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Dale, C.

A Comparison of the abundance of small mammals as revealed by analysis of Tawny Owl pellets with that revealed by live-trapping in the area where the pellets were collected.

by
C.DALE.
(BSc Univ. of Wales)

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Contents

List of Tables

List of Figures

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Chapter 1: Introduction.

Aims.

The purpose of this study was to investigate the diet of the Tawny Owl and to compare the abundance of small mammals in the diet as revealed by analysis of owl pellets with the local abundance as revealed by live-trapping in the area where the pellets were collected. This was carried out at three sites in the Durham area. Comparison was made between the sites and with other work on the subject.

Literature Review.

The Tawny Owl *Strix aluco*.

The Tawny Owl's range extends over the western palaeartic region and into parts of south-eastern Asia. In Britain surveys in 1963 (Prestt, 1965) and 1965 (Prestt and Bell, 1966) showed that the Tawny Owl was common everywhere except in the north midlands and south east england, and was present in more than 60% of surveyed 10 km squares except in north east england and the east midlands.

It is primarily a species of deciduous or mixed woodland, although it is also found in mature coniferous plantations, well-timbered parkland or farmland and is frequent in urban areas (Sharrock, 1976). The nest is usually in a hole either in an old hollow tree or in the face of a cliff or quarry, although occasionally the owl will nest on the ground or take over an abandoned nest of another species of bird; the most frequent being Carrion or Hooded Crow *Corvus corrone*, Magpie *Pica pica*, Sparrowhawk *Accipiter nisus*, or Buzzard *Buteo buteo* in that order of frequency (Sharrock, 1976).

The Tawny Owl is strictly territorial, defending an area of approximately 12ha in woodland (Southern, 1970b). It is mainly nocturnal, although some hunting by day occurs during the breeding season (Southern, 1969). The usual hunting method is to wait on a perch until suitable prey is detected whereupon the Owl flies down and attempts to capture it (Southern, 1970b). However, when hunting in territories which include a lot of open ground it has been seen to hunt on the wing, slowly quartering the area in a zig-zag pattern about 2-3m above the ground (Nilsson, 1978). A different hunting technique is used when the Owls are hunting earthworms. As these would be difficult to detect from a high perch or from the wing the Owls walk around on the ground until they locate a worm, apparently by hearing, and pull it clear of its burrow (MacDonald, 1976). Prey is taken mostly on the ground, although small birds may be taken by flushing them out of their roosts (Witherby et al., 1940; Southern, 1954;). The prey available to the owls will therefore consist primarily of ground dwelling animals which are active by night. Southern and Lowe (1968) studied the pattern of distribution of Tawny Owl predation on rodents in woodland and found that the owls were unable to hunt in very dense ground cover such as bramble or bracken thickets due both to difficulties in locating prey and to the impenetrability of such areas making capture of located prey very difficult.

A wide range of prey is taken which varies according to what is available in the habitat and, unlike the other large british owls, it takes invertebrates as well as vertebrates (Southern, 1954). In a study of owls in mainly deciduous woodland (Southern, 1954) the owls were found to take the following vertebrates :-

1) Small mammals such as Apodemus sylvaticus (Wood Mouse), Clethrionomys glareolus (Bank Vole), Microtus agrestis (Field Vole), Sorex araneus (Common Shrew), S.minutus (Pygmy Shrew), Neomys fodiens (Water Shrew) and some bat species.

2) Larger mammals such as Talpa europaea (Mole), Oryctolagus cuniculus (Rabbit), Rattus norvegicus (Brown Rat), Arvicola terrestris (Water Vole) and Mustela nivalis (Weasel).

3) Small birds, of which 70% were finches, with the Chaffinch Fringilla coelebs being the most common. Species taken include Pigeons (probably Columba palumbis (Wood Pigeon)), Corvus monedula (Jackdaw), Parus major (Great Tit), Turdus ericetorus (Song Thrush), T.merula (Blackbird), Erithacus rubecula (Robin), Chloris chloris (Greenfinch), Carduelis carduelis (Goldfinch), Pyrrhula pyrrhula (Bullfinch) and Chaffinch.

The invertebrates taken included earthworms and beetles of the genera Geotrupes, Melolontha, Carabus, Necrophorus, Feronia and Abax.

Various seasonal fluctuations were seen in the diet of the Tawny Owls in this study, the most obvious of which was the sudden change from small rodents to larger mammals which occurred in spring. In the four months after the leaves fell and the ground vegetation was at a minimum, small rodents constituted nearly 80% of the prey units taken compared with

30-45% in summer and early autumn. (one prey unit is the equivalent of one small mammal of weight 20g (Southern, 1954)). This decline in small rodents in the diet is due both to the total population of rodents being at its lowest level at this time of year (Ashby, 1967; Southern, 1970b) and to the ground vegetation growing up and making hunting for them difficult. For the larger mammalian prey there was a variety of seasonal trends, rabbits rising to a peak in May and June then declining followed by moles rising to a higher peak in July and August. Southern found no evidence of seasonal fluctuations in the numbers of birds or shrews taken, both of these constituting approximately 4% of the diet. Earthworms show a peak in the period August to October when the small rodents are still largely hidden in the ground vegetation, young rabbits have grown too large to catch and moles are decreasing in number (Southern, 1954). Amongst the beetles 81% of those taken were of three genera. Species of Melolontha are taken from May to October with a peak in May caused by the breeding of the Cockchafer Melolontha melolontha, Geotrupes is taken throughout the year with a peak in March\ April and carabids are taken from January to October with a peak in May\ June.

In London Harrison (1960) found that 96% of the diet of a pair of urban Tawny Owls was composed of birds, with Passer domesticus (House Sparrow) being the most important followed by Sternus vulgaris (Starling). Mammalian prey only made up 4% of the diet and only one species, R.norvegicus, was taken. Mus musculus (House Mouse) was present in the area but was apparently difficult to catch due to its habit of staying close to cover.

Uttendorfer (1939) in Germany and Smeenk (1972) in the Netherlands have confirmed the wide range of prey taken. The diet in these countries includes prey species not found in Britain such as the common vole Microtus arvalis and the Greater White-Toothed shrew Crocidura russula.

The Bank Vole.

Clethrionomys glareolus is present over much of Europe except the Mediterranean lowlands of Iberia, Italy and the Balkans. Its northerly limit is the Arctic circle where it is replaced by C.rutilis (Northern Red-Backed Vole) (Corbet, 1966) and it extends eastwards to Lake Baikal (Corbet and Southern, 1977). In Britain it is present throughout the mainland and on several islands although it is absent from most of Ireland.

Clethrionomys is found in a variety of habitats and is particularly abundant in deciduous woodland or scrub. It is also found in coniferous woodland, hedgerows and banks, particularly in areas with dense ground cover which it is known to prefer (Kikkawa 1964; Ashby, 1967). Southern and Lowe (1968) found that the Tawny owls caught substantially more individuals in areas of dense vegetation than in areas of sparse vegetation, as would be expected from their greater abundance. As hunting in areas of very dense ground cover is difficult for the owls Southern and Lowe suggested that areas of intermediate cover density would be the most profitable in which to hunt Clethrionomys. Chitty and Phipps (1966) and Southern (1970b) reported that Clethrionomys could be found in grassland areas, although it does not move far into cultivated fields (Kikkawa, 1964; Pollard and Relton, 1970).

Clethrionomys may be active throughout the 24 hours (Miller, 1955) sometimes with peak activity around dusk and dawn (Corbet, 1966; Ashby, 1971). The crepuscular and nocturnal activity would entail risk of Tawny owl predation. This may be avoided by diurnally active animals but these would then be at risk from diurnally active predators such as Weasels or Kestrels in open country. Nocturnal activity seems to be preferred in the summer (Miller, 1955; Pearson, 1962; Kikkawa, 1964; Ashby, 1971) when ground cover is high and small rodents are at their lowest importance in the Tawny owls diet, although a diurnal preference with crepuscular peaks of activity has been observed in summer in the presence of Apodemus (Brown, 1966; Greenwood, 1978).

The breeding season usually runs from April to September or October (Corbet, 1966; Corbet and Southern, 1977) and so by July and August (the time of this study) juvenile animals should be present and at risk of capture by the owls.

The predators of Clethrionomys include most British birds of prey and mammalian carnivores. Corbet and Southern (1977) considered Tawny Owls and Weasels to be the most important predators: Southern and Lowe (1982) working in Wytham Woods found that the Owls removed from 20-30% of the standing crop each two months, whilst Weasels in nearby Marley Wood were found to remove from 2-20% of the population (mean 7.8%) per month depending on the season (King, 1980).

The Wood Mouse.

Apodemus sylvaticus is present in many of the woodland and steppe regions of the Western Palaearctic. Its range extends from southern Scandinavia to northern Arabia and North Africa, and from Europe eastwards to the Altai and the Eastern Himalayas (Corbet and Southern, 1977). In Britain and Ireland it is present in most regions except for very open, mountainous areas; its altitudinal limit is usually the tree line (Corbet, 1966).

In its European range it is one of the most ubiquitous of small mammals (Corbet, 1966).. It is particulaly abundant in deciduous woodland and has been found to show no preference for the amount of ground cover present (Crawley, 1965; Ashby, 1967). Southern and Lowe (1968) observed that it was trapped in approximately equal numbers in four categories of ground vegetation density, (except for a slight reduction in the densist category which was thought to be due to competion for traps by *Clethrionomys*) and found that it was taken by Tawny owls predominantly from open areas, which would be the easiest to hunt in.

Kikkawa (1964) found that *Apodemus* dispersed freely from an area of deciduous woodland into surrounding fields where it bred in summer and many individuals returned to the woodland in winter. Similarly Pollard and Relton (1970) and Eldridge (1971) observed that Apodemus was present both in hedgerows and in the adjacent cultivated fields. Jefferies et al. (1973) in another hedgerow study postulated that there were two populations of Apodemus, one of which lived continuously on the fields and one which dwelt in the hedgerows and field boundaries and moved onto the field to forage. Apodemus also occurs in rough grassland although Fairley (1967) working in Ireland found it to be more common in areas of slightly denser cover, for example, in grass and bracken or in grass and heather areas. Unfortunately no information about the height or density of the grassland was given.

Unlike Clethrionomys, Apodemus is strictly nocturnal (Corbet, 1966; Corbet and Southern, 1977). Even bright moonlight has been found to diminish its activity (Kikkawa, 1964; Southern, 1970b) and it is therefore rather more at risk from Tawny Owl predation than the slightly more diurnal Clethrionomys, which may have been a contributing factor to the apparent selection of Apodemus as prey seen by Southern and Lowe (1968), along with it not avoiding open ground in the same manner as Clethrionomys. Field studies by Brown (1956b), Kikkawa (1964) and Greenwood (1978) found one peak of activity on summer nights and two peaks on winter nights. A laboratory study by Miller (1955) had found a similar double peak in activity under an eight hour light regime simulating winter conditions but also found two peaks under a 16 hour regime simulating summer conditions. More recent work by Wolton (1983) using radio monitoring methods in the field, which do not restrict or interfere with the animals to the same extent as trapping in the previous studies, found a more complex pattern. In mid-winter activity was very varied with little synchrony between nights. In spring it was bimodal with peaks 2-4 hrs after sunset and 3.5-4.5 hrs before sunrise, and in summer it was unimodal in pattern, with the mice leaving the nest at dusk and returning at dawn.

As with Clethrionomys, the breeding season of Apodemus usually runs from April to October (Corbet and Southern, 1977) which again means that juveniles should be present at the time of the study.

Corbet (1966) considered the most important predators to be the woodland owls, the mustelids and cats (wild and feral). Southern (1954) found that Apodemus comprised 30% of the vertebrate diet of the Tawny Owl (Not enough information was available in his 1982 study to discover the percentage of the population which was taken). Fairley (1972, cited in Corbet and Southern, 1977) recorded that it comprised 22-50% of the prey of the Long-eared Owl in English woodland, and King (1980) found that Weasels in Marley Wood near Oxford took from 1-20% (mean 9.7%) of the population per month according to season.

