Introduction

Tomáš Vrška

Historical changes in forest conditions

The Czech Republic has 2,657,379 ha of forest covering 33.8% of our country. On the European scale, this slightly above-average cover does not have a corresponding level of forest quality, as for forest stand health, tree species composition, spatial structure, or related biodiversity. A total of 67% of our woodland consists of predominantly coniferous stands (i.e. with more than 75% of conifer species). The current proportion of coniferous tree species (74%) is more than twice that of conifers (35%) in natural stands, according to reconstruction (Anonymus 2011b).

Forest management has a rich history. It began in the Neolithic age in the lowest and therefore warmest regions approximately 4,000–5,000 years ago. These beginnings were not purposeful forms of management, but only they just indicate man's influence on forests. As society developed, this impact spread to higher elevations. Medieval colonisation of highlands had a strong impact on forests. Pressure on forest use grew as the technology for cutting and processing large diameter trees developed, and forests were intensively used for grazing, burning charcoal, litter raking, etc. The bad state of the forests and a looming energy collapse (coal was not yet a standard source of energy) led to issuing the so-called Theresian patents (in 1754 and 1756), which meant a fundamental change in the society's view of forests in the 18th century. Forest uses diminishing yields and degrading the production potential were restricted (e.g. litter raking, grazing, etc.), and forest management regulations were introduced, including the first forest management plans.

Planning played a major role in the change of forest conditions. Thanks to the application of procedures adopted from the German forestry school, open and untended stands were restored according to a plan, primarily by the planting of Norway Spruce (*Picea abies*) and Scots Pine (*Pinus sylvestris*). These long-term, targeted efforts not only provided the expected results in gradually increasing production (growth increment) and instantly raising timber supplies in forests, but also led to the creation of standardised, production-focused forestry. Thus forestry entered the 19th century as an established form of human activity. It also conditioned the current state of our forests. In that time the production advantages of using spruce and pine were unquestioned, although repeated regeneration of coniferous monocultures soon began to show its drawbacks: soil podzolisation and corresponding decrease in potential soil production, a significant decline in forest stability due to biotic and abiotic factors, and of course a decrease in forest stand biodiversity. Due to these changes many forest species are currently declining rapidly and are endangered, some have even gone extinct (Farkač et al. 2005).

Forest restoration rehabilitating functional ecosystems

In the second half of the 20th century conditions worsened, and the acid rain catastrophe which struck the Czech Sudeten Range clearly indicated that the state of the forests needed improvement. Research aimed at restoration of the pollution-stricken forests started in the former Czechoslovakia in the 1960s. From today's point of view

Fig. 1. Beech forest, Bílé Karpaty PLA. (B. Jagoš)

Fig. 2. Montane spruce forest after bark beetle outbreak, Šumava PLA. (Z. Patzelt)

the application of its findings were the first tangible results of forest restoration management and restoration ecology in a broader sense. The main issue here was the reinstatement of basic forest functions. Restoration of the production potential was to be the icing on the cake and was, in the earliest stages, not a goal considered to be attainable in the near future. A good example is the restoration of forests in the Jestřebí Mountains in the Trutnov region (Tesař et al. 2011).

In protected areas the acid rain catastrophe in mountain forests was another reason for the first extensive forest restoration. The Krkonoše National Park, in existence since 1963, was one of the most affected areas, where 8,000 ha of forest were destroyed. In 1992–2001 the most extensive and costly action aimed at restoring forest functions and natural forest conditions ever taken in the Czech Republic was carried out here. Thanks to financial support of the Dutch FACE Foundation 5,200 ha of forest were restored (i.e. natural species composition and spatial differentiation of stands, leading to development of natural conditions). FACE invested USD 19.5 million into this project (Anonymus 1998). Forest restoration management projects were also started up in other protected areas, such as the Jizera Mts. and the Eagle Mts.

