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Heat line in permafrost - a large experiment of transformation of the Arctic ecosystems

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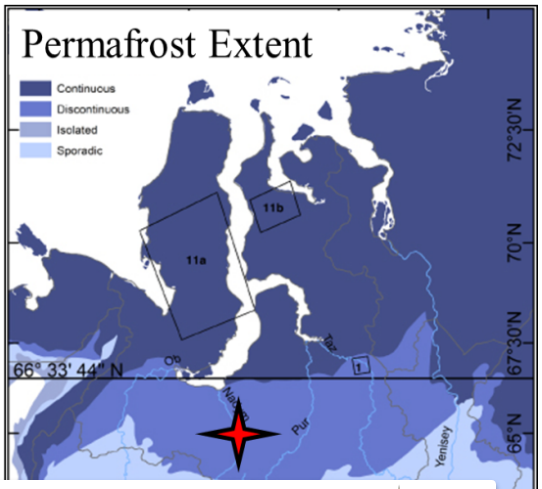
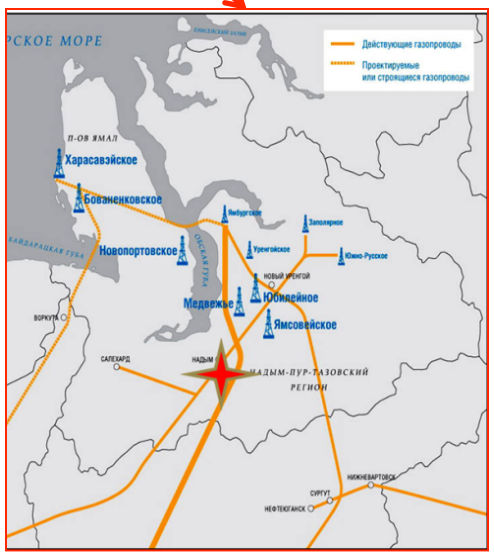
“Heat line” - what is it?

The last 50 years there is an active exploration of Russian permafrost zone, especially on north of West Siberia. The length of gas pipelines in Russia is more than 170 thousand kilometers. More than 10% of them constructed on the territory of the permafrost zone.

10000km of pipeline in permafrost area!





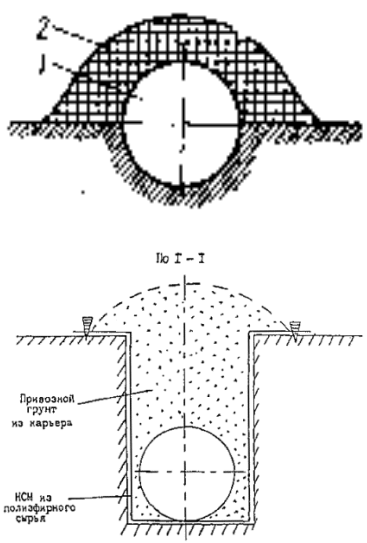
Permafrost extent and gas pipelines in West Siberia, Russia.

The most common method of gas pipelines construction in Russia is laying it on the soil surface or in a trench depth of 1.5- 2 meters and covered it with sandy mound up to 1.5 meters.

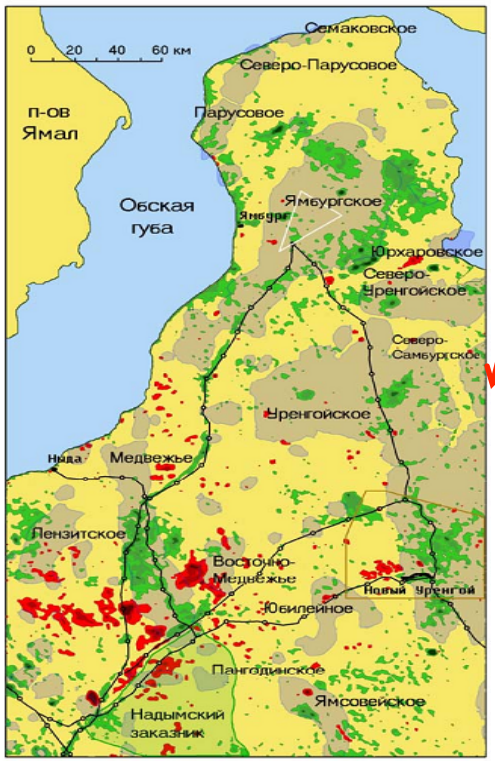
As a result there is a significant mechanical disturbance of the vegetation and soil cover and rapid permafrost degradation along the pipeline.

In many cases, the "hot" gas with a temperature above 0 is transported throughout the year.

Thus in permafrost zone for decades around the clock working
a HUGE HEATER!!



What happens now?

