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Spatial relation between open landscapes and debarking hotspots by European bison (*Bison bonasus*) in the Rothaar Mountains

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Abstract: In 2013, a herd of European bison (*Bison bonasus;* Linnaeus, 1758) was released into the forest region of the Rothaar Mountains, Germany. The species is mostly known as grazer but also browses upon shrubs, tree bark and other roughage forage. Since the reintroduction, the population of E. bison has been growing up to 19 individuals, which started to show debarking behaviour in some areas. This behaviour caused a considerable human/wildlife conflict in the Rothaar Mountains, since the debarked patches were partially situated in privately owned commercial forests, which was connected with economic losses for local foresters. In order to investigate this issue, we determined spatial factors that may be related to debarking behaviour of the E. bison in the Rothaar Mountains, Germany. After establishing a list of potential debarking drivers, we conducted a GIS analysis of the tree utilisation in coherence with the open landscape areas in the Rothaar Mountain areas. The GIS analysis showed that patches with high debarking damage appear to be located closer to artificial feeding plots than to other open landscape types. We thus conclude that there might be an association between artificial feeding plots as open landscape areas and the debarking events of the E. bison in the Rothaar Mountains. Moreover, this case study is an example of how anthropogenic factors may affect scientific research.

Keywords: European bison, debarking, habitat composition, open landscapes, reintroduction, human-wildlife conflict

Introduction

In many parts of the world human/wildlife conflicts occurred since the beginnings of permanent human presence. Especially the expansion of human settlements into natural habitats are playing a key role in this conflicting situation (Woodroffe *et al*. 2005). In central Europe, species like wolf (*Canis lupus*) (Jędrzejewska *et al*.1996), bear (*Ursus arctos*) (Swenson *et al.*1998), and European bison (*Bison bonasus*) (Żabiński 1957) were pushed back into small parts

of their former habitats, due to agriculture, hunting or human related infrastructure. As a consequence, populations of those species decreased considerably almost to the verge of extinction within the last two centuries. However, in the last decade the mindset of the main nature conservation management changed considering the problems of ecosystems' conservation and the intrinsic value of nature. This led to reintroductions of certain species into their natural habitats. These reintroductions also occurred in parts of the world where human population significantly increased its density, thus intensifying the potential for conflicts between people and wildlife (Dickman 2010).

Since the European bison in the Rothaar Mountains are entirely free ranging, their debarking behaviour in this region triggers a human/wildlife conflict due to the debarked trees that decrease in economic value to a limited extent in the privately-owned forest areas, which are used for timber production.

Tree bark is a natural food source for E. bison and is therefore regularly consumed among other food items (Gębczyńska *et al*. 1991; Borowski & Kossak 1972; Krasińska *et al*. 1987). Only little information is known on the E. bison's debarking behaviour in the Rothaar Mountains. The studies of Saint-Andrieux *et al.* (2008), Feher *et al.* (2016) and Zidar (2011) found similar behaviour patterns on the debarking behaviour of roe – and red deer, although the specific reasons are not clarified either. Yet, there are many hypotheses why ungulates in general debark trees, such as parasite protection, nutritional needs or food and water supplementation (Saint-Andrieux, *et al*. 2008).

This research intended to investigate if there is a spatial relationship between debarked patches and spatial patterns of land use, open landscape habitats in particular.

Material and methods

Population

The free roaming herd grew from eight to its highest number of 23 individuals during the years of 2013 to 2017 and currently its population counts 19 individuals. For this study GPS location data from two GPS collars (collars: Vertex Plus Collars by Vectronic Aerospace GmbH) were used, worn by the leading cow and the second ranked female between the 01/05/2013 and 21/12/2016. GPS locations with the same timestamp were deleted to eliminate duplicates in the data set. In total 13,323 GPS locations with one-hour intervals combined from both collars were used for analysis.

