FORESTS AND CLIMATE CHANGE IN CZECHIA: AN APPEAL TO RESPONSIBILITY

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ABSTRACT

Forests cover more than one third of the area of Czechia and provide many environmental, economic, social and cultural benefits. Only a small part of the country´s forested area is left to nature. Most Czech forests are managed, with Norway spruce as the main tree species. The ongoing climate change progressively creates new conditions for the functioning of forests as important components of the landscape and providers of ecosystem services for society. Until recently, Czech forestry policy makers had not paid enough attention to climate change. As a result, Czech forests grapple with increasing instability caused by repeated windstorms, droughts and insect plagues. Traditionally applied management methods and rigid business models are not suitable for resolving the situation. Czech forestry thus takes an exceptional position within Europe. The responsibility for the development of the adaptation strategy and sustainable management policy lies in the hands of forestry policy makers. In order to restore stability and to ensure multifunctionality of forests under new climatic conditions, it will be necessary to introduce a new model of forest management. Compared to the traditional forestry model based on age classes, the new management model must be more flexible and better adapted to the new environmental situation. The principles of the new forestry policy should stem from agreement and cooperation of the forestry sector with scientific and nature protection institutions, as well as from an active discussion within society.

The starting point of the change are the documents Strategy of Adaptation to Climate Change under the Conditions of the Czech Republic and National Action Plan, elaborated in 2016 and 2017 by the Ministry of the Environment, and the Strategic Framework Czech Republic, approved by the Czech government. The chosen adaptation strategy and its implementation must not only restore the stability of forests, but also improve the future position of the Czech forestry sector among European countries.

Keywords*:* Czech forestry; climate change impact on forests; adaptation strategy; forest management innovation; new forestry policy concept; biodiversity; Platform for the Landscape

INTRODUCTION

Forests cover nearly one third of the Czech landscape and affect its environment in a considerable way. Their good state and functioning are the basic preconditions for the provision of optimal ecosystem services to society. As an independent site factor, the climate affects forest ecosystems, which, in turn, moderate local and regional microclimates, soils and water regimes over large areas. Conversely, forest management creates conditions

supporting the production function of forests. These mutual relationships have various consequences not only for forests, but for entire landscapes.

The ongoing climate change has a strong impact on forests. Increasing temperatures, more frequent droughts and extreme climatic fluctuations form the background of disturbances and insect plagues that afflict Czech forestry, alter the biodiversity of forests and bring uncertainties as to the future provision of forest services and the benefits of forests for mankind, including wood production (Fanta, 1992; Moldan *ed.*, 1993; Buček & Vlčková, 2009 a, b; Hlásny *et al.*, 2012). Only some 11 % of Norway spruce forests are growing on natural sites. Most Czech forests are monocultures of Norway spruce planted and growing in unsuitable conditions outside of the species' natural niche. Such commercial forests are highly vulnerable to the new climatic conditions. To minimize the risks, forest management must adapt to the changes. Unlike in neighbouring countries, leading policy-makers of the Czech forestry sector have not reacted to the new situation in time. Instead, they have continued to prefer traditional management methods, which are oriented mainly towards the production of timber and other wood.

Forest management was established in the 18th and 19th centuries as a set of technical operations aimed to maximize wood production, which was indispensable for industrial development at the time (*Silvicultura Oeconomica*, von Carlowitz, 1713). The so-called age-classes forestry approach (Hartig, 1791; Hundeshagen, 1827) combined all temporal and economic aspects in a model corresponding with the ideology of economic growth of the Second Industrial Revolution in the best way. This approach, however, completely ignored natural conditions. This has harmed the forestry sector not only ecologically, but also economically. The development of ecology as a science and attempts to apply ecological knowledge in forest management, although successful (e.g. Gayer, 1886; Möller, 1922; Konšel, 1931), did not change the official concept of forestry policy of that time. Forests of today are ecologically unstable products of previous forestry policy and forest management. To minimize future risks, a new forestry policy and a proper corresponding forest management concept must be developed.