Purpose and aims of forest restoration management

The planning and implementation of restoration management in forests affected by air pollution (either in protected areas or outside of them) was automatically perceived as unquestionable and to be undertaken without delay. In the earliest stages, however, the aims of restoration management on the general level were not dealt with. A major change in the competency of state nature conservation authorities codified in the Act on Nature and Landscape Protection enabled a rapid start to take measures in forests in protected areas (Anonymus 2011a). It then became necessary to answer basic questions about the purpose and aims of restoration management.

Generally, forest restoration management can be broken down into three approaches, each with different aims relating to different functions of the forests to be restored:

1. Forest restoration to rehabilitate a functional ecosystem without emphasising production functions. This is exemplified by the situation in the Jestřebí Mts. (see above), where part of the strategy is also the restoration of the previously stable production potential. These cases of restoration management are not limited to protected areas.
2. Conversion to a near-natural forest, subsequently leaving the forest to spontaneous development. This is, in contrast, almost always applicable to forests in protected areas and with specific aims. Nonetheless, of the three approaches, this one has been least applied. A special variant of this approach is "zero management", i.e. spontaneous regeneration of forest where strong disturbances have taken place either in large areas or affecting basic forest functions (such as wind damage followed by bark beetle infestations, or fires). The ecosystem is in its initial development phase, but its restoration is left to the spontaneous effects of natural forces. Here man is merely an observer of the phenomena taking place.
3. Restoration of forests to a certain state (even if conditioned by man) allowing endangered species to survive and requiring long-term, more-or-less active management, i.e. restoration management with protection of biological diversity as the priority. This approach is currently mostly applied to forests in protected areas, but this does not always have to be the case. Even the Forest Act defines a category of 'Special-purpose forests', with 'Forests necessary for preserving biodiversity' as a subcategory.

Forest restoration aimed at leaving the forest to spontaneous development

If Approach 1 represents the restoration of mountain ecosystems, then Approach 2 typically includes introduction of missing tree species important for development dynamics, and spatial management of forest stands, which are then left to develop spontaneously. In 1992–2012, missing or underrepresented fir was most often introduced, or in some cases supported, in stands dominated by beech in forest reserves. This is a very good illustration of forests having been influenced by man in various ways (selective cutting, occasional grazing, occasional removal of decomposing wood, or formerly managed beech stands on fir–beech sites surrounded by spruce monocultures), which have been designated protected areas with the aim of remediating their state and then leaving them to spontaneous development (Vrška et al. 2002). Fir is either actively introduced to stands by underplanting the beech storey or to small areas affected by disturbance. At other sites where part of the original population has remained, natural regeneration of fir is supported, either by passive protection from wildlife browsing, or actively by increment thinning in the beech storey.

Nature conservation authorities and forestry organisations are more or less in agreement on these procedures, however there is certainly less agreement on the question of what state forests should be left in for spontaneous development. There is of course no single answer to this question. In the field of forest restoration management it is however an issue which has yet to be assessed comprehensively, both within and outside of the Czech Republic.

Forest restoration management for biodiversity protection

The youngest, yet very important, approach to forest restoration management is Approach 3, which was developed in nature conservation at the end of the 20th century in the Czech Republic. The preservation, restoration, and subsequent stabilisation of forest biodiversity, especially when endangered species are involved, mostly concerns low-altitude forests, i.e. forests located under the beech wood belt. In contrast to forests at mid-level altitudes, these forests are not characterised by a dramatic change in tree species composition, but by long-term intensive forest management comprising of coppice systems with short rotation periods to produce fuel wood, agroforestry, pasturing in forests, pruning of branches to create hollows in tree trunks, etc.

Man's intensive and long-lasting influence including a wide variety of forest management techniques has allowed for the survival of species dependent on sunnier and warmer microhabitats. In the 1950s coppicing was strongly limited in order to increase forest productivity and the cultivation of species of higher quality. It is now only used for black locust control, primarily in South Moravia. Oak and hornbeam coppice forests have been converted using whole-area soil preparation after which they were reforested with pine. At sites adjacent to stands where oak is managed, no change in species composition has taken place, but for example standard large-scale oak shelterwood systems, although not posing problems in terms of production and maintaining the production potential of the site, do not create sufficient conditions for the survival of critically endangered insect species.