Site

The study area is located in the Rothaar Mountains, a low mountain range in North Rhine-Westphalia (NRW) in the west of Germany (51°06'00.0"N, 8°20'00.0"E) at 400–760 m above sea level. The ridgeline of the Rothaar Mountains, the Rothaarsteig, separates two neighbouring counties Siegen-Wittgenstein (South) and Hochsauerland (North) from each other and forms a political boarder. Shortly after the reintroduction in Siegen-Wittgenstein, the E. bison herd also utilised and adapted the area north of the ridgeline as part of its home range (Schmitz 2015; Herbst Siebert 2016). A major part of the herd range is located in the Natura 2000 site "Schanze" (No. DE-4816–302) covering an area of 6.153 ha. The region is characterised by mainly cultivated coniferous, broadleaved and mixed forests. The coniferous habitats are dominated by spruce trees (*Picea abies*) with diverse and rich undergrowth such as common wood sorrel (*Oxalis acetosella*), heath bedstraw (*Galium hercynicum*), European blueberry (*Vaccinium myrtillus*) and different species of ferns (*Polypodiopsida*) (Caspers 2013; Schmitz *et al.*, 2013). The deciduous habitats are dominated by shady Luzulo-Fagetum beech forests consisting of mainly beech trees (*Fagus sylvatica*) with scarce undergrowth of acidophilic plant species such as white wood rush (*Luzula luzuloides*) and wavy hair grass (*Deschampsia flexuosa*) (European Environment Agency 2013). Open landscapes form an additional part of the home range as well as the Natura 2000 area. In particular private owned landmarks, however, grasslands and meadows were manured or often turned into artificial feeding plots for wildlife. One man made feeding plot for E. bison is located in Siegen-Wittgenstein in order to decrease economic damage caused by debarking during the winter months. Also this herd frequents another feeding site arranged for red deer in the same county.

Data collection

Locations and information about debarking damage was derived from five different personal sources: three on the Siegen-Wittgenstein side and two on the Hochsauerland side. The quality and the method how information was recorded and passed on differed significantly from each other (analogue land parcel maps, digital screenshots of maps, drawn polygons).

Information about intensity of debarking could only be provided by the sources on the Hochsauerland side. The intensity was classified as migration related damage with single trees being damaged only very sporadically within an area, light damage on trees was considered to be caused less than once a year, intermediate damage was considered to be caused at least once a year and heavy damage was considered to be caused more than twice a year.

