10 Birch Sapling Responses to Severity and Timing of Domestic Herbivore Browsing -- Implications for Management

A.J. Hester, K. Lempa, S. Neuvonen, K. Høgh, J. Feilberg, S. Arnthórsdóttir, G. Iason

Case studies and experimental designs

This section contains details of the four case-study countries, study sites and methods used in the experiments reported in Chapter 10.

Scotland

Scotland's natural forest has been greatly depleted over many thousands of years through clearance, grazing, burning and plantation of exotic trees. Today, less than 4% of the land area is naturally wooded, which probably represents less than 10% of potential forest cover under current climatic conditions (Mackenzie 1999; Hester 2001; Towers et al. 2003). Regeneration is therefore limited to relatively few areas where significant seed sources still exist. The two native species of birch (*Betula pendula* and *B. pubescens*) together make up probably about 90% of the remaining natural forest. *B. pubescens* is probably the most common and widespread native species of tree in Britain occurring throughout the country; it is a particularly dominant species in the remaining wooded areas of the Scottish Highlands (Worrell 1999). However, regeneration of this (and other) species is under great pressure from a range of wild and domestic herbivores. Scotland (land area about 77,000 km^2) has about 2.5 million free-ranging sheep which, together with wild herbivores such as red and roe deer, freely graze both open land and many of the remaining areas of birch forest. In parts of the country, sheep are taken to lower ground in winter, but in other areas they remain all year, particularly where birch forest is present, as it can provide valuable shelter from inclement weather. As a result, many remaining areas of birch are very heavily grazed (by both sheep and deer) and almost all birch regeneration is totally suppressed. Herbivore management is therefore a crucial issue if these forests are to regenerate.

In Scotland, free-ranging domestic sheep share almost all their range with red and/or roe deer, which also browse birch saplings. Locally, mountain hare (*Lepus timidus*) also browse birch quite heavily. To gain maximum information on how differences in severity and timing of browsing might affect regenerating birch, for the resources available, controlled experiments were set up using simulated sheep browsing treatment. Two sites were selected for use, both containing large numbers of regenerating birch (*B. pubescens*) saplings well under 1 m in height (within browse range) and small pockets of mature birch trees. One site is at Drynachan (57°26′N, 3°52′W; 260 m a.s.l.), the second site is at Corrimony (57°19′N, 4°37′W; 280 m a.s.l.). The vegetation at both sites is dominated by *Calluna vulgaris*, with smaller amounts of grasses such as *Molinia caerulea*; this type of vegetation is widespread across Scotland and is closely associated with many of the remaining birch areas. Both sites are on relatively shallow, organic podsolic soils, although soil moisture was greater at Drynachan. From growth ring counts of a sample of saplings cut and taken to the lab, saplings were of similar ages at both sites (and had similar basal diameters, numbers of branches, etc.). Both sites had quite a range of sapling heights, but saplings were on average much smaller at Drynachan than Corrimony (see later), due to combinations of the above site factors, in particular historical differences in browsing intensity. Large herbivores (mainly red deer and sheep) have been largely removed from both sites (over the past 5 years), so there has been little or no browsing activity in the past few years. Thus all/most recent sapling growth was unbrowsed, giving a good baseline for the start of our clipping experiment to simulate sheep damage in a controlled way. At each site, experimental treatment was applied within three fenced enclosures constructed to exclude any remaining large herbivores.

The method of clipping was designed to simulate browsing damage by sheep, based on previous browsing work with sheep plus a survey of local sheep-browsed shoots at the start of the study. Whole long shoots were clipped off if >5 cm long, or if new growth was <5 cm, stems were clipped below the second shoot. Treatment applied was a fully factorial combination of timing and severity of simulated browsing: (1) timing: late summer; dormancy; bud burst; (2) severity: 33% of shoots clipped (one out of every three shoots); 66% of shoots clipped (two out of three). Each treatment combination had 60 'replicate' saplings per site. Each factorial treatment combination was repeatedly applied to the same saplings at the same time of year from summer 2000 to summer 2002. Clippings were all retained to allow quantification of numbers of shoots and buds removed per sapling, as well as total biomass removed. At the end of summer (end August/start of September) every year, detailed measurements of all saplings were made in the field. These included height; basal stem diameter; number of branches; number of long and short shoots; leaves; length of leading shoot; other shoots; canopy area; and many more.

