JOURNAL OF FOREST SCIENCE, *52*, 2006 (7): 329–336

Effects of game on the condition and development of natural regeneration in the Vrapač National Nature Reserve (Litovelské Pomoraví)

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ABSTRACT: In 2001–2005, the effects of game on the condition and development of natural regeneration of a floodplain forest were studied in three permanent transects in the Vrapač National Nature Reserve (NNR). *Fraxinus excelsior*, *Acer pseudoplatanus*, *Acer campestre* and *Acer platanoides* predominated in the regeneration. The species were markedly damaged by roe deer (*Capreolus capreolus*) and fallow deer (*Dama dama*) browsing, the most affected being *Acer pseudoplatanus*. In spite of always newly occurring trees from self-seeding, the abundance of trees decreased during the studied period, self-seeding did not grow up from a height of 30–40 cm, the proportion of *Acer pseudoplatanus* decreased and that of *Fraxinus excelsior* increased. In addition to browsing, in 2003 and 2005 browsing damage to bark was noted in some places and in 2005 also the breaking of trees with subsequent browsing of terminal shoots, the causal agent of both types of damage being fallow deer. The development of natural regeneration is limited in principle by trophic preferences of game and by the tolerance of particular species to repeated damage. On the basis of these conditions it is necessary to consider the present game stock to be contradictory with objectives of area protection and preservation.

Keywords: natural regeneration; *Capreolus capreolus*; *Dama dama*; browsing; tree growth

In forests of the Czech Republic (CR), the extent of natural regeneration increased from about 1,000 ha in 1990 to about 4,000 ha in 2002 (MZe 2003). The present proportion of natural regeneration in the total regeneration amounts to about 18% (in 1990 less than 3%). At the same time (after a decline in the mid-90s) game stocks show an increase reaching the values approaching 1990 (according to game management statistics).

Thus, browsing remains an important limiting factor of the successful growth particularly of broadleaved species, a factor which can markedly reduce or fully preclude the use of natural regeneration in some localities. The high and always existing importance of browsing is also demonstrated by the results of an extensive survey of game damage to forest stands in the whole territory of the CR (MZe 2001) in 2000 and its comparison with similar studies carried out in 1995. Based on the comparison, marked browsing damage to young forest plantations occurred above all due to damage to tree tops but also to lateral shoots (Černý et al. 2002).

In protected areas where the object of protection is a forest ecosystem, an effort to achieve undisturbed natural regeneration should be the inevitable part of the plan of care not only on the ground of the requirement for the natural species composition of plant communities. Adaptation processes taking place during the self-thinning of natural regeneration are an important part of the resilience of forest ecosystems maintaining their ecological stability. Nevertheless, the condition of

Supported by the Ministry of Environment of the Czech Republic, Project VaV 610/10 *Effects of Management Measures on Changes in Biodiversity in Particularly Protected Areas* (2001) and by the Ministry of Education, Youth and Sports of the Czech Republic, Project No. 6215648902 *Forest and Wood*.

a number of protected areas indicates important effects of game on the quality and quantity of natural regeneration.

MATERIAL AND METHODS

Monitoring methods

In selected localities, permanent transects were established. Their position was stabilized by marking trees on the central axis of the transect and surveying geographical coordinates of the first tree through GPS. The transect length was selected in such a way that the transect will be as far as possible homogeneous from the viewpoint of site conditions, a minimum length being 50 m. The transect width was 3 m. For each of the transects the description of natural conditions was carried out, viz. tree layer stratification and determination of the herb layer dominants. In the transects, all trees over 2 m were monitored. Their height was measured to the nearest 1 cm. In all species, the presence of actual browsing damage was determined (damage intensity was not differentiated).

In 2005, browsing was assessed collectively, i.e. together winter browsing in 2004–2005 and summer browsing in 2005, the inspection was carried out at the beginning of September 2005. In previous years, monitoring was carried out separately for winter browsing (April) and summer browsing (September).

As summer browsing was always markedly lower, being predominantly done on trees already damaged in winter, we mention only the results from April dates of monitoring (from 2001 and 2003).