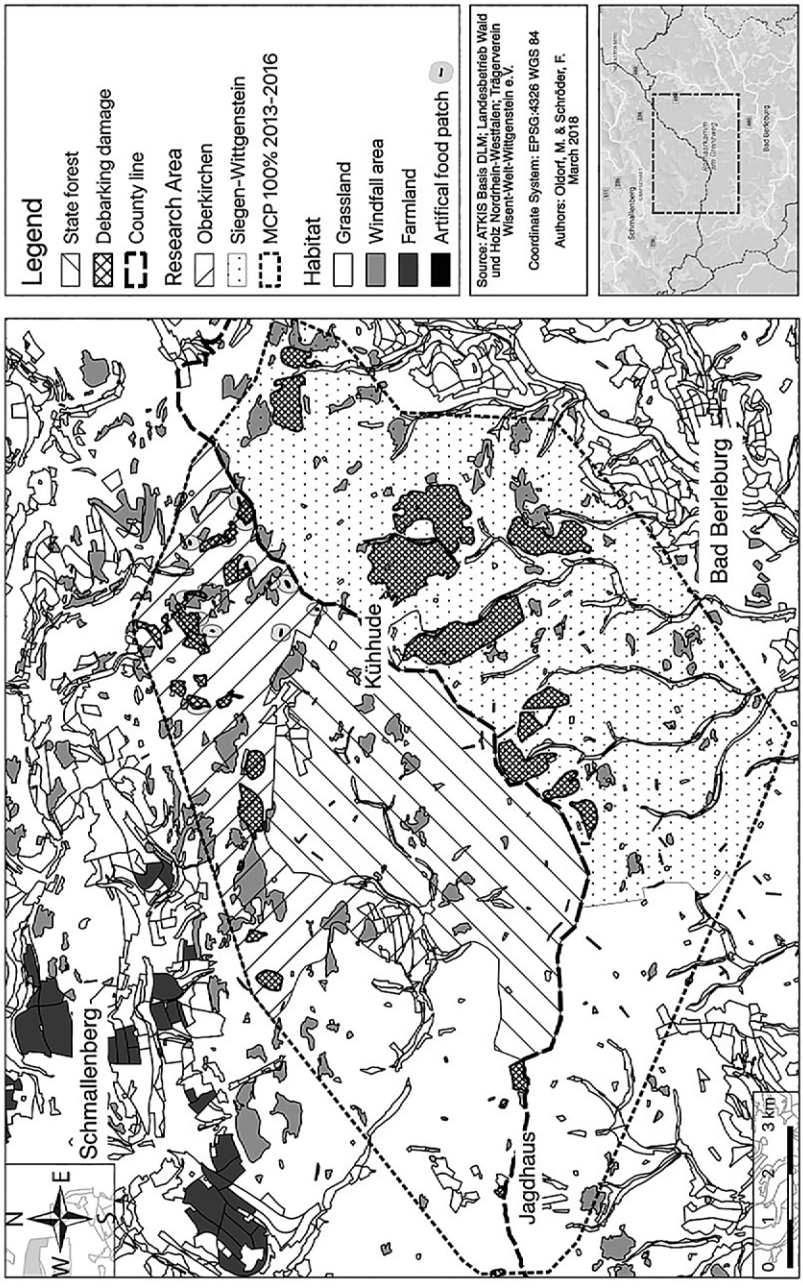

Figure 1 Debarking damage in the home range of the E. bison herd in the Rothaar Mountains in relation to open landscape types. Polygon size of the damage does not refer to the degree of debarking damage. Artificial food patches are highlighted with a buffer to increase visibility due to small area size.

Data analysis

To get the ratio of each available habitat type, the total area of each habitat type was divided by the total area of all available habitats. To compare only the ratios of each available open landscape habitat, forest habitat types were excluded from the calculations.

Results

The open landscapes within the E. bison's home range in the Rothaar Mountains consist of artificial feeding plots (0,04%), farmland (0.01%), grassland (5.90%), and windfall areas (5.33%). The forested areas consisted of: coniferous forests (41.69%), deciduous forests (34.04%) and mixed forests (12.98%). In comparison to other habitat types artificial feeding plots constituted only a very small proportion of the whole area.

The size of the mapped areas did not correlate with the amount of debarking damage. Some parts of the forest were marked as debarked, although the precise number of debarked trees within their area was unknown. On the Siegen-Wittgenstein side debarking records were obtained from three different forestry districts. Seven deciduous and three coniferous tree stands were damaged there. On one occasion a damaged mixed forest was recorded. The damages recorded in the north were mainly located in the forestry district "Oberkirchen" at Hochsauerland county. In this district 15 deciduous and ten coniferous tree stands were damaged through debarking by E. bison.

In the core area of E. bison home range, which is a state forest, no information about debarking damage was obtained. Towards the western areas of the home range, damages were seemingly more scattered. Two coniferous and two deciduous stands were damaged there (Fig. 1).

Debarking damage in the Siegen-Wittgenstein area were recorded seemingly in similar proportion in proximity to windfall areas and grasslands. One hotspot of damages was located near the grasslands of "Kühhude". The second seemingly concentrated damage zone is located in the south with no obvious relation to larger windfall or grassland areas. The third accumulation of damages is located in the north of the Siegen-Wittgenstein area, close to large windfall areas. No information about damage zones close to the artificial feeding plots near the county line to Hochsauerland could be obtained (Fig. 1). Information about the degree of damage could only be obtained in the Oberkirchen area. Heavy debarking damages only occurred on two occasions in the eastern part of the area. The most frequent were slightly damaged areas, followed by spots with migration – and intermediate damages.

