

Habitat factors influencing occupancy
of nestboxes by common dormice
(*Muscardinus avellanarius*) at Slapton Ley National Nature Reserve, Devon

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This report is presented in part fulfilment of the degree B.Sc. Hons Ecology and
Environmental Management.

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1. Abstract

The common dormouse (*Muscardinus avellarius* L.) is a protected woodland species with highly selective arboreal feeding behaviour. It has been historically associated with hazel (*Corylus avellana* L.) and coppiced ancient semi-natural woodland. Dormice require a diversity of plant species to provide a continuous succession of food sources throughout their active season.

Although the dormouse's range within Britain is thought to be contracting southwards, recently there have been a number of recordings of dormice in unusual habitats within their restricted range. At Slapton Ley in south Devon, the subject of this study, dormice have been found in coastal blackthorn (*Prunus spinosa* (L.)), gorse (*Ulex* sp.) and bramble (*Rubus fruticosus* agg. (L.)) scrub as well as the typical hazel coppice. There were three sites studied, with a total of approximately 60 nestboxes which had been monitored once a month, April to November between 2002 and 2004.

The aim of this study was to establish which features determined dormice presence and absence by surveying the habitat structure around the nestboxes and then comparing sites.

The amount of continuous canopy traversable by dormice, was recorded around each nestbox. The horizontal foliage density was also recorded, by observing the percentage visible of a marked rod. A 4m² quadrat, with the nest box at the centre, was used to estimate percentage cover values for all plants above 0.5 meters from the ground. All vegetation was measured during the period of July to September 2004.

This study has shown that not only does coppice woodland not always provide the highest levels of species diversity but it does not support the highest levels of population density. One of the scrub areas had significantly higher species diversity and higher levels of dormice population density. At the lower levels of vegetation, the

first two meters above ground level, density has been a major factor affecting dormice presence, higher density is favoured in the coppice, whilst less density and greater continuity was beneficial in the coastal scrub.

There was significant correlation between dormice numbers and plants such as ash (*Fraxinus excelsior* (L.), blackthorn, western gorse (*Ulex gallii* (Planch.), apple (*Malus sylvestris* (L.) Mill.) in the scrub areas, all plant species considered food sources with edible fruits and flowers. However hazel and honeysuckle (*Lonicera periclymenum* (L.) which are both plants found in previous studies to be significantly associated with dormice in coppice were not significant in this study.

1. Introduction

1.1. Dormice

The common or hazel dormouse (*Muscardinus avellanarius* (L.)) is widely distributed throughout Europe but is rare in large parts of its range (Berg 1998). It is the only native member of the dormouse family (Gliridae) found in Britain. The other member of the Gliridae found in Britain is the edible dormouse (*Glis glis*), which was introduced in 1902 and has become established in the Chilterns area of England (Morris 2003), however this species is not considered here.

The dormouse is a protected woodland species (Bright 1996) that can be identified by its orange brown fur, bushy thickly furred tail and prominent black eyes. It is relatively long lived for a small mammal, up to 5 years of age (Eden and Eden 2001). It is sometime referred to as the hazel dormouse due to its strong historical association with hazel *Corylus avellana* (L.). Dormice feed on hazelnuts in a very distinctive fashion allowing identification from other mammals in areas with fruiting hazel.

Bright and Morris (1993) call the dormouse a specialist, with highly selective, arboreal feeding behaviour. Habitat is critical for dormice, they require a diversity of plant species providing a continuous succession of food items throughout the summer, all within a small area. It has been suggested that the best habitat for this mosaic of different age shrub growth and high species diversity is coppiced ancient semi-natural woodland.

Bright and Morris (1990) comment that dormice are strongly associated with managed coppice which has been in decline for several decades. Coppice woodland is now virtually absent outside the south-east, most former coppice is now derelict and overgrown.

Bright and Morris (1996) describe that from 1900-1970 there was a ten fold reduction in area of actively coppiced woodland. Only 23% of woodland in England is semi-natural ancient woodland, and most of it is now lacking any management. We have

lost approximately 732000 ha ancient woodland since 1930 and 150000 km of hedges, an important arboreal dispersal route for dormice, has been lost since 1945.

On the other hand Eden and Eden (2001) cites Van den Brink (1967) who indicates that dormice in this country are not reliant on coppiced ancient woodland but instead can be found in thickets and copses, hedges, commons and overgrown gardens.

Dormice are small nocturnal, arboreal mammals; they are rarely caught by owls or cats and are seldom caught in small mammals traps. Bright and Morris (1996) suggest that this elusiveness may have caused a false impression of the dormouse's rarity in this country, however there have been several recent studies in Britain which suggest that their range is contracting southwards. Morris (2003) suggests that the main causes of the animal's localised extinctions are inappropriate woodland management and habitat fragmentation.

The Dormouse is classed by the IUCN redlist as LR/nt (Tchabovsky 1996) 'Lower risk, near threatened'. Dormice are a taxon which does not qualify for Conservation Dependent status, but which is close to qualifying as Vulnerable. The dormouse has in recent years become a flagship species to promote conservation issues, due to it's photogenic appearance, especially whilst in torpor (Eden and Eden 2001).

Sanderson (2004) in a study of species decline, showed that in 100 sites monitored by the National Dormouse Monitoring Programme there was a trend of national decline by 27% over 10 years. In Britain dormice are thought to have decreased by 50% since the turn of the century (Berg and Berg 1998) and there has been a progressive local extinction of this species in England particularly in the northern counties.

'The Great Nut Hunt' carried out by Bright *et al.* (1996) found that dormice are now confined to 29 counties. Hurrell and McIntosh (1984) had previously reported the extinction of dormice from seven counties where they had been recorded in the past, the Great Nut Hunt could not find any evidence to contradict this opinion. However, dormice do remain widespread and numerous in some counties. Bright *et al.* (1996) found dormice present in 334 sites in England and Wales, 81 (24%) of those sites were in Devon, which has been described as a dormouse stronghold. Dormice now

occur almost entirely south of a line between Suffolk and Shropshire, with approximately four small populations in the North of England (Bright and Morris 2002).

Coppicing management in woodland prevents canopy shading to the understorey. Shading would decrease the fruiting and flowering productivity and cause spindly growth forms. Vertical branches make movement and foraging more difficult for dormice as they are more unstable in windy conditions. Bright and Morris (1990) showed that dormice preferred spreading shrubs not upright ones.

In Britain, dormice are listed on Schedule 6 of the Wildlife and Countryside Act 1981 and have full protection as a schedule 5 species in 1986. However Bright and Morris (1996) point out that this affords the dormouse protection from taking, killing and trade but does not address the problems of habitat loss or the need to consolidate the species distribution.

In 1996, dormice were targeted as a major component of English Nature's species recovery programme. The UK biodiversity action plan has committed the government to restoring the dormouse's range, by proper management and reintroductions (Bright 1996).

Bright and Morris (1996) suggested that the dormouse is a k-selected small mammal with low population density (5-8 individuals/ha at the best sites) and low rate of population increase, and is therefore vulnerable to habitat fragmentation and climatic stochasticity. This will have both direct and indirect influences, for example climate affects the timing and abundance of their food. This will be particularly important at the edge of their range. They describe the dormouse as a very sensitive indicator species for monitoring future changes in the environment.

Bright (1994) comments that local population extinctions are often due to the dormouse's low reproductive potential (4-8 young/litter each year), large inter-annual variation in reproductive success, and low population densities. Dormice are thought to be poor colonisers due to their arboreal nature, so colonising new sites or old sites following local extinctions is unlikely. They are not thought to be able to be flexible

when faced with rapid changes, population fragmentation or attenuation of average lifespan (Bright and Morris 1996).

Dormouse pelage is very fine and lacks the water repellent guard hairs, therefore precipitation will cause loss of body heat due to wet fur. In Britain, areas with <200 rainy days per year are more likely to have dormice in residence (Bright and Morris 1996).

Bright's (1996) study on the status of dormice in England measured woodland area, isolation and boundaries against known dormice sites, and found that in areas where woodlands and hedgerows were fragmented, dormice occurred only in ancient woodland in sites of >50 ha. However, in areas such as Devon where woodlands were less fragmented, dormice could be found in very small woods of around 5 ha and in recent woodland. This study suggested that habitat fragmentation is a major controlling factor in dormice populations in Britain.

Bright and Morris (1996) suggest that dormice tend to have small ranges, with approximately 1 ha being used annually with different areas exploited with the changing seasons and food availability. Dormice show a patchy distribution and have been known to occur in groups of up to seven in a nestbox, Bright and Morris (1996) suggested that this may indicate a social aspect to their behaviour. Up to 65% of adult dormice were found co-habiting during a monthly nestbox check, (Bright and Morris 1996) and there have been some suggestions of evidence-for a long term pair bond between animals.

Bright (1998) studied the movements of dormice through habitat corridors, with particular reference to their ability to cross gaps in hedgerows. He also placed dormice in the centre of a grass (Poaceae) field to test their willingness to cross open habitat. He found that although the dormice tested were strongly arboreal they were able to cross the field. He suggested that a non-corridor habitat does not represent a complete barrier to their movement, not at least within 100 m. However, Bright and Morris (1991) comment that dormice in low growing woodland were entirely arboreal, making considerable detours rather than crossing open ground. They nested, foraged and travelled off the ground. The study showed that the route detours made up

8-77% of the total distance travelled each night, varying greatly with individuals. They suggested that this circumvention of gaps imposes a substantial energetic burden upon the dormice.

Eden and Eden (2001) comment that although some previous literature on the dormouse considers it a rare species with specialised diet requirements only met by ancient coppiced woodland with a continuous supply of arboreal flowers and fruits (hazelnuts being essential for fattening before hibernation), it is in fact a widespread animal occurring in most arboreal habitats with good insect populations.

Richards *et.al.* (1984) analysed the faecal samples of dormice in South Devon and found that the dormice were eating leaves and flowers from understorey species such as honeysuckle (*Lonicera periclymenum L.*), bramble (*Rubus fruticosus L.*) and willow herb (*Epilobium L.*), but also quite a large proportion of insects in the form of adult and larval Lepidoptera and aphids. The study indicated that in June the dormice's diet included up to 70% insects.

Hurrell and McIntosh (1984) describe the diagnostic way of separating dormice presence from other small mammals as being the characteristic way they open hazel nuts, making a neat round hole with a smoothly chiselled edge.

In Dorset, Eden and Eden (2001) suggest that the dormouse can be found in habitats such as coastal blackthorn (*Prunus spinosa L.*) scrub, conifer plantations and high forest. The dormouse is an opportunistic omnivore, which in some places even appear to choose areas of insect rich vegetation in preference to areas with food such as hazelnuts.

