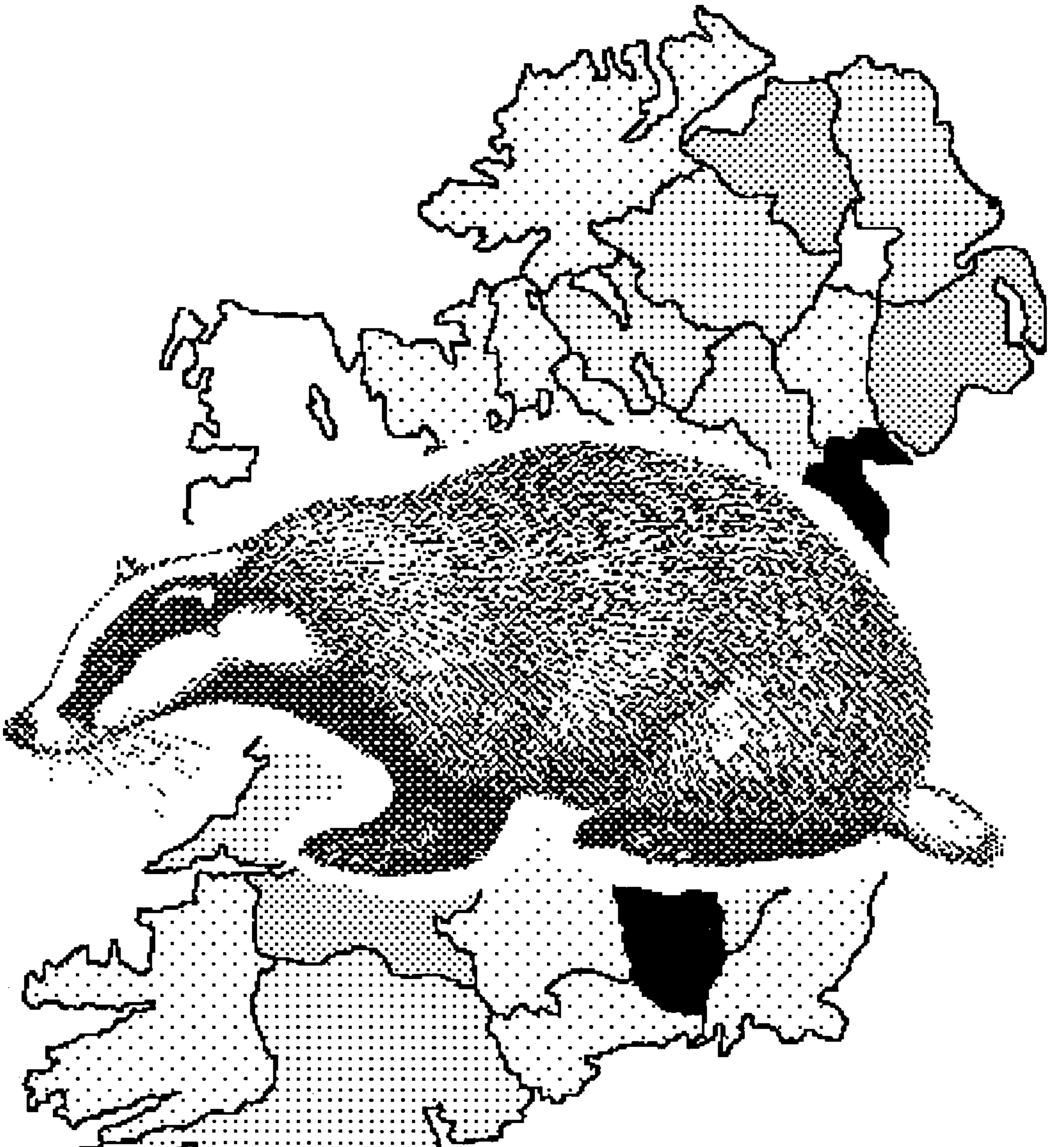
THE BADGER AND HABITAT SURVEY OF IRELAND



The abundance and distribution of the badger *Meles meles* in Ireland, with especial reference to habitat surveys

THE BADGER AND HABITAT SURVEY OF IRELAND

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SUMMARY

A survey of 1% of Ireland's land area was carried out from 1989 - 1993. In total, 729 1km squares were assessed for badger setts and by habitat composition, with surveys undertaken mainly by Wildlife Rangers of the National Parks & Wildlife Service. A similar study has been carried out in Northern Ireland (involving survey of 144 1km squares) under a separate but co-operative project (with Queen's University of Belfast) to complete the survey of the island. Results are presented for the Republic in this report. The survey was conducted to provide information on badger numbers in Ireland and to relate badger density to habitat composition and by geographical area.

In total, 1378 badger setts were observed. Each badger social group was accompanied by an average of 4.09 setts, with 1 active main sett (each social group being defined by one active main sett), 0.19 disused main setts, 0.50 annexe setts, 1.32 subsidiary setts and 1.08 outlier setts. The mean size of main setts was observed to be smaller than in Britain, with each composed of 6.9 entrances on average. There was variation in sett size by county and by region. Badger activity at setts was recorded as was occupancy of setts by other species. Over 75% of setts were located in the vicinity of cattle, and setts were also commonly used by rabbits and foxes. 15% of setts had been disturbed, but proportionately more main setts had been disturbed (21%), with digging and blocking being the main types of interference noted to occur. Disturbance to setts also showed regional variation. Overall sett characteristics were found to correspond to those observed in studies in Britain and elsewhere in Ireland, except that main sett size was found to be smaller and the type of disturbance prevalent also differed.

In the sett surveys, a Poisson distribution of setts was determined, indicating a degree of randomness with regard to location of main and other setts. Difficulties in regard to the size of sampling squares have been discussed.

Analyses of habitats present in each square were carried out with 42 principal habitat types differentiated, but some of these were sub-divided and an assessment was also made of stock-types utilising grazing areas. The survey squares were accorded a landclass status, based on preliminary visually assessed parameters. The overall habitat composition of Ireland was determined from the surveys, with corrections made for areas of sea, coastal margins and inland lakes. The main components of the Irish landscape were: grassland constituting 60% of Ireland's land area, arable land about 7.5%, bog and moorland 16%. Total woodland was about 6%, and hedgerow 1.5% (total length of hedgerow and treeline was estimated at 416,000 km). Total built land and road area was *c.* 3.5%. There was observed to be variation in habitat composition, according to county and region, in line with expectation. The habitat surveys were compared with previous agricultural surveys and correspondence was found to be reasonable. Most grazing land was used for cattle (72%).

