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Grassland vegetation in the former military area Dobrá Voda, the Šumava National Park

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Abstract
Secondary grasslands in the Bohemian Forest contribute substantially to a characteristic landscape pattern and biodiversity of the mountains. However, in the past decades they have degraded in the great extent and the degradation is still in progress. We mapped vegetation units in 17 grassland areas (the total area of 27 km^2) around former settlements in the former military training zone. The vegetation units (31) were defined mostly according to dominant species and they were related to moisture and nutrient gradients and successional age. The vegetation data were elaborated by GIS methods. For the particular units an optimum management was suggested, reflecting both interests of nature conservancy and agricultural use.

Key words: secondary grasslands, succession, management, GIS

Introduction

The upper part of the Bohemian Forest was nearly completely covered by primary forests until the Middle Ages. Originally, there were only small areas which were not covered by a close forest, being attached to peatbogs, steep slopes in corries, and screes. Thus, all grasslands present in the upper part of the mountains are in fact of the secondary origin (Rybníček & Rybníčková 1974).

The first, small secondary grasslands were apparently formed along the trade routes, crossing the mountains as early as in the Bronze Age (ca. 2000-750 BC), possibly even in the La Tene period (500-0 BC) – Beneš (1996). Heliophilous plants could also occur in sites affected by the gold extraction. However, a systematic conversion of the ancient compact forest to meadows and pastures started in the Middle Ages, in the end of the 14th century, and graduated in the 17th and 18th centuries (Prach, Štech & Beneš 1997). The main reasons for the latter deforestation were as follows: fuel needed for abundant glass manufactures, clearings for pastures, and logging to supply various activities in the lowlands.

The grasslands were regularly managed, the most productive ones were cut twice a year, the others cut once or grazed, especially in the late summer (Klečka 1932). Certain information on the vegetation pattern and dynamics of the grasslands under the traditional management is available in the following sources: Klečka (1932), Moravec (1965), Rybníček & Rybníčková (1974), however not just from the study area.

Unfortunately, the regular management of the grasslands was strongly reduced when German inhabitants were expelled from the country shortly after the World War II. Since that time, the grasslands have been gradually degraded of which the large decrease of biodiversity is the evident consequence. Beside the abandonment of the large areas of the grasslands, some parts were ploughed up and sown by a mixture of grasses which were not always a natural component of the meadows. In these aspects the situation is similar to that in most other mountains on the border of the Czech Republic (GUTH & al. 1995, KUČERA & GUTH 1998) and partly also to that in former military training areas in lower elevations (PETŘÍČEK & PLESNÍK 1997).

The processes of degradation were not stopped even after the declaration of the Landscape Protected Area over the whole mountains in 1963 because the earlier communist regime did not respect even its own legislation. A regular, appropriate management of the grasslands was also difficult because of the fact that in the extensive border and military training areas the access was prohibited except soldiers and small number of other people selected by the communist authorities. A new chance for the whole area appeared after the collapse of communism in 1989, especially after the declaration of the main part of the mountains as National Park (in 1991) and the Biosphere Reserve (1989). Since that time, a discussion has been conducted on what would be the best management of the grasslands and to what parts would be directed. The sub-project under the GEF Biodiversity Programme (1994-1997) helped to give the answers.

The main aims of the project were as follows: (a) Evaluation of the present state of the secondary grasslands in selected parts of the upper Bohemian Forest (b) To find relationships of vegetation cover to main environmental factors (water supply, nutrient availability, disturbance regime including management). (c) Reconstruction of past vegetation changes, estimations of the rate and directions of successional transitions and on the basis of these making a prognosis on the future development of the grasslands under various scenarios. (d) To provide recommendations for the National Park Administration Office on the optimum management of particular parts of the grasslands.

This paper aims to present main findings, recommendations and conclusions from the project and to document vegetation cover of the secondary grasslands and their management in the part of the Šumava National Park. A combination of the classical methods of vegetation mapping and GIS methods is demonstrated, incorporating practical implications for landscape management and nature protection.

Material and methods

The area under interest was equal to the former military zone "Dobrá Voda" established there in 1953 and cancelled in 1991. The whole grassland area (of ca. 27 km^2) was subdivided into 17 complexes (enclaves), which approximately correspond to the cadastral areas of former settlements (Fig. 1.). Most former settlements were demolished after expelling the German inhabitants and then during the fifties after the military zone was declared. Only three former villages have been at least partly preserved and several lonely houses survived. However, the traditional management of the grasslands was completely abandoned.