Dormice lack a caecum and it has therefore been suggested that they are less equipped to digest cellulose, not having enteric symbionts (Bright and Morris 1996). They are thus less able to gain energy from major low-grade food sources such as leaves, and their foraging instead tends to concentrate on nutritious high energy, high protein foods such as flowers, fruits and insects, which Bright and Morris (1996) state are only available in arboreal areas and can be limited by time and space.

Dormice have been shown to be highly selective feeders, foraging on relatively uncommon plant species (rare within their habitat). Tree utilisation closely follows the fruiting and flowering phenology, and insect availability on sycamore (*Acer pseudoplatanus* L.) and oak (*Quercus* sp. L.). They have been shown to switch from one ephemeral food source to another as they become available (Bright and Morris 1993). Bright and Morris (2002) suggested that dormice tend to feed initially on flowers and as one species die away move on to another, then insects and later in the year fruits and hazel nuts as they ripen in the autumn.

Tree flowers generally only have a two week period of availability, and inclement weather such as heavy rain decreases the number of flowers available. Ripe fruits and seeds will last between 3 to 8 weeks. There is a period of food scarcity during mid-July when only some honeysuckle and bramble is flowering. Insects are most abundant in May and June with greatest numbers of caterpillars followed by aphids later. Dormice have been shown to eat soft mast such as berries from plants like blackthorn and bramble, and hard mast in the form of acorns and winged seeds from hazel, sycamore, ash (*Fraxinus excelsior* L.), chestnut (*Aesculus hippocastanum* L.) and oak. Flowers from hazel, hawthorn (*Crataegus monogyna* Jacq.) honeysuckle, bramble etc. and insects mainly in the form of caterpillars from oak and aphids from oak and sycamore (Bright and Morris 1993).

Dormice were shown to eat only the most nutritious parts of the flowers or fruits in their diet, such as the nectaries, anthers and seeds. They were also shown to eat more soft mast than hard mast, berries were preferred when available, presumably as they are sugar rich and easily digestible (Bright and Morris 1993).

Bright and Morris (1993) also showed that the number of sites a dormouse visited in a night was negatively related to the dispersion of the food trees. Dormice were limited in the number of sites they could visit because of the patchiness of the trees and the distance they could physically travel in a night. Therefore habitat structure is key to dormouse foraging success as they are limited to foraging close to their nests, and patchiness will affect efficiency.

Bright and Morris (1991) radio tracked dormice during their nightly foraging and found that they utilised approximately 3-5 individual trees each night. Bright (1996) indicates that they are always likely to utilise hazel nuts where available as they are an important pre-hibernal food.

Dormice are principally adapted to the continental climate and arboreal frugivory is rare and risky in Britain's temperate and relatively unpredictable climate (Bright and Morris 1996).

Dormice may have to compete directly for food resources such as hazel nuts, with other animal species e.g. the grey squirrel (*Sciurus carolinensis*), mice (*Apodemus* sp.), nuthatches (*Sitta europaea*) & woodpeckers (*Dendrocopus* sp.). There may also be habitat degradation caused by deer grazing the young shrubs and suppressing the regrowth of the vital understorey (Bright & Morris 1996).

Dormice, not being active during the day, would seem to be at risk mostly from nocturnal predators such as owls, but owls in this country do not seem to take dormice often. Wood mice (*Apodemus sylvaticus*) have been known to attack torpid dormice, as have weasels (*Mustela nivalis*). Corvids, squirrels, foxes (*Vulpes vulpes*) and badgers (*Meles meles*) may all be occasional predators of dormice whilst they are hibernating on the ground (Bright and Morris 1996). Dormice however are mainly unaffected by disease or predators.

Dormice spend approximately half the year in hibernation (October to May) although the timing of the onset of hibernation and the duration varies with region. They hibernate at or just below ground level in nests under leaves and vegetation (Eden and Eden 2001).

During autumn and winter they are vulnerable to disturbance and predation. Juvenile dormice need to be 12-15g in weight before hibernation to survive the winter, therefore juvenile survival is affected by the timing of winter onset whilst adult survival is mostly affected by the nature and duration of the winter period. Animals which are frequently woken during the winter by warmer temperatures, when no food is available, will not survive (Bright and Morris 1996). The maritime climate in

Britain leads to highly variable seasons, therefore hibernation is also a strategy better suited to continental Europe.

Dormice had been historically known to make use of nestboxes set up for hole-nesting birds. Morris *et al.* (1990) reasoned that the scarcity of the dormouse may result from the lack of certain ecological requirements in the available habitat, such as secure, dry nesting that was limiting numbers. Nestboxes were put up specifically for dormice designed with their entrance holes facing the tree trunk to dissuade birds, and a series of studies were undertaken into the biology and life-history of the animal.

Bright and Morris (1996) indicate that in early and late summer ambient temperatures are lower and foliage in the shrub layer is sparse, leaving nests exposed and making tree hollows and nest boxes especially important to dormice. Bright and Morris (1991) whilst radio tracking dormice suggested that when there were nestboxes present almost the whole population used them, as the box will mimic tree hollows. They also suggested that sites with a lack of natural hole availability may have a limited population density and providing nest boxes appears to double the numbers of dormice in an area.

The number of dormice using nestboxes in a site has been suggested by Bright and Morris (2002) to be a reliable estimate of population density. They go on to state that as nest boxes may cause short-distance immigration, density estimates were based on the first year boxes were in full use. Morris *et al.* (1990) suggested that introducing nestboxes into an area enhances population size and thus assists in dormouse conservation. They showed through trapping studies that the numbers of dormice in areas with nestboxes were greater than those in areas of comparable habitat without boxes.

Dormice make three types of nest, the summer breeding nest, the summer juvenile's nest and a hibernation nest. Summer nests are typically composed of stripped honeysuckle bark or grass woven into a ball. This is then covered with concentric layers of leaves which are collected by the dormouse whilst still green (Morris *et al.* 1990). Hurrell and McIntosh (1984) suggest that a freshly constructed nest is quite characteristic, that they can be either round or oval with an average size of 9.26 cm.

In Morris's (2003) review of dormice research he states that in 2003, there were over 6,000 nestboxes in over 100 sites where dormice conservation is a priority. Nestboxes have provided data on dormice body size, parasitology, breeding success, and incidence of summer torpor. They also form the backbone of the National Dormice Monitoring Programme.

Bright and Morris (1989) suggest that nestboxes are an easy way to confirm dormice presence. In immature woodland and woods with recent coppicing, nestboxes may maintain populations where they would otherwise die out for lack of sheltered nest sites. However dormice in nestboxes are vulnerable to disturbance by humans and may attract predators such as weasels.

However Eden and Eden (2001) suggest that the dormouse will not use nestboxes in areas where there is good nest building habitat available already. Berg and Berg (1998) comment that shrubby areas may be crucial for dormice in habitat with very few natural nest holes. Shrub areas provide sheltered nesting areas, with dense vegetation and a high percentage cover, therefore dormice may prefer shrub areas as they are relatively predator safe.

Berg and Berg (1999) state that in Sweden the dormouse has increased its distribution onto deciduous vegetation on abandoned farmlands and the early successional phases of clear-cuts. They studied the dormouse in conifer (Pinopsida) planted pasture using live trapping; a method which is not commonly used for dormice as they do not typically enter live traps. They suggested that re-capture in this type of habitat may be easier due to the lack of high canopy.

Berg and Berg (1998) used the presence of nests as an indicator of dormouse presence, they did however mention the difficulty of then being sure that dormice were absent from areas where nests were not found. Characteristically gnawed hazel nuts only indicate dormice when hazel is present, radio tracking showed that nests can easily be overlooked, and preferences for dormice nesting in shrubs may have been biased by the methodology. Nestboxes have also been shown as stated previously to attract dormice and enhance density in coppiced woodland.

Recently the number of records concerning dormice presence in locations which are considered unusual or unsuitable has increased. Woods (2003) states that dormice have been found living in several sites along the south coast in blackthorn, hawthorn, gorse (*Ulex sp. L.*) and bramble scrub, one of these areas being Slapton Ley in Devon, the site studied in this research.

Woods (2003) comments that the habitat with dormice present at Slapton is a strip of scrub between the A379 road and the reed bed (*Phragmites australis*) of the higher ley. Dormice have also recently been found in the sycamore, gorse, bramble scrub on the edge of the lower ley. He raises the question, how did they get there? and suggests they may have crossed the water of the ley through the reeds from Slapton Wood on the other side.

Hurrell and McIntosh's (1984) survey of dormice in the UK found them present on commons with gorse and bracken, in bramble thickets on the edge of roads, basically anywhere where there was a thick tangle of vegetation.

Bright (1995) studied the distribution of dormice in Wales and showed that more than half of the sites with dormice present were in the deciduous margins of conifer plantations or oak woods. Of all the sites in Wales, 53% of them were considered by Bright to be threatened due to management e.g. clear-felling or lack of coppicing. Grazing was another major threat as it suppresses the shrub re-growth important for dormice foraging.

Eden and Eden (2001) comment that dormice in Dorset are widespread in most types of arboreal habitat such as coast blackthorn scrub, conifer plantations and high forest.

Woods (2003) states that in Slovenia and Germany dormice have been found living in reed beds over water, which may protect them against predators such as weasels. In Devon there have been reports of them in purple moor grass (*Molinia caerulea*). He suggests that they can be found in these 'unsuitable' habitats due to the opportunistic use of nesting sites and foraging for insect food sources.

1.2. Site Description

Slapton Ley National Nature Reserve is situated in south Devon, it is a unique wetland habitat with two 'leys' or freshwater lakes, the lower ley is the largest freshwater lake in the south west of England. Slapton Ley was designated a National Nature Reserve in 1993, it is owned by the Whitley Wildlife Conservation Trust, and managed by the Field Studies Council.

It is situated close to the most southerly point in Devon (Burt 2001). Slapton Ley's ecological richness it has been suggested, is related to climate, which is favourable compared with the rest of Britain. The Nature reserve has a mild and wet climate with few frosts and minimal snowfall (Burt 2001).

The reserve is a mosaic of habitats, such as reed bed, fen, woodland and carr. The reserve supports over 490 plant species and is the only British locality containing the nationally rare species strapwort (*Corrigiola litoralis* L.).

The two leys are separated from the sea by a narrow single ridge and a road, this barrier is constantly changing with the weather and the sea, and contains plants adapted to the salt spray.

There are three sites with dormice present and using nestboxes in good numbers (see figure 1), the first is the Southgrounds coppice area. This is an area of hazel coppice supposedly 'ideal' dormice habitat, with 15 nest boxes in it, affixed to the coppice stools themselves (see figure 2). This area is surrounded by woodland strip and agricultural fields and is situated to the north of the lower ley, The hazel was coppiced in small patches as recommended by Bright and Morris (1989) with the last coppicing being carried out approximately 8 to 9 years previous to this study.