Observations of other mammals were included in the overall surveys, and these have shown that certain species, such as foxes, rabbits, and hares have wide distribution, being found in the majority of squares surveyed. Deer were also more widespread than might have been expected.

The sett surveys were validated by studies on licensed badger-removal areas. Over 36 licence areas were utilised for study (the data for some could be used in part only), and the results evaluated for 36 badger social groups snared in particular, with sett survey carried out beforehand. The basis of the national sett survey was confirmed, though disturbance to setts and the relocation of

badger groups created difficulties because relocation of groups was observed to be a relatively common occurrence. Overall, however, it was considered that the sett survey techniques provided reliable estimates for Ireland and could not readily be improved upon. These studies also provided information on the number of badgers captured at each sett type, the size of social groups (following capture-effort analyses) and also information on differential trappability of badgers, sex ratios and TB status.

Overall group size was estimated at 5.9 adults per group, but it was found that snaring effort affected estimated parameters of population biology substantially. Mean group size may have been overestimated through analyses being undertaken in cattle grazing areas only. Snaring effort was considered to have affected estimates of sex ratios and TB status, and it was concluded that more attention be paid to methodology and trapping or snaring success in badger studies. Even with high intensity snaring, only about 80% of badgers believed present were captured. As a result of these studies, revision of the techniques employed in badger-removal operations has been recommended. The overall sex ratio of badger populations has been determined to be parity, but with females being trapped preferentially. It appeared that diseased males were also more likely to be snared, with an indication that diseased females may also have been trapped preferentially. The conclusion was that TB prevalence in badgers, nationally, might have been overestimated by the sampling methods employed to date. The limited studies carried out here indicated an average of about 7 - 8%, in comparison with national statistics at >10.0% (as determined by visible lesions mainly).

This report has considered the collection of national statistics for TB prevalence in badgers, and a number of recommendations have been made to improve the scientific value of data collected from badger removal areas. The results from studies of a limited number of areas suggests that badger-removal operations were not very successful, in that they removed only 0.5 infected badgers on average, with only about 22% of licence areas yielding infected badgers. These results were based on survey areas of 1km square around affected farms and not the full licence area of 2 km radius around farms.

The number of social groups estimated to be present in Ireland (Republic) was *c.* 34,000, with a total adult population of *c.* 200,500. This may be an overestimate, and, in comparison to other estimates obtained from captures of badgers according to sett type, it was concluded that an estimate of 200,000 was appropriate. The mean group density was 0.5 groups per km^2 with a mean badger density, therefore, of 2.95 individuals per km^2. Badger numbers, overall, are on a par with those of Britain and Sweden, and amongst the highest in Europe. However, *mean* badger densities were not found to be exceptionally high, overall, and were comparable to those in found in south-west Britain. Initial data from Northern Ireland would suggest *c.* 8,900 social groups there, so the total population present in Ireland may be estimated at *c.* 240,000 - 250,000 adults.

Most setts were located in hedgerow and treeline, though woodland and scrub were also favoured locations for setts. Grasslands, moorland, bogs and young coniferous plantation were avoided. Badger preferences for sett location were evaluated in detail and statistically significant preferences were observed for many of the major habitat variables. Generally, sites providing cover were preferred, and, overall, suitable sites were found to be similar to preferences observed in Britain, but, with a different habitat composition in Ireland, far more setts were found to be present in hedgerow and fewer in woodland.

The density of badger social groups was found to be principally determined by the proportion of good (improved) agricultural grassland, and, in particular, with the proportion of cattle pasture. There was a negative association with sheep grazing (and unimproved grassland), probably because most sheep grazing is at higher elevations and in poorer terrain. There was also a negative relationship between badger density and the proportion of bog and moorland. There was a strong positive correlation with hedgerow, but it was shown that, because of the interrelation between pasture and hedgerow in most areas, improved pasture was the more significant of the variables used to explain cattle density. Badger density was correlated with certain other habitat variables, such as natural woodland.

It was found that the six highest density (badger) counties could be distinguished by their habitat composition alone, using few principal habitat variables. Generally, badger densities in Ireland appear to be related to improved grassland and, therefore, associated with the badger's primary food item, earthworms. In most Irish landscapes, cover and locations for sett building were readily available, so that food availability is one of the major factors determining badger density. Other habitat variables influencing badger density were evaluated.

In relation to bovine TB in cattle, a number of approaches were considered that would be worthwhile in future investigations, and recommendations made. In the absence of a satisfactory vaccine for cattle, the suggested lines of investigation included (amongst others) the addition of environmental variables, satellite data, land classes, and cattle, farm, and TB statistics into the current database, and, additionally, several areas of research into badger behaviour and trappability were suggested. The relative success in constructing predictive models of badger density from discriminant analysis and rule-finding systems will be enhanced by the enlarged database and be applied directly to TB evaluations. The database will be valuable in a broader framework of ecological monitoring in the country.

Additional data is required on variation in badger group size in Ireland and clarification of TB incidence in badgers. The effect of differential trappability in TB investigations of badgers also requires attention, as do other sources of TB in wildlife. Previous work on the relationships between badger density, behaviour and habitat composition and TB prevalence in cattle was discussed.

Some comparisons with Britain and Northern Ireland were considered, suggesting that a greater use of pasture for sheep-grazing rather than for cattle in the UK (in comparison with the Republic) may have influenced overall TB levels in cattle. Such an outcome might arise from increased herd dispersion, with a possibility that the transmission cycle of TB from herd to herd and also from cattle to badgers and then from badgers to cattle - and the maintenance of the disease in both species - is disrupted when herds or cattle grazing areas are more dispersed. The key reason for examining this hypothesis was that no other potential badger, habitat or landuse variable was recognised as a distinctive feature of Northern Ireland relative to the Republic, from data obtained in this survey, though cattle TB levels are generally lower in the former. Other attributes of farming practice and veterinary practice that may be of significance were not evaluated here.

