A decade of grey squirrel bark-stripping damage to beech in Lady Park Wood, UK

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Summary

The scale and distribution of American grey squirrel (Sciurus carolinensis) bark-stripping damage to beech (Fagus sylvatica) stems was monitored in a mixed broadleaved woodland retained as a Research Natural Area through the use of permanent transects. During an initial outbreak of debarking damage in 1983 almost one-third of beech individuals ≥24 cm d.b.h. in stands of 40 years' growth were badly damaged and by 1993 this level of damage had risen dramatically to over 50 per cent. One-third of badly damaged individuals in 1983, including a number of potential canopy dominants, died during the decade, but some that survived grew very vigorously. Throughout squirrels preferentially debarked intermediate sized (10–25 cm d.b.h.) stems in particular parts of the stands aged 40–50 years, apparently tending to select stems that were growing rapidly. Other species and stand areas of >100 years' growth remained largely unscathed. Within the 10-year period squirrels had critically affected the successional development of the wood.

Introduction

The American grey squirrel (Sciurus carolinensis) was introduced to Britain at the turn of the century (Middleton, 1931) and now occurs at high densities in mixed deciduous woodlands across lowland Britain (Usher et al., 1992). The species has become well known to British foresters because of its bark-stripping activities, whereby amounts of tree bark are removed from living stems mainly between the months of May and July (Shorten, 1954, 1957; Gurnell, 1987). Considerable research has been undertaken to examine the ecology of grey squirrel bark-stripping damage in Britain (Gill, 1992). It is known that squirrels can cause damage to a wide range of broadleaved tree species but preferentially select beech (Fagus sylvatica) and sycamore (Acer pseudoplatanus) (Rowe, 1984; Rowe and Gill, 1985). Plantations of these species aged between 15 and 40 years with high average stem phloem volume contents in June/July, and in particular large and vigorous individuals, appear most susceptible to attack (Mackinnon, 1976; Kenward, 1983; Rowe and Gill, 1985; Kenward and Parish, 1986; Kenward et al., 1988). Outbreaks of bark-stripping are most likely to occur when squirrel densities are high (Kenward and Parish, 1986), when stands have a diversity of seeding tree species (Kenward et al., 1992), and once damage is triggered...
then yearly repetition is likely (Kenward et al., 1988). The contribution of agonistic behaviour is considered to be as or more important than feeding (Taylor, 1966, 1969; Gurnell, 1987; Gill, 1992).

Nevertheless no published research concerning the long-term effects of grey squirrel damage within mixed British woodlands appears available. De-barking damage could potentially impair the growth of an individual, produce structural weakness and promote consequent wind-snap, result in partial crown die-back or more severe die-back when ring-barking occurs (complete removal of bark around a stem), and may eventually result in, or significantly contribute towards, the death of an individual. When selective outbreaks disturb the canopy of mixed woodland stands then the balance between the resident species could be critically altered and the long-term development modified. To examine this potential the cumulative pattern and effect of grey squirrel de-barking damage was studied over a 10-year period within mixed deciduous stands at Lady Park Wood, in the Wye Valley, UK. As a study site Lady Park Wood has the distinct advantage that it contains a range of mixed broadleaved stand types that for the past fifty years have been purposefully retained as Natural Research Areas (i.e. without silvicultural management). This has allowed natural woodland processes to prevail in relative isolation (Peterken and Mountford, 1995). It is valuable to note that observations collected from reserves of this type continue to provide valuable conclusions for the multi-purpose objectives of modern forestry practice.

The grey squirrel first colonized the area about Lady Park Wood in 1940 (Parsons and Middleton, 1937; Shorten, 1946) and since about 1975 they appear to have existed at high densities even though poison bait has been offered in an attempt to limit their numbers (Roger Warn, personal communication). The first record of de-barking damage by grey squirrels within the wood comes from the winter of 1957/58 when Dr Eustace Jones recorded in the Lady Park Wood Archive that they killed some and caused much die-back of birch stems in parts of the stands. Damage may have occurred sporadically thereafter as there was a break in observational recording from 1960 to 1977, with the next outbreak of damage recorded in June 1983 when beech stems in particular parts of the wood were badly damaged while other species and areas remained largely unscathed (Peterken and Jones, 1989). A decade later, in the summer of 1993, it was possible to assess the long-term impact of this outbreak on stand development and also to provide a record of the accumulating de-barking damage that had continued over this 10-year period.

