Variability of carbon and nitrogen isotopic baselines in Quaternary terrestrial ecosystems

A deep understanding of present and past food web dynamics is crucial for the sustainable management of natural and anthropogenic environments. In this field, isotope paleoecology holds a vast potential. Through the analysis of stable isotopes, it enables tracking the nutrient circulation within past and modern ecosystems. The isotopic composition measured in fossil soils, plants, herbivores, and carnivores, can be used in mathematical modeling for understanding the discrete pathways of nutrient flows, which allows for evaluating the role of each species in the ecosystem. Stable isotopes are like time capsules that help piece together the story of ancient food webs. However, there are still some processes and principles of isotope distribution that remain weakly known, but which are crucial for science. In particular, while the isotope uptake by carnivores is well recognized, the bases of ecosystems – the plant-to-herbivore flow and the overall variability in plants and herbivores – are understudied.

The goal of this project is to uncover the patterns of distribution of carbon and nitrogen stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) in plants and herbivorous mammals in temperate ecosystems. This research aims to fill the gaps in our knowledge by analyzing selected plant species and delving into lesser-studied animals, such as rodents, lagomorphs, and young ungulates.

We focus on terrestrial temperate forest and mammoth steppe, because such ecosystems are common in European Quaternary record and are among the majority of paleoecosystems studied so far. Our focus is on both modern and fossil ecosystems in Poland, including the iconic Białowieża Forest. This forest will serve as a model ecosystem for studying plant-herbivore isotopic patterns due to its preservation and high biodiversity, including one of the richest herbivore communities in Europe and over 1,000 species of vascular plants. Due to its high naturalness with primeval elements and the continuity of forest cover for almost 12,000 years, this ecosystem closely resembles the past Holocene temperate forests. Palynological, archaeological, and historical data documents only a weak anthropogenic footprint compared to other European lowland forests in Holocene history. With one of the largest collections of mammal skulls and skeletons in Europe, housed at the Mammal Research Institute PAS in Białowieża, it is a unique site for the planned research. This project takes a fresh look at the Białowieża Forest nearly natural ecosystem to uncover how specific plant and herbivore groups differ in their isotopic signatures. We selected species that vary in habitat, phylogeny, and physiology—for example, dense forest versus open space inhabitants, or herbivores of variable digestive tracks. For the past, we are uncovering the isotopic distribution patterns in Holocene and Late Pleistocene fossils from two cave sites in the Polish Jura region, which were excavated and studied by our team: Perspektywiczna Cave and Shelter in Smoleń III. We will study Early-to-Late Holocene forest and mid-Vistulian mammoth steppe assemblages; a collection of Late Glacial tundra remains will be also studied for reference. In the case of fossil material, almost no plant remains are available. Therefore, we are going to focus here on the herbivores' isotopic variability, and we will search for similarities in trends of isotopic distribution between the modern Białowieża Forest and the fossil animals. The fossil samples will provide a window into ancient ecosystems, allowing to see if and how the isotopic patterns changed over time.

The project team brings together a diverse group of scientists with expertise covering stable isotope paleoecology, stable isotope geochemistry, ecology, botany, zooarchaeology, and advanced modeling techniques. Such a multidisciplinary and experienced team will allow for comprehensive exploration of the topic that lies at the cross of geoscience, life science, and chemistry: between paleontology, biochemistry, and ecology, and with strong usefulness for wildlife conservation.