Available online at www.sciencedirect.com
ScienceDirect
Forest Ecology and Management 242 (2007) 273–280
Forest Ecology and Management
www.elsevier.com/locate/foreco

Long-term habitat use and browsing by deer in a Caledonian pinewood

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Received 13 September 2006; received in revised form 21 December 2006; accepted 21 January 2007

Abstract

The incidence of browsing to Scots pine (*Pinus sylvestris*) saplings by red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) in Caledonian pinewoods has been shown to be correlated to faecal counts. However, on a seasonal basis, the relationships are weak and vary between habitats, and are therefore of low predictive power. This may in part be because faecal counts provide an index of habitat use integrated over many months, whereas browsing events are of much shorter duration. To examine the relationships between habitat use by deer and browsing further, we use 10 years' dung counts from a Scottish estate to identify which habitats are used most heavily by deer, whether their preferences remain consistent over time and whether local browsing impact is more closely related to faecal deposition when integrated over a period of many years. Spring dung counts along permanent transects were modelled against a range of explanatory variables including habitat type. Indices of long-term browsing pressure were derived from measurements of pine saplings, but showed no clear relationship to habitat use. The two deer species showed broadly similar patterns in relation to habitat and location, but they differed in terms of which habitats showed the strongest changes in use as population levels changed. Model residuals were spatially aggregated and inter-correlated, suggesting that both species responded similarly to unrecorded factors influencing their winter distribution, such as disturbance, use of neighbouring habitats or local variation in forage quality.

Keywords: *Capreolus capreolus*; *Cervus elaphus*; Faeces; Habitat use; Landscape; *Pinus sylvestris*

1. Introduction

The Caledonian pinewoods of Scotland are of international conservation importance, and are designated as an Annex 1 priority habitat under the EC habitats directive (EEC, 1992). Today, these woodlands cover around 16,000 ha of Scotland (Callander, 1995), much less than their previous or potential extent (O'Sullivan, 1977; Miller et al., 1998). Browsing by deer is now recognised to be a principal factor limiting regeneration (Cameron, 1995; Staines, 1995). There is evidence that regeneration will occur in areas where deer are excluded, provided a sufficient seed source is available (Fenton, 1985; Miller et al., 1998). Fencing has been used successfully to promote regeneration (e.g. Edwards, 1981; Fenton, 1985), but more recently, other options have been considered, as fencing is expensive and difficult to maintain (Cameron, 1995). Furthermore, it has been suggested that the complete exclusion of herbivores can have a negative impact on the initial establishment of pine seedlings (Edwards, 1981) and that some grazing by native herbivores is necessary to maintain the natural composition and structure of the forests (Palmer and Truscott, 2003b). With this in mind, current management strategies are focusing on using deer culls to reduce numbers to levels that allow successful regeneration, whilst balancing the requirements for harvest by deer stalking where desired. This requires an understanding of the density of deer that can be supported without limiting regeneration. However, it is not simply the density of deer that affects regeneration, but how they use their range (Palmer and Truscott, 2003a). Although it has often been assumed that browsing damage is positively related to deer population density (Gill, 1992), the relationship is known to be confounded by other habitat features (Putman, 1996).

Previous studies have established that the incidence of browsing to saplings of Scots pine (*Pinus sylvestris* L.) is correlated to the seasonal level of local habitat use by deer, as indexed by their faeces, but that these relationships are weak

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0378-1127/$ – see front matter
doi:10.1016/j.foreco.2007.01.061

and vary with the ground vegetation type, and therefore of low predictive power (Miller et al., 1982; Scott et al., 2000; Palmer and Truscott, 2003b). A likely reason for this is that faecal counts provide an index of habitat use integrated over relatively long periods of time (usually months) (Putman, 1984), whereas browsing events on individual saplings are of short-term duration, perhaps taking as little as a few minutes for an animal to locate and damage a moderately sized sapling, although variation between animals has been shown to be considerable under experimental conditions (Hartley et al., 1997). Thus damage could occur in an area but there be relatively little faecal deposition. On the contrary, an area could be used quite heavily by deer for other purposes, including grazing of the ground vegetation, ruminating or taking shelter from bad weather or perceived predation threat (including human disturbance). In this case, there could be high faecal deposition, but very little browsing of saplings. Furthermore, habitat use will not follow a fixed pattern over time, as it may depend on many factors, including overall deer density, changes in habitat due to stand aging and woodland management activities (Staines and Welch, 1984; Welch et al., 1990), changes in disturbance patterns (Jeppesen, 1987) and interactions between these factors.