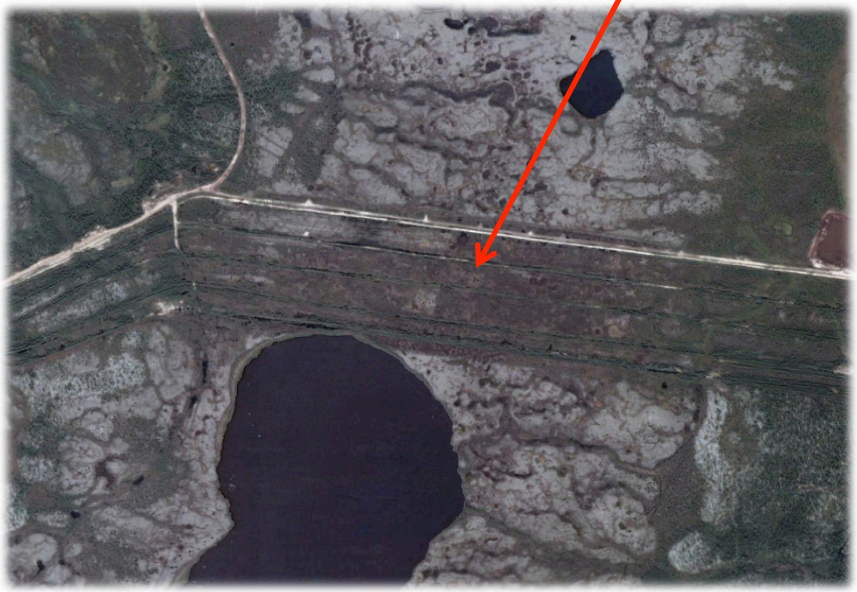


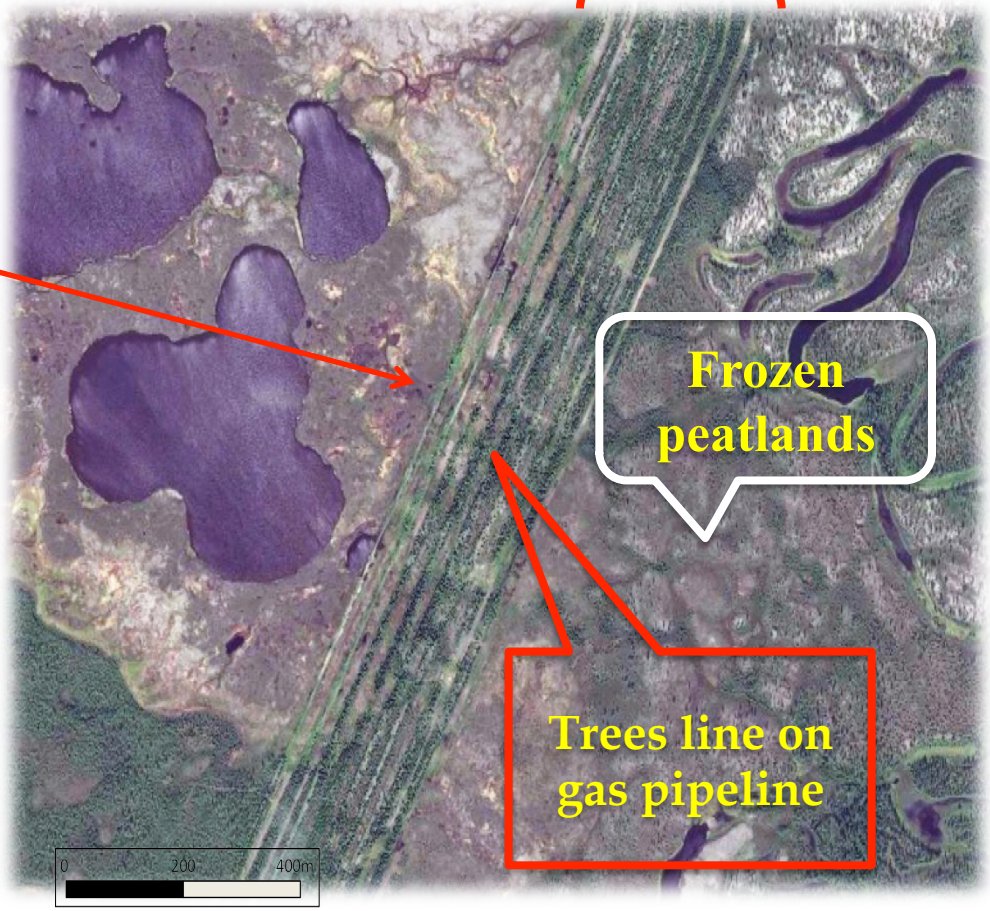
[Kornienko et al. 2005].

Taz Peninsula - area with transformed vegetation take at least 14% (10 thous. Km2). These changes occurred during the period of Urengoy gas field development. One third of these areas relate to the construction facilities of gas pipelines

Gas pipelines

Trees expansion

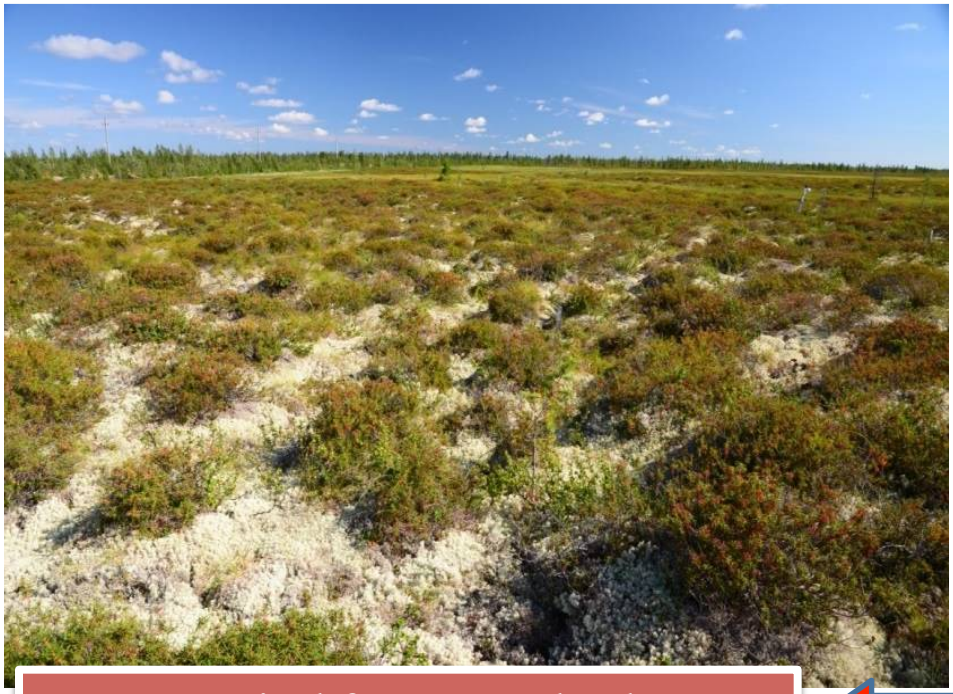




Having grown up on the gas pipeline mushrooms. Forest-tundra

This we see in the field:

Now we can see large difference landscapes along the gas pipeline from the natural undisturbed landscapes.



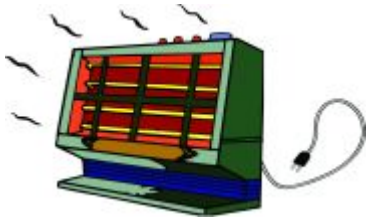
Typical frozen peatland

Thawed peatland near the gas pipeline

100 m

Main Idea

- The pipeline is a kind of "heater", providing year-round warming effect on the surrounding cryogenic ecosystems.



- **The aim** of this study is to evaluate the impact of the gas pipelines construction and operation on the ecosistems in permafrost area

The research area is located within the forest-tundra, the discontinuous permafrost zone. This is hummocky tundra with frozen peatlands which have a complex of vegetation with a dwarf-shrub community on the hummocks and a lichen community in the inter-hummock areas. Permafrost occurs below 60 cm. Typical soils are Turbic Cryosol, Peat thickness < 50cm

Field studies were carried out in August, 2013 - 2015, along the the Nadym-Punga gas pipeline, 40 km south-west from the Nadym city, Yamal Nenets AutonomousDistrict, Western Siberia, Russia (N65º18’53.2’’ E72º 52’ 52.1’’).

Gas pipelines in frozen peatland

In 1974 gas pipeline Nadym - Punga was put on the surface of frozen peatland. After reconstruction in 2004 pipe was buried at a depth of 1.5 m, and the top was covered sandy mound 1 m.

The main types of impacts on ecosystems were: mechanical disturbance of soil and vegetation (5m usually), flooding. Later added warm effects as a result of the warm gas transportation and permafrost degradation.

Pipeline on surface of frozen peatland, 1974

The transported gas is «warm» with temperature from 4 to 22 °C.

