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Functioning of mountain meadows under different management impact – research project

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Abstract
Small interest in agriculture under less favourable natural conditions is one of the phenomena related to political changes in Central Europe at the end of the 20th century. As a result, extensive areas of meadows and pastures have been abandoned and lay fallow. The existence and quality of secondary grassland depend, however, fully on human management. New alternative practices of non-profit grassland management are necessary to preserve the natural values and characteristic appearance of secondary grassland in a seminatural mountain landscape. Mulching has been expected to become one of the prospective practices applicable to the management of mountain grassland. However, it can also bring about some unwanted changes to the grassland ecosystem. So far, only little qualified information has been available on the effects of mulching on mountain grassland. A long-term field experiment has been therefore set up in the Šumava National Park, with the aim to compare the impact of mulching on the grassland ecosystem and its components with the impacts of traditional grassland management by mowing and cattle or sheep grazing. Leaving the grassland fallow is a treatment with which the other treatments of the mountain grassland have been compared. This paper presents some of the problems related to the management of mountain grassland and describes the establishment of the long-term field experiment. It informs briefly about the main results of the experiment and other related investigations.

Key words: Bohemian Forest, secondary grassland, mountain grassland ecosystem, mowing, mulching, fallow

Introduction

The largest part of the Bohemian Forest was covered with primary forests before people settled in this mountain range. The landscape acquired its aspect during the gradual colonisation of the territory between the late Middle Ages and the 18th century. The present mosaic pattern of forests, meadows, pastures, and small groves has resulted from a combination of various human activities. Important for a sustainable existence of the mountain grassland has especially been the low-intensity agriculture practised by small mountain farmers. A sensitive equilibrium has established itself between humans and nature also in the Bohemian Forest thanks to this long-lasting landscape management. It has produced species-rich mountain meadows and pastures which belong to the most valuable ecosystems of the Bohemian Forest. These newly formed and harmonious communities encompass not only such plant spe-