We might expect the relationship between browsing incidence and faecal deposition to improve if integrated over larger spatial areas, but at too wide a scale, the relationship would be of little practical use, as it could not predict where within a woodland regeneration might be prevented by browsing. Furthermore, if the woodland itself, rather than separate locations within it (e.g. transects or plots), were to become the sampling unit, then a large sample of woodlands would be required to parameterise the relationship.

We might also presume that the relationship between browsing incidence and faecal deposition will improve if integrated over time. The more frequently (on a seasonal or annual scale) an area is visited by deer, the more likely a sapling is to be browsed. By extending the time window over which we observe browsing behaviour at the plot scale from a single year to multiple years, then we might also hope to smooth out some of the temporal variation in faecal counts on individual plots. Ideally, one would need to monitor browsing at each sample location on a seasonal basis for many years to determine whether this expectation holds true, but that would be highly labour-intensive. However, Palmer and Truscott (2003b) used the log-ratio of a sapling's height to its basal diameter as an index of previous browsing to the leading shoot(s), on the basis that such browsing would reduce or prevent increase in height but have no significant effect on basal diameter increment.

In this paper we use dung counts collected during a 10-year monitoring programme at a site in the Scottish Highlands to examine two aspects of the relationship between habitat use by deer and browsing incidence. (1) Which habitats are used most heavily by deer, and do their preferences remain consistent over time? (2) Is browsing impact at the plot scale related to faecal deposition when integrated over a period of many years?

2. Methods

2.1. Study site

Glen Tanar Estate is situated in NE Scotland (57°2′N, 2°52′W; Ordnance Survey ref. NO4593), and lies between approximately 150 and 600 m a.s.l. Roughly one-third of the 11,700 ha estate is woodland dominated by Scots pine. While many native pinewoods have few trees in the lower age classes (Cameron, 1995), the forest stands in Glen Tanar cover a wide age distribution, including areas of newly establishing trees, plantations of various ages and open stands of mature pines. In addition, there is extensive cover of moorland and some agricultural land and broadleaved woodland. The heaths and forest are designated as a Special Area of Conservation under the EC Habitats Directive (EEC, 1992) and the estate is a National Nature Reserve. The underlying geology is primarily granite in the south and east of the estate and mixed, basic rock in the north and west.

2.2. Deer management and monitoring

A shield fence was constructed in 1938 to prevent substantial movement of red deer (*Cervus elaphus* L.) from the moorland into the woodland and enable deer numbers within the woodland to be controlled. This has promoted some natural regeneration of Scots pine and colonisation onto the moorland edge (Edwards, 1981). In 1996, the estate began a woodland deer management programme with the aim of reducing the density of red and roe deer (*Capreolus capreolus* L.) to allow natural regeneration of woodlands without the use of internal deer fencing. A series of permanently marked 50 m × 2 m transects, stratified by habitat type, was laid out across the estate to monitor deer numbers (Fig. 1). Standing crop faecal counts (Neff, 1968; Putman, 1984) were carried out by estate staff along these transects in spring from 1996 to 2005 inclusive (under supervision of DES throughout). Deer were culled in accordance with estimates of density derived from these pellet group counts, and culls averaged 65 red deer and 94 roe deer p.a. during the study period. In the autumn of 1999, part of the shield fence was removed, giving access to the woodlands for deer from moorland to the east.

2.3. Habitat characteristics

The location and habitat type of the 130 transects in moorland and woodland were extracted from the estate's geographical information system (GIS). Transects in agricultural habitats were omitted owing to disturbance by livestock and arable management. A minority of transects changed habitat during the monitoring period as a result of woodland management or stand growth (Table 1). Static characteristics (slope, aspect, soil moisture class) were recorded *in situ*.

2.4. Saplings

Thirty-seven transects had Scots pine saplings present. The height and basal diameter of a random sample of saplings