

Zeitschrift: Bulletin of the Geobotanical Institute ETH
Herausgeber: Geobotanisches Institut, ETH Zürich, Stiftung Rübel
Band: 63 (1997)

Rubrik: Summaries of diploma and PhD theses (1996)

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Summaries of diploma and PhD theses (1996)

Diploma theses (9)

Bulbous geophytes in vineyards of north-eastern Switzerland

Frühjahrs-Zwiebelgeophyten in Rebbergen der Nordostschweiz; 57 pp.

DANIEL ARN

A permanent vegetation cover in vineyards has positive effects (reduction of erosion and ground water contamination, promotion of beneficial arthropods) and negative effects besides: plant species adapted to frequent hoeing or shallow ploughing, in particular bulbous geophytes, are suppressed (part of the *Geranio rotundifolii*-*Allietum vinealis* community). In six green-covered vineyards in two sites of the "Zürcher Weinland", I investigated the effects of different undergrowth management on the cover of forbs, grasses, moss, dead organic material, bare soil and on bulbous geophytes. Interviews with farmers provided information about the current cultivation in the vineyards.

1 The following bulbous geophytes occurred in the six vineyards investigated, listed according to abundance: *Ornithogalum umbellatum* L., *Muscari racemosum* (L.) Miller, *Allium vineale* L. and *Gagea arvensis* (Pers.) Dum.

2 Apart from the geophytes, the undergrowth comprised of rather common species. The richness of plant species was relatively small, consisting of 65 species.

3 The abundances of the geophytes and of the perennial grasses were negatively correlated. This might be due to above-ground competition during winter. Additionally, the dense root system of the grasses seems to inhibit the formation of daughter bulbs.

4 Soil movement due to cultivation of vineyards (indicated by >50% bare soil) apparently promoted the abundance of *A. vineale*, *G. arvensis* and *M. racemosum*, probably by increased dispersal of the bulbs. However, under the same treatment the abundance of *O. umbellatum* decreased, probably because of mechanical damage of its relatively large bulbs.

5 *Muscari racemosum* and *A. vineale* were more frequent in the rows of the grape-vines than in the alleys. They seem to tolerate the leaf-applied herbicides regularly used underneath the vines. On the other hand, *G. arvensis* and *O. umbellatum* occurred more frequently in the hoed or mowed alleys than underneath the vines.

6 In plots with a high cutting frequency (more than three cuts per year), *M. racemosum* and *O. umbellatum* were less abundant than in plots with a more extensive mowing regime.

In conclusion I propose specific management practices to preserve and to support the geophytes still present in vineyards. In general, management should not take place during the growing season of the geophytes, i.e. from September to early June. Regular, coarse tillage once every few years helps to spread daughter bulbs and to reduce competition of a dense grass cover. After the tillage, the development of a dominant grass cover can be prevented by an extensive cutting regime.

Seed dispersal above the timberline

Diasporenausbreitung in hochalpinen Lagen; 80 pp.

SYLVIA ERDT

The study deals with the seed rain in intact and in destroyed alpine grasslands in the Swiss Alps. The study sites were located in a natural grassland area and in an adjacent machine-graded downhill ski run at c. 2500 m a.s.l. near Davos, Grisons. Seed rain was recorded with dry funnel traps. In the grassland the intensity of seed rain was six to seven times higher than in the ski run, whereas no significant difference in the number of diaspores occurred between subplots of the same site type. The species composition in

the seed rain was significantly different between the two grassland types, again the subplots within either type did not differ significantly. Seed rain was primarily affected by local site conditions and varied also with time: the fluctuations both in the number of seeds as well as in the species composition were consistent throughout the growth season. The results of the study contribute to the knowledge of the dispersal ecology in alpine grassland sites and support the implementation of restoration measures above the timberline.

Ecosystem development in experimental microcosms

Einfluss von Arten auf ökosystemare Prozesse in Mikrokosmen; 59 pp.

