




FEATURE PAPER

Subsidized Common Agricultural Policy grazing jeopardizes the protection of biodiversity and Natura 2000 targeted species

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Keywords

butterflies; Common Agricultural Policy; *Euphydryas aurinia*; habitats directive; nature reserves; nectar resources; orchids; protected areas.

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Abstract

In Europe, Natura 2000 sites should protect threatened target species and networks of habitats. The management of Natura 2000 grasslands is often financed by subsidized grazing as part of the Common Agricultural Policy (CAP). We studied the extent of CAP grazing for Natura 2000 management and how this affects a butterfly target species (the marsh fritillary) and floral resources. Based on extensive capture-mark-release studies from 2 years in >550 ha grid cells in a 225 km² landscape in Sweden that includes 15 Natura 2000 sites, we compared marsh fritillary occurrence probabilities and population densities in ungrazed and CAP-grazed habitats. Moreover, we analyzed how nectar resources and orchids were affected by CAP grazing based on plants records from 2347 sample plots. We estimated the proportion of butterfly habitats that were CAP-grazed within and outside Natura 2000 sites. In total, 10 453 and 4417 butterflies were marked in 2017 and 2019, respectively. The grid cell occurrence probability was 1.8 times higher and the population density was 2.3 times higher in ungrazed compared with CAP-grazed habitats in 2017, and the corresponding numbers for 2019 were 10 and 5.3 times higher, respectively. The number of flowering plants were on average 6.9 times higher and the density of orchids was 12.3 times higher in ungrazed habitats. Roughly, 30% (130 ha) of the marsh fritillary habitat was CAP grazed, and 97% of this grazing occurred within protected areas, of which 111 ha was situated within Natura 2000 area where the marsh fritillary is the target species. Alarmingly, we show that intense yearly CAP grazing, which is the dominant management strategy in all Natura 2000 sites, has devastating consequences for the target species and other aspects of biodiversity. Less intense management, which would benefit biodiversity, requires changes in the CAP, to allow more flexible payments for habitat management objectives and conservation of target species.

Introduction

Increased efforts and modified strategies that allow for sustainable land use are required to reverse current trends and prevent further losses of biodiversity (Leclère *et al.*, 2020). Current, conservation efforts are not good enough (Tittensor *et al.*, 2014). Recently, the European Commission (2020a) emphasized the need for protecting more areas with important habitats aiming to halting the ongoing losses of biodiversity and the ecosystem services that it provides. To enable the protection of the extraordinary species-rich biomes associated with traditional extensive farming, such as temperate grasslands, alvar, and alkaline fens (Hoekstra *et al.*,

2005), the European Commission encourages that the new “Farm to Fork” strategy (European Commission, 2020c) and the new Common Agricultural Policy (CAP) are combined with the Habitats Directive (European Commission, 2020a). However, the effects of CAP payments often fail on biodiversity (Pe'er *et al.*, 2014; Török *et al.*, 2017). Attempting to preserve the biodiversity of semi-natural grasslands using subsidies is challenging, as no single management strategy is optimal for all vegetation types (Török *et al.*, 2018). It might even be that these subsidies are harmful to biodiversity (Dempsey, Martin & Sumaila, 2020), and one of the main examples of this is financial support for grazing semi-natural habitats (Pe'er *et al.*, 2014).

Grazing is a common measure to prevent succession in open grasslands and is often used to restore and maintain grassland biodiversity (Pykälä, 2003; Pöyry *et al.*, 2004). The effect of grazing may, however, vary among different environments, climates, organism groups, and trophic levels (Filazzola *et al.*, 2020). Grazing most often seems to promote the diversity of plants (Papanikolaou *et al.*, 2011; Báldi, Batáry & Kleijn, 2013; Tälle *et al.*, 2016), whereas other species groups show diverging responses that strongly depend on grazing intensity (Kruess & Tscharntke, 2002; Dumont *et al.*, 2007; Wallis De Vries *et al.*, 2007; Jerrentrup *et al.*, 2014). Too intense grazing (overgrazing) may have large negative impacts on grassland biodiversity (Bonari *et al.*, 2017; Sartorello *et al.*, 2020) and human livelihood (Varga *et al.*, 2021), and the grassland recovery after being overgrazed is most likely slow (Middleton, Holsten & van Diggelen, 2006; Fetzel *et al.*, 2018; Varga *et al.*, 2021). There is a growing awareness that CAP often results in overgrazing (Fetzel *et al.*, 2018; Marques *et al.*, 2020; European Commission, 2020b), and this raises the question of whether CAP-grazing regimes are compatible with Natura 2000 targets for biodiversity.