Characteristics of the studied area

The Vrapač NNR is situated 2 km west of Litovel, the cadastre Mladeč. Its area is 80.69 ha and the average altitude is 235 m above sea level. The area protection was declared in 1989. The reserve is a part of the Litovelské Pomoraví Protected Landscape Area. It is an extensive complex of floodplain forests in an alluvial plain with a natural reach of the Morava River. The meandering river branch Malá voda and the system of periodically flooded river branches run through the forest. Forest stands are classified as *Ulmi-fraxineta carpini superiora*. A more detailed description of monitored transects is given in Table 1.

The Vrapač NNR was a part of the Mladeč hunting district (1,022 ha) until 2003. Roe deer (*Capreolus capreolus*) with the standardized stock of 46 animals and fallow deer (*Dama dama*), the stock of which was not standardized, were reared in the hunting ground. Since 2003 the reserve has been a part of the Nové Mlýny hunting ground (716 ha). In a decision on the hunting ground recognition from April 2003, fallow deer rearing was not standardized although fallow deer showed rather high numbers (Table 2); the standardized stock of roe deer was 41 animals, minimum stock 16 animals (both data related to the hunting ground area).

RESULTS AND DISCUSSION

The following species predominated in natural regeneration: European ash (*Fraxinus excelsior*), sycamore maple (*Acer pseudoplatanus*), field maple (*Acer campestre*) and Norway maple (*Acer plata-*

Table 1. Characteristics of transects

Transect GTG*	Size	GPS	Tree and shrub layers**	Dominant plants of herb layer
Transect 1 *Ulmi-fraxineta carpini superiora*	55 × 3 m	49°42´55´´N 17°02´50´´E	I.–II. *T.* 55%, *F.e.* 10%, *Q.r.* 10%; III. *T.* 10%; IV. *T.* 10%	*Glechoma hederacea, Impatiens noli-tangere, Urtica dioica, Circaea lutetiana*
Transect 2 *Ulmi-fraxineta carpini superiora*	70 × 3 m	49°42´60´´N 17°02´35´´E	I.–II. *F.e.* 40%, *A.ps.* 10%, *Q.r.* 10%; III. *T.* 15%, *A.c.* 15%; IV. *T.* 10%	*Glechoma hederacea, Mercurialis perennis, Urtica dioica, Aegopodium podagraria*
Transect 3 *Ulmi-fraxineta carpini superiora*	50 × 3 m	49°42´71´´N 17°02´19´´E	I.–II. *Q.r.* 50%, *T.* 10%, *F.e.* 5%; III. *T.* 30%; IV. *T.* 15%	*Glechoma hederacea, Mercurialis perennis, Dactylis polygama, Aegopodium podagraria*

* GTG – geobiocenosis type group (Buček, Lacina 1999)

** I. = dominant trees; II. = co-dominant trees; III. = sub-dominant trees; IV. = shrub layer

T. = Tilia spp., *F.e. = Fraximus excelsior*, *Q.r. = Quercus robur*, *A.c. = Acer campestre*, *A.ps. = Acer pseudoplatanus*

Table 2. The abundance of deer (according to hunting statistics)

Year	Game	Abundance (head/1,000 ha)
2001	roe deer	50
	fallow deer	8
2003	roe deer	98
	fallow deer	63
2005	roe deer	*
	fallow deer	*

*Game manager and game office refused the publication of data

noides). All these species were markedly damaged by browsing similarly like other scattered species (Table 3). In all three years, *Acer pseudoplatanus* was the most damaged species (if we do not take into account the species represented by of several trees only). *Acer pseudoplatanus* ranks among the frequently preferred species and results obtained by our research team correspond to a number of similar studies carried out in Europe in various types of forest ecosystems with the presence of sycamore maple (Linhart, Whelan 1980; Eiberle, Wenger 1983; Szukiel 1986; Jamroza 1987; Králík 1999).

