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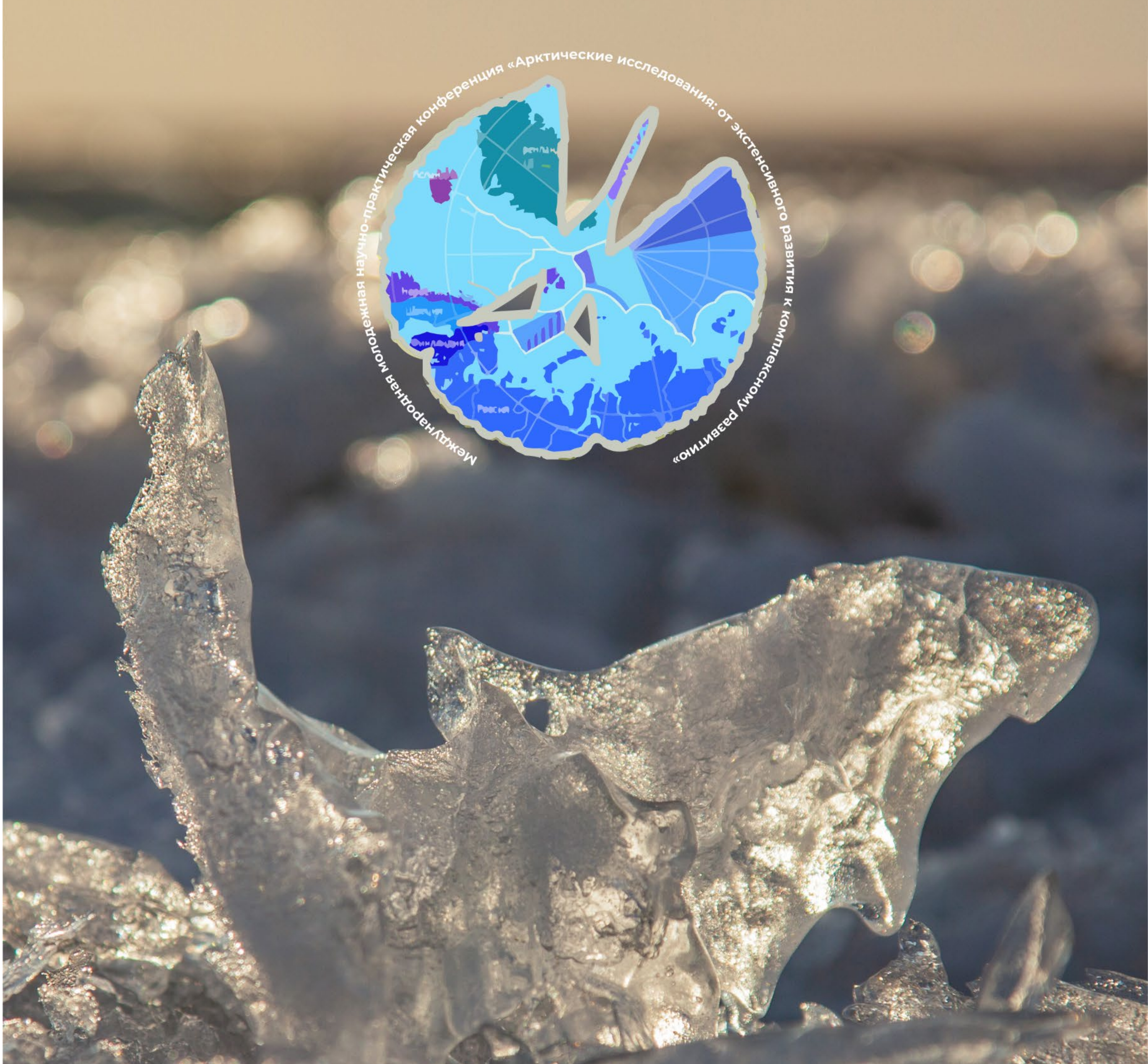

17-19 апреля 2024 года

IV Международная молодежная научно-практическая конференция

АРКТИЧЕСКИЕ ИССЛЕДОВАНИЯ:

от экстенсивного освоения к комплексному развитию

г. Архангельск

Министерство науки и высшего образования Российской Федерации

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АРКТИЧЕСКИЕ ИССЛЕДОВАНИЯ: ОТ ЭКСТЕНСИВНОГО ОСВОЕНИЯ К КОМПЛЕКСНОМУ РАЗВИТИЮ

Материалы IV международной молодежной научно-практической конференции (Архангельск, 17-19 апреля 2024 года)

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А 826 **Арктические исследования:** от экстенсивного освоения к комплексному развитию : материалы IV международной молодежной научно-практической конференции (Архангельск, 17–19 апреля 2024 года) : [16+] / М-во образования и науки Рос. Федерации, Федер. гос. бюджет. учреждение науки Федер. исслед. центр комплекс. изучения Арктики им. акад. Н.П. Лаверова Рос. акад. наук, Федер. гос. образоват. учреждение высш. образования «Сев. (Аркт.) федер. ун-т им. М. В. Ломоносова» ; науч. ред., сост.: Воронина Л. В., Якушева У. Е. — Архангельск : [б. и.], 2024. — 420 с. : ил.