The most important step at the beginning of the project was to classify the diverse vegetation of the grasslands and find main relations to environmental factors including a type of management. We used units mostly defined by their dominant or characteristic species, if convenient we used the terminology of the Curych-Montpellier school (for that see MORAVEC & al. 1995). Nomenclature of plant species follows NEUHÄUSLOVÁ & KOLBEK (1982). A conceptual scheme of the distinguished units emerged from field observations, our experience

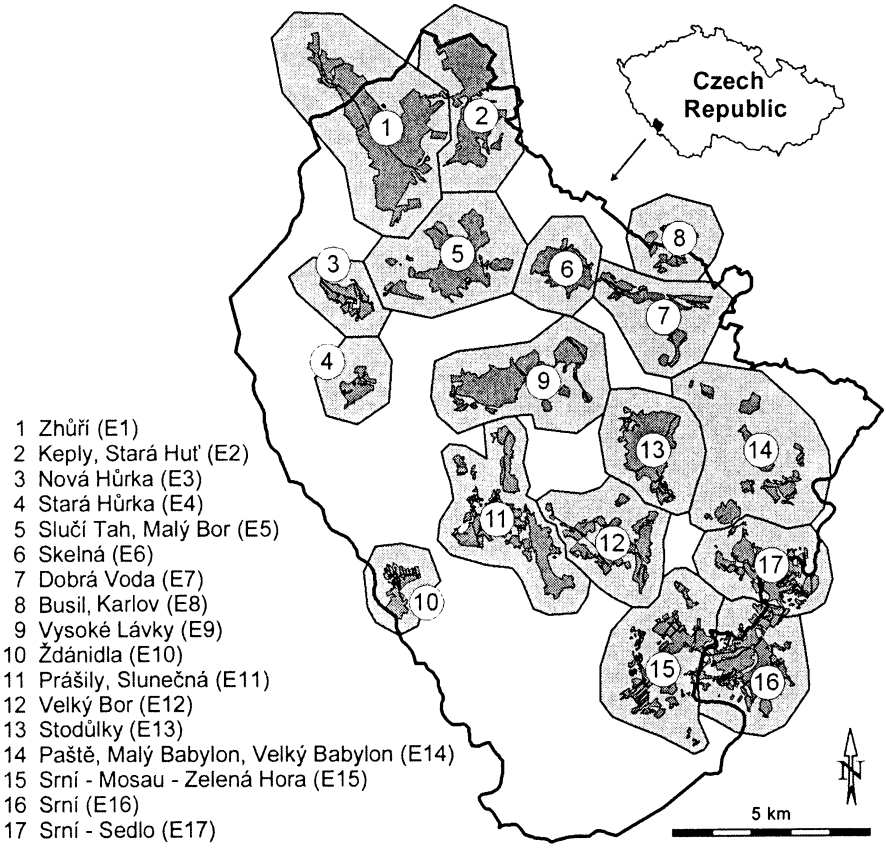

Fig. 1. – The study area of the military area "Dobrá Voda" (bordered by the thick line) and the location of the particular deforested enclaves (E1–E17).

with vegetation dynamics of grasslands in other regions (PRACH 1993, PRACH & al.1996), and information from literary sources (KLEČKA 1932, MORAVEC 1965, RYBNÍČEK & RYBNÍČKOVÁ 1974). The particular vegetation units were used for the mapping. The same sources were used to suggest the management the best fitted to the particular vegetation units. We considered the following basic types of management to be conducted in the studied grasslands: (1) cutting ones a year; (2) cutting twice a year; (3) low impact grazing; (4) left without management; (5) local mechanical disturbance (sod destruction); (6) elimination of woody species (cutting). The proportion of the management types was expressed over the area, an optimum management for each unit was taken for the calculation. The field mapping was done into the aerial photos, scale of 1:5 000, in the top of season in July 1996, before cutting the grasslands for hay in those sites where cutting was still practised. The resulting maps were edited and all grassland complexes were visited again several times to check the maps.

All cartographic sources were tablet digitised using PCI software. After image mosaicking and map registration the results were transferred into ARC/INFO format. The output map was printed in ArcView system.