In trees exceeding a height of 30 cm a notably higher number of individuals was damaged than up to a height of 30 cm; the best part of trees exceeding a height of 30 cm was damaged (2001 – 62%; 2003 – 75%; 2005 – 88%). In 2001 and 2003, browsing (% of damaged trees) was highest in transect B where in 2001 quite numerous and fast-growing regeneration occurred on the open edge of the stand. In the next years, the average height of advance growth decreased instead of the expected increase (Fig. 1), radical browsing often with the breaking of shoots was noted in the transect. The annual increment of undamaged trees ranged from 2 to 15 cm in trees up to 30 cm in height, from 5 to 25 cm in trees up to 50 cm and from 10 to 40 cm in trees exceeding 50 cm. Until 2005, the majority of taller and older trees disappeared in the transect (251 trees taller than 30 cm were recorded in 2001, 102 in 2003 and only 21 trees in 2005). All trees the decline of which was recorded by monitoring (a dead tree was found) were damaged by browsing. In 2005, transect C with small regeneration was most damaged.

In all three transects, a marked decrease in the number of trees occurred although new seedlings appeared in the period 2001–2005 (Fig. 2). In transect A, the number of trees from self-seeding decreased particularly between 2001 and 2003 (Fig. 2) and most of taller trees disappeared (there were 15 trees over 30 cm in 2001 and only 3 trees in 2003). Between 2003 and 2005, the trend was slowed down thanks to the new self-seeding in the period 2003–2005 (there were 158 one-year-old and two-years-old plants in the transect in 2003 and 133 one-year-old and two-years-old plants in 2005) compensating the decrease of older regeneration. In addition to the retardation of the seedling decrease the new self-seeding participates in the present decline of the average height of trees (Fig. 1).

In the already mentioned transect B, roughly a half remained from the original self-seeding in 2003; the rest was created by new seedlings. Trends of the fall of abundance (Fig. 2) and mean height (Fig. 1) are in principle linear – the new self-seeding was not so numerous to compensate for the high mortality of damaged trees more markedly. In transect C with only little numerous regeneration, differences are less marked than in transects A and B, the trend of the development of abundance being similar to the other transects. An increase in the height of trees in transect C between 2003 and 2005 (Fig. 1) occurred in consequence of the occurrence of a new generation of trees (particularly ash) which appeared in 2003. If

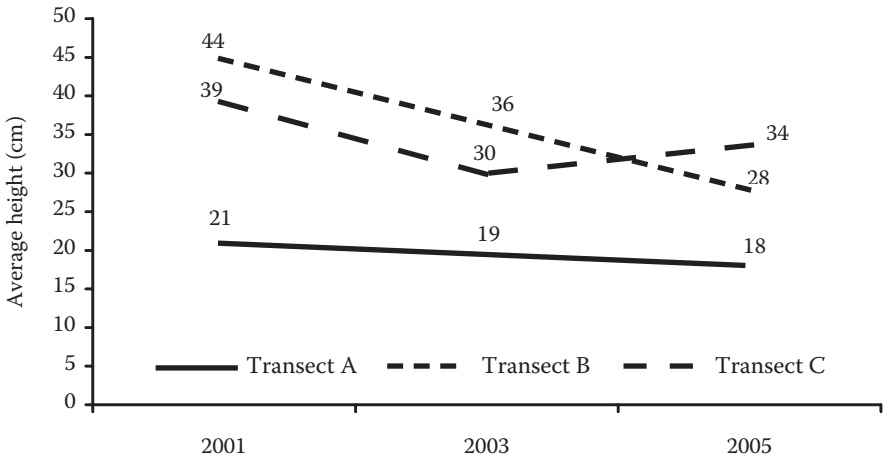

Fig. 1. The average height of trees in natural regeneration

Table 3. The abundance of all trees, the abundance of damaged trees – 2001, 2003, 2005