Therefore, restoration management forms focusing on protecting biodiversity have met with varied reactions. Currently this issue is dealt with by means of experiments with forest grazing (in the Bohemian Karst PLA and Podyjí NP) and to a somewhat greater extent with restoring coppice systems (at Křtiny Training Forest Enterprise of Mendel University Brno and in Podyjí NP).

From the perspective of biodiversity there is also a clear incongruity between active management using old management techniques and leaving forests to spontaneous development. This is caused inter alia by the fact that, logically, we do not have 'traditional' forest reserves at lower elevations, in contrast to mid-altitude and mountain regions (e.g. Žofín and Boubín Virgin Forests). Therefore, we do not yet have knowledge about the disturbance dynamics of forests below the beech vegetation zone. At the same time, forests influenced by man secondarily left to spontaneous development have not yet had sufficient time for disturbance patterns to develop fully: zero management principles have been used here for not more than a few decades.

In contrast to lower altitudes, the restoration of biodiversity at middle and high altitudes is linked to forests which we consider natural (Miko & Hošek 2009) and where there is no fundamental conflict between zero management or minimal maintenance management and biodiversity. Here, biodiversity is linked to decomposing wood and to the natural species composition of forests.

Future issues

Of the total forest area of the Czech Republic, 28.4% is located in protected areas (Anonymus 2011a). One of the main issues for the future is clarifying the aims of restoration management, especially in protected areas, a process which is taking place alongside the gradual renewal of management plans for each area. These plans can lead to further decisions about the management methods to be used.

Forests left to spontaneous development form a specific subgroup. They currently make up 0.95% of the forest area, and consensus has yet to be reached on their total target area (for example, in 2011, a

Fig. 3. Forest along Klaper stream, Podyjí NP. (Z. Patzelt)

Fig. 4. Underplanting of *Abies alba* in spruce forests on slopes of Mt. Velký Blaník, Blaník PLA. (P. Kostečka)

proposal of 4% was not accepted by the coordinating committee of National Forest Programme II). The question in what state we want to leave restoration management forests for future spontaneous development still needs a comprehensive study.

A more serious issue is that of selecting a method of permanent forest management in protected areas and outside them – especially in special-purpose forests for the preservation of biodiversity. As opposed to forests intentionally left to spontaneous development, which will never make up more than a few percent of the forest area, the forest area in protected areas with permanent management will exceed 20%. Their specific management, especially in low-altitude areas, is linked with the adoption of earlier management forms (e.g. coppice systems), as well as with compensation for loss of profit for non-state forest owners due to nature conservation measures. In state-owned forests, a clear policy should be adopted for registering the profit loss by entities operating in them as well as for disputable subsequent state-to-state payments (Nature Conservation Agency of the Czech Republic). Considering assumed future limits on financial resources for special-purpose forest management, today most attention should be focused on selecting important biodiversity protection areas, which will be given funding priority to preserve specific forms of management.

Fig. 5. Forest severely damaged by air pollution, Špindlerova bouda, Giant Mountains (Krkonoše) NP. (Z. Patzelt)

Four case studies in forest restoration management present examples of both spontaneous processes (through zero management) as well as the results of long-term active approaches in forest restoration. These examples come from mountain forests and low-altitude forests. The study of mountain forest restoration in the Jizera Mts. presents the results of 20 years of restoring mountain ecosystems damaged by air pollution in a protected landscape area. On the other hand, the study from the Šumava Mts. gives an example of spontaneous regeneration of a mountain forest after large-scale disturbance in the Core Zone of Šumava NP. A rare, and therefore important, example of spontaneous forest development after fire comes from Bohemian Switzerland (České Švýcarsko) NP. Forest restoration management in the Podyjí NP is presented as a case of gradual conversion of forests earlier dominated by pine to mixed deciduous forests with a rich spatial structure in order to protect the biodiversity of low-altitude forests.