The Field Vole

Microtus agrestis is one of the most abundant and widespread voles of the western palaearctic and is found from the arctic coast south to the Pyrenees and Alps and eastwards to the river Yenesei and Lake Baikal (Corbet, 1966). It is the only species of Microtus on the British mainland and is found on most of the Hebridean islands except for Lewis, Barra and some of the Inner Hebrides. It is absent from Ireland, Isle of Wight, Lundy, Scillies and the Channel Islands (Corbet and Southern, 1977).

Microtus is a grassland species which requires fairly dense ground cover and hence it is not found in areas closely grazed by herbivores, preferring rough ungrazed grassland such as that found in young forestry plantations. It is especially characteristic of wet ground with rushes and sedges (Corbet, 1966) although low density populations can be found in marginal habitats such as woodlands, hedgerows, blanket bog, dunes, scree and moorland (Corbet and Southern, 1977). Tawny Owls whose territory includes open areas of rough grassland will therefore be able to exploit Microtus as prey rather more than owls hunting in woodland, although the latter may still catch individuals from the low density populations present there. Southern (1970b) found that the difference between the two territory types was not great; Microtus comprised 10% of the diet of woodland owls and 15% of the diet of owls whose territory included open ground. Microtus makes very prominant runs through grass at ground level (also used by other small mammals) which in thick and tall grass would make hunting difficult for the owls.

It is active at intervals throughout the 24 hours; Davis

(1933) found greatest activity occured at night and Brown (1956b) reported that peaks of activity occured at dawn and dusk, again with slightly more activity during the night. Erkinaro (1961) (using very few animals in a laboratory study) found peak activity in the afternoon in Summer which changed to the morning in Winter, with transition periods in Spring and Autumn where two peaks were observed in the morning and in the evening.

The breeding season starts in April and usually continues until September (Corbet and Southern, 1977), being slightly shorter than that of Apodemus or Clethrionomys, and again juveniles should have been present at the time of the study.

Microtus population density shows non-annual fluctuations or cycles with a period of three to five years between maximum densities. The amplitude of these cycles may be very great, ranging from plague proportions to an almost total absence of voles (3-300 animals per ha at peak abundance in central Scandinavia (Stenseth et al., 1977)). The more obvious extrinsic factor explanations for these cycles such as weather, disease, parasites, predation, quantitative food deficiency and migration have been discounted by some authors (Krebs and Myers, 1974; Tapper, 1976; Corbet and Southern, 1977). The current intrinsic factor hypotheses of genetical or behavioural causation (see Krebs and Myers or Tapper) are somewhat outside the intended scope of this review.

Microtus is preyed upon by many raptors, owls and Mammalian predators, although those which commonly hunt in rough open grassland will of course have the most important effect on the *Microtus* population.

Selection by the Trapping Technique.

The Longworth live trap is more efficient at catching some small mammal species than others. Adult moles for example would not be caught due to their size and burrowing lifestyle, and even when juveniles (which may be small enough to trap) are dispersing above ground in May and June they tend to avoid rather than investigate box traps (Godfrey and Crowcroft, 1960; Mellanby, 1971). Shrews will enter live traps even if they are not baited and may be caught in greater numbers using bait of mealworms (Crowcroft, 1957). Trapping shrews in longworth traps does involve problems due to both the small size of the animals enabling them to escape through some of the small gaps gnawed in the traps by rodents, and to their light weight being insufficient to trip the release mechanisms of some of the traps. Small rodents are on the whole more readily trapped than shrews, although there are differences between species with *Clethrionomys* and *Apodemus* being easier to trap than *Microtus*. In all these species the siting of the traps is important and ideally should be bedded down in line with natural features such as the side of a fallen branch etc and should be camouflaged with fallen leaves or grass (Linn pers. comm.). The degree of experience at siting the traps may have an important effect on the numbers of animals caught.

Other forms of trapping selection involve differences in response to the traps amongst individuals of the same species. Most of the work on behavioural heterogeneity of this kind appears to have been done on small rodents by authors such as Crowcroft and Jeffers (1961), Kikkawa (1964), Crawley (1965), and Tanton (1965). The behavioural differences which may cause heterogeneity in response to traps include-

1) Differences in activity rythyms may cause some individuals to visit traps before others.

2) Some animals have stronger exploratory drives than others.

3) Some animals are thought to be inherently trap-shy or trap-happy. The trap-shy animals avoid traps, but some of them may overcome this on continued exposure to the traps.

4) Experience of trapping may change the reactions of an individual, some may become trap-shy others may become trap-addicted.

Finally, competition for traps is thought to favour the dominant animals as the subordinate individuals tend to avoid the presence of the dominants which then have a greater chance of being trapped. Thus juvenile and female animals (which are usually subordinate) may be selected against in trapping.

Chapter 2: Materials and Methods.

Trapping Methods.

The trapping was carried out using Longworth live traps (Chitty and Kempson, 1949). These were arranged in two lines of 10 traps with 5.94m (6.5yds) between adjacent traps in a line and 9.14m (10yds) between the lines, in a similar manner to that used by Ashby (1967).

This method was chosen for two main reasons. Firstly, unlike the standard 100 x 100m grid (as used by Flowerdew) it enabled small areas of habitat to be sampled. This was an advantage particularly in Witton-le-Wear Nature Reserve which has quite a diverse range of habitats, most of which would be too small to allow the use of a reasonably sized grid of traps. Secondly the method also has the advantage of having a more compact arrangement of traps than a grid and therefore it is easier to use by one person, whilst because of the catchment area around the lines it still samples a sizeable area of the habitat. Ashby (1967) found that line-trapping gave similar results to those found using a grid of traps, and suggested that the line trapping method gave a reliable index of small mammal abundance.

The traps were baited with whole wheat and dried cat-food of the "Go-Cat" variety was provided as food for shrews. Dry hay was provided as bedding.

Table 2.1 shows the trapping routine, which consisted of two days prebaiting and five days trapping. Originally three days of trapping was intended but after this period at the Durham Field Station the catch was so low that the period was extended to five days; this period was subsequently used at the other sites also.

Table 2.1:Trapping Routine

Day	Procedure
1	Lay traps, Prebait.
2	continue "
3	Set to catch am visit pm.
4	Record + mark any captures am and pm, reset.
5	"
6	"
7	"
8	Empty + lift traps am.

The traps were checked twice per day in the morning and late evening in order to minimise mortality and gnawing damage to the traps as much as possible. Any captures of an individual overnight and also caught the previous evening was considered as a single capture for purposes of calculating the Lincoln Index.

The data recorded included the species, age, sex and breeding condition of each individual. All captures were weighed using a spring balance and the length from nose to anus was also recorded, using the method recommended in Southern (1964).

The animals were marked by clipping the fur so that the darker inner coat of fine hairs was visible. A different site of marking was used each 24hr period so that the number of recaptures (if any) was known.

Vegetation Analysis.

From the work of Crawley (1965) it was thought that the species of plant present in the vegetation would affect the distribution of *Apodemus* or *Clethrionomys* less than the cover or height of the vegetation. It was therefore decided to rate the ground cover and the height of the vegetation on a simple scale as shown in Table 2.2 but not to perform an intensive study of the vegetation using quadrats. However, a species list of the vegetation at each trapping site was prepared and the dominant species were identified. Both the vegetation analysis results and the detailed species lists are given in Appendix One.

Table 2.2: Scales of degree of Ground Cover and Height of vegetation.

Scale	Cover	Height
0	<5%	<5cm
1	5-20%	5-25cm
2	20-40%	25-50cm
3	40-60%	50-75cm
4	60-80%	75-100cm
5	80-100%	100cm +

Pellet Analysis

Both "Fur" and "Fibre" pellets (Southern, 1954) were collected from the various sites. In the laboratory, after soaking them in water to soften them, they were dissected under a binocular microscope. The skulls, jawbones, and pelvic girdles (os coxae) of any small mammals were removed and identified using Yalden (1977) and Lawrence and Brown (1967) (no other bones are readily identifiable down to species level). If any pellets contained unidentifiable bones from larger mammalian prey, fur samples were taken and the contents identified using Day (1966). This key also enabled feather remains to be identified down to order level.

In addition to identifing the remains of small mammals in the pellets, a simple distinction between young and adult individuals was attempted on the basis of the amount of tooth wear seen (Lowe, 1971 for Clethrionomys, Delany and Davies, 1961 for Apodemus).

Chapter 3: Results.

Site Descriptions.

Area One: Durham University Field Station.

The Durham University Field Station is approximately four hectares in area consisting mainly of woodland and situated at an altitude of approximately 250ft immediately west of Hollingside Wood (Figure One), situated about a mile south of the centre of Durham on sloping ground at the western edge of the flood plain of the River Wear. The area as a whole was given to the University by the Dean and Chapter of Durham in 1832 and the tenancy of the Field Station area reverted to the University in 1962, after being farmed.

The underlying geology is subglacial boulder clay with a locally substantial sandy fraction owing to resorting by water.

The dominant trees of the Field Station east of the stream are Beech Fagus sylvaticus and sessile Oak Quercus petraea, with occasional European Larch Larix decidua, Scots Pine Pinus sylvestris and Sycamore Acer pseudoplatanus. The woodland is generally more open in nature to the north with large Beech trees predominating and closes in towards the south where other species, especially Oak, become more important. The positions of the trapping, Nesting and Roosting sites are shown in Figure One, and the ground vegetation and canopy details are summarised in Table 3.1 (Full details are given in Appendix One).

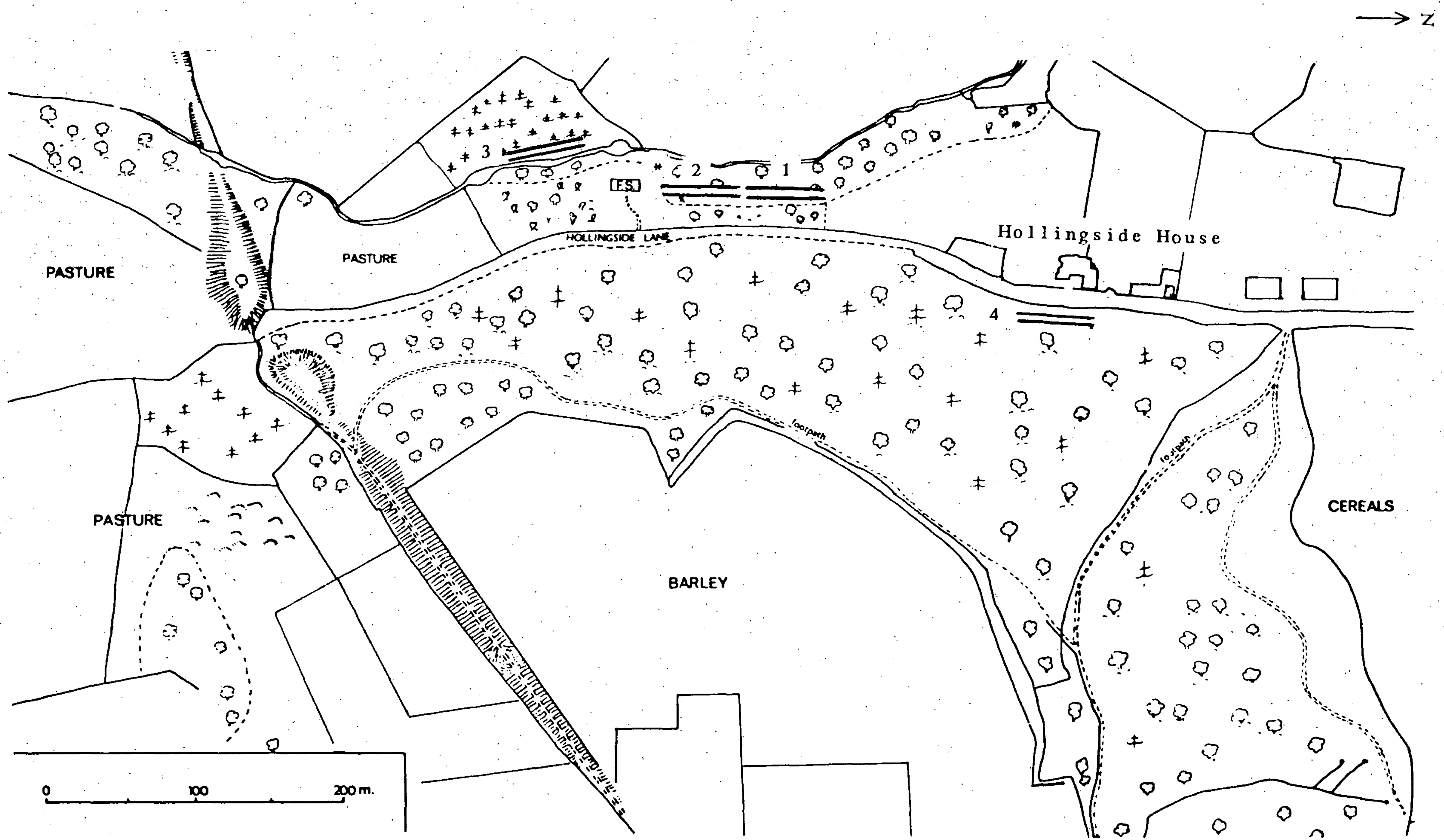


Figure 1: Map of Durham Field Station and Great High Wood showing Trapping Sites.