FLORIAN FREIMOSER

In order to study the influence of species on ecosystem processes and function, a permanent pot experiment was established at the Geobotanical Institute ETH in autumn 1995. The experimental pots had a volume of about 70 l and were filled with a mixture of sand and clay. Four ecologically distinct grass species (*Bromus erectus*, *Bromus sterilis*, *Dactylis glomerata*, *Festuca ovina*) were planted in monoculture as well as in a mixture consisting of all four species. Additionally, three different fertilizer treatments were applied. The pots were located in the experimental garden of the Institute, they will remain there for 5–10 years. The pots are biologically closed but otherwise open microcosms. In contrast to the majority of experiments this array is set to study the effects of biodiversity or species on ecosystems, most of which are implemented

either under completely artificial conditions for very limited duration, or under natural conditions with an unknown initial state. I investigated the development of the microcosms during the first year, and worked on the methods to determine the above- and below-ground biomass.

Bromus sterilis grew very fast and produced most biomass in early summer 1996. In August 1996 the shoots and leaves died, and a few weeks later the next generation germinated. *Dactylis glomerata* grew poorly under nutrient-poor conditions, during winter many plants died. The other species performed well but did not undergo seasonal changes in biomass as *B. sterilis*.

To estimate the root biomass in the pots, samples were taken at different depths with soil corers. This method proved to be accu-

rate. The aboveground biomass was measured by several methods, such as light absorption, capacitance measurement, weighted disc method, and partial harvest. The light absorption measurement proved unreliable, since absorption was not detectable at low nutrient levels. The capacitance method was also unsatisfactory because its accuracy was insufficient. The disc measurement was found to be a fast and repeatable method, revealing

significant differences between species, fertilizer and the interaction of both factors. The partial harvest of one tenth per pot was a time-consuming procedure with highly variable results. For the investigation of this study the weighted disc technique was considered the best method. Additionally, regressions were calculated to predict the aboveground biomass by the non-destructive methods calibrated against the partial harvest.

Effects of nature protection of limestone grasslands on grasshoppers (Orthoptera) and groundbeetles (Coleoptera, Carabidae)

Auswirkungen der Unterschutzstellung von Halbtrockenrasen auf Heuschrecken (Orthoptera) und Laufkäfer (Coleoptera, Carabidae); 58 pp.

THOMAS GLOOR

Assessments and protection measurements within nature reserves are mostly based on vegetation data (surveys, mappings), whereas aspects of animal ecology are often neglected. This study investigates how vegetation-based conservation practice affects characteristic animals of limestone grasslands, such as grasshoppers and groundbeetles.

For this reason in the Schaffhauser Randen region (600–800 m a.s.l.) three limestone grassland sites, which are situated in nature reserves, were compared with three control sites similar in site conditions but situated in non-protected areas. The control sites were moderately nutrient-rich meadows of the alliance Arrhenatherion.

In each of the six study sites (20 m x 60 m) one vegetation relevé was taken. In addition, between May and September 1996 the grasshopper fauna was recorded with a "biocoenosis meter" (seven catch series of 15 throws each), and the groundbeetles were caught with Barber traps (105 catch days). The fol-

lowing criteria were used for assessment: number of species, diversity, number of Red-list species.

The three protected areas comprised 46–54 plant species; a total of 262 adult grasshoppers of 7–15 species, and 1041 groundbeetles of 13–30 species were caught. In the three control sites 27–38 plant species were found; 224 grasshoppers of 4–8 species and 1390 groundbeetles of 21–28 species were caught.

With respect to botanical conservation the protection regulations were successful for the limestone grasslands investigated. However, regarding the protection of grasshoppers a thorough evaluation of the current management practice seems to be necessary; special attention has to be paid to the contractually agreed dates of mowing, and to the size of the area which is mown. This study suggests several improvements for the protection of grasshoppers and groundbeetles: rotation management, habitat networks, and improving the habitat quality beyond the protected areas.

Ecological evaluation on low-intensity grazing in the Zurich upland

“Extensive Beweidung” im Zürcher Oberland aus ökologischer Sicht; 36 pp.

MIRJAM GRAF

This thesis investigates if cattle grazing on hay meadows has negative effects on plant biodiversity. Permanent plots were installed in four study areas. On the plots relevés were taken, and a demographic study on *Knautia arvensis* and *Plantago media* was launched including the reaction of both species to cutting and grazing. Since *K. arvensis* is a typical species of hay meadows and *P. media* for pastures, a better performance of *K. arvensis* on the meadows and of *P. media* on the pastures was hypothesized, based on the common differences between plants of the two grassland types (cf. Harper 1977).

