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## Seasonal variations of fodder quality and availability as constraints for stocking rates in year-round grazing schemes

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### ABSTRACT

Year-round grazing by free-roaming herds of cattle and horses is increasingly applied for conservation management of grasslands. In such grazing schemes, periods of fodder shortage can occur in winter and early spring, but supplementary feeding is usually avoided. Hence, stocking rates have to be adjusted precisely to seasonal fodder availability for animal welfare reasons. We investigated the seasonal changes of biomass quantity and quality at four year-round pastures in northwest Germany, two on nutrient-rich and two on nutrient-poor soils. In total, 248 biomass samples were taken in spring, summer, fall and winter 2013 and 2014, and across different vegetation types. The samples were analyzed for fiber contents, calcium, magnesium, potassium and crude protein. Maximum grazing capacities for all pasture and vegetation types were calculated for each season and for cattle and horses separately. Overall, biomass quantity and nutrient contents were lower in nutrient-poor than nutrient-rich sites. Biomass quality varied less over the year at nutrient-rich compared to nutrient-poor sites. At nutrient-rich sites, a greater fluctuation in biomass quantity was measured over the year. In spring, biomass quantity was lowest in both pasture types, whereas nutrient values were lowest in spring at nutrient-poor and lowest in winter at nutrient-rich sites. Calculated grazing capacities were lowest in spring in both pasture types, but were limited by nutrient content at nutrient-poor sites and by biomass quantity at nutrient-rich sites. Hence, an adjustment of stocking rates simply to fodder quantity seems possible at nutrient-rich sites, whereas at nutrient-poor sites calculations under consideration of nutrient contents are recommendable. Especially for cattle, some nutrient contents of biomass were below requirements in winter and spring at nutrient-poor sites so that we rather propose grazing by horses or nutrient supplementation during the winter season. This study showed that adequate livestock nutrition under year-round grazing is possible, but that additional feeding or other measures might be necessary when pasturing very nutrient-poor habitats.

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### 1. Introduction

Livestock grazing has been a typical component of the traditional management of European cultural landscapes for hundreds of years (Bakker and Berendse, 1999; Wallis de Vries et al., 1998). Due to socio-economic changes and intensification of agriculture, the area of species-rich and structurally diverse grasslands, especially those on nutrient-poor soils, has strongly declined throughout Europe since the 1950s (Bakker and Berendse, 1999; Cousins and Eriksson, 2008; Wesche et al., 2012).

Accompanied by this, many species, especially light-demanding and low-growing ones adapted to nutrient-poor conditions, became rare or endangered. Due to these changes, conservation should mainly focus on the maintenance or restoration of unfertilized oligo- and mesotrophic grasslands (Bakker 1989; Bobbink et al., 1998). To sustain their long-term habitat quality, the introduction of an adequate management is of crucial importance (e.g. Fleischer et al., 2013; Schwabe et al., 2013). Nowadays, low-intensive management is increasingly subsidized via agri-environmental schemes and many sites are managed primarily for conservation reason, especially sand grasslands and heathlands.

During the past two decades, year-round grazing by rather mobile cattle and horse herds, fenced only in comparatively large areas and not on grazed fields, was established in many sites in

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northwest Europe as rather cheap management option, especially for the management of remote or less productive sites. Under such grazing systems, grazing livestock on site even in times of fodder shortage in winter and early spring. Meat and dairy production is usually not the main purpose of such systems, but livestock is kept to slow down succession and maintain open habitats, in contrast to traditional and conventionally pastoral systems. Livestock is not herded by herdsmen, but can move and graze freely. In year round grazing systems, there are always trade-offs between conservation goals and animal welfare. On the one hand, for conservation reasons, grazing livestock is kept to remove biomass and nutrients to counteract eutrophication and fertilization and supplementary feeding are avoided, if possible, to reduce nutrient inputs. However, on the other hand, this should not go at the cost of animal health. Hence, stocking rates have to be adjusted carefully to grazing capacity over the seasons, especially in least productive habitats such as sand grasslands or heathlands (Bokdam et al., 2003; Bokdam and Wallis de Vries, 2003). Hence, for the calculation of grazing capacities of year-round pastures, knowledge about seasonal changes of biomass production and limiting nutritional factors is of crucial importance. Based on our experience, in practice stocking rates are primarily estimated by the quantity of biomass available at the grazing site, neglecting the fact that biomass quality can also constrain stocking density (Grace and Knowles, 2012). Fluctuations in quantity and quality of during the growing season are well established (Beck and Peek, 2005; Holland et al., 2008; Kleinebecker et al., 2009; Mládek et al., 2011), but have rarely been measured in winter (e.g. Bokdam and Wallis de Vries and Daleboudt, 1994).