(Most Roost sites were in the vicinity of Trapping Site 1 with occasional roost around Site 2).

══ Trapping Sites

* = Nesting Site

Table 3.1: Ground Vegetation and Canopy Details for the Trapping sites in the Field Station.

	Canopy		Ground Vegetation Details			
Trapping Site	species	mean density +/-SD	mean cover +/-SD	mean height +/-SD	dominant/ locally dom. species	common species
1 (Mixed Woods)	Beech Oak	1.8 +/-0.98	3.6 +/-1.25	1.9 +/-0.85	A.odor (ld) D.flex (ld)	A.elat F.ovi
2 (Mixed Woods)	Oak Larch S.Birch	1.6 +/-0.67	3.5 +/-0.63	1.1 +/-0.31	L.peri (ld)	D.flex F.ovi R.frut
3 (*)	S.Pine	0.55 +/-0.83	3.7 +/-0.98	2.4 +/-1.21	H.sph (ld) U.dio (ld)	A.elat A.syl
4 (Beech Woods)	Beech Sycamore	2.6 +/-0.58	2.6 +/-0.67	1.0 +/-0.4	H.hel (d) R.frut (ld)	H.n-s O.acet

(*) Trapping Site 3 was half in woodland, half in an open area.

A.odor = Anthoxanthum odoratum, A.elat = Arrhenatherum elatius, D.flex = Deschampsia flexuosa, F.ovi = Festuca ovina, L.peri = Lonicera periclymenum, R.frut = Rubus fruticosa, H.sph = Heracleum sphondylium, U.dio = Urtica dioica, A.syl = Anthriscus *sylvestris*, H.hel = *Hedera helix*, H.n-s = *Hyacinthoides non-scriptus*, O.acet = *Oxalis acetosella*.

Area Two: Witton-le-Wear Nature Reserve

This reserve is situated nine and a half miles south-west of Durham City and three-quarters of a mile east of Witton-le Wear village. It is 34 hectares in area and is owned by the Durham County Conservation Trust.

Before becoming a nature reserve the area was originally farmed and from 1957 to 1964 was worked for gravel extraction (the bedrock is flood plain gravel). When this ceased, the area was landscaped and the land was leased to the Northumberland and Durham Naturalists Trust (later the D.C.C.T.) as a nature reserve. It now has SSSI status.

The reserve is at an altitude of approximately 300ft. Its southern side borders the river Wear. It contains areas of grassland, scrub, young and mature woodland, ponds, streams and a lake with several islands. Figure Two is a map of the reserve showing the main areas of habitat, the nesting and Roosting sites of the owls and the five trapping sites. The vegetation details are summarised in Table 3.2

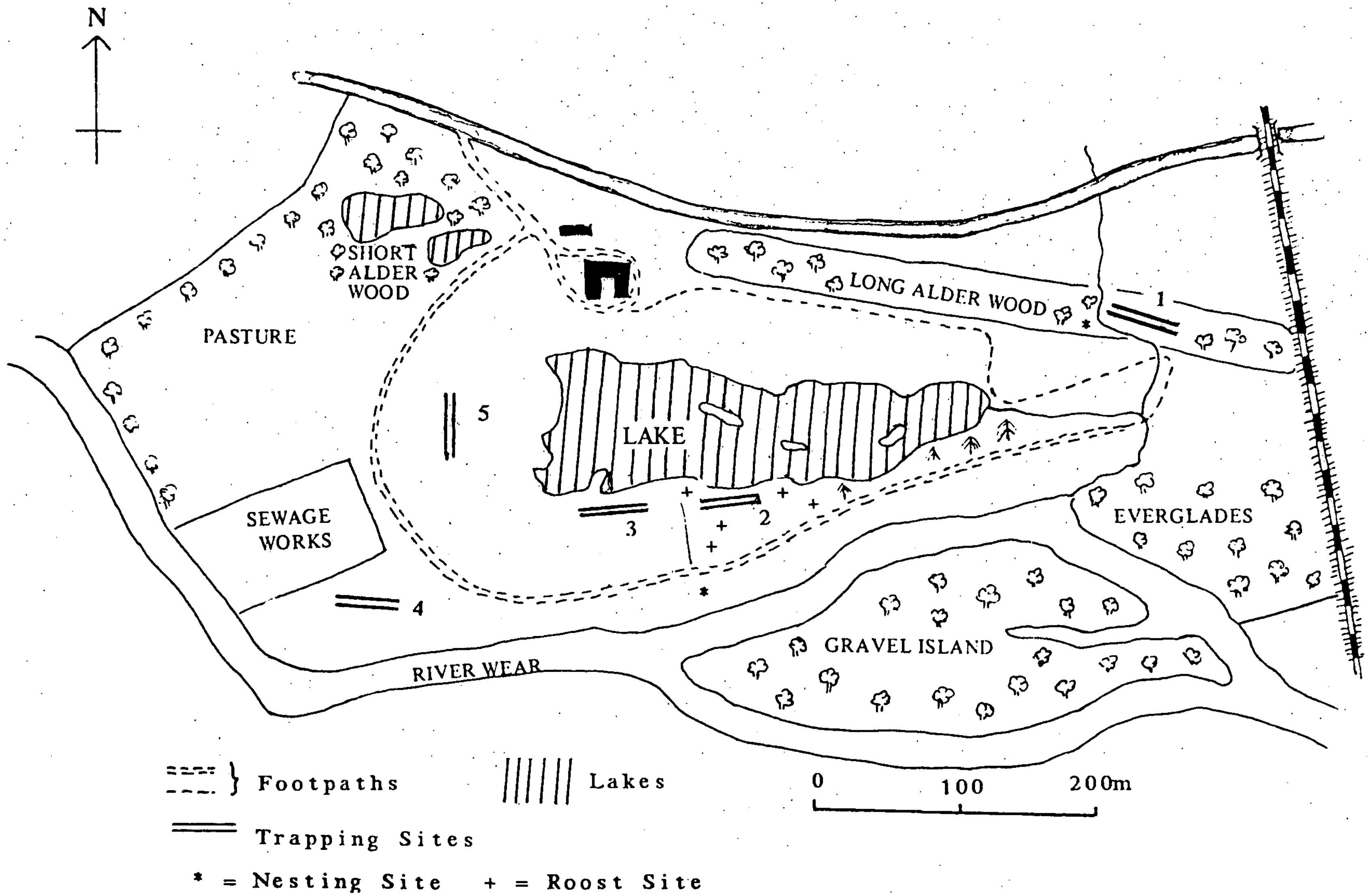


Figure 2: Map of Witton-le-Wear Nature Reserve showing major habitats and Trapping Sites.

Table 3.2: Ground Vegetation and Canopy Details for the trapping Sites in Witton-le-Wear Nature Reserve.

Trapping Site	Canopy Details: species	Canopy Details: mean density +/-SD	Vegetation Details: mean cover +/-SD	Vegetation Details: mean height +/-SD	dominant/ locally dom. species	common species
1 (Alder Wood)	Alder, Ash, Sycamore	2.1 +/-0.63	3.6 +/-0.58	2.2 +/-0.89	R.rep(ld)	D.cesp, M.eff, P.nem
2 (Conifer Wood)	S.Pine, Spruce	1.9 +/-0.89	2.2 +/-0.94	1.6 +/-1.16	E.Ang (ld), R.frut (ld)	R.id, S.dio
3 (Open Grassland)	No Canopy		4.4 +/-0.49	1.7 +/-0.67	No dominant species	A.odor, A.elat, D.glom, H.lan
4 (Open Grassland)	No Canopy		4.8 +/-0.4	2.5 +/-0.8	No dominant species	A.elat, H.moll, C.nig, U.dio, V.sep
5 (Open Grassland)	No Canopy		4.6 +/-0.49	2.1 +/-0.54	A.odor (ld), A.elat (ld)	D.glom, C.arv, T.prat

D.cesp = Deschampsia flexuosa, M.eff = Millium effusum, R.rep = Rannunculus repens, P.nem =Poa nemoralis, E.ang = Epilobium *angustifolium*, R.id = *Rubus idaeus*, S.dio = *Silene dioica*, D.glom = *Dactylis glomerata*, H.lan = *Holcus lanatus*, H.moll = *Holcus mollis*, C.nig = *Centaurea nigra*, V.sep = *Vicia sepium*, C.arv = *Cirsium arvense*, T.prat = *Trifolium pratense*.

Area Three: Hamsterley Forest.

The third area of study was Hamsterley Forest in Weardale, which is approximately 20 miles south-west of Durham City and four miles south of Wolsingham. It is 2020 ha in area and extends from 600-1200ft in altitude on the eastern side of the Pennines.

Before its purchase by the Forestry Commision in 1927 it consisted of approximately equal proportions of moorland and grazing land of varying quality. The initial planting of the Forest lasted from 1927 to 1951 and was in accordance with the then current policy of planting fast-growing softwoods such as Scots Pine, Lodgepole Pine *Pinus contorta*, Sitka Spruce *Picea sitchensis* and Norway Spruce *Picea abies* in large rectangular blocks. Since 1951 many areas have been replanted with softwoods, but the new policy of conservation planting has resulted in some areas of deciduous trees such as Oak, Elm *Ulmus procera* and Alder *Alnus glutinosa*.

The underlying geology of the area is sand- and mudstone of millstone grit age with the small volcanic Hett Dyke running NE to SW through the eastern section of the Forest. The soils are mostly peaty gleys.

Figure 3(a): Outline of Hamsterley Forest showing position of study area.