Finland

The area selected for study in northernmost Finland (Utsjoki) represents the most continental area of the four case studies. Most of the area is covered by mountain birch woodlands, but there are barren fell heaths above the tree line and small Scots pine stands in some valleys. The total area of mountain birch forests in Utsjoki is about 1700 km^2 and their total volume has been estimated at 1.6--1.7 million m^3. The mountain birch woodlands have a low productivity -- the annual volume growth is <1 m^3/ha. The area is one of the most sparsely inhabited areas in Finland. Population density is now about 0.3 inhabitants per km^2 and most of the population lives along water courses and roads, leaving very large areas without permanent habitation. However, the number of summer cottages (also mainly along water courses) has increased dramatically over the last decades. Nowadays, about half of the resident population is Sami, while 50 years ago about three-quarters and 100 years ago more than 90% were Sami. Until the 1950--1960s many of the local households had sheep, but the numbers of sheep have declined very strongly as a part of the general decline of agriculture in northern Finland over the last decades. Reindeer densities in this area have been relatively high since the 1980s (see Chap. 11). In addition to the harsh climate, one of the main factors hampering the regeneration of birch from seed in Utsjoki has therefore been reindeer grazing (and, locally, sheep and mountain hares), as described in Chapter 11. There are both differences and similarities between reindeer herding and sheep farming, depending on the part of Sapmi (the Sami area). In some co-operatives the reindeer are herded in a more traditional way and there is a system for pasture rotation (see Chap. 11). On the other hand, in other northern

Finnish co-operatives, reindeer herding is relatively sedentary and the use of supplementary feeding is common. Thus, it resembles much more closely the methods used for keeping and herding sheep.

Although sheep, at present, play a relatively minor role in many of the birch areas of northern Finland, where reindeer are the main grazers (see Chaps. 9 and 11), there are more sheep in the adjacent Norwegian areas (Finnmark) and, as with Scotland, the benefit of carrying out a simulated browsing experiment is that the results can also be applied to management of other large herbivores (moose, reindeer, deer), as well as sheep. The summer grazing results are most relevant to current reindeer management; the winter/dormant clipping treatment has less relevance to reindeer grazing, but the wild moose in the area also readily browse on birch throughout the year (although over much of the winter saplings are normally snow-covered).

As in Scotland, experiments in Finland were designed to examine the effects of timing and severity of simulated browsing on the sensitive sapling stage of birch at two contrasting study sites. The interactive effects of simulated browsing (clipping) and insect damage (defoliation) were tested; the results of the insect studies are presented elsewhere. Insect outbreaks are common in this area and have dramatic effects on birch; for example in the mid-1960s Utsjoki experienced a major insect defoliation event killing birch forests over hundreds of kilometres (Kallio and Lehtonen 1975). The browsing part of the experiments was designed with several main aims: first, to mimic in particular the periods of the growing season when grazing has the largest effect on birch growth. Second, to examine short-term (with the small number of years of the experiment) recovery from the damage caused by simulated heavy browsing. This will thus give useful initial information for the definition of how long reindeer or sheep should be excluded from heavily browsed areas to allow them to recover; longer-term data from these experiments will also be required, to indicate whether the early recovery rates are sustained or whether they change over time.

The two sites selected for study were both enclosed within fences, so the experimental saplings had not encountered heavy natural browsing in recent years. Skallovarri (69°49′N; 27°08′E; 280 m a.s.l) is an open site near the tree line, but the soil is relatively nutrient-rich and moist. Syysjoenpalo (69°15′N; 27°15′E; 200 m a.s.l.) is situated in a mixed pine--birch forest and is more protected by surrounding mature forest, but the soil is in general nutrient-poor. The field-layer vegetation was a mixture of dwarf shrubs, primarily *Empetrum hermaphroditum* and *Vaccinium* spp, with a small amount of grasses, primarily *Deschampsia flexuosa*. Combinations of timing and severity of clipping treatment were applied at two sites, giving overall combinations of: (1) timing: dormancy, spring (early summer), late summer; (2) severity: 33 and 66% of shoots/buds removed, as in Scotland. Allowing for differences in sapling growth forms, clipping treatment was designed to be qualitatively similar to that applied in Scotland to allow the comparison of results. Treatment started in late summer 2000 at Syysjoenpalo and continued during 2001 at both sites. Number and proportion of buds removed were counted for all clippings. All saplings were recorded in late August 2001 and 2002; measurements included sapling height; basal stem diameter; number of buds; number of short and long shoots; leading shoot and long shoot length.

