FORESTRY NEEDS NEW ROOTS

Climate change is devastating forests in Germany and other European regions. Our traditional understanding of which tree species can withstand heat and drought no longer holds true, which is why ecophysiologist Henrik Hartmann is calling for the creation of an interdisciplinary Institute for Forest Conversion. This new institute would provide scientific insights into how forests can be constituted to be able to withstand ongoing global warming.

Forests are not looking healthy. Several times over the past few years we have flown drones over forests around Jena to document the changes. What the footage reveals is shocking. Many of them are dotted with dead and dying trees. Trees have sparse crowns, with dry branches sticking out where lush green existed just a few years ago. The color of the treetops is also concerning; as early as August, the appearance of many trees resembles what you would normally expect to see in late September, when the leaves gradually take on the hues familiar in fall. These observations exemplify a more general development: climate change is threatening the long-term sustainability of agriculture and forestry in Germany and Central Europe. Many ecosystems are already under threat in their current form, and prospects for the coming decades are also bleak. The extreme summers of 2018 and 2019 left devastation in their wake, particularly in forests, several hundred thousand hectares of which were destroyed. In many cases, these were spruce monocultures ravaged by the bark beetle, but the spruce was not the only species affected. Many deciduous and pine trees, which had previously been considered to be relatively drought-resistant, also suffered severely. The die-off rates of various tree species have increased exponentially since 2017. The resilience of German forests to climate change has also been a matter of public debate, at

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VIEW POINT

HENRIK HARTMANN

ILLUSTRATION: SOPHIE KETTERER FOR MPG

Henrik Hartmann studied forestry and biology at the Canadian universities of New Brunswick and Quebec, where he also earned his PhD. He has been the Head of a Research Group at the Max Planck Institute for Biogeochemistry in Jena since 2014. The group conducts research into such questions as how trees react to drought stress and how they deal with resource scarcity more generally. It also investigates how trees control the storage of nutrients, particularly carbon and nitrogen. Hartmann is extremely concerned about the condition of German forests, which is why he is keen to bring together experts from the fields of forest science, forestry, and biology as well as from the social sciences with a view to equipping forests to deal with climate change.

least since the summer of 2018, and the topic of Waldsterben, or forest dieback, is discussed almost daily in newspapers and on the radio and TV. It is also often the subject of controversial public debate.

Long before the general public took an interest in forests, forestry researchers were studying the question of whether or to what extent some of our native tree species would be able to cope with the climatic conditions of the future. In 2004, for example, one group at the University of Freiburg led by Heinz Renneberg looked into whether beech would be a suitable species for future silviculture when climate change intensifies. The study found that the "species, which is sensitive to drought stress and flooding" is already suffering significantly from "reduced growth and competitive vigor," a trend "that will continue and probably worsen over the coming decades." The article triggered a whole series of responses from other scientists, who, as late as 2016, insisted that beech could continue to be one of the predominant species in Germany's forests even in the face of progressive climate change. This was in spite of the fact that it had become clear by then that when a beech tree sheds its leaves during a drought, it is not a protective mechanism against drought stress, but is due to the consequential damage the tree has suffered. So, rather than "allowing" its leaves to wilt to reduce the total surface area of the leaves and thus evaporation, the leaves wilt because their water supply has been cut off. The events of 2018 and 2019 also showed that the beech not only responds to climate change with reduced growth and competitive vigor – as predicted by Renneberg and his co-authors – but that it also suffers severe damage, often even dying off, which few would have thought possible just a few years ago. Similar concerns apply equally to other tree species, particularly in the face of progressive climate change. Maple, ash, pine and other species are similarly affected, and it is currently entirely impossible to predict the climatic conditions under which previously robust species, such as the oak, will reach their stress limits.

NEITHER FOREST MANAGERS NOR FOREST SCIENTISTS CAN CONTINUE AS THEY HAVE DONE FOR CENTURIES

In light of the ongoing climate change, neither the forestry industry nor forestry science can continue as they have done for centuries, because it is no longer possible to use past experience to plan for the future. As the example of the beech demonstrates, previous findings collected under different climatic conditions can only be projected onto the expected climatic developments to a limited extent. This retrospective approach also completely misses the mark in public discourse about the future viability of forestry, which is often profoundly influenced by self-appointed experts and armchair foresters. For example, there is no scientific basis for calling for a greater role for the much-exalted, species-rich, mixed deciduous forest as the resilient forest of the future – as the die-off rates of many deciduous species clearly demonstrate. A recently released analysis of forest inventory datasets from the U.S. and Canada shows, for example, that tree mortality rates in temperate forests rise with increasing species diversity, especially under extreme climatic conditions. Obviously, this finding cannot and should not be used as an argument in favor of the expansion of monocultures, but it does raise serious doubts about simplistic approaches, which may seem sound and obvious at first (who would intuitively call the benefits of diversity into question?), but which are based on emotions, rather than empirical science.