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Сборник содержит результаты исследований и разработок международных и российских ученых, аспирантов, студентов. Труды исследователей охватывают целый спектр вопросов и проблем развития Арктики: ее социально-культурное и экономическое становление, существующие медико-биологические проблемы, специфику адаптации человека в арктическом регионе, состояние и сохранение экосистемы и система охраны окружающей среды, особенности промышленного производства и хозяйственного уклада, а также перспективные для внедрения и уже применяемые в нем информационные технологии. Материалы конференции предназначены для научных работников, преподавателей вузов, аспирантов, студентов и специалистов.

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ECOLOGICAL ASPECT OF PERMAFROST DEGRADATION

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Abstract: Permafrost plays an important role in global climate change, in the balance of greenhouse gases, arctic environment ecosystems, and human activities in the Polar Regions. Permafrost, characterized by the continuous presence of frozen ground for two or more consecutive years, constitutes a vital component of Earth's cryosphere and plays a pivotal role in global climate regulation and ecosystem functioning. However, with accelerating climate change, permafrost degradation has become increasingly pronounced, posing significant ecological challenges worldwide. This review provides a comprehensive overview of the ecological implications associated with permafrost degradation.

Keywords: Degradation, Permafrost, Ecological, hydrological, greenhouse gas, Ecosystem, Soil, Vegetation.

Firstly, the physical changes induced by permafrost degradation, including ground subsidence, thermokarst formation, and altered hydrological regimes, have profound effects on terrestrial ecosystems. These alterations disrupt habitat suitability, soil stability, and nutrient cycling, thereby influencing the distribution and abundance of plant and animal species. Additionally, the release of greenhouse gases such as methane and carbon dioxide from thawing permafrost exacerbates climate change, creating a positive feedback loop that further accelerates permafrost degradation (Figure-1).

Secondly, permafrost degradation alters the dynamics of soil microbial communities, which play crucial roles in nutrient cycling, decomposition, and greenhouse gas emissions. Shifts in microbial composition and activity can lead to changes in ecosystem productivity and resilience, with potential cascading effects on higher trophic levels.

Besides, thawing permafrost affects the availability and quality of freshwater resources, particularly in Arctic and sub-Arctic regions, where permafrost underlies extensive areas. Changes in hydrological regimes influence the structure and function of aquatic ecosystems, including alterations in water temperature, nutrient concentrations, and habitat availability for aquatic organisms (Table-1). Moreover, permafrost degradation poses significant socio-economic challenges, especially for Indigenous communities reliant on traditional livelihoods and ecosystem services. Disruptions to infrastructure, such as roads, buildings, and pipelines, further compound the economic costs associated with permafrost thaw. Here, permafrost degradation usually occurs when wildfire disturbs the surface organic layer, changes in lateral flows of water thaw the edges of permafrost plateaus, or changes in air temperature or snow cause raised permafrost communities to collapse into the wetlands [1].

