JOURNAL OF FOREST SCIENCE, *50*, 2004 (11): 526–532

Sustainable management of mountain forests in the Czech Republic

S. VACEK, V. BALCAR

Forestry and Game Management Research Institute, Jíloviště-Strnady, Opočno Research Station, Czech Republic

ABSTRACT: Forest management in the Czech Republic (CR) was not shaped in the environment of natural forests but in the territory that was influenced by unregulated felling and animal grazing for a long time. Hence the fear for sustainable and balanced benefits from forests endangered by long-term uncontrolled exploitation was legitimate. Almost after three centuries of application of the sustainability principle, forests are considered not only as a source of renewable wood raw material but also as a tool of the environment formation. Mountain forests are an important landscape component of this country. They are an object of specific importance from the aspect of natural environment conservation, stabilization of natural processes and general landscape homeostasis. In addition, they fulfil a number of production and non-production functions. Cardinal elements of sustainable forest management in the CR conditions are as follows: management of the forest as an ecosystem, i.e. transition from exclusive care of forest tree species and their stands to care of the whole forest ecosystems; restructuring (conversion, reconstruction) of damaged and declining forests; optimum (species, genetic, spatial, age) structure of forest ecosystems differentiated according to site conditions and management targets; differentiated transition from general management to group or individual methods; utilization and support of spontaneous processes such as natural regeneration, competition and other principles of self-regulation. The above cardinal elements of sustainable forest management are applicable to forests of the CR in general, but their importance considerably increases in mountain forests where many species survive on the margin of subsistence. Moreover, mountain forests of CR have been heavily destroyed by anthropogenic factors, especially air-pollution ecological stresses, during the last three or four decades.

Keywords: Czech Republic; mountain forest; sustainable management

Similarly like in the neighbouring countries of Central Europe, the present condition of Czech forests is a result of cultural, economic and political development. Forest management in this region was not shaped in the environment of natural forests but in the territory that was influenced by unregulated felling and animal grazing for a long time. Hence the fear for sustainable and balanced benefits from forests endangered by long-term uncontrolled exploitation was legitimate (POLENO 1996).

The requirement for sustainable benefits provided by the forest has become one of the basic postulates throughout the centuries. It has been the reason to improve silvicultural technology of forest establishment, tending and regeneration of forest stands that appropriately satisfy the requirements for sustainable and balanced production. But these silvicultural systems have not been sufficiently elaborated until now as can be seen from a high proportion of salvage fellings in the Czech Republic (CR, Fig. 1).

The object of sustainable forest management is a forest ecosystem with its structures, functions, dynamics and stability. In the Czech Republic, this European trend was specified in *Fundamental Principles of State Forest Policy* (1994) and *National Program of Nature and Landscape Conservation* (1998) that were followed by other documents. *Forest Strategy of European Union* (1998) is based on the same principles; it accentuates the multifunctional role of forests and their sustainable management aimed at social, economic, environmental, ecological and cultural functions of forests (VACEK, BALCAR 2002a).

Importance and characteristics of mountain forests

Mountain forests are an important landscape component of this country. They are an object of specific importance from the aspect of natural environment conservation, stabilization of natural processes and general landscape homeostasis (VACEK, BALCAR 2000b). In addition, they fulfil a number of production and non-production functions. They involve not only the production of wood, game, forest fruit, etc. but also socially important functions in the sphere of hydrology, soil conservation, climate protection, recreation, nature conservation, biodiversity, etc.

