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MAN-MADE NORWAY SPRUCE ECOSYSTEMS IN THE CZECH REPUBLIC AND THEIR ECOLOGICAL CONSEQUENCES

As compared to the present distribution of spruce in the Czech Republic, the original area was much smaller. For example, its boundary was in the Giant Mts. at an altitude of 1200-1350 m. The establishment of pure spruce stands was brought about particularly by economic reasons associated with increasing demands for wood. In addition to positive consequences (increased production of wood etc.), possible negative impacts were also discussed, particularly effects on soil and the extent of damage caused by biotic and abiotic factors.

The National forestry programme (NFP) of the Czech Republic for a period until 2013 stresses important ecological functions from the point of view of preserving and improving the biological diversity, integrity, health and resistance of forest ecosystems to effects of supposed global and landscape changes and to effects of negative stresses from the past NFP (2008). The total area of forests in the Czech Republic is 2 646 thousand ha, ie about 33% forest cover out of the total area. The ownership of forests markedly changed after 1990 when the CR owned 95.8% forests. This area gradually decreased within privatization of forests to 60% at present.

Intensive anthropogenic effects show their origin already in the Middle Ages when felling forest stands continued due to the increasing consumption of wood in mines – production of iron ore, silver mining and charcoal burning. It referred particularly to beech forests also at lower locations. Results of these activities consisted in the increased soil erosion and sedimentation in the alluvial area of rivers. The original species composition of forests was replaced by planting spruce monocultures even outside their natural range. This process was intensified particularly in the course of the 18th century.

At present, the species composition of forests in the Czech Republic is as follows:

Natural, current and recommended composition of tree species, % of forest land area

Composition	Spruce	Silver fir	Conifers Total	Oak	Beech	Broadleaves Total
Natural	11.2	19.8	34.7	19.4	40.2	65.3
Current	53.3	0.9	75.5	6.5	5.5	23.4
Recommended	36.5	4.4	64.4	9.0	18.0	35.6

This process took place similarly also in other countries of Central Europe (Tesař, Klimo in Spiecker et al. 2004).

Country	% spruce out of the stand area	% spruce monocultures out of the stand area
Czech Republic	54	22
Slovakia	26	9
Austria	48	33.4
Germany	30	19.1

Norway spruce spread from mountain areas to lower locations partly naturally, especially at northern slope locations, and to moist and cold valleys (Nožička 1972). The establishment of spruce monocultures showed also positive consequences particularly in the increased and faster production of wood, which stimulated the origin of various industrial enterprises. At present, however, mainly negative impacts of spruce monocultures are discussed. The majority of spruce monocultures in the Czech Republic occurs in the 1st or the 2nd generation.

Long discussions, mainly in a period after the World War Two, were brought about by an opinion presented particularly by Pelíšek (1955) on a rather fast process of the origin of podzol soils under spruce stands. Many scientists opposed to this opinion (eg Šály 1978 etc.). The process of podzolization under spruce stands evidently exists, which can be demonstrated by the analysis of lysimetric waters. Nevertheless, there is a question, if a morphologically marked podzol originates in the course of one generation of spruce.

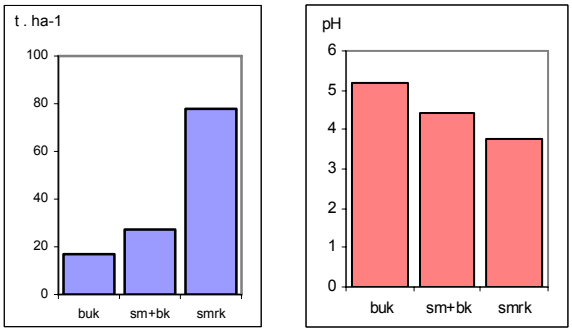
The most marked changes of the soil environment due to spruce monocultures occur in the accumulation of organic material on soil surface and, in some cases, also changes in the humus form from moder to mor-moder and thus also changes in the cycle of elements, particularly of nitrogen. Its accumulation, mainly in H layer, manifold surpasses N accumulation under a beech stand.

The weight (t/ha) and accumulation of nutrients in the surface humus in a beech and spruce stand (kg/ha)

Layer	Stand	Weight	N	P	K	Ca	Mg
L	beech	10.0	153	11	20	68	4
	spruce	11.5	155	4	12	37	7
F	beech	12.6	161	14	59	29	7
	spruce	15.8	276	16	20	19	13
H	beech	0.5	7	1	3	0.5	0.2
	spruce	22.3	350	27	36	14	24
Total	beech	23.1	321	26	82	97	11
	spruce	49.6	780	47	68	70	44

The process of high accumulation of organic matter on the soil surface is also associated with the process of acidification, which is more intensive under spruce stands (Tesař, Klimo 2004).

