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Diversity in Danger

Biodiversity holds the key to the survival of many plant species, and also to our own future.

A horse chestnut tree in full bloom

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It is very difficult for plants to avoid or even mitigate the threats they face, because they are confined to one location and simply have to cope with various types of environmental stress. Their natural adaptability is usually sufficient as long as the environment does not change too much or too rapidly. Unfortunately, however, more and more species are teetering on the brink of extinction. The Polish Red List of Pteridophytes and Flowering Plants, published in 2016, names 765 taxa, or about 30% of Poland's flora of vascular plants. Endemic and relict species are especially at risk: they inhabit small territorial ranges and often have a very narrow scope of ecological tolerance. The growing number of species at risk of extinction is linked to anthropogenic stress, ongoing climate change, and the presence of invasive species. Biodiversity is essential to the proper functioning of ecosystems, so its loss poses an increasingly acute problem.

In-situ conservation

A variety of strategies are used to protect nature and ensure the safety of rare and endangered species. One of these is called *in-situ* conservation. As the name suggests (Latin for "on site"), *in-situ* strategies are aimed at protecting species in their natural habitats. *In-situ* conservation can be passive, when human intervention is limited as much as possible in order to preserve natural processes, or active, when it is necessary to take certain measures such as mowing xerothermic grasslands or introducing grazing animals to counteract natural succession. *In-situ* conservation methods are numerous and include both species protection of endangered taxa and the establishment of reserves and national parks to protect areas of exceptional natural value. Creating such areas makes it possible to protect biodiversity on its three key levels: the genetic level (genetic diversity within a species), species level (species diversity in an area), and ecosystem level (habitats, communities, and ecological processes). In addition, this method allows us to protect potentially undiscovered species.

Choosing a good site for establishing a protected area requires knowledge of many factors. The most important criterion is a high level of biodiversity, associated with the presence of rare and endangered species. It is likewise necessary to take into account the requirements of local communities, which need areas to use as agricultural fields and resources to harvest from the natural environment, such as timber. Other criteria include environmental conditions: regions with a stable climate make the best locations for protected areas. Such places are often refugia, abundant in relict species that have become extinct elsewhere as a result of climate change. To detect such areas, we can use regionalization analyses that look at environmental conditions and the presence of endemic species – they make it easier to identify regions that should be prioritized for conservation due to exceptional biodiversity (examples include the Rif Mountains in Morocco). Unfortunately, existing refugia may not necessarily retain their status in the future. To assess which of them are the most stable, we use models of the future climate and try to project potential future species ranges.

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If the gene pool of an endangered taxon is known, planned conservation strategies should also take into account the level of genetic variability. The highest priority is given to highly diverse populations and to ones that clearly stand out from the rest. If an endangered species population is too small, it may undergo a slow extinction associated with inbreeding depression (resulting from the breeding of individuals that are too closely related genetically). Individual populations may be so distant that a natural gene flow between them becomes impossible. To counter inbreeding depression, a method called assisted migration can be used. It involves selecting populations with exceptional genetic diversity and then moving some individuals (or, for example, seeds) to other natural sites characterized by

a lower level of genetic diversity. In this way, their gene pool can be given a boost, which improves their adaptability to environmental changes and resilience to adverse factors such as diseases. Research conducted at the Institute of Dendrology, Polish Academy of Sciences, suggests that such a strategy might be effective for the horse chestnut (*Aesculus hippocastanum* L.), which is found naturally only in isolated sites in the mountains of the Balkan Peninsula. Since some populations are genetically distinct from the rest and show a relatively high level of genetic diversity, the method of assisted migration could be used to enrich poorer natural sites, as well as the artificial horse chestnut sites spread across Europe. This could improve the condition of a species like the horse chestnut, threatened by the spread of diseases and pests.

> The Wollemi pine was thought to have been completely extinct for perhaps 2 million years, when a relict population was discovered in Australia.