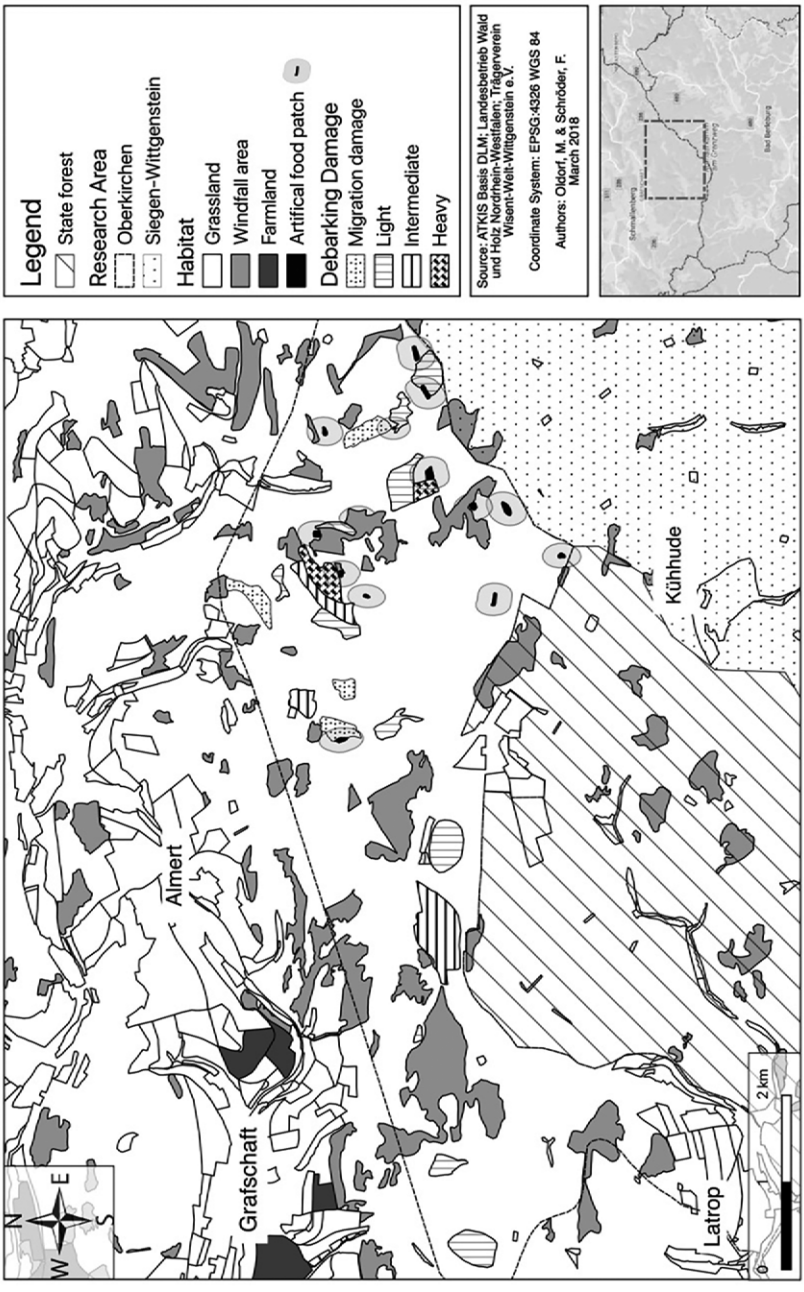

Figure 2 Debarking damage in relation to open landscape areas in the research area Oberkirchen in Hochsauerland county. Artificial food patches are highlighted with a buffer to increase visibility due to small area size.

In relation to open landscape habitats, heavy damage zones could be recorded only near and around artificial feeding plots. Also, damaged spots appeared to be spatially related to windfall areas. However, larger and more numerous windfall areas occur towards western extents of the research area, where only light and intermediate damages were recorded. Locations of spots with migration type damages enclosed the heavy damage hotspots near the artificial feeding plots in the east of the study area in Hochsauerland. No damaged zones were recorded in direct proximity to grasslands (Fig. 2).