Many Natura 2000 sites are established to protect semi-natural open habitats and the associated biodiversity, with management plans developed to protect specific habitat types and target species (Bouwma *et al.*, 2016). Grazing is usually the suggested type of management in these plans and is often implemented using CAP payments. However, it is unclear whether the management of semi-natural Natura 2000 sites fulfills the goals with stable or increasing populations of the target species. On the contrary, biodiversity, including target species, continues to decline, and the EU has failed to meet 2020 targets against biodiversity loss (Visconti *et al.*, 2019; Müller, Schneider & Jantke, 2020; Pe'er *et al.*, 2020). Several studies have shown that CAP grazing may have negative consequences for grassland biodiversity (e.g., Ribeiro *et al.*, 2014; Fetzel *et al.*, 2018; Ramos *et al.*,

2021), but surprisingly few studies have explored the effects of CAP grazing in Natura 2000 areas. Such information is a prerequisite for developing evidence-based conservation strategies (e.g. Downey *et al.*, 2021) that can fulfill sustainability goals and halt biodiversity loss.

Our aim was to study the extent of CAP grazing as a management strategy in Natura 2000 grasslands, and how this affects the appointed target species and its resources, as well as other aspects of biodiversity. We do this in an extraordinary species-rich area west of Slite on Gotland (an island in the Baltic Sea on the Swedish east coast), within a 225 km² landscape covering 15 Natura 2000 sites. Specifically, we analyzed the effects of CAP grazing on the (1) occurrence probability and population density of the threatened marsh fritillary (*Euphydryas aurinia* – the Natura 2000 target species, Fig. 1) and (2) the abundance of its potential nectar resources (flowering plants). We do this using extensive capture-mark-release data comprising almost 15 000 unique marsh fritillary individuals from 2 years that vary in overall population densities (one “normal” year and 1 year with low population densities due to a major drought, Johansson *et al.*, 2020) and extensive plant surveys. We also (3) evaluated if the marsh fritillary can be taken as an indicator of how other aspects of biodiversity in low-productive grasslands may respond to CAP grazing using data on the abundance of orchids (a prioritized subgroup in the Natura 2000 sites). Moreover, we (4) mapped how much land was grazed due to CAP and the proportion of this being a part of the management in existing Natura 2000 sites and (5) quantified the amount of open semi-natural habitats that are grazed within protected areas compared with other parts of the landscape.

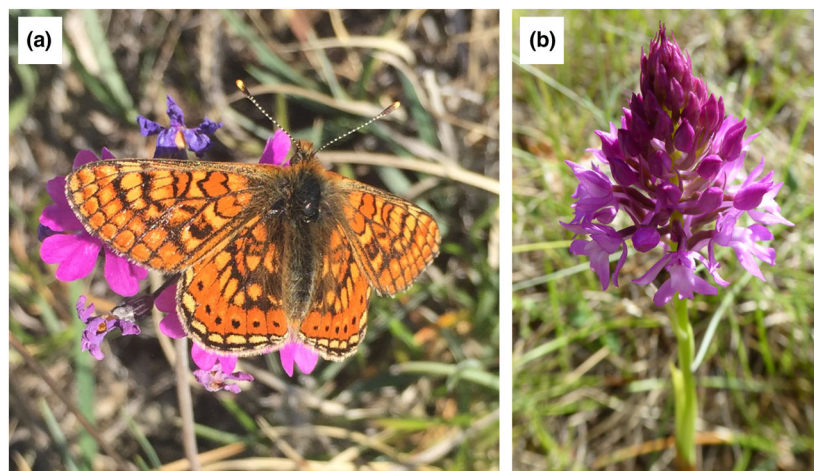


Figure 1 The marsh fritillary, *Euphydryas aurinia* (a), feeding on a bird's-eye primrose *Primula farinosa* (one nectar source in the studied area) and the pyramidal orchid *Anacamptis pyramidalis* (b; one of the rare orchids found in the study area).