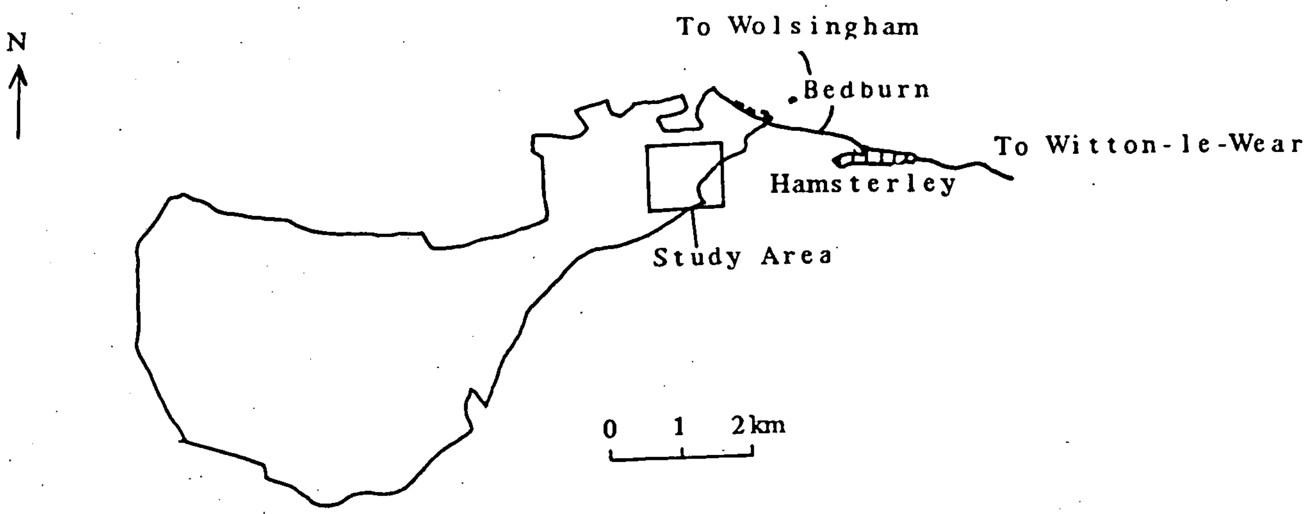
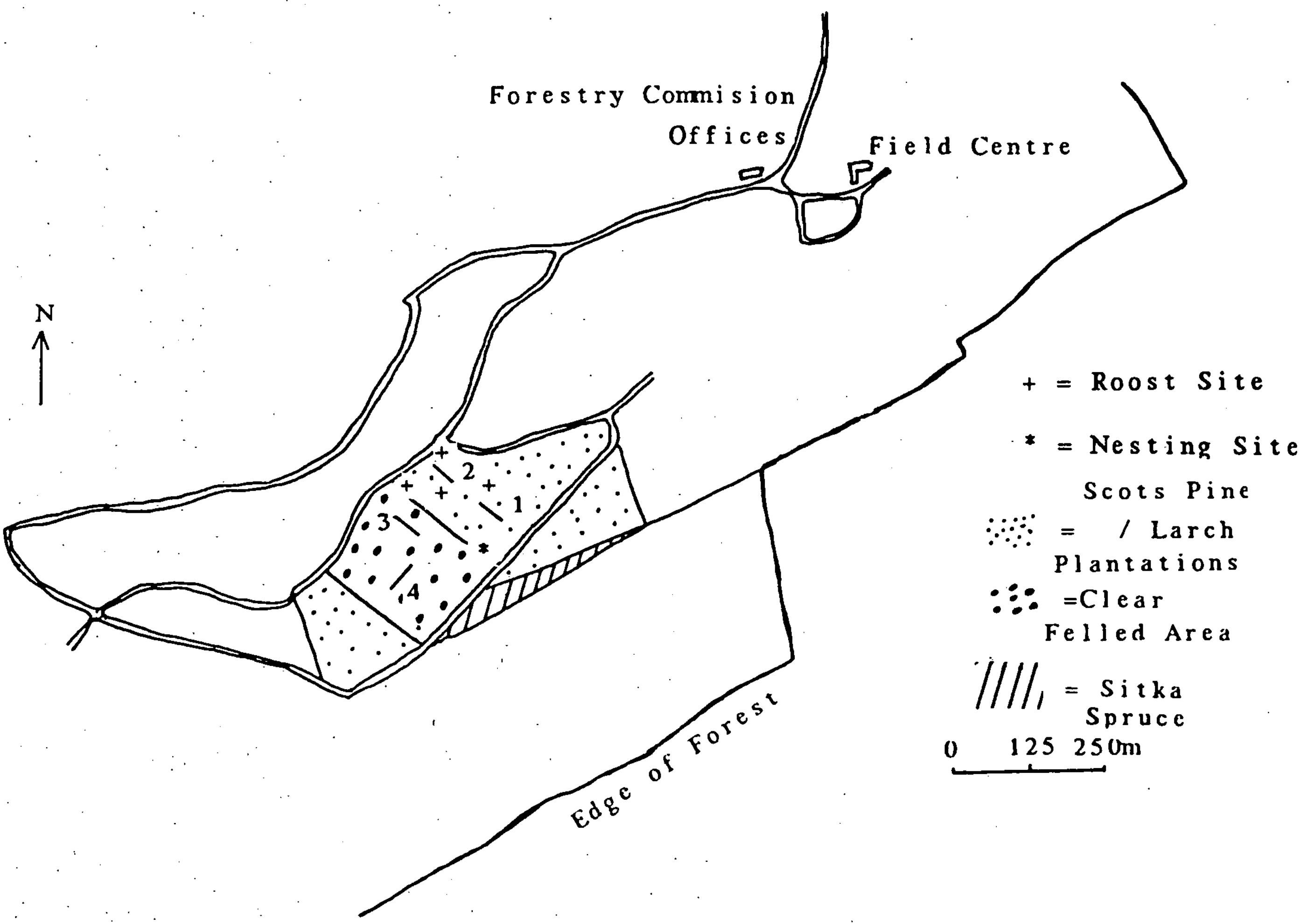


Figure 3(b): Detailed Map of Study Area showing habitat types and Trapping Sites.



The study site was in the north-eastern area of the Forest as shown in Figure Three (a) and consisted of a Scots Pine and European Larch stand which had been planted in the 1940s. The central area had been clear-felled in 1983 and since then had been replanted with Larch seedlings which had reached approximately 45cms in height. Figure Three (b) shows the relationship of the stands to the four trapping sites and the Nesting and Roosting Sites. Table 3.3 shows the ground vegetation and Canopy details for this area.

Table 3.3: Ground vegetation and Canopy Details for the Trapping sites in Hamsterley Forest.

	Canopy Details		Vegetation Details			
Trapping Site	species	mean density +/-SD	mean cover +/-SD	mean height +/-SD	dominant/ locally dom. species	common species
1 (Conifer Plantation)	S.Pine E.Larch	1.9 +/-0.63	3.1 +/-0.72	1.4 +/-0.67	P.aquil (ld) R.frut (ld)	D.flex H.moll V.myrt O.acet
2 (Conifer Plantation)	S.Pine E.Larch	1.8 +/-0.4	2.9 +/-1.25	1.2 +/-0.4	P.aquil (ld) R.frut (ld)	D.flex H.moll V.myrt O.acet F.ovi
3 (Open Grassland)	No Canopy		3.6 +/-0.63	1.7 +/-0.49	D.flex (ld) H.lan (ld) H.moll (ld) R.frut (ld)	G.alb
4 (Open Grassland)	No Canopy		3.6 +/-0.49	1.7 +/-0.67	D.flex C.vulg R.frut	F.ovi

P.aquil = Pteridium aquilinum, C.vulg = Calluna vulgaris, V.myrt = Vaccinium myrtillus, G.alb = Galium album.

Trapping Results.

The total numbers of Apodemus and Clethrionomys caught at the various sites are shown in Table 3.4 and are broken down by sexes and into Adult and Juvenile numbers in Table 3.5.

In addition to these species, individual Sorex araneus were caught once at Field Station Site 3, at Witton-le-Wear Site 3 and at Hamsterley Site 1. One specimen of Mustela nivalis was caught at Witton-le-Wear Site 3. No Microtus agrestis was caught at any Site.

The population size at each trapping Site was estimated where possible using Hayne's formula as given in Blower et al. (1981).

$$\hat{P} = \frac{\sum n_i x_i^2}{\sum m_i x_i}$$

Where $\hat{P}$ = Population estimate, n_i = Number in sample i, m_i = Number of marked animals in sample i, $x_i = \sum_{j=0}^{j=i-1} (n_i - m_i)$ or the cumulative of unmarked animals before sample i.

This method requires the satisfaction of several assumptions, as follows: 1) All the marks should be permanent. 2) All marks are noted on recapture. 3) The marking technique should not affect the the probability of survival.

Table 3.4a: Trapping Results and Estimates of Absolute Density for Clethrionomys.

	Capt.	Recapt.	Pop.Est. (A)	Pop.Est. (B)	Density / Ha From (A)	Density / Ha From (B)
Field Station						
Site						
1	0	0	0.0	0.0	0.0	0.0
2	1	0	2.8	2.1	6.3	4.7
3	4	1	8.4	6.3	18.9	14.2
4	2	0	5.6	4.2	12.6	9.4
Witton-le-Wear						
1	4	0	11.2	8.4	25.2	18.9
2	3	0	8.4	6.3	18.9	14.2
3	4	0	11.2	8.4	25.2	18.9
4	3	1	5.6	4.2	12.6	9.4
5	0	0	0.0	0.0	0.0	0.0
Hamsterley						
1	1	0	2.8	2.1	6.3	4.7
2	0	0	0.0	0.0	0.0	0.0
3	3	2	2.8	2.1	6.3	4.7
4	0	0	0.0	0.0	0.0	0.0
Overall	24	4	4.5	3.4	10.2	7.6

Table 3.4b: Trapping Results and Estimates of absolute Density for Apodemus.

	Capt.	Recapt.	Pop.Est. (A)	Pop.Est. (B)	Density / Ha From (A)	Density / Ha From (B)
Field Station						
Site						
1	0	0	0.0	0.0	0.0	0.0
2	0	0	0.0	0.0	0.0	0.0
3	1	0	1.6	1.8	3.3	3.7
4	0	0	0.0	0.0	0.0	0.0
Witton-le-Wear						
1	2	0	3.2	3.6	6.6	7.4
2	7	4	4.6	5.4	9.5	11.1
3	0	0	0.0	0.0	0.0	0.0
4	0	0	0.0	0.0	0.0	0.0
5	5	1	6.4	9.1	13.2	18.7
Hamsterley						
1	0	0	0.0	0.0	0.0	0.0
2	0	0	0.0	0.0	0.0	0.0
3	0	0	0.0	0.0	0.0	0.0
4	3	0	4.6	5.4	9.5	11.1
Overall	18	5	1.6	1.8	3.2	4.0

Estimate of population (A)= From Hayne's estimate on the total data. (B)= From the recapture proportion (See text).

Table 3.5: Numbers of Adults and Juveniles Caught.

	Adult			Juvenile	
	Male	Female	Esc	Male	Female
Clethrionomys					
Field Station	3	2		1	0
Witton-le-Wear	2	5		1	4
Hamsterley	0	2		0	0
Apodemus					
Field Station	0	0	1	0	0
Witton-le-Wear	7	1		0	1
Hamsterley	2	1		0	0

Esc =Escapees.

These first three assumptions may be met with careful trapping and examination of the captures and the use of non-harmful marking such as the fur-clipping technique used here, which is unlikely to attract the attention of a possible predator. Other assumptions include: 4) That the population is a closed one with no loss or gain during the study. As the trapping period in this study was only five days this is a reasonable assumption to make. 5) The probability of capturing marked and unmarked animals is equal. There seems to be no biological reason why the marking itself should affect the probability of recapture but it is possible that some animals will be affected by their capture and become either trap-shy or trap-addicted: therefore this assumption and the final assumption 6) That the probability of capture of a given individual is constant, may be violated at least to some extent.

Due to the low capture numbers and to the even lower numbers of recaptures it was only possible to use the Hayne's estimate for each species at two out of the thirteen individual sites. (This gave rise to estimates of 4.7 Clethrionomys at site 3 in the Field Station, 1.0 Clethrionomys at site 4 Witton-le-Wear, 2.5 Apodemus at site 2 Witton-le-Wear and 6.7 Apodemus at site 5 Witton-le-Wear).