FORESTRY AND CLIMATE CHANGE ACTIONS IN EUROPE

In the founder countries of the EU, foresters have been paying attention to climate change and its impact on forests and forestry since the beginning of the international discussion headed by the Intergovernmental Panel on Climate Change (IPCC, 2014) and later, with declining biodiversity also by the Intergovernmental Science-Policy Panel on Biodiversity and Ecosystem Services (IPBES, 2018). In some countries, working teams have been established already in the 1990s, to investigate various aspects of the problem and to identify strong and weak points of the matter (Fanta, 1992). Climate change has become one of the most important research topics of the European Forest Institute and, to date, hundreds of scientific publications have appeared in scientific journals worldwide. The complicated nature of the matter has stimulated broad international communication among specialists from different parts of Europe (*e.g.* Bolte *et al.*, 2009; Lindner *et al.*, 2010; Hanewinkel *et al.*, 2012; de Frenne *et al.*, 2013; Fitzgerald & Lindner, 2013; Wagner *et al.*, 2014; and Nabuurs in this issue), especially in the fields of climatology, biology, pedology and ecology, and brought them together with foresters to find answers to both scientific and practical questions connected with climate change. Moreover, respected international organizations such as the European Environment Agency, the Food and the Agricultural Organization, the International Union of Forest Research Organizations and European Academies´ Science Advisory Council are participating in this process, discussing topics such as short rotation

forestry and accounting procedures used in the LULUCF sector. Last but not least, the two main forest management certification organizations, the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC), saw an increase in the area of certified forests; however, the percentage of the total forest area covered by such forests is still low (http://web.unep.org). Because of the aforesaid strange attitude of the Czech forestry policy-makers, hardly any Czech foresters were involved in these international research and policy programmes.

IMPACT OF CLIMATE CHANGE ON FORESTS: LESSONS FROM THE PAST CENTURIES

The present climate change is not the first to occur in Central Europe. The results of palaeoecological investigations concerning changes in forests and vegetation development over the Holocene in Central Europe are a good basis for imagining the course of changes we will be confronted with in forests and vegetation under the current climate (e. g. Firbas, 1949, 1952; Ložek, 1973; Holten, 1990; Jankovská & Pokorný, 2008; Pokorný, 2013). In most cases, the changes were rather rapid and not reverting, leading to the development of new types of vegetation cover or to the shifting of vegetation zones (see Machar, *et al.* in this issue). In the historical period, the changes in vegetation cover have been concurrent with human activities in the landscape. For example, the warm climate in the first half of the Middle Ages (in the 9th and 13th centuries) facilitated the colonization of lowland areas of Northern and Northwestern Europe, accompanied by extensive deforestation and the development of large areas of wind-blown sand landscapes in today's Flanders, in the Netherlands, northern Germany and northern Poland, which nearly ended in desertification (Koster, 1978; 2010). The colonization of uplands and low mountains, accompanied by extensive deforestation in the Czech lands, formed the basis of prosperity of the Bohemian kingdom in the 13th and 14th centuries. However, a rapid swing in the opposite direction – the cool and wet period of Little Ice Age (in the 15th–19th centuries) – caused the abandonment of many settlements in hilly areas and led to the cessation of agricultural land use of upland areas. This development was followed by extensive soil erosion of abandoned agricultural land. As a result, the 14th century has been identified as the period of greatest displacements of soil matter in the history of the Central-European Quaternary (Bork *et al*., 1998).

At the end of the 17th century, Central Europe had the lowest forest cover in its history. It was a crisis which developed as a result of former extensive clearing of previously unmanaged forests. The inception of organized forestry (von Carlowitz, 1713), in reaction to this new situation, made it possible to resolve the first Central-European energy crisis, which was caused by a lack of firewood and timber – the basic energy and construction materials of the time. The cool and wet Little Ice Age was a favourable period for the development of coniferous forests. Organized forest management had made it possible not only to restore cleared forests, but also to afforest abandoned agricultural land, and, in the following centuries (i.e. the first industrial period), to produce previously unheard of quantities of firewood and timber. Unfortunately, this was achieved by the establishment of monoculture plantations, at the expense of natural conditions. What is even worse is that the age-classes forestry model developed at that time survives virtually unchanged to this day.

The aforesaid examples show that the impact of climate change on forests will potentially be great. Moreover, the speed of the ongoing change confirms the knowledge gained by the palaeoecological research.