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Active restoration and management of forest habitats

Lukáš Čížek

With more than a third of its area covered by forests, the Czech Republic is among the European countries with a high forest cover, and woodland organisms constitute a substantial portion of its biodiversity. Czech forest cover increased from ~25% to 33.7% between 1790 and 2010, and the standing timber stock per unit area nearly doubled between 1930 and 2010. More than half of the forests is owned by the state and run by state-owned companies. Over a quarter is part of conservation areas. Some forest reserves belong to the oldest on the continent and date back to the mid-19th century.

The above picture seems optimistic not only in comparison with the usual reports on forest destruction in the tropics, but thanks to the large share of state forests also in comparison with western Europe, where state-owned land is rather easily accessible to nature conservation. However, the picture drawn by information on the state of forest biodiversity based on facts from distribution atlases and other biological data is strongly different. Not only has forest expansion taken a dramatic toll on non-forest biodiversity, the newly created forests are also biologically inferior. This, together with a dramatic decline in old-forest biodiversity, contributes to the fact that many forest-dwelling organisms are highly endangered or locally extinct, although they were common some 50–100 years ago (Beneš et al. 2002, Farkač et al. 2005, Konvička et al. 2005). The rather peculiar fact that most forests in conservation areas are production forests managed under a uniform clear-cut system is only partly to blame for the current poor forest biodiversity.

Fig. 1. Stand of pollarded willows near Vojkovice u Brna hosting a number of endangered beetles associated with tree hollows including Hermit Beetle (*Osmoderma barnabita*). (L. Čížek)

Fig. 2. Abandonment threatens stands of pollarded willows in two ways. Neglected pollards are unable to support heavy branches and break down, or the trees are overgrown and killed by young neighbours. (L. Čížek)

Naturally, conifers would constitute ~35% of trees in the Czech forests, with Silver Fir (*Abies alba*) accounting for nearly two thirds and Norway Spruce (*Picea abies*) nearly a third of all conifers. Today, however, conifers cover ~75%, and spruce alone more than half of forested land. While silver fir cover has declined to <1%, other trees have nearly completely disappeared from the country's woodlands, including elms (*Ulmus* spp.), Crab Apple (*Malus sylvestris*), Wild Pear (*Pyrus pyraster*), and Common Juniper (*Juniperus communis*). Numerous organisms associated with these tree species have declined strongly. Nevertheless, such organisms form a rather small portion of the country's threatened woodland biodiversity. Most of the biota associated with open and semi-open woodlands, senescent trees, early successional woodland habitats, and fine mosaics of various seral stages are endangered or even extinct. Despite the strong alteration of species composition, the main problem of woodland biodiversity in the Czech Republic is formed by unification of forest spatial structure (including high canopy closure), and absence of senescent trees and insolated habitats. Attempts to reverse forest species composition to near-natural are relatively common (see case study 'Conversion of pine monocultures to mixed deciduous forests in Podyjí National Park'), but attempts to diversify the spatial and age structure of forests and actively restore habitats of endangered organisms are extremely rare.

The changes brought about by agricultural and industrial revolutions, including extreme intensification of forest management, have fallen particularly hard upon the Czech forests. In the second half of the 18th century, the Habsburg empress Maria Theresia and her son Joseph II attempted to secure supplies of strategic raw materials such as fuel and construction timber. They issued forest acts which indeed increased timber production, while on the other hand suppressing customary rights of forest use. In the second half of the 20th century, more than 99% of the Czech forests came in the hands of the communist state with its well-organised, unified, and intensive forestry. The clear-cut management system was presented to several generations of foresters as the only suitable silvicultural system. Wood pastures, tree shredding, pollarding and coppicing were regarded as detrimental to forest health and production potential, and therefore prohibited or abandoned. Forest management has become extremely unified in the whole country, and clear-cut management is widely applied even to

nature reserves and other protected forests. The virtually only alternative to clear-cutting in forests of protected areas used to be absence of active management. This has led to increased canopy closure and decline of disturbance-dependent species. The vital role of disturbances in sustaining biodiversity, and thus the key role of an active approach to the management of habitats of many endangered species have yet to be fully recognised in the Czech Republic.

