Why Biodiversity matters and its role in climate regulation

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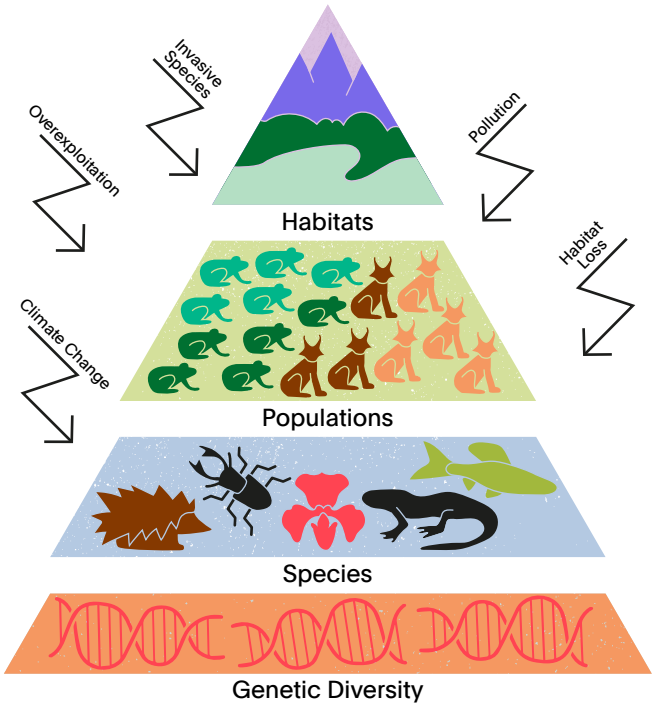
1. What is biodiversity?

Biodiversity—short for biological diversity—is the variety of life on Earth and its interactions, from genes, populations, and species to communities and ecosystems. We often think about biodiversity in terms of the number of species in a location. However, biodiversity has multiple facets and can also reflect the evolutionary history (phylogenetic diversity), ecological functions (functional diversity), or the distinctness of different communities. As a result, biodiversity cannot be reduced to a single number.

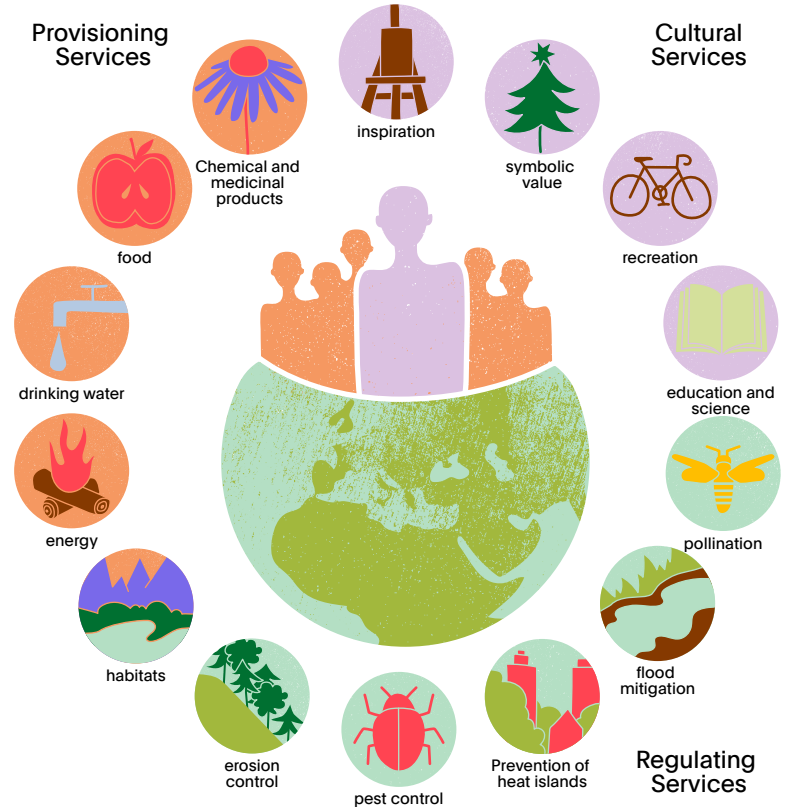


The different facets of biodiversity and the main drivers for its change.