In accordance with the FMI concept, the category of mountain forests comprises forest ecosystems classified into the 6th–9th forest vegetation zones (FVZ), i.e. Beech with Spruce, Spruce with Beech, Spruce and Dwarf Pine zones (Fig. 2). A high proportion of mountain forests in

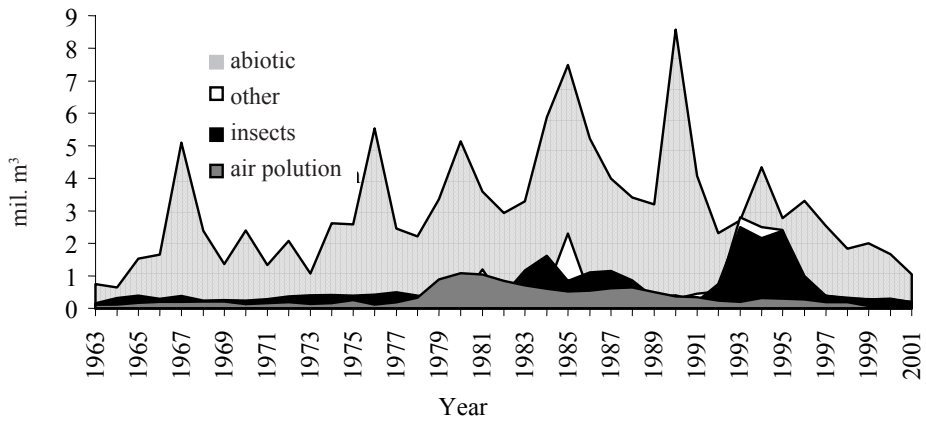

Fig. 1. Development of salvage fellings in the CR according to the types (data of the Institute for Forest Management at Brandýs nad Labem)

the forest natural regions with similar natural conditions of the CR where at least 6th–8th FVZ occur is evident from Fig. 3. Table 1 shows FVZ and their proportions in mountain forests of the CR, Table 2 documents the natural, present and target species composition of mountain forests of the CR.

FNA in the Czech Republic are as follows: 1 – Krušné hory Mts., 3 – Karlovy Vary Hills, 11 – Bohemian Forest

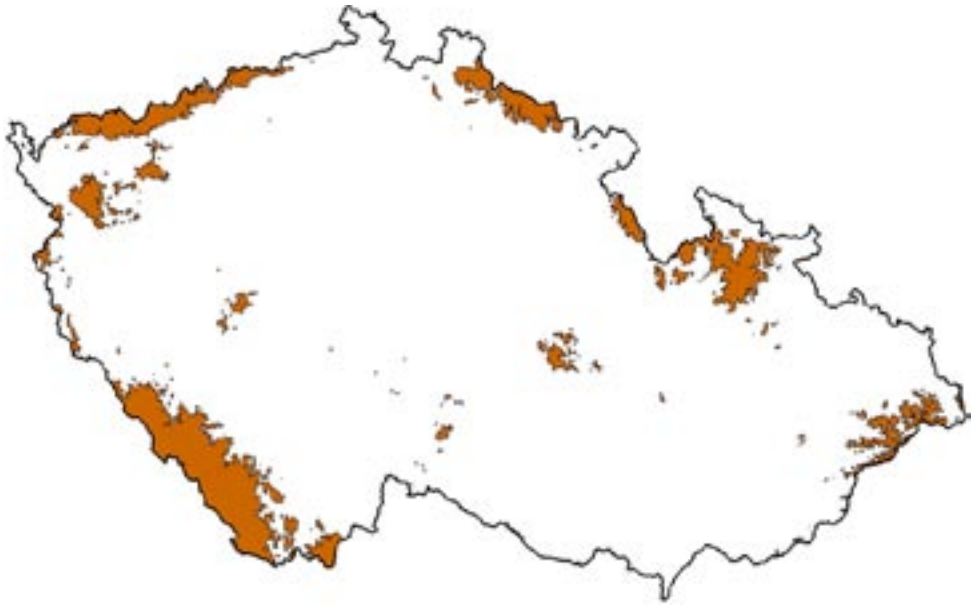

Fig. 2. Mountain regions of CR (GIS K. Matějka – IDS)