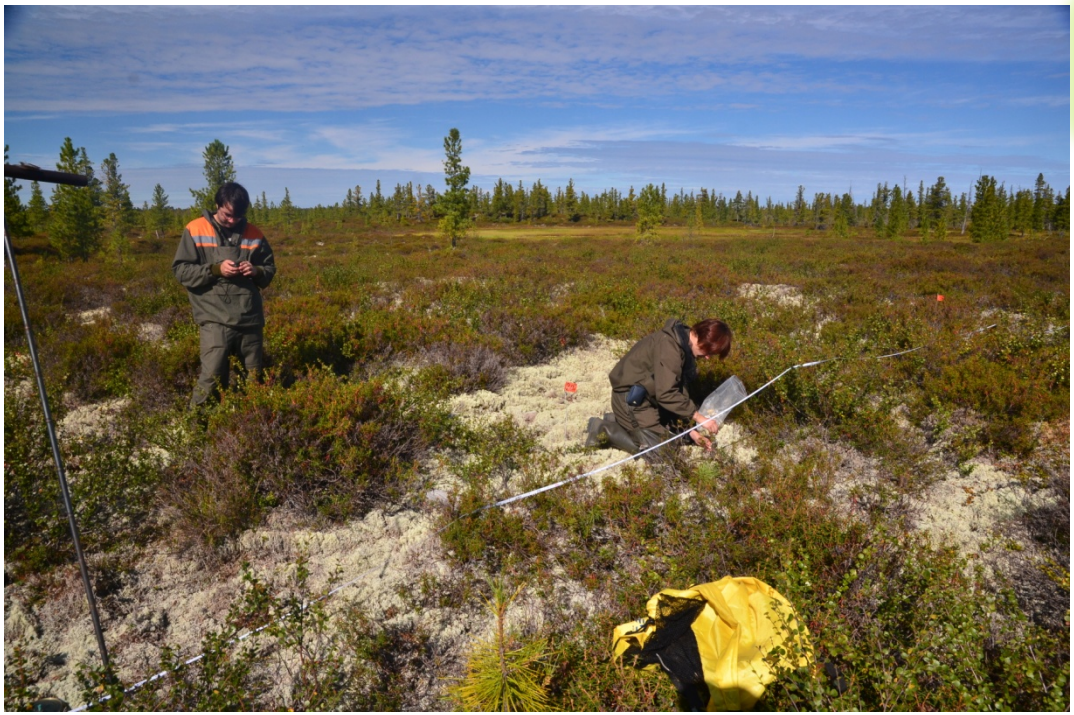
2004

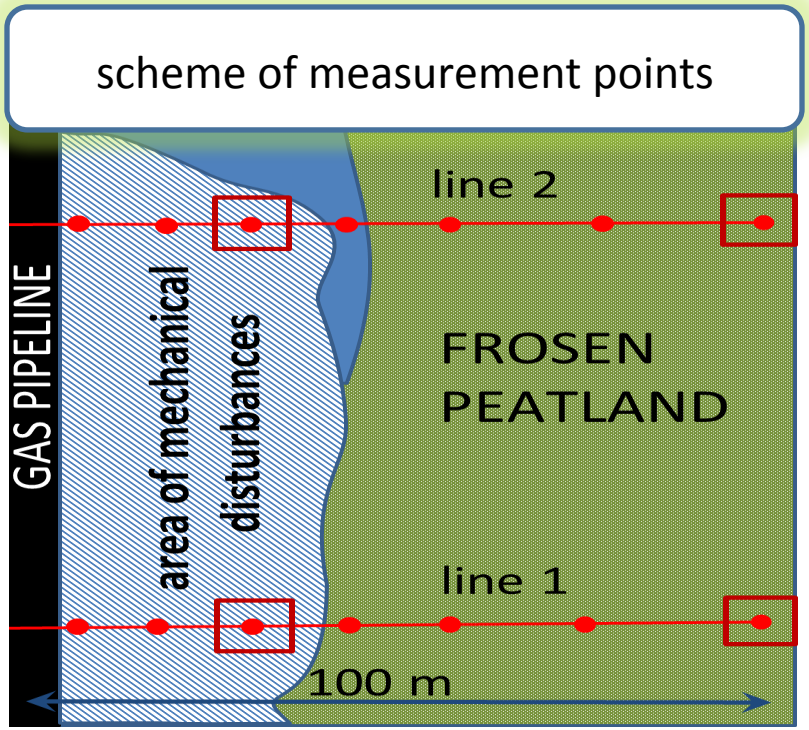
2007

2009

2014

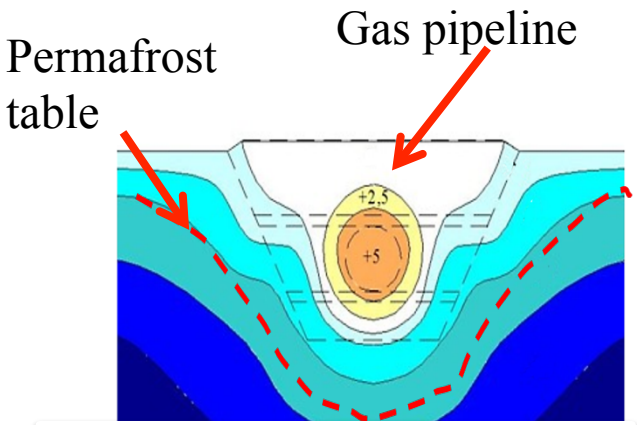
During 2013-2015 were carried out monitoring the active layer depth, soil temperature and moisture, CH_4, CO_2 efflux. 5 transects (40 m) with sampling points every 5 meters were made across the pipeline and undisturbed sites of typical frozen peatlands. In the laboratory typical properties of soils, microbiological activity and the labile organic matter were measured. Analysis of the data carried out in the Statistica 7.0 for the 5 transects.



