Effect of varying coppice height on tree survival and ground flora in Brasenose Wood, Oxfordshire, UK

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SUMMARY

Coppicing is a commonly used management intervention to increase structural diversity in woodlands, but coppiced trees are vulnerable to browsing by deer. We investigated the effect of coppicing hazel stools at different heights on the survival of trees, and also the species richness of the ground flora. Plots were cut at experimental heights of 0.7 m and 0.8 m, with plots cut at 1.2 m and ground level as controls. All the stools cut at 1.2 m were alive five years after cutting. In the plots cut at 0.7 and 0.8 m, some shoots were eaten by deer but less than 10% of stools died. Less than 5% of stools in the plot cut at ground level survived. After 7–8 years, coppicing at 0.7 m and 0.8 m supported a higher species richness of angiosperm ground flora than either of the control heights. We conclude that high-level coppicing offers a cost-effective opportunity to achieve a rotation frequency that increases tree survival and supports a diverse coppice-woodland angiosperm flora.

BACKGROUND

Deer are partial to the growing tips of hazel *Corylus avalana* shoots and with the sizeable growth of deer populations in the woodlands of southern Britain over the past forty years, the traditional and widespread management practice of coppicing hazel at ground level has been called into question (e.g. Joys *et al.* 2004). Indeed, where wildlife conservation is a key management objective in deer-browsed woodland, the case for no longer coppicing in the traditional way, which may lead to tree deaths and loss of biodiversity, is especially strong (Goldsmith 1992, Hambler & Speight 1995). Efforts to maintain ground-level coppicing that enhance species diversity are costly, involving, for example, secure durable deer fencing or labour-intensive protection for individual coppice stools.

A simple alternative to ground-level coppicing is cutting hazel too high for deer to browse the regrowth. This option has been suggested for a number of years, and we are aware of some English woodlands where it has been tried. Yet, so far as we are aware, no results have been published for any high-coppice trials where wildlife diversity is the priority. If successful, high-level coppicing could potentially be cheaper than ground-level cutting plus protection wherever woodland management aims to enhance diversity but deer browsing is a significant factor.

In this study we assess the effects of coppicing at different heights in Brasenose Wood, near Oxford, UK (51°45'18"N, 1°11'8"W, altitude 171 m a.s.l.), part of the Brasenose Wood and Shotover Hill Site of Special Scientific Interest (SSSI). The area has been woodland since before the thirteenth century and has been coppiced, probably almost continuously, since the sixteenth century (Steel 1984, page 15). Coppicing of the remnant 26 ha greatly declined through the mid-twentieth century but was reinstated for wildlife purposes in 1975 (Fuller & Steel 1990, page 7). The woodland structure consists of oak standards with hazel coppice, and hazel stool density in the area of the trial is 880 stools/ha (± 80 stools/ha S.E.). No attempt was made to estimate the deer populations; however, Reeves's muntjac deer *Muntiacus reevesi* are known to breed in the SSSI and the number of roe deer *Capreolus capreolus* is thought to have increased steadily since the species was first recorded in the vicinity in 1981. Damage to ground-level hazel stools from deer is extensive throughout Brasenose Wood.

ACTION

A coppice coup (a subdivision of woodland delineated for the purposes of coppice rotation) (C1) with an area of 0.91 ha, which had been coppiced 18–19 years previously, was selected for the first stage of the trial. In December 2008 the coup was divided into three similar-sized sections in which all hazel trees were coppiced. After discounting areas of dead wood habitat and an 8 m margin for edge effects, each study section had an area of about 0.15 ha. One section was cut at an experimental height of 0.7 m (Figure 1a) and the other two cut at 0.0 m (ground level) and 1.2 m (Figure 1b) as control plots for comparison.

In November 2009 a second coup (C2) of 0.74 ha, contiguous with the first and coppiced 17 years previously, was cut at a height of 0.8 m. The higher cut was made in response to observed severe browsing of hazel shoots in the section cut at 0.7 m, suggesting that this might have been too low. Stool density was low in much of the second coup, but a central area of 0.2 ha was more typical of the woodland and considered suitable for subsequent monitoring.

To ensure accuracy and consistency of cutting, each coppice worker was supplied with a height-gauge stick. Typically, one hectare of high-level coppicing in Brasenose Wood, which often included felling, cutting and stacking 15- to 20-year-old regrowth of aspen *Populus tremula* growing among the hazel stools, required about 250 volunteer hours of labour.

Stool and stem mortality were monitored for the first five years of the trial. The ground flora was surveyed by recording species occurrence during a complete search of each section before cutting, in the second summer following coppicing (2010 for C1 and 2011 for C2), and thereafter in 2012, 2015 and 2016, i.e. four, seven and eight years after cutting in C1and three, six and seven years after cutting in C2. Sapling trees and woody shrubs were excluded from the ground flora survey. To

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Figure 1. Plots in 2008, immediately after cutting. **a)** Experimental plot cut at a height of 0.7 m. **b)** Control plot cut at a height of 1.2 m.

eliminate any biases in the analysis due to isolated occurrences of locally infrequent species, the reference-point species richness for the trial was defined as those species that were common to all high-cut plots in the second summer after cutting - 43 species in total.