To overcome this problem the data from all sites had to be combined for each species and from the result of the Hayne's estimate on all the data, a conversion factor to obtain the estimate of the total population from the numbers caught at individual sites was calculated. For Apodemus this multiplication factor was 1.6 and for Clethrionomys was 2.8. The results of the total population estimates using the correction factors from the overall Hayne's estimate are shown in Table 3.4 (estimate of population (A)).

In addition to the method outlined above, the total population was also estimated using the proportion of marked animals which were subsequently recaptured one or more times to give an estimate of the likihood of an individual being caught in each period of 24hrs of trapping. This was calculated to be 12.1% per day for Clethrionomys and 14.8% for Apodemus.

Assuming that these percentages of the unmarked population were caught each day for five days it was calculated that by the end of the trapping period a total of 47.6% of the Clethrionomys population and 55.1% of the Apodemus population had been captured. Therefore, in order to calculate the whole population the original figures need to be multiplied by 100% \ 47.6% =2.1 for Clethrionomys and 100% \ 55.1% =1.8 for Apodemus in sample sizes of 20 Clethrionomys and 13 Apodemus. These conversion factors are in fairly close agreement with those found using the Hayne's estimate. The populations estimated using them are shown in Table 3.4 (estimate of population (B)).

The recapture proportions per day were compared with those obtained by Ashby (1967) and Mitchell-Jones (1979) (both of whom worked in Great High and Hollingside Wood), using 2x2 contingency table analysis on the actual numbers of individuals recaptured and not recaptured. The recapture proportions in the present study were found to be significantly lower than those of Ashby (1967), as shown in Table 3.6. (Ashby's recapture proportions were 55.6% per day for a sample of 586 Apodemus and 52.7% per day for a sample of 419 Clethrionomys). No significant difference was found between the recapture proportions of Mitchell-Jones (1979) and the present study (Table 3.7), and on comparing Mitchell-Jones' results with those of Ashby they were found to be significantly different (Table 3.8). (Mitchell-Jones' recapture proportions were 31.3% per day in a sample of 135 Apodemus and 26.4% per day in a sample of 163 Clethrionomys).

Table 3.6: Comparison of Recapture Proportions found by Ashby (1967) with those found in the present study.

(A) *Clethrionomys*

	Present Study	Ashby (1967)
Recaptured	4	221
Not recaptured	29	198

$\chi^2 = 19.51$, 1 d.f., $P<0.001$

(B) *Apodemus*

	Present Study	Ashby (1967)
Recaptured	4	326
Not recaptured	23	260

$\chi^2 = 17.32$, 1 d.f., $P<0.001$

Table 3.7: Comparison of Recapture proportions found by Mitchell-Jones (1979) with those found in the present study.

(A) *Clethrionomys*

	Present Study	Mitchell -Jones
Recaptured	4	43
Not recaptured	29	120

$\chi^2 = 3.05$, 1 d.f., N.S.

(B) *Apodemus*

	Present Study	Mitchell -Jones
Recaptured	4	41
Not recaptured	23	94

$\chi^2 = 2.72$, 1 d.f., N.S.

Table 3.8: Comparison of Recapture Proportions found by Ashby (1967) with those of Mitchell-Jones (1979).

(A) *Clethrionomys*

	Ashby	Mitchell-Jones
Recaptured	221	43
Not recaptured	198	120

χ^2 = 32.92, 1d.f., P<0.001

(B) *Apodemus*

	Ashby	Mitchell-Jones
Recaptured	326	41
Not recaptured	260	94

χ^2 =28.02, 1 d.f., P<0.001

From the two estimates of the total population at each site, the very approximate absolute density was estimated following the method used by Ashby (1967). This involves calculating the 'catchment area' of the trapping units as the area enclosed by the lines of traps plus a border zone in which the home range of animals includes some of the traps. The width of the border zone was taken as the average home range radius of the species, which was obtained from other work. Crawley (1965) found home range radii of 23m (25yds) for *Clethrionomys* and 26m (28yds) for *Apodemus*. These results are similar to those quoted in other trapping studies such as Brown (1956a) and to the movements seen by Ashby (1967), and lead to catchment areas for this trap arrangement of 0.45 ha (1.1 ac) for *Clethrionomys* and 0.49 ha (1.2 ac) for *Apodemus*. From these areas the absolute densities per hectare were calcalated and are given in Table 3.4.

As a comparison with the data from the three study areas in the present work Table 3.9 shows the results of the annual March trapping done in an undergraduate practical class at sites 3 and 4 in the Field Station and on the upper half of Ashby's (1967) transect II. At each of these sites two lines of 10 traps were used for one days trapping after two days prebaiting. The figures in Table 3.9 are averages for all three sites combined. These results show that the population of Apodemus has been low and the population of Microtus extremely low since March 1986. The March average for 1969-1986 shows the more usual levels.

Table 3.9: Average Captures per Day in March and July 1986 at the Undergraduate Practical Sites.

	Apodemus	Clethrionomys	Microtus
July 1986*	0.5	3.2	0.0
March 1986	1.0	6.0	0.0
March average 1969-1986	6.9	6.2	2.7

(*The July results are a composite of the present study's results for sites 3 and 4, and Ashby's results for Transect II upper half obtained in early July 1986).

The catches for each species in each trapping area were analysed to see if they depart from a random distribution between trapping sites. In a random or Poisson distribution the variance is equal to the mean and so departure from it can be examined by using the variance to mean ratio $I = s^2 \backslash \bar{x}$. For a random distribution this value will be unity, for an aggregated distribution it will be greater than unity and for an overdispersed distribution it will be less than unity. As no formula for the standard error of this ratio could be found, the significance of any departure from a poisson distribution was assesed using chi-squared as I (n-1) approximates χ^2 with (n-1) degrees of freedom. The formula for χ^2 was given in Elliott (1977) as follows:

$$\chi^2 = \frac{s^2(n-1)}{\bar{x}} = \frac{(x-\bar{x})^2}{\bar{x}}$$

Table 3.10: Variance to Mean Ratio Analysis.

	$\bar{x}$	s^2	$s^2 / \bar{x}$	χ^2	d.f.	Sig.
Apodemus						
Field Station	0.25	0.25	1.0	3.0	3	N.S.
Witton-le-Wear	2.8	9.7	3.46	13.86	4	P<0.05
Hamsterley	0.75	2.25	3.0	9.0	3	P<0.05
Clethrionomys						
Field Station	1.75	2.92	1.67	5.01	3	N.S.
Witton-le-Wear	2.8	2.7	0.96	3.86	4	N.S.
Hamsterley	1.0	2.0	2.0	6.0	3	N.S.

and the 5% significance levels were given in figure 8 in this text. The results of this analysis are given in Table 3.10. The only significant results were for Apodemus at Witton-le-Wear and Hamsterley where the distribution was found to be significantly aggregated ($P<0.05$).

The mean catch of Apodemus at Witton-le-Wear appeared to be greater than at the other two sites and so, despite the known heterogeneity in the data for Apodemus at the Field Station and at Hamsterley, a comparison was made between the mean catch at Witton-le-Wear and that at the other sites using Table 36 of Pearson and Hartley (1966) (Comparison of means of two small samples from Poisson distributions). No significant difference was found ($P>0.1$).

Results of Pellet Analysis

The pellets collected were of two kinds; the fur and fibre pellets mentioned previously (the fur pellets are the familiar greyish pellets consisting mainly of vertebrate bones embedded in a felt-like matrix of fur or feathers whilst fibre pellets are brownish in colour and are made up primarily of vegetable remains together with earthworm chatae and sand from earthworm guts).

Table 3.11 shows the numbers of individuals of the various species recovered in the pellets. The results are presented in terms of actual numbers of each species found (Nos), number of vertebrate prey units these numbers represent (Southern, 1954)

(PU) and the percentage of total vertebrate prey units (%PU). In the table it is assumed that juvenile animals are equivalent to half the prey units of an adult. The number of fibre pellets is also given; the percentages associated with these numbers are the percentages of fibre pellets out of the total.

Table 3.11: Species and Number of Individuals found in the Pellets.

	Field Station			Witton-le-Wear			Hamsterley		
Species	Nos	PU	%PU	Nos	PU	%PU	Nos	PU	%PU
Talpa europaea	2	10	17.6	1	5	22.9	2	10	37
Microtus	20	17	30.0	0	0	0	9	9	33.3
Apodemus	5	4.5	7.9	4	4	18.3	3	3	11.1
Clethrionomys	23	19	33.5	4	4	18.3	6	4.5	16.7
Sorex araneus	8	4	7.1	10	5	22.9	1	0.5	1.9
S.minutus	1	0.2	0.4	4	0.8	3.7	0	0	0
Passerine Birds	2	2	3.5	3	3	13.8	0	0	0
Fibre Pellets	3	(8.3%)		6	(31.6%)		2	(13.3%)	

The proportion of the various prey species in the diet can be seen to differ substantially at the three sites. In terms of % prey units, at the Field Station *Microtus* and *Clethrionomys* are most important followed by *Talpa* whereas at Witton-le-Wear the diet is more varied with *Sorex araneus* and *Talpa* being most important, closely followed by *Clethrionomys*, *Apodemus* and Birds, with an absence of *Microtus*. At Hamsterley *Microtus* and Moles are most important, followed by *Clethrionomys*.

Table 3.12 shows the proportion of adult and juvenile rodents found in the pellets. (Some remains were lost in the laboratory and therefore these results do not represent the total animals found in the pellets. These losses were presumably at random and so should not affect the analysis of the numbers of adults and juveniles).

Table 3.12: Numbers of Adult and Juvenile Small Rodents found in the Pellets.

	Clethrionomys		Apodemus		Microtus	
	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile
Field Station	10	5	4	1	11	5
Witton-le-Wear	4	0	4	0	0	0
Hamsterley	3	3	3	0	9	0

Comparison of Rodent Abundance in Pellets with Abundance found by Trapping.

Due to the low numbers involved in this comparison it was necessary to use the exact 2x2 contingency table analysis as given by Bailey (1959). With the 2x2 format it was necessary to apply the test for each combination of pairs of the three rodent species at each site. The contingency table technique cannot be used where one of the marginal totals of the table is zero, as occured at Witton-le-Wear with *Microtus*. Apart from these two occasions the contingency tables and results are given in Table 3.13.

Table 3.13: Numbers of Rodents in Pellets compared with those Trapped.

Field Station

	Apod	Cleth
Pellets	5	23
Trapping	1	6

P=0.424, N.S.

	Cleth	Micr
Pellets	23	20
Trapping	6	0

P=0.89, N.S.

	Apod	Micr
Pellets	5	20
Trapping	1	0

P=0.23, N.S.

Witton-le-Wear

	Apod	Cleth
Pellets	4	4
Trapping	9	13

P=0.7, N.S.

Table 3.13 continued.

Hamsterley

	Apod	Cleth		Cleth	Micr		Apod	Micr
Pellets	3	6	Pellets	6	9	Pellets	3	9
Trapping	3	2	Trapping	2	0	Trapping	3	0
	P=0.58, N.S.			P=0.21, N.S.			P=0.044, *	

Apod = Apodemus, Cleth = Clethrionomys, Micr = Microtus.

The only significant result was for Apodemus and Microtus at the Hamsterley site where Microtus remains were found in the pellets but none were caught in the traps; the importance of Microtus is borne out by the result of an overall analysis using a 3x2 contingency table which was highly significant, (Table 3.14), with the highest χ^2 components again coming from the fact that more Microtus than the expected value from the contingency table were found as remains in the pellets and fewer than expected were caught in the traps.

Table 3.14: Overall 3x2 contingency table analysis.

	Clethrionomys	Apodemus	Microtus
Pellets	33	12	20
Trapping	20	13	0

χ^2 =19.34, 2 d.f., P<0.001

Comparison of Adult: Juvenile Rodent Ratios in the Trapping Results with those found in the Pellet Remains.