The other two sites are found on 'Backslope' which is situated on the ley edge of the single ridge. It is a gorse and blackthorn scrub with some sycamore and bracken (see figure 3). This site is divided into two, one on the lower ley and one on the upper ley separated by a road and a bridge. Between them these two sites hold approximately 45 nest boxes fixed to posts within the scrub as there were very few trunks capable of supporting the boxes within the sites.

The nestboxes were put up in 1998 in the higher ley area and monitored, however the road between the Backslope and the sea had to be moved during 2001, and boxes were placed in the lower ley site, as it was believed that the disturbance caused the dormice to redistribute themselves. So that for the period of the study dormice were found in both the Lower and Upper Backslope sites.

Figure 1. Map of Slapton Ley Nation Nature Reserve.

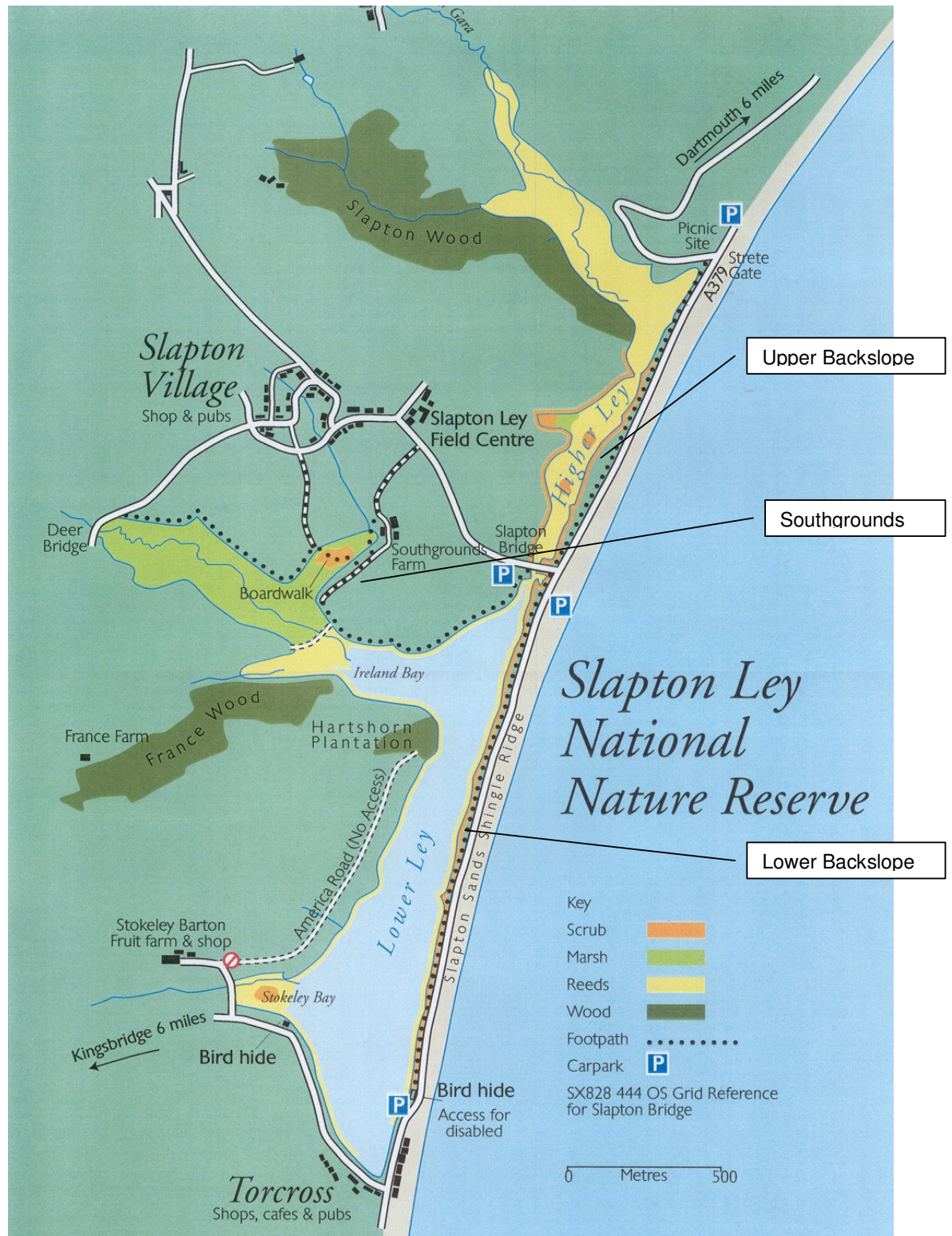


Figure 1. Southgrounds coppice site, box number 25.



Figure 3. Backslope nestbox fixed onto a pole within the scrub.



1.3. Aims

The main objective of the project was to survey habitat structure around nest boxes to establish which features are important in determining dormice presence/ absence. An additional aim was to compare sites – specifically Bright and Morris’s historically ‘optimal’ habitat (Southgrounds) with ‘unsuitable’ habitat (Backslope).

1.4. Hypotheses

1. Dormice presence positively correlated with Honeysuckle presence and higher percentage cover (Morris *et al.* 1990).
2. Dormice presence and greatest abundance positively correlated with boxes with greater continuous canopy
3. Dormice presence and greatest abundance positively correlated with boxes with greater vegetation density (less visibility)
4. Higher species diversity in understorey, greater dormice occupancy and density (Morris *et al.* 1990).

2. Methodology

2.1. Vegetation survey

2.1.1. Continuous canopy

The length of continuous canopy traversable by dormice for up to 4 meters from the nestbox was recorded, at heights of 1,2,3,4 and >4 m above ground level. This was recorded for eight compass points around the box. The canopy was judged to have stopped being continuous if a 20 cm gap occurred in the horizontal layers at the given height; 20 cm being approximately 3 times body length, an approximate jumping distance. Bright (1998) suggested that a gap of 1m is likely to be too wide for a dormouse to jump.

2.1.2. Percentage visible – horizontal foliage density

At 2 and 4 meters distance from the nestbox a bamboo cane 4 m tall, marked with 10 cm divisions was placed vertically upright in the ground, an observer at the nestbox then recorded the number of divisions for each 1 m quarter un-obscured from view by foliage. These measurements, at 2 and 4 meters were made in each of the eight compass points away from the nestbox. Foliage density was estimated by averaging across the eight compass direction values for each quarter, to obtain two means for each quarter, one for each of the two distances from the box (Ferns & Hinsley 1995).

2.1.3. Percentage cover

4 m x 4m quadrats, with the nestbox at the centre were used to record percentage cover values. In each quadrat the species were identified and the abundance estimated using the Domin Scale (Kirby 1990) assessing by eye the percentage cover of all parts of the plants in the quadrat above 0.5 m from the ground. (Rodwell 1998) see figure 2.

Figure 1. Domin Scale.

Cover of	91-100%	Is recorded as Domin	10
76-90%		9	
51-75%		8	
34-50%		7	
26-33%		6	
11-25%		5	
4-10%		4	
<4%		3-With many individuals	
<4%		2- With several individuals	
<4%		1-With few individuals	

2.2. Dormice survey

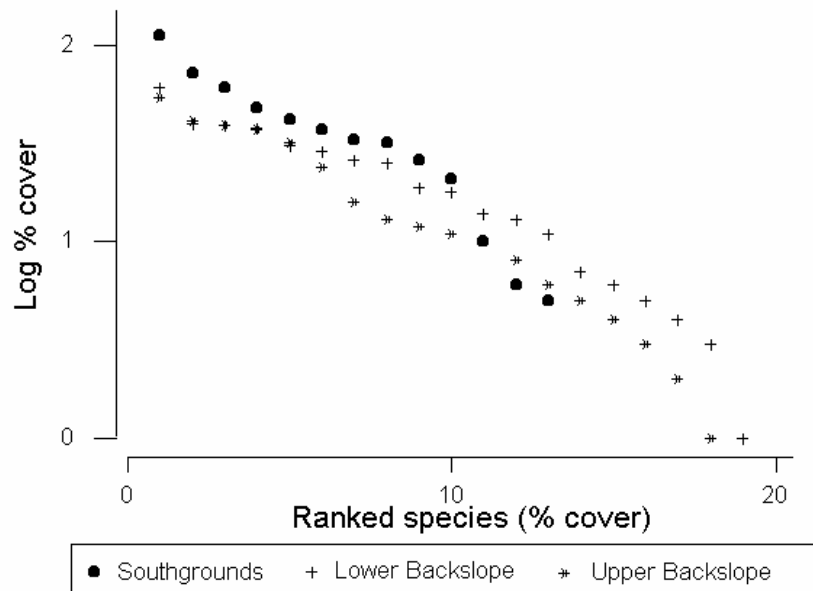
Nestboxes were inspected once a month, April to November, 2002 to 2004 by English Nature licensed individuals from the nature reserves wardens. Each box was opened and any dormice present were caught, weighed, sexed and activity level was recorded. Where no dormice were present their nests were recognised by the distinctive woven structure, with honeysuckle bark present in some cases (Morris 1990).

Wood mice were the only other mammal species regularly found in the boxes. Their nests were distinguished from dormice by the composition of leaves and moss loosely packed not woven (Morris 1990). Birds nests were also found despite the awkwardness of the entrance hole facing the trunk.

All nestboxes were cleaned of nests during the winter whilst they are not in use. This allowed the assumption to be made that any nests found were freshly made that year, and therefore the box had been in use that year.

Results

Figure 1. Rank- abundance graph of plant species at the three sites.



All three sites were dominated by one plant species (see figure 1). In Southgrounds it was hazel, in Lower Backslope various grass species dominated and in Upper Backslope it was bramble. None of the sites showed a large proportion of rare species with less than 2 percent cover. Southgrounds had no species with a percentage cover below 5. Lower Backslope had a few low percentage cover species, such as herb robert (*Geranium robertianum* (L.) and bindweed species (*Calystegia* sp.). Upper Backslope had a few more uncommon species, with a little less than a third being 5 or less percent, these were species such as honeysuckle (*Lonicera periclymenum* (L.), common toadflax (*Linaria vulgaris* (Mill.) and yellow flag (*Iris pseudacorus* (L.). All the sites showed percentage cover values which were spread fairly equally between species indicating a good choice of food plants, although Southgrounds does have significantly less species diversity than the other sites, see below, figure 11.

Figure 2. Southgrounds, Average continuous canopy, meters, (\pm SE) at different heights above ground level.