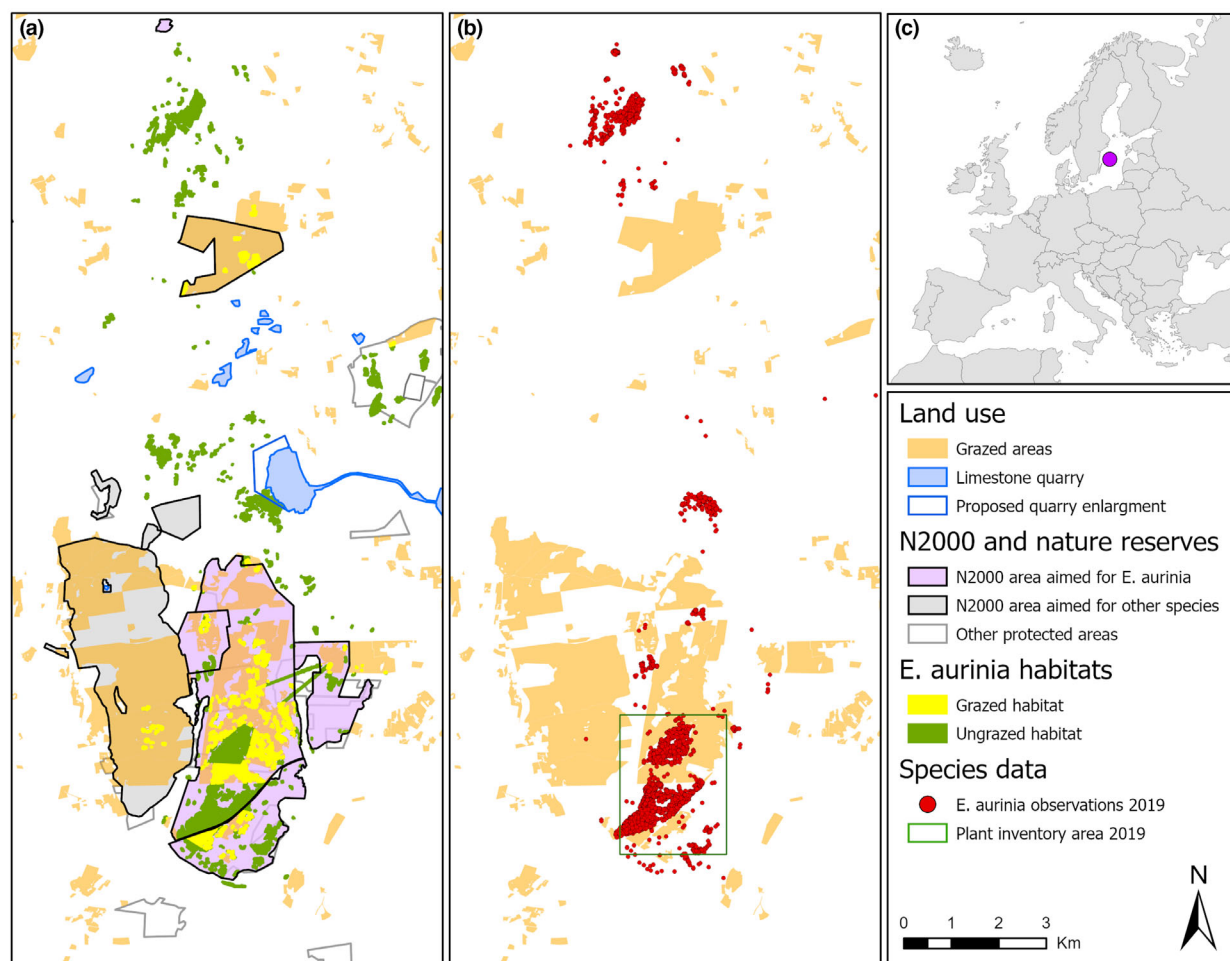


Figure 2 Maps of the study area on the Swedish Island Gotland (c), showing land use in terms of grazing (a, b), Nature 2000 sites, and other protected areas (b), the distribution of the marsh fritillary butterfly, *Euphydryas aurinia* (b) and its habitats (a), and both existing and planned limestone quarries (a). The indicated area where the plant inventory was conducted (b) is shown in more detail in Fig. 3. Natural Earth (naturalearthdata.com) is used in the overview map (c).

Materials and methods

Study area and species

The 225 km² large study area (Fig. 2) is situated on the island of Gotland in the Baltic Sea (18.7°E, 57.7°N). It is an area that includes exceptionally large natural calcareous wetlands, including alkaline fens, with almost intact hydrology and with unique ecological values (Veen *et al.*, 2009). Adjacent to the very species-rich fens is a mosaic landscape on Precambrian calcareous bedrock and outcrops with both open alvar vegetation and old-growth pine forest with extraordinarily high amounts of dead trees and woody debris. A combination of regular summer droughts and dynamic freezing and flooding during wintertime keeps many areas naturally open and hinders the regrowth of trees and bushes, and succession is therefore very slow without any management. Besides all the large areas of semi-natural habitats, the

landscape includes areas with small-scale agriculture, but also land used for limestone quarries.

Most parts of the wetlands constitute a very specific type of environment with a highly variable water status, ranging from very dry conditions during summer to more or less waterfilled situations during other parts of the year. The marsh fritillary butterfly *Euphydryas aurinia* mainly occurs on damp to wet calcareous grasslands (including the habitat type 7230 Alkaline fens) in which its larval food plant, devil's-bit scabious *Succisa pratensis*, occurs (Seer & Schrautzer, 2014). The marsh fritillary has declined dramatically in Europe and is regarded as endangered or vulnerable in most of its European range (EEA, 2021; JNCC, 2021). Based on existing knowledge, the study area constitutes one of the European strongholds for this species (Johansson *et al.*, 2019, 2020). This implies that actions are required to improve the conservation status of the marsh fritillary, and the species is appointed as the target species for several

Natura 2000 sites in the area. Thus, the study area offers a great opportunity to improve and conserve large amounts of habitats and large populations of this declining species. In this study, we mapped all potential habitats for the marsh fritillary within the study area, based on high-resolution land cover data (Swedish land cover data, CadasterENV), tree cover information from laser radar data (LiDAR), and the distribution of its host plant (Johansson *et al.*, 2019).

