GRAZING AND CUTTING REGIMES FOR OLD GRASSLAND IN TEMPERATE ZONES

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Keywords: eutrophication, land use dynamics, networks, MOSAIK, butterflies, *Maculinea*

Contents

Summary

Old temperate grassland ecosystems are briefly characterized, especially with respect to their grazing and cutting regimes, which are, in turn, related to nutrient and land use dynamics as well as aspects of area size and habitat networks. Their effects on the biodiversity of these systems are briefly described. Present and potential future developments are critically assessed concerning their direct and indirect impact on biodiversity. The effects of different cutting and grazing approaches on different species in different geographical settings are exemplified by some butterfly examples.

It is concluded that not all conservation targets can be achieved on single remnant

grasslands, rather that a system of grasslands is required in which each patch is treated slightly differently so that together the patches can safeguard the conservation of all species typical for seminatural grassland systems. Regional differences have to be considered when implementing cutting and grazing regimes, as these strongly affect acceptance by farmers as well as the maintenance of species.

The optimal management system for grassland biodiversity probably is a complicated combination of continuity (similar grazing pressure or cutting intervals over a long time) and stochasticity (variation in grazing pressure and cutting intervals; rotational grazing; abandonment and resumption of grazing) and of different grazing pressures and animals over a variety of spatial and temporal scales.

1. Grasslands in the Temperate Zone: Distribution and History

Grasslands exist both as natural ecosystems and as seminatural human-generated systems. They form a natural biome where a low level of rainfall together with disturbance by fire inhibits the establishments of forests. These natural grasslands have been the habitat of huge herds of large herbivores. Humans likewise used these natural grasslands since the beginning of pasturalism. With the expansion of human populations in more humid areas of the temperate zone, people created seminatural grasslands in regions that naturally would be covered mainly by forests. Most probably, these human-generated grasslands were not the first in these regions, since large herbivores may have widened gaps in the forests that finally resulted in pockets of grassland. Whereas scientists still debate whether large herbivores really had any noticeable effect on the formation of grassland, it is clear that humankind greatly expanded these grasslands by the clearing of forests, grazing, and cutting. As a result, permanent pastures and meadows became an important component of the landscapes in the temperate zone. This expansion of grassland allowed species adapted to natural grasslands of southern and eastern Europe and Asia to follow the pasturalists and to establish themselves in more northern regions coevolving with the grazing and cutting systems implemented by pasturalists. In addition, without livestock grazing and mowing, the cooling of climate during the Holocene would have led to the extinction of many thermophilous species in northern Europe. As a consequence, seminatural grasslands show a high biodiversity. Because of this level of biodiversity, and since they provide refugia to threatened species, grasslands that are grazed and cut are regarded as very valuable for the conservation of biodiversity.

Natural and human-generated temperate grasslands once were widespread throughout the world, but are dramatically declining because of a combination of factors. Intensification of agriculture and the abandonment of traditional forms of agriculture caused this decline in Europe. The decline began at the end of the nineteenth century and meanwhile has become very severe in most European countries. In some countries, more than 50% of the seminatural grasslands are lost. The remaining grasslands have changed dramatically in their characteristics since the 1960s because of increased isolation and eutrophication. In eastern Europe extensive seminatural grasslands still exist, but they are also already increasingly abandoned or transformed into agricultural fields.

Natural temperate grasslands have suffered an even more serious loss. In southeastern Australia, for example, less than one percent of the approximately two million hectares that existed prior to European settlement still remain. Thus, native grasslands are the most endangered of all vegetation types in Australia. The remaining grasslands are threatened by urban and agricultural expansion, weed invasion, and grazing by stock and rabbits.

In the remaining part of this chapter, Europe will be the focus of interest, since other chapters in this Theme deal with the management of (natural) rangelands as well as grazing in wetlands, and because our knowledge of changes in grasslands in recent decades is particularly well developed for Europe.

2. Characteristics of Old Temperate Grassland Ecosystems

Traditional land use regimes for grasslands included livestock grazing, mowing, fences, hay piles, local and regional transport of livestock, and others. These are all methods that did not cause nutrient enrichment to managed seminatural areas. Instead, they were driven by traditional husbandry. Until the nineteenth century in Europe, most herbaceous vegetation was used as hay meadows and/or pastures. Forested areas were cleared to form meadows for grazing and for winter fodder. Many areas were occasionally ploughed, and fields were grazed when fallow. Fertilization of crops with manure caused a nutrient export from grazed grasslands (and forests) to cultivated fields, which led to nutrient depletion in most seminatural grasslands. Thus, the existence of these highly valued conservation areas in Europe is due to a large extend to unsustainable land use practices in the past.

2.1 Grazing and Cutting Regimes

Traditional grazing regimes on grasslands range from extensive use by occasional visits of grazing animals on the sites to systems with a nearly permanent presence of the animals. Most of them have been of rather low intensity and normally led to small-scale mosaics of disturbances that created regeneration niches for different plant species. This fine-scale heterogeneity contributed to the biodiversity of seminatural grasslands.

