

## INFORMATION NOTE

BY RALPH HARMER OF FOREST RESEARCH

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### SUMMARY

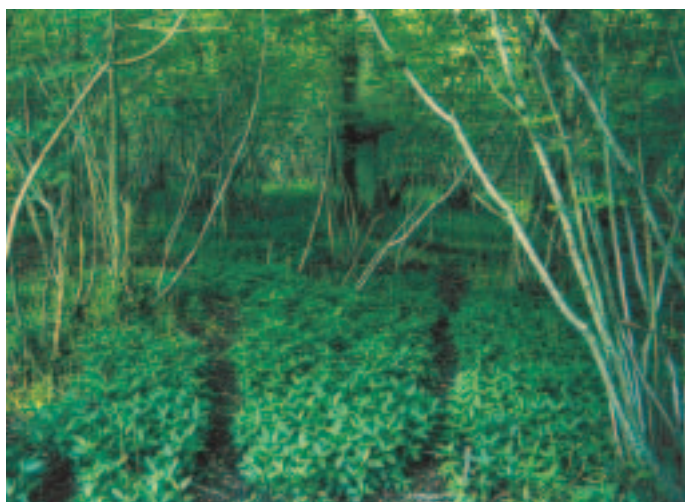
The biology and silviculture of hazel coppice woodlands are briefly explained. Practical procedures for management of stools are described and the results of a recent case study on growth and yield are presented. The month of felling, or height at which stools are cut, has little long-term effect on either mortality of stools or regrowth of coppice shoots. Adequate protection from browsing animals is necessary to ensure success. Excessive browsing will reduce economic potential and may kill stools.

### INTRODUCTION

In bygone days hazel coppices played an important role in the rural economy by providing small diameter material for a wide range of products. While such woodlands remain a valuable part of the landscape, many are neglected (Figure 1) and generally thought to be in need of management to ensure that they retain the biological interest for which they are highly regarded (Buckley, 1992; Fuller and Warren, 1993).

**Figure 1**

Neglected hazel coppice with standards at Herriard Park, the study site, which had not been cut for about 50 years.



The area of woodland actively managed by coppicing has been in decline for many years. The recently completed National Inventory of Woodland and Trees found a total of only 1671 ha of hazel coppice with standards and 1335 ha of simple coppice (Table 1). Precise data on the total

**Table 1**

Estimated areas (ha) of simple hazel coppice, and hazel coppice with standards, in different regions of Great Britain. Data taken from the National Inventory of Woodland and Trees.

	Simple coppice	Coppice with standards
South of England*	1113	1378
North of England	102	260
Wales	104	–
Scotland	16	33
<b>Total</b>	<b>1335</b>	<b>1671</b>

\*All counties to the south of, and including, Gloucestershire, Wiltshire, Berkshire and Greater London.

amount of hazel coppice are unavailable. Some areas of the country appear to have no hazel coppice, but this is probably an artefact of the sampling system used; woodlands were recorded as hazel coppice only when there was obvious evidence that they were being worked or capable of being worked. Consequently the figures are unlikely to be a good indicator of either the area of neglected hazel coppice or that available for restoration. For example, the National Inventory estimated that there was a total of 211 ha of hazel coppice in Hampshire, which is less than the 345 ha of in-cycle coppice in 1994 (Howe, 1995). In addition *c.*650 ha were restored with grant aid from Hampshire County Council between the mid-1980s and mid-1990s, and most of this should be in-cycle or capable of being worked if it has been managed properly. All of these figures are small when compared with the 1947 census (Anon., 1952; 1956) that estimated an area of *c.*13 000 ha of hazel coppice which was 20%

of Hampshire's total woodland area. How much of this remains in a neglected state and is suitable for restoration is unknown.

Although many hazel coppices are long-established ancient semi-natural woodlands, their wide range of wildlife interest generally relies on regular management to provide discrete patches with canopies that differ in age-class. However, the species mixture and structure of these woodlands is artificial and has been strongly influenced by their past management; for example increasing the proportion of hazel, planting oaks to grow as standards, and the unintentional promotion of a flora and fauna that thrives under a regime of regular felling at short intervals. Much of the recent management of coppice woodlands has been carried out for conservation purposes, but the long-term viability of this as a reason for managing woodlands as coppice should be carefully considered before restoration of a coppice regime (Booker and Tittensor, 1992; Goldsmith, 1992).