Field data collection

Data on the marsh fritillary comes from 2 years (2017 and 2019) of extensive capture-mark-release surveys (CMR). In 2018, a major drought hit the study area which reduced the marsh fritillary metapopulation by over 30% (Johansson *et al.*, 2020). We therefore expect that 2019 represents a year with very low population densities, while the population densities in 2017 should represent a relatively “normal” year (the precipitation was close to its long-term average both in 2016 and 2017, Johansson *et al.*, 2020). The CMR was performed in 1-ha grid cells distributed across the landscape during May–June, covering the whole activity period. The distribution of grid cells was stratified to cover both grazed and ungrazed habitats. Each grid cell of butterflies were marked and recaptured along irregular routes focused to cover suitable habitat that was utilized by the butterflies. In total, 559 and 871 ha grid cells were visited six times in 2017 and 2019, respectively. Each adult caught was marked individually using a permanent marker pen and immediately released at the point of capture. The surveys were performed between 9 AM and 5 PM. Surveys were not performed in unfavorable weather conditions such as during rain (within 1 h after rainfall) and temperatures below 17°C.

Data on orchids and flowering plants used as nectar resources by the marsh fritillary (and many other insects) were sampled during the butterfly flight season in 2019. These data consist of plant counts in 2347 circular sample units (size = 0.5 m²) located at randomized positions within 93 ha grid cells (Fig. 3d) covering both grazed and ungrazed marsh fritillary habitat within one of the Natura 2000 sites. All plants were identified as species except the genera *Galium*, *Lathyrus*, *Ranunculus*, *Rosa*, and *Taraxacum*. For orchids, we included both flowering and nonflowering individuals of all species. Some nonflowering individuals could not be determined to species and were therefore noted as *Orchidaceae* sp. The density of nectar resources only included species known to be utilized by the marsh fritillary and only plant individuals that were actually flowering at the time of the survey. Orchids were studied as they are legally protected, prioritized in nature conservation tasks, and considered good indicators of a healthy and functioning ecosystem (Vogt-Schilb *et al.*, 2015).

Mapping Natura 2000 and CAP grazing

To calculate the size of Natura 2000 sites and other protected areas and to obtain information on areas used for grazing, we used National GIS data provided by the Swedish

Environmental Protection Agency and the Swedish Board of Agriculture. All grazing in the area is done with an intensity required to receive EU subsidies in accordance with the CAP. This means yearly grazing that results in a low vegetation structure that is clearly affected by grazing animals. In the study area, this means grazing from late May to late September with sheep or cattle (Angus and Charolais) with approximately 0.3 animals/ha.

Statistical analysis

Based on capture-mark-release data, we estimated local population sizes in each hectare grid cell using Craig’s population estimator (Craig, 1953). Craig’s model is quite simple and only considers the number of captured individuals and the total number of captures within the grid cell to estimate the population size. The model was originally developed to estimate the size of butterfly populations and most often gives similar results as the more advanced Jolly-Seber model (Ranius, 2001; Drag *et al.*, 2011). For simplicity, we only included grid cells that were entirely grazed or ungrazed (559 grid cells in 2017 and 871 in 2019). As the butterfly species was not found in all grid cells, we first modeled its occurrence probability in relation to grazing using year-specific generalized linear models with a logit link function (logistic regression). As explanatory variables, we included the categorical variable grazed/ungrazed, habitat area (to account for the fact that the survey area differed between grid cells depending on the total amount of habitat in the cell), and connectivity to surrounding habitat (to account for a potential spatial structure as a result of grid cells surrounded by much suitable habitat is more likely to be occupied). Habitat connectivity of grid cell i (HS_i) was modeled as follows:

$$HS_i = \sum_{j=1}^n e^{-d_{ij} \times \alpha_h} PA_j, \quad (1)$$

where d_{ij} is the center-to-center distance in kilometers between focal grid cell i and surrounding cells j , PA_j is the total area of suitable habitat in plot j , and n is the total number of grid cells (Hanski, 1999). The spatial scaling parameter α_h was set to 4.08 based on the distribution of observed movements between grid cells (mean = 0.245 km, unpublished data). Second, we modeled the population density (estimated population size/habitat area) for each year using data from occupied grid cells. We log-transformed population density and used generalized linear models with a normal distribution. Explanatory variables were the categorical variable grazed/ungrazed and habitat connectivity (HS_i).

For orchids and flowering plants, we summarized the number of plants (separately for each group) for every grid cell and modeled their number (in two separate models) using generalized linear models with a negative binomial distribution (as the data were overdispersed counts). Explanatory variables were the categorical variable grazed/ungrazed and the number of sampling plots (to account for the fact that the number of plots varied between grid cells).