Results

Vegetation units, their characteristics, and recommendations for their management

Serie 1 – EXTREMELY WET, NUTRIENT POOR

1a – *Carex rostrata* communities: stabilised without evident successional transitions; left without management, protect from eutrophication and drainage

1b – peat bogs usually dominated by *Eriophorum vaginatum* and *Sphagnum* species: see 1a

Serie 2 – PERMANENTLY WET, NUTRIENT POOR

2a – initial *stages* after mechanical disturbance with typical species such as *Philonotis fontana, Carex echinata, Pinguicula vulgaris, Juncus bufonius, Lycopodiella inundata*: often occurrence of rare and endangered species; usually left without management, however small scale mechanical disturbances are locally desirable to form microsites suitable for endangered populations

2b – *Carex nigra* communities (short sedge grasslands): usually stabilised if protected from eutrophication (then successional transitions to Calthion) and drainage; manual cutting in two years period would be an optimum management, however, in reality it can be performed only in limited area in the most valuable sites, elsewhere left without management

2c – *Eriophorum angustifolium* communities (on shallow peat soils): left without management

2d – willow carrs (*Salix aurita* as usual dominant): slow *expansion* of willows which can be artificially stopped if a population of a rare species is immediately endangered, elsewhere left without management

Serie 3 – PERMANENTLY WET, NUTRIENT RICH

3a – various communities of the sub-alliance Calthenion: usual transitions to the following units if neglected; an optimum management includes regular cutting in July, in reality it can be performed only in the most valuable localities (species rich)

3b – various communities of the sub-alliance Filipendulenion: originate from the previous unit if left without management, then expansion of a dominant species such as *Filipendula ulmaria, Carex brizoides,* or *Scirpus sylvaticus*; re-establishment of regular cutting (see 3a) is suggested, however it can be practically realised only in valuable localities

3c – stages with shrubs and trees (expanding into 3a or 3b): establishment of woody species is usually possible only in mechanically disturbed sites (in the studied area usually by military activities); generally left without management; only in localities where a population of an endangered species is immediately threatened by expansion of woody species they can be carefully removed

Serie 4 – DAMP, NUTRIENT POOR

4a – initial stages after mechanical disturbance, species rich: fast expansion of grasses especially if eutrophicated, for management see 2a

4b – the same but species poor with expanding *Deschampsia cespitosa* or *Juncus effusus*: left to spontaneous succession

4c – damp communities of the Violion caninae alliance, species rich: occasionally grazed (sheep is the best)

4d – damp communities of the Violion caninae alliance, species poor, dominated by *Nardus stricta*: for management see 4c

4e – damp heathlands with a typical occurrence of *Vaccinium uliginosum* resulted by a long-term succession from the previous units after abandonment, usually stabilised; left without management

4f – degraded stages dominated by grasses (*Deschampsia flexuosa, Calamagrostis villosa, Holcus mollis*): extensive grazing desirable, left without management also possible

4g – stages with shrubs and trees (*Salix* spec.div., *Picea abies, Alnus incana, Betula pubescens*): generally without management except valuable localities of the previous units when expansion of woody species starts

Serie 5 – DAMP, NUTRIENT RICH

5a – species rich communities of *Deschampsia cespitosa*: usually in alluvial sites, threatened by expansion of *Carex brizoides*; regular cutting once a year or extensive grazing (more realistic alternative)

5b – species rich meadows with *Trisetum flavescens* (Polygono-Trisetion alliance): dump to mesic, for simplification they are considered only here, under damp sites; they represent remnants of the typical former, regularly managed meadows which were widespread over the region; frequent and fast transitions to the unit 5g; optimum management represents cutting in the end of June or in July, then extensive grazing in August-September is desirable

5c – meadows with *Alopecurus pratensis*: occur in alluvial sites with a higher level of nutrients, two cuts during season represent the best management

5d – degraded stages dominated by *Deschampsia cespitosa*: originated from 5a after abandonment; large tussocks make cutting difficult, thus, extensive grazing undisturbing adjacent, often valuable bank vegetation could be recommended despite the fact that the dominant species is not very attractive for cattle

5e – swards of *Carex brizoides*: the worst vegetation cover from the point of view of both nature conservancy and agriculture exploitation; often a monospecific cover, unpalatable; restoration is extremely difficult, slow and expensive; the most urgent task is to protect adjoining vegetation from the expansion of the sedge by an appropriate management (mosaic with another vegetation types can be used for example as a horse pasture)

5f – swards of *Calamagrostis villosa*: usually occur in the vicinity of forest margins, grazing is recommended

5g – degraded meadows of the alliance Polygono-Trisetion: dump to mesic, for simplification they are considered only here, under damp sites; they develop from 5b after abandonment, then an expansion of *Hypericum maculatum, Holcus mollis,* and *Agrostis capillaris* is typical; if cutting (preferably) or extensive grazing are re-established, a rather fast restoration is still possible

