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Invasive Species

Some alien species are able to quickly colonize new areas, causing damage to the environment and the economy. Which species pose the greatest threat to the forest ecosystems? How will climate change affect biological invasions?

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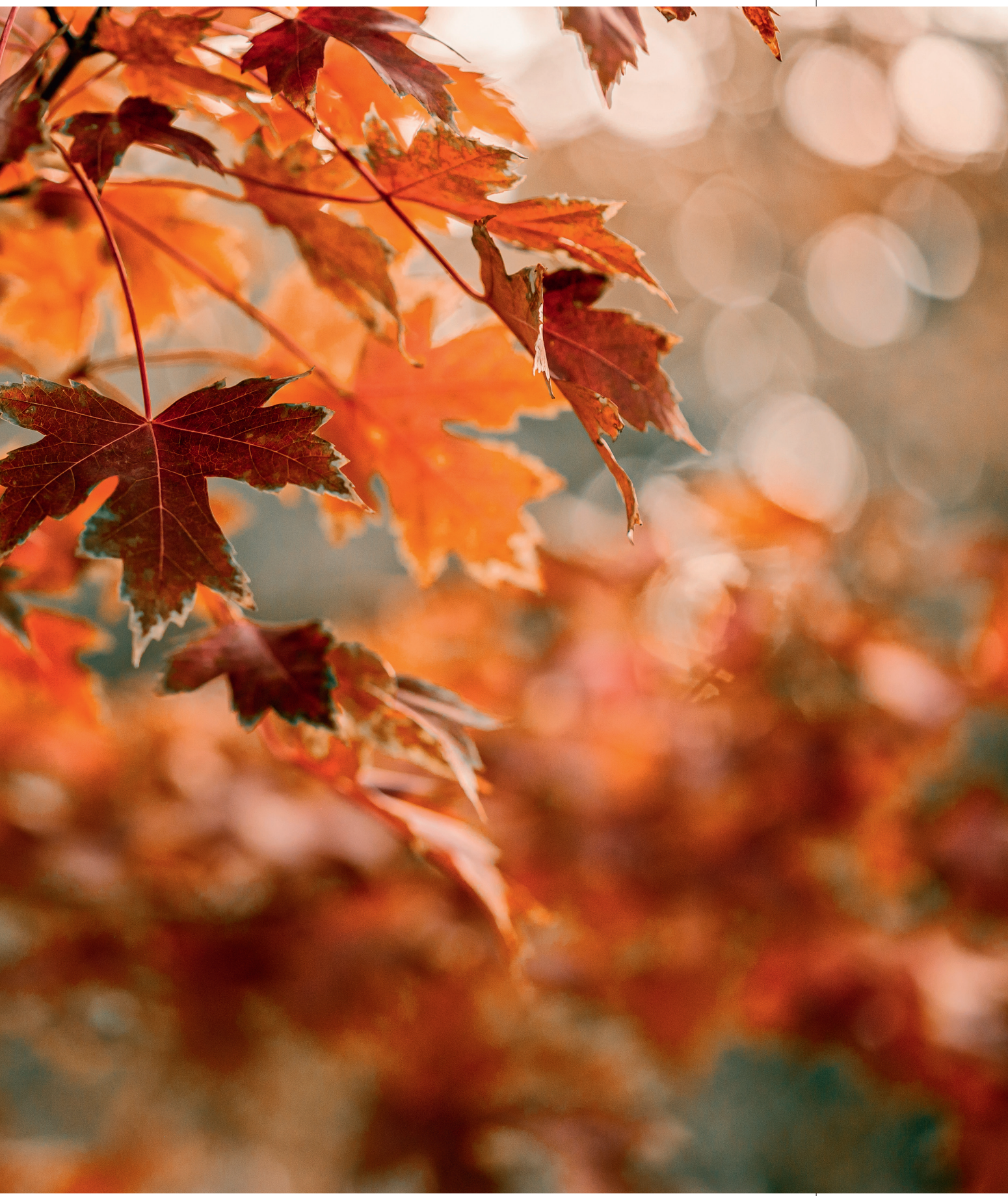

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One of the challenges of contemporary nature conservation is reducing the impacts of invasive species. This is a problem that affects most areas in the world. The breaking down of geographical barriers, along with the invention of new ways of transport during the industrial revolution, allowed many species of plants, animals and fungi to be spread outside their natural area, where they have become alien species. An invasive species is an alien species capable of quickly colonizing new areas, which can have significant negative effects on natural and semi-natural ecosystems, as well as on the economy. Biological invasions are considered to be one of the key drivers of the progressive loss of biodiversity on a global scale.