The average number of individuals of *P. media* and of *K. arvensis* did not differ significantly between pasture and meadow, but it varied between the study areas. Some plant traits showed significant differences between pasture and meadow, even before the management was set up. This indicates that the

two types of management had already affected the morphology of the two species investigated. However, the species-specific differences in the parameters measured were not consistent over time. No difference in the damage of plants was observed between cut and grazed plots which suggests that the two types of management did not affect the two species differently. However, the height and the number of leaves differed significantly in *K. arvensis* between pasture and hay meadow after the management. The individuals on the hay meadow performed poorer in all traits probably due to the late mowing date which leads to less successful regeneration.

Harper's (1977) postulate about differences between plants of meadows and of pastures could not be confirmed in this study. Possible reasons are the extensive grazing on the rather nutrient-poor meadows.

Effects of grazing by Scottish Highland Cattle on a subalpine pasture

Einfluss von Schottischen Hochlandrindern auf eine subalpine Weide; 48 pp.

DOMINIK KÄUFERLE

This study deals with the impact of the spatial behaviour of Scottish Highland Cattle, and with the effects of nutrient transfer by the animals on a subalpine pasture in the Malcantone (Tessin, Switzerland). The investigations are based on standard field methods in plant, soil and animal ecology, and on data query and spatial analysis conducted in GIS.

1 Large parts of the 116 ha study area were covered by vegetation types dominated by *Nardus stricta*. Soil and vegetation analyses

differentiated an area of 2.4 ha covered by a *Festuca* vegetation type which contrasted strongly with the *Nardus*-dominated sites.

2 Two types of Nardetum (*Calluna-Vaccinium*-Nardetum, 14 species; Nardetum, 9 species) occurred within the study site, which varied little in soil conditions but strongly in slope and average solar. The cattle avoided both vegetation types. This suggests that the site factors were more important for the development of these vegetation types

than grazing. The slope was a major factor controlling the distribution of vegetation types as well as the spatial behaviour of the cattle.

3 The cattle used the pasture unevenly and preferred *Molinia*-Nardetum and Festucetum vegetation types for grazing ($P_{i, \text{Molinia-Nardetum}} = 0.56$; $P_{i, \text{Festucetum}} = 0.50$).

4 Frequently used areas were less steep and were located close to water holes.

5 Visual interpretation of a model on phosphorus transfer revealed that cattle dropped

little manure in heavily grazed areas such as the Festucetum and *Molinia*-Nardetum vegetation types. Using the model calculations the total area of phosphorus net gain was 14% of the study area.

6 Cattle grazed on an average area of 13 m² to transfer the phosphorus contained in the feed into one single cow-pat. Model calculations showed that if a constant transfer occurred to a nutrient-poor site (*Nardus* vegetation type), it would take approximately 225 years to increase the phosphorus content by 100%.

The use of plant species as indicators for nitrogen availability in an alpine valley (Dischma): a spatial analysis

Pflanzen als Indikatoren für Stickstoffverfügbarkeit in einem alpinen Tal (Dischma) – eine räumliche Analyse; 101 pp.

BARBARA SCHNEIDER

1 The nitrogen conditions of subalpine grasslands along the river Dischma near Davos were investigated at a landscape scale by means of a simple, newly-developed method based on the use of indicator species. The prevailing nitrogen conditions were explained in terms of local factors and site factors of the river catchment. This study analysed data in a 50-m grid with a Geographical Information System (ARC/INFO) based on the MAB-Davos project.

2 The grasslands were divided into 50-m raster squares. Where this was not possible they were bounded by natural relief forms. Ten plant species, which are nitrogen indicators, i.e. N-indicator value of 4 or 5 according to Landolt (1977), and ten indicators of low nitrogen content (value 2) were mapped on 114 sample areas. The mean nitrogen indicator value and the C/N-ratio of the upper soil layer were calculated for every area. The ordination of the vegetation lists revealed an upstream gradient, which indicates lower nitro-

gen supply with increasing altitude and decreasing intensity of agricultural land use.

3 The comparison of the species lists with six relevés (Braun-Blanquet 1964) led to the conclusion that the field method of this thesis is only suitable for coarse recording of the nitrogen conditions, since it takes local variation not into account. The method should be validated with additional complete vegetation relevés.

4 Based on the C/N ratio, the indicator value system of Landolt (1977) was evaluated for certain species. In this context, the suitability of the 20 high or low nitrogen indicator species was tested with a logistic regression model. Only eleven of the species were suitable as nitrogen indicators.