Table 3.5 shows the numbers of adult and juvenile rodents in the trapping catch for the three rodent species, these data can be compared with the respective numbers found in the pellets already given in Table 3.12. The results were analysed using the exact 2x2 contingency table as above. Again there were occasions where the technique could not be used due to a marginal total of zero. This occured for *Microtus* at all three study areas as no individuals were captured during the trapping and at Hamsterley where no juvenile *Apodemus* were found in the pellets or caught in the trapping. The results which can be calculated are given in Table 3.15.

Table 3.15: Comparison of Rodent Adult: Juvenile ratio's found by Trapping and found in the pellets.

Field Station:

Clethrionomys

	Adult	Juvenile
Pellets	10	5
Trapping	6	1

P=0.61, N.S.

Apodemus

	Adult	Juvenile
Pellets	4	1
Trapping	1	0

P=0.17, N.S.

Table 3.15 continued.

Witton-le-Wear:

Clethrionomys

	Adult	Juvenile
Pellets	4	0
Trapping	7	6

P=0.24, N.S.

Apodemus

	Adult	Juvenile
Pellets	4	0
Trapping	8	1

P=0.69, N.S.

Hamsterley:

Clethrionomys

	Adult	Juvenile
Pellets	3	3
Trapping	2	0

P=0.46, N.S.

An overall analysis was then carried out using all the data for *Apodemus* in an exact 2x2 contingency table and for *Clethrionomys* using a normal 2x2 table (Table 3.16), neither showed a significant difference between methods of sampling. It may therefore be concluded that no difference in the ratio of adults to juveniles taken by the owls and caught by the traps has been demonstrated.

Table 3.16: Overall analyses for *Apodemus* and *Clethrionomys*.

(1) *Apodemus*

	Adult	Juvenile
Pellets	11	1
Trapping	12	1

P=0.52, N.S.

(2) *Clethrionomys*

	Adult	Juvenile
Pellets	17	8
Trapping	14	6

X^2 =0.017, 1 d.f., N.S.

Comparison of Shrew abundance in Pellets and in trapping.

Due to the low numbers of shrews involved it was necessary to combine the data from all three areas for each species and to analyse it in 2x2 contingency tables in comparison with the data for *Apodemus* and *Clethrionomys* combined (which from the previous analysis appeared not to show any significant difference between numbers found in the pellets and caught by the traps). The results are given in Table 3.17.

This analysis shows that significantly more *Sorex araneus* were caught by the owls than were caught by the traps, in comparison with the data for *Clethrionomys* and *Apodemus* combined. The situation for *S.minutus* was similar and although it did not reach significance it was approaching significance at the 5% level and with more data it would probably have reached it.

Table 3.17: Results of Comparison of Shrew abundance in Pellets with abundance in Trapping studies.

(1) Common Shrews.

	Common Shrews	*Apodemus* and *Clethrionomys*
Pellets	19	45
Trapping	3	42

$\chi^2 = 8.69$, 1 d.f., $P<0.01$

(2) Pygmy Shrews

	Pygmy Shrews	*Apodemus* and *Clethrionomys*
Pellets	5	45
Trapping	0	42

$P=0.0604$, N.S.

Chapter 4: Discussion of Results.

Prey Abundances

It was not possible to estimate the population size of shrews in this study as only three individuals (of S.araneus) were captured and none were recaptured. Little work seems to have been done on the population density but Michielson (1966) (cited in Corbet and Southern, 1977) reported densities of Sorex araneus of 12.3 per ha in spring, 18.5 per ha in autumn and densities of S.minutus of 10.5 per ha in summer, 5 per ha in spring in a Dutch dune system. Work by Crowcroft (1957) on S.araneus reported densities of up to 49 per ha may be seen in British Woodlands.

No Microtus were caught in any of the trapping sessions despite some of the trapping units being in the favoured habitat of dense grassland. As Microtus does not enter traps as readily as either Apodemus or Clethrionomys (Ashby, 1967; Southern, 1970b) it would be possible for individuals to be present at the trapping sites but not to be captured. This possibility was investigated by searching the grassland areas for Microtus runs at the surface of the soil. Whilst these runs were numerous in most areas, there were no signs of recent use such as droppings, freshly chewed grass stems or firm floors or walls and many runs had spiders-webs in them, which Hansson (1979) took to be a sign of disuse.

It therefore seems likely that the lack of Microtus catches during the trapping sessions was a reflection of a low population level during the study and not simply a result of a bias in the trapping technique. This finding agrees well with the results of the March trapping on the undergraduate practical sites where no Microtus were trapped. It also agrees with recent results of Ashby's (unpbl) long term study in Great High Wood, Durham. For the last seven years no Microtus have been captured in Great High Wood in the July trapping sessions and have only rarely been captured in the December sessions.

Microtus agrestis is known to undergo cycles of approximately four years duration in population density in some areas (Elton, 1942 and Chitty, 1952 in Britain; Myllymaki, 1977 and Stenseth, 1978 in Scandinavia and Wendland, 1981 and 1984 in Germany) and even in areas in which it is non-cyclic its abundance shows irregular fluctuations of considerable amplitude. It is therefore feasible for this present study to be at a low point in a series of either cycles or fluctuations.

The numbers of Clethrionomys caught averaged 1.6 per site. This led to estimated average densities of 10.2 per ha (from Haynes estimate) and 7.6 per ha (from recapture proportion) with a range of densities at individual sites from 0 to 25.2 per ha. The numbers of Apodemus caught at the various sites were slightly less and averaged 1.0 per site, which led to estimated average densities of 3.2 per ha and 4.0 per ha with a range of densities at individual sites from 0 to 18.7 per ha.

Due to several potential sources of error it is not possible to assess the accuracy of the estimated densities. These sources of error include: 1) the low numbers of captures and recaptures making errors due to random effects in relation to the size of the estimates likely to be large, 2) possible errors introduced by inexperience with positioning and baiting traps, 3) by using conversion factors based on the Hayne's estimate for the overall data to obtain individual site estimates, and finally 4) as more recent studies of the home range of small mammals using radio-tracking techniques have resulted in larger estimates of home range size than previous trapping work, such as Crawley's (1965) study (whose average home range radii were used in calculating the catchment area of the trapping lines in the present study), the catchment area used may be an underestimate of the actual size. Nevertheless, the results obtained in Crawley's study were used because home range sizes obtained from radio-tracking studies were only available for Apodemus (Brown, 1969; Attuquayefio et al., 1986). In addition to this, trapping studies (Brown, 1956b 1969; Crawley, 1965; Ashby, pers. comm.) have suggested that movements over long distances do occur, particularly in Apodemus, as has been shown more recently by radio-tracking, but that the great majority of movements are short.

However, comparison of the estimates of density obtained during this study with results obtained in deciduous woodland at the same time of year by other workers (See Table 4.1) suggests that the estimated average densities for Apodemus are similar to the summer densities found by Crawley (1965) working in Castle Eden, Ashby (1967 and unpbl) working in Houghall Wood and Southern (1970b) working in Wytham Wood.

Table 4.1: Summer Density estimates of Apodemus and Clethrionomys obtained by other workers

	Clethrionomys	Apodemus
Ashby (1967 and unpbl)		
Average 1954-1986	12.8 per ha	3.0 per ha
Average 1980-1986	19.2 per ha	1.0 per ha
Crawley 1962-1964	30.1 per ha	3.7 per ha
Mitchell-Jones 1974-1976	13.0 per ha	0.0 per ha
Southern 1945-1970	17.2 per ha *	4.1 per ha

*Irregular

The values for the years 1980-1986 in Ashby's results were estimated using the recapture proportions of Mitchell-Jones (1979) quoted earlier, who was working on the same sites in Great High Wood. This was necessary because of a decrease in the recapture proportions for both species in the latter half of Ashby's census which was seen by both Ashby and Mitchell-Jones (the recapture proportions of Mitchell-Jones and the present study were found not to be significantly different from each other but both were significantly lower than those found by Ashby (1967)). This use of a lower recapture proportion gives an increase of approximately 30% in the estimate of density for Clethrionomys and approximately 23% for Apodemus.

Table 3.4b suggests the distribution of Apodemus among the sites appears to be patchy with densities of 0 per ha seen at the majority (eight) of the sites (as found by Mitchell-Jones (1979) and similar to the 1.0 per ha found by Ashby in recent years) and rather higher densities seen at the remaining sites. This apparent 'patchiness' was confirmed by the use of the variance to mean ratio; the captures at Witton-le Wear and Hamsterley were in fact significantly aggregated. Of the four highest density sites two were in woodland (Sites 1 and 2 at Witton-le Wear) and two were in Grassland (Site 5 at Witton-le-Wear and Site 4 at Hamsterley). Although Apodemus is predominantly a woodland animal it is known to move out into nearby grassland and farmland from woodland (Kikkawa, 1964) and to live all year round in fields (Jefferies et al., 1973). As none of the grassland sites in this study were far away from woodland areas it is impossible to say whether the Apodemus found in these areas are permanant populations or merely summer residents; a year round study would be necessary to determine this.

A possible explanation of the somewhat patchy distribution of Apodemus amongst the sites could be the presence of a similarly patchy food supply; in summer animal food (such as insects) is very important in the diet and the animals could be moving to areas rich in insect food. Alternatively animals could be present in areas where none were caught but could be showing a lack of interest in the traps and bait due to an abundance of animal food, as suggested by Kikkawa (1964) and Tanton (1965). As no survey of food availability was undertaken this suggestion must remain as speculation.

The average density of Clethrionomys in this study was similar to that of Ashby's average result for 1954-1986 and to that seen by Mitchell-Jones in Great High Wood but was rather less than the results reported by either Crawley or Southern, or those of the more recent years of Ashby's long term study. The distribution of captures of Clethrionomys between sites was not significantly different from that expected on a random basis.

There is little evidence that Clethrionomys in England undergoes the kind of population cycles seen in Northern Scandinavia (Ashby, unpbl; Southern, 1970b; Southern and Lowe, 1982) but the populations do undergo irregular fluctuations in density from year to year, as seen in long term studies by Ashby (1967 and unpbl) and Southern and Lowe (1982). It may therefore be the case that the population could be at a minimum level in such a fluctuation.

The Diet of the Owls.

Summer is the worst season for searching for pellets due to height and density of the ground vegetation hampering the search and to the fact that as all the trees are densely foliated there is a wide choice of suitably dense trees which can provide shelter for digestion of prey and roosting.

The percentages of fibre pellets of the total numbers of pellets found in this study are given in Table 3.11. The only other work on the percentage of fibre to fur pellets in the diet is that of Southern (1954) who found proportions of approximately 30 % in areas of mixed farmland \ woodland and approximately 13% in pure woodland. An exact comparison with the present study is impossible as Southern used percentages of fibre pellets by weight in the total pellet collection whereas in the present study percentages by number were used. However since similar sized fur and fibre pellets are of similar weight (Southern, 1954) and as the fibre pellets in the present study were usually smaller than the fur pellets, it can be concluded that the percentages of fibre pellets by number are modest overestimates of the percentages by weight.

Even taking account of this overestimation of the percentage of fibre pellets in comparison with Southern's work it can be seen that the percentages of fibre pellets produced at the Field Station (3 = 8% of 36 pellets) and at Hamsterley (2 = 13% of 15 pellets) are closer to Southern's figures for woodland (which is by far the dominant habitat at Hamsterley and is likely to be the predominantly used habitat at the Field Station) whilst that at Witton-le-Wear (6 = 32% of 19 pellets) is close to the result for farmland \ woodland, which is as expected considering the more varied nature of the habitat in the reserve.