Description of site and study areas
Lady Park Wood (National Grid reference SO 546 145) is situated in the lower Wye Valley, astride the border of England and Wales. This 35 ha ancient semi-natural woodland has been the focus of long-term woodland research spanning half a century (Peterken and Jones, 1987, 1989; Mountford, 1994; Peterken and Mountford, 1996), with a synopsis provided by Peterken and Mountford (1995).

A full description of the reserve is provided by Peterken and Jones (1987, 1989). Apart from beech, the most common species within the stands at Lady Park Wood are ash (Fraxinus excelsior), birch (Betula pendula and B. pubescens), field maple (Acer campestre), hazel (Corylus avellana), lime (Tilia cordata and T. platyphyllos), sessile oak (Quercus petraea) and wych elm (Ulmus glabra). These aggregate into a number of stand types conforming mainly to type 8E acid and calcereous sessile oak—ash—beech woodland of Peterken (1993) or beech woodland types W12 and W15 of the National Vegetation Classification (Rodwell, 1991). The wood is set within a carboniferous limestone gorge, and rises across bouldered slopes to a cliff line and then across 20° to 30° slopes towards an uppermost plateau, providing a number of topographical stand areas (Figure 1). Traditionally the wood was managed as coppice-with-standards but from 1900 was promoted by thinning practice towards a beech high forest. Then, when the stands were largely aged between 40 and 70 years approximately two-thirds were virtually clear felled between 1940 and 1944 except for a scatter of standard beech and oak trees that were retained for
Amenity. Since this time the whole wood has been allowed to develop naturally without any silvicultural management.

Three woodland areas were available for analysis (Figure 1), each containing contrasting beech populations (Figure 2). The *young-growth stands* (Peterken and Jones, 1989; Mountford, 1994) contained a relatively large number of mostly even-aged beech stems within a dense and mixed birch stand of 40–50 years’ growth. The beech were generally distributed and included both single and multi-stemmed individuals from all parts of the canopy range. Most stems were mainly small to medium size (5–25 cm d.b.h.) but the retained standards from 1944 provided a scattering of larger sized stems (>25 cm d.b.h.).
Young-growth stands (1977)
Old-growth stands above cliff (1977)
Old-growth stands below cliff (1985)

Figure 2. Size class distributions of beech in 1977 and 1985 for the study transect areas of the young-growth stands, old-growth stands above the cliff, and old-growth stands below the cliff (see Figure 1 for location of stands).

The old-growth stands above the cliff (Peterken and Jones, 1987) contained a moderately large number of beech stems for analysis from a mixed beech high forest stand of around 100 year’s growth. The available beech population was generally distributed through the stands and contained many large upper and mid canopy individuals (>25 cm d.b.h.) in addition to a significant number of smaller (<25 cm d.b.h.) sub and lower canopy stems. The old-growth stands below the cliff (Peterken and Jones, 1987) included few beech from a wide range of size classes.

Recording
The basis for this study was the long-term woodland monitoring scheme at Lady Park Wood (Peterken and Backmeroff, 1988), whereby nine permanent transects (I–IX), each 66 feet wide (c. 20 m), provided samples from all of the main stand areas (Figure 1). Full details of the record up to 1985 are described by Peterken and Jones (1987, 1989).

During 1977 detailed charts were prepared for the young-growth stands, mapping the position and d.b.h. of stems on all tree and large shrub individuals. In 1983 a follow-up survey recorded the status of all charted stems and noted the scale of damage to beech due to a recent outbreak of grey squirrel bark-stripping. In June 1993 stem girth sizes at breast height were measured, while mortalities and recruits were noted. At the same time the extent of all visible bark-stripping damage (i.e. both recent and aged) to living beech stems was quantified using a five point scale adapted from Stribley (1990):
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0 = no damage (no bark removed)
1 = limited damage (<10 per cent bark removed)
2 = moderate damage (10–50 per cent bark removed)
3 = severe damage (>50 per cent bark removed)
4 = very severe damage (ring-barked)

Bark-stripping damage was recorded first for the lower (<2 m height) and then for the upper stem (>2 m height), with each stem then categorized according to the maximum damage score observed. Thus a stem that scored 0/2 (i.e. no lower stem damage and moderate upper stem damage) was classified into the moderate damage category, whereas a stem that scored 3/1 was classified into the severe damage category.