The management and utilisation of large areas of neglected hazel coppice remains a problem for many owners. While demand for good quality crops from in-cycle coppice remains high in some parts of the country, the complexities of managing for a regular supply of good hazel coppice may not be a realistic option for many woodlands.

The only Forestry Commission publication dedicated to the silviculture and utilisation of hazel was published nearly half a century ago (Anon., 1956) when the total area of hazel coppice and scrub was 60 times that estimated for today by the National Inventory of Woodlands and Trees. The earlier publication described the underwood industry, the management of woodlands, and use of produce from worked coppice, but a substantial part of the publication comprised the results from a study of yield from worked and unworked coppice. However, no clear conclusions were drawn or recommendations made. The aim of this Information Note is to provide silvicultural information about hazel coppice to aid the restoration of neglected coppice woodlands. Existing information is summarised and supporting data from a recent case study are presented.

## BIOLOGY OF HAZEL

Hazel is native and common more or less throughout Great Britain, occurring at altitudes of up to 600–700 m. While it will tolerate a wide variety of soil types, hazel

grows best on well-drained, reasonably fertile, moderately acid to basic soils; it will thrive on both loam and chalk. It is a widespread component of many woodland communities and is often the dominant species of the shrub layer. It is typical of lowland oakwoods that were previously managed as coppice with standards.

Hazel grows quickly and individual stools can produce a large number of small diameter stems that can be cut using simple hand tools. The shoots are supple, readily split, and can be easily twisted and woven by hand to make a range of products. During the past few centuries hazel was primarily used for wattles ('wattle and daub' plaster), sheep hurdles, sheep cages (to hold fodder), barrel hoops (for dry or solid goods), crate rods (for packaging of pottery), garden fencing, pea sticks, bean rods, thatching spars, hedge stakes and ethers, faggots (fuel for kilns and ovens), and fascines (bundles of rods for river control or revetments). A typical crop from 1 acre (0.4 hectare) of good hazel coppice would have yielded around 10 000 rods which was enough to produce about 300 sheep hurdles of 6 ft x 3 ft (1.8 m x 0.9 m) in size, 5000 pea sticks, 250 bean rods, thatching wood, stakes and other material (Durham, 1956). The initial felling to restore neglected hazel coppice will produce relatively few of such products, but if stools and woodlands are properly managed useful crops can be produced at subsequent harvests.

Although hazel can grow as a small, single-stemmed tree, it is naturally shrubby – having a tendency to form many basal branches – and is usually found as a large multi-stemmed shrub up to 5–6 m tall. Bud burst occurs in April and the shoots grow indeterminately throughout summer, with leaves persisting until October or November. Female flowers are wind-pollinated by pollen shed from catkins during the leafless period of winter/early spring. Nuts ripen in September and October. While hazel will tolerate some shade and persists beneath reasonably dense canopies, it performs best in open sunny positions.

After felling, new coppice shoots regrow from dormant buds on the remaining stumps. New shoots can also arise from buds located below ground. Stools of managed hazel coppice are generally long-lived and some can probably survive for several hundred years attaining large diameters. Neglected stools which develop massive stems can become unstable and are likely to have shorter lifespans, perhaps a maximum of 70–100 years. However, such stools can resprout naturally if they are windblown.

## SILVICULTURE

Hazel coppice can be grown either as simple coppice or coppice with standards. In simple coppice there are no overstorey trees and the woodlands are managed by sequential cutting of small coupes, creating single-storied, even-aged patches. Woodlands managed as coppice with standards are multi-storied with even-aged patches of understorey coppice, and a partial overstorey of uneven-aged standards. In Great Britain hazel coppice with oak standards is the classic example of this system. Coppice with standards is more difficult to manage than simple coppice. There is some recent evidence to suggest that hazel stools in some areas may have been managed on a selection system with stems harvested as required (Coppins *et al.*, 2002).