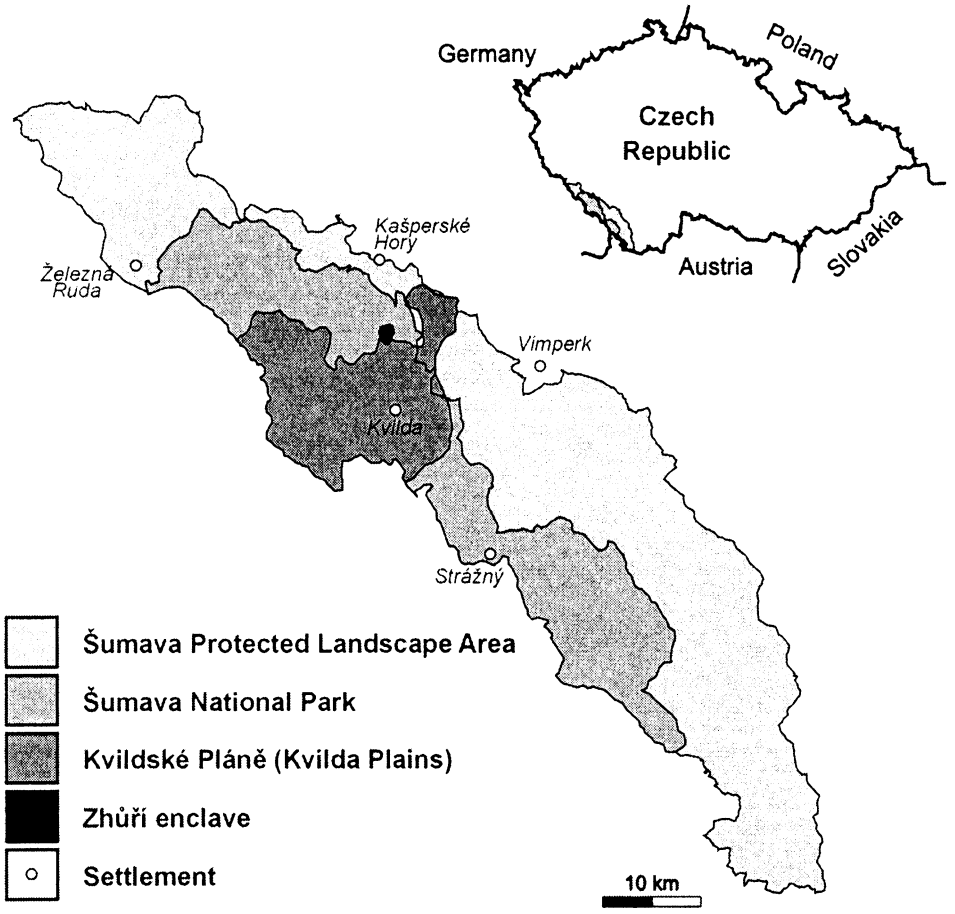

Fig. 1. – Location of the study area within the Czech Republic and within boundaries of the Šumava National Park and Protected Landscape Area (Biosphere Reserve). The map also shows the extent of the Kvildské pláně (Kvilda Plains) mountain plateau and the position of the Zhůří enclave with experimental grassland sites and plots on the Huťská hora Mt.

cies that are characteristic of original forest stands, spring-heads, wetlands and river valleys, but also species introduced by humans. The stability and species composition of these communities and their biotopes thus fully depend on their management. Breaking off from the traditional mountain farming practices threatens the mountain meadows and can cause an uncontrolled propagation of alien and/or ruderal plant species. Scattered shrubs and trees gradually develop into forest, which was cleared in the past in order to give way to grassland. This development threatens the existence of those plant and animal species, populations, and communities, which can survive only in open biotopes.

The risk of disturbing the established balance between humans and nature increased in the Bohemian Forest (the Šumava Mts.) mainly after World War II, when most of the ethnic German population was transferred to Germany and the borderland territory became almost de-

populated. Many villages, hamlets or crofts were abandoned. Houses became ruined and dilapidated, and large areas both of grassland and arable land were left fallow.

In 1950–1960 a new wave of large-scale farming, heavily subsidised by the state, was established there. Many small groves, borderlines of grassland with shrubs separating individual plots, and heaps of stones were removed from cultivated plots and disappeared from the countryside during the esta lishment of collective farming in the Bohemian Forest. Most of the plant communities of the still managed or restored meadows were thus degraded by excessive doses of manure and fertilisers, and by superfluous drainage of the mountain grassland. Moreover, the time pattern of mowing and grazing of grassland plots has often become completely irregular.

The beginning of the 1990's has brought fundamental changes to the agricultural policy in Czech mountain regions, including the Bohemian Forest. The heavy state subsidies were reduced and agriculture now promises very little profit, if any, to the mountain farmers. Cooperative and state-owned farms collapsed economically, and recently only a few people are interested in farming without regular subsidies in this region of relatively high altitudes (often over 1000 m), rough climate and poor soils. But the importance of these meadows and pastures is not economic. They should function as landscape-forming elements. The long-term strategy of management of mountain secondary grassland should aim at soil conservation, biodiversity maintenance and protection of water resources. New alternative management practices of a non-profit management of mountain meadows and pastures are needed. They should be acceptable both economically and ecologically.

One of the prospective ways of managing the mountain grassland may be mulching i.e. leaving finely cut mown green plant parts on the site to decompose and release a large proportion of their mineral nutrient contents. This measure, however, can also bring about some unwanted changes to the grassland ecosystem, e.g. its unfavourable changes in the species composition (both quantitative and qualitative), nutritional quality and functioning of the grassland vegetation as well as for its mineral nutrient and water budgets. In this way, mulching could also influence the quality and discharge of groundwater. So far, only little qualified information is available on the effects of mulching on mountain grassland. A research project has therefore been launched to deal with all the above aspects to the problem of mountain grassland management.