5h – swards of *Phalaris arundinacea*: usually develop from 5c in alluvial sites; because of its sporadic occurrence it can be left without management, however cutting twice a year is the best for restoration of more species rich alluvial meadows

5i – intensively used meadows with sown *Alopecurus pratensis*: continuation in the present practice, however avoiding overfertilisation

5j – ruderalised meadows: usually around or in settlements; re-establishment of cutting (twice a year) is recommended

5k – degraded pastures: usually overgrazed and degraded by trampling; decrease in intensity of grazing is recommended

Table 1. – Presence of the particular vegetation units (their area in hectares) in the studied grassland patches (enclaves E1-E17).

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	Σ
1						2.6			0.7				2.4					**5.7**
1a	0.1	0.4	5.4		7.4				0.1		6.4	2.4				1.2		**23.5**
1b	16.4	0.1	0.6		3.6				12.4	1.3	3.3				5.2	2.9		**45.8**
Σ	**16.5**	**0.5**	**6.1**	**0.0**	**11.0**	**2.6**	**0.0**	**0.0**	**13.3**	**1.3**	**9.6**	**2.4**	**2.4**	**0.0**	**5.2**	**4.1**	**0.0**	**75.0**
2a											0.2	2.1			0.1			**2.4**
2b	12.1	6.3	6.3		5.0				0.6		2.8	3.1	2.9	1.9	5.6	2.4	0.8	**49.6**
2c	2.5	0.7	0.3		0.1	0.5			0.5		4.1	1.5	3.0					**13.3**
2d		0.4				2.1					3.4						0.5	**6.4**
Σ	**14.6**	**7.5**	**6.6**	**0.0**	**5.0**	**2.6**	**0.0**	**0.0**	**1.1**	**0.0**	**10.5**	**6.7**	**5.8**	**1.9**	**5.7**	**2.4**	**1.2**	**71.7**
3a	1.4	0.6			0.4	0.2			0.4		10.1		0.5	0.3	2.3	0.4	0.6	**17.2**
3b	11.9	3.0	9.1	1.6	11.1	3.1	1.1	3.1	5.3		1.4		5.1	1.7	0.7	11.2	2.8	**72.2**
3c							0.1				3.6	1.1			1.0	0.3	4.7	**10.9**
Σ	**13.4**	**3.5**	**9.1**	**1.6**	**11.6**	**3.3**	**1.2**	**3.1**	**5.6**	**0.0**	**15.1**	**1.1**	**5.7**	**2.0**	**4.0**	**11.9**	**8.1**	**100.4**
4a											1.3				1.1			**2.4**
4b		0.3										2.8						**3.1**
4c					17.3						0.9			2.7	7.6	2.9		**31.4**
4d	5.2	0.6								0.7	0.5			1.4	0.6	3.5		**12.6**
4e	0.1						2.0		0.4				0.3			1.0		**3.8**
4f	18.5	3.6									2.3		0.6					**25.1**
4g		8.4							4.4		8.7		2.8	2.3		1.0		**27.7**
Σ	**23.9**	**12.9**	**0.0**	**0.0**	**17.3**	**0.0**	**2.0**	**0.0**	**4.8**	**0.7**	**13.6**	**2.8**	**3.7**	**6.4**	**9.3**	**8.5**	**0.0**	**106.1**
5a									1.6		0.2	7.6	8.4		0.4		5.5	**23.7**
5b	10.1	20.6	1.6	12.0	0.7					7.3	21.4	9.4	9.4	56.6			45.9	**195.0**
5c	1.1				0.7						8.5							**10.3**
5d	14.3	11.5	1.7		66.8				0.8		7.6	12.0	42.5			73.3		**230.6**
5e	32.0	2.1	0.8		16.9	32.6	4.0		32.7	1.8	36.8	5.9	17.3	10.3	1.4	0.6	2.6	**197.7**
5f		0.3								0.6	48.1	7.2	1.9			5.4		**63.5**
5g	213.5	59.8	21.6	18.1	56.7	19.6	19.1	33.0	127.4	35.5	36.5	48.9	55.7	14.2	68.5	36.5	11.9	**876.5**
5h						61.4	12.8	3.4	4.9					0.1				**82.6**
5i	4.8	11.0	0.3	1.2	6.7						13.6	30.4			8.2	6.6		**82.7**
5j	4.7	6.6	6.5	3.8	8.6	1.6	6.4		6.1		2.0	18.0	3.0	9.7	9.6	62.4	29.6	**178.6**
5k		8.7				6.3	1.3									0.7	11.9	**28.9**
5l		2.0					0.2		14.6				1.5				0.7	18.9
5m													0.6	0.7				**1.3**
Σ	**280.4**	**122.5**	**32.5**	**35.2**	**157.1**	**121.5**	**43.8**	**36.4**	**188.1**	**45.2**	**174.6**	**139.3**	**140.3**	**91.6**	**88.0**	**185.5**	**108.1**	**1990.4**
6a	21.6	4.0			7.8					0.5	8.5	1.0	8.6			0.4		**52.5**
6b	3.5	1.5	2.0		6.1				1.1		2.1		5.1	1.7	2.8	1.0	9.5	**36.4**
6c	1.2	0.3									3.1	0.3			10.5		0.5	**15.9**
6d		0.6		0.2	0.4						4.1		3.0	2.1			0.9	**11.1**
6e																		**0.0**
Σ	**26.4**	**6.5**	**2.0**	**0.2**	**14.2**	**0.0**	**0.0**	**0.0**	**1.1**	**0.5**	**17.7**	**1.4**	**16.7**	**3.8**	**13.2**	**1.4**	**10.9**	**116.0**
7a																		**0.0**
7b	64.9	83.6			2.0		40.0	4.6					2.4	0.2	19.7	9.7	23.1	**250.2**
7c													8.7					**8.7**
Σ	**64.9**	**83.6**	**0.0**	**0.0**	**2.0**	**0.0**	**40.0**	**4.6**	**0.0**	**0.0**	**0.0**	**0.0**	**11.1**	**0.2**	**19.7**	**9.7**	**23.1**	**258.9**