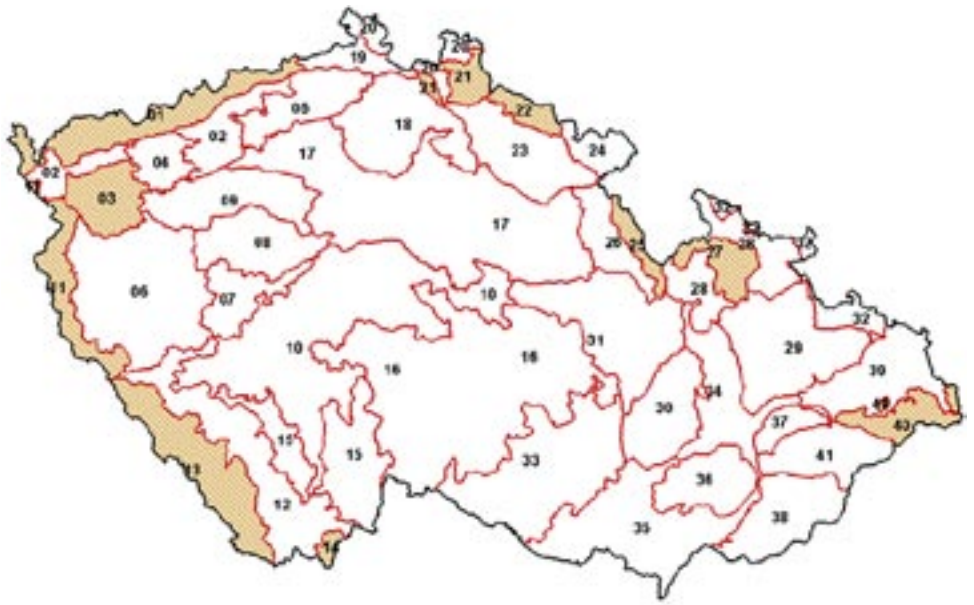

Fig. 3. Forest natural regions of the CR (data of FMI at Brandýs nad Labem; regions with mountain forests are grey)

Table 1. Characteristics of forest vegetation zones in mountain forests of CR

Forest vegetation zone		Forest land area (ha)	Proportion of (%)		Altitude (m)	Average temperature (°C)	Annual precipitation (mm)	Vegetation period (days)	Forest percentage (%)
			FVZ 6–9	FVZ 0–9					
6	Beech with Spruce	309,367	67.32	11.75	700–900	4.5–5.5	900–1,050	115–130	49.1
7	Spruce with Beech	99,824	21.72	3.79	900–1,050	4.0–4.5	1,050–1,200	100–115	51.6
8	Spruce	44,522	9.69	1.69	1,050–1,350	2.5–4.0	1,200–1,500	60–100	91.6
9	Dwarf Pine	5,857	1.27	0.22	> 1,350	< 2.5	> 1,500	< 60	99.3

Total forest area in the CR is 2,632,000 ha, of it the area of mountain forests (6th–9th FVZ) amounts to 459,570 ha, i.e. 17.45% (data of FMI at Brandýs nad Labem)

Mts., 13 – Šumava Mts., 14 – Novohradské hory Mts., 21 – Jizerské hory Mts. and Ještěd ridge, 22 – Krkonoše Mts., 25 – Orlické hory Mts., 27 – Hrubý Jeseník Mts., 40 – Moravian Silesian Beskids Mts.

Besides the wood-producing function, mountain forests of CR fulfil important ecological and environmental functions. In the mountains of CR there are large specially protected areas (national parks and protected landscape areas – Fig. 4) and "small" specially protected areas (particularly national nature reserves and nature reserves), systems of ecological stability (including supra-regional biological centers) and priority biotopes of European Union in the context of NATURA 2000. Establishment of large protected areas was during more than 40 years aimed at protection of the most well – preserved parts of territory with characteristic nature.

Mountain forests have positive soil-conservation and hydrological functions. Forests in mountain locations do not influence only the environment of the site where they grow, they also produce remote effects. They fulfill erosion and flood control functions and ensure water supplies in the production landscape at lower altitudes. Mountain forests are specific areas with increased interest in the soil-protection function of forests, and they are classified as hydrologically important forests.