A more detailed comparison of the vertebrate componants of the diet in the present study (Table 3.11) with the results reported by Southern (1954) was attempted. It is difficult to assess the reliability of any trends revealed by the comparison in the present study given the small sample sizes. The comparison nevertheless indicates that at all sites in the Durham area less large prey is taken than at Oxford, the only species found being Talpa. Southern reported a total of 59% of the July \ August diet in prey units to be large prey, of which 44% were moles (all percentages of the July \ August diet in Southern's work refer to an average sample size of 203 prey units (1627 prey units over the eight years of the study)). The percentage of moles found in the present study approaches this figure at Hamsterley (37% of 27 prey units) but at the Field Station and at Witton-le-Wear the proportion is somewhat lower (18% of 57 prey units and 23% of 22 prey units respectively). This difference in proportion of large vertebrate prey may be assumed to reflect the differing abundances of prey between Southern's Wytham Wood and the three areas studied here, but there may also be some difference in preference on the part of the owls. Although in general Rabbits are not as common in County Durham as in the south, they were seen quite frequently at all three sites.

The proportion of small rodents in the diet at the Field Station (71%) and at Hamsterley (61%) bear out the similarity of the diet at these sites to that indicated by Southern's (1954) data for owls living in woodland where they comprised 62% of the yearly diet. Due to the low proportion of large vertebrate prey taken at both these sites the percentages of the three small rodent species taken were greater than those seen at the same time of year by Southern (small rodents made up only 30% of the July \ August diet in Southern's study). At both sites Clethrionomys and Microtus were most important with Apodemus being less so, whereas in Southern's results Apodemus and Clethrionomys were most important (13% and 12% respectively with Microtus only making up 5% of the diet).

The proportion of Shrews in the diet was low at both sites, only 1.9% at Hamsterley and 7.5% at the Field Station, which is again close to Southern's result of 9% of the diet at this time of year. The situation for birds is similar; they made up 3.5% of the diet at the Field Station and no remains were found at Hamsterley, both of which are fairly close to Southern's result of 3% in summer.

The diet of the owls at Witton-le-Wear is composed of the same species as at the other sites but there was less concentration on one particular type of prey. Small rodents only made up 37% of the diet at this site, which is greater than Southern's (1954) figure of 30% of the July \ August diet and is closer to the figure of 43% of the yearly diet of owls living in open country than to the figure of 62% for woodland owls. Of the small rodents Clethrionomys and Apodemus were most important. If, as suggested, these owls were hunting in more open areas than those at the Field Station or at Hamsterley, it might have been expected that Microtus (a predominantly open grassland species) would have figured more importantly in the diet than it did. However, Southern (1954) found that Microtus actually figured slightly less in the diets of open country owls than woodland owls, making up 8% (of 4306 prey units) and 12% (of 8033 prey units) of the diet respectively.

The proportion of Shrews taken at this site (27%) was much higher than at the other sites and higher than the 9% observed by Southern (1954). Although Crowcroft (1957) stated that the Common Shrew in particular is most abundant in areas of thick grass, hedgerows and bushy scrub rather than woodland, Southern (1954) found very little difference in the proportion of Shrews in the diet inside or outside woodland (5.4% and 4.7% respectively).

The percentage of birds in the diet was also highest at Witton-le-Wear, although there is no obvious reason for birds to be caught more easily in open country than in woodland. Southern (1954) found very little difference in the proportions of birds in the diet inside or outside woodland (4.1% in open country, 3.3% in woodland).

The lack of concentration on small rodents and the utilisation of other species instead at this site would suggest that the small rodents were not readily available to them, but the results of the trapping would seem to disagree with this as the areas studied in Witton-le-Wear had the highest densities of both Apodemus and Clethrionomys of the three sites. However, as it was not feasible in the time available to establish the territorial boundaries of the owls or their favoured hunting areas, representative areas of the habitat had to be chosen as trapping sites. As these were limited by the size of the trapping units it is possible that the owls were hunting in areas not studied, which had low densities of rodents.

Comparison of Prey Abundances and adult: juvenile ratio's in Pellets with that found from Trapping.

While the small sample sizes for both the trapping results and the pellet recoveries limited the amount and type of analysis that was possible, the exact Chi-squared technique did achieve significance at Hamsterley and in the overall Chi-squared analysis in respect of *Microtus* and suggested that in comparison with other species the owls are significantly better at catching them than are the traps. The likelihood that the *Microtus* populations were at very low levels during the study means that either the owls had a preference for *Microtus* or that they are more vulnerable to predation by the owls than other species at these sites. Again, with the data available it is impossible to determine if either of these possibilities are true.

Southern and Lowe (1968) investigated prey selection as between *Apodemus* and *Clethrionomys* and found that *Clethrionomys* were caught by the owls in numbers expected from their abundance as indicated by trapping, whereas the owls captured *Apodemus* proportionaly more than the traps in areas bare or almost bare of vegetation and proportionaly much less than the traps in areas of dense vegetation. This was likely to be due to the greater vulnerability of *Apodemus* foraging on bare ground in sight of the owls. The ratio of *Apodemus* to *Clethrionomys* caught in the traps in Southern and Lowe's study was approximately 2:1 as opposed to a ratio of 9:7 taken by the owls, which is slightly suggestive of an overall selection of *Apodemus* as prey in all vegetation types considered together. In the present study there was no indication of selection of this type either in the analysis or in the raw data themselves in the present study, and in fact there is no reason to expect it given the different conditions and different prey abundances.

The drawbacks of low sample sizes also apply to the comparison of the ratio of adults to juveniles in the trapping captures with the ratio found in the pellets.

The breeding seasons of both *Apodemus* and *Clethrionomys* usually start in April and other workers have found that juveniles were trappable from June in the case of *Apodemus* and July in the case of *Clethrionomys* (Kikkawa, 1964; Ashby, 1967; Crawley, 1970), therefore as the present study commenced in July the low numbers of juveniles caught were probably a consequence of the generally low abundances and not because the young animals were too small to trap.

No significant difference was found between the adult : juvenile ratios found by trapping and found as remains in pellets either for *Apodemus* or for *Clethrionomys*. With due allowance being made for the crudity of the ageing techniques and the possibility of errors caused by individual variation in tooth wear, this result may be concluded to confirm the conclusion of Southern and Lowe (1968) who, in a more detailed study based upon recoveries in pellets of animals of known size, found no evidence for selection by the owls of particular size classes in either rodent species.

The results of the comparison of shrew abundance in pellets with that in the trapping results indicated that in the case of S.araneus the owls are significantly better at catching them, relative to Apodemus and Clethrionomys, than the traps. (The result for S.minutus was approaching significance, again with the owls appearing to be more succesful than the traps at catching them). Southern (1970b) stated that shrews, or at least S.araneus, probably counted as unpalatable prey as they were often found killed and discarded. However, Crowcroft (1957) stated that Southern's owls ate 1146 S.araneus in the same time period as 2783 Apodemus and 2920 Clethrionomys, (a ratio of approximately 1:3:3), whilst he quoted Southern's (unpubl) trapping results for the same period as indicating that the proportion of S.araneus to Apodemus and Clethrionomys was far lower (except in October). Crowcroft suggested that this was evidence that the owls were at least not avoiding shrews as prey. With such small sample sizes and with the possibility that the number of shrews trapped may have been an underestimation of the number actually entering the traps, due to possible escapes through holes gnawed in the older traps, it is difficult to decide with the data available which of the above two possibilities may be correct.

Conclusions

This study seems to bear out the differences in the diet between owls foraging in woodland and those foraging in more open areas as described by Southern (1954). As it was not possible to determine the hunting areas or territories of the owls, this cannot be a definite conclusion.

There was evidence of prey selection by the owls in the taking of Microtus proportionaly more than its abundance as indicated by trapping at the Field Station and in the overall analysis for all sites together. There was no evidence of the selection of Apodemus as prey as found by Southern and Lowe (1968) although in the present study no distinction could be made between Apodemus taken from bare ground and those taken from areas with dense cover. As in Southern and Lowe (1968) there was no evidence of size selection in the prey. There was some evidence that the owls were taking shrews somewhat more than their abundance as indicated by trapping.

This investigation could be improved with the collection of more data by collecting more pellets, which was made difficult in the present study by transport difficulties at the start and during the project. Working in a year when rodents are more abundant would also provide more data for analysis.

Extensions of the work could include studying the territorial boundaries and favoured hunting areas of the owls. Two trapping sessions, one at the start of the investigation and one near the end, would enable the changes in proportion of the rodents in the diet with respect to their abundances over the summer to be determined.

A study of this kind of the dietary ecology of the Tawny Owl could form a part of a longer and more intensive study which, if performed in an area of coniferous woodland such as Hamsterley Forest, would provide a comparison with data from English decidous woodland such as the study by Southern (1970b).

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Appendix One: Results of Vegetation Analysis and Detailed Species Lists for each Trapping Site.

Area One: Durham University Field Station.

Table 1: Ground Vegetation and Canopy details at Site One, Durham Field Station.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
	V.cover	3	3	4	3	5	5	5	4	4	5	4.1
Line	V.height	2	2	3	3	3	3	3	2	2	3	2.6
A	Canopy species	B	B\O	O\B	B	-	-	B	B	B	O\B	
	" density	2	2	1	1	0	0	1	3	3	1	
	V.cover	1	1	3	3	5	5	4	4	3	2	3.1
Line	V.height	1	1	1	2	3	3	2	1	1	1	1.6
B	Canopy species	B	B	B\S	B\	O\B	B	B	B	B	B	
	" density	3	3	2	1	2	2	1	2	3	3	

V.cover = Ground Vegetation cover

V.height = Ground Vegetation height

Species: B=Beech, O=Oak, S=Silver Birch, P=Scots Pine, N=Norway Spruce, H=Hawthorn, SY=Sycamore, A=Alder, AS=Ash, L=European Larch, R=Rowan, -=Absent .

Density: 1=Sparse, 2=Medium, 3=Dense, 0=No Canopy

The species present were as follows:- Locally dominant species: Anthoxanthum odoratum (Sweet Vernal Grass), Deschampsia flexuosa (Wavy Hair Grass), Lonicera periclymenum (Honeysuckle), Rubus fruiticosa (Bramble). Common Species: Arrhenatherum elatius (False Oat Grass), D.cespitosa (Tufted Hair Grass), Festuca ovina (Sheeps Fescue), Holcus lanatus (Creeping Soft Grass), H.mollis (Yorkshire Fog), Galium sylvaticum (Wood Bedstraw). Locally Common Species: Poa nemoralis (Woodland Meadow Grass), Occasional Species: Dactylis glomerata (Cocksfoot), Galium aparine (Cleavers), Ilex aquifolium (Holly).

Table 2: Ground Vegetation and Canopy details at Site Two, Durham Field Station.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
	V.cover	3	3	3	4	4	4	4	3	2	4	3.4
Line	V.height	1	1	1	1	1	1	1	1	1	1	1.0
A	Canopy species	O	O\S	O\	O	-	O	-	O\S	O\S	S	
	" density	2	2	2	1	0	1	0	2	1	1	
	V.cover	3	3	3	4	4	4	4	3	3	4	3.5
Line	V.height	1	1	1	1	2	2	1	1	1	1	1.2
B	Canopy species	O	O	O	O	O\S	O	O\P	P\L	O\	O	
	" density	1	2	2	2	2	2	2	2	2	2	

The species present were as follows:- Locally Dominant Species: L.periclymenum. Common Species: D.flexuosa, F.ovina, H.mollis, G.sylvaticum, R.fruiticosa. Locally Common species: A.odoratum, H.lanatus, Stellaria holostea (Greater Stitchwort). Occasional species: P.nemoralis, Digitalis purpurea (Foxglove), *Galium rotundifolium* (Round-Leaved Bedstraw), *Hyacinthoides non-scriptus* (Bluebell), *I.aquifolium*, *Oxalis acetosella* (Wood Sorrel), *Potentilla reptans* (Creeping Cinquefoil), *Teucrium scorodonia* (Wood Sage).

