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Winter food and cover refuges of large ungulates in lowland forests of south-western Poland

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ABSTRACT

We examined the winter habitat selection of forest types and age classes of tree stands by red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*) and determined potential refuges for these ungulates in the Bory Dolnośląskie forest, which covers an area of 644 km^2 in south-western Poland. We determined habitat use from ungulate tracks in the snow in February 2009 and 2010 on line transects (total length = 365 km) and the numbers of animals that crossed the transects, and their locations related to forest types (n = 9), and age classes of tree stands (n = 6). Significant preferences by red deer were for hygric mixed coniferous and mesic mixed deciduous forest and young forest plantations, thickets, and tree stands over 60 years old. Roe deer preferred mesic mixed coniferous forests, young plantations and tree stands older than 60 years. Hygric mixed coniferous and hygric deciduous forests, and thickets and tree stands aged from 61 to 80 years were preferred by wild boars. Habitat preferences were associated with higher food reserves, better thermal and hiding covers, and energy requirements of large ungulates. The patches of forest types and age classes of tree stands preferred by large ungulates which overlapped on digital maps were treated as refuges. Refuges (n = 19) for red deer occupied 131 km^2. Roe deer refuges (n = 24) covered 54 km^2, and those of wild boars (n = 18) covered 53 km^2. In the Bory Dolnośląskie forest, daily activity of large ungulates is disturbed by forest managers practices, hunting and tourism. Determining winter refuges can be used by forest management to do the following: to shift forest management from winter to autumn, to exclude the use of hiking/biking trails and camping sites in the winter season, as well as to design changes in the distribution of drive hunt areas.

1. Introduction

In Poland, forest managers use the harvesting of timber to create clearcuts and forest gaps of various sizes. This harvesting results in stands that differ by forest type, dominant species and age classes. Therefore, in the forest environment, a mosaic of patches emerges consisting primarily of three elements: forest types, predominating tree species destined for timber, and the age classes of tree stands. Individual patches of the mosaic differ in biomass and quality of potential forage for wildlife (Dzięciołowski, 1969; Bobek et al., 1992), and by the effectiveness of shelter against adverse weather conditions (temperature, wind, precipitation) (Mysterud and Østbye, 1999; Geiger et al., 2009; Renaud et al., 2011). Ungulates tolerate low temperatures by reducing the temperature of distal parts of their bodies (Arnold et al., 2004), heat produced by metabolism, and insulation provided by their hair (Parker and Robbins, 1983). However, they face major problems in compensating heat losses when exposed to strong wind, and when soaked by rain or snow precipitation (Grace and Easterbee, 1979; Parker, 1987). It is particularly significant in winter when the quantity and quality of potential forage is limited and the harsh weather conditions adversely affect the energy balance in animals.

The particular fractions of time budgets in wild ungulates such as foraging, ruminating and resting may also be disturbed by forest exploitation (Theuerkauf and Rouys, 2008), tourism (Gander and Ingold, 1997; Jayakody et al., 2008; Sibbald et al., 2011) and hunting (Sunde et al., 2009; Bonnot et al., 2013; Thurfjell et al., 2013; Jarnemo and Wikenros, 2014). This disturbance results in additional energy expenditures devoted to escape whereas interrupting foraging and ruminating, apart from the additional energy spent on moving also has negative physiological consequences, especially in wild ruminants (Bateson and Bradshaw, 1997; Mason, 1998).

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At present, there are an increasing number of studies documenting the negative effects of human disturbance on wildlife populations (see above and also Frid and Dill, 2002), and studies pertaining to resource selection by large ungulates (Mysterud et al., 1999; Fonseca, 2008; Godvik et al., 2009; Allen et al., 2014; Alves et al., 2014). Unfortunately, they do not translate into practical guidelines to determine refuges capable of providing an undisturbed daily rhythm of activity to large mammals. Thus, the objective of this study is to determine preferences for forest habitats among wild ungulates and refuges which best support the ecological and behavioural needs for red deer, roe deer and wild boar populations inhabiting the Bory Dolnośląskie forest.

2. Study area and methods

The study area was a piece of lowland forest covering an area of 664 km^2. This area lies within the much larger Bory Dolnośląskie forest, which, in total, covers an area of 1720 km^2 and is situated in south-western Poland near the Polish-German border. The study area within it lies between 14°58′ and 15°37′ longitude E, and between 51°14 and 51°27 latitude N (Fig. 1).

The principal habitats are mixed coniferous forests, and coniferous forests occupying respectively 47.4% and 46.5% of the study area. The remaining part (6.1%) is covered by mixed deciduous and deciduous forests. The principal forest tree is pine *Pinus sylvestris* which constitutes 93% of all tree stands. The remaining part is formed chiefly by birch (*Betula* sp.), beech (*Fagus sylvatica*), and oak (*Quercus robur*). The age structure contains mostly mid-age classes of which tree stands aged from 41 to 60 years predominate (35.1%). Tree stands aged more than 80 years constitute 15.8% of the total area of all forest stands. These are stands with gaps, not exceeding an area of 0.2 ha, occurring among mature trees, taken over by young forest plantations. The proportion of young forest plantations (aged 1–10 years) is 7.1%, whereas thickets (age 11–20 years) account for 4.9% (Kobielski et al., 2007).