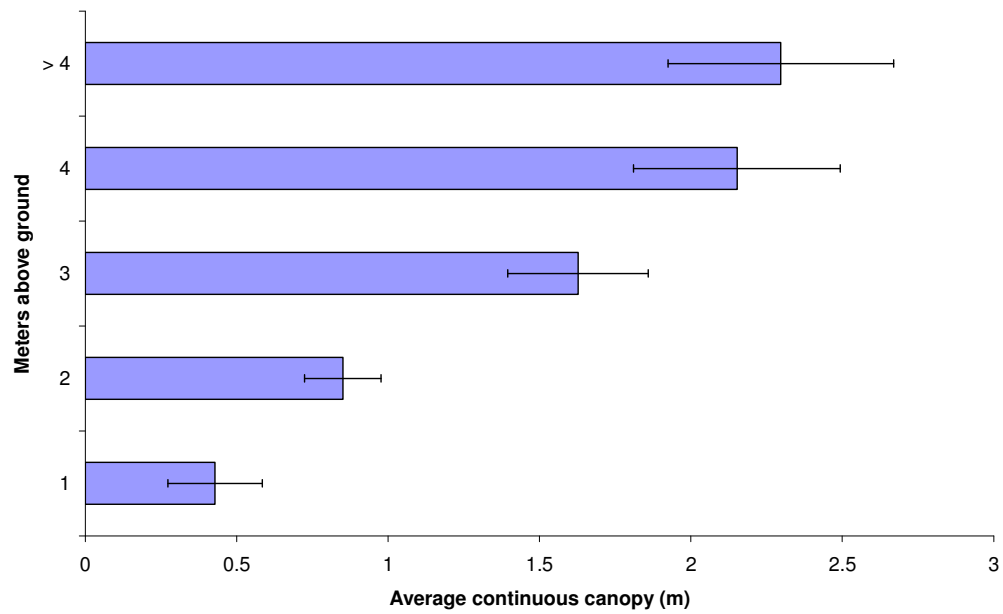


Figure 3. Southgrounds 2 m from boxes, Average percentage visible (\pm SE) for the four quarters of the pole.

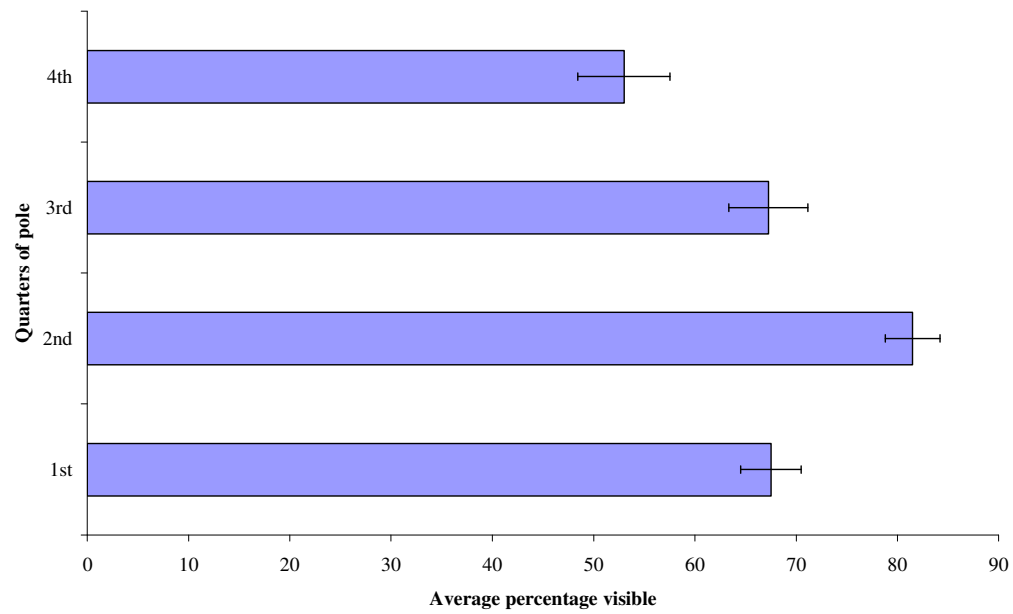
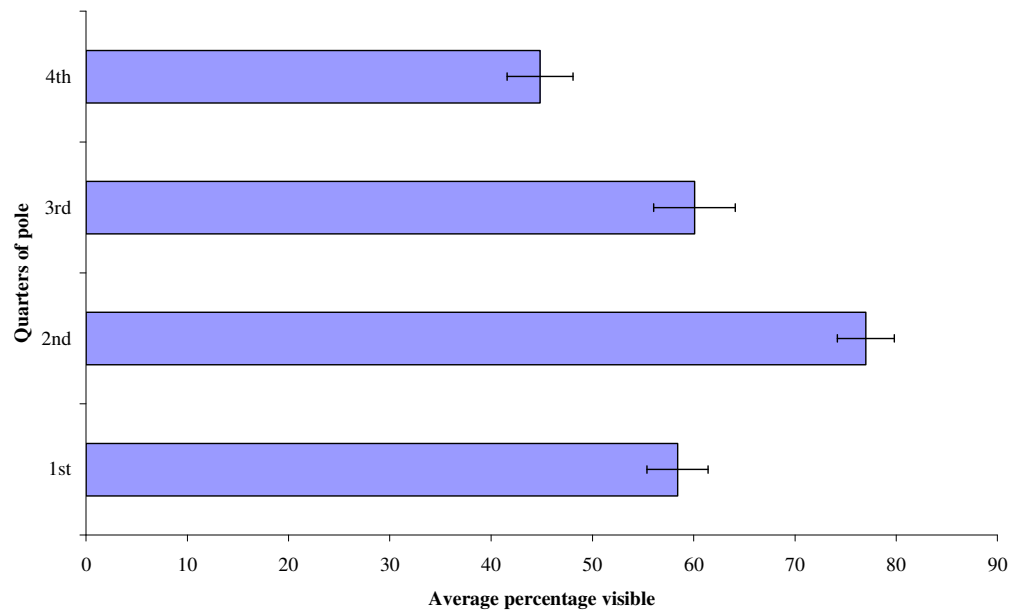


Figure 4. Southgrounds 4 m from boxes, Average percentage visible (\pm SE) for the four quarters of the pole.



Southgrounds showed a larger continuous canopy at 4 meters or above from the ground, as the coppiced woodland tended to have little vegetation underneath the coppiced hazel canopy (see figure 2). This upper layer of vegetation was not that dense at the most it only reduced visibility by 50 percent compared to 70 – 80 percent at the backslope sites (see figures 3 and 4).

Figure 5. Lower Backslope, Average continuous canopy, meters, (\pm SE) at different height above ground level.

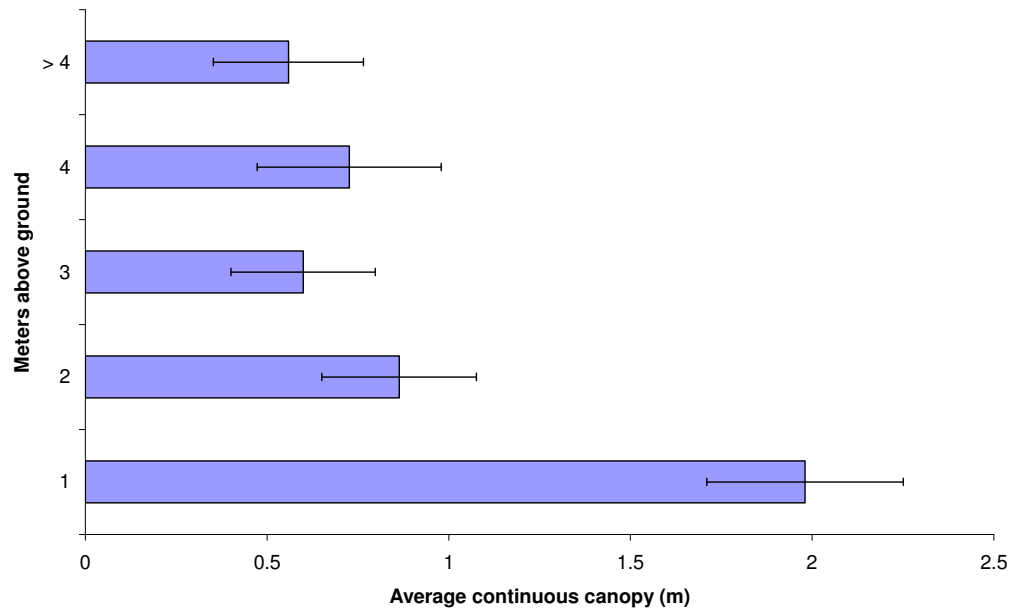


Figure 6. Lower Backslope 2 m from nestboxes, Average percentage visible (\pm SE) for the four quarters of the pole.

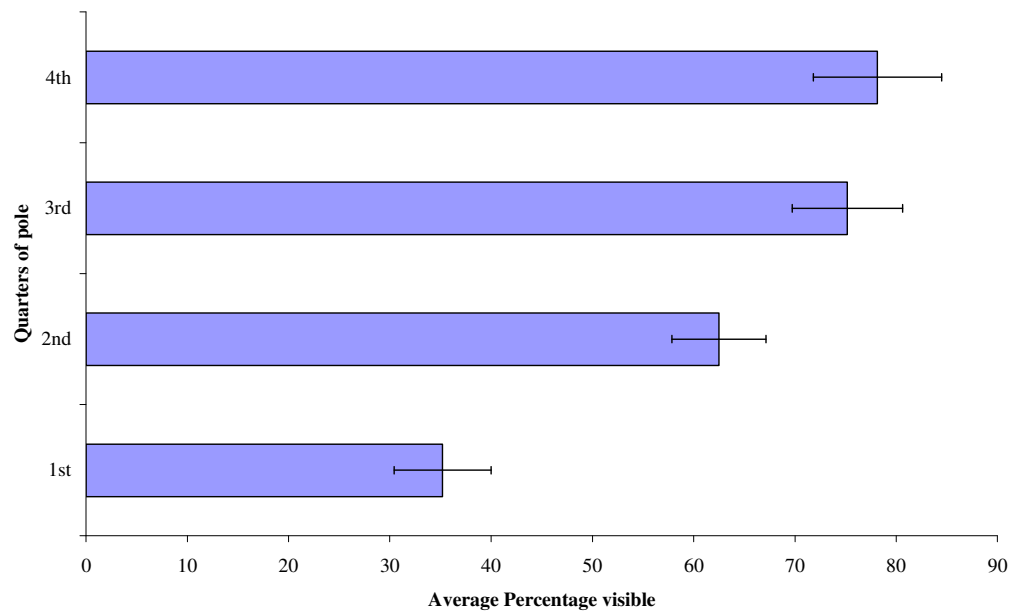
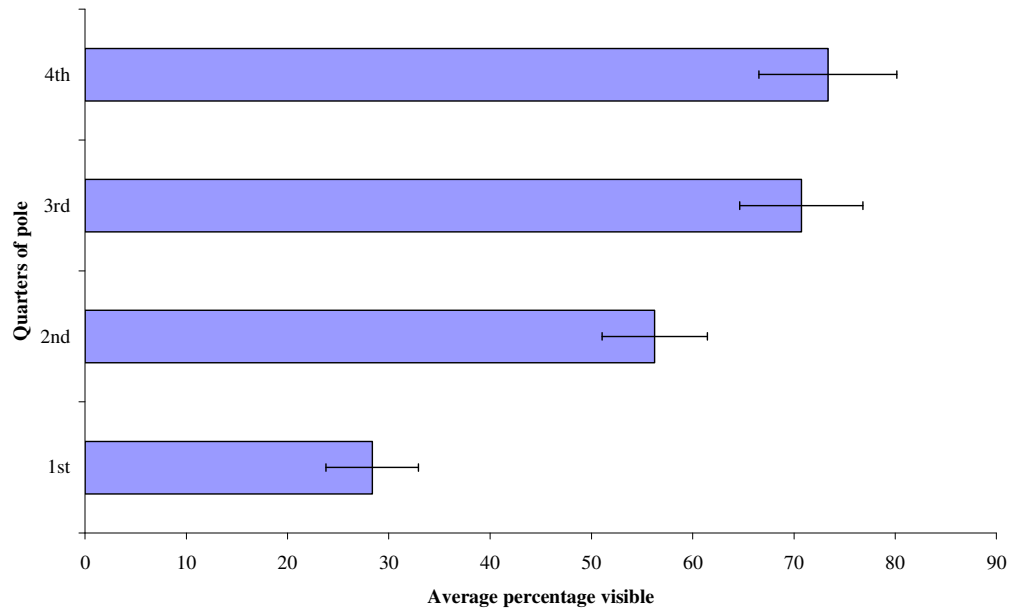