2. What is at stake, why does it matter?

Biodiversity is not merely a vast collection of flora and fauna; it is the very foundation of our existence. Within this rich tapestry of life, an uncountable number of species contribute to the functioning of ecosystems. These ecosystems, in turn, provide us humans with a plethora of services essential for our survival and quality of life. They are our natural pantry and pharmacy, offering an abundance of healthy foods and medicinal resources. The air we breathe, the water we drink, and the soil that nourishes our crops are all purified and maintained through the processes of diverse species interacting in natural communities[1]. Pollinators, such as bees, are vital for the production of many food varieties we consume, and their dwindling numbers lead to measurable declines in food production already today[2].

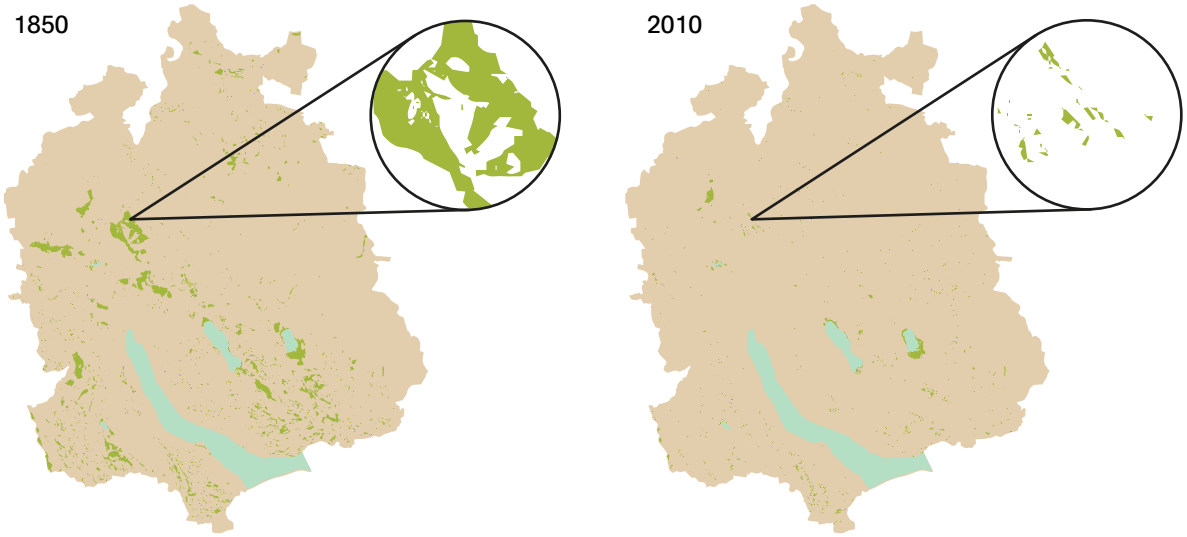
Ecosystems also act as natural carbon sinks, mitigating the effects of climate change by absorbing carbon emissions. The diversity of nature maintains humanity's ability to choose alternatives in the face of an uncertain future. Beyond physical needs, biodiversity is integral to all facets of human well-being. In embracing biodiversity, we do not only gain material or economic benefits but we also enrich our psychological well-being, cultural connections, and educational and recreational pursuits. The value of Swiss forests for recreation alone, for example, has been estimated at about 3 billion CHF per year[3]. The value of biodiversity, therefore, is immense and multifaceted, highlighting its indispensability to human existence[4].



Excerpts of the various contributions of nature to people.

3. Importance of habitats and recent developments

In the maintenance of biodiversity and ecosystem services, habitats assume a pivotal role[4,5]. They harbor communities of species which provide a large array of ecosystem services. Mires and bogs, for example, store carbon; riparian zones and wetlands attenuate runoff of rainwater, buffer floods and provide clean water, preventing soil erosion and recharging the groundwater[6]. Mountain forests protect settlements in alpine valleys from avalanches, rockfall or mudslides, and provide wood for many purposes such as constructions or energy. Moreover, many threatened species are bound to specific habitats. The dwarf bulrush, a critically-endangered pioneer species, for example, needs dynamic river systems with regularly reshaped shorelines to thrive[7]. The many species we find in Switzerland inhabit 230 officially distinguished habitat types from wet to dry, warm to cold, from downy oak forests to Alpine sedge lawns[11]. Furthermore, species compositions vary in identical habitat



The reduction of wetlands between 1850 and 2010, at the example of the canton of Zürich[17].