Woodlands with coupes that are cut at an appropriate time in order to produce a crop of the required size and quality, are described as being ‘in-cycle’ or ‘in-rotation’. Relatively small areas of woodlands traditionally managed as hazel coppice are currently in-cycle.

### Management of standards

It is necessary to give careful thought to the management of standards as they can have an adverse effect on the regrowth of coppice shoots and the quality of the habitat for conservation purposes (Harmer and Robertson, 2002). Traditionally, standards were grown to provide large timber and they were managed on a longer rotation than the underwood, for example hazel coppice is often felled at 7–10 year intervals whereas mature standards are felled at 100+ years old. In theory, standards were managed so that each coupe had large numbers in the small-sized, youngest age-class and progressively fewer in older age-classes with least in the large-sized, mature, ready-to-fell category (Matthews, 1989). The numbers of standards present in each age-class were adjusted after the understorey had been felled. However, neglected hazel coppices (Figure 1) often have too many large, over-mature oak standards which cast excessive amounts of shade. In many woodlands it will be necessary to reduce their number and canopy cover to get good regrowth of coppice. Current recommendations advise 20–30% canopy cover for conservation purposes (Watkins, 1990; Warren *et al.*, 2001) but as best yields of hazel occur on sites well stocked with stools and little overstorey, canopy covers of 15–20% after felling will be better.

### Restoration felling

The initial felling to restore neglected coppice can probably take place at any time of the year with little effect on the

survival of stools and the growth of new shoots. However, it is generally inadvisable to carry out operations during late spring and early summer (April–July) when they may disturb or damage nesting birds and other wildlife. As wood from coppice cut in summer appears to be less durable, subsequent cuts of the restored, in-cycle coppice should be made during the dormant season (approximately October to March) when the quality of the crop is thought to be highest. The coupe size felled will depend on management objectives, but areas of 0.5–2 ha are probably appropriate (Forestry Commission, 1994).

### Tools

Whereas in-cycle hazel can be readily cut with a billhook, a chainsaw is probably the only option for the large stems on neglected stools. In general, all stools of hazel should be cut as close to the ground as possible. This will encourage new shoots to grow near or below ground level, allow them to develop their own root system and reduce the risk of instability and butt rot. It is often recommended that cuts should be angled to shed water from the cut stumps and stools, but there is no good evidence to suggest that this is necessary for hazel.

### Harvesting damage

During restoration it is important not to damage the existing stools and standards during harvesting operations, e.g. when driving machinery across the site. All produce should be extracted before new shoots develop.

Large amounts of unusable lop and top and other small diameter wood are usually produced by the initial restoration felling. While this can be constructed into dead hedges or left to rot *in situ* it is commonly burned (Figure 2).

### Figure 2

When burning unusable material, care should be taken not to kill or damage stools, as shown here.



If bonfires are used, keep them small, and locate them away from standards in areas poorly stocked with stools. Re-use the same sites in subsequent years. Use 10 or less fires per hectare.

## Mammal damage

Deer browsing can prevent successful regeneration, and adequate protection from browsing animals for 2–3 years after felling is the most important operation necessary to ensure satisfactory restoration of hazel coppice. The damaging effects of animals on regrowth of shoots has been known for many years (Figure 3). In earlier times there were laws to try to prevent damage by domestic stock, but nowadays damage is generally caused by high, uncontrolled populations of deer and rabbits. There are a variety of methods for preventing or reducing damage (Harmer and Howe, 2003; Hodge and Pepper, 1999; Mayle, 1998; Pepper, 1992, 1999), most of which rely on exclusion of animals from the felled site. These include the use of harvesting residues for brush piles and dead hedges, temporary or permanent fences and reduction in the size of animal populations by culling. Whichever method is chosen it should allow sufficient regrowth of coppice to achieve the management objectives for the site. Attempts to avoid the use of exclusion methods to reduce animal damage, by cutting large coupes, are likely to fail unless there is also rigorous control of animal populations. It may be very difficult for an individual owner to control deer adequately and joint working at a landscape scale (such as that facilitated by deer management groups) may be the best option (Mayle, 1999).