The first detailed charts of the old-growth stands above the cliff were also made in 1977. A follow-up survey in 1983 involved a full enumeration of charted stems, while a qualitative survey in 1986 recorded descriptive details of all stems, noting their canopy position, crown status, and other visible characteristics including squirrel damage. During 1992 a complete re-enumeration and qualitative assessment were undertaken with girth measurements taken and descriptive details recorded as in 1986. Detailed surveying of the old-growth stands below the cliff began in 1985 and they were resurveyed in 1992.

The data set used in the study was large and generally reliable. Most stems were relocated but where doubt existed about the status or size of a particular stem or individual then it was excluded from the particular analysis.

Table 1: The distribution of bark-stripping damage (see text for details) to beech stems in relation to stem size (d.b.h. cm) for 660 stems surveyed in Lady Park Wood young-growth stands in 1993

<table>
<thead>
<tr>
<th>Stem d.b.h. size (cm)</th>
<th>None</th>
<th>Limited</th>
<th>Moderate</th>
<th>Severe</th>
<th>Very severe</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5.0</td>
<td>165</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>176</td>
</tr>
<tr>
<td>5.0–9.9</td>
<td>161</td>
<td>26</td>
<td>12</td>
<td>32</td>
<td>22</td>
<td>253</td>
</tr>
<tr>
<td>10.0–14.9</td>
<td>41</td>
<td>17</td>
<td>10</td>
<td>44</td>
<td>36</td>
<td>148</td>
</tr>
<tr>
<td>15.0–19.9</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>16</td>
<td>15</td>
<td>54</td>
</tr>
<tr>
<td>20.0–24.9</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>&gt;25.0</td>
<td>11</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>390</td>
<td>59</td>
<td>35</td>
<td>100</td>
<td>76</td>
<td>660</td>
</tr>
</tbody>
</table>

Damage levels in the young-growth stands, 1977–93

The 1977 survey of the young-growth stand transects I–VI did not mention any signs of squirrel damage. However, the qualitative survey made in 1983 stated that 29 per cent of all maiden and coppice individuals attaining 4 cm d.b.h. had been significantly damaged by a recent outbreak of squirrel de-barking (Figure 10 Peterken and Jones, 1989).

The 1993 survey examined the extent of bark-stripping damage to 660 living beech stems within the study transects (Table 1). The vast majority of the stems were still relatively small in size (87 per cent <15 cm d.b.h.) and represented the essentially even-aged post-1944 cohort, while the 15 individuals greater than 25 cm d.b.h. (ranging from 32 to 90 cm d.b.h.) were all standards that had been retained in 1944. De-barking damage was widespread with almost one-third (32 per cent) of all stems at least moderately damaged. In most cases these damaged stems had been stripped of large patches of bark with nearly half (47 per cent) recorded as severely damaged and over a third (36 per cent) as very severely damaged. This level of very severe damage meant that 12 per cent of all stems had been ring-barked and this included a number of potential canopy dominants that had become reduced to sub-canopy individuals.

To compare 1993 damage levels with those recorded in 1983, the damage categories of severe and very severe used in the 1993 survey were considered to equate with significant damage as recorded in 1983. This was justified.
by the fact that all surviving significantly damaged stems were recorded with either severe or very severe damage in 1993. As in 1983 multi-stemmed individuals were assessed according to the status of their largest stems. On this basis damage to the beech population had almost doubled by 1993 with 53 per cent of all individuals attaining 4 cm d.b.h. recorded as significantly damaged in comparison to the 29 per cent recorded in 1983.