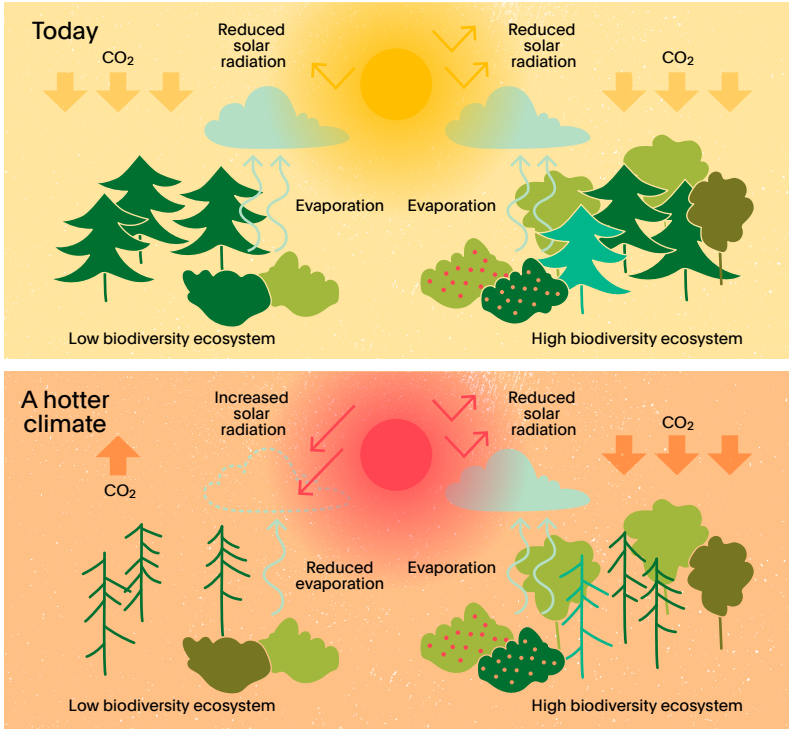
types in different regions of Switzerland.
Yet, not only the presence of a habitat is important to guarantee the survival of its inhabitants but also its area[5]. In order to thrive, species need to sustain viable populations, i.e., sufficient individuals. But the maximum size of populations that can be maintained within a habitat, i.e., the habitat's carrying capacity, is determined by its area. Populations of small species may be able to persist locally, but many large species, such as apex predators, require vast areas. In fact, the notion that larger areas sustain more species is one of the most universal principles in ecology[8,9]. It is therefore not sufficient to solely protect small areas, as it will nott provide sufficient room for many species to survive, and it will not contain many different habitats[10]. Moreover, it is not advisable to only protect few larger areas in selected regions, even if they contain diverse habitats. Such an approach would leave many species from the remaining regions unprotected and the protected areas would tend to be poorly interconnected.

Unfortunately, however, in Switzerland the red lists are longest for habitats. In 2016, almost half of them were threatened[12], a fraction that is even higher than the third of species that are currently red listed[13]. These threats primarily affect open and aquatic habitats, especially on the Swiss plateau, where the pressure from urbanization and agriculture is highest, while forests are less under pressure also because of higher legal protection and more extensive usage. Between 1985 and 2018 about 1.3 square meters of open habitats were lost per second, and 54% of them turned into settlement area[14]. The remaining 46% became forests[14], which largely happened on abandoned pastures at higher elevations and to a lower degree due to upward shifting treelines in response to ongoing climate change[15].

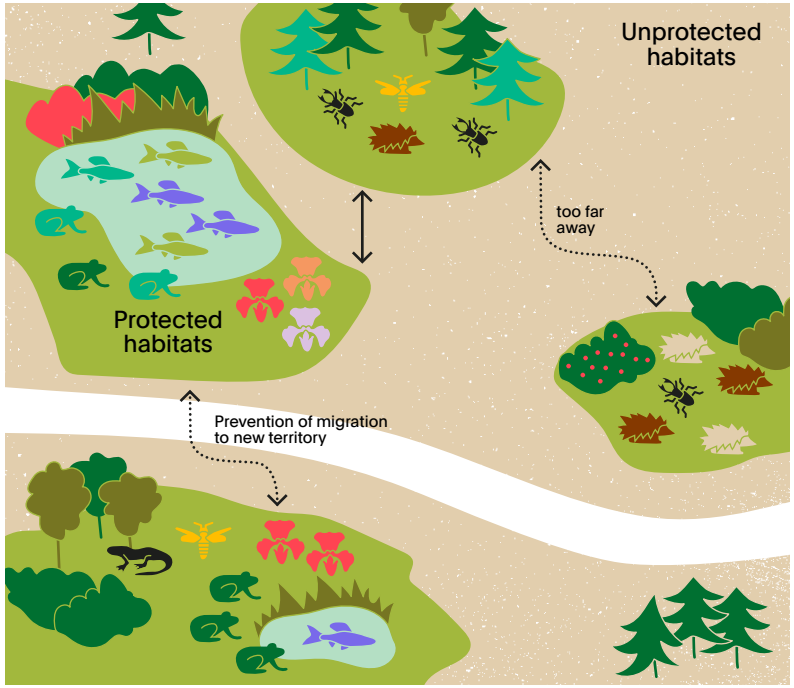
How profoundly the Swiss landscape is transforming becomes even more strikingly apparent when looking back a bit further. Since 1850 we have lost >90% percent of floodplains and bogs in response to urbanization, drainage for agricultural intensification, and river regulation[16]. Similarly, >95% of dry meadows and pastures have been lost since 1900[16]. The species-rich places we have in mind when thinking about these habitats are therefore merely lingering fragments of a once much more diverse landscape. We should treat them carefully if we want to sustain the species they harbor and the services they provide us.