**Figure 3**

Hazel stool with shoots showing evidence of deer browsing damage.

## Stocking density and yield

The number of stools required and their distribution across the site will vary with management objectives, but it is important that the stocking density is sufficient to ensure good canopy cover across most of the site within a few years of cutting. Woodland restored with the intention of growing good hazel crops on rotations of 6–10 years should have about 1250–2000 stools ha<sup>-1</sup> that will produce about 25 000 rods ha<sup>-1</sup> (Table 2).

Low stool densities will reduce yield and quality of the crop: stools in poorly stocked areas will form wide, spreading, bushy crowns with curved, branched stems of variable size.

**Table 2**

Number of useable rods per stool needed in hazel crops with different stool densities to achieve different quality grades.

Stool density (ha <sup>-1</sup> )	Grade 1	Grade 2	Grade 3
1000	30	20	10
1375	22	15	8
1875	16	11	5

A rod is a stem which has a minimum usable length of 2.5 cm but may be up to 5 m, with a basal diameter in the region of 1.5–5 cm. Data adapted from Wessex coppice group guidance.

Growth of hazel is fast but the crop has its greatest value when stems are small with butt diameters around 7.5 cm or less. Large diameter stems have little saleable value and felling old, dense crops is an expensive operation. The yield of material that can be harvested from neglected hazel coppice will depend on a variety of factors such as age and stool density. Estimated volumes for trimmed shoots in unworked coppices 15–23 years old vary between 27 and 60 m<sup>3</sup> ha<sup>-1</sup> (Jeffers, 1956). These data were collected from young coppices and those that have been neglected for longer will probably have a much greater standing volume.

Assuming best practice is followed, a new crop can be harvested after 6–10 years. The yield will depend on stool size and density but it is likely to improve after the second cut. The subsequent value of the crop will depend on the size and number of rods, and the markets available, but if it is of good quality, then given the short rotation, it is likely to provide better returns than many high forest stands.

In those sites restored for purely conservation purposes some open areas or patches at a lower stool density may be acceptable as they will provide structural diversity that may encourage other desirable flora and fauna. However, large open areas may become dominated by weed species such as bramble and grasses.

Where there are insufficient stools to meet management objectives their number can be increased by layering (Harmer and Howe, 2003; MacDonald, 1986) or planting robust transplants 50 cm tall with minimum root collar diameters of 9.5 mm.

## RECOMMENDATIONS

- Although felling to restore neglected hazel coppice is a simple operation, the viability of coppice as a method to manage a woodland needs careful consideration. If the achievement of management objectives requires the use of a coppice system then appropriate techniques must be used and sufficient resources must be available to ensure that successful management as coppice is sustained in the long-term.
- Neglected coppice can be felled at any time of the year with little effect on subsequent growth, but it is inadvisable to cut during spring and early summer when it will disturb nesting birds.
- Stools should be cut as close to the ground as possible. While this may reduce the numbers of new stems produced, the remaining stools will be less prone to damage from any machinery used on site. New stems will probably develop closer to, or below, ground level and may develop their own root systems and have greater stability.
- Coppice with standards is more complicated to manage than simple coppice. Standards reduce the size and vigour of coppice shoots and stools, and if necessary overstorey canopy cover should be reduced when the understorey is cut. After felling, their cover should not exceed 25–30%, although lower amounts of 15–20% may be better if good crops of hazel are wanted.
- New shoots must be protected until they have grown beyond the height at which browsing damage occurs, for vigorous crops in good growing conditions this will be a minimum of two growing seasons. The method of protection used must be adequate to exclude damaging

animals present on and around the site (Figure 4a and b). Prevention of damage by controlling animal populations is unlikely to succeed unless it is rigorous and maintained for a sufficiently long period of time over an extensive area around the site.



**Figure 4**

(a) Temporary fencing erected around a coupe of hazel coppice with oak standards.

(b) Permanent deer and rabbit fence being erected around newly felled broadleaved coppice.