In 1997, a long-term field experiment was therefore set up within this project in the Bohemian Forest. Its aim was to assess the functioning of the mountain grassland ecosystems under different management impacts. Special attention was paid to the following aspects:

i) Effects of mulching on the mountain grassland ecosystems.

ii) Comparison between the impacts on the mountain grassland ecosystems of mulching and traditional management practices, namely mowing, with the impacts of no grassland management at all.

iii) Proposals for an optimum grassland management in the Bohemian Forest.

iv) Use of the project results for elaborating general scenarios of the development of mountain meadows within the changing agricultural policy.

The project makes use of the results of other studies on ecological aspects of the management of seminatural meadows (e.g. FIALA 1997, GÁBORČÍK 1989, GRIME 1979, MORAVEC 1965, REGAL 1967), especially those carried out in the Bohemian Forest (e.g. KLEČKA 1930), and in the Giant Mts. (e.g. HERBEN & al. 1993a, HERBEN & al. 1993b, KRAHULEC 1990a,b, ŠTURSOVÁ 1974) and in the Bohemian-Moravian Highlands (RYCHNOVSKÁ & al. 1972, 1985, 1987, 1990, 1993).

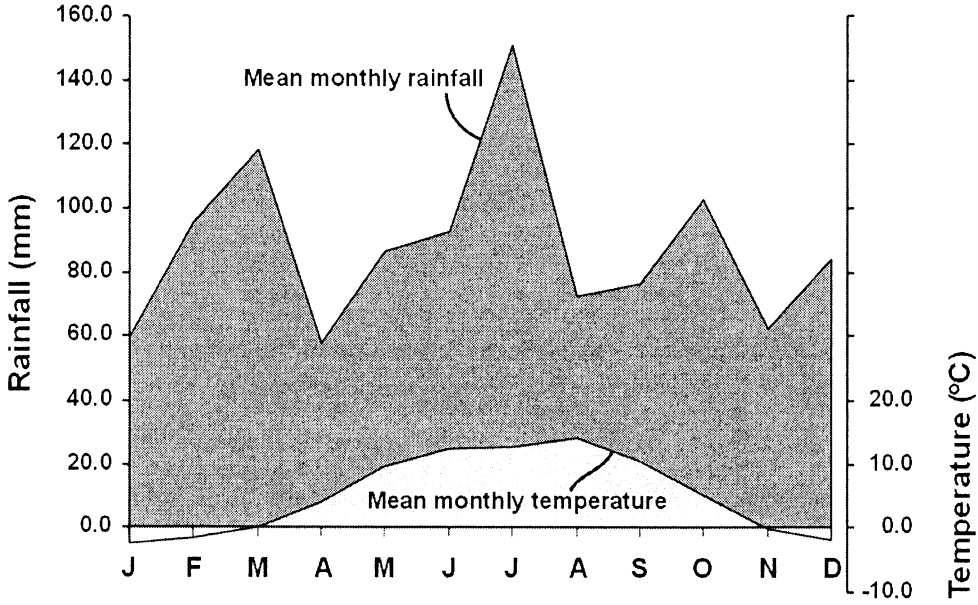

Fig. 2. – Climatic diagram based on measurements recorded at the Churáňov meteorological station situated at a similar altitude (1120 m a.s.l.) as the Zhůří enclave, about 9 km from Huťská hora Mt. The diagram includes data recorded between 1997 and 2000, i.e. during the period of implementation of the research project.