Badgers may play a rôle in the transmission of TB, but any relationship between badgers and the disease will continue to be difficult to interpret as badger numbers in Ireland appear to be largely determined by the proportion of improved pasture and agricultural land best suited for, and used for, cattle-farming.

INTRODUCTION

The Eurasian badger *Meles meles* (L. 1758) belongs to the family Mustelidae and is Ireland's largest terrestrial carnivore. The species occurs throughout the Palaearctic but would appear to be most abundant in Ireland, Britain, Norway, Sweden and Finland (Griffiths & Thomas, 1993). Whilst the species is protected in many countries, it has traditionally been hunted for sport and has also been utilised as a commodity species in many parts of Europe (Griffiths, 1991, 1993). The badger is protected in the Irish Republic under the Wildlife Act (1976) but may be removed under licence for research purposes. The digging out of badgers for sport is believed to be widespread. The badger has also been regarded as a minor pest species in Ireland, particularly with regard to protection of game and domestic fowl stocks.

Prior to this survey, there has been virtually no reliable information on the abundance of the badger in Ireland. Its status was briefly reported in 1893 (Anon.). Foster (1917) suggested it was scarce in Northern Ireland. Neal (1948) produced a speculative distribution map of badgers in Ireland, and an incomplete distribution map for Ireland was included in the UK badger survey (1972). Ní Lamhna (1979) reported, on the basis of submitted distribution records, that the badger had a widespread distribution in Ireland. The species is accepted as being one of the commonest of the larger mammals present on the island. Barrington (1926) suggested its numbers had increased, and it is probable that badger numbers have indeed increased in Ireland this century, probably as a result of pasture improvement and changes in farming practice since Ireland joined the EEC (Moynagh, pers. comm., quoted in Griffiths & Thomas, 1993). These changes have been coupled with a decline in traditional gamekeeping (McAleer, 1990). Whilst badger numbers may have increased, there would not appear to be any way to confirm this. Downey (1990) suggested that badger numbers have increased as a result of the introduction of the Wildlife Act (in 1976) and, also, with the abandonment of bounties for foxes *Vulpes vulpes* (as badgers were often caught in traps set for foxes) but, again, there is no firm evidence available to support this viewpoint.

Badgers and bovine tuberculosis

There has been considerable research on badgers and their ecology in recent times, principally in the UK. The species is a reservoir for rabies and for bovine tuberculosis, two major diseases of man and his domestic animals: whilst rabies is absent from Britain and Ireland, bovine tuberculosis has been a significant problem in Britain, and remains so in Ireland. The motivation and funding for the present research into badger ecology in Ireland, of which this report forms one part, arises from the urgent need to address and deal with the acute economic difficulties created for farmers and for export markets by the disease in cattle.

The first tuberculous badger was identified in Switzerland (Bouvier, Burgisser & Schneider, 1957, 1962) with the first in Britain being confirmed in Gloucestershire in 1971 (Muirhead, Gallagher & Burn, 1974). Subsequent survey of the disease in badgers in the UK led to a disease control strategy - aimed at reducing the levels of the disease in cattle - which involved removal of badgers over large areas on the reasoning that badgers transmitted the disease to cattle. This policy and discussion of its success or economic benefit have been the subject of considerable debate, controversy, and two government reports (Zuckerman, 1981; Dunnet, Jones & McInerney, 1986). In Ireland, TB in badgers was first reported in one individual from West Cork in 1974 (Noonan *et al*, 1975); the species has since been identified as a significant wildlife reservoir of tuberculosis in this country (O'Connor & O'Malley, 1989). The Department of Agriculture, Food & Forestry arranges the licensed removal of badgers from areas where the badger is considered the primary cause of a TB breakdown in cattle (licences are in fact granted by the Office of Public Works, being the statutory body under the Wildlife Act).

Whilst bovine tuberculosis has been identified in a wide range of animals and some may also act as reservoirs for the disease (*e.g.* red deer, dogs, cats and goats), the badger is considered at present to be the principal wildlife reservoir of the disease in Ireland and the species most likely to bring the disease into contact with cattle. On average, 18% of badgers reveal gross TB lesions on post-mortem (range 5 - 40% dependent on location, with samples primarily obtained from badgers in areas with TB breakdowns in cattle [Downey, 1990]). County means of 8-50%, with a national mean of 17% are the figures given by Dolan & Lynch, 1992. The national data currently suggests a mean of *c.* 11% (Table 34).

It is now generally accepted by researchers from all spectra of the scientific disciplines involved in the investigation of the disease that badgers *are* involved, to some extent at least, in the transmission of TB to cattle. However, the principal mode of transmission of the disease to cattle remains unclear as does the overall contribution of the badger to the bovine tuberculosis problem in Ireland - and in Britain (Hayden, 1993). Laboratory studies in the UK showed that the disease was eventually transmitted from penned (diseased) badgers to cattle kept in proximity but the process was not rapid even in conditions ideal for transmission (Little *et al*, 1982). The Wildlife Link report (1984) considered that this experiment showed that 'the probability of cross-infection from badgers to cattle is extremely low'. Behavioural studies also indicated that badgers and cattle generally avoid each other in the field (Benham & Broom, 1991). Some attention has been focused on the possibility that cattle may come into contact with tuberculum bacilli from badger carcasses, from cattle drinking troughs that are used by badgers (Sleeman & Mulcahy, 1993), or from pasture contaminated by badger faeces or urine (Benham & Broom, 1989, 1991; Benham, [1993]; Hamer, 1993; White, Brown & Harris, 1993). Initial experimental studies in Ireland, involving either the removal of badgers from large areas (East Offaly Project: Dolan, Eves & Bray, 1993) or vaccination of badgers in Co. Cork, have had some preliminary indication of success in reducing breakdowns in cattle. However, the trends from the East Offaly Project (Dolan, Eves & Bray, 1993) remain confusing, as the prevalence of disease in cattle outside the badger removal area has also declined, thus reducing the validity of suggested causal links between the disease in badgers and its transmission to cattle.