METHODS

Research of sustainable forest management has been performed on the base of published works and results of investigation in network of research, monitoring, and pilot plots and areas. Principal problem of present Czech mountain forests influenced by air pollution stress is to maintain their stability and biodiversity, as the chief preconditions for sustainability. Main types of the Czech mountain forest ecosystems were analyzed, in order to investigation of disturbances and modifications of relations into woody plant component of ecosystem. Obtaining results were checked and applied for management measures formulation, aimed to the "available" stability formation of studied mountain forest ecosystems growing in various ecological conditions. As tools for solution of the mentioned problems, besides silvicultural, dendrometrical and forest management procedures, also ecological, climatological and biometrical investigation methods were used.

Research attention was paid to 10 of the Czech Forest natural regions (Fig. 3). Performance of ecosystems was continually or periodically investigated on representative studied areas and plots. Attention was not only paid to woody species (growth, injury, mortality etc.), but performance of other ecosystem components were studied as well (insects, fungi, herbs, soil, air pollution). Applied assessment methods (including statistics) see VACEK (1996).

RESULTS

Monitoring in mountain forests

All mountain forests in the Czech Republic have been exposed to air pollution since the 50ies–80ies of the 20th century. Quality, quantity and time dynamics of air-pollution stress have been monitored to describe the type and extent of damage to forest ecosystems (ICP Forest, etc.) that have crucial consequences for the choice of tree species composition in regeneration targets. To set up the fundamental principles of tending and regeneration, the anticipated dynamics of forest stand damage by air pollutants is taken into account. Potential effects of air pollution upon forests have been expressed by pollution threat zones (zones A–D) delimitation (Fig. 5). The zones are the areas where the shortening of lifetime of mature spruce forests shows a relatively similar trend under the influence of air pollutants, climatic, orographic and site conditions and genetic characteristics of forest stands.

Fig. 4. Large specially protected areas (CHKO = Protected Landscape Areas and NP = National Parks) in the CR (data Agency for Nature Conservation and Landscape Protection of the CR; GIS K. Matějka – IDS)

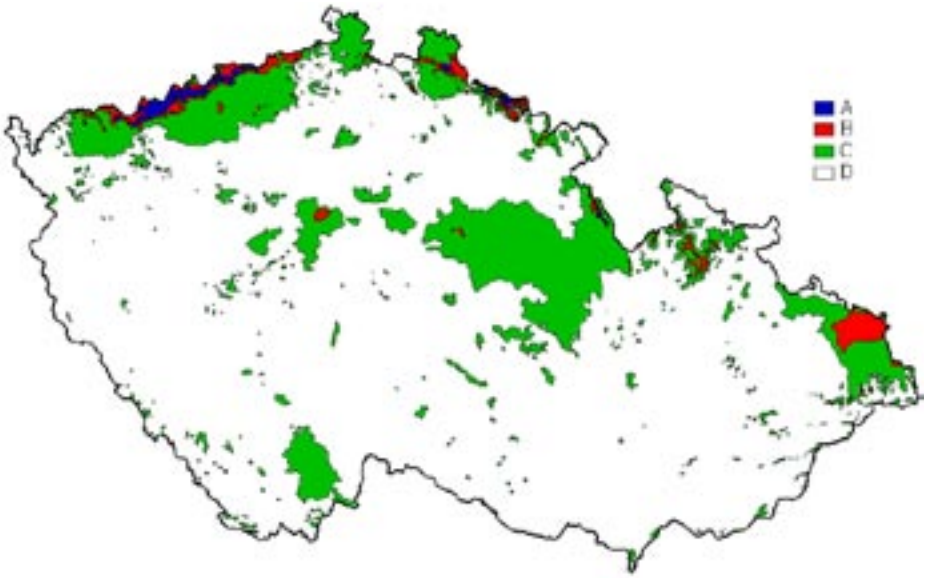

Fig. 5. Zones of risk of exposure of forest stands to air pollution in the CR (data of FMI at Brandýs nad Labem, 2001; GIS K. Matějka – IDS)

Table 2. Natural, present and target species composition in mountain forests of CR