CURRENT SITUATION IN CZECHIA

In contrast to other European countries, the leading bodies of the Czech forestry sector had until recently (January 2019) not taken any clear position on the matter of climate change. This has several causes. The first reason stems from the discontinuity in the political development of the country since the half of the past century (Petřík *et al.*, 2015). In that period, the totalitarian regime was not interested in environmental issues and blocked any rational discussion in this field. This was logical. The second half of the 20th century was a period that left heavy environmental damage to forests from industrial pollution (Hruška & Cienciala, 2001; 2003). However, the chaotic political situation after the Velvet Revolution in November 1989 had a similar effect. Initial attempts to change the course for the better, such as the Conference on European Environment (held in Dobříš in 1991; Moldan, 1993), were successful, but they did not gain sufficient attention. The political mood was geared above all towards economic aspects, at the expense of the environment. Under the influence of this approach, for example, the main Czech forestry organization (the Czech State Forest Service) decided to outsource all field operations (such as tending, felling and reforestation), and to largely limit its own activities on administrative tasks, with economic aspects at the forefront. The ecological aspects of forest management were sidelined. Hardly any attention was paid to the potential danger and prevention of windbreaks, and even the effects of the Kyrill storm in 2007 did not bring any change in approach.

A new impulse came with the accession of the country to the European Union. The National Forestry Program II (2008–2013) explicitly addressed all important topics pertaining to the impact of climate change on forests and forestry. However, because of an unstable political situation at the time, the reality fell flat. Forest diebacks of Norway spruce forests in some parts of the country, caused by drought, root rot or bark beetles, have already reached dimension on which they are hard to address within the regular forest management scheme. Several climate-change-oriented publications (e.g. Buček & Vlčková, 2009a, b; Hlásny, 2012) were published but did not find immediate continuation and support in institutional research programmes or in forestry practice. Not even the Principles of the state forestry policy, accepted in 2012 by the Czech government, mentioned the need for change in the approach to forests and forestry under threat from climate change. In the meantime, however, the technical means for tackling bark beetle outbreaks turned out to be ineffective and the outbreak became a calamity. In 2017 a state of emergency was declared in three Moravian provinces. One year later, clearings covered an area of 40,000 hectares, and other areas are exposed to the same danger. It is clear that the present concept of forestry and forestry policy has failed spectacularly.

FUTURE CLIMATE AND ITS POTENTIAL IMPACT ON FORESTS AND FORESTRY

The current climate change will affect not only the nature of forests as ecosystems and vegetation formations, but also the quantity and quality of benefits and services they provide, which contemporary society cannot do without. Certain processes, including some that are invisible, are already under way, and others can be expected to start taking place sooner or later. Examples of such processes are numerous. Many of them have already been investigated in other countries, for example Slovenia, Austria, Germany and Switzerland.

Several examples:

- Change in the course of ongoing temperatures and precipitation, their distribution during the year and potential extreme fluctuations (droughts and floods; *e.g*. Bässler, 2008; Pretel, 2009; Remund *et al.*, 2016).

