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THE EFFECT OF WHOLE–TREE HARVESTING ON EARLY GROWTH OF SITKA SPRUCE ON AN UPLAND RESTOCKING SITE, by Janet Dutch

Abstract

Whole-tree harvesting is likely to be used increasingly in British forestry. The resulting increase in nutrient removal is a potential concern. An experiment is described which demonstrates growth reductions in a second rotation Sitka spruce crop caused by brash removal. The possible mechanisms responsible for this reduction in growth are discussed.

Introduction

1. The main advantages of whole-tree harvesting[1] (WTH) are, firstly, leaving the site clear of brash which makes restocking easier and cheaper and, secondly, generating brash residues which can be marketed for fuel, fibre and mulching. However, there are disadvantages associated with WTH. The concentration of nutrients in fine branches and foliage is greater than in stem wood (Figure 1). Harvesting of the former will result in a large increase in nutrient removal which may have implications for site nutrition and future tree growth. In some circumstances WTH may also affect future site productivity through damage to the soil structure (Skinner *et al.*, 1989), although this aspect will not be dealt with here.

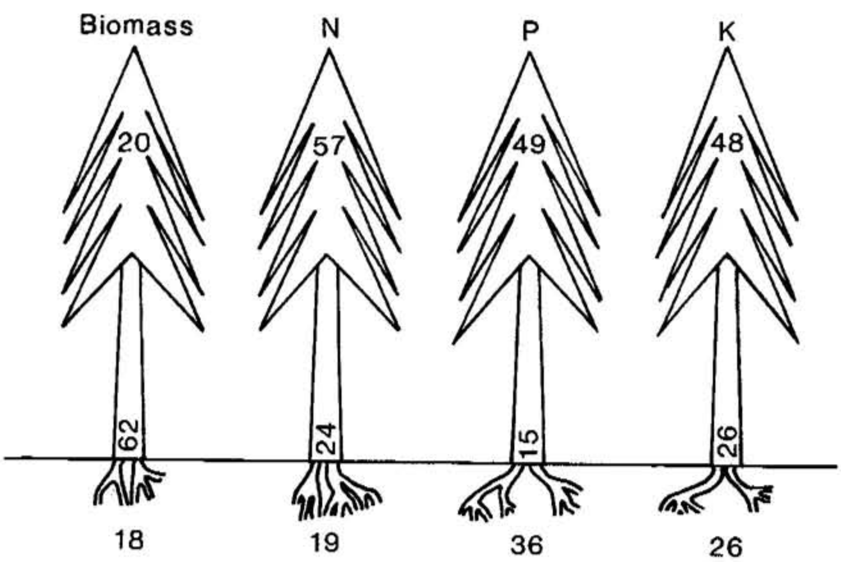

Figure 1. Percentage distribution of biomass, nitrogen (N), phosphorus (P) and potassium (K) in foliage and branches, stems, and root systems of a 50-year-old, yield class 20, Sitka spruce stand (from Carey, 1980).

2. An experiment was established in 1981 to allow a direct comparison of the growth of second rotation Sitka spruce following conventional and whole-tree harvesting. Results from this experiment are described together with a discussion on the possible mechanisms responsible for observed differences in growth.

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[1] Whole-tree harvesting is taken here to mean the removal of all branches and needles from the harvesting site in addition to the stem wood. It does not include removal of stump and root material. Conventional harvesting (CH) refers to the removal of only the stem from the site.

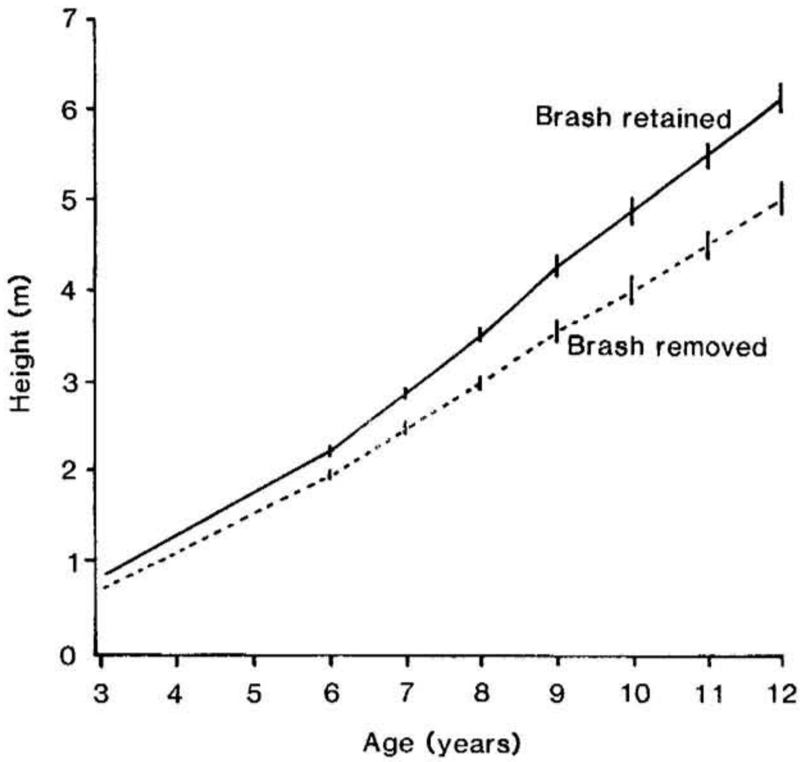
Experiment details

3. The experiment is located in Falstone Forest, Northumberland. The site is a peaty gley at an elevation of 290–330 m, with a southerly aspect. A 40-year-old first rotation stand of Sitka spruce was clear-felled in November 1979. Brash was either retained on site (treatment B), or was removed by hand while still green (treatment O). The plots were then replanted with the same species in spring 1981. The treatment plots are 0.1 ha with an internal assessment plot of 0.05 ha. There are four replicates within the experiment. (For further details of the experiment and results see Proe and Dutch, 1994.)