Composition	*Picea abies*		*Abies alba*		*Pinus sylvestris*		*Pinus mugo*		Other conifers	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Natural	226,163	49.7	97,753	21.3	0	0	5,142	1.1	0	0
Present	355,341	77.7	3,347	0.7	16,390	3.6	5,461	1.2	20,104	4.4
Target	346,516	75.4	56,475	12.3	742	0.2	5,084	1.1	0	0

Composition	*Fagus sylvatica*		*Betula pendula* *B. pubescens*		*Alnus glutinosa* *A. incana*		*Sorbus aucuparia*		Other broadleaved	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Natural	118,358	25.7	8,896	1.9	309	0.1	291	0.1	2,683	0.6
Present	22,133	4.8	16,001	3.5	6,565	1.4	10,644	2.3	3,581	0.8
Target	48,324	10.5	1,887	0.4	62	+	290	0.1	835	0.2

Data of FMI at Brandýs nad Labem (J. MACKŮ)
Other conifers: *Larix decidua, Pinus × pseudopumilio, Taxus baccata,* introduced conifers (*Pseudotsuga taxifolia, Pinus strobus, Picea pungens, Picea omorika, Pinus contorta*, etc.)
Other broadleaves: *Quercus petraea, Acer pseudoplatanus, Acer platanoides, Tilia platyphyllos, Ulmus glabra, Populus tremula, Betula carpatica, Alnus viridis, Cerasus avium*

Fig. 6. Formation of a regeneration basis in the parts of the Jizerské hory Mts. exposed to heavy air pollution (photo by S. Vacek)

Situation in mountain forests in the period of air-pollution ecological disaster

We have witnessed an obviously deteriorating condition of forests at mountain locations since the early seventies (in the Krušné hory Mts. since the mid-sixties). Dynamic disintegration of forest, decrease in its production functions, failure of its ecological and environmental functions and disappearance of tree species genetic resources have immense ecological and social consequences. The most afflicted area in Central Europe – "black triangle" – involves the Krušné hory Mts., Jizerské hory Mts. and Krkonoše Mts. (VACEK, BALCAR 2002b). After declining forest stands were felled (47,300 ha since 1958, i.e. ca. 2% of forests), there arose problems of forest regeneration on vast clearings due to salvage felling. In general, the situation was worst in protection mountain forests that were neglected for economic reasons for a long time (TESAŘ 1993). Thus in the seventies continuous, old spruce stands approaching the physical age generally prevailed e.g. at higher locations of the Sudetes (VACEK et al. 1997). The situation was similar in other mountain regions of the CR. These stands were exposed to natural disintegration without sufficient regeneration that was largely damaged, or many times fully destroyed, by high stocks of hoofed game. The stands in such condition were affected by air-pollution ecological stresses. Very dynamic, locally general destruction of forest stands due to air pollution and concomitant climatic extremes, insect pests and fungal pathogens, and subsequent felling of declining or declined stands, produced a highly unfavorable ecological situation for the origination of successive forest stands.

Principles of sustainable mountain forest management

Cardinal elements of sustainable forest management in the Czech Republic's conditions are as follows:

- management of the forest as an ecosystem, i.e. transition from exclusive care of forest tree species and their stands to care of the whole forest ecosystems,
- restructuring (conversion, reconstruction) of damaged and declining forests,
- optimum (species, genetic, spatial, age) structure of forest ecosystems differentiated according to site conditions and management targets,

Fig. 7. Small-area regeneration elements at lower locations of the Orlické hory Mts. (photo by S. Vacek)

– differentiated transition from general management to group or individual methods,
– utilization and support of spontaneous processes such as natural regeneration, competition and other principles of self-regulation,
– support and creation of flexible multiple-purpose management methods, differentiated according to the functions and capacities of forest ecosystems in order to achieve their functional equilibrium.

The above cardinal elements of sustainable forest management are applicable to forests of the CR in general, but their importance considerably increases in mountain forests where many species survive on the margin of subsistence (VACEK et al. 1997). Moreover, mountain forests of CR have been heavily destroyed by anthropogenic factors, especially air-pollution ecological stresses, in the last three or four decades.

