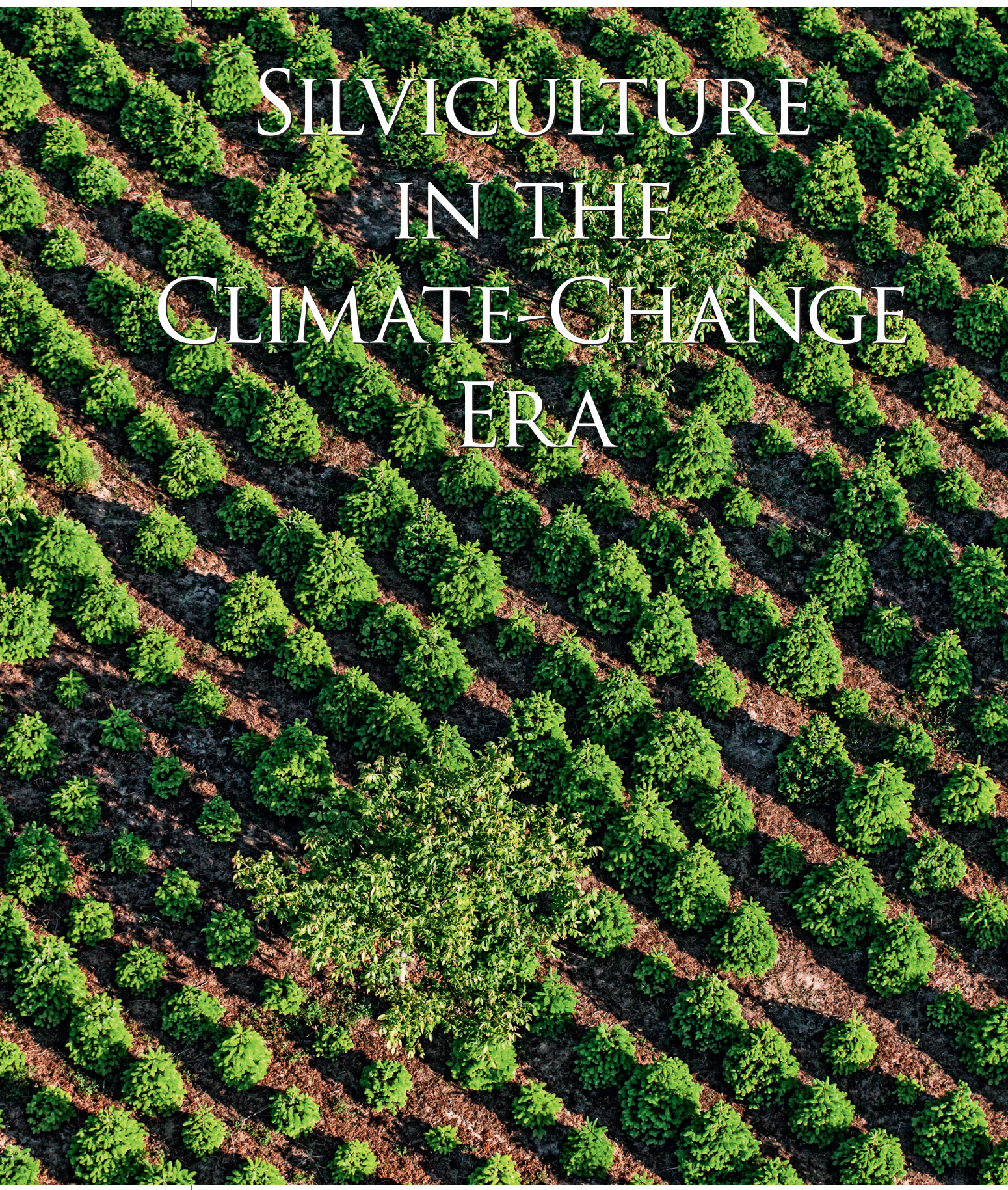
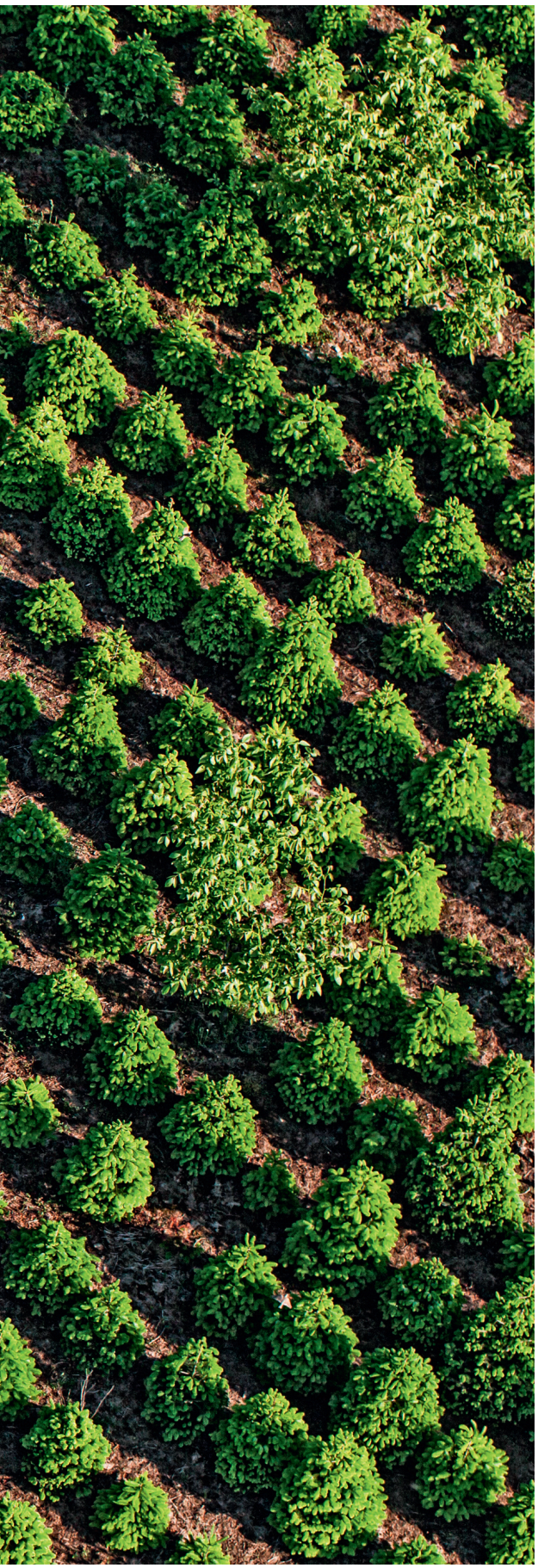
Silviculture in the Climate-Change Era