In this perspective, we hypothesize that there are differences in the suitability of sites and vegetation types for year-round grazing due to differences in soil conditions and productivity (Wallis de Vries, 1996; Gilhaus et al., 2015, 2014). Furthermore, type of grazers, especially ruminants and hind-gut fermenters, vary in their grazing habits and nutrient demands (Holland et al., 2008; Rook et al., 2004) so that we presume differences in their suitability for year-round grazing in certain vegetation types. For our study, we focused on cattle and horses as typical representatives of ruminant and non-ruminant digestion, which are often used as grazers in year-round pastures.

To give an overview about the seasonal changes of fodder supply and nutritional biomass quality and hence of grazing capacities within different pasture and vegetation types, we address the following question: How do seasonally changing biomass quantity

and quality influence grazing capacities of year-round pastures of different productivity and of different vegetation types?

## 2. Methods

### 2.1. Study sites

We studied biomass features of four pastures managed in a year-round grazing scheme in northwest Germany (Table 1). Climate of the region is suboceanic with relatively mild winters and moderately warm summers. Whereas the sites Emsaue Pöhlen and Hervester Bruch have nutrient-rich soils (mean calcium-acetate-lactate (CAL) soluble phosphorous contents  $4.37 \text{ mg} \times (100 \text{ g})^{-1}$  soil (except restored sand grasslands:  $1.62 \text{ mg} \times (100 \text{ g})^{-1}$ ) and  $3.6 \text{ mg} \times (100 \text{ g})^{-1}$  soil, respectively, mean CAL soluble potassium contents 7.3 and  $6.3 \text{ mg} (100 \text{ g})^{-1}$  soil, respectively; own data) and were formerly used as agricultural land, the nutrient-poor pastures Brügggen and Höltingbaum (mean CAL soluble phosphorous contents  $0.4 \text{ mg} \times (100 \text{ g})^{-1}$  soil and  $2.5 \text{ mg} \times (100 \text{ g})^{-1}$  soil, respectively, mean CAL soluble potassium contents 3.0 and  $6.4 \text{ mg} \times (100 \text{ g})^{-1}$  soil, respectively; own data) are former military areas and have never been fertilized, but grazed by sheep with low stocking rates prior to the establishment of a year-round grazing scheme. Note that due to the absence of fertilization, all year-round pastures, even those called 'nutrient-rich', are mesotrophic to oligotrophic compared to conventionally managed pastures. However, as we only compared year-round pastures, we used 'nutrient-rich' and 'nutrient-poor' to describe differences in pasture type.

All studied pastures are grazed by herds of robust cattle (Heck and Galloway breeds). At some sites, additionally konik horses or sheep and deer are used as grazers (Table 1). Stocking rates are below  $0.3 \text{ livestock units per ha (LU ha}^{-1}\text{)}$  at the two military training areas, and about  $0.6 \text{ LU ha}^{-1}$  at Pöhlen and Hervester Bruch. In all cases the entire study site is accessible for the grazers year-round.

Vegetation is structurally diverse at all sites comprising different vegetation types. Prior to sampling the study areas were stratified based on aerial photographs with validations in the field. To estimate biomass quality and quantity, we sampled three to four structurally well-defined major vegetation types at each site (Table 1, Appendix A1). Dry heathlands, dominated by *Calluna vulgaris*, and sandy grasslands with species such as *Aira caryophylla*, *Filago minima* and *Jasione montana* exclusively occurred on nutrient-poor sandy soils (Appendix A1). Grazing lawns comprised short-growing vegetation shaped by regular

**Table 1**  
Characteristics of the year-round pastures investigated in this study.

Study site	Coordinates	Federal State	Size [ha]	Elevation [m a.s.l.]	Grazing animals [numbers]				Percentage area of each vegetation type [%] <sup>a</sup> (number of plots per vegetation type and season)				
					Heck/Galloway cattle	Konik horses	Sheep	Fallow deer	Dry heath	Sand grassland	Grazing lawn	Forb dominance	Wet grassland
Nutrient-poor sites													
Brügggen	51°16'N, 06°09'E	North Rhine-Westphalia	260	58	12	13	700 <sup>b</sup>	>150	20 (4)	8 (4)	1(4)	–	3 (4)
Höltingbaum	53°37'N, 10°12'E	Hamburg	180	45	75	–	140	–	–	10 (4)	60 (4)	5 (4)	5(4)
Nutrient-rich sites													
Emsaue Pöhlen	52°01'N, 07°46'E	North Rhine-Westphalia	22	53	10–15	5	–	–	–	20 (5)	60 (5)	–	10 (5)
Hervester Bruch	51°41'N, 07°01'E	North Rhine-Westphalia	24	35	10–15	–	–	–	–	–	40 (5)	20 (5)	20 (5)

<sup>a</sup> Rest of the area mainly woodland/ponds.

<sup>b</sup> Only in some parts of the area and for few weeks per year as mobile herd.

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