5 Technical difficulties were encountered in integrating the field data and the MAB data set. Therefore, the structure of existing spatial data should be carefully considered before a research project with GIS is taken up.

6 Multiple regression analyses were calculated to explain the nitrogen status of the grassland. Present and past agricultural land use were the dominant factors controlling ni-

trogen availability. Other local site factors like soil properties and climate as well as river catchment site-factors were less important.

Genetic variability of *Erigeron annuus* in Switzerland

Genetische Variabilität von Erigeron annuus im Raum Schweiz; 56 pp.

MARCO SOLIVA

1 In summer 1995 and in spring 1996 406 individuals of *Erigeron annuus* (L.) Pers. were collected from 82 populations in 23 cities of Switzerland with two different sampling strategies.

2 The borderline between the subspecies in Switzerland cannot be drawn by using morphological features.

3 All investigated plants were triploid and showed the chromosome number $2n = 27$.

4 Genetic variability was investigated by using RAPD. Four primers were used which generated 59 molecular markers. 108 genotypes could be discriminated among the 212 individuals investigated; 70 singular genotypes were observed.

5 For the investigation of the genetic variability of *E. annuus* it seems to be not sufficient to collect specimens only within Switzerland. However, the most appropriate sample size is still under debate.

Morphological and genetic variability of *Erigeron annuus* (L.) Pers. within the city of Zurich

Morphologische und genetische Variabilität von Erigeron annuus (L.) Pers. in der Stadt Zürich; 62 pp.

MARTINA WALSER

1 *Erigeron annuus* (Compositae) is a triploid neophyte which reproduces obligate apomictically. In the area of Zurich, the variability of *E. annuus* was studied by morphometric, cytological and molecular methods (RAPDs).

2 Statistical analysis (ANOVA, Pearson correlation) of the 49 plants investigated did not reveal any correlation between morphometric characters like serration of leaves, leaf index, hair length, density of stem hairs and the relation discus to ligules.

3 The phenotypical plasticity of *E. annuus* was very high. The division of this species into the subspecies *annuus*, *septentrionalis*,

and *strigosus* based on morphological traits does not seem justified.

4 Cytological investigations confirmed that *E. annuus* is a triploid species with $2n = 27$ chromosomes.

5 The genetic variability of the plants was remarkably high within the study area (76 km²). Among 137 individuals 70 genotypes were observed.

6 Individual genotypes appeared in different frequencies. However, 70% of the genotypes were only found once, whereas the most frequent type was detected 14 times.

7 Since the differences between the individual genotypes were small, it was not possible to form groups on the basis of RAPD markers.

8 There was no correlation between genotype and phenotype.

PhD theses (3)

Influence of physiological, environmental and genetic factors on long-distance flights of *Cydia pomonella* L. (Lepidoptera: Tortricidae) measured by a flight mill

Einfluss von Physiologie, Umwelt und Genetik auf die Langdistanz-Flüge von Cydia pomonella L. (Lepidoptera: Tortricidae), gemessen in einer Flugmühle; 101 pp.

PETER SCHUMACHER

1 The flight capacity of *Cydia pomonella* L. (Lepidoptera: Tortricidae) was measured in the laboratory by computer-linked flight mills. This method was used as model system for the investigation of physiological, environmental and genetic factors influencing long-distance flights. Such flights are mainly important for the colonization of new or unoccupied habitats. Long-distance flights have also an economic significance, because the implementation of novel pest managements, e.g. pheromone confusion technique, may fail due to immigrating gravid females.

2 The flight capacity showed a continuous but skewed frequency distribution, therefore the separation of long-distance flights from short-distance flights was defined arbitrarily at 5 km; flights over more than 5 km were referred to as long-distance flights.

3 The following factors were investigated and found to have a significant effect on flight capacity: age, mating status, temperature and light intensity during flight, larval food, temperature during the larval period, and genetic variability. Only few factors showed no significant influence: previous larval diapause, geographic origin and sex.

4 The males reached their highest flight capacity 1–2 days later than the females but no

significant difference in the maximal flight distance was found between males and females, and it was concluded that both flights within and between habitats are similar in number and magnitude for both sexes. In the field, females are thus potentially able to undertake flights of up to 11 km, which has been reported for males by other authors. Long-distance flights were mainly undertaken 2–7 days after emergence, i.e. in the first third of their lifetime in the laboratory. Gravid females were also capable of long flights but their capacity declined faster than that of virgin females.