Figure 7. Lower Backslope 4 m from boxes, Average percentage visible (\pm SE) for the four quarters of the pole.



The Lower Backslope site was a mixture of gorse, bracken (*Pteridium aquilinum* (L.) Kuhn) scrub and ash, sycamore stands; therefore unlike the Upper Backslope there was vegetation over 3 meters above ground. However the majority of continuous canopy was found between ground level and 1 meter. The vegetation was quite dense with visibility down to approximately 30 %. There was high visibility at 3 and 4 meters above ground at around 70 % (see figures 5, 6 and 7).

Figure 8. Upper Backslope, Average continuous canopy, meters, (\pm SE) at different heights above ground level.

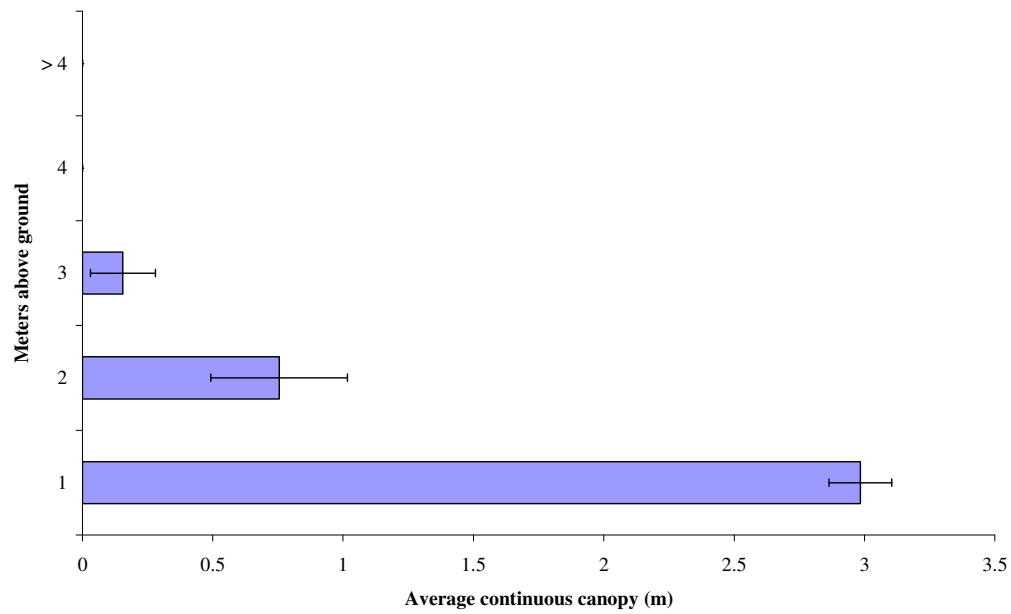


Figure 9. Upper Backslope 2 m from boxes, Average percentage visible (\pm SE) for the four quarters of the pole.

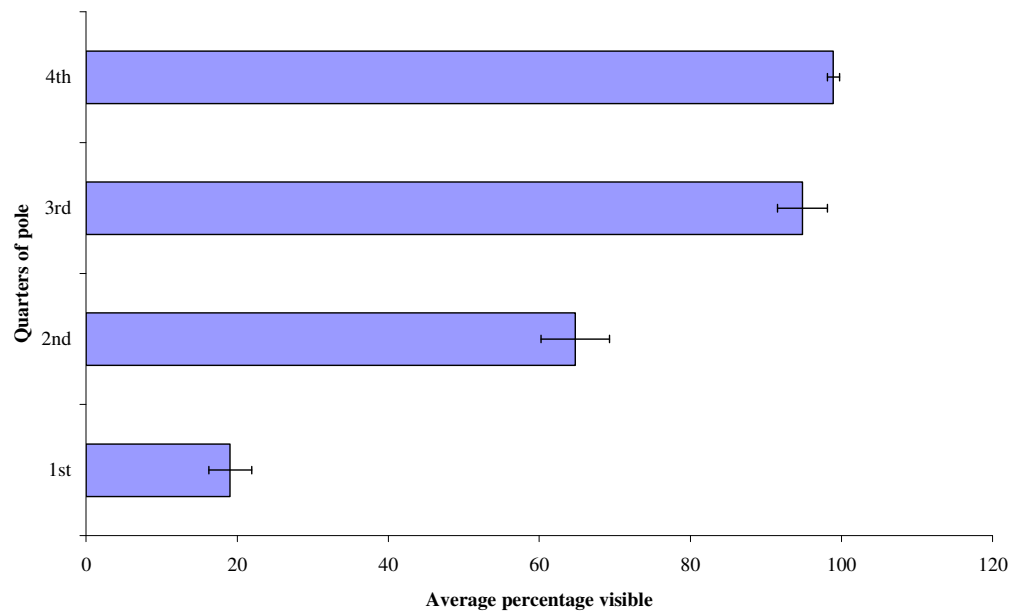
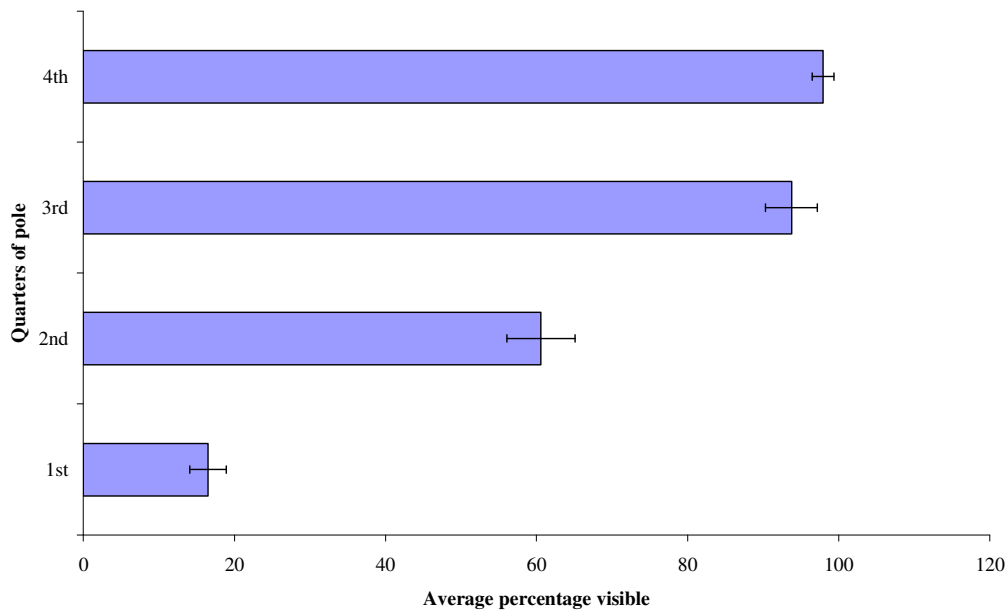


Figure 10. Upper Backslope 4 m from boxes, Average percentage visible (\pm SE) for the four quarters of the pole.



At Upper Backslope there was almost no vegetation above 4 meters from the ground, as the majority of the site was blackthorn and gorse scrub, at approximately 2 meters high. Continuous canopy was almost exclusively found between ground level and 1 meter, and at that level the vegetation was extremely dense with visibility being between 20 and 30 % (see figures 8, 9 and 10).

Species diversity between Southgrounds and the two Backslope sites was tested using t-tests. There was a highly significant difference ($P < 0.001$, Southgrounds compared with lower backslope $t = -6.45$, $df = 244$, Southgrounds with upper backslope $t = -5.68$, $df = 186$), Southgrounds had significantly less species diversity compared with the two backslope sites, see Figure 11.

Figure 11. Shannon Diversity Index (H values) for the three sites.