Bovine tuberculosis is an economically significant disease in Ireland, and considerable sums have been expended in reducing the prevalence of the disease in cattle through regular testing and slaughter of infected stocks. Whilst badgers appear to play a rôle in maintaining the prevalence of the disease, certain attributes of farming and veterinary practice in Ireland are believed to be the main contributors to the maintenance of the disease and its transmission from herd to herd (O'Connor, 1986; Downey, 1990). Ireland has a very high volume of cattle movement, which O'Connor & O'Malley (1988) considered to be an important factor in the spread of disease in Ireland, along with the stress that accompanies it. A long-term study in Northern Ireland (McIlroy, 1988; DANI, 1984) showed that spread of infection from herd to herd (lateral spread) accounts for 70% of all herd breakdowns, with another 26% attributed to disease brought in with purchased animals, leaving only 4% unattributed (and thus the maximum proportion of herds that may have acquired disease from wildlife sources). Whilst this study is of considerable interest, it was based on a comparatively small sample of 50 herd breakdowns in the study area. McIlroy, Neill & McCracken (1986) note a more general attribution of breakdowns in cattle, namely 30% attributed to purchased animals and 40% to spread from a contiguous herd, leaving a more substantial margin to 'unknown' sources, which might include various wildlife sources. O'Connor, Conway & Murphy (1993) identified a number of constraints in any attempts to reduce bovine tuberculosis in cattle, including the wildlife reservoir. However, their analysis of farm survey results showed that wildlife sources did not contribute more than 2% to regressions.

Downey (1991) presented tentative estimates that wildlife sources contributed 10,000 reactors out of a total of 65,000 reactors believed present in Ireland, *i.e.* a 15% contribution. Griffin & Hahesy (1992) identified wildlife as the source of herd breakdowns in one study as 14%. The level of bovine tuberculosis in cattle in Northern Ireland has been significantly lower than that in the Republic for some time, though breakdowns have been increasing recently. The Department of Agriculture there has not considered the badger route of transmission as of sufficient importance - as yet - to require removal of badgers from farms (or areas) where breakdowns have occurred. The badger control operations in south-west England have had no impact on TB levels in cattle and the incidence of tuberculosis in cattle is increasing (MAFF, 1991). The British authorities appear confused by the source of infection as each year has seen an increasing proportion of breakdowns being attributed to badgers, rather than other sources or unknown (MAFF, 1992; Hancox, 1992, unpublished). The circumstances, with regard to badger density and incidence of the disease in badgers and cattle in Britain, may mean that the failure of badger control operations to reduce or eliminate the disease problem there has little bearing on the likelihood of success of similar operations in Ireland.

Aims

Despite the commitment to research on bovine tuberculosis in the UK and in Ireland, the badger's rôle has remained one of considerable uncertainty and debate. At the extremes of the debate, the species' attributed rôle, assessed as a contribution to cattle breakdowns, varies between zero and *c.* 40%. An ERAD farmer survey (1991) indicated that 15-17% of farmers considered that action was required to eliminate the wildlife sources of infection. Clearly the disease cannot be eradicated or reduced to tolerable and manageable levels unless the rôle of the wildlife reservoirs is evaluated firstly and, if found to be significant, that means of managing cattle, the wildlife species, the farming environment, or the disease (*e.g.* by vaccination) can be devised and implemented.

Since so little was known about the badger's abundance and distribution in Ireland, this study was established in 1989 to provide this baseline information. An equivalent body of information such as that compiled by the Mammal Society and many local badger groups throughout Britain (for a review, see Cresswell, Harris & Jeffries, 1990) has not been available to researchers in Ireland. The Nature Conservancy Council's recent report (Cresswell *et al*, 1990) concluded that there were *c.* 43,000 badger social groups in Britain - giving a total population estimate of *c.* 250,000 badgers, that are unevenly distributed, with higher badger densities prevailing in a broad region of south-west England and south Wales. A similar study had been carried out over south-west England a few years earlier (Thornton, 1987, 1988). Both studies related estimated densities of badger groups to the habitats in survey areas.

This project's principal aims have been to assess the overall numbers of badgers in Ireland and to provide a base-line for assessment of any future changes in badger numbers, to identify regional variations in density, to evaluate the extent of illegal digging or disturbance of setts and to relate badger density to the distribution and type of habitats present in an area. The overall value of the study has been to provide basic information on badgers in Ireland and to create a framework for preliminary and further examination of badgers and habitats in relation to the TB problem in cattle. The surveys allow for addition of environmental variables into the database leading to extrapolation of badger densities and habitats to unsurveyed areas and creating a means of examining inter-relationships between these various variables and bovine tuberculosis in cattle. The work of Cresswell *et al* (1990) made use of an existing land classification of Britain: a similar classification is not available for the Republic though one has recently been published for Northern Ireland (Murray, McCann & Cooper, 1992). The present survey serves as a framework for the establishment of a land classification for Ireland that will enhance the predictive capability of the survey. The survey's methodology has established a framework for investigation of other wildlife species that may play a rôle in TB transmission and also for the investigation and control of other diseases - the risk of rabies entering the country is one example.

The methodology adopted in this survey has been largely based on that of the Nature Conservancy Council's recent survey in Britain (Cresswell *et al*, 1990; Harris, Cresswell & Jeffries, 1989): this uniformity of approach has allowed for a comparison and for conclusions to be drawn from the two islands with relative ease. In practice, the survey of badgers has been achieved through an enumeration of badger setts in a sizeable sample of 1km squares evenly distributed throughout Ireland. In all, 1% of Ireland's land area has been surveyed, with emphasis being placed not only the survey of badgers but also on survey of the habitats present in the survey areas.

Smal (1992) reported on the progress and preliminary results of the survey in the Republic of Ireland. The need for a similar survey to be carried out in Northern Ireland and thus to obtain results on an all-Ireland basis was recognised at an early stage (Smal, 1989). Fortunately, co-operation between the research co-ordinators in the Republic and researchers from Northern Ireland was realised with a project undertaken under a post-graduate studentship funded by the North's Department of Agriculture (the badger and habitat survey there forms part of a larger study of badger ecology and behaviour). The survey in the North commenced in 1990 with close co-ordination of methods and data-handling between researchers in the North and in the Republic. Initial results from both the Republic and Northern Ireland were presented in an unpublished report (Smal, Feore & Montgomery, 1992). Analysis of the data from Northern Ireland is underway there and this report's analyses are confined to the data from the Republic. It is anticipated that the studies will be combined for further evaluation and publication at a later stage.