Discussion

This case study proved that in the Rothaar Mountains open landscapes represent only a very small proportion of habitats available for E. bison. The open landscapes are represented there by grasslands and farmlands around a large continuous forested area and mainly by forest gaps within forest stands caused by windfalls. Forest gaps are important habitats as they are rich in pioneer vegetation. They provide an important food source for all kinds of ungulate species, including E. bison (Kuijper *et al.* 2009). Also, artificial feeding plots are only a small part of E. bison home range. Those feeding plots tend to be an even richer food source than forest gaps, since they are established to provide supplementary forage and attract game species (Völk 1999). Until 2015, those artificial feeding plots were cultivated with fodder beet. This practice however is illegal nowadays, allowing only the maintenance of grasslands used for attraction of game species (Ministry NRW 2019). Regarding the nutritional values, grasslands are the least rich habitat but, according to Kerley *et al.* (2012), represent historically the most natural habitat in accordance to the original niche of the E. bison (Kuijper *et al.* 2009).

Based on conducted research in the reintroduction sites of Białowieża and Kraansvlak, drivers of debarking appear to be artificial feeding sites (Caboń-Raczyńska *et al*. 1987; Kowalczyk *et al*. 2011; Cromsigt *et al*. 2017), seasonal nutritional requirements (Caboń-Raczyńska *et al.* 1987; Kemp Cromsigt 2012; Cromsigt *et al*. 2017; Vlasakker 2014; Lehto 2015), and limited availability of grass within a home range (Cromsigt *et al*. 2017).

In the Rothaar Mountains within the winter supplementary feeding plots higher utilisation rates were recorded compared to the surrounding area, resulting in obvious tree damage in its close proximity. This effect was possible to be observed in Białowieża where winter feeding sites strongly affect the home range size of E. bison herds and result in their strong aggregation around the area where food is provided (Mysterud *et al.* 2007).

An intense utilisation of an area by ungulate species, including E. bison, close to attractive food sources could also be observed in a study by Kuijper *et al.* (2009). He found that preferential foraging led to an uneven distribution of foraging behaviour, which again had an influence on the size of the home range and utilisation distribution. His study provides evidence that E. bison may be confined to an area due to the availability of attractive food, resulting in intense utilisation of an area and thus potentially in more intensive debarking.

However, this assumption might only be valid if the overall amount of debarking damage in the home range of E. bison does not change significantly over the years. If debarking is increasing, other factors such as nutritional needs must be taken into account. The urge to compensate with woody materials after the ingestion of a certain food items may play a crucial role. A study conducted by Kowalczyk *et al.* (2011) on the diet of herbivores in Białowieska Forest revealed that increasing access to supplementary fodder in the form of dry hay significantly reduced the amount of woody materials consumed by E. bison. Similarly, Cromburgghe (1965) found a significant increase in debarked beech trees by red deer in summers with more precipitation, thus where there were higher amounts of wet food available. This suggests that E. bison might compensate ingestion of wet food with relatively dry fibre of tree bark (Gill 1992; Reimoser Gossow 1996). This supports the findings of more intensive debarking close to artificial feeding plots, which tend to be more wet than other types of open landscape (Claußen 2014). Nevertheless, also seasonal changes in general may have an influence on the debarking behaviour of ungulates. Cromsigt *et al.* (2017) recorded debarking damage in Kraansvlak, Netherlands, mainly during winter and early spring, assuming that this phenomenon occurred due to limited grass availability during winter followed by higher intake of woody tissues.

Therefore, debarking could be related to climatic fluctuations, particularly differences in precipitation, or various levels of supplementary feeding which would support the assumption that debarking is a form of foraging compensation resulting from nutritional deficiencies.