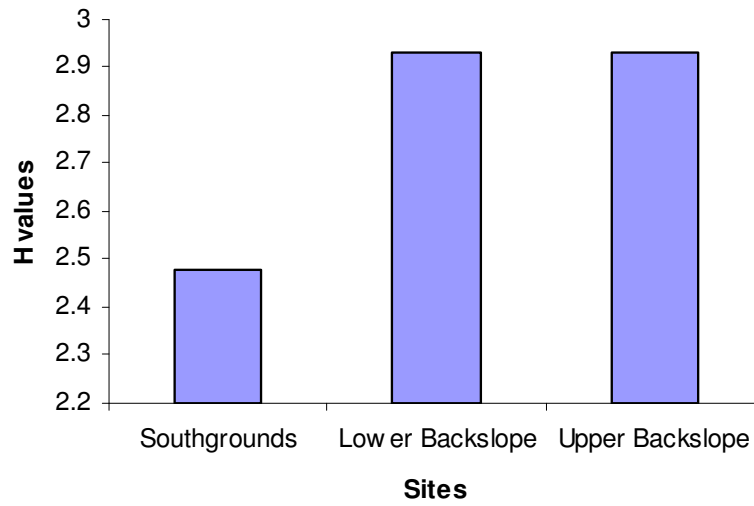
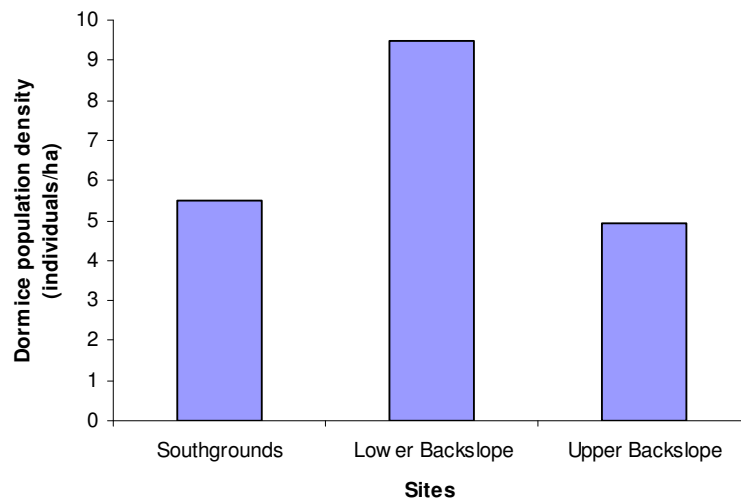
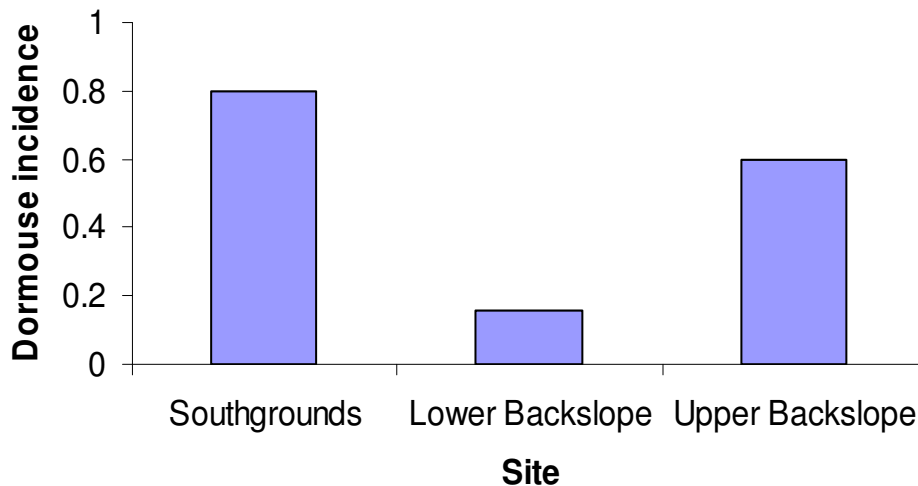


Figure 12. Dormice population density, number of adult and sub-adult (>10g) individuals/ ha, for each of the three sites.



The area that the nestboxes covered for each sites was, 0.61 ha for Southgrounds, 0.73 ha for Lower Backslope and 0.55 ha for Upper Backslope. Population density was estimated using the dormice numbers for the first full year that the boxes were in full use. This gave values of 5.49 dormice/ ha for Southgrounds, 9.5 dormice / ha for Lower Backslope and 4.91 dormice / ha for Upper Backslope. These observed values where compared with the expected value of 6.6 dormice / ha for all sites using a Chi squared test. $X^2 = 1.89$, critical value = 5.991, DF = 2. There was therefore no significant difference between the sites, Lower Backslope did not have significantly larger population density (see figure 12).

Figure 13. Dormice incidence (proportion of boxes in a site with dormice present for at least one year of the study) at the three sites .

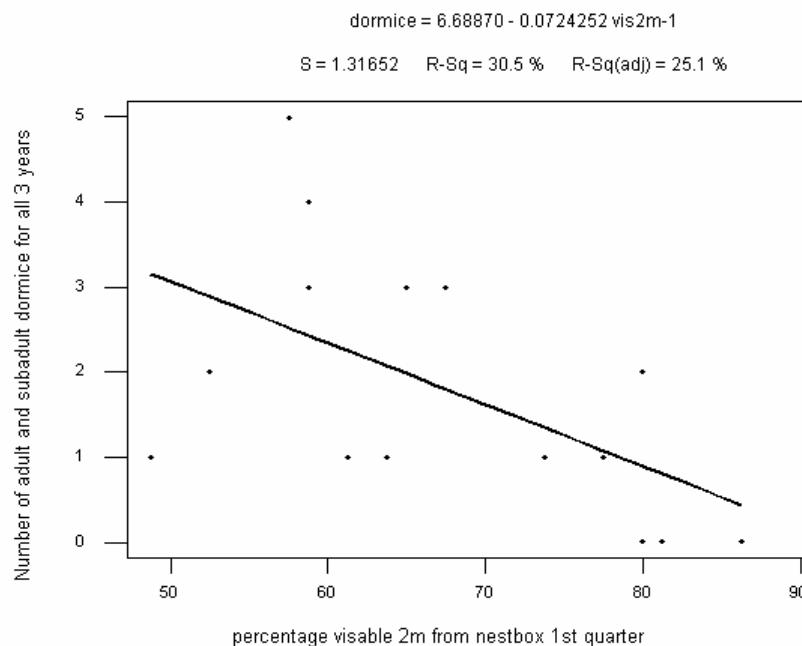


There were 12 boxes occupied by dormice for at least one year of the study at Southgrounds, 3 at Lower Backslope and 9 at Upper Backslope. These values were compared with an expected value of 8 at each site, using a Chi squared test. $X^2 = 5.25$, critical value = 5.991, DF = 2. At $P = 0.05$ there was no significant difference between the observed and expected values (see figure 13.). Lower Backslope did not have significantly smaller occupancy than the other sites.

Therefore although species diversity was significantly higher at Lower Backslope and the site had the highest dormice population density, it also had the lowest incidence level. Neither was significant and therefore the hypothesis that the site with the highest diversity has significantly higher density and incidence is rejected.

Correlations were carried out between the number of independent (adult and sub-adult >10g) dormice found in each box and vegetation variables for each box. In Southgrounds the only significant correlation was with the percentage visible (horizontal foliage density) 2 meters from the nest box in the 1st quarter ($r = -0.552$, $P = 0.033$). A regression was then carried out which was significant ($F = 5.69$, $P = 0.033$), 30.5 % of the variance in dormice numbers was explained by the percentage visible of the 1st quarter of the stick 2m from the nest box (see Figure 14.). There were no other significant correlations between dormice numbers and continuous canopy or percentage visible values for any of the sites.

Figure 14. Regression, number of independent dormice for each nestbox (2002-2004) compared with percentage visible 1st quarter of stick 2 m from the nestbox.



Numbers of independent dormice were then compared with individual plant species percentage cover values for all boxes at each site using Spearman's Rank non-parametric correlation analysis as the data violated the assumptions of Pearson's parametric correlation. At Southgrounds Hart's tongue fern was significantly correlated with dormice numbers ($r_s = 0.571$, $P = 0.026$). At the lower backslope site percentage cover of Ash, Blackthorn, Western Gorse and Apple were significantly correlated with dormice numbers ($r_s = 0.532$, $P = 0.019$; $r_s = 0.491$, $P = 0.033$; $r_s = 0.475$, $P = 0.040$; $r_s = 0.474$, $P = 0.040$). Upper backslope dormice numbers were negatively correlated with grass percentage cover ($r_s = -0.560$, $P = 0.030$). Honeysuckle was not found to be correlated with dormice numbers at any site, therefore the hypothesis of honeysuckle importance with dormice presence is refuted at Slapton.

Figure 15. Southgrounds, Average percentage visible at 2 m for nest box, 1st quarter (\pm SE) Dormice absence or presence at each nestbox.

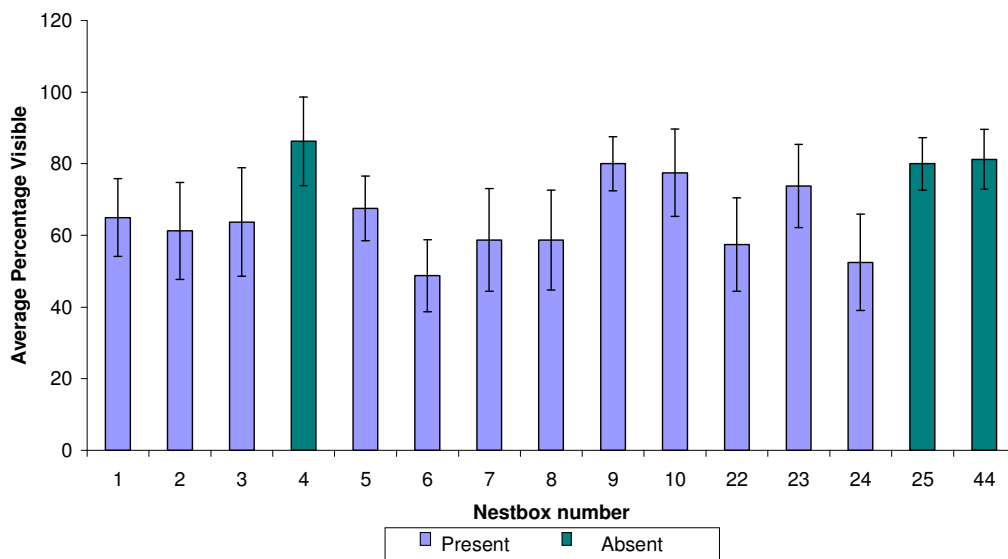
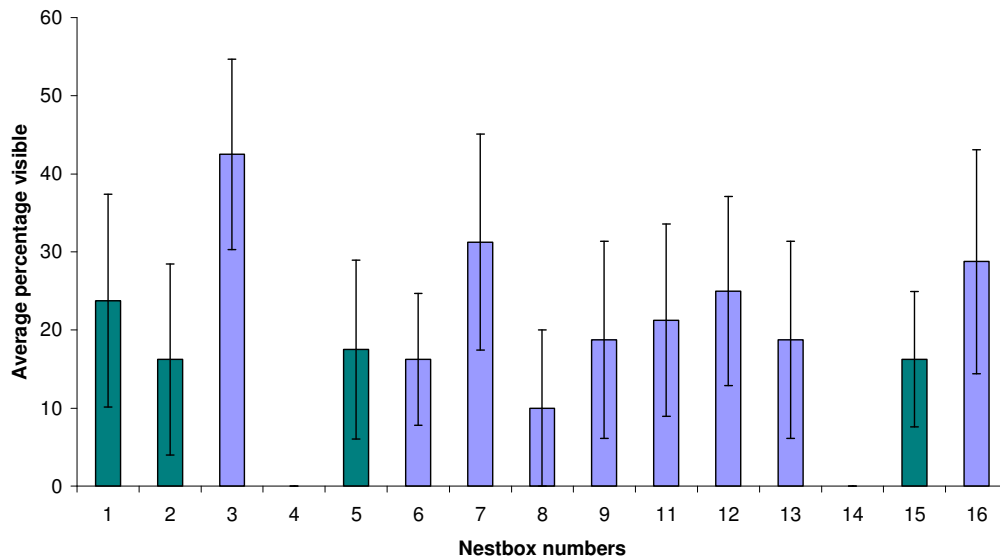


Figure 16. Upper Backslope Average percentage visible (\pm SE), at 2 m from the nestbox, 1st quarter. Dormouse presence (blue) or absence (green) at each box.



