Polar Ecology Course 2024

The course is intended to show the students not only the attractive polar landscape and wildlife but also to actively engage them in ongoing research activities. Emphasis will be placed on involving students in research planning, designing research projects, and ensuring necessary logistics.

The course is divided into **a theoretical part**, taking place in České Budějovice during the week of May **20th to 24th, 2024**. During this phase, students will familiarize themselves with the functioning of polar ecosystems and their distinctive features compared to well-known mid-latitude environments. Lectures will be complemented by discussions on research planning and study design.

The **practical part** of the course is scheduled to be conducted at the Czech Arctic Research Station in Petuniabukta (Svalbard) for the **first two weeks of July 2024**. All students will participate in general excursions, showcasing prominent Arctic landscape processes (Holocene deglaciation, recent glacier retreat, water cycling, sediment budget, energy balance, climate fluctuations), wildlife (seals, reindeer, birds, microfauna, and potentially polar bears), vegetation (tundra habitat, pioneer species), and soil (micro)biology.

In addition to these experiences, students will work in three groups, each focusing on a specific research task led by an experienced researcher (Group 1 – botany and vegetation; Group 2 – soil microbiology; Group 3 – soil and freshwater zoology). The collected data and samples will be processed in the field lab and upon returning to České Budějovice.

A **final workshop**, featuring the presentation of results and in-depth discussions on the outcomes, will be held in České Budějovice **in the autumn 2024**."

Requirements:

1/ All students from the Faculty of Science are eligible to apply, provided they are enrolled during the course period (July 2024).

2/ Proficiency in English is mandatory, as fieldwork is typically conducted in collaboration with local researchers.

3/ A motivation letter is a prerequisite for application. Please explain your reasons for wanting to attend the course, emphasizing its significance for your future studies. Include any pertinent experiences from research, work, or travel in similar extreme conditions. Specify your research interests for this course. The letter should not exceed 5000 characters (ca 2 pages).

4/ While the course is financially supported by the Faculty of Science, applicants are expected to contribute 5000 CZK to cover additional expedition costs.

Topics covered by the course

In general, the course is focused on investigating the impacts of recent rapid warming on various aspects of polar ecosystems. For that we will examine diverse landscape processes (Topic 1) starting from the glacier dynamics and retreat. The retreat of glaciers creates new, untouched terrain for colonization by microorganisms, plants, and animals. Detailed exploration of these aspects will be undertaken within the subsequent three topics, each aligned with a specific research group (Topics 2, 3, 4).

1/ Landscape Processes

The biology of the Arctic is profoundly shaped by environmental processes operating on a landscape scale. Therefore, it is crucial to comprehend these processes to understand the ecological characteristics of the region. Students will have the opportunity to explore various landscape features that are distinctive to the polar environment, including glacier surfaces, glacier forefields, rugged mountain slopes, flat tundra plains, and coastal zones. They will gain insights into the long-term evolution of the landscape during the Holocene, with deglaciation as a primary driver of ecological development. Demonstrations will showcase recent indicators of past dynamics, such as marine uplift terraces, paleo samples like whalebones and mollusc shells, and geomorphic evidence of glacier-related activities such as moraines, eskers, and roche moutonnées. Students will also explore historical evidence of environmental changes by comparing historic photographs from the early 20th century with the current state of the environment. Past processes have left lasting imprints on the landscape, and we will investigate contemporary counterparts of such events, including glacier retreat and the reshaping of forefields through paraglacial processes such as fluvial, slope, and aeolian activity. The field course location has been under long-term monitoring, encompassing detailed atmospheric and soil observations through a network of automatic weather stations, as well as freshwater system monitoring. Modern monitoring methods will be introduced to students, and they will have the opportunity to see how long-term instrumental observations can be integrated with remote sensing techniques, such as drone mapping and the utilization of multi-temporal, high-resolution satellite-derived indices.

2/ Soil microbiology

Global climate change has led to retreating ice fronts in polar and alpine regions, uncovering previously ice-covered landscapes. This exposure has allowed microbial and plant colonization, as well as soil formation. Microbes are the initial colonizers of these barren surfaces, with their distribution influenced by nutrient availability. Simultaneously, they play a pivotal role in nutrient and mineral cycling during the early stages of soil stabilization and plant establishment. Plant colonization and interactions with microbes are the primary factors shaping microbial community composition and nutrient accumulation in alpine and low-latitude chronosequences. In contrast, polar forefields are primarily populated by cryptograms, lichens, and bryophytes, often devoid of vascular plants for extended periods. Nevertheless, shifts in microbial communities occur in polar regions over short timeframes, although the driving factors and their interactions with carbon sources are still debated.