5l – stages with shrubs and trees: they usually developed only in mechanically disturbed sites; generally left to spontaneous succession

Serie 6 – MESIC AND DRY, NUTRIENT POOR

6a – initial stages after mechanical disturbance: usually species rich; locally expansion of woody species – then transitions to 5e; no large-scale management, locally a repeated artificial mechanical disturbance is recommended to ensure the continuous existence of the initial successional stages

6b – communities of the Violion caninae alliance on dry sites: occur on shallow soils, usually on slopes, extensive grazing is recommended (preferably by sheep)

6c – dry heathlands: usually stabilised; left without management, valuable unit typical for the area

6d – stages with shrubs and trees (Scots Pine, birch, aspen): left to spontaneous succession unless a valuable locality is endangered by the woody species expansion, then careful artificial elimination of woody species

Serie 7 – MESIC AND NUTRIENT RICH

7a – communities of the Arrhenatherion alliance (recorded only in small patches less than the scale of the map in Fig. 2): occur in lower altitudes on the margin of the investigated area; often species rich with the occurrence of orchids; two cuts a year are strongly recommended especially in valuable localities

7b – various intensive meadows: usual agricultural practice can continue avoiding overfertilisation

Results based on the vegetation mapping

The occurrences of the distinguished units in the particular complexes (enclaves 1–17) and its summarised occurrence in the whole study area are evident from Tables 1 and 2. The most common grasslands in the area belong to the damp and rather nutrient rich types (Serie 5), among them various degraded meadows of the alliance Polygono-Trisetion largely prevail (representing site moisture conditions from damp to mesic). In the map presented in Fig. 2, the series 1–7 were mapped by different symbols, with two other distinct units being separated: grasslands intensively used by agriculture (units 5c, 7b), and stages overgrown by woody species (units 2d, 3c, 4g, 5l, 6d). The proportions of the particular management types,

Table 2. – Proportional (in %) presence of the series of vegetation types S1–S7 in the studied grassland enclaves and summarised occurrence in the whole study area.