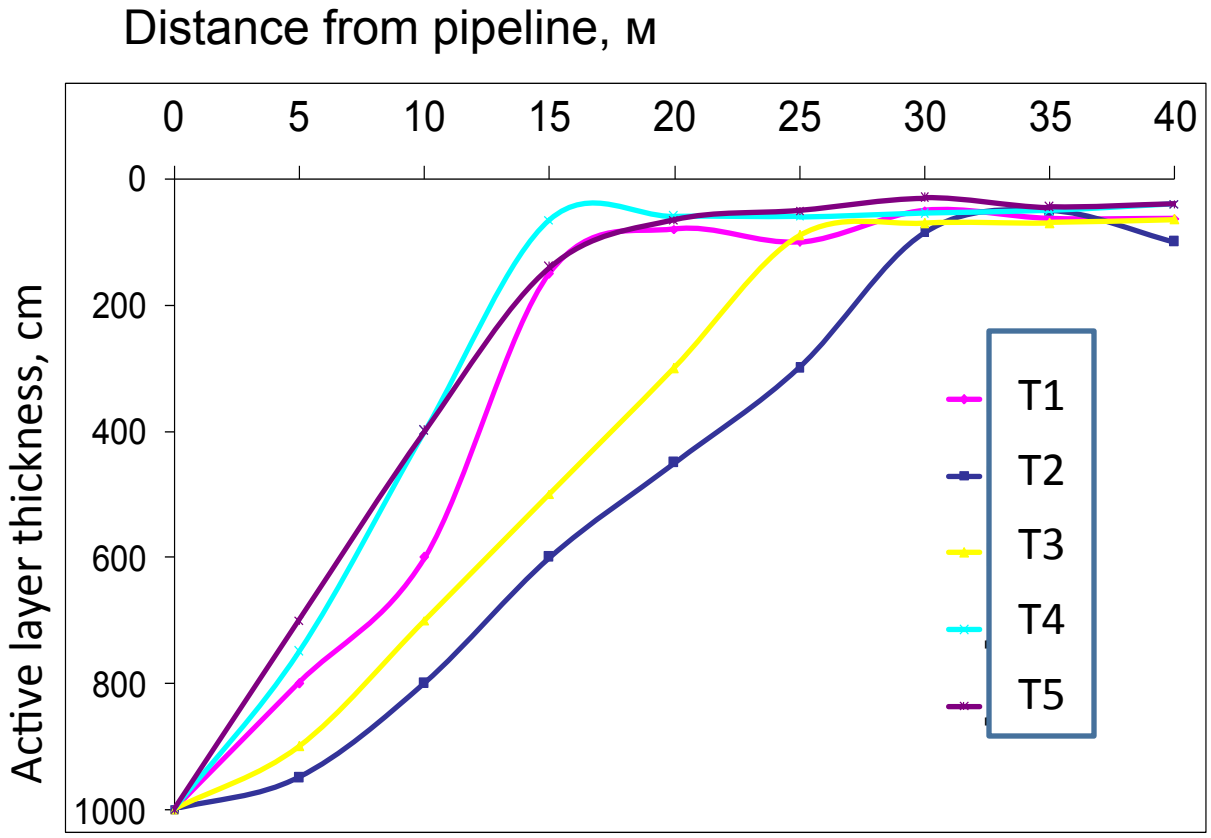


RESULTS, DISCUSSION

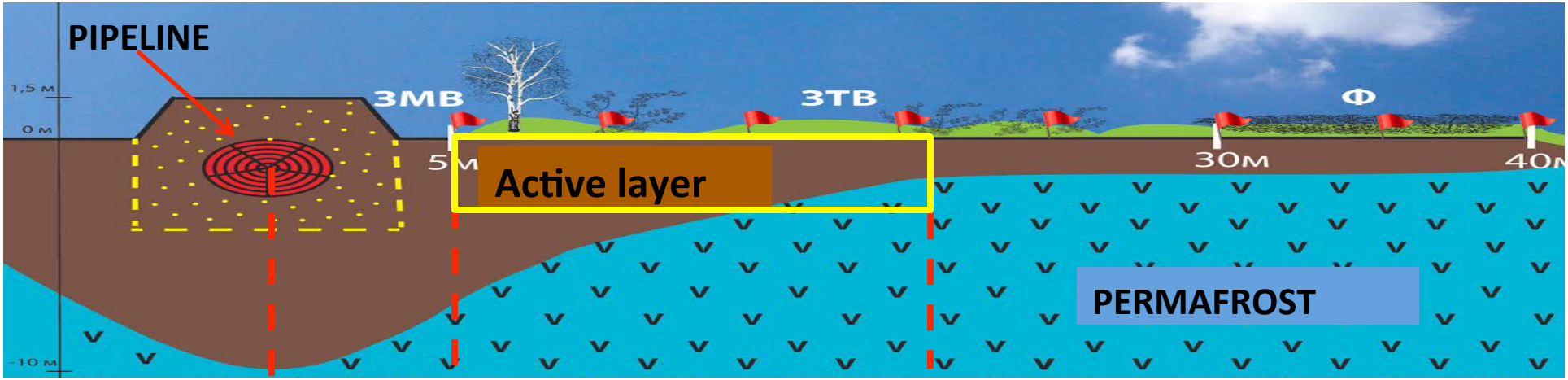
The first question is - how far the impact?



Permafrost table under the gas pipeline dropped from **0.5 to 6 meters** during the first 2 years of pipeline operation [Kharionovsky, 2000].!



Active layer thickness at distances up to 20 m from the pipeline is significantly increased (2-3 times) than on the control sites (30 m and more from pipeline).



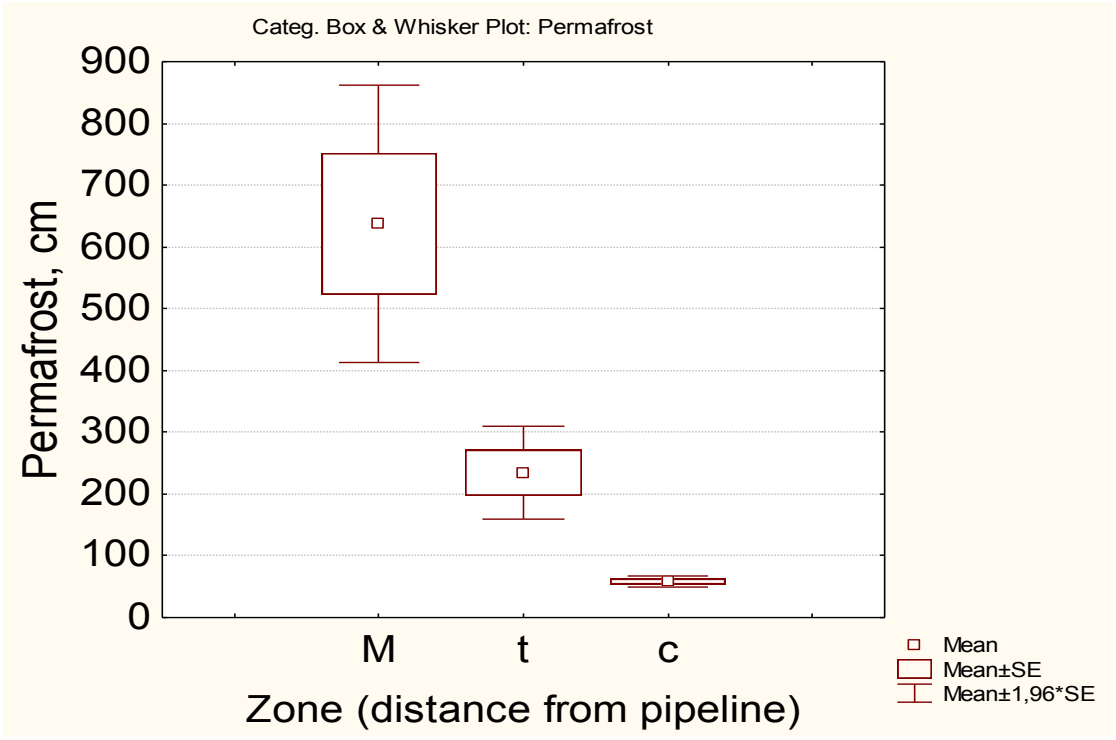
Zone M
(mechanical disturbance)
0-5m from pipeline

Zone t
(warming disturbance)
5-20m from pipeline
Active layer >2m.