Human activity, which leads to changes in natural ecological systems by enriching the soil with nutrients, excessive grazing, wetland drainage, as well as climate change, has greatly facilitated such biological invasions, helping to increase the number of invasions and invasive species and strengthen their impact. Invasive species have an adverse effect on native species, competing with them not onlyw for food resources, but also for breeding sites. Large numbers of invasive predators or herbivores can cause significant declines in the numbers of various native species. One example is the American mink and its negative impact on the number of birds, especially wetland species. Moreover, invasive species may be carriers of dangerous parasites or pathogens to which native species are not resistant. Another threat is the possibility that the genetic diversity of native species will become deteriorated through cross-breeding with alien species, such as the crossing of native and endangered black poplar trees with alien Canadian poplars.

Invasive blue gum eucalyptus (*Eucalyptus globulus*, background) and Monterey pine (*Pinus radiata*, foreground), occurring together in a forest plantation in central Chile

Reasons for ecological success

Invasion ecologists have developed several hypotheses about what underlies the success of certain alien species. One of these is the "enemy release hypothesis." According to this assumption, alien species lost their natural enemies in the new environment, such as various pathogens, viruses, parasites, herbivores or seed consumers occurring in their original area. However, whether invasive species populations can survive in a new environment depends on resources, intraspecific and interspecific competition, and natural enemies (both specialists and generalists). Natural enemies may adversely affect native species, thereby reducing competition for resources and facilitating invasive species. On the other hand, the opposite may happen, where native animal species with a wide food spectrum can negatively affect invasive species. In addition, invasive species may cope better in their new environment due to their different evolutionary history back in their natural geographical range. This may include faster absorption of nutrients, the release of chemicals harmful to native species, or growth strategies (forming dense thickets that impede penetration by other species).

Ecosystems resistant to the invasion of alien species

According to the "biotic resistance hypothesis," in turn, ecosystems with high species diversity are more resistant to the invasion of alien species, as compared to ecosystems with low diversity. In robust habitats, alien species are not able to utilize the pool of available nutrients as efficiently due to stronger competition from native species. In addition, pressure from natural enemies (pathogens, seed consumers, and herbivores) may be stronger. On the other hand, habitats rich in resources (including water, light, and nitrogen) are susceptible to colonization by both native and foreign species. This means that ecosystems rich in species may also be home to many alien species. Recent studies have shown that, in smaller areas, ecosystems with

An invasive West Indian lantana (*Lantana camara*) bush, often cultivated for beautiful flowers, here growing in a garden in Bangkok

high species diversity are more resistant to invasions by alien species, while in larger spaces alien species are much more common.

Foreign tree species

Particularly striking examples of the major impact alien species may exert on the environment can be found in invasions of certain trees and shrubs, such as the Monterey pine, the blue gum eucalyptus, and the West Indian lantana – each of which we will examine in turn. Such species threaten the functioning of forest ecosystems, due to the special role of trees in creating the conditions under their canopy. The biological features of trees, such as their crown structure, leaf thickness or growth rate, affect the amount of light reaching the forest floor, as well as the amount and rate of vegetation decomposition. These factors, in turn, affect many other organisms, such as herbaceous plants, bryophytes, fungi and soil invertebrates. In invasion ecology, species that significantly change existing environmental conditions are called transformers.