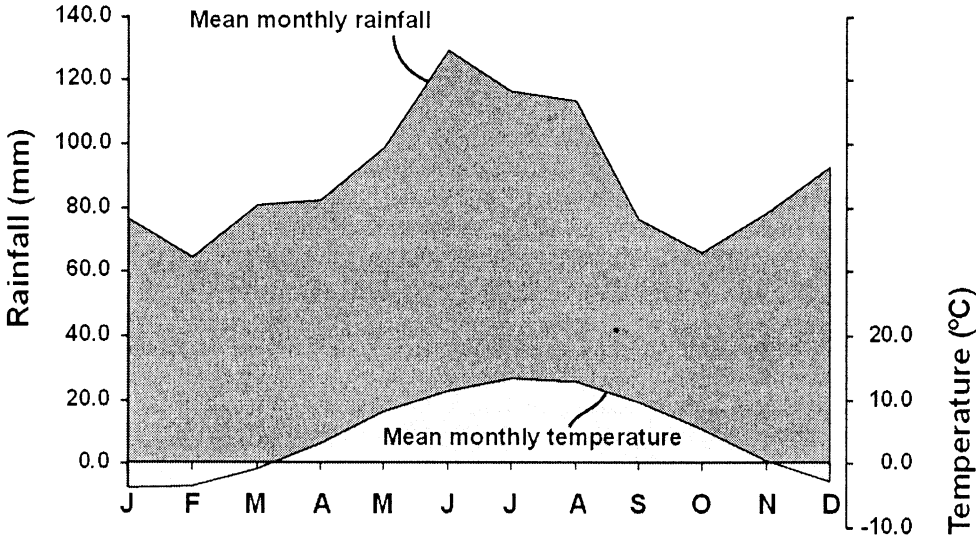

Fig. 3. – Climatic diagram based on measurements recorded at the Churáňov meteorological station situated at a similar altitude (1120 m a.s.l.) as the Zhůří enclave, about 9 km from Huťská hora Mt. The diagram presents averages of data recorded between 1956 and 1998.

Study area

The experimental site lies in an enclosed grassland area below the top of Huťská hora Mt. (1187 m above sea level). The whole study area is part of the Kvilda Plains (Kvildské pláně) mountain plateau in the central Bohemian Forest (Fig.1). Originally a hamlet was established here in 1760–1770, after 1950 the area became a military base which was abandoned by the army in 1990 (Mašková & al. 2001). Administratively, the Zhůří grassland enclosure belongs to zones II and III of the Šumava National Park and, simultaneously, to the buffer zone of the Šumava Biosphere Reserve.

The altitude of the site ranges between 1090 and 1180 m. The basic climatic characteristics of the site are presented in the Tables 1 and 2, and in the Figs. 2, 3 and 4.

The experimental site is 300×400 m in size, on a SW-facing slope, inclination 0° to 10°. Climatic conditions and underlying paragneiss parent rock gave rise to acid brown soils (Acid Distric Cambisol). The soils can be characterised as clay-sandy on medium-grained siltstones, of medium depth and inexpressive structure, with a low biological activity and relatively deep and dense root penetration (Kvítek & al. 2001). The vegetation on the experimental site is subjected to a low-impact management. Phytocenologically, it can be characterised as an acidophilous meadow – association *Cardaminopsio halleri-Agrostietum,* alliance *Polygono-Trisetion* (Moravec 1965), with *Deschampsia cespitosa*, *Festuca rubra* and *Hypericum maculatum* as dominant vascular plant species.