In addition to the enumeration of badger setts and habitats, surveys were undertaken on a limited number of areas licensed for badger removal operations, which were followed by monitoring of the operations. These studies have provided preliminary information on the number of badgers present within a social group in Ireland, thus giving estimates not only of badger social groups present in Ireland but of badger numbers. They have also been instrumental in a re-evaluation of the techniques used in the sett surveys and providing a calibration of the survey leading to corrected and refined estimates as well as consideration of the limitations of sett survey in assessing badger numbers. Badgers removed in these areas have also yielded information on the TB status of these individuals. A short trial was also undertaken in an established badger study area in West Cork to provide additional guidelines in interpretation of the sett surveys. This and other studies on badger populations in Ireland (Sleeman & Mulcahy, 1993; O'Corry-Crowe, 1992; O'Corry-Crowe, Eves & Hayden, 1993) have also yielded results on group sizes and sett distribution relevant to the present national survey of badgers. However, as these studies have been restricted to limited geographical areas, the application of their results to a national survey over Ireland's much broader range of habitats is, of necessity, very limited. Nevertheless, they have provided useful comparative information with the present national survey.

The papers presented at the Irish Academy conference of March 1991 (Hayden [ed.], 1993) and subsequent work and publications (O'Corry-Crowe, 1992; selected papers, TB Investigation Unit, UCD, 1991, 1992), as well as the earlier reports of O'Connor (1986), O'Connor & Malley (1989), Downey (1990) and O'Connor, Conway & Murphy (1993) together constitute an overall account of our knowledge of badgers in Ireland, and their relevance to the TB problem, to date. Some ancillary studies on badger diet have also been conducted (Fairley, 1967; Boyle & Whelan, 1990). The feasibility of vaccinating badgers against tuberculosis has been evaluated in a recent report (Hughes & Rogers, 1994).

This report completes an account of the studies involved in the National Badger and Habitat Survey. Methodology and results are presented on a chapter by chapter basis, accompanied by preliminary discussion of methodology and results. There is a concluding section of discussion and recommendations. The principal aim of this report has been to provide baseline information on the distribution and abundance of the badger in Ireland; thus, while due reference is made to the underlying reasons for this research, *i.e.* the TB problem, the present document addresses these issues incidentally, with proposals being suggested for ways in which the badger and habitat survey can be utilised for TB-related investigations. Nevertheless, the implications of the survey results - of badgers and of habitats - are potentially profound. For example, if badgers are equally plentiful in counties where the prevalence of disease in cattle is markedly different, then the rôle of badgers in transmission may be considered to be less important than other routes of infection. Alternatively, there may be particular aspects of badger ecology or behaviour that differ between such counties, thus pointing to means of managing the problem. Amongst the matters addressed in this report, therefore, are a number of such observations that appear relevant to the problem of tuberculosis in cattle.

BADGER SURVEY

Methods

Choice of survey areas and project initiation

The National Survey of Badgers and Habitats began in August 1989 with the project's framework being established following preparatory field studies and visits to researchers and research sites in the UK and Ireland (Smal, 1989). The survey in the Republic commenced fully in January 1990 and has been principally undertaken by the author and *c.* 50 Wildlife Rangers of the National Parks & Wildlife Service co-ordinated by the author through the management side of the Service. Volunteers from the Irish Wildlife Federation and Badgerwatch Ireland assisted with the survey of some areas, mainly close to Dublin. In comparison to the Nature Conservancy Council survey in the UK, volunteer effort has been minimal.

The survey is based on the field enumeration of setts and habitats within a 1% sample of the island's land area, with a similar survey being carried in Northern Ireland from 1990 to 1993 by researchers from the Department of Biology and Biochemistry Queen's University of Belfast (Smal, Feore & Montgomery, 1992) with the assistance of state organisations and volunteers. Overall survey techniques were adapted from the recent badger survey of Britain (Cresswell *et al*, 1990; Harris *et al*, 1989). Only results from the surveys in the Republic are reported here.

The methodology consists of a full field survey of pre-selected 1km squares throughout the country. 735 1km squares were chosen from the Republic (144 in Northern Ireland; total for Ireland 879), each square being that at the extreme south-west corner of every 10km square of the island's National Grid. Coastal squares that contained any land above tidal limits were included, as were inland squares that were comprised wholly or partially of inland waters. Allowance has been made for these areas of sea and lake in analysis of the results. Island squares were included, even if the islands were known to contain no badgers, in order to complete assessment of the country's habitat composition. The sampling design, therefore, chose a systematic sample, which simplified mapping in the laboratory and field. A systematic approach is very efficient for sampling landscapes (Harrison & Dunn, 1993) and, for all practical purposes, may be considered as random (Krebs, 1989), since periodic variation is unlikely on a national scale.

Preliminary field work ascertained that the majority of squares could be surveyed within an acceptable period of approximately 2 days each, with some squares requiring 5 hours at a minimum and others up to 4 days for an acceptable standard of search. It was concluded that a survey of the 735 1km squares chosen was feasible given the time constraints on staff time and the project's anticipated duration and costing. This proved to be the case though departmental difficulties with the funding of staff travel expenses delayed some of the field work in 1990.

Training of surveyors and allocation of survey squares

The Wildlife Service Rangers in Ireland are organised by district, each district approximating to a geographic region of the country. A training course was given to each district's Rangers at the district base, comprising a half day's preliminary discussion of techniques and completion of data sheets and maps, followed by a day surveying the nearest 1km square in which practical problems in conducting the surveys were identified. Through the course of the survey, visits were paid to selected Rangers to assist in surveys or provide additional guidance. Wildlife Service Rangers have considerable experience of survey work and also of animal observation. The training period was therefore required mainly for explanation of recording sheets and methods, and to also to elucidate difficulties of sett classification and habitat differentiation. Volunteer effort was small in comparison, and prior training was given to volunteers either by assisting individuals in survey of a square or training small groups at pre-selected squares. On occasion, this training was given by experienced Rangers.