Control zone – c
(no disturbance)
>30m from pipeline

sampling points

disturbed soil



0 m (pipeline)

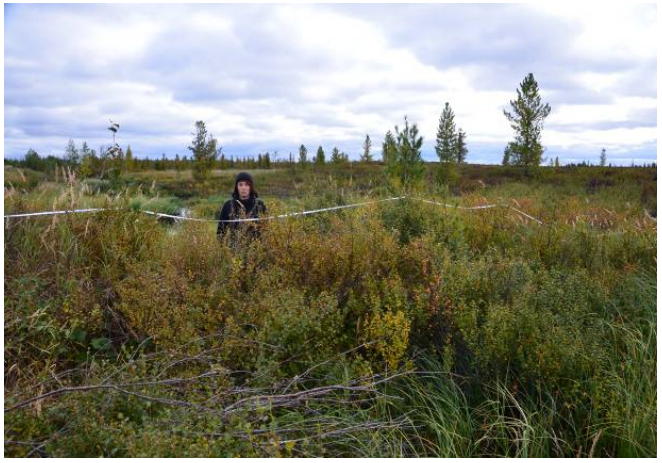
40m(typycall frozen peatland)

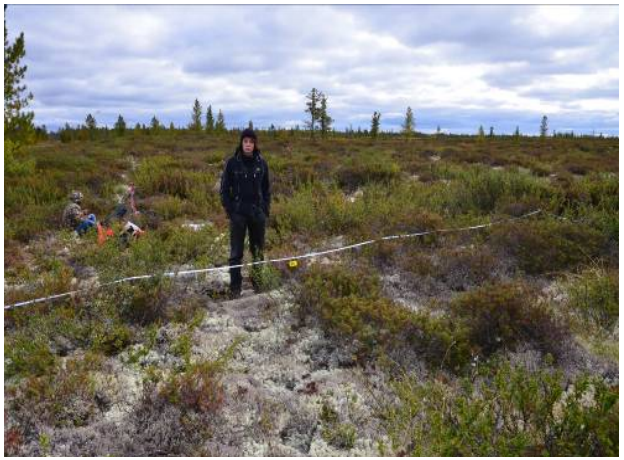
Transect 1

Zone M
(0-5m from
pipeline)

Zone t
(5-20m from
pipeline)

Control zone
(>30m from pipeline)