Damage patterns in the young-growth stands, 1983–93

As in 1983 (Figure 9 Peterken and Jones, 1989), damage recorded in 1993 was largely confined to the intermediate-size classes (10–25 cm d.b.h.) (Table 1). Few of the smaller stems (<5 cm d.b.h.) and larger standard trees (>25 cm d.b.h.) were recorded with more than limited amounts of damage, whereas 64 per cent of the intermediate-sized stems were at least moderately damaged. Damage within these intermediate-sized stem classes tended to be either severe or very severe and one-quarter had been ring-barked. From the chart data it was possible to examine the spatial distribution of damage to the most heavily damaged size classes (10–25 cm d.b.h.) (Figure 3). Damage was noticeably patchy, being concentrated at the lower end of transect I, along transects III 0–400, IV 0–500, and parts of V. This aggregation meant that major loss of beech canopy had occurred in some transect areas (e.g. IV 300–400). Comparison with the 1983 damage distribution (Figure 10 Peterken and Jones, 1989) indicated that squirrels had generally continued to focus their activities within similar stand areas between 1983 and 1993. Curiously a number of stems in severely damaged areas remained unscathed (e.g. IV 200–200) and in direct contrast portions of the transects remained largely unaffected by the decade of squirrel activity (e.g. III 630–700).

Performance of damaged individuals in the young-growth stands, 1977–93

It was possible to identify 56 individuals (34 maiden and 22 coppice) from those that were significantly damaged in 1983 and examine their performance through to June 1993 (Figure 4). Mortality had been considerable with 18 (32 per cent) individuals having died. In comparison, only 38 (12 per cent) of the 309 individuals in the beech population as a whole died between 1983 and 1993. Evidently the loss of significantly damaged individuals accounted for almost half (47 per cent) of the 10-year period beech mortality. Loss of damaged maidens (41 per cent) was far greater than coppice (18 per cent), presumably because they lacked the compensatory advantage which additional undamaged stems offered to multi-stemmed coppice individuals. Mortality occurred across the whole size range and although mainly small, and therefore suppressed, maiden individuals died, some of the better developed individuals in the population also succumbed.

Although the size of badly damaged stems on significantly damaged individuals was not recorded in 1983, the 1977 d.b.h. measurements allowed an analysis of stem size change between 1977 and 1993. From the records it was possible to identify 40 stems for analysis. Stem d.b.h. change was notably variable and ANOVA inferred that no significant difference ($f = 2.00, P = 0.11$) existed between the mean d.b.h. change of maiden or coppice stems or those of the remaining beech stems that were not severely damaged in 1983 (Figure 5). Nevertheless a number of the damaged stems had clearly shown superior growth performance in comparison to the whole population, with 9 of the 58 beech stems that attained 6 cm or more growth between 1977 and 1993 being recorded as severely damaged in 1983.

A further growth analysis was undertaken to examine the performance of stems within the most heavily damaged size classes (10–25 cm d.b.h.) in 1993. For each of the five damage classes the stem d.b.h. change rate between 1977 and 1993 was compared (Figure 6). Individual stem performance within each of the damage classes varied considerably, but the mean d.b.h. change rates of the limited, moderate and severe damage classes were all very similar ($0.33, 0.37$ and $0.34$ cm a$^{-1}$ respectively) and somewhat greater than those of the undamaged and very severe damage classes ($0.21$ and $0.25$ cm a$^{-1}$ respectively). ANOVA inferred that the mean
Figure 3. Schematic diagram showing the distribution of grey squirrel de-barking damage to beech stems sized 10-25 cm d.b.h. along the young and old-growth stand study transects (see Figure 1 for location), recorded in 1993 and 1992 respectively. Each circle shows the location of an individual stem and the scale of damage recorded (see text for details).
Figure 4. Fate of maiden and coppice beech individuals in the young-growth stands between 1983 and 1993 that were recorded as significantly damaged by grey squirrel de-barking in 1983 (see text for details). The individuals are shown according to their size in 1977 with coppice individuals represented by the size of the largest stem on the stool.