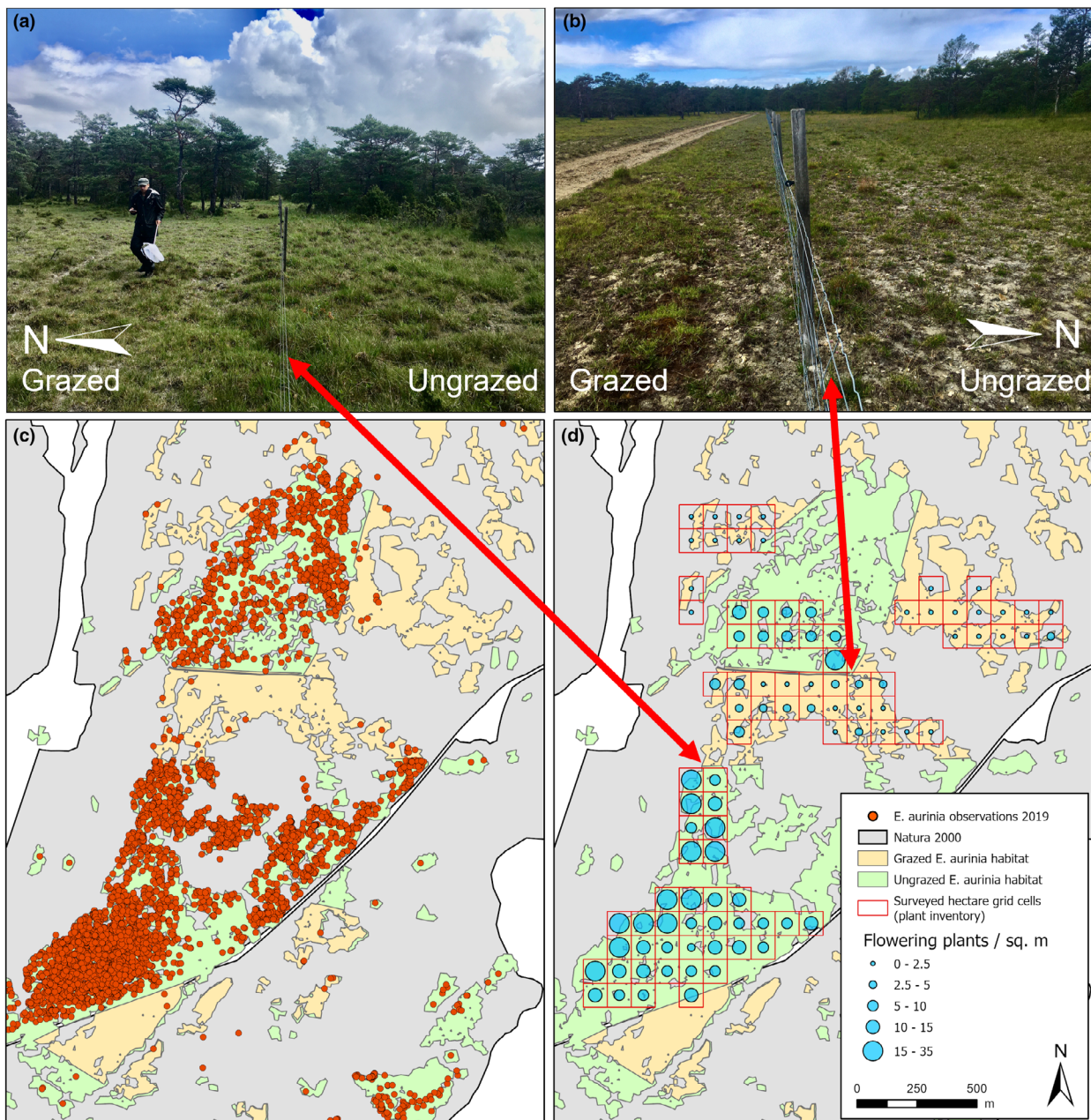


Figure 3 Photos (a, b) and maps (c, d) from the southernmost part of the study area, where the grid-based plant inventory (d) was conducted (see Fig. 2b for the location). Both the distribution of observed specimens of the marsh fritillary butterfly, *Euphydryas aurinia* (c), and numbers of flowering plants (d) show clear associations with the ungrazed parts of the butterfly habitats. The photos show two examples of ungrazed and grazed habitats sharply separated by fences. The *E. aurinia* habitat south from the fence indicated by the left red arrow has not been grazed since the 1950s according to the local farmers.

All analyses were performed using R.4.0.3 (R Core Team, 2020) with add-on library MASS (Venables & Ripley, 2002).