Year	Woody plant	Transect A			Transect B			Transect C			Total		
		total	dam.	% dam.	total	dam.	% dam.	total	dam.	% dam.	total	dam.	% dam.
2001	*Acer pseudoplatanus*	34	20	59	230	171	74	46	29	63	310	220	71
	Fraxinus excelsior	323	103	32	63	37	59	3	0	0	389	140	36
	Acer campestre	9	3	33	25	10	40	2	1	50	36	14	39
	Tilia spp.	1	0	0	3	0	0	1	0	0	5	0	0
	Crataegus spp.	6	6	100	1	1	100	1	1	100	8	8	100
	Acer platanoides	–	–	–	10	1	10	6	0	0	16	1	6
	Euonymus europaeus	3	0	0	–	–	–	–	–	–	3	0	0
	Total	376	132	35	332	220	66	59	31	53	767	383	50
2003	*Acer pseudoplatanus*	13	9	69	88	83	94	22	20	91	123	112	91
	Fraxinus excelsior	212	84	40	70	49	70	9	1	11	291	134	46
	Acer campestre	4	3	75	23	12	52	2	2	100	29	17	59
	Tilia spp.	5	0	0	4	4	100	1	0	0	10	4	40
	Crataegus spp.	5	5	100	–	–	–	–	–	–	5	5	100
	Acer platanoides	1	0	0	31	11	35	3	1	33	35	12	34
	Juglans nigra	1	0	0	–	–	–	–	–	–	1	0	0
	Quercus robur	1	0	0	–	–	–	1	0	0	2	0	0
	Total	242	101	42	216	159	74	38	24	63	496	284	57
2005	*Acer pseudoplatanus*	13	7	54	20	18	90	16	15	94	49	40	82
	Fraxinus excelsior	173	60	35	33	18	55	10	4	40	216	82	38
	Acer campestre	–	–	–	17	11	65	–	–	–	17	11	65
	Tilia spp.	5	4	80	3	1	33	1	0	0	9	5	56
	Crataegus spp.	5	5	100	–	–	–	–	–	–	5	5	100
	Acer platanoides	–	–	–	24	14	58	2	2	100	26	16	62
	Total	196	76	39	97	62	64	29	21	72	322	159	49

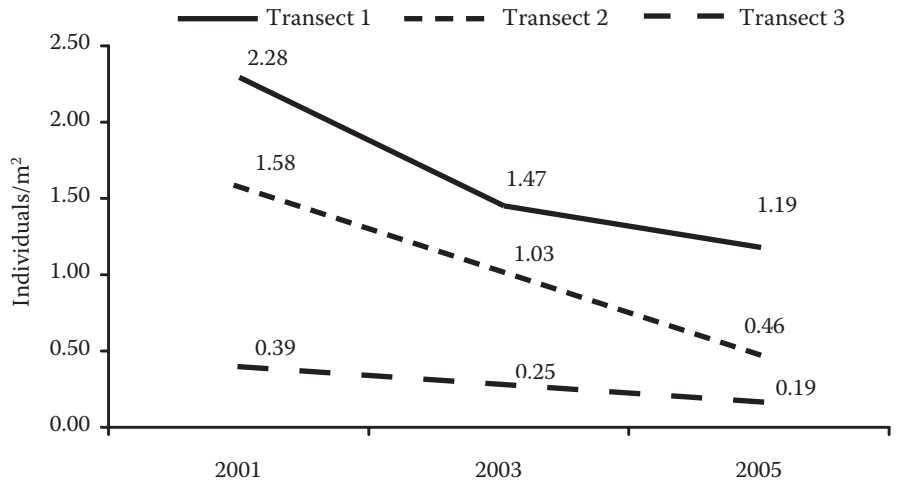

Fig. 2. The density of natural regeneration (individuals/m^2)

Fraxinus excelsior was not damaged, it reached quite large increments, viz. 10 to 20 cm. Generally, the results from the transect are, however, unfavourably affected by the total low density of trees.

In predominating tree species, a decrease in their number corresponds to the rate of damage (the percentage of trees damaged by browsing throughout the studied period). The highest decrease in abundance was found in the most damaged *Acer pseudoplatanus*, a smaller decrease in less damaged *Acer campestre* and the least decrease in virtually undamaged *Fraxinus excelsior* (Fig. 3). There was a close correlation (r = 0.9952, p < 0.05) between the percentage decrease in the number of dominant trees and the percentage of damaged trees throughout the studied period. Thus browsing can be regarded as a dominant factor causing a reduction in the number of trees and changes in their proportion – particularly increasing the proportion of *Fraxinus excelsior* at the expense of *Acer pseudoplatanus* (Fig. 4). Of course, negative selection showed unfavourable effects also in the other species. In transect A, *Acer campestre* totally disappeared during monitoring (9 trees were found in 2001, 4 trees in 2003 and no tree in 2005); it also disappeared in transect C (however, only 2 individuals occurred there).