Monterey pine (*Pinus radiata*). Perhaps the greatest examples of such species are pine trees, which are native to the northern hemisphere but have been massively introduced into temperate countries of the southern hemisphere, sometimes becoming invasive. Pine trees have lighter wood, so they need fewer environmental resources to grow faster than native species. The invasive Monterey pine reaches maturity for felling at the age of 20–30, while native species need about 80 years. Fast growth requires a high rate of photosynthesis, and hence high transpiration, i.e. active water evaporation. For this reason, the Monterey pine dries out the soil more than native species. In addition, through shedding its needles, which decompose longer than the leaves of native species, it increases the amount of dead organic matter on the forest floor. It is flammable, thus increasing the risk of fires. Moreover, conifers require symbiotic relationships with mycorrhizal fungi and usually form them with alien species of fungi. The undergrowth in such forests is poorer, because few species of trees are able to grow under the canopy of alien pine species. Invasive pines can colonize non-forest ecosystems, such as the Patagonian steppes, where there are no native tree species capable of colonizing them. Here, the main invasive species is the lodgepole pine, widely grown on plantations, from which it colonizes surrounding ecosystems. This not only leads to altering the type of the ecosystem, it also causes the disappearance of plant species that have evolved in conditions of low competition for light and are not adapted to competing with trees. Longer periods of drought and rainless days increase the likelihood of fires, which promotes the release of large amounts of carbon dioxide accumulated in the soil and vegetation, as well as toxic smoke that degrades the ecosystem. This also affects animals, which avoid places with limited visibility.

Blue gum (*Eucalyptus globulus*). This tree of Australian origin can now be found on all continents of the world, except Antarctica. It grows even faster than the Monterey pine and can be felled as early as 8–10 years after planting. It significantly increases the water deficit, contributing to conflicts between foresters and farmers. In Spain, for example, it reduces groundwater levels so much that growing citrus in the vicinity becomes unprofitable. In Chile there have even been cases of arson on eucalyptus plantations responsible for drying out crops and pastures. Due to the high content of essential oils, these plantations are flammable, which increases the frequency of fires. The blue

A Polish forest stand overgrown by the black cherry (*Prunus serotina*), together with a close-up on its fruit, Wielkopolski National Park

gum eucalyptus, however, easily restores itself after a fire both from seeds and through roots. This is not conducive to the natural exchange of species and ensures the persistence of invasive species.

West Indian lantana (*Lantana camara*). The significant environmental impact of an invasive species is not always due to large size. An example of an invasive shrub that can significantly change the environment is the West Indian lantana, native to Central and South America, but now found in all tropical and subtropical regions, including the Mediterranean. It gained popularity due to its beautiful flowers and the fact that it helps enrich the soil with nitrogen. It quickly began being grown on pastures in many areas to increase their productivity. However, it is highly poisonous to animals as it damages the digestive system and causes photoallergy (an immune response of the body), turning the skin orange, and so herbivores tend to avoid it. It also transforms savannah or grasslands into thickets. It causes not only economic losses, which are of great importance to the pastoral and agricultural communities of Africa and South Asia, but also leads to widespread ecological consequences. Lantana is cultivated as an ornamental plant in Poland, but in the current climate it is unable to survive the winter in the ground.

A northern red oak (*Quercus rubra*) stand lets little light through to the forest floor, while also forming a thick layer of slowly decomposing vegetation, Wielkopolski National Park

Alien species in Poland

Polish forests are also susceptible to invasions by alien species of trees and shrubs. The most common of these are the black cherry, the northern red oak, the black locust, and the boxelder maple. They are all native to eastern North America, and they were all initially introduced to new environments for decorative purposes. It was not until the turn of the 19th and 20th centuries that these species began being cultivated in forests, to a greater or lesser extent, with the exception of the boxelder maple, which was introduced to forests as a street and park tree. All of them are able to spread in our climate, not only within a human-altered environment, but also in more natural forests.

Black cherry (*Prunus serotina*). In its natural geographical range this tree can reach up to 30 m in height and is the source of valuable wood. There were high hopes for it in Europe, assuming that it would also be able to provide valuable wood raw material here. When it failed to do so, it was introduced on a massive scale as a phytomelioration species to improve soil quality in the poorest habitats by producing easily decomposable vegetation. However, this wide-scale introduction produced many seed sources. Research conducted at the PAS Institute of Dendrology has shown that the black cherry can effectively spread within a radius of 600 m and that the presence of seed sources is the most important factor responsible for its ecological success. It is now commonly found in forests, especially pine monocultures, growing in fertile habitats. By restricting the availability of light to the forest floor, it not only limits the biodiversity of undergrowth plants, but also prevents native tree species from regenerating. In addition, it causes significant changes to element circulation, accelerating the circulation of matter in the ecosystem. This affects the rate of carbon dioxide binding by the forest ecosystem. Young black cherry trees are able to stop their growth in adverse conditions, thanks to which they can wait out several years of low light and then achieve rapid biomass growth. Our research has shown that in favorable conditions, black cherry can increase its biomass by more 20,000 times in 8 years.