Table 3: Ground Vegetation and Canopy details at Site Three, Durham Field Station.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
	V.cover	4	3	3	4	4	3	4	2	1	3	3.1
Line	V.height	2	1	1	3	2	1	1	1	1	2	1.5
A	Canopy Species	H	P	P	-	-	B	NS	-	B	L	
	" Density	2	1	1	0	0	2	1	0	2	2	
	V.cover	4	4	4	5	5	5	4	4	4	4	3.1
Line	V.height	5	4	4	4	2	2	2	3	3	3	1.5
B	Canopy species	-	-	-	-	-	-	-	-	-	-	
	density	0	0	0	0	0	0	0	0	0	0	

The species present were as follows:- Dominant species: *Heracleum sphondylium* (Hogweed), *Urtica dioica* (Nettle). Common species: *Aegopodium podograria* (Ground Elder), *Anthriscus sylvestris* (Cow Parsley), *A.elatius*, *D.glomerata*, *G.aparine*, *H.lanatus*, *H.mollis*, *P.nemoralis*, *Stachys sylvatica* (Hedge Woundwort). Locally Common species: *Cirsium arvense* (Creeping Thistle), *Epilobium angustifolium* (Rosebay Willow-Herb). Occasional species: *Lolium perenne* (Perennial Rye Grass), *Lotus corniculatus* (Birds-Foot Trefoil), *Phleum pratense* (Timothy

Grass), P.reptans, Rannunculus repens (Creeping Buttercup) and Tussilago farfara (Coltsfoot).

Table 4: Ground Vegetation and Canopy Details for Site Four, Durham Field Station.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
	V.cover	1	3	3	4	3	3	2	1	2	2	2.4
Line	V.height	0	1	1	1	1	1	1	0	1	1	0.8
A	Canopy species	B	SY/	B	B	B	B	B	B	B	B	
	" density	2	2	2	2	3	3	3	3	2	1	
	V.cover	2	2	2	2	2	2	3	2	2	2	2.1
Line	V.height	1	1	1	1	1	1	1	2	1	1	1.1
B	Canopy species	B	B/L	B/L	SY/	B	B	SY	L/B	B/SY	B	
	" density	2	2	2	2	3	3	3	2	2	3	

The species present were as follows:- Dominant species: Hedera helix (Ivy). Locally Dominant species: R.fruiticosa. Common species: Millium effusum (Wood Millet), H.non-scriptus, O.acetosella. Locally Common species: G.aparine. Occasional species: H.lanatus, Luzula sylvatica, Geranium robertianum (Herb Robert), Sambucus nigra, S.sylvatica.

Area Two: Witton-le-Wear Nature Reserve

Table 5: Ground Vegetation and Canopy Details for Site One, Witton-le-Wear.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
	V.cover	4	3	4	4	4	3	2	3	3	4	3.4
Line	V.height	3	2	2	3	2	1	1	1	2	4	2.1
A	Canopy species	A/AS	A	A/SY	A	A	A	A	A	A	A	
	" density	2	2	3	2	2	2	2	2	2	3	
Line	V.cover	4	4	3	3	3	3	3	3	3	4	2.2
B	V.height	3	3	2	1	2	2	2	2	2	3	2.2
	Canopy species	A	A	-	A	A	A/SY	A	A	A	A	
	" density	2	2	0	3	2	3	2	2	2	2	

The species present were as follows:- Locally Dominant species: R.repens. Common species: D.cespitosa, M.effusum, P.nemoralis, G.aparine, Rumex obtusifolium (Broad-Leaved Dock), Stellaria nemorum (Wood Stitchwort), U.dioica. Locally Common species: Caltha palustris (Marsh Marigold), Daucus carota (Wild Carrot). Occasional species: Carex sylvatica (Wood Sedge), D.glomerata, A.podograria, Chrysosplenium oppositifolium (Opposite golden-leaved Saxifrage), H.sphondylium, Impatiens glandulifera (Indian Balsam), Rubus idaeus (Raspberry), S.nigra, S.sylvatica and Veronica officianalis (Heath Speedwell).

Table 6: Ground Vegetation and Canopy Details for Site Two, Witton-le-Wear.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
	V.cover	2	2	2	2	1	2	3	3	1	1	1.9
Line	V.height	1	1	1	1	0	1	2	2	1	1	1.2
A	Canopy species	SP	P	SP	P	SP	P	P	P/SP	P	P	
	" density	2	1	3	2	2	3	3	3	3	2	
	V.cover	2	2	3	4	4	2	3	2	1	1	2.5
Line	V.height	1	1	3	5	3	1	1	1	1	1	2.5
B	Canopy species	P	P	P	-	-	P/SP	P	P/SP	SP	P	
	" density	1	1	1	0	0	2	2	2	2	3	

The species present were as follows :- Locally Dominant species: E.angustifolium, R.fruiticosa. Common species: R.idaeus, Silene dioica (Red Campion). Locally Common species: H.lanatus, M.effusum, G.aparine, H.sphondylium, Mercurialis perennis (Dogs Mercury), S.sylvatica. Occasional species: A.elatius, D.glomerata, D.cespitosa, H.mollis, L.perenne, L.sylvatica, Sycamore seedlings, G.robertianum, Polygonatum multifolium (Solomons' Seal) R.obtusifolium, T.scorodonia

Table 7: Ground Vegetation Details for Site Three Witton-le-Wear.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
Line	V.cover	4	4	4	5	5	5	5	4	5	5	4.7
A	V.height	2	2	2	2	3	2	2	2	2	3	2.2
Line	V.cover	5	4	4	4	4	4	5	4	4	4	4.3
B	V.height	2	2	1	1	1	1	1	1	1	1	1.6

The species present were as follows:- Locally Dominant species: A.odoratum, A.elatius, D.glomerata, H.lanatus, H.mollis, Achillea millefolium (Yarrow), C.arvense, L.corniculatus, Plantago lanceolata (Ribwort Plantain), Trifolium pratense (Red Clover), Vicia sepium (Bush Vetch). Locally Common species: Agrostis capillaris (Common Bent), Senecio vulgaris (Groundsel). Occasional species: Campanula rotundifolium (Harebell), Centaurea nigra (Knapweed), Leucanthemum vulgare (Ox-Eye Daisy), Potentilla anglica (Trailing Tormentil), R.fruiticosa, R.obtusifolium, Torilis japonica (Hedge Parsley), D.glomerata and Ulex europaea (Gorse).

Table 8: Ground Vegetation Details for Site Four Witton-le-Wear.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
Line	V.cover	5	5	5	5	5	4	5	5	4	4	4.7
A	V.height	5	2	3	3	1	2	2	3	3	2	2.6
Line	V.cover	5	5	5	5	5	5	5	5	5	4	4.7
B	V.height	3	3	3	2	2	2	2	3	3	2	2.5

The species present were as follows:- Common species: A.elatius, H.mollis, C.nigra, L.corniculatus, U.dioica, V.sepium. Locally Common species: D.glomerata, C.arvense. Occasional species: D.cespitosa, F.ovina, H.lanatus, L.perenne, A.millefolium, A.podograria, Geranium pratense (Meadow Crane's Bill), H.sphondylium, R.fruiticosa, R.obtusifolium, S.vulgaris and V.officianalis.

Table 9: Ground Vegetation Details for Site Five Witton-le-Wear.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
Line	V.cover	4	5	5	4	5	4	4	4	4	4	4.3
A	V.height	1	3	2	2	3	2	2	2	3	2	2.2
Line	V.cover	5	5	5	5	5	4	4	5	5	4	4.7
B	V.height	3	2	2	2	2	1	2	2	2	2	2.0

The species present were as follows:- Locally Dominant species: A.odoratum, A.elatius. Common species: D.glomerata, C.arvense, L.corniculatus, T.pratense. Locally Common species: F.ovina, H.lanatus, L.perenne, S.vulgaris, T.japonica, V.sepium. Occasional species: D.flexuosa, H.mollis, P.lanceolata, A.millefolium, C.nigra, H.sphondylium, Potentilla anserina (Silverweed), R.repens, R.obtusifolium and U.dioica.

Area Three: Hamsterley Forest.

Table 10: Ground Vegetation and Canopy Details for Site One, Hamsterly.

		Trapping position										
		1	2	3	4	5	6	7	8	9	10	Mean
	V.cover	3	4	4	4	4	3	2	3	3	2	3.2
Line	V.height	1	2	2	1	1	1	1	1	1	1	1.2
A	Canopy species	P	P	P	AS/P	P	P/S	P	P/R	P/L	P	
	" density	2	2	2	3	1	2	2	2	2	1	
	V.cover	4	4	3	3	2	3	3	2	3	3	3.0
Line	V.height	3	3	1	1	1	1	2	1	1	1	1.5
B	Canopy species	P	P	L	P/R	P/R	R/P	P	-	P	P	
	" density	2	2	2	2	2	2	2	0	2	3	

The species present were as follows:- Locally Dominant species: P.aquilinum, R.fruiticosa. Common species: D.flexuosa, H.mollis, O.acetosella, Vaccinium myrtillus (Bilberry). Locally Common species: F.ovina. Occasional species: A.odoratum, Calluna vulgaris (Heather), I.aquifolium, M.effusum, P.nemoralis, R.idaeus and U.europaea.

Table 11: Ground Vegetation and Canopy Details for Site Two, Hamsterly.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
	V.cover	4	3	2	4	5	4	4	4	4	5	3.2
Line	V.height	1	1	1	1	1	1	1	1	1	1	1.0
A	Canopy species	L/P	P	P/L	P	L/P	L	L	L	L	P	
	" density	2	1	2	2	2	2	1	2	2	2	
	V.cover	3	3	4	5	5	5	5	5	5	3	4.3
Line	V.height	1	1	1	1	1	2	2	2	2	1	1.4
B	Canopy species	P	L	L	L/P	L	L	L	L	L/P	P	
	" density	2	1	2	2	2	2	1	2	2	2	

The species present were as follows:- Locally Dominant species: P.aquilinum, R.fruiticosa. Common species: F.ovina, G.sylvaticum, O.acetosella. Locally Common species: C.vulgaris, H.lanatus, P.nemoralis. Occasional species: Sycamore seedlings, A.odoratum, T.scorodonia, Crataegus monogyna (Hawthorn), D.cespitosa, D.flexuosa, D.purpurea, H.mollis, I.aquifolium, M.effusum, P.reptans and R.idaeus.

Table 12: Ground Vegetation Details for Site Three, Hamsterly.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
Line	V.cover	4	3	4	4	4	4	5	3	4	4	3.9
A	V.height	2	1	2	2	2	2	2	1	2	2	1.8
Line	V.cover	3	3	3	3	3	4	3	4	3	3	3.9
B	V.height	1	2	2	1	1	2	2	2	1	1	1.5

The species present were as follows:- Locally Dominant species: D.flexuosa, H.lanatus, H.mollis, R.fruiticosa. Common species: Galium album (Hedge Bedstraw). Locally Common species: P.aquilinum. Occasional species: Sycamore seedlings, A.odoratum, C.arvense, D.cespitosa, D.purpurea and L.perenne.

Table 13: Ground Vegetation Details for Site Four, Hamsterly.

		Trapping Position										
		1	2	3	4	5	6	7	8	9	10	Mean
Line	V.cover	4	3	3	3	3	3	4	4	3	3	3.3
A	V.height	2	1	1	2	1	1	2	1	2	1	1.4
Line	V.cover	4	4	3	3	3	4	4	4	4	3	3.6
B	V.height	2	3	2	2	2	1	1	2	3	2	2.0

The species present were as follows:- Dominant species: D.flexuosa. Locally Dominant species: C.vulgaris, R.fruiticosa. Common species: F.ovina. Locally Common species: G.album.

Occasional species: Silver Birch seedlings, *D.purpurea*, *H.lanatus*, *H.mollis*, *I.aquifolium*, *O.acetosella*, Rowan seedlings, *U.europaea* and *V.myrtillus*.