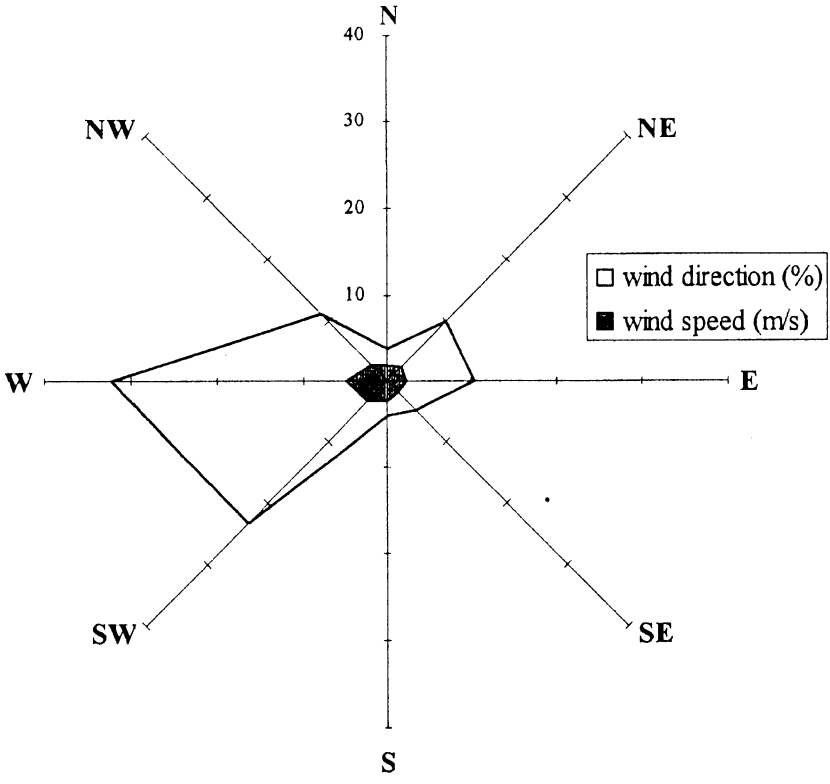

Fig. 4. – Distribution of wind directions and wind speeds in the study period of 1997–2000.

Table 1. – Basic climatic characteristics of the Kvilda Plains area (station Churáňov, altitude 1120 m a.s.l.) for the 1997–2000 study period.

Feature/Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Monthly mean temperature (°C)	–2.5	–1.7	0.1	4.1	9.7	12.4	12.7	14.0	10.4	5.1	–0.2	–1.9
Monthly mean maximum temperature (°C)	12.0	12.3	13.7	17.6	23.2	26.9	25.7	27.1	22.6	19.2	14.2	9.4
Absolute monthly maximum temperature (°C)	16.9 1998	17.5 1998	15.5 1998	22.1 2000	24.1 1999	28.7 1998	30.5 1998	30.0 1998	24.0 1998	21.6 2000	17.4 1999	13.6 2000
Monthly mean minimum temperature (°C)	–16.9	–14.9	–9.7	–6.5	–0.7	0.2	4.1	4.1	2.5	–4.4	–10.9	–13.7
Absolute monthly minimum temperature (°C)	–18.9 1997	–16.7 1999	–12.9 1998	–9.1 1997	–2.0 1997	–1.4 1997	2.3 2000	2.0 1998	0.6 1997	–9.8 1997	–15.3 1998	–14.6 1998
Monthly mean sum of precipitations (mm)	59.8	95.4	118.4	57.8	86.4	92.7	151.3	72.7	76.3	102.8	62.2	84.4
Absolute maximum of monthly mean sum of precipitations (mm)	85.9 1999	151.1 1999	184.7 2000	106.0 1997	110.3 2000	144.3 1998	231.1 1997	107.4 1999	144.8 1998	87.4 1997	107.5 1998	124.7 1999
Absolute minimum of monthly mean sum of precipitations (mm)	12.1 1997	23.9 1998	45.8 1999	31.4 2000	60.8 1998	60.7 1997	91.3 1998	45.8 1997	28.9 1997	26.2 1999	35.0 2000	53.4 1998
Absolute daily maximum of precipitations (mm)	22.8 29.1.2000	26.5 25.2.1997	21.0 24.3.2000	14.0 24.4.2000	49.9 18.5.1997	42.1 12.6.1998	64.5 9.7.1999	66.3 28.8.1998	30.0 14.9.1999	70.8 28.10.1998	18.4 1.11.1998	24.1 10.12.2000
Monthly mean snow cover (cm)	26.3	39.0	24.0	3.3						0.5	8.5	16.8
Monthly mean of days with snow cover (cm)	29	25	27	10						4	19	27
Absolute maximum high of snow cover (cm)	66 30.1.2000	106 25.2.1999	78 1.3.1999	20 1.4.2000						20 31.10.1998	39 22.11.1998	54 29.12.1999
Monthly mean cloud cover (%)	66	71	74	68	62	63	71	54	57	70	75	73
Monthly mean of Sun shine (h)	87	81	106	147	201	194	160	221	169	105	72	58
Monthly mean of relative air humidity (%)	82	84	87	80	76	77	83	76	84	86	88	88

Table 2. – Comparison between selected climatic characteristics of Kvilda Plains area (station Churáňov, 1120 m a.s.l.) for the study period 1997–2000 and characteristics for the 1956–1998 period.