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	Σ [ha]	Σ[%]
S1	3.7	0.2	10.8	0.0	5.0	2.0	0.0	0.0	6.2	2.7	4.0	1.6	1.3	0.0	3.6	1.8	0.0	**75**	2.8
S2	3.3	3.2	11.7	0.0	2.3	2.0	0.0	0.0	0.5	0.0	4.4	4.4	3.1	1.8	3.9	1.1	0.8	**72**	2.6
S3	3.0	1.5	16.1	4.3	5.3	2.5	1.4	6.9	2.6	0.0	6.3	0.7	3.0	1.9	2.8	5.3	5.3	**100**	3.7
S4	5.4	5.5	0.0	0.0	7.9	0.0	2.3	0.0	2.3	1.5	5.7	1.8	2.0	6.1	6.4	3.8	0.0	**106**	3.9
S5	63.7	51.7	57.8	95.2	72.0	93.4	50.3	82.5	87.9	94.8	72.4	90.6	75.5	86.5	60.6	83.0	71.4	**1990**	73.2
S6	6.0	2.7	3.6	0.6	6.5	0.0	0.0	0.0	0.5	1.0	7.3	0.9	9.0	3.6	9.1	0.6	7.2	**116**	4.3
S7	14.7	35.3	0.0	0.0	0.9	0.0	46.0	10.5	0.0	0.0	0.0	0.0	6.0	0.2	13.6	4.4	15.3	**259**	9.5
Σ [ha]	**440**	**237**	**56**	**37**	**218**	**130**	**87**	**44**	**214**	**48**	**241**	**154**	**186**	**106**	**145**	**224**	**152**	**2718**	
Σ [%]	16.2	8.7	2.1	1.4	8.0	4.8	3.2	1.6	7.9	1.8	8.9	5.7	6.8	3.9	5.3	8.2	5.6		

Table 3. – Recommended (optimum) management that should be implemented in the particular grassland enclaves E1-E17. The management types: M1 – without management, M2 – once a year cutting, M3 – twice a year cutting, M4 – low impact grazing

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	Σ [ha]	Σ[%]
M1	22.3	12.1	40.0	4.8	23.9	31.5	8.5	6.9	33.5	7.4	36.3	13.2	25.5	17.9	17.7	9.4	8.9	**564**	20.8
M2	2.6	8.9	2.9	32.5	0.5	0.2	0.0	0.0	0.9	15.2	13.2	11.0	9.9	53.8	1.8	0.2	34.3	**236**	8.7
M3	17.1	42.7	12.1	13.7	8.3	48.4	68.1	18.3	5.2	0.0	10.0	31.4	7.6	9.4	25.8	35.2	34.8	**613**	22.6
M4	58.0	36.3	45.1	49.0	67.3	19.9	23.5	74.8	60.4	77.3	40.6	44.3	57.0	18.9	54.6	55.2	22.0	**1305**	48.0
Σ [ha]	**440**	**237**	**56**	**37**	**218**	**130**	**87**	**44**	**214**	**48**	**241**	**154**	**186**	**106**	**145**	**224**	**152**	**2718**	
Σ [%]	16.2	8.7	2.1	1.4	8.0	4.8	3.2	1.6	7.9	1.8	8.9	5.7	6.8	3.9	5.3	8.2	5.6		

proposed for the studied area, are evident from Table 3, considering the particular grassland enclaves. The extent of the management types over the enclaves is evident from the map in Fig. 3. (The complete data for all the particular areas are available at the authors and were also given to the National Park authorities.)

Discussion

The secondary grasslands in Bohemian Forest represent one of the largest grassland area in central European mountains (see ELLENBERG 1988). Beside the practical outputs, our results have some theoretical implications. For example, they did not confirmed the traditional opinion that many if not all abandoned secondary grasslands successionally develop to close woodland communities if neglected (see, for example, BURROWS 1990). As we experimentally showed in our other study (PRACH & al. 1996), successful establishment of woody species is largely protected by intensive competition from grasses. That is just the case of the majority of the studied grasslands except the sites where competition from grasses is reduced, i.e. by a mechanical disturbance or low nutrient content (VAN DER WALK 1992, PRACH & PYŠEK 1994, etc.). Generally, our results are in accordance with the expectation that if secondary grasslands should be maintained for a long time, the traditional management must be ensured (BERENDSE & al. 1992, HERBEN & al. 1993, etc.). The space-temporal pattern of grasslands in the studied area described here is in accordance with previous studies on Bohemian Forest grasslands conducted earlier by KLEČKA (1932), MORAVEC (1965), RYBNÍČEK & RYBNÍČKOVÁ (1974), BLAŽKOVÁ (1995), VACKOVÁ (1997), although the studies were performed in other parts of the region and usually covered specific problems. Conclusions similar as here were done by KUČERA & al. 1995, GUTH & al. 1995, KUČERA & GUTH 1998) in the Český les Hills far to the north-west from Bohemian Forest.