Wood pasture

Pasture of domesticated animals in forests has been banned from the territory of the Czech Republic for more than 250 years. With the exception of some fragments found in game reserves, grazed woodlands are thus virtually non-existent here. Serving as hunting grounds for the nobility, game reserves have often been spared from logging and fuel extraction. In the past century, they have also been partly spared from forestry intensification, increased canopy closure and related changes. The fragments of pasture woodlands in game reserves thus host a number of highly threatened organisms associated with open woodlands, old trees and dead wood. Last century, the game reserves fell into state hands, and many are still owned by the state. Today, despite their high value for biodiversity conservation, many game reserves lack any relevant protection status. Due to a recent increase in demand for revenues from state-owned forests, even the last fragments of grazed forests are in serious danger of, or are already succumbing to clear-cutting and replacement by plantation-like stands with a closed canopy.

Although giant oaks and silver firs – typical attributes of pasture woodlands – have always drawn attention, nature conservation in the Czech Republic has yet to realise the importance of wood pasture. Many formerly grazed woodlands have been designated reserves of "virgin" or "primeval" forest; whereby the presence of massive trees often served as evidence of forest "virginity". Hands-off management applied to such forest reserves has led to an inevitable biodiversity decrease due to canopy closure, substitution of the main tree species (oak, fir) by other species, and to gradual disappearance of tree veterans (e.g. Vrška et al. 2002, Vrška et al. 2006) and other valuable habitats. After it had been prohibited by law for more than two centuries, it is no wonder that wood pasture is returning painstakingly slowly. Following nearly a decade of discussions within the conservation community, wood pasture was started only recently as an experiment rather than management in Podblanicko, the Bohemian Karst near Prague, and Podyjí NP along the upper Dyje (Thaya) river.

Coppicing

The only actively coppiced woodlands today are stands of exotic, invading black locust (*Robinia pseudacacia*), which have no conservation value. Nevertheless, coppices uncut for over 50 years currently cover several thousand hectares, mostly in lowlands and foothills. Although many open woodland specialists have disappeared, the old coppices still retain continuity and are key habitats for a number of endangered organisms, including e.g. Stag Beetle (*Lucanus cervus*), Violet Click Beetle (*Limoniscus violaceus*) and Lady's-Slipper Orchid (*Cypripedium calceolus*). Rather than being restored, the old coppices are often clear-cut and replanted, even in conservation areas. In most nature reserves and national parks, on the other hand, coppices are being sacrificed to succession.

After nearly having been forgotten, coppicing was reintroduced in the Czech Republic as a hot novelty by the end of last century. Active coppicing was first restored near the town of Moravsky Krumlov in the mid-1990s. Led by economic rather than conservation reasons, it was the first and by far the largest (>100 ha) attempt to date (Utinek 2004). However, the area has now been destroyed by clear-cutting. Recently, coppicing was restored in the Bohemian Karst, Moravian Karst and Pálava PLAs, and in Podyjí NP. Active coppices are confined to small areas of mostly 1–2 ha, and coppicing has yet to be accepted as conservation management and a sometimes even economically viable, nature-friendly alternative to commercial forest management.

Pollarding

Although pollarded trees were much more common in the past, pollarding is still the most widespread traditional woodland management in the country. Pollarded willows (*Salix* sp.) are found in many areas, mostly in or near towns and villages. In extensively managed agricultural landscapes or human settlements, pollards often facilitate survival of fauna associated with veteran trees and tree hollows, including e.g. Hermit Beetle (*Osmoderma barnabita*), Red Click Beetle (*Elater ferrugineus*) and Stag Beetle (*Lucanus cervus*) (Šebek et al. 2010). Thanks to a recent increase in fuel-wood prices, pollarding is probably the most commonly restored traditional woodland management.

