

# BIODICE

*Promoting greater awareness  
and understanding of  
biodiversity in Iceland*

This document contains the combined view, vision and recommendations of many biologists in Iceland, covering a number of disciplines, towards the state of nature and ongoing threats to biodiversity in Iceland and elsewhere. We highlight an urgent need for a concentrated effort to react systematically to this situation through three pillars targeting: **1) research, 2) the transfer of knowledge to education and policy for conservation and management, and 3) capacity building for research and transfer of knowledge.**

There is a consensus within the scientific community of the importance of biological diversity for its intrinsic value as the sum of all life on earth, sustaining ecosystem function, buffering against environmental pressures and supporting evolutionary change. The significance of biodiversity is well captured by the definition of the United Nations (UN) Convention on Biological Diversity (CBD), Rio 1992 stating that:

*“Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.”*

The loss of biodiversity worldwide has been faster and more pronounced in the last 100 years than previously documented during the human era. At present, more than 30,000 of the 120,000 assessed species on the International Union for Conservation of Nature's (IUCN) Red List are listed as threatened, and this number has tripled in the last 20 years. Considering the number and abundance of species as baseline components of biodiversity has considerable appeal both for policy making and practical applications. However, this level of detail tends to overlook other aspects of biodiversity, including the loss of diversity within species. This diversity can contribute to ecosystem functioning as much as between-species diversity, not least in rapidly changing environments. Similarly, the important ecological and evolutionary processes which drive and maintain both within species and among species biodiversity are also infrequently addressed in biodiversity inventories. This is despite ongoing global anthropogenic threats to the ecosystems, which enable these processes.

In a recent report from the United Nations Environment Program (UNEP) it is emphasized that human well-being critically depends on the Earth's natural systems. Yet, society is failing to meet most of its commitments to limit environmental damage. Human knowledge, ingenuity, technology, and cooperation need to be redeployed from transforming nature to transforming humankind's relationship with nature. Sustainability and prosperity for our societies into the future cannot be reached without addressing this. “The de-

velopment of the goals, targets, commitments and mechanisms under the key environmental conventions and their implementation need to be aligned to become more synergistic and effective" (UNEP 2021). Part of the CBD's Strategic Plan for Biodiversity 2011-2020 presented specific ten year targets focused on biodiversity conservation (Aichi 2020 Biodiversity Targets). It is now clear that these targets have only been met in a minimal way, and in 2019 the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) published a pessimistic report on the alarming loss of biodiversity during this period. The CBD is now developing new goals for a post 2020 global biodiversity framework. Accordingly, the Icelandic government is currently working on a new policy and goals for biodiversity. Furthermore, Iceland participates actively in the Arctic Council's working group on biodiversity, Conservation of Arctic Flora and Fauna (CAFF). Several of the UN Sustainable Development Goals (SDG) set in 2015 refer to biodiversity conservation and management. Also, to face the challenge, the European Union (EU) has developed a biodiversity strategy to 2030 and beyond, covering several key issues.

## Biodiversity in Iceland

Iceland has many unique characteristics that provide exceptional opportunities to study and better understand the origin, nature and significance of biodiversity, thereby developing effective conservation strategies. In this respect Iceland can be a source of important case studies for other geographical areas/countries.

- Iceland is situated at the boundaries of large oceanic systems where cold and warm currents meet. This creates steep marine and terrestrial temperature gradients, reflected in the characteristics of the respective biota.
- Iceland is characterized by tectonic and volcanic activities providing unique and diverse habitats for its biota, many of which are rapidly developing at present.
- The Icelandic habitats now covering the continental shelf and terrestrial areas are young, with only about 10,000 years since the last glaciation. New habitats are emerging rapidly due to retreating glaciers, providing opportunities for colonizing species and formation of new ecosystems. Habitats can also be altered at a human time-scale due to seismic and geological processes.
- Due to its geographic isolation and short time since glaciation, Iceland hosts relatively few species compared to neighbouring continents, many of which have evolved independently from sister populations on mainland Europe or America. For many species, the variety of physical habitats and lack of interspecific competitors has provided ample ecological opportunities for the

rapid evolution of genetic and phenotypic diversity resulting in a number of diverse populations and varieties. This characterizes the structure and function of ecosystems in Iceland.