We are aware of some limitations of our results, especially we faced the problem how to combine a detailed, site specific knowledge with a broader scale view. It is evident that some information was generalised and even lost in effort to make the outputs understandable and accessible for a practical use. (All the specific information is, however, included in our detailed manuals and can be available on request.) The simplification was accepted already in the delimitation of vegetation units. For the purpose of the study the units defined by dominant species mostly appeared to be more convenient than using traditional Curych-Montpellier syntaxa, as various successional, rapidly changing and degraded stages of a problematic syntaxonomical position were subjected to the study. Because site moisture conditions and soil nutrient contents were not exactly measured, we only used broad and relative, empirical categories of these factors. Moreover, they are valid for the mountains, as for example really

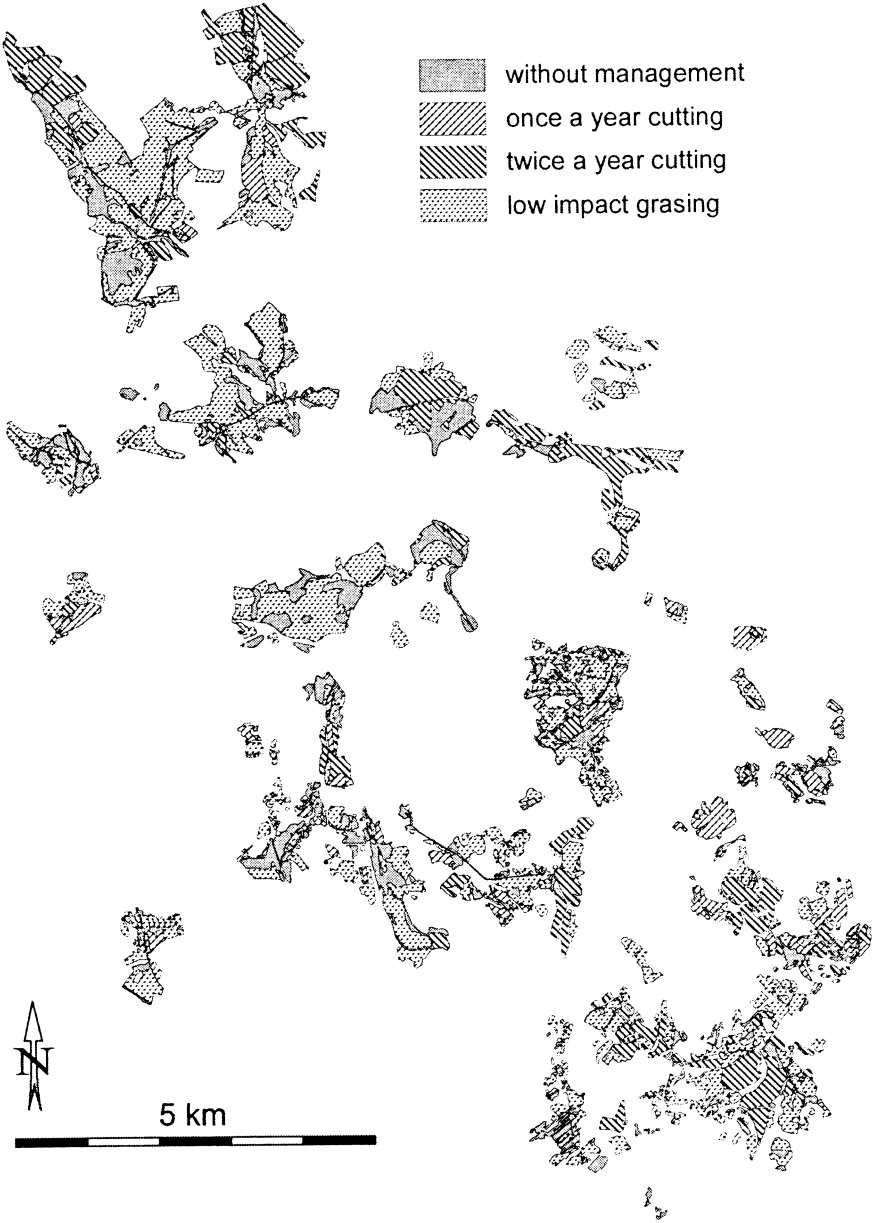

Fig. 3. – Types of recommended (optimum) management in the studied grassland patches.

dry sites do not occur in the region with rather high annual precipitation (often over 1000 mm) and rather low annual temperature (often below 5°C).