Greenland

The mountain birch (*Betula pubescens* ssp. *czerepanovii*) came to S Greenland 3600--3400 B.P. (Fredskild and Ødum 1990). Small mountain birch forests emerged soon after in sheltered inland valleys. The Greenland mountain birch hybridises intensely with the North American *Betula glandulosa,* and therefore the Greenland mountain birch population is unique.

The Norse landnam in S Greenland, just before 1000 A.D., drastically changed the nature of land use: grazing of sheep, goats, cattle and horses, tree cutting for fuel and timber, peeling of sods for house building, etc., and led to reduced tree growth, broke the thin vegetation cover (Fredskild 1978, 1988) and caused soil erosion in those areas most exposed to the foehn winds (Jacobsen and Jakobsen 1986). However, after 4--5 centuries of utilization of the land, the Norsemen gradually departed, which resulted in some recovery of the birch forest, at least locally (Feilberg 1984). In recent centuries, local populations have cut birch for fuel mostly on slopes close to the fjords, so the wood could be transported to the settlements, leaving the birch in remote valleys much less exploited (Oldendow 1935).

The introduction of sheep breeding, at the beginning of the last century, once again locally changed the vegetation severely and, whereas *Salix glauca* can stand quite heavy browsing, negligible regrowth of *Betula pubescens* is found where sheep graze. The Greenlandic sheep population belongs to the North-European short–tailed sheep breed. Its origin can, in the main, be traced back to the importation of Faroese sheep in 1906 and Icelandic sheep in 1915. A breeding program to increase lamb production, carcass weight and carcass quality was initiated 3 years ago and today some 10% of the sheep population is registered, with increasing interest among the remaining sheep farmers to join the program. Today, there are 55 sheep farms in SW Greenland, with 20,000 breeding ewes and a total of 45,000--50,000 animals on summer grazing areas. The average herd size per farm is 350--400 breeding ewes. Most of the summer grazing takes place in the subarctic areas within the willow and birch areas. Some farms still carry out winter grazing as well and this is the cause of much current debate. The simultaneous interest in the expansion of sheep-farming activities and awareness of the vulnerability of the ecosystem of the birch forest zone, over the last decade, have resulted in more comprehensive investigations (Thorsteinsson 1983; Feilberg 1997). The work presented here was designed to add further important information to this process.

Sheep were the only large herbivore present in the part of Greenland used for this study, therefore, their impact on birch could be directly measured in the field. Mountain hares were also locally present. A field site was identified for experimental study near the bottom of Tunulliarfik fiord (61°15′N, 45°30′W, 5--100 m a.s.l,), close to the settlement of Narsarsuaq, with the cooperation of a local sheep farmer who grazed sheep in the birch areas around his farm all year. This farm was selected as fairly typical of many farms, but was also chosen as the farmer still carried out winter grazing as well as summer, which gave the opportunity of making comparisons between birch in summer and winter grazing areas. The vegetation was mainly birch, open grassland and heath, dominated by *Betula glandulosa* and *Salix glauca* ssp. c*allicarpaea*. Fencing treatments included an open grazing area (summer and winter grazing), an area with summer grazing only, and a fenced area (no grazing 'control'). Approximately 20 birch trees were marked for study within each of the three 'treatment' areas. One branch per tree well within browse range of the sheep was selected for detailed study, and all dead shoots were removed (cut) in summer 2001. All branches were re-surveyed 1 year later (summer 2002) and all damage to any new shoots on that branch was recorded as either sheep, insect, other (frost, etc.).

As well as studying the impacts of all-year versus summer-only grazing on the birch, a longer-term study compared sheep production under the two grazing regimes, which is highly relevant to the work presented in Chapter 10. Figure 10A shows the data to support the summary results given in Section 10.4.1.