Game management belongs to 845 members of 13 hunting clubs. During 2009–2010 the average annual hunting bag amounted to 802 red deer, 552 roe deer and 1,125 wild boar. Collective hunts are permitted from October to January. One collective hunt includes 5–6 plots that are driven by beaters and dogs. The population densities of the studies species were estimated by means non-linear regression, where the relative population density (N/km) was the independent variable, and population density – the dependent variable. In 2009, the red deer population density in the study area amounted to 39.0 individuals/1000 ha, and these of roe deer and wild boar – 59.9 individuals/1000 ha and 19.5 individuals/1000 ha respectively. In 2010 the densities of the species per 1000 ha of forest was estimated at 39.0 (red deer), 57.2 (roe deer) and 19.3 (wild boar). There were no statistically significant differences found between the densities in the two years compared (Bobek et al., 2012; Furtek, 2014; Bobek, unpubl. data).

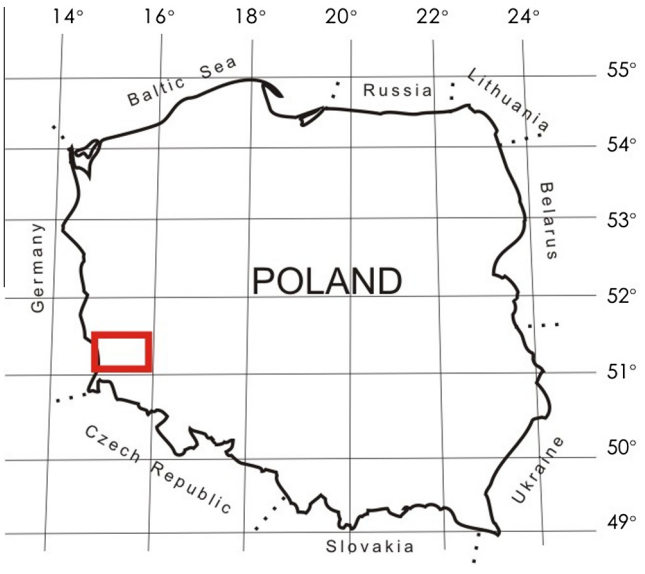

Fig. 1. Bory Dolnoslaskie forest – location of the study area in southwestern Poland.

Within the study area, 73 more or less regularly arranged transects were marked, with a total length of 365 km (Fig. 2). The transects were forest roads and forest division lines that are driveable by all-terrain vehicle in winter. The studies of habitat selection by red deer, roe deer, and wild boar were conducted in February 2009 and 2010 (Table 1). On the first day, all-terrain vehicles (n = 10) drove through all the transects and all tracks of red deer, roe deer, and wild boars were erased. Over the next five days the number of red deer, roe deer, and wild boars were recorded by counting their tracks crossing the line transects over a 24-h period; the readings of the metre or GPS at these places of crossing were also noted. In order to avoid multiple records of the same animals, in each of the separate patches representing a given type of forest habitat or age class of tree stand only one crossing by given individual or group of red deer and wild boar differing in numbers were considered in calculations. This procedure was applied to each transect and each day of tracking. For roe deer such calculations for 1 km intervals of line transects were applied. Digital forest management maps were used to determine the location of the animals vis-à-vis the habitat type and age class of forest to the left side of the transect. The numbers of located animals were cumulated the data from 2009 and 2010, separately for each of the three species studied, and for habitat types of forest and age classes of tree stands.

The lengths of sections occupied by particular types of forest or age classes of forest stands along the line transects were measured and their proportions were defined as the availability of forest habitats. The numbers of red deer, roe deer, and wild boars which crossed the sections occupied by particular forest types or age class of tree stands were added up separately for each of the three species. Next, their proportions were calculated and adopted as measures of the use of forest habitats. The habitat selection index (HSI) for particular types of forest and age classes of tree stands were then calculated as quotients of the use of a particular habitat (U) and its availability (A). The significance of habitat selection indexes were then tested using Bailey's simultaneous confidence intervals (Bailey, 1980; Cherry, 1998). The preference of a given forest habitat by red deer, roe deer, and wild boars occurred when its proportion on the transects was below the lower limit of the 95% simultaneous confidence intervals. If the proportion of a forest habitat exceeded the higher limit of the confidence intervals then such a forest habitat was avoided by the studied animal species. The random use of a forest habitat occurred when its proportion fell within the confidence intervals.

Next, the digital maps of forest districts with marked layers of forest types and age classes of forests helped to determine these subdivisions of forest compartments where habitat types of forest and age classes of tree stands preferred by red deer, roe deer and wild boars overlapped. This task was implemented by the use of ArcMap™ software developed by ESRI® (2008). The refuges for red deer and wild boars consisted of those subdivisions of forest compartments in which the types of forest and age classes of tree stands overlapped, the distances between two forest compartments were not greater than 500 m, and the combined area of forest compartments meeting this condition was not less than 1 km^2. The refuges for roe deer consisted of forest compartments where the types of forest and age classes of tree stands preferred by