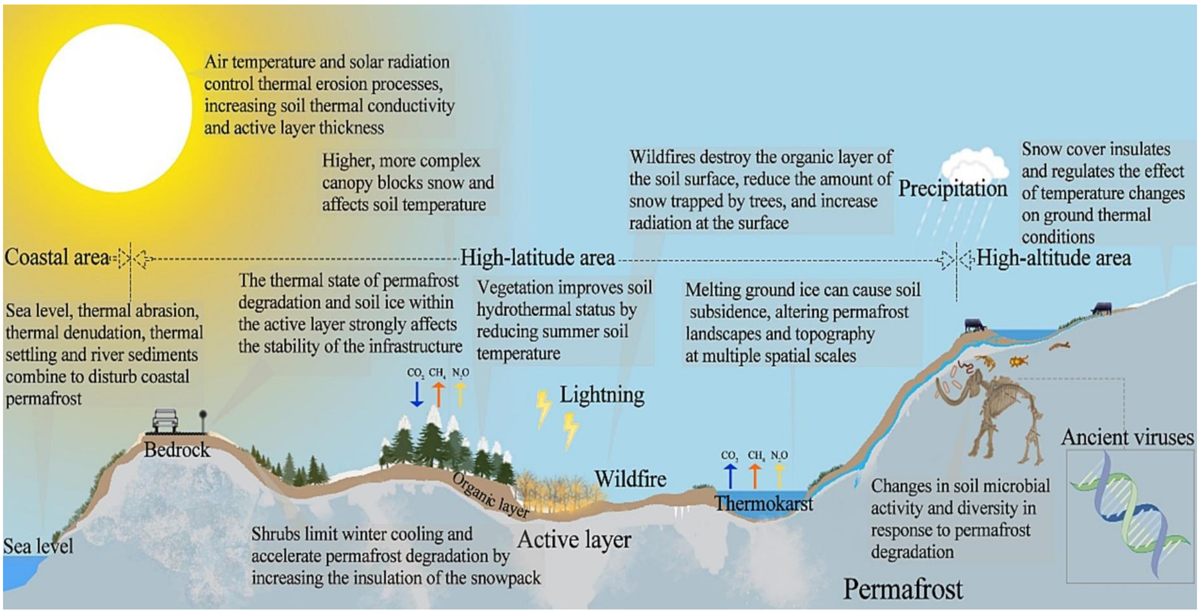

Figure 1 – A schematic representation of the factors influencing the degradation of permafrost in the Arctic and Subarctic [2]

Ecological and geomorphological processes are highly sensitive to the phase change between water and ice. This transition point makes the structure and function of permafrost ecosystems unique and also vulnerable to major change in a warming climate. However, with accelerating climate change, permafrost degradation has become increasingly pronounced, posing significant ecological challenges worldwide. Here is a comprehensive overview of the ecological implications associated with permafrost degradation [3].

Table 1 – Ecological Influences on Permafrost

Region	Year	Permafrost Degradation	Change in Ecosystem/ Vegetation type/Soil water content	Change in Dominant Species	References
Northwest Canada	2001	35% degraded of the 263,964 hm^2	24.2 ± 0.3) % in forest and (72.5 ± 1.9)% in bog Increased	Nutrient regime is higher in collapse scar compared to bogs	[4]
Siberian Low Arctic, Russia	2018	Ground warming and Active layer increase (11.8 to 4.3m)	Shrub expansion	Alder (Alnus)	[5
Yukon Kuskoswim Delta, Alaska	2018	(5.3 ± 2.2)% of area	Terrestrial Ecosystem to wetlands	Lowland moist birch-ericaceous (5.0%) and water sedge (+1.7%)	[6]
Northern Siberia, Russia	2016	Active Layer Increase	N/A	Nonvascular plant diversity decreased	[7]
Arctic Lowland	2016	Permafrost thaw	(24.2 ± 0.3)% in forest and (72.5 ± 1.9)% in bog	Increase Nitrogen availability	[8]
Canadian Arctic	2015	Thaw Slump	Graminoids and forbs to forbs, dwarf shrub and bryophyte	Arctarostis latifolia and Salix arctica, S. pulchra and S. reticulata at 250-year tree site.	[0]
Northwest Territories, Canada	2014	Permafrost Thaw	Forest loss (0.26 ± 0.03)% per year from 1977 to 2010	N/A	[10]
Alaska	2012	Permafrost thaw	Water content was lower in permafrost Plateau (7.8 ± 0.0)%	Soil organic carbon is greater in permafrost plateau (137 ± 37kgCm^2)	[11]
Tundra near Prudhoe Bay Alaska	2015	Thermokarst extent increased 7.5% In 1949 to2012	Shrub to aquatic mosses and forbs	Dryas integrifolia, Salix arctica and S. Ianata to Calliergon giganteum	[12]
Canadian Arctic	2009	Ground Warming	Vegetation greening increased 0.49%e0.79% and 0.46%e0.67% over the High Arctic and Low arctic	Dwarf shrubs, forbs, mosses and lichens in High Arctic and dwarf shrubs in Low Arctic	[13]

In conclusion, permafrost degradation represents a multifaceted ecological issue with far-reaching consequences for terrestrial and aquatic ecosystems, global climate dynamics, and human societies. However, the role of summer precipitation relative to temperature is less significant. Although summer temperatures can be quite variable from year to year explaining the large temporal variability of ALT, permafrost temperature is a function of mean annual temperature and its amplitude and hence a more conservative characteristic, since inter-annual variations are smaller than seasonal variations from year to year. Addressing this challenge requires interdisciplinary research efforts to enhance our understanding of permafrost dynamics, develop effective mitigation strategies, and inform adaptive management practices that promote ecological resilience in a rapidly changing Arctic and sub-Arctic environment. Hence, it is suggested to coordinate a systematic approach by using the latest technologies for observations, monitoring and numerical modeling in the characterizing the degrading permafrost and vegetation with soil hydrology, as well as to understand the physical and biogeochemical mechanisms of ecological influences. Among them, monitoring, mapping and forecasting of ecological influences and permafrost ecological processes by using geophysics, remote sensing, laboratory incubation, and sophisticate permafrost ecological models deem necessary.

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