- Changes in the tree species composition of managed forests (strong impact on Norway spruce forests growing on unsuitable sites; regional differences related to site conditions (*e.g*. Leuzinger *et al.*, 2005; Hlásny, 2012; Lévesque *et al.*, 2013).
- Latitudinal and elevational shifts in the distribution of forest communities and their transformation are predicted (*e.g*. Buček & Vlčková, 2009a, b; Brus *et al.*, 2011; Zimmermann, 2013; Machar *et al.* in this issue).
- Stimulation and suppression of soil processes in some areas and on sensitive sites (abundant nitrogen release and rapid growth stimulation of Norway spruce; growth restriction of vegetation and trees on dry sites; *e.g*. Rothe *et. al.*, 1998; Rothe & Mellert, 2004).
- Changes in ecological tolerance of tree species, forest growth and biomass production - biomass reduction at lower elevations due to drought; greater wood production in mixed forests compared to monocultures (*e.g.* Lafond *et al*., 2014; Pretzsch *et al*., 2015a); and contemporary excessive growth of Norway spruce and its low ability to resist wind and snow (*e.g*. Boisvenue & Running, 2006; Bolte *et al*., 2010; Braun *et al.*, 2015; Pretzsch *et al.*, 2015b; Bosela *et al*., 2016).
- Insect outbreaks in forests (bark beetle infestation of Norway spruce plantations at lower elevations and on sensitive sites, see *e.g*. Engesser *et al.*, 2008*;* Hlásny & Turčány, 2009; Příhoda & Lukášová, 2014).
- Changes in the occurrence of saprophytic and saproxylic organisms on forest trees, *e.g. Chalara fraxinea* on indigenous ash trees; *Gemmamyces piceae* on the introduced species *Picea engelmannii* (Loo, 2009; Sturrock *et al.*, 2011; Černý, 2016); root rot on Norway spruce at lower elevations; potential root rot on young Douglas fir trees planted on sites formerly occupied by Norway spruce (Vor *et al.*, 2015; Holderegger *et al.*, 2017); loss of mycorrhizal fungi on trees on some places (*e.g.* Oliva & Stenlid, 2012; Desprez-Loustau *et al.*, 2016).
- Changes in natural regeneration of forest trees: the rise and following decline of natural regeneration of Norway spruce on unsuitable sites; increase of natural regeneration of European beech and other broadleaves in lower elevation zones (Ott *et al.*, 1991; Bugmann, 1999; Moser *et al.*, 2015).
- Increased danger of wind- and stormbreaks in Norway spruce monocultures (Schelhaas *et al.*, 2003) and forest fires under dry conditions, especially in the summer period, *i.e.* during harvesting of agricultural crops.

The mutual relationships of these and other examples of climate change consequences for forest trees and sites create innumerable possibilities of how forest ecosystems will react to climate conditions changing in time and space. In the long term, climate change will alter the conditions for forest growth and the functioning of forests as ecosystems. It will influence local ecosystem services (*i.e*. production, supporting, regulation and cultural – see the Millenium Ecosystem Assessment, 2005). This will inevitably create vastly different conditions for the management of forests as a renewable natural resource.

The decision on how to properly manage forests under future climatic conditions should be based on basic research knowledge, a modern approach to forestry, practical experience and public awareness.

TRANSITION TO SUSTAINABLE FOREST MANAGEMENT

Thanks to environmental science, forests are no longer viewed merely as a source of wood, but as ecosystems and irreplaceable structural components of the landscape. The goals of modern forestry are defined in terms of sustainability, multi-functionality, biodiversity and provision of ecosystem services (see *e.g.* MCPFE/PEBLDS consultation meeting on pan-

European recommendations for afforestation and reforestation in the context of the UNFCCC). Under these conditions, forest management must be understood as a coordinated activity based on the integration of ecological and economic insight and executed as an integrated process enabling and securing the aforesaid functions and goals. The close-to-nature management model expresses the character of this approach in the best way. The word 'nature' does not mean that technical management interventions should be excluded. Instead, it indicates the respect for the broad context of ecological relationships and processes mentioned above; management interventions should not be carried out as a rigid set of prescribed technical operations; each intervention has to be in line with natural development. Logically, any forest management concept must be adaptive, meaning flexibly adaptable to various situations, closely corresponding to local conditions and aimed towards the achievement of forest management goals.

In fact, such a concept is not new to Central European or even to Czech forestry. Similar concepts of forest management have been developed and applied, both in the past and recently, mostly in response to the dissatisfaction with the old-fashioned age-classes-forestry model (*e.g.* Rubner, 1968). Some forest owners in Central Europe have decided to apply this management approach as a general strategy – and with good results, even with regard to economy. In Czechia, good examples are provided by Konias (1951) and Košulič (2010). Recently, this approach has been strongly advocated by the organization *Pro Silva Europa* with its national branches in various countries (see *Pro Silva Bohemica* in Czechia; Remeš in this issue). Based on broad scientific knowledge and practical experience, leading European forestry bodies and institutions recommend the close-to-nature management model as the best strategy to cope with the uncertainties brought by climate change (*e.g.* Kolström *et al.*, 2011). An analogous response can be found in presentations from the EASAC (European Academic Science Advisory Council) 'Beyond Wood Conference', held on 23 May 2016 in Brussels.