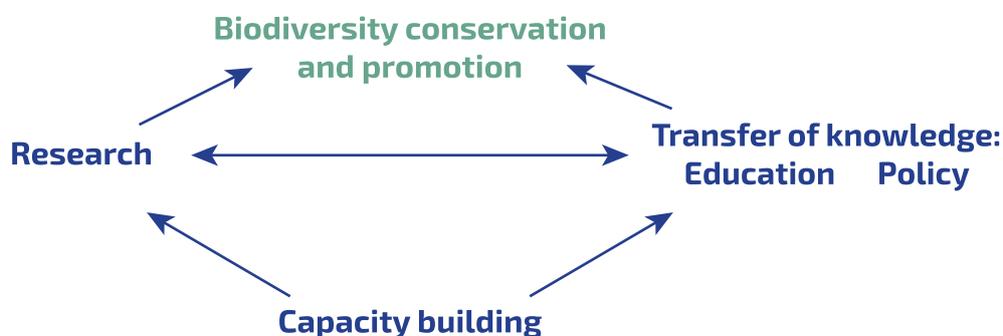
- The Icelandic biota has been shaped by the island's well-known and fluctuating climatology history. Furthermore, since the settlement, human activities have significantly influenced the biota.
- The Icelandic biota has been shaped by the island's well-known and fluctuating climatology history. Furthermore, since the settlement, human activities have significantly influenced the biota.
- Icelandic aquatic environments host large populations of valuable fish populations and are very important for several migratory and transient-migratory species, e.g. birds and marine mammals.
- Iceland has diverse, easily accessible and relatively simple ecosystems with steep habitat gradients, offering excellent opportunities to explore the relations between biodiversity, environment and ecosystem function.
- Biodiversity in Iceland is highly dynamic. To better understand these dynamics ecological, genetic, organismal and developmental processes, and their interactions, must be studied in an evolutionary context. Regions of high intraspecific diversity may be crucial for maintaining species resilience and future diversity. This fact has been emphasized for the post 2020 biodiversity strategies. All this variation can be accessed and sampled with relative ease as Iceland has good infrastructure and very steep gradients in environmental conditions over short distances.

Based on the above, Iceland can be promoted as a case study for biodiversity research, policy and education, especially considering human environmental pressures such as climate change.

Many different pressures are being exerted on Icelandic ecosystems, ranging from global impacts such as climate change and invasive species to local factors such as government-supported, large-scale afforestation, hydro-, geothermal- and wind power plant construction, planning for a new highland national park, tourism, livestock grazing and agricultural activities. Some of these factors lead to unsustainable use of natural resources and declining biodiversity. Furthermore, fisheries constitute a large industry in Iceland and aquaculture has been growing rapidly in recent years. These pressures are not unique to Iceland but have global relevance to biodiversity conservation and understanding of the web of life, which can be easily investigated in a small country like Iceland. Routes between research and policy making are also short in Iceland, providing opportunities to test and implement conservation science and action.

Conserving biodiversity remains one of the biggest challenges for scientists, decision-makers and citizen alike; for example, it touches upon almost all aspects of human life including our economy, resource availability, environmental threats and necessary living conditions, and requires unprecedented integration of science and policy. However, quick action can be taken to improve our understanding of biodiversity and its immediate threats in Iceland, and transfer our current and future knowledge to decision-makers and society for a better future. Several recent actions and initiatives demonstrate that a well-developed framework for biodiversity conservation can help restore ecosystems, promote their conservation, and ultimately revive highly threatened species, populations or ecosystems.