Results

In total, 10 453 and 4417 unique individuals of the marsh fritillary were marked during 2017 (in 559 ha grid cells) and

2019 (in 871 grid cells). The species occurred in 63.3% of the surveyed grid cells in 2017 and the estimated population density of occupied cells was on average 63.9 butterflies/ha ($SE = 4.2$). The corresponding occupancy for 2019, 1 year after the severe drought, was 39.7% with an average population density of 31.1 butterflies/ha ($SE = 2.5$). Both the grid cell occurrence probabilities and population densities were

Table 1 Parameter estimates with 95% confidence intervals for the generalized linear models of occurrence probability (binomial distribution) and population density (log-normal distribution) in hectare grid cells for the marsh fritillary in 2017 and 2019

	Occurrence probability		Population density	
	2017	2019	2017	2019
Intercept	2.76 (2.18 to 3.44)	0.25 (0.03 to 0.48)	3.63 (3.51 to 3.76)	2.69 (2.56 to 2.82)
Grazing	-2.10 (-2.88 to -1.38)	-3.25 (-3.99 to -2.58)	-0.84 (-1.10 to -0.59)	-1.66 (-2.16 to -1.14)
Habitat connectivity	3.14 (2.52 to 3.86)	1.91 (1.58 to 2.26)	0.76 (0.65 to 0.87)	0.51 (0.39 to 0.64)
Habitat area	1.05 (0.68 to 1.43)	0.49 (0.26 to 0.72)	NA	NA

significantly higher in ungrazed habitats compared with grazed habitats, both in 2017 and 2019 (Table 1; Fig. 4). The difference between grazed and ungrazed habitats was greatest in 2019 when the overall population size was clearly lower than in 2017. In 2019, grazed habitat harbored very few butterflies in general, and the spatial distribution of butterflies was clearly structured by the existing livestock fencing (Fig. 3c). The occurrence probability was 10 times higher and the population density 5.3 times higher in ungrazed compared with grazed habitats in 2019 (Fig. 4), and the corresponding numbers for 2017 were 1.8 times higher and 2.3 times higher. Taken together (i.e., multiplying occurrence probability and population density), this implies that grazing lead to an over the fourfold reduction of habitat quality for adult butterflies in 2017 and a reduction of over 50 times in 2019 (when population densities are low).

In total, we found 29 flowering plant taxa (Supporting Information Appendix S1) during the flight period of the marsh fritillary. The two most abundant species (together comprising almost 90%) were *Allium schoenoprasum* and *Potentilla erecta*. There were significantly more flowering plants in ungrazed compared with grazed habitats (Table 2), and the density was 6.9 times higher in ungrazed habitats (Fig. 5; Table 2). The number of orchids was also significantly higher in ungrazed habitat (Table 2), with an even larger difference in density (12.3 times higher) compared with grazed habitat (Fig. 5).

In the study area, 3440 ha were protected, which constitutes over 15% of the entire landscape. All grazing was financed by the CAP and occurred within 2323 ha of the study area, and 65% of the grazed land (1510 ha) belonged to protected areas (Fig. 2). Among the protected areas, Natura 2000 sites covered 2937 ha in total, and over 53% of these areas (1561 ha) had the marsh fritillary listed as the target species in the current management plans (Fig. 2). The total amount of CAP-grazed marsh fritillary habitat in the study area was 130 ha, which is roughly 30% of the total amount of habitat (466 ha) for the species. For the total area grazed, 97% (127 ha) occurs in protected areas, of which 111 ha is situated within Natura 2000 sites specifically aimed at protection of the marsh fritillary.

Discussion

We show that CAP grazing is the dominant management strategy in the Natura 2000 sites, even though this grazing is

clearly detrimental to the appointed target species – the marsh fritillary. CAP grazing leads to a fourfold reduction in habitat quality for the species in years with “normal” population densities and up to a 50 times reduction in years with low population densities. We also show that grazing reduces nectar (and pollen) resources for flower-visiting species and the number of legally protected orchids.

Effects of CAP grazing on Natura 2000 biodiversity

The current management, with compulsory CAP grazing in the Natura 2000 sites, results in too intense grazing pressure that clearly reduces the population of the marsh fritillary. This agrees with earlier studies showing clear negative effects of too intense grazing on the marsh fritillary (Johansson *et al.*, 2019), other butterflies (Ellis, 2003; Schtickzelle, Turlure & Baguette, 2007; Johansson, Knape & Franzén, 2017), as well as many other grassland insects (Kruess & Tscharntke, 2002; Jerrentrup *et al.*, 2014). Potential reasons are fewer or smaller host plants in grazed areas (Schtickzelle *et al.*, 2007; Johansson *et al.*, 2019), a reduction of nectar resources (as shown here and in Bubová *et al.*, 2015), and that grazing animals eat or trample down egg/larvae/pupae (Van Noordwijk *et al.*, 2012). Our present results show that the earlier reported fivefold reduction in habitat quality due to grazing (based on larvae counts Johansson *et al.*, 2019) may become 10 times worse when population densities are low, for example, after a drought (as in 2019). One reason is that the negative impact of grazing most likely becomes more serious under the lower forage availability during drought years. It is also evident from our results that the marsh fritillary may be a good indicator of how other aspects of biodiversity are affected by the current grazing regimes in these Natura 2000 areas. We show substantial negative responses also on orchids which is a prioritized subgroup in the Natura 2000 sites. Hence, not even vascular plants, which usually are believed to benefit from rather intense grazing (Papanikolaou *et al.*, 2011; Báldi *et al.*, 2013; Tälle *et al.*, 2016), cope with the current management strategy in the area. Thus, CAP grazing, aimed at promoting biodiversity in Natura 2000 areas, instead has negative effects on the target species and other aspects of biodiversity.