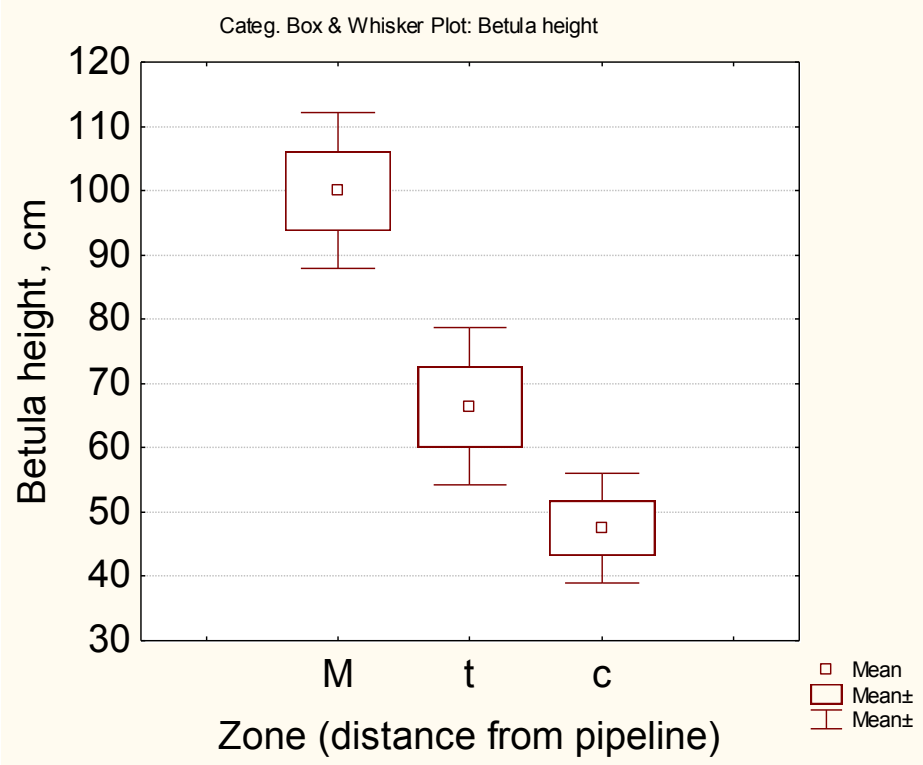


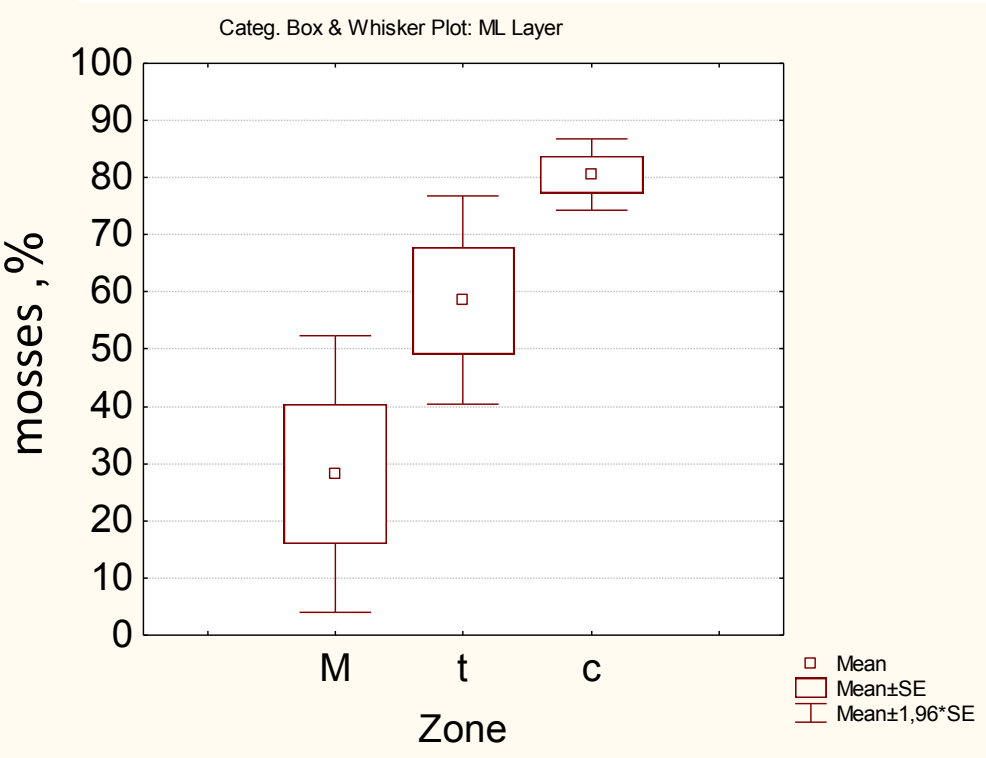


Transect 2

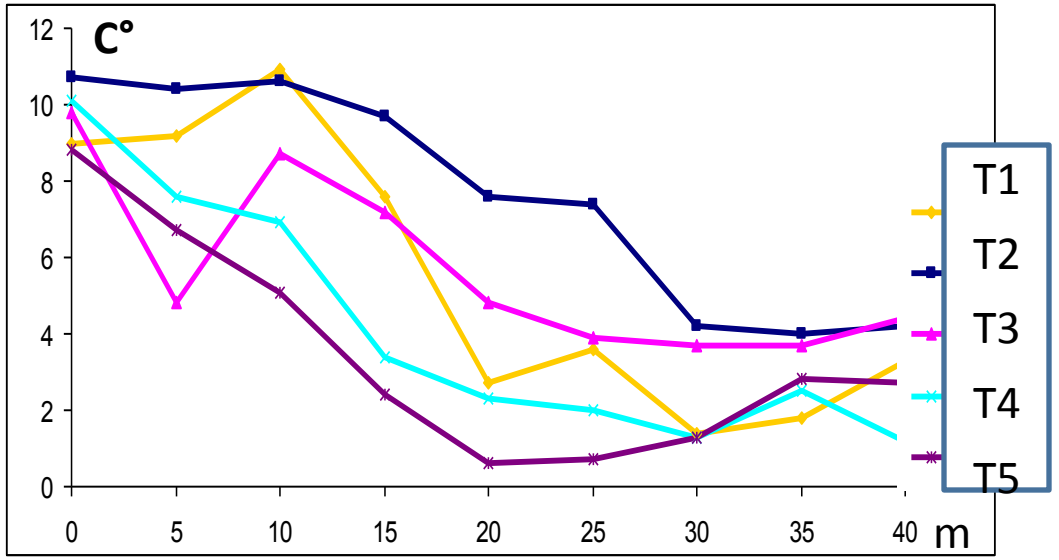
Betula nana near pipeline – А
Typical Betula nana – Б

After 40 years of operation, the area along the pipeline is actively overgrowing with not specific vegetation communities for peatlands, there is an active expansion of tree species (birch, etc.). Significantly reduced cover of mosses and lichens and increasing proportion and size of vascular plants.

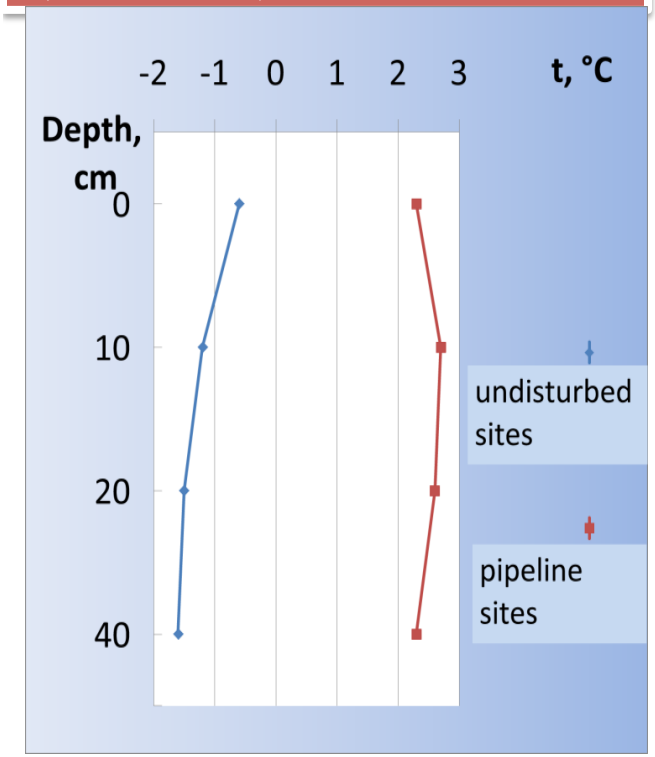




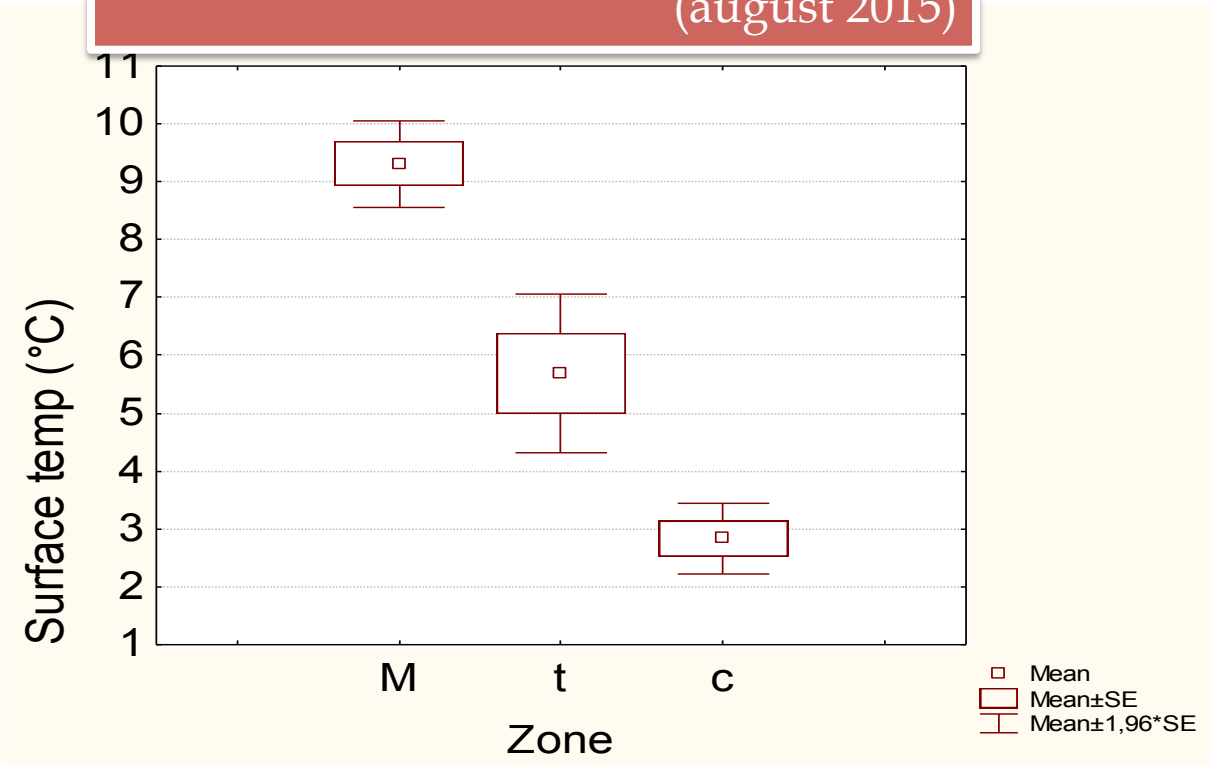
Soils near the pipeline are warmer. Average annual temperatures of soils close pipeline are **2-3 times higher** the average temperatures of the undisturbed soils. Summer temperatures of soils close pipeline **are higher by 5-10°C**. Soils close pipeline are unfrozen **for 2-3 months longer**.