Whether there was a significant difference between the nestboxes with dormice present compared with boxes where dormice were absent for all the years of the study, was tested using two-tailed, two sample T-tests after the data was tested for normality and homogeneity of variance. The average percentage visibility at 2m from the nest box in the first quarter of the stick (up to 1m from the ground) was significant for both the Southgrounds site and Upper Backslope ($T = -3.25$, $P = 0.006$, $DF = 13$; $T = 2.21$, $P = 0.046$, $DF = 13$). See figures 15 and 16. There was also a significant difference between the nestboxes with dormice present and absent at the Upper Backslope site, average percentage visible, 4 meters from the box in the 1st quarter ($T = 4.22$, $P = 0.001$, $DF = 13$) see figure 17. Average percentage visible was also significantly different at Southgrounds 4 meters from the boxes in the 2nd quarter ($T = -2.32$, $P = 0.038$, $DF = 13$) see figure 18. In continuous canopy there was a significant difference between nestboxes with/out dormice present at the Lower Backslope site 2m above ground level ($T = 3.24$, $P = 0.007$, $DF = 12$) see figure 19.

Figure 17. Upper Backslope, average percentage visible (\pm SE), at 4 m from the boxes, 1st quarter. Dormice presence (blue) and absence (green) at each box.

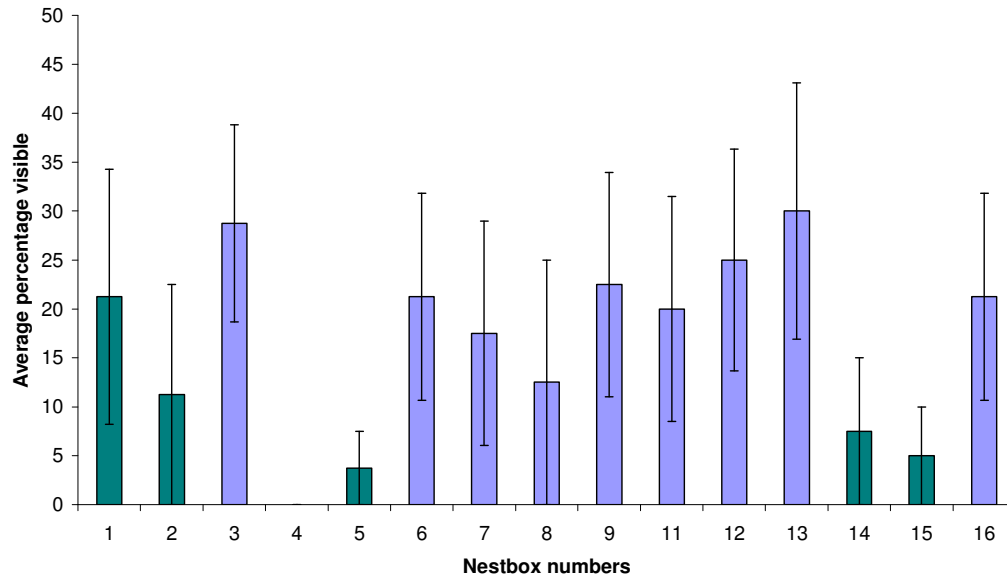


Figure 18. Southgrounds, Average percentage visible (\pm SE), at 4 m from the nestboxes, 2nd quarter. Dormice presence (blue) and absence (green) at each nestbox.

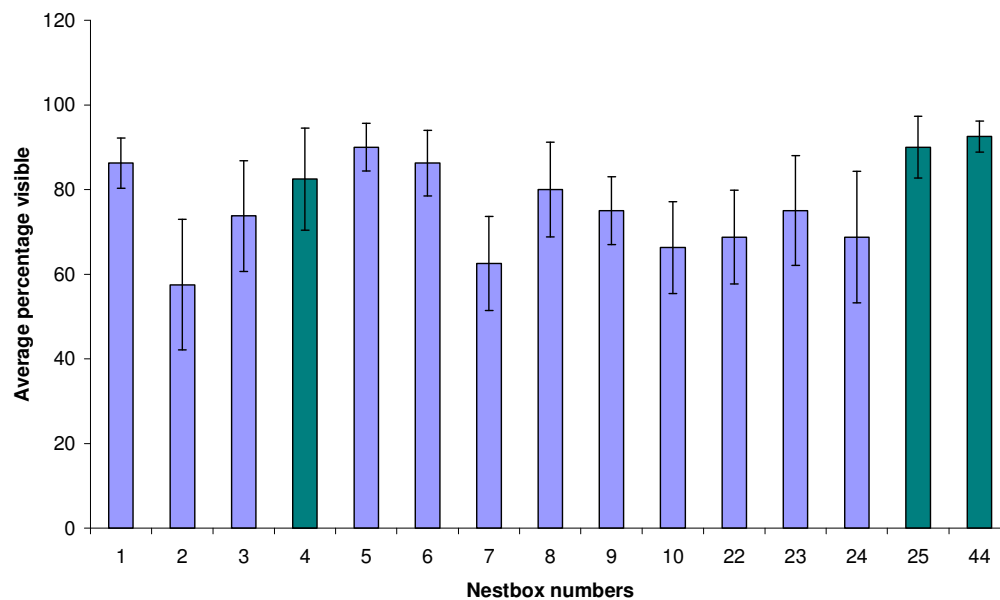
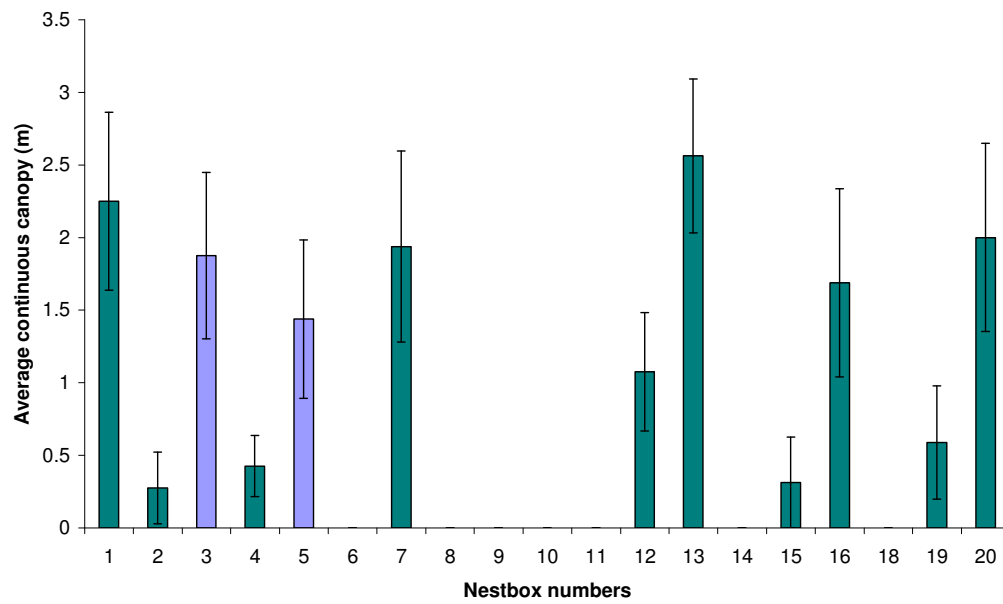


Figure 19. Lower Backslope, Average continuous canopy, meters, (\pm SE) 2 m above the ground, dormice present (blue) and absent (green).



5. Discussion

In Southgrounds canopy is continuous at 4 or more meters above ground level. There is little vegetation in the first and second meters, the coppice shades the ground layer leaving sparse vegetation consisting mainly of shade tolerant species. This is reflected in the percentage visibility. Visibility was slightly higher in the first and second quarters of the pole. At 2 meters from the nestboxes there was a significant correlation and regression between dormice numbers and the first quarter of the pole's percentage visibility. As density of vegetation decreased so did dormice numbers. Dormice were also significantly absent from boxes with higher visibility in that first quarter.

At 4 meters from the box there was a significantly absent from boxes with more visibility in the second quarter. These results for Southgrounds suggest that dormice presence and abundance is affected by the horizontal vegetation density at the lower levels (1 and 2 meters from the ground). Within the hazel coppiced woodland at Slapton Ley dormice prefer thicker vegetation at the lower levels. These results do verify the original hypothesis that there would be greater presence and abundance of dormice at boxes with less visibility, however, only in the lower layers.

At the Lower Backslope the majority of the continuous vegetation was at the level of 1 meter or below. Half of the site has stands of sycamore, ash surrounded by gorse, bracken scrub and the other half is elder and ash in large areas of tall grass and scrub. Therefore although there was reduced continuous canopy at all levels at Lower Backslope compared to the Southgrounds site; there was still continuous canopy at all heights for the boxes with standards in the vicinity. However for the majority of the boxes in the site, the vegetation was at 1 meter above ground level and quite dense with visibility down to 30 – 40 percent. Dormice were found to be significantly present in boxes with greater continuous canopy at 2 meters above ground level. This shows some support for the hypothesis that boxes with greater continuous canopy would have dormice present but significant results were only found in this one site at one level.

Upper Backslope had almost no vegetation after three meters above ground level reflecting the fact that the whole site was covered in 2 m high gorse, blackthorn and

sea radish with patches of taller elder (*Sambucus nigra* (L.) and apple (*Malus sylvestris* (L.) Mill.). The vegetation was very dense at all levels, especially the first two meters above ground level where visibility did not get above 20 percent. Dormice were absent from boxes with less visibility, i.e. more dense vegetation, at 1 meter above the ground, both 2 and 4 meters from the boxes. This was the opposite of the findings for the coppiced site. It would seem that in this coastal scrub dormice prefer continuous vegetation which is less horizontally dense.

It is possible that this could be due to the density being so extreme in places that the dormice found their movements curtailed. Also in areas where the vegetation was very dense there tended to be a monoculture of plants with blackthorn and gorse dominant, these may have reduced the diversity of plant food species by suppressing them through competition. However blackthorn has been shown in previous studies to be an important food source for dormice.