5 The multiple-trait-restricted-maximum-likelihood method was used for the estimation of genetic variances and covariances. The heritability of the total flight distance was 0.57 for the field strain and 0.38 for the laboratory strain. Both values were significantly different from zero ($P < 0.05$). High positive genetic correlation was found between total flight distance and body weight for the field strain, whereas a negative correlation was found between total flight distance and body weight for the laboratory strain. This difference between the two strains was interpreted as an indication of a trade-off between flight capacity and fecundity.

Clonal growth and fragmentation in the alpine tussock-forming grass *Poa alpina*

Klonales Wachstum und Fragmentierung bei dem alpinen Horstgras Poa alpina; 126 pp.

THOMAS WILHALM

This thesis deals with clonal growth and tussock fragmentation in *Poa alpina*. The first part concerns the contribution of clonal growth to the performance of *Poa alpina*. The main issues addressed in the second part are: (i) patterns of clonal fragmentation, (ii) factors determining self-cloning, and (iii) the role of the fragmentation as a component of a developmental programme in *Poa alpina*. The last part of the thesis includes a survey of clonal fragmentation in numerous tussock-forming grasses.

The results of the study may be summed up as follows:

1 *Poa alpina* was found to have several traits useful for the consolidation of habitats including a high relative growth rate, a viable bud bank, the ability to store resources, and regrowth after damage. A high plasticity was detected in absolute shoot size and leaf mass, as well as in allocation to reproductive and vegetative structures. This plasticity may be important in allowing the species to inhabit a wide range of different habitats.

2 Tussocks of *Poa alpina* fragmented spontaneously. The sequential fragmentation resulted in a clear structural hierarchy including three different levels, viz. the tussock, the tiller group and the individual tiller. Plasticity in morphological traits was particularly evident at the level of the tussock and the tiller but less clear at the tiller group level. Tiller groups did not necessarily show the same allocation patterns as tussocks as a whole; these differences reflect functional autonomy of the tiller groups, and may possibly contribute to a better performance of the genet in a given habitat.

3 Tussock fragmentation, i.e. self-cloning, was found to follow regular patterns, with mother plants mostly including three tiller generations; in contrast, the separating daughter plants mostly consisted of two tiller generations. Fragmentation depended more on the structural size of the plant than on its developmental stage or chronological age. Although a rather constant number of simultaneously attached tillers was observed on a common axis, fragmentation is not regarded as a simple morphological constraint since tillers might to a great extent escape spatial constraints through effective internode elongation.

4 The fragmentation of tussocks was accompanied by the formation of active abscission layers. This phenomenon has not been reported before in caespitose grasses. While abscission processes in plants are frequently associated with shedding of dead or dying plant parts, abscission during self-induced fragmentation of a clonally growing plant results in a group of structural individuals which stay alive and are capable of further development.

5 The pattern of self-cloning was not influenced by nutrient supply or/and clipping. While the biomass of separating tiller groups was reduced by clipping and enhanced by nutrient supply, the number of integrated tillers was not affected by these treatments. On the other hand, the pattern of self-cloning changed with the onset of flowering: tussocks including flowering tillers were less fragmented than tussocks composed only of non-flowering tillers.

6 Tracer experiments (¹⁴C) demonstrated that tiller groups were equivalent to integrated

physiological units in *Poa alpina*; clonal fragmentation is thus suggested to control physiological integration. Physiological integration and source-sink interrelationships were found to follow a similar pattern to that reported for caespitose grasses: (i) youngest tiller generations and flowers represent the strongest sinks for assimilates, and (ii) the intensity of assimilate export declines significantly with increasing distance from the source.

7 Clonal fragmentation in tussock-forming grasses was found to be a widespread phenomenon. A comparative study of 24 peren-

nial and 3 annual caespitose grasses revealed that clonal fragmentation takes place in all perennial grass species investigated, tiller groups comprised on average less than 10 tillers, in 90% less than 20 tillers.

The results support the hypothesis that self-cloning in *Poa alpina* and possibly also in other tussock-forming grasses is governed by inherent rather than by external factors. Self-cloning is a process which apparently is part of the developmental programme. Consequences and evolutionary meaning of this process are discussed and further research directions are briefly indicated.