In the course of monitoring, *Euonymus europaeus* and *Quercus robur* represented only by several individuals also disappeared (Table 3); because no game damage to the species was noted during monitoring, their absence did not have to be related to browsing. *Acer platanoides* was the only species the abundance of which (as well as percentage) increased during monitoring. Particularly relatively numerous natural regeneration in transect B, which occurred in 2003, participated in the increase of abundance. These trees were relatively little damaged compared with the other species (Table 3). The reason for this fact was likely their very slight growth and small height. In 2005, their damage was already higher being comparable with the other species except the considerably damaged *Acer pseudoplatanus* (Table 3).

Fundamental impacts of intensive browsing on the structure and dynamics (tree abundance, height

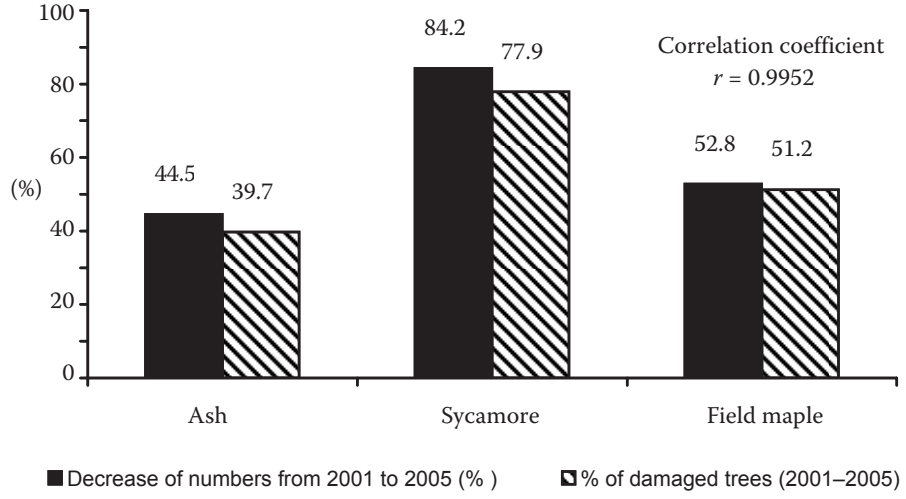

Fig. 3. The decrease of tree numbers and the percentage of damaged trees (2001–2005)

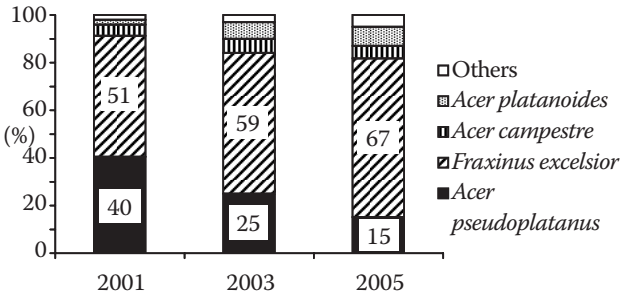

Fig. 4. The species composition of natural regeneration

increment, species composition) of natural regeneration in mixed stands of various types were described by a number of other authors in many types of localities (Perko 1983; Burschel et al. 1985, 1990; Ammer 1996; Čermák 2000; Modrý et al. 2004). The rate of these effects and developmental trends resembled the situation found by our studies in the Vrapač NNR. A decrease in the proportion of *Acer pseudoplatanus* in newly originating stands due to intensive browsing was reported by Burschel et al. (1990) in mixed stands in the Bavarian Alps.