Management complexes (MC) are fundamental superstructural units of forest typology for forest operations and forest planning in the CR. The framework of permanent natural conditions in these complexes is constituted by cognate management of associated "forest site type groups" that have common target methods and forms of management and target tree species composition. There are 24 target MC in the category of commercial forests that are also applicable to special-purpose forests, and 3 MC in the category of protection forests.

Management of forests at the highest locations, i.e. in Dwarf Pine, Spruce and Spruce with Beech forest vegetation zones, and in the remaining mountain locations of lower altitudes is completely different. In the first case, it is management at elevated mountain locations (MC 71 – exposed, 73 – acid, 75 – fertile, 77 – gleyic and 79 – water-logged sites of mountain locations) and in respective protection forests (MC 01, 02 and 03, i.e. extremely unfavorable sites, high-elevation forests below the forest limit, forests in the dwarf pine vegetation zone). A spruce forest or a forest with dominant Norway spruce grows in almost marginal conditions of subsistence and is strongly exposed to air pollution (Fig. 6). The disintegration of older, particularly allochthonous stands is inevitable at these locations; therefore their regeneration should start as soon as possible. On the other hand, complex silvicultural measures can prolong the lifetime of young and medium-age stands and of many older autochthonous stands.

Management at lower mountain locations (MC 51, 53, 55, 57, 59, i.e. management of exposed, acid, fertile, gleyic and water-logged sites at higher altitudes) in the Beech with Spruce and Beech with Fir vegetation zones with much lower air pollution stress (Fig. 7). As the dynamics of damage is slower, so called conservation strategy trying to maintain the present stands in a functional condition as long as possible can be applied intentionally (TESAŘ 1993).

It is advisable to apply a set of preventive measures aimed at stabilization of the internal stand structure (optimally expanded crowns, closed canopy, etc.), adjustment of the species and ecotype structure (preference of tolerant autochthonous species), and silvicultural (biological and chemical) reclamation.

CONCLUSIONS

As the social requirements for forests to fulfill not only production but also ecological or environmental functions were increasingly accentuated, methods of multifunctional mountain forest management were gradually elaborated. Simultaneously, forest owners and the public increasingly claimed rationalization of management methods and economic autonomy of forest property. Accordingly, to ensure sustainable as well as economically efficient management of mountain forests appropriate methods of management of forest stands are sought, with maximum use of creative forces of the nature.

The rational trend of sustainable management of mountain forests set in the CR in the nineties brought about a new quality of the approach to forest stands that is markedly different from a large-area clear-cutting system used mainly in the seventies and eighties, when the biological nature of the forest was neglected. The tradition of shelterwood forest management practiced by enlightened forest managers before World War II and still in the fifties and sixties was resumed. Current trends of sustainable forest management are based on maximum utilization of the existing knowledge of forest typology and forest ecosystem ecology. Such an approach in today's forest political environment of the CR and close joining in the present Pan-European forest environment allowes to make great progress toward the acceptable ecosystem-based forest management, particularly by uniting scientific knowledge and extensive silvicultural experience within this country and adjacent European countries as well.

References

POLENO Z., 1996. Sustainable Management of Forests in the Czech Republic. Praha, MZe ČR: 61.

TESAŘ V., 1993. Obhospodařování horského lesa Českého masívu v současných ekologických poměrech. In: HLADÍK M. (ed.), Hospodárenie v lesoch horských oblastí. Písek, Matice lesnická: 11–31.

VACEK S. (ed.), 1996. Monitoring, výzkum a management ekosystémů na území Krkonošského národního parku. Sbor. z mezinár. konf., Opočno, 15–17. 4. 1996. VÚLHM, VS Opočno: 350.

VACEK S., BALCAR V., 2000. Sudeten Mountains in the Czech Republic – growing conditions, regeneration and stabilization of mountain forests. In: Multipurpose management of mountain forests: concepts, methods, techniques. Symposium International Communications. Pralognan-la-Vanoise, France, 25–30 June 2000. EOMF, IUFRO: 168–177.