Iceland

Only 1% of Iceland (land area: 108,000 km^2) is covered by pristine birch (*Betula pubescens*) forests, this being the only natural forest type in Iceland (Aradóttir et al. 1992). However, low-growing willows (*Salix* spp.) and dwarf birch (*Betula nana*) scrublands are also widespread. *Betula pubescens* occurs throughout Iceland below the 400 m a.s.l. tree line, and regeneration occurs both from seed and by vegetative reproduction. However, as in Scotland, the birch forests in Iceland have been cleared and grazed for centuries. Domestic sheep are the main large herbivore, in fact, the only one over much of Iceland; Iceland only has one species of large wild mammalian herbivore, the reindeer, which is only present in eastern Iceland. However, avian herbivores are also important consumers in birch ecosystems. There are an estimated 600,000 free-ranging sheep in Iceland, while other livestock are usually not free-ranging. While forest burning and the use of birch for firewood has been almost nonexistent for over five decades, traditional grazing of birch woodlands by domestic sheep is still very common. However, land use has been changing on many sheep farms in recent decades, with widespread reductions in sheep grazing in many areas, but increases in others. However, despite local differences, overall there has been a significant reduction in grazing loads in recent years, resulting in widespread recovery of the birch forests.

Winter, as well as summer, grazing of sheep and horses probably contributed to the destruction of woodlands in earlier times (Hólmgeirsson 1977/1978), but winter grazing is now very rare in birch forests in Iceland. Most of the sheep are transferred from the lowlands to common-ground highland areas in early summer; while many return by themselves to the lowlands later in the summer, some remain in the highlands and are rounded up in the autumn. When returning from the highlands, the sheep commonly roam in the birch woodlands, where the birch and a rich field-layer vegetation provide food. In northern Iceland, the sheep are commonly found at the upper forest edges, in the valleys and along streams and trails. It is considered likely that the birch on the forest edges, particularly the upper forest, where small birch grows often in gravelly slides, may be particularly sensitive to grazing. Improved management practices are needed to regulate sheep grazing within the birch forest areas, particularly for the most fragile areas.

The study reported here was carried out in northern Iceland, where the average density of sheep in birch woodlands is one sheep per hectare of woodland during the grazing period. There are on average 3--4 inhabitants per 100 ha of woodland in northern Iceland, and close to 30 sheep per inhabitant in the area. This means that a high proportion of the inhabitants in the area rely on sheep for at least a part of their livelihood. However, there are still extensive areas of birch (*Betula pubescens*) forest, with trees reaching 400 m a.s.l. in some places (Icelandic Foresty -- Forestry Association of Iceland 1977). Previously, the woodlands covered more ground than at present, but they have been replaced by other moorland vegetation and even bare ground (Aradottir and Arnalds 2001). There is much historical evidence of overgrazing of the birch woodlands in times of hardship, population increase and during the addition of new farms in northern Iceland, while the woodlands have also declined due to large-scale wood gathering, particularly in Fnjóskadalur (Bjarnason 1980).

The study site was in the Fnjóskadalur valley. One woodland area was grazed by sheep (Belgsárskógur) and the other (Þórðarstaðaskógur) was fully protected from grazing. Results from the latter site are reported here. The birch saplings were mostly 30--50 cm high, growing in disturbed areas of gravel beside small streams running into the river Fnjóskaá. Field-layer vegetation was mainly grassy with a few herbaceous species. Previous studies conducted in southern Iceland on the responses of *Betula pubescens* to browsing demonstrated negative responses of both saplings and mature plants to early season browsing (Arnþórsdóttir and Ólafsdóttir 2001). Conditions in northern Iceland are more continental than in southern Iceland, the growing season is normally shorter and the average temperature lower even in the summer in the north than in the south. The experiment presented here was carried out in summer 1991 in Þórðarstaðaskógur to investigate the effect of severity (not timing) of simulated browsing on sapling growth responses. Shoots were clipped (as per the experiments in Scotland and Finland) in June 2001 from a sample of 9 saplings per treatment, plus 9 controls (unclipped), with 3 severities of clipping (25, 50 and 75% of current year's growth), giving 36 saplings in total. Clippings were removed and weighed, to allow an assessment of the actual biomass being removed from the saplings. Sapling growth was then recorded at 3--4 week intervals through the growing season, until senescence (August); measurements included numbers of buds, leaves, branches and shoot elongation.

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