Feature/period	1997–2000	1956–1998
Yearly mean temperature (°C)	5.2	4.3
Absolute maximum temperature (°C) (month/year)	30.5 *(7/1998)*	34.2 *(1983)*
Absolute minimum temperature (°C) (month/year)	–18.9 *(1/1997)*	–32.6 *(1956)*
Yearly mean number of arctic days	1	3.2
Yearly mean number of ice days	54	64
Yearly mean number of frost days	145	162
Yearly mean number of summer days	6	5.8
Yearly mean sum of precipitations (mm)	1060.1	1074.7
Absolute maximum high of snow cover (month/year)	106 *(2/1999)*	197 *(1988)*

Methods

Three permanent experimental plots, of 50×100 m each, subjected to different management, were established on the experimental site in 1997 (Fig. 5.).

i) Mowing and drying the vegetation to produce hay and subsequent removal of the hay from the plot is the treatment applied to the first plot.

ii) Mulching once in a year is applied to the second plot. This treatment involves cutting and crushing the vegetation and leaving it to decompose on the spot.

The former management type follows a régime corresponding to standard low-impact agricultural practice typical of highland regions in Central Europe: mowing once in a year (in July), employing low impact mechanisation. The latter management type is new to the highland regions: it consists of mulching the grassland vegetation once in a year (also in July).

iii) The third plot has been left fallow, i.e., to a spontaneous vegetation development since the beginning of the experiment, with no management applied to it.

The whole project (no. 206/99/1410, supported by the Grant Agency of the Czech Republic) consists of several relatively independent sets of experiments or quantitative observations carried out between 1997 and 2001; their methods are described in more detail in other papers of this issue of Silva Gabreta. Here, we will just briefly list the main ecosystem components and processes considered and investigated within the project during the above mentioned study period:

1997–2001: – structure and species composition of plant communities;
– production, quality and decomposition of plant biomass;
– growth and phenological development of the plants;
– physical properties of the top soil horizon;
1998–2001: – precipitation totals and atmospheric deposition;
1998–2000: – radiation and heat balance, selected bioclimatological characteristics;
1999–2001: – selected microbiological and chemical features of the soils with respect to the budgets of carbon and nitrogen;
– behaviour of some highly endangered plant populations;
– phytopathogens of grass species;
2000–2001: – the behaviour of selected groups of soil macrofauna.