The outputs of the project are based on the theoretical assumption that the suggested management will be possible to ensure. However, we are aware that the reality is something different and the whole extensive areas of the secondary grasslands cannot be properly managed under the present economic and social conditions. Thus, we only supply information what would be the best to do. The suggested management is in accordance with principles recommended by the Agency for Nature Conservation and Landscape Protection of the Czech Republic (PETŘÍČEK 1999).

Among peculiarities of the studied area is the occurrence of disturbed soils with various initial stages of succession (types 2a, 4a, 6a). Such habitats mostly resulted from the former military activities like shutting or transport of heavy military vehicles. They comprise a wide spectrum of abiotic site conditions and significantly enrich species diversity in the area. Numerous less competitive and often endangered plant species have found the temporary refugia in these newly appeared habitats and their local populations increased. They include both species related originally to managed, low productive meadows or wetlands (*Parnassia palustris, Pedicularis sylvatica, Pinguicula vulgaris*, *Botrychium lunaria,* etc.) and species exclusively accompanying bare soils and being rare in the area at any time (*Lycopodiella inundata, Diphasiastrum alpinum*). Because of a rather fast successional change, compact swards of grasses often develop there and the above mentioned species retreat again. Thus, we suggest a local mechanical disturbance of these sites, repeated in approximately 10 years period especially in the localities of the endangered species. The same can be applied in sites where close stands of woody species are gradually formed and rare species are retreated.

The specific „military management" locally enhanced development of secondary woodlands. Small patches of bare soils provided suitable microsites for the establishment of woody species, being effective especially in productive sites where competition from the herb layer inhibited the establishment. Consequently, different successive stages of trees and shrubs in diverse mosaic with treeless vegetation is the characteristic features of the military training zones (see also KUČERA & GUTH 1998, PETŘÍČEK & PLESNÍK 1997).

The importance of secondary grasslands for maintaining of both biodiversity and overall landscape pattern in the area has been already discussed (KOPECKÝ 1990, PRACH, ŠTECH & BENEŠ 1997). As we documented in our earlier work (PRACH, ŠTECH & BENEŠ 1997), nearly two thirds of all species of higher plants, known from the whole upper part of the Bohemian Forest, occur in the secondary grasslands. This species richness is, however, gradually decreasing if the grasslands are both left without management and overexploited. It is evident, that the effort which should be invested to the management of the grasslands is of an eminent importance and we believe that the results presented here contribute to stopping the degradation and even more, help to restore the natural value and beauty of the montaneous grasslands.

Successful implementation of described management is possible only under collaboration with farmers, and for that a certain restoration of local farming is necessary. It is among management priorities of the Šumava National Park Administration as described in the Management Plan for the Šumava NP (ZATLOUKAL & al. 2000). The restoration of local farming must correspond to conservation purposes in the area and it does not mean restoration of agriculture in the extent before World War II. The present situation concerning the agricultural activities in the studied area can be summarised by the following way: (i) a lack of small local farm units, (ii) inappropriate facilities, especially the lack of light machinery, (iii) in some parts still too intensive farming, (especially large farms conduct rather uniform, intensive and less diverse management), and (iv) the existence of large, for a long time neglected

areas, in some parts being so deeply altered that they are not suitable for immediate effective agricultural use. Some suggested management practices are apparently too expensive and additional financial supports provided by the Ministry of Environment, and the Ministry of Agriculture are necessary. Some measurements can be implemented under collaboration with local NGOs (Non-Government Organisations) or universities (student practices). Moreover, plenty of additional local problems related to existing inappropriate management have to be resolved such as a prevention of too intensive pasture, local wetland disturbance by herds, accumulation of unremoved cut biomass, conflict of agriculture with specific wildlife management, etc. However, there is no other way than to resolve the problems if we want to preserve both biodiversity and the landscape pattern.

Conclusions

Secondary grasslands, the distinct phenomenon of the Šumava National Park, can be preserved only if an appropriate management is implemented. Often deep and rapid degradation of the grasslands is a result of both abandonment (prevailing in the studied area) and too intensive management. The optimum management is suggested here being related specifically to 31 vegetation units distinguished. However, we are aware of the fact that it can be hardly realised over the whole extensive area of the grasslands. Thus, at least localities of the highest priority, i.e. those with the occurrence of rare and endangered species, and/or forming the typical landscape character, must be preferably managed following the suggestions given here. The results presented here demonstrate that the combination of the detailed field work and GIS methods is a powerful tool with various theoretical and practical outputs. We believe that the practical outputs contribute to the preservation and restoration of the valuable grasslands.

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