In this course, students will collect soil samples along a carefully selected glacier forefield chronosequence to assess key physicochemical parameters, including bulk density, pH, temperature, and moisture content. These measurements will be complemented by biological parameters such as soil respiration, enzyme activities, and microbial biomass. The main objective is to gain insights into the variations in soil microbiome activity at different stages of soil development after glacial retreat.

Subsequently, soil samples from more advanced stages of development will be collected under distinct plant types to investigate the impact of specific plant rhizospheres on soil microbiome composition. Additionally, the study will explore the potential release of greenhouse gases, namely CO_2, N_2O, and CH_4, into the atmosphere. To facilitate a comprehensive analysis of vegetation patterns, a high-resolution drone equipped with a camera will be employed to scan and monitor the vegetation across a broader scale.

3/ Soil and freshwater zoology

Despite the seemingly barren nature of the Arctic terrestrial environment, where the majority of biodiversity is concentrated in the marine ecosystem, there exist numerous microhabitats that support a rich array of invertebrate organisms. The extreme climatic conditions often give rise to unique adaptations that reflect these harsh conditions. Consequently, it is not surprising that the diversity of soil organisms is relatively high. Our exploration will encompass various specific habitats, many of which are closely linked to the glacial environment. While glaciers may initially appear practically lifeless, this is far from the truth. Cryoconites, tiny microhabitats on the glacier surface, harbour a diverse spectrum of organisms, including bacteria, viruses, algae, and tardigrades/rotifers. As glaciers recede, they often leave behind numerous lakes, which also serve as habitats for these organisms. Additionally, the development of soils during the warmer periods between glacial maximums has created suitable environments for soil organisms.

High-Arctic soils typically exhibit low organic matter content, often less than 1%. Various soil organisms contribute to the accumulation of organic matter, and given that much of Arctic biodiversity is linked to marine habitats, significant sources of nutrients in terrestrial environments include sea bird droppings, which frequently influence plant succession and soil formation. Soil fauna serves as an accelerator for (plant) litter decomposition, and the properties of Soil Organic Matter (SOM) play a pivotal role in shaping soil fauna communities. One of the objectives is therefore to investigate the coupling of terrestrial and marine habitats.

Freshwater environments in the Arctic provide valuable models for studying relationships among diverse biota and their physicochemical factors. The impact of depth, lake age, trophic status, or the presence of predators on bacterial, algal, and zooplankton communities can be easily studied, with results visible even without intricate analyses. Various types of lakes, all within walking distance from the station, will be available for study. Students will also analyze the development of soil communities, from microbial to faunal, in the area.

4/ Botany and vegetation ecology

More than half of Svalbard is currently covered by glaciers and ice caps, while the remaining portion consists predominantly of rocks and barren land. This distribution was even more pronounced during the maximum glacial extent at the end of the Pleistocene, with only a small coastal zone in western Svalbard and a few nunataks remaining ice-free. Over time, the lowlands with a milder climate have developed into a rich tundra ecosystem, featuring diverse plant life. Despite the relatively short vegetation season, our field course, scheduled for the first half of July, coincides with the peak blooming season, providing an optimal opportunity for exploration. The most fertile parts of the tundra have taken several thousand years to evolve into their present state. The successional stages which have led to formation of the tundra can be observed on the colonization of new deglaciated areas resulting from extensive glacier retreat following the Little Ice Age (around 1900 AD). In addition to our microbiological colonization study, we will monitor the process of colonization by pioneering and later successional species in these glacier forefields, and we will link their occurrence with abiotic characteristics of soils (pH, temperature, moisture, soil depth).

Students will study the same sites as in the microbiology section, so they can use measured abiotic parameters in both parts. In the botanical part, they will focus more on the vegetation itself – they will map vegetation cover by pin-point or Brown-Blanket strategy of vegetation survey. Moreover,

they will collect leaves of a plant commonly occurring along the whole glacial foreland transect to see whether the species has capacity to allocate more resources in leaves if available.

The main aim of this small survey is, however, to teach students the most common plant species of the area, to show them how many diverse biotopes can be found in the high Arctic (from dry desert to wetland), and to make them think about factors which form the local flora.