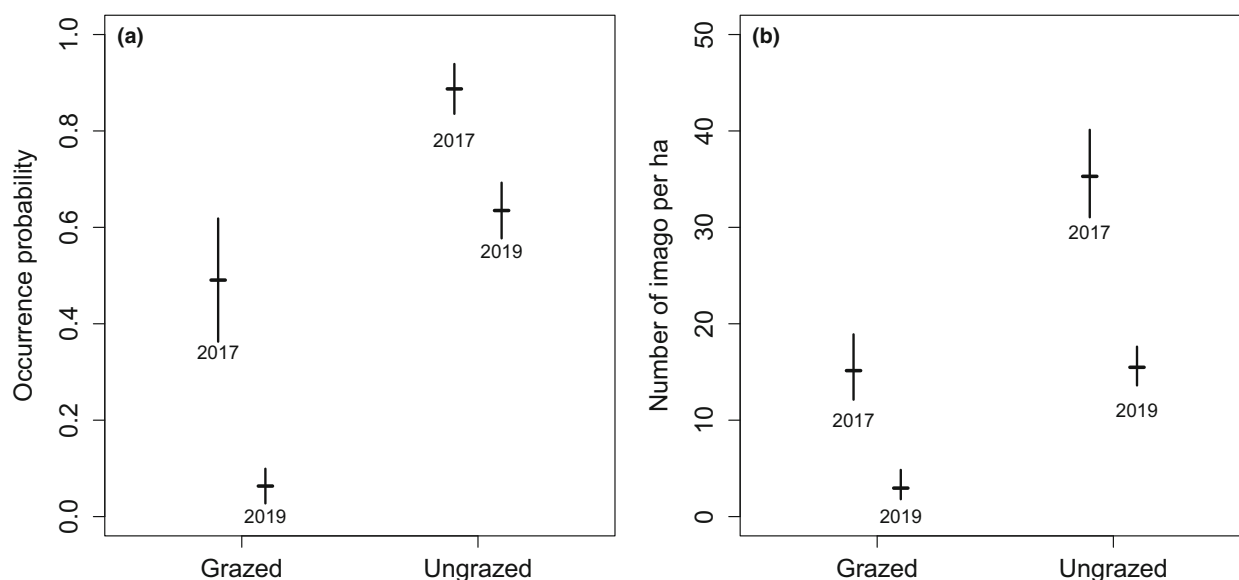


Figure 4 The predicted occurrence probability (a) and density (b) of marsh fritillary butterflies in grazed and ungrazed habitats in 2017 and 2019 from generalized linear models based on the estimated population sizes in hectare grid cells from mark-recapture data (Table 1). For the occurrence probability model, predictions were made for a grid cell with average habitat area, and average habitat connectivity and for the population density model predictions were made for a grid cell with average connectivity. Horizontal lines show the mean values and vertical lines show the 95% confidence intervals.

Table 2 Parameter estimates with 95% confidence intervals for the generalized linear models (negative binomial distribution) of the number of orchids and flowering plants in a 0.5 m² sample plot

	Orchids	Flowering plants
Intercept	0.87 (0.57 to 1.19)	5.08 (4.89 to 5.28)
Grazing	-2.50 (-3.32 to -1.78)	-1.93 (-2.23 to -1.62)
Number of plots	0.37 (0.07 to 0.68)	0.45 (0.30 to 0.60)

Management of grasslands within CAP and Natura 2000

Our findings highlight an increasing problem across Europe, where large areas of habitat for different organism groups are negatively affected by CAP management (Ribeiro *et al.*, 2014; Santana *et al.*, 2014; Fetzl *et al.*, 2018; Faria, 2019; Ramos *et al.*, 2021). A large proportion of the Natura 2000 sites in our study area were managed with CAP grazing, while very small parts of the marsh fritillary habitat outside these areas were currently grazed. Some ungrazed habitats (with high population densities) have not been grazed in several decades, without being markedly different from the adjacent grazed areas when it comes to the succession of vegetation (Fig. 3a). Hence, it is obvious that the yearly intense grazing, that is, a prerequisite to receive CAP subsidies, is not necessary to keep the landscape open, and it is clearly not beneficial for biodiversity on the shallow calcareous soils of our study area. The number of Natura 2000 sites is increasing in our study area, which will lead to more CAP

grazing, and is contradictory to its purpose, hence, will have further negative consequences for biodiversity.