The average annual temperature of soils, (2013-2014)

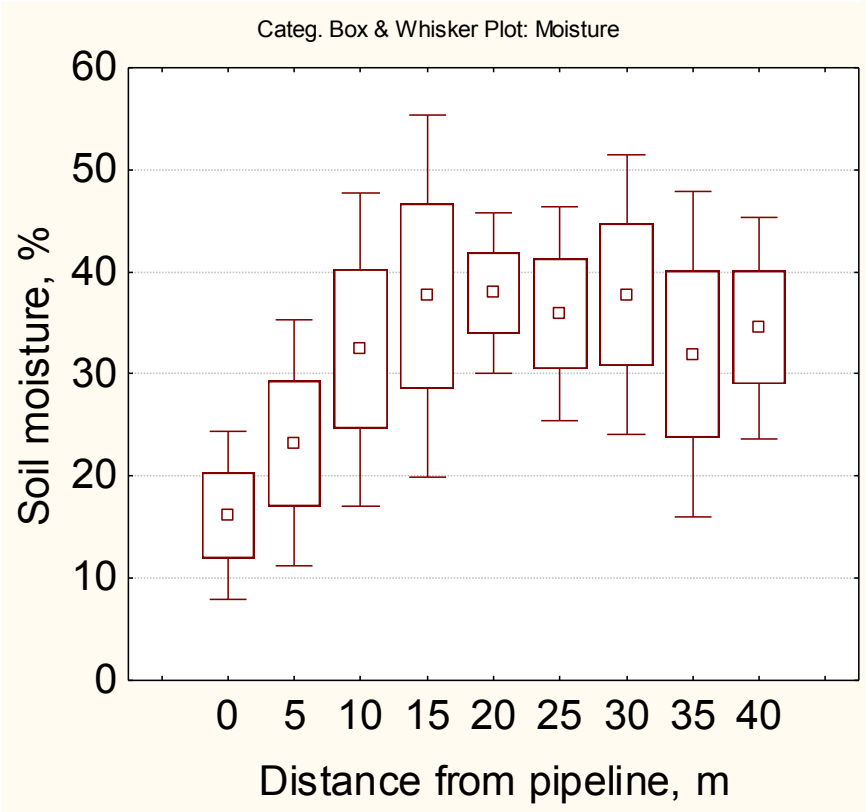


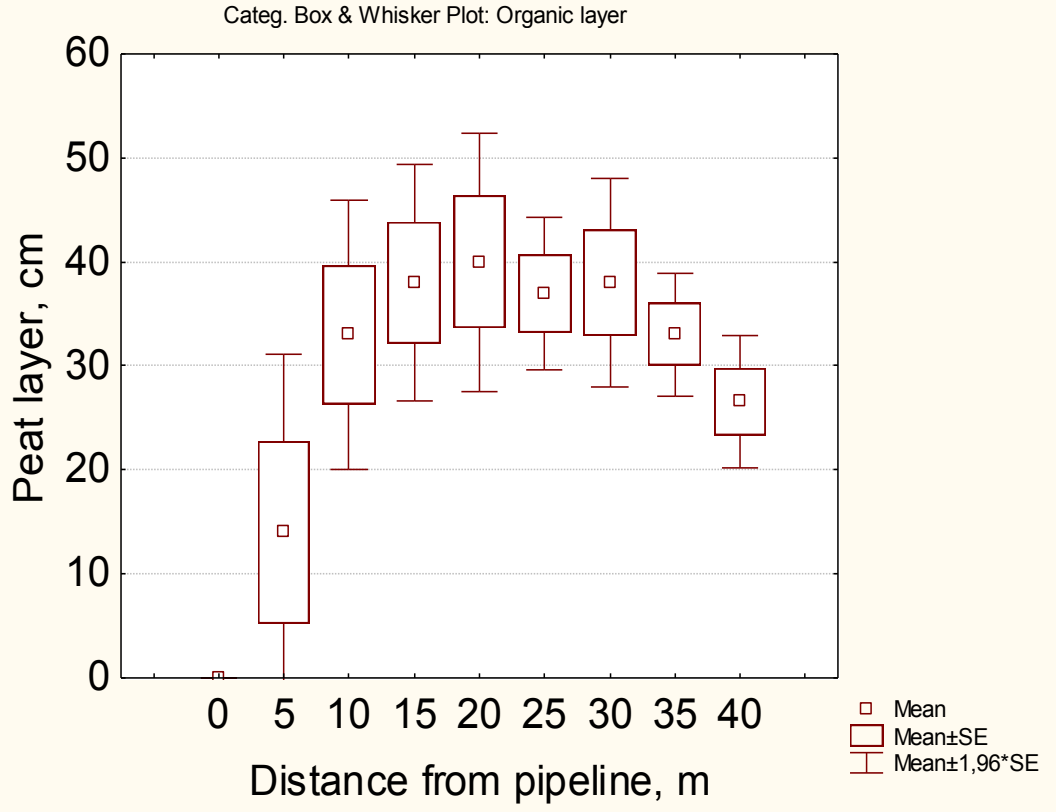
The average daily temperature of soils, (august 2015)



As a warming effect on the soil properties after 40 years?

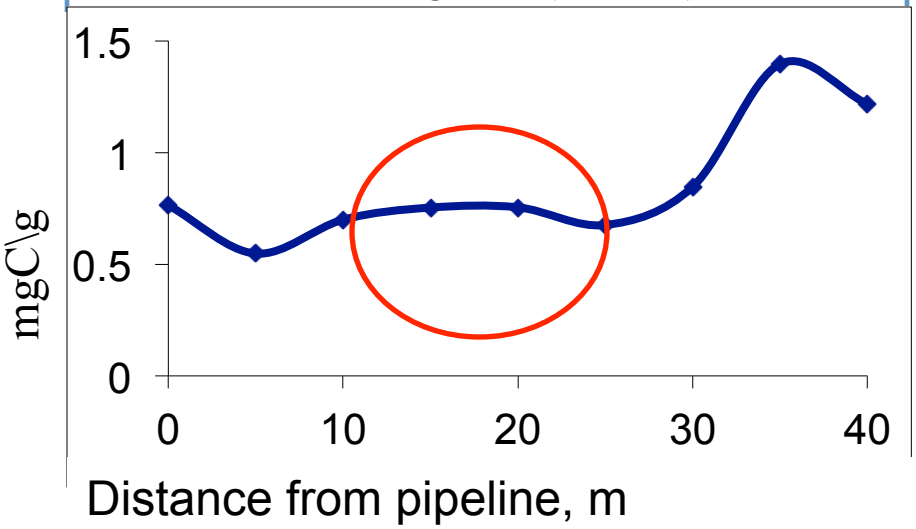
Moisture and peat thickness - no differences



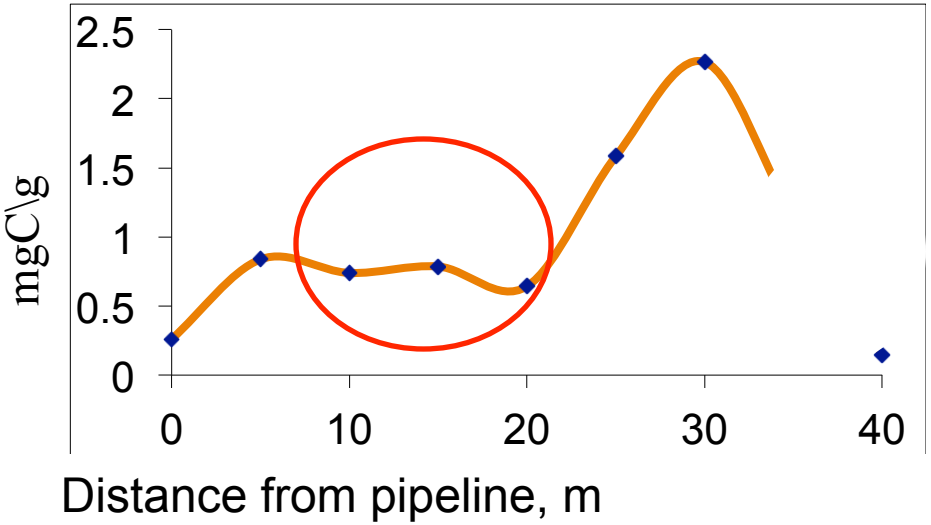


Laboratory experiments have shown that there is a significant change in the biological activity of the soil around the pipeline: increased microbial biomass, reducing its activity, increased of labile organic matter (*WEOC, WEON*).