Squares within each administrative region (district) were issued to each of the 7 District Wildlife Officers and the Officers allocated the surveys of these squares to the Wildlife Rangers responsible to them. Usually, the allocation was made on the basis of the Ranger's proximity to the squares. Some counties (Louth and initially Westmeath and Dublin) had no Rangers living within them and squares to be surveyed in these areas were allocated to staff after completion of their own areas/counties, dependent on their availability from other duties. Squares that could not reasonably be conducted in the time available were returned and re-allocated to adjoining Region staff, to volunteers, or completed by the author. Neighbouring Rangers sometimes agreed to survey squares jointly to reduce time spent on the survey and limit travel expenses. Ranger density is uneven throughout the country, with some Rangers conducting as many as 20 surveys, and some just 4 or 5. Volunteers were allocated squares closest to their homes.

Results were requested to be submitted as soon as possible after survey and each completion logged and acknowledged, with any queries. Reminders were issued on a regular basis, listing squares to be completed. Final survey work was completed in March 1993, with virtually all surveys completed within 3 years of the survey's commencement in January 1990.

Maps and materials

Surveyors were required to have half-inch (1:126,720) Ordnance Survey maps for initial location of squares and a compass for orientation (1":1 mile scale {1:63,360} OS maps are only available for very limited areas of the Republic). They were provided with photocopies of the relevant section of 6":1 mile (1:10,560) OS maps with the 1km square marked out (a standard overlay was used for all 6":1 mile scale maps, positioned on the map in the correct location of the 1km square and the map photocopied): a grid dividing each square into 1 ha blocks was marked on the square's borders. This map allowed for further orientation in the field and for marking of setts and habitats outside of the 1km square. The main survey map to be filled in with details of sett locations and habitats within the 1km square was an enlargement of the 6" scale map (enlarged to approximately 9":1 mile {approximately 1:7040}, the 1km square fitting conveniently on an A4 sheet). Each map distributed was clearly marked with its Irish grid reference (*e.g.* W 20 90).

The Irish National Grid is not shown on most Irish 6" scale maps and the location of the 1km square given to field workers was determined from topographical features present on the half-inch maps (or 1":1 mile maps where available): consequently, there was some error in the precise location of each 1km square, but this has been determined (by comparison with maps including a marked National Grid) not to exceed 50 m and usually less. Overlays were provided for the 6" and 9" scale maps giving a full grid of 1 ha squares to allow field workers to provide setts located with a 6 figure grid reference. Many of Ireland's 6":1 mile maps pre-date 1920, and subsequent changes in field boundaries and land use created difficulties, on occasion, for surveyors in determining the exact location of 1km squares on the ground which sometimes required considerable re-interpretation of the habitats and field boundaries present.

Overall, the available maps were adequate, and may allow for some interesting analyses, in the future, of changes in land use since the original OS maps were prepared. The majority of OS maps used in preparing squares were obtained from the archives of the Office of Public Works and the National Parks & Wildlife Service: any not available were obtained from various University map libraries.

Consultation with landowners

Due to the small average size and high degree of fragmentation of farms or land-holdings in Ireland, landowners were, generally, not consulted prior to entering their lands for the survey. However, it was normal practice to seek approval from farmers when they were encountered in the field or at farmsteads and also to seek information from them on any badgers known to them on their land or adjoining lands. This approach is similar to that used by Soil Survey staff in the Agricultural Institute (Teagasc). The level of assistance that farmers were able to give in this regard was very variable, some having no knowledge of badgers on their land (even though setts may have been located by the surveyor), whilst others were keenly aware of the locations of badger setts.

Hostility to surveyors was encountered infrequently: only some small portions of land could not be surveyed for this reason, with permission to enter lands absolutely refused; the majority of farmers proved both helpful and interested in the survey work. For security reasons, some squares located on the border with Northern Ireland were not surveyed. Additionally, some squares falling on western islands were inaccessible, for practical purposes, and surveys were not carried out there.

Data sheets

In total, 5 different data sheets were supplied for recording badger, habitat and environmental information for each square (examples of the data forms are given in Appendix B).

The 5 forms were as follows:

a data sheet summarising totals of setts and occupancy found in the 1km square,

a badger sett record sheet giving details of each sett observed, a 1km square field record sheet for recording details of location, environmental information, notes and other mammal species observed,

a sheet for additional notes,

a sheet summarising information for the 10km square (allowing information on mammals present and other information previously known to the observer to be included in the database).

Habitats were marked in on the 9" scale map using coloured pencils and each habitat numbered appropriately or a suitable key to the colouring scheme attached. 42 principal habitat types were considered, some of which were subdivided, and, additionally, the use of grazing lands were noted as being utilised for cattle, sheep, both, or other stock. Generally, any square would contain less than 10 habitat types, so the surveyor was allowed to use his own colouring scheme using a selection of 12 colouring pencils which were provided, though a basic colouring scheme was recommended.

Surveyors were issued with adequate supplies of each data sheet and at least 5 copies each of the 6":1 mile scale and 9":1 mile scale survey maps. They were requested to cross-check data sheets upon completion, to complete the sett summary sheet, and to re-draw the habitat map before submission. Inevitably, maps drawn in the field were rough and often drawn in poor weather conditions, though surveys could not be carried out in very poor weather.

Surveyors were also issued with a plastic A4 folder to protect data sheets and a protected folder containing full details of instructions, and keys for soil and sett classification and habitat categories. Relevant pages from the Collins *"Guide to animal signs and tracks"* (Bang & Dahlstrom, 1974) and the Mammal Society Handbook *"Surveying badgers"* (Harris *et al*, 1989) were also distributed.

Sett survey

All portions of each 1km square were walked and searched for setts. Surveyors were requested to be meticulous in the search for setts, to cover all areas of woodland and walk both sides of hedgerows where these were too wide to adequately cover in a single walk on just one side. The survey period was restricted to late October to mid-May when vegetation cover was low, as sett survey was difficult, if not impossible, during the summer, except in certain upland or moorland areas. Each sett was marked on the map with a cross and a name assigned to it that referred clearly to the relevant sett data sheet: sett names were usually of the form S1, S2, S3, *etc*. The size and activity of each sett located was noted (number of entrances, level of use of the entrances, presence of tracks, fresh digging, bedding latrines, occupancy by other mammals, *etc*.).