## CASE STUDY: Restoration of neglected hazel at Herriard Park, Hampshire

This case study was established in consultation with Jonathan Howe who, at the time, was the county council officer responsible for promoting the restoration of the large areas of neglected hazel coppice in Hampshire (Howe, 1995). The experiment was designed to examine the following recommendations that were being made in 1994 for the management and restoration of hazel coppice:

- Avoid cutting in the growing season due to the adverse affect on regrowth.
- Traditional practice suggests that hazel should be cut as close to the ground as possible, at a maximum of 15 cm above ground level. Reasons for this are unclear but probably relate to rooting, stability and longevity of the stool.
- Fencing to protect stools from browsing animals is not necessary on large, open coupes.

The experiment also planned to assess the yield from the stools after one coppice cycle. The establishment of the experimental site was partly funded by Hampshire County Council.

The information describes results for stools protected by fencing. The study of regrowth from unfenced stools was abandoned after two seasons as there were very few shoots greater than 30 cm tall; and it was obvious that the site would fail to recover without the protection of stools from browsing by deer (Figure 5a and b). The area was subsequently fenced by the estate and the hazel has regrown.

### Methods

The study took place at Herriard Park, Hampshire within an area of neglected hazel coppice with standards which had not been cut for about 45–50 years (see Figure 1). During February 1994 an area of about 1 ha was enclosed with combined deer and rabbit netting (Pepper, 1992). The site was divided into 4 approximately equal blocks, and 5 groups of 10 hazel stools (200 in total) were selected in each area, in locations that were not directly beneath the canopy cover of an overstorey tree. One group of stools from

**Figure 5**

(a) Unfenced area in summer 6 months after felling with stools showing no evidence of regrowth.

(b) Fenced area at same time of year showing good regrowth from stools.



each block was cut in February, April, June, August and October. Two different methods of cutting were used each month: half of the stools were felled approximately 30 cm above ground level, the remainder were cut as close to the ground as possible. These are referred to as the High and Low treatments. All felling was carried out with a chainsaw. A majority of the stools on site formed a non-experimental matrix, some of which was cut from around the experiment stools when they were felled. The remaining matrix was finally removed in October 1994. Cordwood was stacked, and lop and top from all fellings was burned on site during October.

### Assessments

The initial size of the stool was assessed by:

- Measuring the diameter at ground level in two directions at 90° to each other; one of these was the longest diameter of the stool.

- Counting and measuring the diameter of live stems 30 cm above ground level.

After felling the following were observed on each stool:

- The number of live and dead stumps present in 1995 and 1997.
- Annual assessment of the number of live stems regrowing and the length of the 5 tallest live stems present.

The yield was assessed in 2001. Stems were felled in February 2001 (Figure 6) and those from each stool were bundled together for subsequent working into a marketable product. This part of the experiment was curtailed by the restrictions to site access caused by foot-and-mouth disease, but one complete block of 40 stools was cut and its marketable yield was assessed by Jonathan Howe in June 2001.



**Figure 6**

Felling of experimental stools during February 2001.

## Results

### Initial stool size

The initial size of the stools was very variable (Table 3), for example the total number of live stems present varied between 1 and 46, with basal areas from 12 to 1029 cm<sup>2</sup>. Overall stools were about 70 cm maximum diameter at ground level covering a ground area of 2500 cm<sup>2</sup>; they had an average of 13 live stems and a total basal area at 30 cm height of about 185 cm<sup>2</sup>.

**Table 3**

Initial diameter, ground area, number of stems and basal area of experimental stools. Values are means with maximum and minimum values in brackets.

Month of cut	Diameter (cm)	Area (cm <sup>2</sup> )	Stems	Basal area (cm <sup>2</sup> )
February	61 (12–100)	1936 (66–5184)	10 (1–20)	157 (23–476)
April	61 (26–120)	2049 (308–6315)	11 (4–32)	169 (59–499)
June	86 (9–145)	4485 (35–9924)	17 (2–46)	223 (12–594)
August	88 (47–162)	4444 (772–20178)	19 (8–44)	250 (83–1029)
October	80 (32–143)	3445 (279–10847)	21 (8–39)	245 (48–622)

Diameter = length of longest diameter of stool; area = ground area of stool (estimated from the stool's diameters); stems = numbers of stems on stool; basal area was measured at 30 cm above ground.