VACEK S., BALCAR V., 2002a. Strategy of Forest Restoration in the Czech Part of the "Black Triangle". In: Documenting Forest Restoration Knowledge and Practices in Boreal and

Temperate Ecosystems. Vejle, Denmark, 28. 4.–3. 5. 2002, IUFRO: 147–148.

VACEK S., BALCAR V., 2002b. An approach for conciliating public expectations and biological capaties. In: The formulation of integrated management plans (IMPs) for mountain forests. 30. 6.–5. 7. 2002, Bardonecchia, Italy, EOMF, Universita di Torino: 59–66.

VACEK S., LOKVENC T., BALCAR V., HENŽLÍK V., 1997. Obnova a stabilizace lesa v horských oblastech Sudet (Forest regeneration and stabilization in the Sudeten mountain regions). In: PASCHALIS P., ZAJACZKOWSKI S. (eds.), Protection of forest ecosystems, selected problems of forestry in Sudety Mts. Wyd. 2., niezm., Warszawa: 93–119.

Trvale udržitelné obhospodařování horských lesů v České republice

S. VACEK, V. BALCAR

Výzkumný ústav lesního hospodářství a myslivosti, Jíloviště-Strnady, Výzkumná stanice Opočno, Česká republika

ABSTRAKT: Hospodaření v lesích České republiky bylo v minulosti často ovlivňováno a utvářeno neregulovanými těžbami a pastvou dobytka. Na poměrně velkých rozlohách tak došlo k oslabení a narušení přirozené rovnováhy lesních ekosystémů a jejich ekologické funkčnosti. Rozvojem aktivit společnosti – zejména průmyslové výroby od padesátých let minulého století – byly lesní ekosystémy vystaveny dalším negativním tlakům a poškozovány a ničeny. Současně stoupaly nároky společnosti na tzv. mimoprodukční užitky lesů v oblasti ekologické a environmentální. Zvláště dramaticky se situace vyvíjela v horských oblastech, kde lesy exponované přírodním stresům více než v nižších polohách, zčásti oslabené nevhodnými způsoby hospodaření (snižování biodiverzity, změny v genofondu pěstovaných dřevin), odumíraly. Na jejich zániku se podílely i doprovodné negativní faktory abiotické i biotické. Vzhledem k velkému významu horských lesů jak pro plnění významných celospolečenských funkcí (vodohopodářských, půdoochranných), tak i pro plnění nezastupitelných funkcí v tvorbě prostředí a udržení rovnováhy celých ekosystémů jsou v současné době při hospodaření v horských lesích prosazovány nové lesopěstební metody blízké přírodním procesům. Za jejich hlavní zásady se přitom považují: změna v zaměření hospodářských opatření od péče o lesní porosty k péči o celé lesní ekosystémy; rekonstrukce a přeměny poškozených a odumírajících lesů; stanovení optimální druhové a genetické skladby a prostorové i věkové struktury lesních ekosystémů, diferencované podle růstových podmínek a celospolečenských požadavků včetně hospodářských cílů; diferencovaný přechod od velkoplošných opatření ke skupinovým a jednotlivým zásahům; využívání spontánních přirozených procesů, jako jsou přirozená obnova, kompetiční vztahy a samoregulační procesy. Význam a nezbytnost použití zmíněných metod v horských lesích v porovnání s jinými lesními oblastmi (střední a nižší polohy) spočívá ve specifice horských lesních ekosystémů, jejich exponovanosti k přirozeným ekologickým stresům, narušení antropogenními faktory i vysokým nárokům společnosti na plnění mimoprodučních funkcí v současnosti.

Klíčová slova: Česká republika; horské lesy; trvale udržitelné hospodaření

Corresponding author:

Doc. RNDr. STANISLAV VACEK, DrSc., Výzkumný ústav lesního hospodářství a myslivosti, Jíloviště-Strnady, Výzkumná stanice Opočno, Na Olivě 550, 517 73 Opočno, Česká republika
tel.: + 420 494 668 391, fax: + 420 494 668 393, e-mail: vacek@vulhmop.cz