Conclusion

The past decade has seen efforts by a growing number of conservationists and forestry experts in introducing active conservation management in woodlands in protected areas. However, the process is

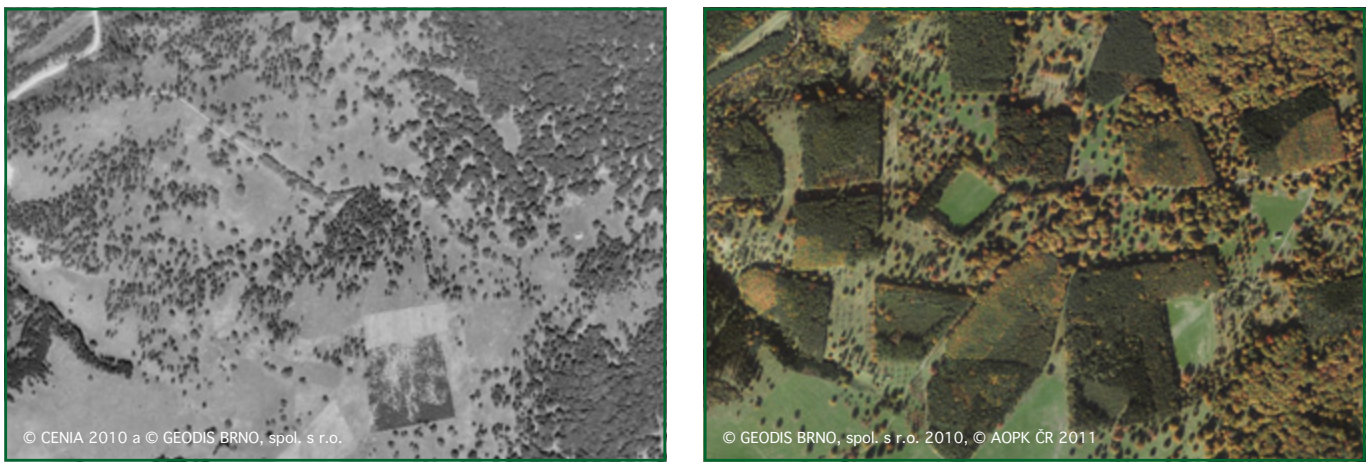

Fig. 3, 4. Lány game reserve serves as a hunting ground for Czech presidents. It is one of the last places in the Czech Republic where grazed open woodlands – key habitats to many protected organisms – still exist. Their extent, however, decreases even here as apparent from aerial photographs from 1953 (left, provided by VGHMÚř, Dobruška, © MO ČR 2009) and 2010 (right).

Fig. 5, 6. Formerly open Pannonian oak woodland on sandy deposits managed as coppice-with-standards, aerial photo from 1953, provided by VGHMÚř, Dobruška, © MO ČR 2009 (left). In half a century it has changed to closed-canopy oak woodland with a perspective of gradual replacement by pine plantations (darker patches) (right). Many Pannonian oak wood inhabitants, such as Woodland Brown (*Lopinga achine*) butterfly, are gone. Others, such as Clouded Apollo (*Parnassius mnemosyne*) and Emerald Jewel Beetle (*Eurythyrea quercus*) have so far survived. Their perspectives are however bad, despite their legal protection and the fact that the site is part of the Lower Morava (Dolní Morava) UNESCO Biosphere Reserve.

slow, mostly due to reluctance of their more conservative colleagues. On the other hand, the rapid decrease in biodiversity in conservation areas makes it inevitable to shift the emphasis from conservation of vaguely defined communities and "natural" processes to evidence-based biodiversity conservation. Although not much has been done in the field during the past decade, the attitude of the professionals concerned, including biologists, conservationists and foresters, has substantially changed. The road to restoration of traditional woodland management and active biodiversity conservation in the Czech woodlands is certainly not free of obstacles. It is, however, open.

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