CONSEQUENCES

Survival of hazel stools. Stools in the section cut at ground level grew an abundance of shoots, all of which were browsed within the first growing season, and all but two stools within the survey plot were dead after five years (96.4% mortality, Table 1). In the section where stools were cut at a height of 1.2 m from the ground, growth from the top of the surviving cut stems was vigorous and by May of the second growing season had reached 3.0 m from the ground, with the canopy of leaves already beginning to close between stools. No stools died as a consequence of the 1.2 m cut; however, 13.7% of cut stems died (Table 1).

In plots cut at 0.7 m and 0.8 m, within the first few years there was clear evidence of browsing of shoots at the cut height. Nevertheless, most of the surviving stools extended shoots beyond the reach of browsing deer during the following years. After five years, in the plot cut at 0.7 m two of 49 monitored stools had died, while in the plot cut at 0.8 m five of 64 stools had died. Approximately 25% of cut stems within the live stools had died in both these plots five years after cutting (Table 1).

Table 1. Stool and stem mortality in the coppice plots five years after cutting at different heights.

Plot	Cut height (m)	Number of stools monitored	Stool mortality (%)	Stem mortality (%)
C1	0.0	55	96.4	—
C1	0.7	49	4.1	26.1
C2	0.8	64	7.8	25.6
C1	1.2	44	0	13.7

Effect on ground flora. Before the trial plots were coppiced, most of the woodland floor was bare of any ground flora including bryophytes, and so plots appeared homogeneous before management treatments (bearing in mind that seed banks and abiotic variables might have differed). All species of substantive ground flora occurred sporadically under areas of less-dense hazel canopy: namely, isolated tufts of wood sedge *Carex sylvatica* and wood false-brome *Brachypodium sylvaticum*, and small patches of yellow archangel *Lamiastrum galeobdolon*.

Ground flora richness declined at all four plots between two and eight years after coppicing, but the declines were steepest at the ground-cut plot and the 1.2 m cut plot (Figure 2). Among the species that appeared in the first two years after cutting, but were no longer visible in any plot in the third or fourth year, were selfheal *Prunella vulgaris*, goldilocks buttercup *Ranunculus auricomus*, hedge woundwort *Stachys sylvatica* and black bryony *Tamus communis*. After a further three years, the closing canopy of the plot cut at 1.2 m had reduced the ground flora to 12 species, including such shade-tolerant species as yellow archangel, wood anemone *Anemone nemorosa*, wood spurge *Euphorbia amygdaloides*, bluebell *Hyacinthoides non-scripta* and wood millet *Milium effusum* (Figure 3b). In comparison, the plots cut at 0.7 m and 0.8 m still retained 26 species, including bramble, bugle *Ajuga reptans*, pignut *Conopodium majus*, honeysuckle *Lonicera periclymenum*, common figwort *Scrophularia nodosa* and common dog-violet *Viola rivinianai* (Figure 3a). Flora species lasting 3-4 years in plots cut at 0.7 m

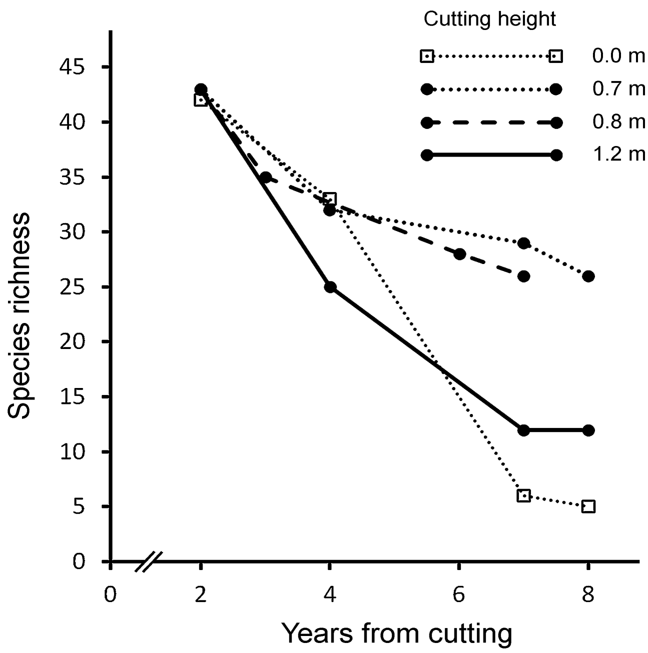

Figure 2. Decline in ground flora species richness in coppice plots, two to eight years after cutting at different heights.