Limitations for research and future perspectives

The study was based upon various sources allowing the collection of data on debarking damage. Ongoing human/wildlife conflicts caused obstacles in obtaining data. The political situation in the study area made it difficult to collect precise data since landowners estimated debarking in different ways or were reluctant to help in this research due to the conflict. Records of damages could only be obtained from the official damage surveyors for compensation

payments and from rangers on duty in the southern area of the home range. As a result, data that was collected following varying standards, lacked accuracy in the spatial component and an intensity of damage. Furthermore, the refusal of some forestry units within the studied home range resulted in large "no data" areas. All records were based on random findings by forestry officials. Therefore, to fully understand the extent of the debarking and potential drivers of such behaviour a standardised data collection method is necessary. Furthermore, there were no data on the available biomass within particular non-forested patches. Therefore a large grassland area might have less biomass available than a smaller windfall forest gap.

Future work in the Rothaar Mountains should focus on obtaining reliable data with a standardised method to analyse the causes of debarking in detail. This includes precise spatial information collected with GPS devices rather than personal communication which was used in this study. As discussed earlier, nutritional needs might have an impact on the debarking intensity in certain parts of the home range. Therefore, also the nutritional values of particular components of E. bison food base such as artificial feeding plots should be studied in more detail.

Conclusion

According to obtained results, there may be a relationship between open landscapes and the locations of debarking events. Artificial feeding plots for game species are apparently closer to high damage zones than other open landscape types. The primary findings of the study indicate that the E. bison may be spatially restricted by attractive food sources, leading to high debarking intensities in certain, intensely used areas. This, however, should be considered in relation to nutritional needs of those animals, perhaps as a compensation of deficiencies resulting from consumption of other forages. This case study provides some indication which spatial factors should be considered in order to mitigate local human/wildlife conflict and to allow successful E. bison reintroduction projects in the future. However to explain the relationship between debarking behaviour and habitat type, more information on location, time and intensity will be necessary. This can only be done in collaboration with all landowners and other stakeholders involved in the ongoing human/wildlife conflict. These anthropogenic influences, such as political disruption partly caused by human/wildlife conflicts must not be underestimated in planning future research, especially regarding the possibility of data collection. This case study showed clearly that for successful nature conservation it is crucial to obtain a political and social conflict-free interaction with all parties involved.

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Przestrzenna analiza miejsc występowania spałowania przez żubry (*Bison bonasus*) w relacji do terenów otwartych w górach Rothaar

Streszczenie: W roku 2013 stado żubrów (*Bison bonasus*) zostało wsiedlone do leśnego regionu gór Rothaar w Niemczech. Jak wiadomo żubr jest gatunkiem spasającym, ale częściowo jego dieta składa się liści, gałęzi i kory krzewów i drzew. Od momentu reintrodukcji populacja żubra wzrosła do 19 osobników i w niektórych obszarach stado to pozostawiało po sobie wyraźne ślady spałowania. Stwierdzane szkody spowodowały narastanie konfliktu między ludnością a dzikimi zwierzętami w tym rejonie gór Rothaar, ponieważ częściowo zniszczone drzewa znajdowały się w prywatnych lasach utrzymywanych dla celów komercyjnych, co wiązało się ze stratami ekonomicznymi dla właścicieli. W celu zbadania skali problemu określiliśmy jakie czynniki środowiska mogą być związane z intensywnością spałowania. Po zdiagnozowaniu wielkości i miejsca uszkodzeń przeprowadziliśmy analizę GIS w powiązaniu z otwartymi obszarami krajobrazu gór Rothaar. Analiza GIS wykazała, że fragmenty z silnymi uszkodzeniami drzewostanu wydają się znajdować bliżej miejsc dokarmiania w stosunku do innych elementów przestrzeni. W związku doszliśmy do wniosku, że może istnieć związek przestrzenny między przygotowanymi poletkami żerowymi w otwartym krajobrazie a przypadkami spałowania przez żubry w rejonie gór Rothaar. Na podstawie tego studium przypadku można pokazać jak czynniki antropogeniczne mogą wpływać na wyniki badań.