4. Mean tree height was assessed at year 3, year 6 and annually from then on. Mean diameter at breast height (dbh) was measured at age 11. Whole-tree sampling was carried out at age 9 on three trees per plot, selected to represent the height distribution of the plot. The sample trees were subdivided into three sections and weighed. Stem discs were taken from the centre of each section and subsamples of branches, twigs and foliage were removed from each whorl and interwhorl. Root systems were cleaned, weighed and separated into three size classes. These subsamples were then subjected to moisture content determination and chemical analysis. This whole-tree sampling allowed an estimate of biomass production and allocation to be made.

Results

5. The height growth of the trees planted in the B plots (brash retained) has been consistently greater than that in the O plots (brash removed) (Figure 2). The latest assessment at age 12 shows a difference in mean height of over one metre, with the two treatments continuing to diverge. The diameter assessment at age 11 also showed that the trees in the O plots had a significantly smaller ($p<0.001$) mean dbh than those in the B plots (7.12 v. 9.13 cm). The whole tree harvesting at age 9 indicated that the trees where brash had been retained had a biomass 39% greater than those where brash had been removed (Table 1). The differences in biomass are of a similar magnitude to the differences in volume production.



Note: error bars show one standard deviation about the mean, n=4

Figure 2. Effect of brash on mean height.

Table 1 Effect of brash removal on biomass in second rotation Sitka spruce aged 9 years (kg ha^{-1})

	Treatment		*SED*
	O	*B*	
Foliage	7786	10380	1178
Twigs	3763	5067	362
Branches	4926	6621	447
Stems	6942	10528	971
Roots	7400	10300	–
Total	**30817**	**42896**	–

SED = standard error of the difference between means, n=4

6. There are several possible reasons for these differences in growth. As brash was removed from the plot by hand, the difference cannot be attributed to soil compaction or damage. Quite small differences in initial planting height can cause appreciable differences 6–10 years later (South and Mason, 1993). Although no measurements of initial planting height were made at Falstone, all the plants came from one batch. In a more recent experiment at Kielder where all the plants came from a single batch, there were no differences in height immediately after planting between trees planted in brash and those planted in WTH plots. It is therefore felt the differences at Falstone were associated with brash removal rather than differences in initial height.

Discussion

7. There are three main ways in which brash could influence tree growth. Firstly the retention of brash may improve the site's fertility either directly by providing a source of nutrients, or indirectly by modifying the availability of soil nutrients. Secondly, the micro-climate may be influenced by the presence of brash e.g. provision of physical shelter for the newly planted trees, or alteration of soil temperature. Thirdly, ground vegetation may be suppressed by brash. Ground vegetation may inhibit tree growth initially by competition during the establishment phase but may also act as a temporary nutrient store, 'mopping-up' nutrients early on, which may otherwise be lost by leaching, and releasing them later as the tree canopy suppresses the vegetation (Fahey *et al.*, 1991; Emmett *et al.*, 1991).

8. Increases in soil temperature, and the cessation of tree uptake after harvesting usually result in a flush of nutrients into available soil pools and drainage water (Vitousek and Melillo, 1979). Such a flush was observed following both CH and WTH of a first rotation Sitka spruce crop at Beddgelert, north Wales (Stevens *et al.*, 1988). At Falstone, it is likely that a similar flush of available nutrients after felling would have prevented nutrient availability from being a limit to tree growth in the first few years after felling. It is therefore unlikely that nutrition accounts for the observed early differences in growth between the two treatments.

9. The sheltering effect of the brash may be more important than nutrition during the initial establishment phase. However, shelter is unlikely to have any effects after the first year or two once the trees grow above the height of the brash mat. Growth later in the establishment or early thicket stage could then be affected by nutrition, once the initial flush of nutrients after felling has passed. Recent visual observations at Falstone suggest nutritional differences between treatments are becoming more important.

10. Weed suppression by the brash mulch retained after CH may help to promote early tree growth. However, vegetation regrowth on the site type at Falstone has been relatively slow (Titus and Malcolm, 1991) and may not have been important in this case.

11. Further work by the Forestry Commission, the Macaulay Land Use Research Institute and Edinburgh University aims to identify the role of physical shelter, nutrient supply and weed suppression in tree growth after both WTH and CH. The implications of WTH on other sites, future rotations, and long-term site quality will vary according to which of these effects is found to be most important in influencing tree growth.

Conclusions

12. The Falstone experiment provides evidence that, at least at some sites, WTH may have an immediate negative consequence on subsequent tree growth, although the long-term effects are still being investigated. Financially, such a reduction in growth may be offset by a reduction in restocking cost, better stocking and revenue from the sale of brash.

13. The aims of current research are to identify the reasons for brash removal affecting tree growth and to provide guidance to forest managers in identifying sites where brash removal during whole-tree harvesting may have detrimental effects on future timber production.

14. Until definitive recommendations are available from current studies, the following provisional generalisations can be drawn from the Falstone and Beddgelert studies. Firstly, the more exposed and/or infertile (i.e. low in nutrient capital) a site is, the greater are the potential risks of WTH. Secondly, since the biomass of a forest canopy changes relatively little after canopy closure, the loss of nutrients in WTH when expressed on an average annual basis will be the greater the shorter the rotation length being used. Thus the risks would be greatest on a high hazard class, nutrient poor, peat or heathland soil.

15. A guide to WTH practice is due to be published later in 1995.

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