### Regrowth after felling

The month of cutting influenced the timing of subsequent regrowth. Although 95% of the stools cut in February had started growth by the end of May, only 70% of those felled in April had new actively growing shoots. By the end of October all live stools cut in February, April and June had produced new shoots, but only 40% of those cut in August had regrown. During the 1995 growing season all stools in the August and October treatments produced new shoots.

### Mortality

Only one of the 200 experimental stools died. However, on most of the stools some of the cut stumps remaining after felling failed to produce new shoots and died. The percentages of dead stumps present at the end of 1997 are shown in Table 4.

**Table 4**

Percentage of dead stumps present on stools cut Low and High in 1997.

Month of cut	Low	High
February	29	24
April	23	22
June	29	23
August	20	21
October	21	15
<b>Overall mean</b>	<b>24.4</b>	<b>21</b>

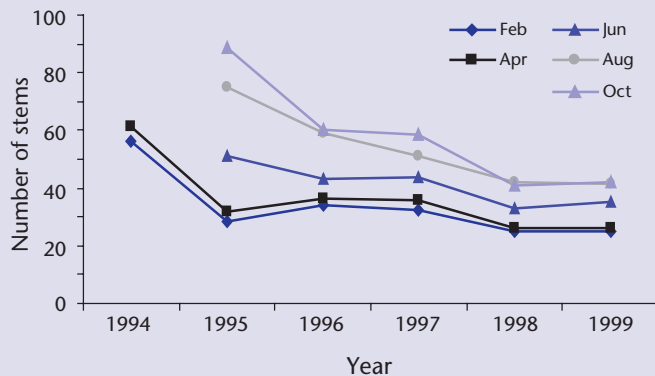
Overall about 20% of stumps were dead, but neither the time nor height of cutting had an effect on the percentage that died.

### Number of stems

The mean number of stems present on the stools declined with time and by the end of the 1999 season there were 25–40 on each stool (Figure 7). There appears to be a difference in the number of stems present on stools felled in each month, with those felled in February, April and June having fewer than those felled in August and October. However, a large part of the difference can be accounted for by initial stool size (those cut in February and April were smaller, Table 3), and the timing of growth (initial numbers in 1994 for the February and April cuts were similar to those in 1995 for the August and October treatments). Stools that were cut High produced significantly more stems than those cut Low. Throughout the period of the experiment High cut stumps had more new stems than those cut Low. Initially the difference was 13 and although this declined with time after 6 seasons High cut stumps still had 5 more stems than those cut Low.

**Figure 7**

Mean number of stems present between 1994 and 1999 on stools felled in different months during 1994.

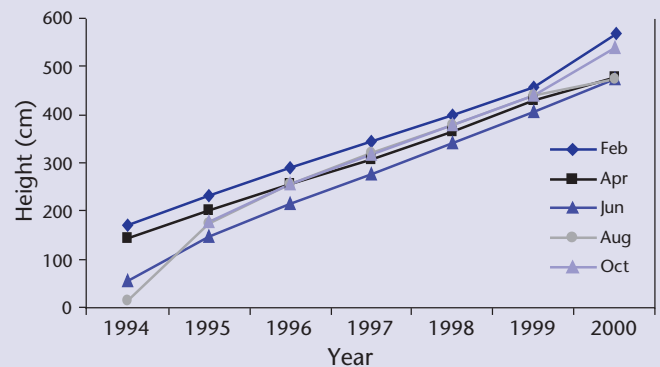


### Lengths of new coppice shoots

The height at which the stems on the stool were cut had no effect on the length of the shoots that regrew, but the time of cutting can have a marked effect on growth immediately after felling. The few shoots that grew in 1994 following the August cut were very short (15 cm) and those initially produced after the June cut were also short in comparison with those felled in February and April (Figure 8). Mean height growth of the 5 tallest stems during the first growing season

**Figure 8**

Mean height of the 5 tallest stems present between 1994 and 2000 on stools felled in different months during 1994. Data for 2000 is for 1 block only (see Methods).