With respect to the rate of browsing and its selection character it is possible to expect that in less regenerating but attractive species such as elm (*Ulmus minor*) in the Vrapač NNR, total elimination from natural regeneration can occur in the species – seedlings are repeatedly damaged immediately after their appearance and often disappear even before their registration. This presumption results from comparisons with fenced plots outside the reserve (in the same hunting ground and stand type) where the elm regularly occurred unlike other stands. The trend of the intensive damage to food-attractive but scarcely occurring species often resulting in their gradual elimination from natural regeneration was repeatedly documented in the mixed self-seeding of tree species (Eiberle, Bucher 1989; Čermák 2000).

In 2003 and 2005, browsing damage was sporadically noted in trees taller than 1 m and with the stem diameter of 5–10 cm and in 2005 the individual breaking of already grown up trees with subsequent browsing of terminal shots was also observed (in ash and sycamore maple). With respect to the character of damage (the size of marks caused by teeth, the height of breaks) it is possible to state that the damage was caused by fallow deer (*Dama dama*). Breaking damage to grown up trees is common in elk (*Alces alces*), which is a typical browsing animal (Lavsund 1987; Histol, Hjeljord 1993, etc.). Of food "opportunists" (Hofmann 1989) with fallow deer ranking among them Heroldová et al. (2003) described the breaking of trees also in red deer (*Cervus elaphus*) in the Beskids. Particularly rowan trees 1 to 3 m in height were affected. In fallow deer, these feeding habits have not been noted so far although they are generally known to practical foresters.

On the basis of the condition and development of natural regeneration it is necessary to consider present populations of game to be incompatible with objectives of landscape protection and conservation. The increase of damage to trees and their mortality in 2003 correspond to the increase in the stocks of fallow deer (Fig. 2). With respect to the fact that in 2001 the numbers of fallow deer were not standardized, it is possible to suppose that in that year its actual number could be underestimated. An increase in the number of fallow deer between 2001 and 2003 would be then less marked than shown by statistics. The rate of negative impacts of fallow deer populations is amplified by browsing and breaking damage. Both the types of damage markedly increase the period of damage to trees by browsing.

CONCLUSION

On the basis of results obtained from the particular transects it is possible to conclude that promising natural regeneration in 2001 was substantially reduced (both its number and growth) in the next years. Although new self-seeding always appeared, the abundance of trees decreased: in 2005 there were only 42% of the original number of trees in 2001 on transects (transect A – 52%, transect B – 29%, transect C – 49%). Trees were kept at a height of max. 30 to 40 cm for a long time, the mean height of self-seeding decreased instead of growth. The proportion of the particular species changed, the proportion of *Fraxinus excelsior* increased (2001 – 51%, 2005 – 67%), the proportion of *Acer pseudoplatanus* decreased (2001 – 40%, 2005 – 15%), the proportion of less damaged *Acer platanoides* increased (2001 – 2%, 2005 – 8%). With respect to the close correlation ($r = 0.9952$, $p < 0.05$) between the decrease of abundance of three dominant tree species and the percentage of trees damaged during the studied period due to browsing it is possible to state that browsing is the primary cause of the reduction of natural regeneration.

If the pressure of browsing animals does not decrease, it is not possible to expect the origin of natural regeneration of stands as for its extent and species composition corresponding to present site, stand and climatic conditions in the Vrapač NNR. The structure, abundance and growth of surviving regeneration will be fundamentally limited by food preferences of game and by the tolerance of the particular species to repeated damage.

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Received for publication November 22, 2005
Accepted after corrections March 9, 2006

Vliv zvěře na stav a vývoj přirozené obnovy v NPR Vrapač (Litovelské Pomoraví)