Fig. 1. Total accumulation and pH (in H_2O) of the surface humus in stands of various species composition (buk = beech, sm+bk = spruce+beech, smrk = spruce).



Changes in pH values or more intensive acidification in the surface humus layers were also demonstrated by our measurements in the Bohemian-Moravian Uplands where spruce was planted on the original site of beech at the beginning of the 20th century.

pH values of the surface humus layer under a spruce and beech stand

Stand	L		F		H	
	H_2O	KCl	H_2O	KCl	H_2O	KCl
Beech	5.56	4.82	4.88	4.66	5.26	4.80
Spruce	4.53	3.66	4.14	3.60	3.84	3.32

The process of acidification under spruce stands as compared with original beech or mixed stands is also more intensive in soil horizons A as indicated by our measurements:

Beech stand – 100 years	pH in H_2O	3.83
	in KCl	3.30
Spruce stand – 80 years	pH in H_2O	3.60
	in KCl	2.90

In addition to soil changes, other ecological impacts of growing spruce monocultures are also noted, namely wind damage to spruce stands occurring nearly every year and mainly under exceptional situations such as, for example, Kirill hurricane in January 2007.

In total, Forests of the CR Co. recorded about 5 million m^3 damaged timber after the Kirill hurricane disaster. It represented roughly two-thirds of the annual planned cut and thus, it referred to the greatest disaster in the history of the Forests of the CR Co. The total removal/processing of damaged timber including subsequent operations took until the end of the year 2007.

So far, the unverified proportion of broken and uprooted trees of spruce and broad-leaved species offers a question of the relationship between windfalls and the character of a soil type (pseudogley) and generally waterlogged sites where spruce shows spreading its root system markedly in the surface layer of soil.

In addition to this, considerable damage originates due to the occurrence of bark beetles and game damage.

Harmful impacts of industrial air pollution on forest ecosystems and particularly spruce stands appear to be a serious ecological problem in the Czech Republic in the course of recent 50 years. Nevertheless, in this case, the combination of various negative factors was devastating, particularly the combination of meteorological fluctuations, decreased vitality of stands and air pollution. In connection with the establishment of pure spruce stands, technologies of regeneration, tending, logging and the use of wood of spruce stands have been developed. Special attention is primarily paid to the technology of regeneration where, in addition to the clear-felling system, the proportion of natural regeneration gradually increases particularly in association with the transformation of spruce monocultures occurring outside their natural range to close-to-nature forests.

Naturally, the question of growing spruce monocultures can be also related to possible climatic changes at the global level as well as to episodic variations of meteorological conditions at the level of regions.

Of course, according to Tesař and Klimo (2004), disadvantages of growing spruce are not generally so large to make its growing impossible. It is, however, necessary to change methods of management taking into account ecological carrying capacity and multiple functions of forest ecosystems and to reduce its proportion according to management and ecological criteria to recommended 36-37%.

Certain starting points are included in the NFP (2008). Although the NFP does not deal with the problem of the spruce monoculture conversion specially, the programme of the species composition arrangement of forests and silvicultural measures is involved in its content, namely in two directions supposed:

Problem	Sustainable management	Close-to-nature procedure of management
Clear felling	Regulation of the extent of clear felling	Exclusion of clear felling
Structure and species composition	Mixed stands with the preference of economically important species	Taking into account potential natural vegetation
Introduced species	Introduced species are admissible	Only autochthonous species

Recommended species composition as an optimized compromise between the natural species composition and economically advantageous composition supposes the proportion of spruce 37% as against the present proportion 53% and natural proportion 11% (as mentioned above).

Considerable deviations of the stand condition of spruce monocultures from the principle of sustainable forest management resulted already in former times in searching management procedures, which ensure fulfilling also other forest functions in addition to the wood-producing function. In the Czech Republic, possibilities of the transformation of spruce stands are demonstrated by results in silviculture in the course of last 40-60 years on 48 example plots of a total area of 11 600 ha. The areas show the various degree of transformation of stands according to the site potential, initial condition of the forest, duration of the stand preparation by tending and duration of the actual transformation during the forest regeneration.