Similar effects have been produced by traditional cutting regimes. They have been small in spatial extent and had large temporal variability that resulted in high heterogeneity of grassland growth stages and thus structural diversity, creating development opportunities of the majority of the regional biodiversity.

2.2 Nutrients

The decisions of which parts of the landscape were used as grasslands were based mainly on the availability of nutrients and the distance from human settlements. Distant and nutrient-poor areas were predestined for grasslands. In the total balance of historical land use systems, seminatural grasslands have been the nutrient and energy sources for agricultural production leading to a further nutrient reduction of grassland systems.

2.3 Area Size and Networks

Due to the low energetic efficiency of the production of animals for human consumption, large areas were required to achieve sufficient meat production. Thus, grazing systems required large areas. Animals were moved regularly among different grasslands and ponds and stables in villages. In addition, traditional transhumance ("migratory shepherding") in central Europe created networks of pastures over hundreds of kilometers. These networks also formed networks of transport for plant seeds and animals that hitchhiked on sheep.

2.4 Dynamic Land Use

Many grasslands nowadays appear rather static. This, however, does not reflect the historical situation. In periods of lack of food, grasslands have been converted into arable fields especially on better soils near villages. However, also many of the worse soils could support a temporally limited use as arable land (e.g., so-called *Dreifelderwirtschaft* and similar systems of regular changes of land use on the same piece of land). Permanent grassland only reflects a minor portion of former land use. The temporal change between grassland and arable fields has been at least as common. Thus, historical land use has been highly dynamic with respect to area expansion as well as land use type.

2.5 Species Richness/Biodiversity

Due to most of the factors mentioned thus far, species richness in seminatural grasslands of the "old temperate zone," measured as species density per area, generally is much higher than in natural and seminatural forests. Certain grasslands are among the most species-rich ecosystems in Europe. Consequently, seminatural grasslands have high conservation priority in Europe (as opposed to elsewhere), partly due to the long history of coevolutionary interaction between people and nature. The ecological interactions between species there became highly differentiated (see Section 3.5 for *Maculinea* butterfly example).

The high biodiversity of these grasslands might additionally be due to the fact, that e.g. in Northern and Central Europe, methods applied in traditional grassland management replace some human-suppressed natural processes (natural disturbances like floods, fires, windbreaks, beavers, etc.) that maintain biodiversity and mitigate other deleterious effects. Thus, traditionally managed areas can harbour many features of pristine habitats. Grazing cattle could have compensated for the loss of many native large herbivores.

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Bibliography

Beinlich B. and Plachter H., editors. (1995). *Schutz und Entwicklung der Kalkmagerrasen der Schwäbischen Alb.* Beihefte zu den Veröffentlichungen für Naturschutz und Landschaftspflege in Baden-Württember 83, 1–520. [This is a brilliant multiauthored case study on the development, biodiversity, and conservation options of calcareous grasslands in southern Germany; in German (ISSN 0342-6858).]

Benstead P., Jose P., Joyce C. and Wade P.M., editors. (1999). *European Wet Grassland—Guidelines for Management and Restoration,* 169 pp. Sandy, UK: Royal Society for the Protection of Birds. [This takes a northern and central European overview of the importance of wet grassland to both wildlife and people, and concentrates on the practical aspects of management and rehabilitation.]

Breymeyer A.I., editor. (1990). *Ecosystems of the world 17A: Managed Grasslands—Regional Studies,* 388 pp. Amsterdam: Elsevier Science Publishers. [In conjunction with Snaydon (1987), this volume provides a complete cross section of current knowledge of the structure and function of managed grasslands throughout the world, including all the processes determining the productivity of these ecosystems.]

European Grassland Federation (1997). *Management for Grassland Biodiversity* (Proceedings of the 1997 International Occasional Symposium of the European Grassland Federation), 412 pp. Warsaw: European Grassland Federation. [This volume gives an overview of different European approaches for the management of grassland biodiversity.]

Hodgson J. and Illius A.W., editors. (1996). *The Ecology and Management of Grazing Systems,* 466pp. Wallingford, UK: CABI International. [This is a synthesis of a range of perspectives on grazing systems drawn from plant science, animal science and ecology.]

Johst K., Drechsler M., Thomas J.A. and Settele J. (2006) Influence of mowing on the persistence of two endangered large blue butterfly species. *Journal of Applied Ecology* 43: 333–342. [Shows an example of the interaction of metapopulation dynamics and larger-scale mowing regimes with respect to the survival probability to *Maculinea* butterflies.]

Kleyer M., Biedermann R., Henle K., Obermaier E., Poethke H.-J., Poschlod P., Schröder B., Settele J. and Vetterlein D. (2007) Mosaic cycles in agricultural landscapes of Northwest Europe. *Basic and Applied Ecology* 8: 295—309."

Poschlod P., Kiefer S., Tränkle U., Fischer S., and Bonn S. (1998). Plant species richness in calcareous grasslands as affected by dispersability in space and time. *Applied Vegetation Science* 1, 75–90. [This is an instructive case study on the relevance of grazing regimes for the dispersal of seeds and related effects].

