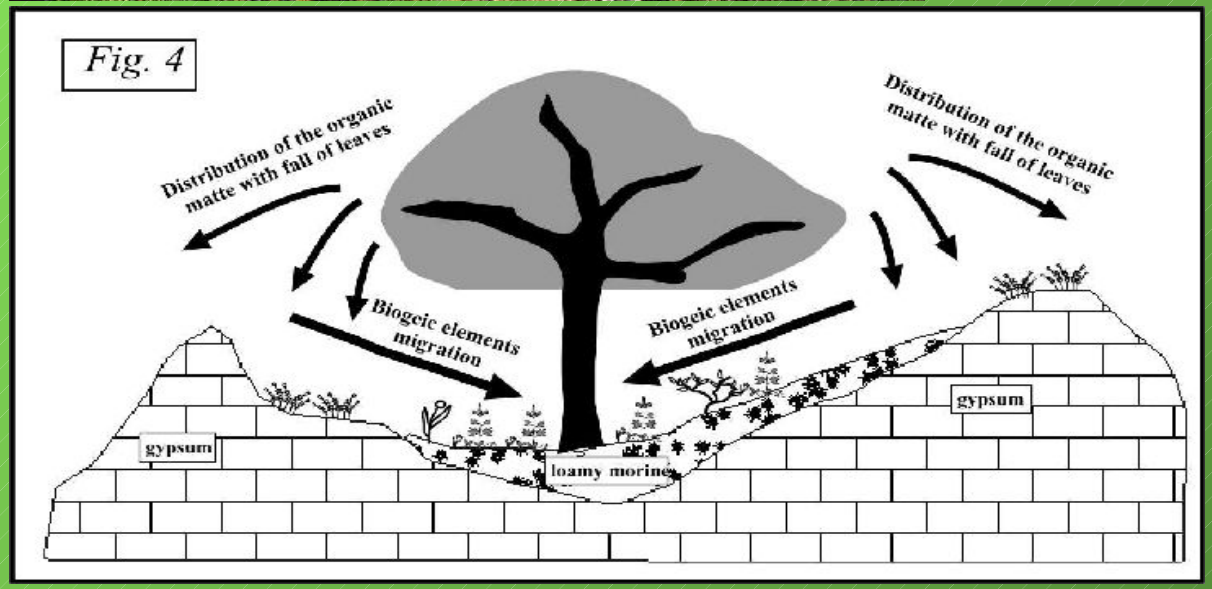
The prevalence of rare but abundant species of fungi together with their "dotted", random pattern of isolation is caused by barrenness and discreteness of organic substrates existing in cave clays, which is a specific feature of cave habitats. The massive growth of one predominant population (one species) within such discretely distributed substrate-containing areas is possible in the absence of interspecific competition in the circumstances of disruption or termination of continuous progression of fungal succession which takes place in the process of decomposition of organic substrates



Oligotrophic karstified open woodlands

Trees and shrubs grow only in depressions, whereas residual hills and steep slopes are occupied by lichens and grasses. Our observations on the colonization of bare rock surfaces and sod formation allow us to suggest that the relationship between the vegetation and the degree of topography dissection is even greater. Trees obtain mineral nutrients from silicate moraine deposits accumulated within karst depressions. The fall-off (leaves, needles, etc.) from the trees is distributed over a wide area including the tops of residual hills.

We also studied the rates of cellulose destruction (by application of paper filters) in these soils. The cellulose destruction in the soil litter under trees (that consists mainly of green mosses) is faster than in the soil litter of the bare patch (that consists of green mosses and lichens): 40% vs. 29% per month. However, such rates in mineral horizons are approximately the same: about 4-5% per month.



The influence of karst on forest vegetation in the zone of tundra.

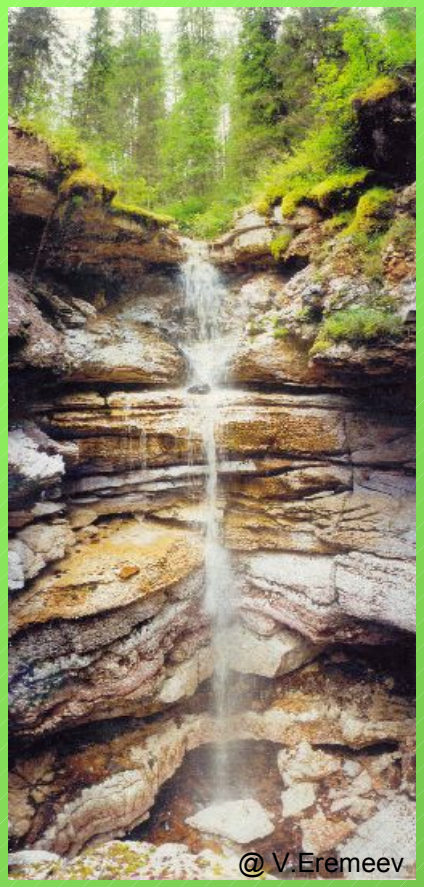
Typical ”south tundra”

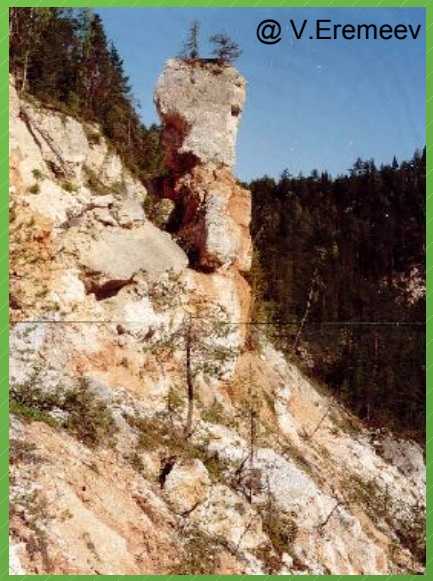
The possible reason of the growth of trees at karst area:

1. A snow in sink-holes protects young plants and seeds from strong frosts in winter period.

2. Good drainage and low content of ice in frozen soils

The area in the same region, where gypsum bedrocks bedd in the depth about several meters under loamy morine deposits





BIODIVERSITY

The diversity of habitations, biotopes

Geodiversity:

bedrocks, relief, geochemistry

Microclimate diversity:

destribution of a warm and a moisture caused by karst relief and caves

Speed of processes:

daily contrasts, collapses and landslides

Conclusion

!!! The biodiversity is higher in areas were karst processes have a place. !!!

Thus, the wide spectrum of temperature and moisture conditions in karst areas accounts for the close co-existence of species of soils, plants and animals that are typical for both colder and warmer regions. The appearance of new, atypical regimes of soil functioning affects soil microorganisms, plants and, consequently, cursorial animals that choose their food base and place for resting and nesting. Karst areas in northern taiga can shelter some relict arctic-alpine species within sink-holes and support specific oligotrophic plants growing on rock outcrops; karst areas in tundra provide for the development of forest vegetation. In other words, karst processes & topographical features are able to support more sophisticated landscape structures and ecological systems due to the diversity of habitats.