Higher vegetation density would have presumably protected dormice from predators. Møller (1989) cited by Berg and Berg (1998) studied bird nest predation and found density of vegetation and degree of cover decreased predation rates at shrubby forest edges. Berg and Berg suggested from this that shrubby areas preferred by dormice are relatively predator safe. It was therefore hypothesised for this study that dormice would be present in nestboxes with higher vegetation density, due in part to the reduced risk of predation, this was shown for Southgrounds but not for the coastal scrub. Predation rate studies in different types of habitat would make an interesting further study.

Southgrounds coppice was dominated (highest percentage cover) by hazel and then sycamore, both important dormice food plants, however when plant percentage cover values were correlated with dormice numbers the only significant relationship was with hart's tongue fern (*Phyllitis scolopendrium* (L.) Newman). This is a species described by Stace (1999) as being found in shady, moist, rocky places. It may be that this species is found in areas of the coppice where the canopy is providing greater shade, and is denser.

Lower Backslope was dominated by grass and sea radish (*Raphanus raphanistrum* ssp. *Maritimus* (Sm.) Thell.) which are not plants typically associated with dormice

presence. The correlations between plant percentage cover and dormice numbers were significant for four plant species which would be counted as food plant species for dormice, they were ash, blackthorn, western gorse and apple. Both blackthorn and western gorse are dense, thorny plants. Hurrell and McIntosh (1984) found in their national survey of dormice in Britain, nests were found in bramble, hawthorn, rose, gorse, blackthorn and holly. They suggested that as all of these are spiky plants, building nests in these locations was for protection from predators and disturbance.

Upper Backslope had highest percentage cover values and was dominated by bramble and sea radish, however the only significant correlation between dormice numbers and percentage cover for that site was a negative one with the grass species. Grass was not present at any of the boxes containing dormice. However Morris *et al.* (1990) state that nests are often built of grass if honeysuckle is not available

Woods (2003) states that bramble is a very important component of dormice habitat. It provides impenetrable dense cover, which supports their nests, protects them from predators and has flowers and fruits which are edible. In Hurrell and McIntosh's (1984) study 42 percent of nests found nationally were in bramble.

If redesigning this study, plant species and percentage cover all the way to the ground, instead of from 0.5 meters above ground level should have been recorded. It was thought that as this was an arboreal mammal utilising plant species within the understorey, ground flora was unnecessary. This study also should have recorded individual grass species cover as they were significantly correlated with dormice numbers. However the surveyor was not experienced in grass identification and as a previous study at the Backslope sites had identified approximately 25 grass species it was felt that a detailed examination of all grass species would have taken too long in the limited time frame for this study.

Bright and Morris (1990) used nestbox surveys combined with live trapping to estimate dormice population densities and compare these values with vegetation data for different coppiced woodland sites. This is the only study using nestbox numbers compared with vegetation variables, which is relevant to the results of the study at Slapton.

In their study Bright and Morris (1990) showed that dormouse population density was significantly correlated with several habitat factors. Diameter/height ratio, how vertical the branches were, was the main correlate, with dormice being most abundant in sites where branches were sprawling. Another factor was the degree of overlap between adjacent shrubs. Both of these factors relate to this current study's results in that dormice occurred in boxes where vegetation had greater connectivity, so probably greater overlap and more sprawling growth form.

The other factors affecting dormice density in Bright and Morris's (1990) study were the number of soft mast shrubs such as blackthorn, the number of honeysuckle plants within the vicinity, the diversity of understorey and canopy species. They stated that honey suckle plants were more numerous near nestboxes used by dormice than those boxes that weren't in use.

In this study no honeysuckle was found in any quadrats, 4m² around the nestboxes, within the Southgrounds site. Honeysuckle was only recorded at one box for each of the other two sites and was not found to be significantly correlated with dormice numbers. This disproved the hypothesis that dormice presence was positively correlated with Honeysuckle presence, and higher percentage cover, a hypothesis which was based on Morris *et al.* (1990) whose results showed a marked association between nestboxes used and proximity of honeysuckle within their 10x10 meter quadrats around the box.

In several studies the species diversity of a site has been an important factor in the abundance of dormice. Bright (1996) suggested that sites with higher species diversity had a more continuous succession of arboreal food resources. Morris *et al.* (1990) showed that more boxes were occupied in areas with high species diversity in its understorey. Bright and Morris (1995) state that a heterogeneous woodland structure is important for this specialised feeder, and that coppicing creates a mosaic of different age shrub growth, with increased species diversity and temporal availability of food. In study at Slapton however, coppiced woodland showed a significantly lower species diversity than the two sites of predominately coastal scrub. However

Bright and Morris (1990) do state that the amount of diversity needed in a site depends on the combination of species found at that site.

The coppice site showed a higher proportion of boxes in use by dormice over the study period, but this was not significantly greater than the proportions in use at the other sites. Interestingly, although Lower Backslope had the lowest proportion of boxes in use, 3 out of 19, the site showed the highest values of density at 9.5 individuals / ha. This is a figure which is quite a bit larger than the usual figures quoted for dormice density. Bright and Morris (1996) state that only densities of 5 – 8 adult dormice/ ha are found even in the best sites.

There is some controversy surrounding population density estimates gained from the number of dormice using nestboxes. Bright and Morris (1990) state that this is a reliable estimate of population density. However Eden and Eden (2001) state that when a dormouse had used a box, the box seemed to then become attractive to other dormice, and would be frequently in use. They suggest this may be due to scent. They state that this choice and usage of nestboxes by dormice is therefore not random, and therefore using nestbox data to assess population density may not be suitable.

Eden and Eden (2001) suggest that boxes in many sites may measure dormice willingness to use the boxes rather than the population size.

Berg and Berg (1998) used nests found in shrubs as evidence of dormice occurrence at two sites in Sweden. At one site the number of shrubs species, coverage and distance to the forest edges all significantly affected whether dormice were found within the test plots. At the other site total cover of all shrub species was higher in plots with nests. In the study at Slapton, shrub species such as blackthorn and western gorse coverage affected nest location.

Morris *et al.* (1990) used the numbers of dormice found as an indication of box use and not number of nests as one individual dormouse may use several boxes and build nests in each. Therefore nests found in boxes were not used for analysis in this current study although it may have increased the occupancy of the nestboxes at some sites thus altering findings and possibly lead to more significant results.

In further studies of dormice habitat requirements in coastal scrub it would have been interesting to study insect species and abundance in the different areas. Research would show how much of dormice diet is made up of insects in a habitat lacking some of the plant species such as hazel that are usually fed upon. Eden and Eden (2001) state that coastal scrub is very rich in insect life such as moths and that in this type of habitat insects may be an important constituent of their food for much of the year. Richards *et al.* (1984) showed that 70 percent of the diet in June was insects with larval Lepidoptera and aphids dominating the samples.

Eden and Eden (2001) commented on the fact that wood mice will often injure or kill a dormice when found in torpor. Dormice appear to avoid boxes which have been used by wood mice.

For the last year of this study occupancy of wood mice in nestboxes was recorded along side dormice numbers. In Upper Backslope in 2002, and 2003, 6 and 7 boxes respectively were occupied by dormice, in 2004 no boxes were occupied by dormice and 11 of the boxes contained wood mice. At Lower Backslope in the first two years of the study no dormice had been recorded and in 2004 3 boxes were used by dormice. It is not known the occupancy numbers of wood mice in previous years but it could be suggested that dormice moved into Lower backslope in 2004 due to the invasion of their boxes by wood mice.

A recommendation for the sites would be continued monitoring of wood mice numbers and considering measures to provide the dormice with extra nesting in sites with wood mice. Eden and Eden (2003) recommend putting up nest tubes in scrub with high wood mice levels as wood mice do not appear to use these as frequently as boxes.

Morris (2003) indicates that the common dormouse is a highly sensitive bioindicator for the presence of a habitat with rich botanical composition. Also being sensitive to habitat fragmentation they indicate the integrity of their habitat. In further studies of this site an assessment of the fragmentation of the habitat, reviewing the number of hedges and distances to the nearest woods of the three sites, could be undertaken.

Bright and Morris (1989) state that dormice in nestboxes are vulnerable to disturbance by humans and suggest that the boxes be positioned well away from paths. In all three of the study sites at Slapton, nestboxes are close to paths which are accessible to the public and their dogs, and in places are quite visible. Although the waist high gorse and blackthorn may stop much of any possible disturbance at the Backslope sites, it may still be a factor reducing the conservation effort at Slapton. In the future an assessment of the levels of disturbance, such as the distance to paths and levels of usage, could be carried out and mitigation put in place.

It is known that dormice occupy sites on the other side of the upper ley and at Slapton wood, where approximately 100 boxes were put up and only one nest found over a number of years, it was hypothesised by wardens at the park that they were present but the habitat was so good as far as nest sites were concerned that the dormice did not need to use the artificial nestboxes. It would have been interesting to assess dormice numbers in Slapton Wood by means of tubes or live trapping, to assess if there really is a healthy population in this large wood that may have colonised the Upper Backslope site.

It would also be interesting to know population size and density in Slapton wood as the sites assessed in this study are relatively small; it has been suggested by Bright (1996), in his survey of Dormice for English Nature, that in the Devon area dormice have been found in 5 ha woodland but that isolated woodland needs to be at least 20 ha to support a viable population, maintaining numbers and genetic diversity.

Radio tracking studies of dormice in coastal scrub could tell conservationists a lot about how dormice are utilising their resources and coping with the gaps and detours they may have to deal with in this patchy habitat. It may show movements between sites, and it would be interesting to see if they do travel across reed beds as suggested by Woods (2003). Another important fact radio tracking may reveal is where the dormice hibernate in this kind of habitat. At Slapton dormice are existing on top of a shingle ridge between the sea and the Ley, where there is probably a lack of dry hibernation sites.

So many other studies have only worked at sites with higher species diversity woodland, with a prerequisite being heavily fruiting hazel for hazelnut assessment. The majority of the work on dormice looks at their habitat requirements in woodland. They exist in many other situations and their life histories and requirements are not known, conservation management for this species has been based around providing coppice. Work needs to be done to provide management recommendations for sites with dormice living in coastal scrub, heathland or coniferous woodland.

Bright and Morris (1995) state that a heterogeneous woodland structure is important for this specialised feeder, and that coppicing creates a mosaic of different age shrub growth, with increased species diversity and temporal availability of food. Eden and Eden (2001) call for caution of the belief that coppicing is essential for dormice as it removes arboreal pathways and associated insects.

More studies in the future on the dormice in 'unusual' habitats would be beneficial, as Hurrell and McIntost (1984) found dormice anywhere with a thick tangle of vegetation.

6. Acknowledgements

Slapton Ley National Nature Reserve's staff, especially Nick and Stuart, for carrying out the monthly surveys, providing the dormice survey data and information on the sites.

Natasha DeVere, Paignton Zoo Environmental Park, for advice on methodology.

Dr. Ferns for help with methodology and advice on the manuscript.

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