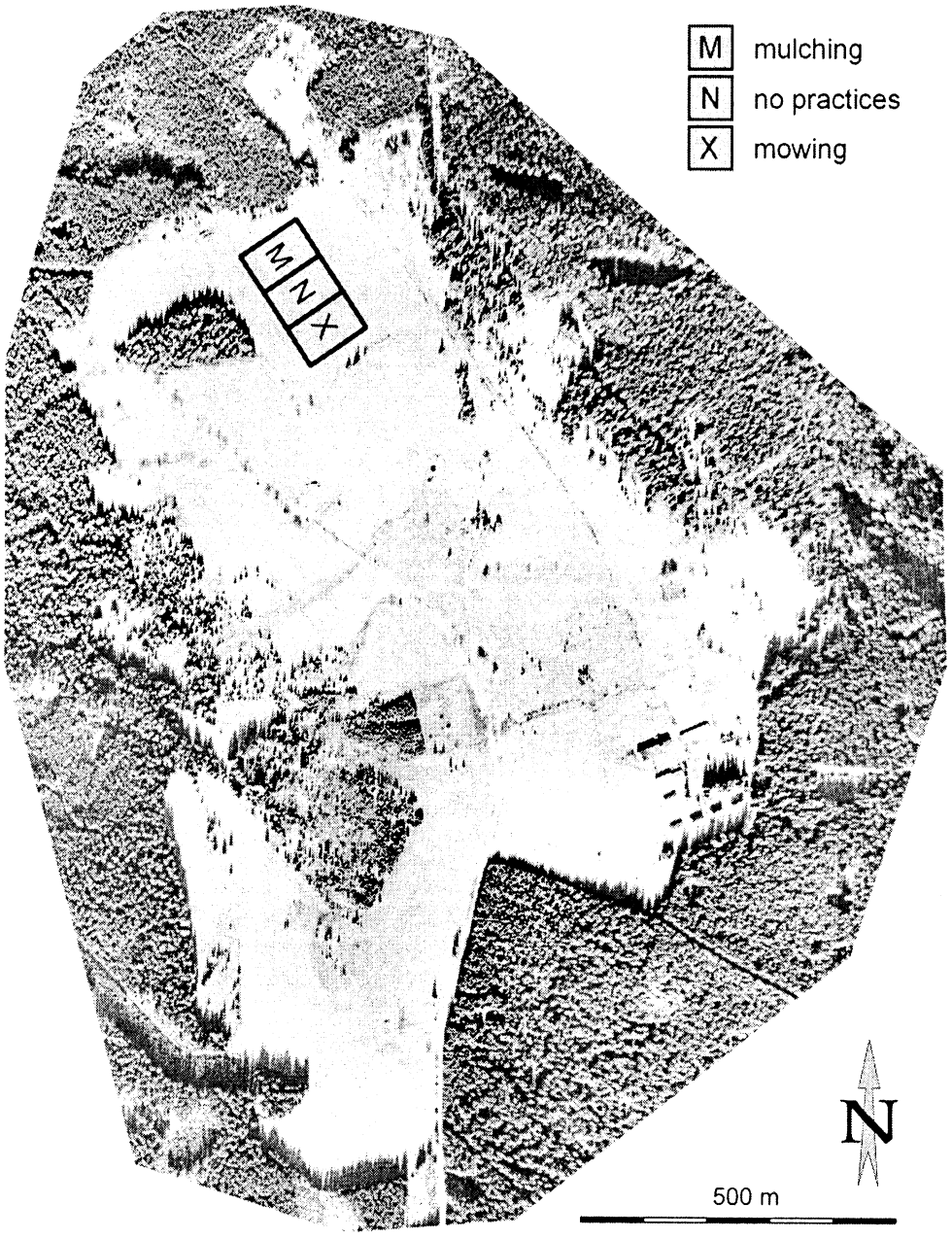

Fig. 5. – Aerial view of the Zhůří enclave and surroundings showing the position of the experimental site and plots on Huťská hora Mt.

Results

Results obtained in the project up to date can be summarised as follows:

The results of research carried out within this project, together with some earlier results, are still to be regarded as preliminary. The duration of our experiments on the effects of repeatedly applied different grassland management measures (mowing or mulching at the peak of the growing season, in some instances also moderate grazing, all in comparison with the control, i.e., leaving the meadows fallow) has been too short to provide unambiguous evidence proving the importance of the management measures, or experimental treatments simulating them, on the functioning of such conservative ecosystems as mountain meadows which are exposed to wide both short-term and long-term fluctuations of climatic factors. So far, the habitat has been more decisive than the management for both the species composition and diversity of the studied plant and animal communities, soil physical and chemical characteristics and biotic processes, net primary production and litter decomposition. The management measures applied do, however, control the heat budget and microclimate in differently managed meadow vegetation and the incidence of its fungal infestation. The results of experiments carried out in the Bohemian Forest at altitudes of about 1000 m and 1180 m, respectively, indicate the following sequence of feasibility (considered from the present human viewpoint of sustainable land use) of different ways of managing mountain meadows:

i) mowing once a year combined with moderate grazing;
ii) the same, but with no grazing;
iii) moderate grazing and mowing of leftovers;
iv) mulching at a few years' intervals;
v) mulching every summer;
vi) intensive grazing;
vii) leaving the meadows fallow.

Mulching, as a relatively new and unproven technique applied to large grassland areas, seems to be connected with a number of hazards. Neither can the effects of the other management measures tested be evaluated unambiguously, and further continuation of the experimentation is thus desirable.

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