BIODICE suggests the development of three pillars to promote actions for biodiversity conservation: 1) research, 2) the transfer of knowledge to education and policy for conservation and management, and 3) capacity building (Figure 1).



*Figure 1: Three pillars to promote biodiversity conservation in Iceland. Arrows denote feedbacks.*

## 1. Research

Despite various research efforts, our knowledge of Icelandic biodiversity is fragmented, e.g. regarding taxa, ecosystem characteristics, and evolutionary processes. This lack of knowledge impedes the sustainable use of resources and biodiversity conservation.

- a) Comprehensive long-term monitoring of biodiversity should be organized and implemented further in Iceland. Monitoring involves for example: a) comparison of past, present and predictions of future biodiversity using currently available and newly developed technologies (ancient and environmental DNA, climatology, etc.) as they relate to human activities and climate fluctuations; and b) reporting on colonizing and invasive species.
- b) Studies on selected ecosystems should be strengthened, exploring their structures and functions covering all trophic levels, including the role of microbiota; and evaluating the role of biodiversity for ecosystem function and service.
- c) Comprehensive evaluation of how various land use and management activities, e.g. livestock grazing, agriculture, forestry, power plants (geo-, hydro- and wind-) and tourism, influence biodiversity and ecosystems - in the past, present and future - should be promoted.
- d) It is also necessary to assess and study phenotypic and genetic diversity within species in order to understand the ecological and developmental foundations of such diversity. Recent research has shown that diversity within species can have equal or more importance for the structure of communities and maintaining ecosystem function (especially in changing environments) than diversity among species, and this needs to be better understood.
- e) To understand and monitor biodiversity changes, it is urgent to study functional connections and ecosystem processes through whole-genome sequencing, metagenomics and their relation to phenotypic diversity. Whole-genome sequencing will facilitate and promote environmental DNA, metagenomics and genotype-phenotype studies, and studies of the role of adaptive variation in evolution in the face of climate change and anthropogenic activities. In this context, it is necessary to gather an excellent genomic reference database based on clearly identified Icelandic species (voucher samples). For this, an open-access genomic facility in Iceland is needed.

## 2. Transfer of knowledge to Education and Policy for conservation and management

There is a need to develop a centralized bio-monitoring infrastructure that will educate and facilitate knowledge transfer to society:

- a) There is an urgent need for the compilation, centralization and dissemination of information and data available, providing an overview of best current knowledge of biodiversity in Iceland and its unique characteristics, including phenotypic, genomic and ecosystem diversity.
- b) Day-to-day action and messages to the public which will benefit the environment and biodiversity conservation will be implemented through a website and BIODICE initiatives for knowledge transfer. Communication will be ensured through regular publication of newsletters, the promotion of research on biodiversity, and specific events.
- c) Promote community science projects through available applications such as eBird, and develop framework/applications for this with BIODICE partners' action (conferences, workshops, biodiversity day etc.).
- d) Support and develop educational programs in elementary and high schools (gymnasiums) and nature clubs to promote awareness about science, nature and biodiversity conservation.
- e) Support and strengthen on-going, and develop new, University programs to train students for biodiversity conservation and create science jobs to support local and global biodiversity goals.
- f) Organise workshops, seminars and events to promote the redeployment of knowledge from transforming nature to transforming humankind's relationship with nature.

There is a need to synchronize and continuously update information on biodiversity in Iceland, and make it accessible and applicable for policy making. It requires the following actions:

- a) Support and develop further the infrastructure that maps biodiversity patterns comprehensively, including specific threats, possible action, and centralised transfer of knowledge to decision making bodies.
- b) Identify serious knowledge gaps and support systematic monitoring and research initiatives on Icelandic biodiversity, addressing this lack of information (see also 1).
- c) Develop a management framework for biodiversity conservation for all biota based on an ecosystem approach. This will incorporate an adaptive management process to continually improve scientific understanding and conservation outcomes. A workshop will be organized to develop this framework and promote it.