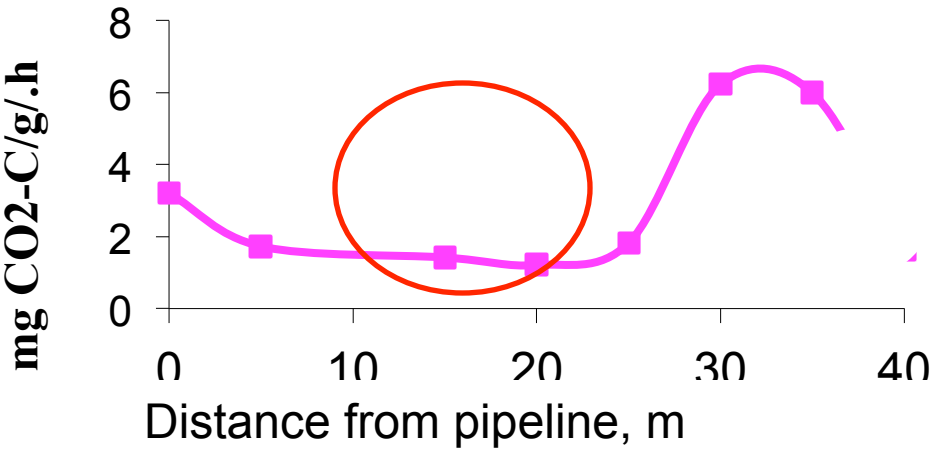
labile organic (*WEOC)*



microbial biomass (C mic)



Basal respiration



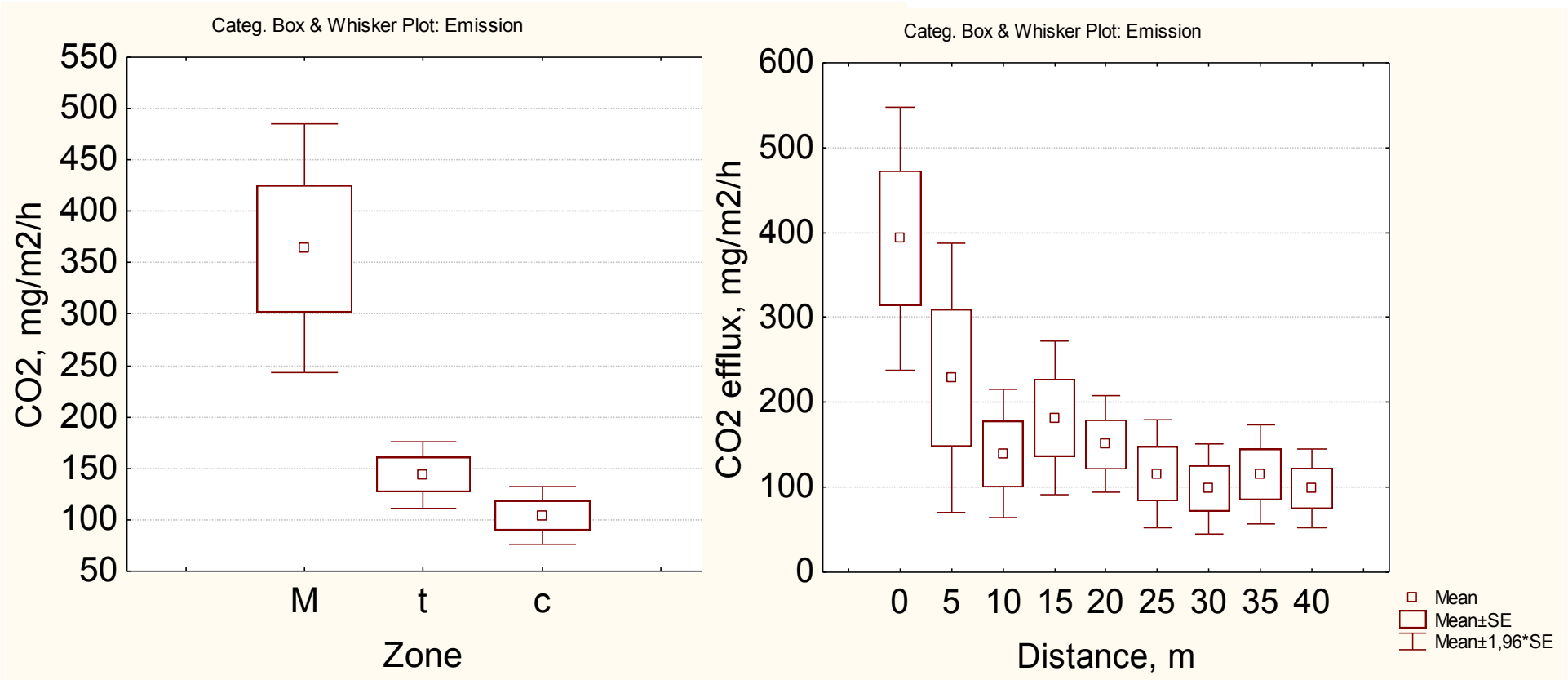
ZONE t

Warming - a negative effect on microorganisms

In dry conditions, not found differences CO2 efflux close pipeline and undister. Increase **by 3-5 time**s (100 – 500 $mgCO_2m^{-2}h^{-1}$ resp.) we see only in the zone of mechanical disturbances. In wet conditions was an increase in CH4 efflux by **3-10 times** (5 – 50 $mgCO_2m^{-2}h^{-1}$ resp.).

Nature is the very buffer system and can adjust the impact

CO2 efflux, mg/m2/h - no differences! (have only in the zone M)



CONCLUSIONS

Construction and exploitation the pipelines with warm gas in Permafrost zone give a significant warming effect. The width of the pipeline influence up to 30 meters on each side. So - hundreds km2 cryogenic landscapes along the gas pipeline system on Russian North are in the impact zone.

The main result is permafrost degradation and changing ecosystem.

Nature is the buffer system and can adjust the impact

The impact of the pipeline with a warm gas can be regarded as a model of warm effects on the ecosystem of the North in the study of the climate change effects.

ACKNOWLEDGMENTS

Thank you for attention

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