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One of the most significant challenges facing forestry in Poland involves devising new silvicultural strategies in the face of ever-faster climate change.

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The changes projected to take place in forest ecosystems over the next 50 years are expected to be revolutionary and unprecedented in the history of forestry. It is therefore difficult to propose simple measures that would mitigate the potentially negative consequences entailed by predicted climate change. Sustainable and multifunctional forest management measures taken in Poland already include the conversion of tree stands (and therefore forests). Adapting the species composition and genetic structure of populations to habitat conditions and increasing the biodiversity of forest ecosystems to make them more stable are crucially important. Action has been taken, but certain species and ecological systems may not survive the changes brought about by global warming. Thus, it is necessary to work out new strategies based on knowledge in the field of provenance experiments and the population genetics of forest trees that will facilitate greater dispersion of climate change-related silvicultural risks in forestry.

Selection and migration

Forest trees adapt to new climate conditions chiefly through natural selection and migration. In the optimistic scenario, we may assume that in the genetically diverse populations found in Poland the individuals that are poorly adapted to changing conditions will be naturally replaced by better adapted individuals. For this reason, high hopes are being pinned on the genetic resources maintained by the State Forests in the form of selected seed stands (excluded from logging), gene conservation stands, and the material deposited with

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the Kostrzyca Forest Gene Bank. But what should be done if the rate of climate change proves much faster than local populations can adapt? This is a highly likely scenario for reasons related to the strong, genetically determined adaptation of forest trees to local habitat conditions and their characteristically slow pace of migration.

Possible unconventional measures therefore include assisted migration, which involves moving trees better adapted to projected climate changes to a specific area. Wide-ranging species such as the Scots pine have formed many ecotypes (local populations) adapted to the climate conditions in which they live. If we know the direction of climate change, we can choose populations suited for such changes from the entire range of the species. Material from the selected populations can be outplanted directly on experimental plots or crossbred with individuals from local populations. Hopefully, the new gene pool enriched with new versions of genes (new alleles) will translate into a greater adaptive capacity of these artificially established populations, which may prove crucial for their functioning in the changed climate conditions. Over the past several years, assisted-migration measures have been successfully taken in Canada and in the United States.