Ex-situ conservation

In-situ strategies are not always sufficient to effectively protect an endangered species. In such situations, we may resort to *ex-situ* conservation methods (Latin for "off site"). These involve relocating individuals of an endangered species to areas outside their range, including natural areas with suitable environmental conditions and artificially created environments (such as botanical gardens). *Ex-situ* conservation, which is by definition a form of active conservation, is a lot more costly and problematic than *in-situ* strategies. As a rule, it is also less effective: it allows us to protect individual species, but not entire ecosystems. However, this type of conservation also has its advantages – it can be used to control the conditions in which plants grow and to support their reproduction. Also, it can serve as a method of last resort for critically endangered species. Examples include one of the rarest gymnosperms – the Saharan cypress (*Cupressus dupreziana* Camus). It is native to the Tassili n'Ajjer mountains in southern Algeria, where the natural population consists of only 233 trees. Young specimens and seedlings are practically not found there at all, due in part to the decline in groundwater levels and the stress posed by the farming of goats, which eat young plants. To rescue this relict species, material collected in the wild was used to establish a collection in Australia. It now has about 1,300 trees, so it is a lot larger than the whole naturally occurring population. In the future, it could serve as a reservoir from which the species can be reintroduced back into its natural range. Such a strategy, in which *in-situ* conservation is supported by the cultivation of a species outside its range, allows populations to recover if natural regeneration is hindered. Examples include the box tree found in northern Iran (*Buxus hyrcana* Pojark., often treated as synonymous with the common box, *B. sempervirens* L.). Populations located in the mountains are threatened by climate change, and sites along the Caspian Sea are grappling with the invasion of the box tree moth. For this reason, it is difficult to find an area safe enough for the box tree populations to survive. Consequently, *ex situ* cultivation was initiated at the National Botanical Garden of Iran. Every year, the Garden is able to provide 5,000 seedlings, which are then used to restore natural sites.

An interesting example of a rare woody tree taxon protected using both *in-situ* and *ex-situ* methods is the Wollemi pine (*Wollemia nobilis* W.G.Jones, K.D.Hill & J.M.Allen). This critically endangered species is a "living fossil" – its ancestors are known from the Jurassic, and similar plants were extremely common in Australia in the Cretaceous. Since the youngest described fossils were older than 2 million years, the plant was believed to be completely extinct. In 1994, however, a Wollemi pine population was discovered in the mountains near Sydney. So far, several populations have been studied, and they remain under strict protection. Their exact location is kept secret to protect the trees from becoming damaged or infected with diseases. The sites can only be visited in exceptional situations, justified by scientific research. Even then, the research equipment must be thoroughly sterilized, and the researchers must change clothes before they can take any measurements. In addition to *in-situ* conservation, an extensive campaign has been organized to protect the species outside its natural habitat. A collection has been established at the Australian Botanical Garden Mount Annan, including vegetatively propagated clones of every known mature specimen. In addition, efforts have been made to promote the planting of Wollemi pines in home

Buxus hyrcana damaged by the box tree moth

gardens as an ornamental tree. The Wollemi pine is a well-known example of a species that has "made a successful comeback," but other such taxa continue to be discovered. Relatively recently, in 2022, a site with the tropical tree *Gasteranthus extinctus* L.E.Skog & L.P.Kvist was discovered in Ecuador. The species had been considered extinct for almost half a century. Unfortunately, it is by no means easy to ensure the safety of such taxa, and very few of them can be as successful as the Wollemi pine.

Biodiversity in danger

It is not only wildlife that is affected by biodiversity loss. Various crop plants are also at risk of gene pool depletion, with many old and traditional varieties sinking into oblivion. For example, an estimated 80% of the gene pool of the apple tree has been lost, and 88% of the gene pool of apricots. Cultivating only high-yielding varieties is of course profitable, but in the long term it can lead to genetic erosion and endanger the entire species (for example, if the most popular variety is not resistant to a new disease). For this reason, a crucial role in the future may be played by special collections focused on the preservation of former biodiversity. They serve as a protective measure for agriculture, as a sector of crucial importance. In the case of plants, it is relatively easy to create gene banks, which are simply collections of seeds. One of the most famous and most important of such collections is the Global Seed Vault, built in the permafrost of Svalbard. It stores the genetic material of crop plants from all over the world (by 2021, it was already safeguarding more than one million different samples). This collection has already been put to use: in 2015 and 2017, the International Center for Agricultural Research in the Dry Areas (ICARDA) took seeds from the bank and sowed them in Lebanon and Morocco.

Nature conservation currently stands as one of the most serious challenges facing humanity. Its significance extends beyond the preservation of natural ecosystems, intertwining with human well-being and the stability of the global economy, as biodiversity loss can have a major impact on multiple industries. Determining the best or most effective conservation strategies is not easy: the choice between *in-situ* or *ex-situ* methods depends largely on the particular characteristics of the species in need of protection and the environment it inhabits. Although a significant portion of former biodiversity has been lost beyond recovery, numerous conservation projects have proven successful. We can only hope that future efforts will embrace new, more holistic, and more effective strategies to safeguard our planet's priceless biological heritage. ■

Further reading:

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