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Figure 3. Plots in 2016, eight years after cutting. **a)** Experimental plot (cut at 0.7 m). **b)** Control plot (cut at 1.2 m).

or 0.8 m but no longer extant in at least one plot after 7–8 years included wood avens *Geum urbanum*, ground ivy *Glechoma hederacea*, wood melick *Melica uniflora*, primrose *Primula vulgaris*, greater stitchwort *Stellaria holostea* and bush vetch *Vicia sepium*.

Although the numerical responses of species richness in plots cut at 0.7 m and 0.8 m were similar (26 species after 7–8 years, Figure 2), the contributing species were somewhat different between the two plots. Ground ivy, greater stitchwort and yorkshire-fog *Holcus lanatus* all persisted in the plot of C1 cut at 0.7 m but soon disappeared from the C2 plot cut at 0.8 m, and the reverse was true of primrose, wood meadow-grass *Poa nemoralis* and broad-leaved dock *Rumex obtusifolius*. This was likely due to characteristics of the plots rather than the 0.1 m difference in cut height, and highlights the fact that caution should be used when extrapolating these results, as each coppicing height was applied at only a single site.

DISCUSSION

The choice of the initial cutting height at 0.7 m was based on the findings of Welch *et al.* (1991) that deer rarely browse the leader buds of sapling trees above a height of 0.8 m, with most damage occurring 0.3–0.5 m from the ground. This suggested that 0.7 m would be low enough for deer to reach but high enough for a proportion of shoots to escape browsing and eventually close the canopy (for this study the onset of canopy closure is reached when the leaf canopies of adjacent stools begin to overlap). The control height of 1.2 m, selected to be out of reach of all deer, was suggested by the Forestry Commission (Richard Pearce, personal communication). A notable finding from this study was that, despite our initial worry that a cutting height of 0.7 m might prove too low, increasing it to 0.8 m made no appreciable difference, either to stem mortality after five years or ground flora species richness after 7–8 years; outcomes for both variables were very similar (Table 1, Figure 3a).

The percentage of stools that died after cutting at 0.7 m (4.1%) and 0.8 m (7.8%) is greater than with traditional or fenced ground-level coppicing. Harmer (2004) reported negligible stool mortality after hazel was cut at 0.3 m in fenced enclosures. But the proportion of stems within live stools that died after cutting at 0.7 m (26.1%) and 0.8 m (25.6%) may be of greater concern. Harmer (2004) found very similar stem mortality in winter-cut unenclosed hazel: 24% at a cut height of 0.3 m and 29% when cut at ground level. The more vigorous growth and better survival of stems cut beyond the reach of deer (87% overall in the plot cut at 1.2 m) suggests that in high-level coppicing it would be best to tend toward the highest cut that achieves the required delay in canopy closure. Another factor to bear in mind is that the development and persistence of the under-canopy scrub layer is of prime importance for nesting and feeding birds (Fuller & Steel 1990, Fuller & Green 1998). The C1 plot cut at 1.2 m, with a much more rapid canopy closure and a much reduced ground cover (Figure 3a), may therefore be the least favourable for some species of breeding birds.

Although the results described here are specific to the site, with only a single measure of floral species richness for each treatment, the basic method could be adjusted for sites with different characteristics, on the basis of either prior knowledge (e.g. the extent of browsing damage) or observations after cutting. Granted the number of potential variables and their interactions are considerable, principally: coppice stool density; density of oak standards; density of the deer population over time; desired coppice-rotation period; and the health, vigour and abundance of shoots at the tip of a cut stem. Nonetheless, the technique is highly flexible in response to these variables. For example, where coppice stool density is high, the cut height could be lowered to produce the required delay in canopy closure, or conversely the cut height could be raised where stool density is lower. Similarly, where deer are especially abundant, the cut could be higher to ensure that more shoots grow out of reach in a shorter time. Results from further trials on different sites could be of great value in refining the method.

A limitation of our technique is that, while it is capable of restoring the traditional rotation period for hazel to regrow and reach canopy closure, it does not mitigate the influence of deer grazing on the ground flora of the woodland, and so could never be as beneficial for floral diversity as placing a deer fence around the plot. Indeed, some plants that are selectively eaten by deer, such as orpine *Sedum telephium* in Brasenose Wood, will not survive without complete exclosure. On the other hand, it should be noted that many of the plants that persisted in plots cut at 0.7 m and 0.8 m are important nectar and food plants for invertebrates. Also, high-coppicing leaves multi-stemmed stool bases largely undisturbed, which may be more conducive to invertebrate diversity than cutting at ground level (Sterling & Hambler 1988).

Overall, our study has shown that, in deer-browsed coppice woodland where wildlife diversity is a key objective, high-level coppicing can potentially offer an alternative, cost-effective technique that simulates traditional coppice rotation.

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