Damage in the old-growth stands, 1977–92

Although beech was abundant within the old-growth stand transects I–V above the cliff line, no significant mention was made of squirrel damage when the first detailed charts were prepared in 1977, when they were enumerated in 1983 or when they were surveyed in 1986. The 1992 transect survey examined the remaining living 259 beech stems for signs of squirrel damage and overall damage still remained negligible (Table 2). This was despite the fact that the population included a large number of stems within the intermediate size class (10–25 cm d.b.h.), which in many parts of the young-growth stands had been badly damaged by squirrels (Figure 3). The mean growth rate of intermediate sized stems in the old-growth stands between 1977 and 1992 was 0.12 cm a⁻¹ and this was significantly lower (ANOVA $f = 20.9$, $P = <<0.001$; Tukey–Kramer test, $P_{\text{min}} = 0.001$) than that of any damaged intermediate sized stem classes in the young-growth stands (Figure 6).

The few beech within the old-growth stand transects VII–IX below the cliff line were examined during the survey of 1985 but no damage was noted and by 1992 the position remained the same (Table 2).
Figure 5. Stem d.b.h. change in relation to initial size between 1977 and 1993 for beech stems in the young-growth stands. Individual maiden stems (●) and coppice stems (○) that were recorded as significantly damaged by grey squirrel de-barking in 1983 are shown together with the mean d.b.h. change and standard deviation for stems that were recorded as not significantly damaged in 1983.

Discussion

Although grey squirrels had existed in the Lady Park Wood area for several decades, except for some damage to developing birch in the late 1950s, it was not until in June 1983 that the first large-scale de-barking damage was recorded. Within the first 2 months of the summer of 1983 almost one-third of all established beech individuals within particular parts of the young-growth stands were badly de-barked by squirrels
Table 2: The distribution of bark-stripping damage (see text for details) to beech stems in relation to stem size (d.b.h. cm) for 298 stems surveyed in Lady Park Wood old-growth stands in 1992

<table>
<thead>
<tr>
<th>Stem d.b.h. size (cm)</th>
<th>Old-growth stands above cliff (transects I-V)</th>
<th>Old-growth stands below cliff (transects VII-IX)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total number of stems</td>
<td>Number of damaged stems</td>
</tr>
<tr>
<td>&lt;5.0</td>
<td>62</td>
<td>1†</td>
</tr>
<tr>
<td>5.0–9.9</td>
<td>57</td>
<td>0</td>
</tr>
<tr>
<td>10.0–14.9</td>
<td>26</td>
<td>2†</td>
</tr>
<tr>
<td>15.0–19.9</td>
<td>16</td>
<td>1*</td>
</tr>
<tr>
<td>20.0–24.9</td>
<td>15</td>
<td>1*</td>
</tr>
<tr>
<td>&gt;25.0</td>
<td>83</td>
<td>1*</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>259</td>
<td>6</td>
</tr>
</tbody>
</table>

*, limited damage at stem base †, severe damage at 3 m height

(Figure 10 Peterken and Jones, 1989). By 1987 only a small minority of these badly damaged stems had been killed outright and some were sprouting vigorously (Peterken and Jones, 1989), but by June 1993 around one-third had died (Figure 4), accounting for almost half of the beech mortality between 1983 and 1993. Although most of the fatalities were relatively small maidens under considerable competitive and shade stress, a number were either large maiden or coppice stools that were vigorous potential canopy dominants (Figure 4). Nevertheless no detectable effect was found on the overall growth of surviving badly damaged stems between 1977 and 1993 and some even showed vigorous growth during the decade (Figure 3).

Despite continued efforts to control squirrel numbers using poison bait during the decade 1983–93, damage levels to beech in the young-growth stands increased substantially (Table 1). In comparison to 1983, damage levels to established individuals almost doubled, with many recorded as ring-barked, including several potential canopy dominants. Although Lady Park Wood contained a diversity of seeding tree species and a large number of 40–50-year-old beech stems making it susceptible to attack by squirrels (Rowe, 1984; Rowe and Gill, 1983; Kenward et al., 1992), the escalation and severity of this damage are noteworthy.