- d) Scientists need to actively communicate their findings and recommendations to policy makers, building a culture of trust and an ongoing dialog. This will involve a formal advisory group through BIODICE.

### 3. Capacity building

- a) There is a need to support institutions that focus on biodiversity research, education, management and conservation, and these institutions – and the scientists within them – need to systematically network to optimize the work required for future biodiversity research, management and conservation. Support and networking will be ensured by regular meetings of the scientists involved and by annual workshops and conferences. This will facilitate and promote:
  - The development of an open-access structure to whole-genome sequencing facilities, powerful computer cluster, experimental facilities, and laboratories in which all Icelandic research institutes and groups will collaborate and participate.
  - The creation of a centralized database(s) with references to voucher samples for as many organisms as possible, for which phenotypic data, tissues samples and genome/genetic/barcoding information are available and phenotypic-environment relationships depicted.
- b) There is an urgent need to establish a centre for the storage of information and dissemination to the general public, the education system, policy makers and the scientific community. This would include databases and websites. Such a platform will be accomplished by combined actions of the Icelandic Museum of Natural History and the Icelandic Institute of Natural History in close collaboration with other institutions. A centralized platform will promote the development of educational materials and exhibitions, workshops and dissemination events to the public.
- c) To support all the above and stand behind BIODICE, a team of scientists and their institutions will develop a network under the umbrella of the Icelandic Museum of Natural History. A board and a chair will manage the network. The network will focus on all visions and actions proposed in this document, with emphasis on research, policy and education; work closely with all the stakeholders involved, and develop comprehensive and regular communication and advocacy about biodiversity, e.g. through newsletters, formal statements, meetings, workshops, advisory groups, and conferences. The board and chair will seek support from the Icelandic institutions and/or societies involved and build active international relations. BIODICE will be introduced and promoted through a website hosted by the Icelandic Museum of Natural History.

## Key Supporting References:

- 1** CBD. Rio Earth Summit, 5 June 1992; United Nations Convention on Biological Diversity, 1992.
- 2** United Nations Environment Programme. Making Peace With Nature: A Scientific Blueprint to Tackle the Climate, Biodiversity, and Pollution Emergences; Nairobi, 2021.
- 3** CBD. Strategic Plan for Biodiversity 2011–2020, Including Aichi Biodiversity Targets <https://www.cbd.int/sp/>.
- 4** CBD. Quick Guides to the Aichi Biodiversity Targets; Convention on Biological Diversity, 2013.
- 5** IPBES. Summary for Policymakers of the IPBES Global Assessment Report on Biodiversity and Ecosystem Services; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: Bonn, Germany, 2019.
- 6** CBD. Zero Draft of the Post-2020 Global Biodiversity Framework; Kunming, China, 2020.
- 7** United Nations. Department of Economic and Social Affairs: Sustainable Development Goals [www.sdgs.un.org](http://www.sdgs.un.org).
- 8** European Commission. Biodiversity Strategy for 2030 - concrete actions [https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030\\_en](https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en).
- 9** Government of Iceland. Vinna við nýja stefnumótun fyrir líffræðilega fjölbreytni að hefjast <https://www.stjornarradid.is/efst-a-baugi/frettir/stok-frett/2020/01/10/Vinna-vid-nyja-stefnumotun-fyrir-liffraedilega-fjolebreytni-ad-hefjast/>.
- 10** CAFF. Conservation of Arctic Flora and Fauna <https://www.caff.is/>.
- 11** Arctic Council. Conservation of Arctic Flora and Fauna Working Group <https://arctic-council.org/en/about/working-groups/caff/>.
- 12** Icelandic Government; Ministry of the Environment; Icelandic Institute of Natural History. Biological
- 13** Diversity in Iceland: National Report to the Convention on Biological Diversity; 2001.