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Living on the boundary of a post-disturbance forest area: The negative influence of security cover on red deer home range size

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ABSTRACT

In the face of climate change and the probable rise in the frequency of severe natural disturbances, successful management of forest ecosystems requires profound knowledge, including the one connected with the temporal and spatial relations between populations of wild herbivores and their habitats. Animal location data collected with VHF collars and spatial GIS data were used to investigate home range size of red deer living along the boundary of two contrasting forest environments which were created after a large-scale (10,000 ha) stand-replacing fire in south-western Poland. We found male home ranges to be nearly twice as large as female ones. Surprisingly, the percentage of the burned area (less penetrated by humans, although of lower food availability) was negatively correlated with deer home range sizes in all seasons. The conditions in the post-disturbance forest were relatively stable during the year, which could explain the lack of differences between seasonal home ranges. Our findings suggest that the relationship between home range size and open habitats may be determined by the distribution of the latter: patches offering the best forage seem to be worth the effort of travelling, even at the cost of home range expansion. Heterogeneity features (patch and edge density) of forest interior habitats in this study did not emerge as an important determinant of the total size of home ranges. When burned and unburned areas were analysed separately, the results revealed that their size could be at least seasonally adjusted to habitat heterogeneity: in the burned area, deer seemed to travel longer distances between preferred patches (an increase in patch density was positively correlated with home range size), whereas the opposite was observed in the undisturbed forest in winter and spring. Our findings suggest that in populations under strong hunting pressure, security cover is a key resource, determining deer space use, especially in post-disturbance forests. We concluded that large areas of cover-offering habitats may lead to local increase in deer population and higher browsing pressure also in surrounding forests. Proper planning and introduction of feeding places (open areas) might help to control the population size by hunters and thus mitigate this effect.

1. Introduction

Ecosystem-based management requires thorough knowledge of the patterns of natural disturbances (Morgan et al., 1994; Cissel et al., 1999; Landres et al., 1999). Such knowledge is also needed for conservative management of forest ecosystems (Atwill, 1994). Global warming is likely to increase the rates of forest disturbance, and changes in weather patterns will result in more forest fires caused by drought, wind and natural ignition, more convective windstorms, coastal flooding and hurricanes (Overpeck et al., 1990). In densely populated habitats, cervids exert a considerable effect on forest ecosystems, in particular young tree stands (McShea et al., 1997; Côté et al., 2004), and forests may be difficult to re-establish, naturally or artificially, after a large-scale disturbance. In Europe, the relationships between deer and post-disturbance forests have been studied by several authors (Gaillard et al., 2003; Borkowski, 2004; Widmer et al., 2004; Saïd and Servanty, 2005; Storms et al., 2006; Richard et al., 2011; Borkowski and Ukalski, 2012), however, most of the existing studies analysed the areas affected by hurricane Lothar. This paper deals with a forest area damaged by a large-scale fire and the sur-

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rounding undisturbed forest in southwestern Poland (see *Study area*).

Effective management of deer populations and forests in post-disturbance areas requires an understanding of the relationships between animals and space use. Large-scale, stand-replacing disturbances create two contrasting habitats: a relatively undiversified post-disturbance area where forests regenerate and an undisturbed forest characterized by significantly higher heterogeneity. Individuals use the space within their home range which is defined as the "area travelled by the individual in its normal activities of food gathering, mating and caring for young" (Burt, 1943), therefore, the factors that influence the size of the home range and its establishment patterns have to be identified. In general, animals use space which is a combination of various habitats. The use of habitats by ungulates reflects coping with main limiting factors (i.e. predator avoidance and forage quality/quantity) (e.g., Fryxell et al., 1988; Rettie and Messier, 2000), therefore their home ranges include habitats providing security cover and food. If so, habitat heterogeneity is an important feature of the space used by ungulates (Kie et al., 2002; Saïd and Servanty, 2005), because in highly heterogeneous habitats, even a small home range offers both food and cover.

If a forest fire increases availability of high quality forage, the attractiveness of the burned area for deer grows (Sachro et al., 2005). However, domination of a burned area shortly after a disturbance by tree species of relatively low palatability, e.g., Scots pine (*Pinus sylvestris L.*) or silver birch (*Betula pendula L.*), along with the existing poor cover conditions, contributes to the relatively low use of such an area by deer (Borkowski, 2004). Little is known about the attractiveness of such areas for red deer in subsequent stages of forest succession. It was found that in pre-thicket and thicket stages (for details see *Material and Methods*), post-disturbance areas provide ample security (concealment) cover, but are less abundant in food resources than undisturbed forests (Gmitrzuk and Obidziński, 2007).