A number of holes close together constituted a single sett if it was probable that the holes were connected underground. This was not always clear, so entrances close to each other were considered as constituting a single sett unless the distance between them exceeded

15m (or if there was an obvious major physical boundary, such as a stream or river, between them).

Activity of individual holes was determined as well-used, partially-used, or disused. Well-used entrances were usually clear of debris and clearly in regular use. Partially-used entrances would have leaves, twigs, or moss growing in or around the hole, but the passage would be largely free but not showing signs of recent use or clearance. Disused holes were either partially or totally blocked by collapse or have considerable debris - leaves, twigs, branches, *etc.*, and the entrance would clearly not have been used for a considerable period.

Human disturbance to setts was noted as present or absent, and information on the type of disturbance detailed in notes. Commonly encountered forms of disturbance were digging (by badger-baiters for sport), snares set at the entrances or nearby, blocking with large stones or branches (usually by farmers), collapse caused by agricultural machinery, or partial destruction of the sett caused through hedgerow clearance, *etc.* On occasion, officially licensed snaring was observed and recorded.

The habitat at each sett was recorded (details of principal habitat types are given later in the section dealing with habitats): larger setts might spread over two or more habitats (*e.g.* in hedgerow and spreading into grassland) but field workers were requested to give one principal habitat type only for each sett, with allowance given for additional information in sett description notes. Indication of soil type in which the sett was located was given using the key adopted by Harris *et al* (1989).

In the course of field survey, surveyors encountered other signs of badgers (and other mammals), including hairs, latrines, droppings, feeding signs, footprints, which they were requested to locate on maps and give details on the data sheets.

Sett classification

Each badger sett was given a preliminary classification as main, annexe, subsidiary or outlier, in accordance with Thornton (1988). Badgers are organised socially into territorial groups (Kruuk, 1978) with a variable number of setts. A social group will contain, within its territory, one main sett (which is in use throughout the year), an annexe sett or setts nearby (but not always present), subsidiary setts at an intermediate distance and outlying setts at a further distance.

The initial definitions were as follows:

Main setts:

These usually have a large number of entrances (used and disused) with conspicuous soil heaps. The setts look well used, with the paths between entrances and to and from the sett being obvious and well-worn. Main setts are breeding setts and are normally in continuous use. However, main setts may become disused due to disturbance or some other reason and should be recorded as Disused Main Setts.

Annexe setts:

These are close to a Main sett, between 50 m and 150 m away, and are usually connected to the Main sett by well-worn paths. They usually have several holes, but may not be in use all the time, even if the Main sett is very active.

Subsidiary setts:

These have an intermediate number of entrances and are not connected to another sett by obvious paths. They are usually at least 50 m from a Main sett and are not continuously active.

Outlier setts:

These usually have only one or two holes, often with little spoil outside the hole, and have no obvious path connecting with another sett. Outlier setts are used only sporadically, and, when not in use by badgers, they may be taken over by foxes or rabbits *Oryctolagus cuniculus.*

The survey relies upon the correct classification of setts: in particular, the correct identification of active main setts is crucial to the survey. Each active main sett is deemed to be the focal point of a single social group of badgers and this determines the assessment of the number of social groups present in Ireland. By multiplication by the mean number of badgers present within a social group, the number of badgers present in Ireland is also estimated from the count of main setts. Errors in the classification of the other sett types affect certain estimates of badger density but errors are of less consequence.

Surveyors were requested to re-evaluate their sett classifications following completion of the survey of the 1km square. Sett classification relies, in part, upon determination of the overall distribution of sett types within an area, and what may appear to be a main sett might prove to be an annexe or subsidiary sett when a larger or more active sett is found to be present nearby. In cases of difficulty, surveyors were requested to search areas outside the 1km square to confirm their classifications. Given the fragmented nature of Ireland's landscape, often with many small fields and much hedgerow in comparison with Britain, the surveys took considerable time and it was not usually feasible to search considerable areas outside of the 1km squares themselves.

Additionally, some field workers were noted to have identified several setts as main setts even though they were probably too close together to constitute separate social groups. Consequently, all sett data and classifications submitted were subjected to re-evaluation, with corrections being forwarded to Rangers or volunteers for comment.

An additional difficulty is that main setts in upland regions are known to be smaller (and their social groups smaller) than at lower altitudes or in better badger habitats. For example, Neal (1986) reported 12 badgers emerging from a single entrance sett, and single entrance main setts were not uncommon in this survey, particularly in upland regions. There is then, a degree of subjectivity in the classification of setts, and correct classification depends upon the field worker's expertise with regard to field signs. There were found to be instances in which even adequate field experience was insufficient to allow for 100% confidence in classification. Human disturbance to setts and social groups (mainly by digging) was a common cause of difficulties arising in the classification of all setts in an area.

Initial validation exercises (see later chapter) suggested that, even with the above corrections and referrals to the surveyors, there was a tendency to overestimate the number of main setts present within a 1km square. This results, partially at least, from the adoption of a 1km square as a survey area rather than a larger area: these matters are discussed more fully in the discussion. For example, when only one active sett of, say, 3-4 entrances was located within a square, the tendency by the surveyor was to identify this as the main sett, though such a sett may have been a subsidiary - with the main sett perhaps located over 1km away (an example was revealed in one of the validation exercises). The initial conclusions from the validation exercises prompted a re-evaluation of all data submitted, based upon much stricter criteria for main sett classification than that suggested by Thornton (1988) and utilised in the survey of badgers in the UK. It should be noted that Thornton used tetrads (2km x 2km survey areas), which eased difficulties associated with sett classification. The result of the stricter criteria applied here in conjunction with the survey of 1km squares has been to reduce preliminary estimates given in previous reports by *c.* 15%.

The criteria adopted for main sett classification, in addition to those given by Thornton (above), are as follows:

1) that a main sett should usually have a minimum of 4-5 entrances, unless there is specific evidence of breeding at the sett, or if the sett occurs in poorer badger habitat (*e.g.* uplands, moorland); that no larger setts are known nearby within the 1km square or adjacent areas and that the sett and its immediate vicinity possess sufficient signs of activity to be reasonably considered a main sett.