Alien species

Similar yet more controversial assisted-migration measures may pertain to alien species, which do not occur naturally in Poland. Many scientists and social groups have negative attitudes towards the introduction and use of alien species in tree breeding, pointing out chiefly to the threats related to their invasiveness. Such fears are justified in a stable climate that influences native forest ecosystems. In light of the scale and rapid nature of the predicted changes and the related changes in ecosystems, however, we should not rule out the use of alien species. Their presence must be seen as a chance, especially in light of the need to maintain the productive function of forests in the course of the establishment of new forests. Many alien species such as the black locust, the northern red oak, and the Douglas-fir have been brought to Europe starting from the 17th century. Over time, these trees have adapted perfectly well to local conditions, creating different ecotypes that may be successfully used for the purposes of tree breeding and improvement.

Epigenetic modifications

The projected responses and adaptation of trees to new, changing climate conditions are considered from the perspective of the principles and laws of classical genetics. In line with these principles and laws, the adaptation of a specific species requires changes in its genetic material. These are permanent changes that are passed down to next generations. However, recent studies show that epigenetic modifications also play an important role in the adaptation of populations. As a result of chemical modifications, chromatin (a complex of DNA found in cells) may change its spatial structure. Such changes make it possible to control which genes will be read at a given time to lead to the synthesis of products that determine specific traits of an organism. Consequently, epigenetic mechanisms facilitate the use of the same genetic information in different ways. What is more, they enable a quick and reversible reaction to changing environmental condi-

A progeny test of Scots pine in the Międzychód Forest District

tions. Such a reaction, unlike changes in the genetic code, does not require many generations, and thus the time that trees do not have given the rapid pace of climate change. Most importantly, some of the adaptive traits acquired in the course of epigenetic modifications may be inherited, thus impacting on the adaptation and evolution of both specific species and their individual populations.

Shortened-rotation forest stands

The emergence and maintenance of beneficial epigenetic changes in response to ongoing rapid climate changes may be promoted by planting stands in shortened-rotation programs (on the scale of a few decades). In this way, it is possible to reduce risks to some extent thanks to the faster rotation of the planting stock, which is increasingly adapted to changing climate conditions. However, the effective growth of such tree stands requires carefully-selected high-quality planting stock. Unfortunately, we have no such material yet.

In Poland, selective breeding in forestry started in the second half of the 20th century with the selection of the parent trees, characterized by the best growth and quality. It was initiated by the PAS Institute of Dendrology and continued by the Forest Research Institute. Trees selected in this way were used to establish first generation seed orchards. However, their ability to pass down beneficial traits must be confirmed in relevant progeny tests, which are conducted by the PAS Institute of Dendrology, among other institutions. Most of the selective breeding efforts in Poland are based on population selection, which is based on the selection of seed stands. By contrast, tree breeding programs in many other countries focused mainly on intensive individual selection, which made it possible to achieve considerable progress. These experiences show that intensive selection may increase the biomass of trees even by over 20% after only three generations. It is likewise possible to concentrate the selection efforts on traits important from the perspective of adaptive capacities. Consequently, it is necessary to take action immediately with a view to promoting individual selection, which will allow the establishment of next-generation seed orchards. Shortened rotations will result in the orchards supplying seeds for the production of material with an improved growth potential and better adaptation to changing climate.

Identifying the leading functions of forests

In Poland's forestry policy, the environmental, social, and productive functions of forests are treated as equal. However, a single tree stand or even a larger spatial unit cannot fulfill all these functions to the same extent, especially in the face of rapid climate changes. Consequently, we should consider identifying individual types of forests with a focus on their primary functions. Such a differentiation should be made within the current structure of the State Forests to focus on specific goals and therefore boost the effectiveness of such measures. This applies in particular to productive functions, which are treated as secondary in current policy, with logging being increasingly likely to encounter resistance on the part of local communities. Timber ranks among fully renewable, clean, and environmentally friendly resources. Consequently, we should prioritize efforts to manage the changing forests in a way that will also provide a sustained supply of timber, in addition to other functions.

Collaboration between forest science and management

The Polish State Forests have supported scientific research for many years. In the face of numerous uncertainties related to climate change and the responses of forests to these processes, we need to work out concrete solutions. Further collaboration between forest science and management is necessary for the better adaptation of Polish forests and forestry to imminent changes.

A plus tree of Scots pine in the Gołdap Forest District

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