IT IS THE TALLER AND OLDER TREES IN PARTICULAR THAT SUFFER THE MOST UNDER DROUGHT CONDITIONS

The same applies to *Wenn Wälder wieder wachsen: Eine Waldvision für Klima, Mensch und Natur* (When forests grow again: envisioning forests for the climate, humankind and nature), a study commissioned by Greenpeace e. V. and published in 2018, which is touted as a guide to forest management for the coming decades. It states that trees should only be harvested “when they are older and thicker,” and that interventions in the forest should be “less frequent and less severe” with a view to almost tripling the number of thick trees compared to the numbers achieved under conventional forest management systems. The positively idyllic image of “a colorful array of tall and short, thick and thin trees standing side by side” that this study evokes is emotionally appealing, but it is no substitute for a scientific basis for the sustainability of older forests as suggested in the study, because the opposite has been proven to be true. It is the taller and older trees in particular that suffer the most under drought conditions, and we can even expect forests to become generally younger and smaller under future climatic conditions, as the taller and older trees suffer greater exposure to the stresses and upheavals associated with climate change and become subject to a greater die-off rate.

Clearly, the debate about the future of the forest must encompass a broad range of opinions and views, but we should not allow emotionally appealing but misleading and scientifically questionable reports to dominate dis-

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cussions. But unfortunately it is precisely this type of report that often has a significant impact on public perception.

A future-oriented forestry strategy must be based on empirical evidence and facts rather than on beliefs and wishful thinking. The requisite knowledge can only be obtained by conducting a systematic survey of what actually takes place in the forest. This data can then be used to correct and augment previous site-specific and phytosociological positions. For example, die-off rates can provide important information, particularly if the data can be used to identify precisely which tree species are acutely affected and where they are located. However, we still lack a comprehensive and detailed overview of how climatic trends are affecting die-off rates at different sites. Numerous surveys of forest conditions have been carried out, from the federal forest inventory to state surveys, to an annually recurrent survey carried out as part of the International Cooperative Program on Assessment and Monitoring of Air Pollution Effects on Forests (or ICP Forests for short). But none of them provides the spatial and temporal resolution that would be needed to establish causal relationships between developments at specific sites and climatic events. Survey data is also usually kept in archives that are not openly accessible, which hinders any decentralized analysis by the scientific community.

THERE IS NO LEGAL FRAMEWORK FOR THE AGGREGATION OF DATA WITHIN AN OPEN INFRASTRUCTURE

In recent years, remotely-sensed time series (such as satellite data) have been used more frequently to monitor forest vitality, because they provide a high temporal resolution (a few days to weeks). However, the spatial resolution does not usually enable an evaluation of forest damage at the individual tree level. There is, therefore, a temporal and spatial resolution gap between local and remote monitoring. As such, it is not possible to draw conclusions about climate-related forest damage at the regional level, which in turn makes it difficult to expand our knowledge at the site-specific phytosociological level. One way to close this gap would be to systematically merge the various data sets, using the data recorded in the forest to better evaluate remote sensing data and to contribute to a near real-time monitoring of forest vitality. However, the necessary legal framework does not exist that would provide for the systematic aggregation of data within an openly accessible infrastructure, which would then enable or even oblige the responsible institutions to provide access to their data. For this reason legislators ought to specifically promote the idea of data sharing and demand its implementation. Any turf wars between institutions must also be stopped, as these disputes often stand in the way of data sharing.

Furthermore, existing synergies between the various federal and state institutions and academic experts (chairs, research institutes, scientific networks, etc.) who have an interest in evaluating the data should be promoted through the coordination of their research agendas. Collaborations between the disciplines that are important for forest restructuring should also be intensified. Germany's scientific community has an enormous amount of expertise in these disciplines (which include vegetation modeling, forest ecology and ecophysiology, as well as economics and the social sciences), but there is also a lot of fragmentation. Bringing all of this expertise together in a (virtual) Institute for Forest Conversion would counteract this problem and make it possible to exploit the many existing synergies. Then, in addition to monitoring the forests in real time, research topics that are relevant in this context would have to be identified and a much greater emphasis placed on the use of modeling in forest planning. The empirical models that have been used up until now, which forecast future changes in forests on the basis of past trends, are of limited use when it comes to extrapolating from the data to make predictions into a climatically uncertain future. Mechanistic models, which comprise the fundamental processes that occur in trees, also need more data concerning the physiological properties and adaptive abilities of our native tree species. This data could be obtained through intensive forest monitoring programs, but also through experiments both in the forest and in the greenhouse.

AN INTERDISCIPLINARY INSTITUTE FOR PLANNING THE FOREST OF THE FUTURE

An interdisciplinary institute of this type would provide the best conditions for planning the future direction of forestry research and forest management. Interconnecting state research agencies, forestry practitioners, fundamental research, and forestry policy would provide a holistic understanding of the forest as a system, forming a basis for future-oriented forestry. To define society's demands on forests, but also the needs of the forests themselves, various interest groups, such as conservation initiatives or hunting associations, should also be involved in forest policy planning. Thus, such an approach to forest management and forest science of the future should be characterized by complexity and diversity – like the forest itself.

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