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ABSTRAKT: V letech 2001–2005 byl na třech trvalých transektech v NPR Vrapač sledován vliv zvěře na stav a vývoj přirozeného zmlazení lužního lesa. Ve zmlazení převažovaly: *Fraxinus excelsior*, *Acer pseudoplatanus*, *Acer campestre* a *Acer platanoides*. Dřeviny byly okusem výrazně poškozovány, nejvíce postižen byl *Acer pseudoplatanus*. Přes stále nově se objevující jedince v náletu se početnost dřevin ve sledovaném období snižovala, nálet neodrůstá z výšek 30–40 cm, snižuje se zastoupení *Acer pseudoplatanus* a zvyšuje se zastoupení *Fraxinus excelsior*. Kromě okusu bylo v letech 2003 a 2005 pomístně zaznamenáno poškození ohryzem kůry, v roce 2005 jednotlivě také lámání

již odrostlých dřevin s následným okusem terminálu; původcem obojího byl daněk. Vývoj přirozeného zmlazení je zásadně limitován potravními preferencemi zvěře a tolerancí jednotlivých dřevin k opakovanému poškození. Na základě tohoto stavu je nutné považovat současné stavy zvěře za neslučitelné s cíli ochrany území.

Klíčová slova: přirozená obnova; *Capreolus capreolus*; *Dama dama*; okus; růst dřevin

Pro potřeby projektu *Vliv hospodářských zásahů na změnu biologické rozmanitosti ve zvláště chráněných územích* (2001), v rámci zpracování podkladů pro plány péče (2003) a v rámci projektu Ministerstva školství, mládeže a tělovýchovy České republiky *Les a dřevo* byl v letech 2001–2005 monitorován stav a vývoj přirozeného zmlazení na třech trvalých transektech v Národní přírodní rezervaci Vrapač.

V přirozeném zmlazení převažoval jasan ztepilý *(Fraxinus excelsior)*, javor klen *(Acer pseudoplatanus)*, javor babyka *(Acer campestre)* a javor mléč *(Acer platanoides)*. Všechny tyto druhy byly výrazně poškozovány okusem stejně jako ostatní jen vtroušené dřeviny (tab. 3). Ve všech třech letech byl dřevinou s největším poškozením *Acer pseudoplatanus* (nepočítáme-li dřeviny zastoupené jen několika jedinci). V případě dřevin nad 30 cm výšky byl poškozen znatelně větší podíl jedinců než u dřevin do 30 cm výšky; nad 30 cm výšky byla poškozena převážná většina jedinců (2001 – 62 %; 2003 – 75 %; 2005 – 88 %).

Na všech třech transektech došlo v období 2001 až 2005 k výraznému úbytku početnosti dřevin (obr. 2) i přesto, že se objevovaly nové semenáče. U převažujících druhů dřevin koresponduje pokles početnosti v relativních hodnotách s jejich mírou poškození (procentem okusem poškozených jedinců za celé sledované období). Největší úbytek početnosti byl zjištěn u nejvíce poškozovaného *Acer pseudoplatanus*, menší úbytek u méně poškozovaného *Acer campestre* a nejmenší u nejméně poškozovaného *Fraxinus excelsior* (obr. 3). Okus lze proto jednoznačně považovat za dominantní faktor vyvolávající redukci početnosti dřevin a změny v jejich zastoupení – především zvyšování zastoupení *Fraxinus excelsior* na úkor *Acer pseudoplatanus* (obr. 4).

Na základě stavu a vývoje přirozeného zmlazení je nutné považovat současné stavy zvěře za neslučitelné s cíli ochrany území. U populace daňka je míra negativního působení umocněna dalšími popsanými škodami – olamováním a ohryzem. Oba tyto typy škod výrazně prodlužují dobu ohrožení dřevin okusem.

Výsledky z jednotlivých transektů lze shrnout a konstatovat, že nadějně se vyvíjející zmlazení zaznamenané v roce 2001 bylo v následných letech početně i růstově zásadně redukováno. Přes stále nově se objevující nálet se početnost dřevin snižovala, dřeviny jsou dlouhodobě drženy do 30–40 cm výšky, mění se zastoupení jednotlivých druhů. Pokud nedojde ke snížení tlaku okusovačů, nelze v NPR Vrapač předpokládat vznik přirozené obnovy porostů v rozsahu a druhové skladbě, odpovídající současným stanovištním, porostním a klimatickým podmínkám; složení, početnost a růst přežívajícího zmlazení budou zásadně limitovány potravními preferencemi zvěře a tolerancí jednotlivých dřevin k opakovanému poškození.

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