The crucial point of the adaptation of Czech forestry to the new climatic situation, however, is the need to change the present business model of the Czech State Forest Service. The present concept is explicitly economy-oriented and does not properly respect the ecological conditions of forests. In fact, this discordance is at the roots of the problems of contemporary forestry, including the expanding bark beetle calamity. The business model must be revised and brought into balance with the regionally different ecological conditions of particular forest areas. This balance is the basic precondition for the development and application of sustainable forest management – the only acceptable model for the future, which can bring stability to local forest environments and the forestry sector as a whole. The development of this new concept is the main contemporary task of Czech forestry policy. It is without doubt that the final result of this process must be a new forest bill.

FORESTRY AND BIODIVERSITY CONSERVATION

In the new concept of forest management, the maintenance and restoration of biodiversity is an important point. Indigenous trees, plants and other organisms provide greater ecological and physical stability of ecosystems than planted monocultures, which are a cause of severe biodiversity degradation. The problem of biodiversity restoration must be addressed systematically and in coordination with nature and landscape protection administrations (Vor *et. al.*, 2015). Foresters may base their practice on information revealed by long-term investigations in national parks, nature reserves and areas left to natural development. Last but not least, this adaptation process must be related to broader landscape circumstances (Hrnčiarová *et al.*, 2009; Fanta & Petřík, 2014). In principle, two main approaches to the

conservation or improvement of forest biodiversity are being discussed: (i) the creation of wilderness areas (maintenance of natural processes with minimum intervention; and (ii) sustainable management linking productive and non-productive functions of forests. The former point pertains to species depending on the continuity of the forest cover, dead wood and large trees (i.e. some bryophytes, lichens, fungi, saprophytic beetles, cavity-nesting birds associated with old forests), which are negatively affected by intensive forest management (Gregory *et al.*, 2007; Virkkala *et al.*, 2008; Moning & Müller, 2009; Scheidegger *et al.*, 2009; Paillet *et al.*, 2010). The latter approach is applicable to the protection of endangered species through management with shorter rotation times in place of high forest systems, such as coppicing with standards (see Konvička *et al.*, 2006; Hédl *et al.*, 2010). In Europe, progress towards sustainable forest management is periodically monitored (see Lindenmayer *et al.*, 2006; and MCPFE). Silvicultural diversification (sometimes called 'polyculture') is recommended for the mitigation of risks to the biodiversity of forests and the ecosystem services they provide (Felton *et al.*, 2010; Gamfeldt *et al.*, 2013; Löhmus & Runnel, 2014; Hofmeister *et al.*, 2015). Forest certification as applied by the Forest Stewardship Council (FSC) should be preferred because it leads to the application of stronger measures (Elbakidze *et al.*, 2011).

A CHALLENGE FOR CZECH FORESTRY AND LESSONS FROM OTHER COUNTRIES

The ongoing climate change is a long-term phenomenon; progressively, it will alter our present environment and create an entirely new set of conditions for the existence of forests in this part of the European continent. Some of these changes are already underway, especially on dry lowland sites. In the short term, however, these changes will also take place under different conditions (Vitasse *et al.*, 2012; Moser *et al.*, 2015). Their impact on forest growth and forest management will be both beneficial (*e*.g. increased biomass production at higher elevations) and adverse (*e.g*. lower resistance of damaged forests to diseases). Both local and regional differences in forest management will therefore increase. The future principles of forest management must be derived from detailed knowledge of site conditions and processes of natural ecosystem development.

A good example of a creative approach to the formulation of a new concept of forest management and planning is the forest development type model developed in Baden-Wuerttembergia, Germany (von Teuffel & Krebs, 1999; von Teuffel, 1999) and officially implemented there since 2014. This model comes as an alternative when monocultures and forestry based on age classes fail (Perpeet, 2001). The Czech alternative of this forest management and planning concept (Černý, 2004) was rejected by the leading Czech forest planning authorities and remains limited to national parks and a few experimental plots (*e.g*. Forest Enterprise of Mendel University in Křtiny).