Toward evidence-based adaptive management and favorable conservation status

While current Natura 2000 site management plans are well written, with the aim of protecting target species and habitats, this is not implemented in the real world. CAP is a strong economic force that drives management toward intense yearly grazing. Local authorities are well aware of the negative effects of too intense grazing and have therefore fenced an area within the Natura 2000 sites that harbor 39 ha of marsh fritillary habitat with high population densities. Despite the insights from this initiative, this area was grazed in 2018 (due to fodder deficiency) and the responsible authorities conclude that current intense grazing regimes shall continue across the Natura 2000 sites. The main reason is that the fenced area (with no grazing) does not qualify for CAP subsidies, which leads to a substantial financial loss for the landowners. In another part of the study area, one landowner has not agreed to establish Natura 2000 areas on his land that therefore remain ungrazed even though he could receive funding for CAP grazing. This results in 65 ha of marsh fritillary habitat being left ungrazed, which (together with the fenced area), ironically, most likely saves the marsh fritillary population. If intense CAP grazing was implemented also in these two areas, the marsh fritillary population would decrease by roughly 1000–2500 individuals (based on the average population densities in grazed and

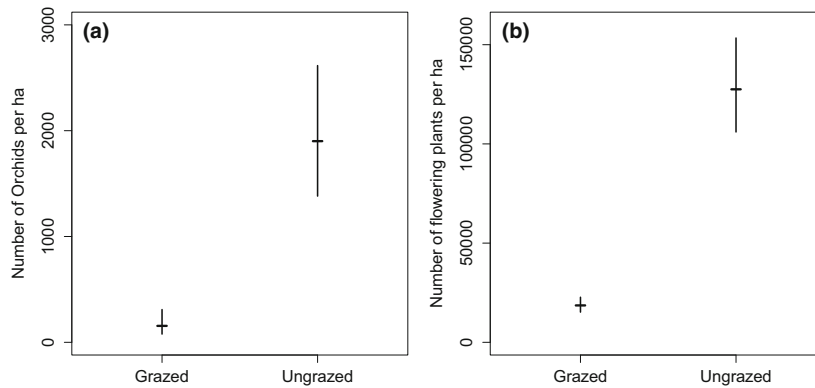


Figure 5 The density of orchids (a) and of flowering potential nectar plants (b) within grazed and ungrazed marsh fritillary habitat. Model predictions (based on Table 2) were made for a grid cell with an average number of plots and then extrapolated to a density per hectare. The graphs show the mean number of plant specimens per hectare with 95% confidence intervals.

ungrazed habitats from 2017 to 2019). In contrast to the implementation of CAP grazing, other land-use changes that may affect the conservation status of Natura 2000 target species require careful investigations and compensatory measures. For example, 7.5 ha of new functional marsh fritillary habitat must be created to compensate for the loss of 6.5 ha of habitat due to an expanding limestone quarry in the area (The Land and Environmental Court, 2020). At the same time, the current management strategy may reduce the effective habitat area by ~96–125 ha. As target species and habitats are declining, adaptive management needs to be implemented in Natura 2000 sites to achieve the “favorable conservation status” of target species and habitats. Natura 2000 management needs to be prioritized and get the funding to match, and be able to overrule, CAP-grazing regimes when required, or CAP needs to be more flexible and allow less intense grazing regimes (Pe’er *et al.*, 2021).

Implications for management

Some grassland types, such as alkaline fens, have a naturally slow succession rate due to spring flooding, summer droughts, and disturbances/grazing by wild animals (Middleton, 1999). Moreover, rare extreme weather events such as storms, flooding, and burst of ice will further prevent succession and create habitats that may favor species that respond rapidly to such natural disturbances (Pickett, Pickett & White, 1985). However, if the hydrology is not intact (e.g., due to ditching), the succession rate of shrubs and trees will increase due to reduced water levels. Restoring intact hydrology (by refilling/blocking ditches) would, thus, be an important and relatively easy measure to maintain the alkaline fens open without yearly grazing. The amount of Natura 2000 grassland areas is expanding dramatically in recent years and many more areas are planned to be established in the future. If high-intensity yearly CAP grazing continues to be the general and only management of these grasslands devastating consequences for Natura 2000 habitats and target species will follow. To improve the situation, CAP should support more low-intensity grazing regimes (Pe’er *et al.*, 2021).

Yearly grazing may not be appropriate at all in low-productive grasslands, even when regulating livestock densities, livestock breeds, or excluding grazing during parts of the season, which could work in areas with higher productivity (Ravetto Enri *et al.*, 2017). In our study area, grazing should preferably be excluded from large areas for several years to benefit the marsh fritillary and other grassland species. However, this requires changes in the CAP, to allow more flexible payments for habitat management objectives and conservation of regional target species.

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Authors’ contributions

O.K., J.A., M.F., A.F., and V.J. conceived the ideas and methodology; O.K., J.A., and M.F. collected data; V.J. analyzed the data; and O.K., M.F., and V.J. wrote the manuscript. All authors contributed to the manuscript and approved publication.

Data availability statement

We intend to make data available via the Dryad Digital Repository.

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1. The species list from the plant survey.