Our overall objective was to assess the effects of a large scale forest fire on space use of red deer at different temporal scales. Home range size is usually negatively correlated with food availability/habitat structure (Tufto et al., 1996; Relyea et al., 2000; Saïd and Servanty, 2005). Therefore, the size of red deer home ranges should be positively correlated with the percentage of a post-disturbance area in pre-thicket and thicket stages (P1a). However, little is known about the influence of increased security cover (burned area) on home range size and its seasonal variability. This point is of importance since it has been documented that for sedentary (non-migrating) ungulates, predation avoidance is a determinant of their space use (Fryxell et al., 1988; Rettie and Messier, 2000).

In winter, cervids reduce their food intake and live to a remarkable extent off fat reserves (Putman, 1988). In that season, cover availability is especially important for red deer (Borkowski and Ukalska, 2008). Consequently, we predicted that in winter, home range size should be negatively correlated with the percentage of the post-disturbance area in pre-thicket and thicket stages (P1b). We also expected home ranges that contained higher proportions of post-disturbance area to be smaller in autumn (P1c) although for a different reason. In autumn, due to hunting season, cover availability is particularly important (Naugle et al., 1997).

Habitat attractiveness may be difficult to define in areas combining contrasting habitats. Due to habitat dissimilarities, home range size in post-disturbance and undisturbed areas may be influenced either by different environmental factors or in different ways by the same factors. Since as mentioned earlier, cervids tend to include in their home ranges the habitats that provide both food and cover, our general prediction is that the percentage of the home range occupied by the two contrasting areas will be determined by habitat type. We specifically predicted that the size of the part of the home range size located in the undisturbed forests[1] (more abundant in food) should be negatively correlated with the percentage of habitats providing food as well as the percentage of habitats offering security cover (P2a). The post-disturbance forest home range size (less food, abundant cover) should be negatively correlated with the percentage of habitats abundant in food and should be independent of the percentage of habitats providing cover (P2b). The reason why the post-disturbance area home range size should be independent of habitats providing cover is that the cover due to its amount is probably not a limiting factor. In autumn, due to hunting, cover-providing habitats should be negatively correlated with the size of the home range in both post-disturbance and undisturbed forests due to hunting pressure (P2c).

As mentioned above, one of the factors affecting space use by ungulates is habitat heterogeneity. It has been shown that patch number and edge density negatively influence the size of deer home ranges (Kie et al., 2002; Saïd and Servanty, 2005) and in heterogeneous habitats, even within small home range they can satisfy their needs for both food and cover. Therefore, we predicted that the length of the boundary between the post-disturbance forest (offering ample cover and probably used mostly for resting) and the undisturbed forest (more abundant in food) will negatively influence home range size (P3a) because it will provide the animals with instant access to feeding and resting areas. The previous studies focused mostly on patches of distinct habitats offering either food or cover (forest clearings or ecotones between a forest and farm fields), especially on a larger spatial scale (Kie et al., 2002; Saïd and Servanty, 2005). However, much less is known about the influence of habitat heterogeneity on a smaller scale and, consequently, about relatively undiversified habitats in the forest interior. This is an interesting consideration because deer were found to respond even to small patches of different forest habitats (Borkowski, 2004; Borkowski and Ukalska, 2008). We predicted that in the more heterogeneous, undisturbed forest, home range size will be negatively correlated with habitat patch density and edge density (P3b), whereas in the post-disturbance area, home range size will not be influenced by habitat heterogeneity (P3c). The last prediction is based on the fact that the area in question is quite homogenous and we believe that in such conditions home range size should be independent of habitat heterogeneity. The predictions tested in this study are listed in Table 1.

2. Materials and methods

2.1. Study area

The study was carried out in the Forest District of Rudy Raciborskie with an estimated area of 17,500 ha in southwestern Poland. In 1992, nearly 10,000 ha of forest area burnt down in three adjoining forest districts. Rudy Raciborskie sustained the greatest loss with nearly 5000 ha of forest burned to the ground. After the fire, the remaining trees were cut down, the stumps were removed, and the area was regenerated in 1993–1997.

Habitat composition in the post-disturbance forest was much less diversified than in the undisturbed forest. It was dominated by pine and non-pine (mostly birch) pre-thickets and pine thickets. Patches of old pine stands that survived the fire as well several small grassy patches were also present. Coniferous habitats accounted for approximately 65% of the undisturbed area. Scots pine was the dominant tree species with up to 85% cover. The

[1] For the sake of brevity, hereinafter, the term *undisturbed/post-disturbance forest home range size* will be used instead of *size of the proportion of home range located in undisturbed/post-disturbance forest*