Northern red oak (*Quercus rubra*). This is a tree species that does not require as much soil moisture as Poland's native oaks. It grows faster, and although it produces inferior wood material, it is sufficient enough to ensure profitability. This species produces a large number of leaves, which provide plenty of shade for the forest floor and decompose very slowly. They lie on the bottom for a long time, forming a thick layer that prevents the seeds of many native plant species from germinating. Although the northern red oak grows the slowest among the invasive species described here, its seedlings have the highest survival rate. Thanks to the reserves stored in acorns, young trees are able to survive not only a lack of light, but also attacks by deer, for which acorns are valuable food, as well as for jays, rodents, as well as insects from the weevil and warbler family. Moreover, fallen northern red oak acorns, which used to be occupied by

Grassland colonized by black locust (*Robinia pseudoacacia*), together with a close-up on its fruit, Warta Valley in Poznań

insect larvae, are now occupied by ant colonies of the species *Temnothorax crassispinus*. Due to their solid shell structure, northern red oak acorns are a more preferred home for the colonies than native acorns of the pedunculate oak.

Black locust (*Robinia pseudoacacia*). This is a tree in the Leguminosae family, capable of symbiosis with microorganisms that bind atmospheric nitrogen. This enables it to grow faster in soil where this element is lacking, which normally impedes plant growth. When the leaves fall, this nitrogen enters the soil, significantly impacting the species composition of the undergrowth plants. For example, on post-industrial land, the understory beneath black locust stands is very different from the understory formed beneath other tree species often used for reclamation of degraded habitats resulting from opencast lignite mining. It contains many species of ruderal plants and agricultural weeds. Due to its bark's large water capacity, it is also a habitat for many bryophytes. Its toxins and spikes make it more resistant to attacks than Poland's native plant species. Despite its seedlings' very low survival rate (our research shows that only about 0.2% of seedlings survive the first year), thanks to its large number of seeds it effectively colonizes often disturbed habitats, such as tracks, forest borders or urban areas. It is also a great threat to dry grasslands (steppe-like ecosystems), where its presence leads to the disappearance of rare herbaceous species.

Boxelder maple (*Acer negundo*). One of the most common tree species found in Polish river valleys. Thanks to its resistance to disturbances and fast growth rate, it has adapted to living in unstable environments. Although it grows more slowly than willows and poplars, which dominate the areas of alluvial forests closest to the riverbed, it is less light-demanding, and its seeds are more durable. Therefore, it is able to grow under a canopy of willows and poplars and ultimately replace them, whereas the native species are unable to regenerate under a maple canopy. Its seeds can spread as far as 500m away, carried by the wind or a river current. The boxelder maple also affects the nutrients cycling in the river valleys and vegetation beneath its canopy. As its wood is harder than that of willows and poplars, it is more resistant to winds and floods and dies more slowly. In alluvial forests, dead trees of native species are important habitats for birds and insects, which is why the boxelder maple may in the long run reduce the biodiversity of these animals.

Global environmental changes are a decisive factor influencing rates of biological invasion, enabling many alien species to expand their range. More frequently occurring extreme weather phenomena, as well as intensive international and intercontinental transport, may further facilitate the spread of alien species, including invasive ones. Global warming is responsible for the appearance of some of these, such as the widely spreading English walnut (*Juglans regia*) and tree of heaven (*Ailanthus altissima*) species. Predicting the future impact of climate change on the geographical range of invasive species is currently a major challenge. Modern statistical methods used in ecology allow us to model climate change and its impact on the distribution of invasive species for various climate change scenarios. The predicted reach of alien species and global climate models are tools that can help us develop lists of alien species that may pose threats to Polish ecosystems in the future. This work is therefore a priority for the study of invasion ecology in Poland today.

PHOTOGRAPHY BY **MARCIN K. DYDERSKI**

Further reading:

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