Pykälä J. (2000). Mitigating human effects on European Biodiversity through traditional animal husbandry. *Conservation Biology* 14, 705–712. [This is a review of the role of traditional husbandry for the biodiversity of European grasslands; close relation to cutting and grazing regimes.]

Snaydon R.W., editor. (1987): *Ecosystems of the world 17B: Managed Grasslands—Analytical Studies,* 350 pp. Amsterdam: Elsevier Science Publishers. [In conjunction with Breymeyer (1990), this volume provides a complete cross section of current knowledge of the structure and function of managed grasslands throughout the world, including all the processes determining the productivity of these ecosystems.]

Thomas J.A. and Settele J. (2004) Evolutionary biology: Butterfly mimics of ants. *Nature* 432: 283-284. [briefly summarizes the state of knowledge on the evolutionary biology and ecology of Large Blue butterflies]

Various authors. (2001) Grasslands, grazing and biodiversity. *Journal of Applied Ecology* 38(2), 233–338. April 2001: (pp. 233-338). [This Special Issue contains nine relevant articles; April 2001.]

Wade P.M. and Joyce C.B., editors. (1998). *European Wet Grasslands—Biodiversity, Management and Restoration,* 340 pp. Chichester, UK: Wiley. [There is growing scientific and political concern over the loss of, and damage to, biodiverse lowland wet grasslands on a European scale. This book examines the status and biodiversity of European lowland wet grasslands, giving information on their hydrology and management, especially for conservation objectives, and investigations concerning the restoration of these endangered habitats. A balance is struck between the different elements of the wet grassland landscape, with contributions dealing with flora, fauna (invertebrates and birds), and the physical and chemical elements.]

Wallies DeVries M.F., Bakker J.P., and VanWieren S.E., editors. (1998). *Grazing and Conservation Management*, 374 pp. Boston: Kluwer. [This provides a fully up-to-date account of current theories, practices, and case studies; deals with theoretical considerations, grassland development, herbivore communities, diversity, and the effects of grazing in different landscape settings.]

White R.P., Murray S., and Rohweder M. (2000). *The Pilot Analysis of Global Ecosystems: Grassland Ecosystems*, 89 pp. Washington, DC: World Resources Institute. [This report examines grassland ecosystems of the world using a large collection of spatial and temporal data, analyzing data sets primarily at the global level. It presents quantitative indicators and qualitative information on the condition of the world's grasslands, looking at the current and future capacity of these ecosystems to provide goods and services important to humans. The report warns that the world's grasslands have declined in their extent and condition, as well as their ability to support human, plant, and animal life.]

Biographical Sketches

Josef Settele, born in 1961, did his doctoral work in agricultural sciences. His thesis dealt with the effects of land use changes to the community structure and dynamics of invertebrates in Philippine rice terraces. From early childhood, he was fascinated by insects, and entomology became the guiding line for his career. His second stronghold is invertebrate conservation biology with a strong focus on butterflies as model organisms. He passed his habilitation in landscape and agricultural ecology with a grid-based modeling study on butterfly metapopulations. Throughout the 1990s, he coordinated several research projects on the integration of land use and conservation. Since 1993 he has been employed at the UFZ Centre for Environmental Research Leipzig-Halle, where in 2001 he changed from the Department of Conservation Biology and Natural Resources to the Department of Community Ecology, where he became head of the animal ecology section. He teaches different topics within ecology for students of biology, ecology, and agriculture at several German universities. He coordinates and/or is otherwise involved in several multidisciplinary and international research projects dealing with land use, nature conservation and biodiversity. He coordinated the EU project ALARM (Assessing LArge scale environmental Risks for biodiversity with tested Methods), which consisted of a global network of 68 partner institutions in 35 countries (www.alarmproject.net)..

Klaus Henle, was born on January 5, 1955. He studied biology at the University of Stuttgart-Hohenheim, Germany. In 1988, he obtained his doctoral degree at the Department of Zoology, Australian National University, Canberra, with a thesis on "Population ecology and life history of a lizard community in arid Australia". He started his scientific career at the Institute for Landscape Planning and Ecology, University of Stuttgart, Germany, developing the conceptual basis for a national research initiative of the German Ministry of Science and Technology on nature conservation. With the foundation of the UFZ - Helmholtz Centre for Environmental Research, he was appointed head of the Department of Conservation Biology and Natural Resources. His duties are the development, coordination, and synthesis of large interdisciplinary research projects in conservation biology. Major research projects deal with:

a) Species survival in fragmented landscapes, including the development of software for population viability analyses and rules of thumb for the development of habitat networks;
b) Development of a robust indicator system for ecological changes in flood plain systems;
c) Methods for the development of an effective net of conservation priorities sites in mining landscapes;
d) The role of disturbances in the evolution, maintenance, and loss of biodiversity;
e) Fragmentation of the Mata Atlantica in Brazil;
f) Rangelands and semiopen cut grasslands as alternative options for the management of dry habitats and their consequences for the survival of flora and fauna;
g) Biodiversity assessment; and
h) Conceptual and theoretical basis of conservation biology