Damage throughout the decade was characteristically selective, repetitive and patchy. Between 1983 and 1993 intermediate sized stems were selected while smaller saplings and large trees in all parts of the wood were largely ignored (Figure 9 Peterken and Jones, 1989; Tables 1 and 2). This preference for medium sized stems has been similarly recorded by Stribley (1993) in her studies on Sussex beech woodlands, by Rowe and Gill (1985) who recorded selectivity of 10–40-year-old plantations and is widely observed in other damaged British woodlands. At the spatial scale it was evident that only particular patches and individuals in the young growth were being targeted by the squirrels. In 1993 most stems were severely rather than just moderately damaged (Table 1) and cases of accumulated damage were widespread. Additionally, similar general damage distributions were recorded in both 1983 and 1993 (Figure 10 Peterken and Jones, 1989; Figure 3). Kenward et al. (1988) report on this tendency to repeatedly damage stands and particular individuals, apparently in relation to the occurrence of high average stem sap contents and corresponding high growth rates (Kenward, 1982; Kenward, 1983; Kenward and Parish, 1986; Kenward et al., 1988). Examination of the growth performance of intermediate sized stems (i.e. those that were preferentially attacked) suggested that similar tendencies had occurred in Lady Park Wood. In comparison with those intermediate sized stems that were damaged in the young-growth, similar stems in old-growth...
Figure 6. Stem d.b.h. change rates between 1977 and 1992/3 for intermediate sized (10–25 cm d.b.h.) beech stems in the young and old-growth stands above cliff. Stems in the young-growth stands are categorized according to five de-barking damage classes recorded in 1993 (see text for details), while only stems recorded with no damage in 1992 are shown for the old-growth stands. Each sub-figure shows the individual stem change rate in relation to stem size in 1992/3, together with the mean and standard deviation of the class.
stands that were largely ignored by the squirrels (Figure 3) showed significantly lower average growth rates between 1977 and 1992/3 (Figure 6). Their shaded position in the sub-canopy apparently conferred protection against squirrel attack. Also, intermediate sized stems in the young-growth stands recorded with no apparent damage in 1993 showed significantly lower average growth between 1977 and 1993 in comparison with those with limited, moderate or severe damage. However, this relationship did not hold true for those stems that had been most severely attacked and ring-barked, for there was no significant difference between their average growth rate and that of undamaged stems between 1977 and 1993. No doubt this reflected the large loss of canopy that some of these individuals incurred, a factor that presumably accounted for the notably poor growth of some badly damaged stems attacked in 1983 (Figure 5). Other studies based on even-aged plantations have, not surprisingly, found that as a result of selecting fast growing stems squirrels inevitably tend to select the largest sized stems in the stand (Mackinnon, 1976; Kenward et al., 1988). Yet, despite the fact that all stems in the young-growth stands within the intermediate size stem class were essentially even aged (Peterken and Jones, 1989), there was no evidence to suggest that only the fastest growing (Figure 6) or the largest stems were selected (Table 1). Although stem growth rate appears to have been an important factor, it was certainly not the only deterministic factor that accounted for the observed damage distribution (Figure 3).

The half century of studies at Lady Park Wood Natural Research Area have clearly demonstrated the pervasive nature of human activities within British woodlands, even where active management is not pursued (Peterken and Mountford, 1995). Given the scale, patchy distribution and recorded performance of badly damaged beech individuals, it is clear that at Lady Park Wood the introduced American grey squirrel has now become an important disturbance agent in the natural development of the wood. In the absence of catastrophic disturbance it would be predicted that beech, as a shade-tolerant long-lived species, would increase in dominance (Jones, 1945; Peterken and Jones, 1987, 1989), but a number of potential canopy dominants have already succumbed to the effects of severe squirrel de-barking and this potential looks set to continue. The ability of grey squirrels rapidly to damage susceptible stands is recognized in many British woodlands and has serious implications for timber and coppice production (Gurnell, 1987; Gurnell et al., 1992), woodland regeneration (Gill et al., 1993), and, as evidenced by this study, the conservation of native beech woodland stands, potentially, across the whole European landscape.

Acknowledgements

The provision for such long-term woodland research has been made possible by the Forestry Commission, who, in conjunction with English Nature and Countryside Council for Wales, continue to manage the wood as a Research Natural Area. Dr Eustace Jones, Mr Alan Orange, and Dr George Peterken and colleagues have collected large amounts of the archive data set. Graham Berry assisted with the 1993 field survey. Dr George Peterken, Dr Ian Powell, Anne Hargreaves and an anonymous referee critically reviewed drafts of the paper. The 1993 field survey was conducted whilst studying at Edge Hill University Sector College, Ormskirk.

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