Mown and grazed meadows in the City of Zurich – How to increase or preserve plant diversity of urban meadows?

Wiesen und Weiden in der Stadt Zürich. Untersuchungen zur Erhaltung und Förderung der Pflanzenvielfalt; 143 pp.

MARKUS WILHELM

The aim of this thesis is to investigate the optimal management type to increase or preserve plant diversity of urban meadows. Between 1990 and 1994, 241 meadows in the area of the City of Zurich were studied with phytosociological and ecological methods, and with management experiments on five permanent plots.

Vegetation and site conditions

1 In the City of Zurich traditional meadows of a moderately nutrient-rich type (*Arrhenatheretum elatioris typicum*) are no longer found. Due to altered management practice this grassland type has been transformed into communities with only few species (*Lolium-Cynosuretum*), either by more intensive management, or by at least temporary abandonment. The reduction of fertiliser input affected the succession of the *Arrhenatheretum*, which was either transformed into a

nutrient-poor type with an urban character (revised name: *Arrhenatheretum elatioris salvietosum*, drought-resistant *Trifolium dubium* type), or into a nutrient-poor type similar to limestone grasslands. Vegetation changes also occurred on more or less humid sites near settlements on rich urban meadows and pastures (revised name: *Arrhenatheretum elatioris Lysimachia nummularia* subass., urban *Primula vulgaris* type). The urban character was indicated by the high frequency of plants with higher temperature requirements, and by the invasion of plants from gardens and by ruderal plants.

2 Most meadows and pastures of the City of Zurich were relatively rich in species. On the 241 plots, 444 plant species were found (413 vascular plants and 31 mosses).

3 Some sites were especially rich in species, particularly on south-facing slopes (> 30%) (rarely north-facing), with calcareous (cal-

cium carbonate > 20%) and nutrient-poor (phosphate < 25 ppm) soil. These meadows were usually found in semi-public urban places or in public rural places.

4 Meadows on urban slopes with nutrient-poor soil (nitrogen < 0.3%, phosphate < 25 ppm) were also sites of rare and endangered plant species, which occurred on older (> 75 years) rural slopes rather than on private property.

Management experiments

1 The experiments showed, in three of four cases, that cutting of a former urban pasture leads to losses of typical pasture plants, whereas the vegetation of grazed control plots remained more or less stable. On one plot we observed a parallel variation in the composition of the vegetation. The development in both the grazed control plots and the mowed plots had obviously been caused by strong external influences.

2 In one experimental site the number of plant species increased on all mowed plots after changing the management practice, and remained constant on the grazed ones. In one site we found opposite results, and in two further study areas no variation of richness of species could be observed. These differences were explained by the following factors: nature of the original vegetation, local conditions, former grazing intensity and age of the meadow.

3 *Agrostis stolonifera*, *Bellis perennis*, *Cardamine hirsuta*, *Cerastium caespitosum* and *Poa trivialis* are species whose abundance was increasing after several years of grazing. *Bromus erectus*, *Galium album* and *Lotus corniculatus* had decreasing cover-abundance values. Species which benefitted from the change to mowing are: *Helictotrichon pubescens*, *Salvia pratensis* and *Medicago lupulina*. *Trifolium dubium*, *Trifolium repens* and *Ononis repens*

showed a decreasing cover-abundance value in response to the change from grazing to mowing.

4 The concentration of potassium rose significantly from 1.5 to 1.8 ppm on grazed control plots, but not in the mowed plots. Due to the systematic removal of grass cuttings, the concentration of phosphate decreased from 3 to 2.3 mg per 100 g on mowed plots and remained stable on grazed ones. The concentration of nitrogen fluctuated below the limit of detection.

Conclusions

1 It is not possible to preserve or increase the plant diversity of meadows in the City of Zurich exclusively by cutting or by grazing. Both management systems complement each other: grazing stimulates the spread of new plant species and species from adjoining populations (by opening the vegetation, exchange of diaspores by sheep, changing the grazing intensity etc.), while cutting preserves the typical flora of meadows due to a continuous and constant cutting regime.

2 Traditional maintenance should remain the same, not only for grasslands of old cemeteries, public gardens and parks, but also for sites with a value as a natural monument or a natural area. All other types of urban meadows should be subject to management according to ecological principles and economic requirements.