4. What are the links between biodiversity and climate change

Climate conditions, such as temperature and precipitation, significantly influence biodiversity, with stable, favorable climates supporting greater species diversity. In turn, biodiversity plays a central role in climate regulation, with biodiversity and ecosystems together contributing to the removal of around 31% CO_2 emissions every year[18]. Biodiversity affects climate through processes such as carbon and water exchange and solar radiation reflection, which in turn depend on factors like plant productivity and vegetation density. Biodiversity supports crucial ecosystem functions that regulate climate and respond to disturbances. It reduces variability in climate-affected processes and boosts ecosystem resilience. Species-rich ecosystems are better equipped to handle extreme events like droughts or heat waves, protecting essential functions and Nature's Contributions to People, such as food and water provision, as well as pest and disease control than if the same ecosystem is species-poor. If more species are present in a specific ecosystem, the more species are available that may tolerate a specific extreme in weather conditions, helping prevent a collapse of an ecosystem.



A simplified explanation of the interactions between climate conditions and biodiversity.



Examples of networks of protected areas of the same habitat along which species can migrate to adapt to climate change.

Loss of biodiversity, driven by climate change or human activities, can create feedback effects on the climate system. For example, forest degradation due to heat and drought may lead to forest diebacks, thus worsening climate anomalies, leading to even higher heat and water loss. To mitigate these negative impacts, it is essential to address biodiversity loss across all scales, from large landscapes to smaller areas. The link between climate and biodiversity is however, highly complex. This interdependence means that the negative impacts of climate change on biodiversity threaten not only the long-term capacity of the Earth's ecosystems to provide various Nature Contributions to People[19] but also the capacity of the ecosystems to regulate climate itself. Switzerland (with currently 2.8°C) is warming more than the global average, due to its location as part of the mid-northern latitude landmass[20] which additionally stresses the importance of a healthy biodiversity in Switzerland.

Ongoing climate change requires many species to leave their current distribution ranges in order to survive[21,22]. The continued warming (and the often associated drying) pushes species to find new locations that match their requirements regarding temperature and humidity. As a consequence, species are moving, often to higher elevations[23].

Both migration as a natural part of a species life and migration as a reaction to climatic changes requires sufficient space and connectedness of habitats. Most species cannot simply move across the landscape. Instead, they tend to migrate along patches of their preferred habitat[24], which requires sufficiently short distances between such patches. Also, migrating to higher elevations has its limits, as the available area becomes increasingly smaller with elevation, meaning that cold-adapted specialist species in the alps are getting under severe pressure[25].

Consequently, current protected areas cannot be seen as guaranteed "safe zones" and there is an urgent need to rethink biodiversity hotspot planning and protection, incorporating potential climate refuge and resilient habitats. Additionally, we must support species migration in response to changing conditions by increasing the connectedness of habitats and protected areas. Connectivity is essential for populations to maintain genetic diversity. If patches of similar habitat are located too far from each other, species cannot genetically exchange and migration, especially under a changing climate becomes impossible. Genetic diversity, however, is vital for species populations to be robust under varying environmental conditions. The positive impact of area and connectedness on richness and the negative impact of habitat loss is well established[26]. From a scientific perspective, to maintain and recover biodiversity, there is thus an urgent need for sufficient area prioritised (or co-used with humans) for biodiversity, sufficient habitat quality, and sufficient connectivity.

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