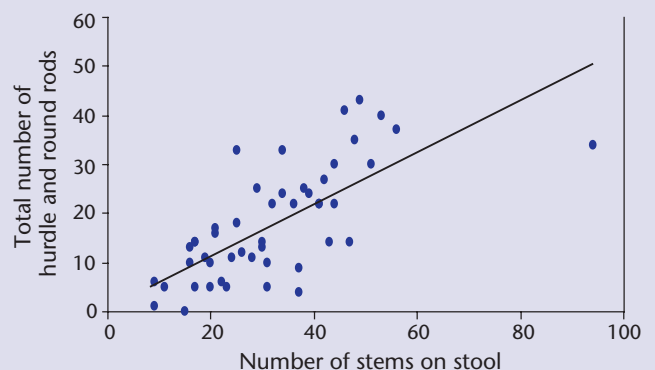
varied between 150 and 175 cm for February, April and October treatments. In subsequent years annual height increments were about 50 cm for all treatments. Although stools cut in February and April had stems that were initially the tallest, and June the shortest (Figure 8), the significant differences between treatments disappeared with time. At the end of the experiment those cut in February and April were apparently no longer than those cut in August and October, despite having had an extra growing season.

### Yield

There was a significant linear relationship between the numbers of stems on each stool and the total number of hurdle and round rods produced (Figure 9) and the model accounts for 49% of the variation. The quality of the stools and stems was variable but Jonathan Howe classified the crop as Grade 2 hazel coppice (Table 2).

**Figure 9**

Relationship between the number of stems growing on a stool and the combined yield of hurdle and round rods ( $y=0.527x + 1.13$ ,  $R^2 = 49\%$ ).





A total of 1767 marketable pieces were produced from the 1553 stems present on the 40 stools harvested (see Figure 10). The stems were worked-up into 7 products in the assortment listed in Table 5.

**Figure 10**

Jonathan Howe working up the hazel coppice.



## Conclusions

- The time of cutting had few long-term effects on regrowth, and no significant effects on either mortality of stools overall or individual stumps

within stools. Although there were more stems on stools cut in August and October this was largely explained by stool size. In comparison with February and April treatments felling in June initially reduced the lengths of new stems produced. Little regrowth occurred until the following season on stools felled during August. However, differences between treatments declined with time and after 4–5 seasons of growth there were no significant differences between the mean lengths of the 5 longest shoots on stools cut at different times of the year.

- The height at which the stools were cut had no effect on either stool mortality or lengths of shoots produced, but the number of new stems was greater on stools cut high.
- Stools failed to regenerate satisfactorily unless they were fenced.
- The effects of cutting height and month of felling on yield could not be properly investigated due to the problems caused by foot-and-mouth disease. There was a significant relationship between the number of stems on a stool and the number of hurdle and round rods produced, suggesting that a count of standing stems is a reasonable predictor of yield.

**Table 5**

Total number of pieces of 7 types of product from 40 stools of restored hazel coppice harvested after 6–7 years of growth.

Product	Length (m)	Number	Average	Minimum	Maximum
<b>Hurdle rods</b> for splitting and weaving into a hurdle	3–4	551	9	0	31
<b>Hurdle round rods</b> used at the top and bottom of the hurdle	2–3	370	7	0	27
<b>Sail rods</b> straight rods for uprights in hurdles	1.5–2	70	0	0	7
<b>Pea sticks</b> bushy sprays for supporting herbaceous plants	–	397	6	0	27
<b>Spar gads</b> round rods that are split into 4–8 thatching spars	0.75	263	5	0	17
<b>Hedge stakes</b> robust stakes for hedge laying	1.75	48	1	0	4
<b>Bean sticks</b> for garden use	2.5	68	1	0	2

Average = median value. Minimum/Maximum = the minimum and maximum quantities produced from a single stool. Note that not all products are produced by all stools.

## ACKNOWLEDGEMENTS

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