Despite the fact that timber production will remain one of the primary purpose of majority of forests, it is essential to find harmony between wood production and other ecosystem functions, such as carbon sequestration in vegetation and soil, water retention, maintenance of biodiversity and social functions (see Stachová in this issue). This coherence must be attained in a both economically and ecologically efficient way. This is a task that requires both an intensive cooperation of the forestry sector with the scientific community and intensive intersectoral cooperation between foresters and nature protection authorities. It also requires an effective system of subsidies supporting the adjustment of forestry policy and the creation of legislation that will open the way towards flexible and adaptive forest management respecting the balance among economic, ecological and social conditions. This is the way to restore the stability of forests and to ensure forest ecosystem services – the most

important obligations of Czech forestry today (*cf.* Putz & Redford, 2009; Harvey *et al.*, 2010; Lindenmayer *et al.*, 2012).

The Czech government has revitalized the Governmental Advisory Board for Sustainable Development and, simultaneously, entrusted the Ministry of the Environment to elaborate the Strategy of Adaptation to Climate Change under the Conditions of the Czech Republic (https://www.mzp.cz/cz/zmena_klimatu_adaptacni_strategie) and its follow-up the National Action Plan (https://www.mzp.cz/cz/narodni_akcni_plan_zmena_klimatu). These initiatives are being followed now by analyses of the effects of the changing climate on the development of various aspects of the economy, the environment and public life. The first good examples of an effective cooperation of the forestry sector with researchers in biology are documents dealing with adaptation of forest management to climate change (Hlásny *et al.*, 2016; Čermák *et al.*, 2016). Further steps should be oriented towards a new, more flexible concept of forest site typology, management of tree species and species mixtures, game management and transitioning from even-aged silviculture to selective cutting in multi-age forests, eventually resulting in the introduction of small-scale management into forest law. In Czechia, specific attention must be paid to the execution of management measures including the use of heavy machinery and to the involvement of the forestry sector in countryside development, especially in cooperation with the agricultural sector.

CONCLUDING REMARKS

From its very beginnings, organized forestry has focused primarily on the provision of firewood and timber in amounts required by the rapidly evolving industry. The development of methods of silviculture, forest protection and wood harvesting has led to massive changes in tree species composition, the introduction of non-native provenances of forest trees and the introduction of a homogeneous structure of forest stands. At the same time, clear-cutting followed by tree planting represented a technically and economically efficient approach to forest management. Developments over the last decades characterized by dramatic Europe-wide damage to forests and growing demands of the society on the multifunctional character of forests have raised the need for changes in the current paradigm of forest management.

In the face of climate change and related changes in forest disturbance regimes, risk-oriented management becomes the key concept for future development. Unstable monocultural forests need to be transformed into stable, uneven-aged and mixed forests. Only such forests will be able to ensure the provision of the desired forest functions, even in cases of local failure of some tree species, be it as a result of the adverse effects of climatic factors or of pests. Such an approach will reduce the risk of sudden destruction of large forested areas and facilitate the desired asynchronous dynamics and ecological stability of forests and forested landscapes. The landscape framework must also be taken into consideration. With respect for natural conditions, valuable open habitats should not be afforested but kept open to support the landscape diversity. With regard to the needs for multifunctional management that supports biodiversity, water retention in the landscape, accumulation of carbon, etc., it is necessary to create a framework for the implementation of a wider spectrum of management alternatives supporting these functions. Forestry policymakers must also take into account the social significance of these functions and implement an effective subsidy policy.

More than ten years ago, specialists in the field of forestry became divided by the publication of a critical standpoint of Czech scientists and professionals devoted to the protection of Czech forests, which called for systemic changes in forestry (Fanta *et al.*, 2006).

For the forestry sector such a direct approach was not acceptable. Today, it is clear that it was impossible to achieve positive change in the divided forestry community of that time. With the increasing impact of climate change on forests, however, the need to change the concept of forest management became more pressing than before. Therefore, the Forum 2000 conference (2016) aimed to first ascertain the positions of various groups as the starting point of a discussion about the future concept of Czech forestry. The Platform for the Landscape (www.nasekrajina.eu), a new initiative of the Czech scientific community administered by the Institute of Botany of the Czech Academy of Sciences, offers a forum for such a discussion. The Platform for the Landscape aims to give impetus to the process of elaborating a coherent future-oriented national forestry policy that will be based on scientific, economic and social foundations, and on effective intersectoral cooperation. This initiative is in line with the document Strategic Framework Czech Republic 2030 (2017), which formulates, in general terms, the principles of ecosystem management to secure biological diversity and the provision of ecosystem services in Czechia.

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