2) that each main sett should be separated from an adjoining main sett by at least 300 m, unless there is a major physical boundary separating these setts, such as a large river. This is based on work carried out elsewhere which suggests that the minimum separation between main setts is at least 300 m even in high badger density areas.

3) if boundary latrines suggest a division between social groups, then main setts may be reasonably identified.

4) that the overall distribution of setts in an area would conform with a pattern of setts indicating that each sett identified as a main sett is likely to be one.

5) that the overall distribution of habitats in the area and likely territorial boundaries (woodlands, hedgerows, rivers and roads, *etc.*) conforms with the sett interpretation.

6) if setts classified as main setts have other occupants, such as foxes or rabbits, then they are less likely to be considered as active main setts, unless the degree of activity or sett size would indicate otherwise.

7) that setts classified as main setts, but small in size, should possess other signs of considerable badger activity such as bedding and latrines nearby.

8) that particular attention be paid to setts close to the boundaries of the 1km square and that positive identification as a main sett would depend, in difficult cases, upon whether the surveyor had surveyed the area around the 1km square.

9) if there were strong indications of human disturbance to a possible main sett, then the setts in an area be re-evaluated to consider the possibility that a social group had re-located to a nearby smaller sett, if the latter was especially active (disturbance to setts proved to be a frequent cause of difficulty in determining sett classification).

10) that other observations be taken into account, if available: these might include observations of badgers carcasses, road kills and local reports of sightings and of breeding badgers, *etc.*

With regard to other sett types, any sett obviously active, regardless of size, close to a main sett was classed as an annexe sett, providing that it appeared to be connected by a path or paths to the main sett. It seems arbitrary and inappropriate to classify adjoining setts as annexe or subsidiary on the basis of size alone. Subsidiary and outlier setts followed more closely the classification of Thornton. Nevertheless, the results suggest that setts in these categories in Ireland were more likely to be classed as subsidiary setts rather than outlier setts. Generally, any sett of 2-4 entrances within 200 m or so of a main sett was classed as a subsidiary (unless an annexe) rather than an outlier: outlying setts were usually single entrance setts at some distance from the nearest observed main sett.

It has become clear that sett classification within a 1km square area is, to some extent, at least, subjective: the surveys of 'licence' areas have therefore been fruitful in resolution of some of these difficulties. The results for the corrected surveys are presented in this report, followed by a report on the results of the validation exercises which gives an initial estimate of the degree of error associated with the survey work utilising the criteria adopted above.

Data-checking and analysis

All badger and habitat survey data were entered onto an IBM compatible 386DX based computer (4MB RAM) using database and spreadsheet software. An input entry form utilised for the database reduced entry errors. Setts identified outside the 1km square areas were not included in the databases but this data was often instrumental in the classification of setts within the square.

All maps and data submitted were thoroughly checked for discrepancies between data sheets and with the mapped information and any queries or changes were sent to the surveyors for comment or correction. In the initial phases of the survey work, different approaches to use of colour schemes for habitats and attention to detail were observed: circulars were issued to all surveyors to clarify the use of habitat descriptions and keys.

A limited number of checks on survey work by return to the field were made by the author and also by District Wildlife Officers. Additionally, four squares were allocated accidentally to more than one surveyor and, in 3 of these 4 instances, sett information and habitat descriptions corresponded well to each other. In the other case, a main sett complex had been overlooked.

Database entries were finally checked for input errors and translated to spreadsheets, where totals for each square were cross-checked across data-sheets and any discrepancies altered by reference to original data submitted or referral to the surveyor. The numerous cross-checks have eliminated most likely keyboard entry errors and identified most discrepancies. The size of the databases - comprising approximately 200 database fields for each of the 735 squares (147,000 field entries) - created some difficulties in dealing with the data, given the memory requirements, with the habitat database alone requiring 3MB of memory. Statistical data was principally derived using Unistat version 4.5 for DOS, with elementary statistics obtained from the spreadsheet software, and advanced routines for specific purposes from software provided by Krebs (1989).

RESULTS: BADGER SURVEY

Overall survey progress

Of the total of 735 squares designated for survey in the Republic, 729 were surveyed (99.2%). The remaining 6 squares that could not be surveyed fell either on the border with Northern Ireland or on western islands that proved inaccessible for practical purposes. Figure 1 shows coverage of the survey in the Republic, each 1km square being represented by the 10km square in which it was located (each 1km square being located at the extreme south-western corner of every 10km square).

For management purposes, the island was subdivided into 8 regions, illustrated in Figure 2. These regions comprise areas formerly chosen, by the National Parks & Wildlife Service management section, for the management of staff on a regional [district] basis. These regions approximate to geographically distinct areas, with Northern Ireland considered in its entirety as one of these regions. Each region comprises 2 or more counties, the location of which is illustrated in Figure 3: Co. Tipperary and Co. Leitrim were divided in the management structure. The results presented here have been compiled on a strict county by county basis but analyses performed on regions are based on Figure 2, which divides north and south Co. Tipperary and also north and south Co. Leitrim. The number of squares allocated for survey within each county varied, of course, according to the size of the county, the largest county being Co. Cork with a total of 78 squares allocated, and the smallest counties being Cos. Carlow and Louth with only 8 squares each being allocated. Certain squares could not be surveyed in 5 counties, namely, Cos. Cavan, Donegal, Galway, Mayo and Monaghan.

Table 1 presents the number of squares allocated for survey and the number of squares subsequently surveyed on a county by county and region by region basis. At the time of writing this report, the badger survey in Northern Ireland, for which 144 squares were allocated has been completed, barring a small number of squares, but the results of that survey await final analysis. It should be noted that all squares that fell on the border with Northern Ireland and thus included land within both territories were allocated solely for survey by staff within the Republic: the 735 squares thus represent an area fractionally larger than that proportionate for the Republic. The allocation had been made prior to initiation of the survey in Northern Ireland.

On average, each square required 2.1 man-days of field work to complete its survey. The quality of survey data submitted was generally very high as Wildlife Service staff have considerable research and survey experience from previous studies: additional attention and referral to the surveyor with queries were made when presentation was poor and attention to detail inadequate. A sample completed survey map is illustrated in Figure 5.

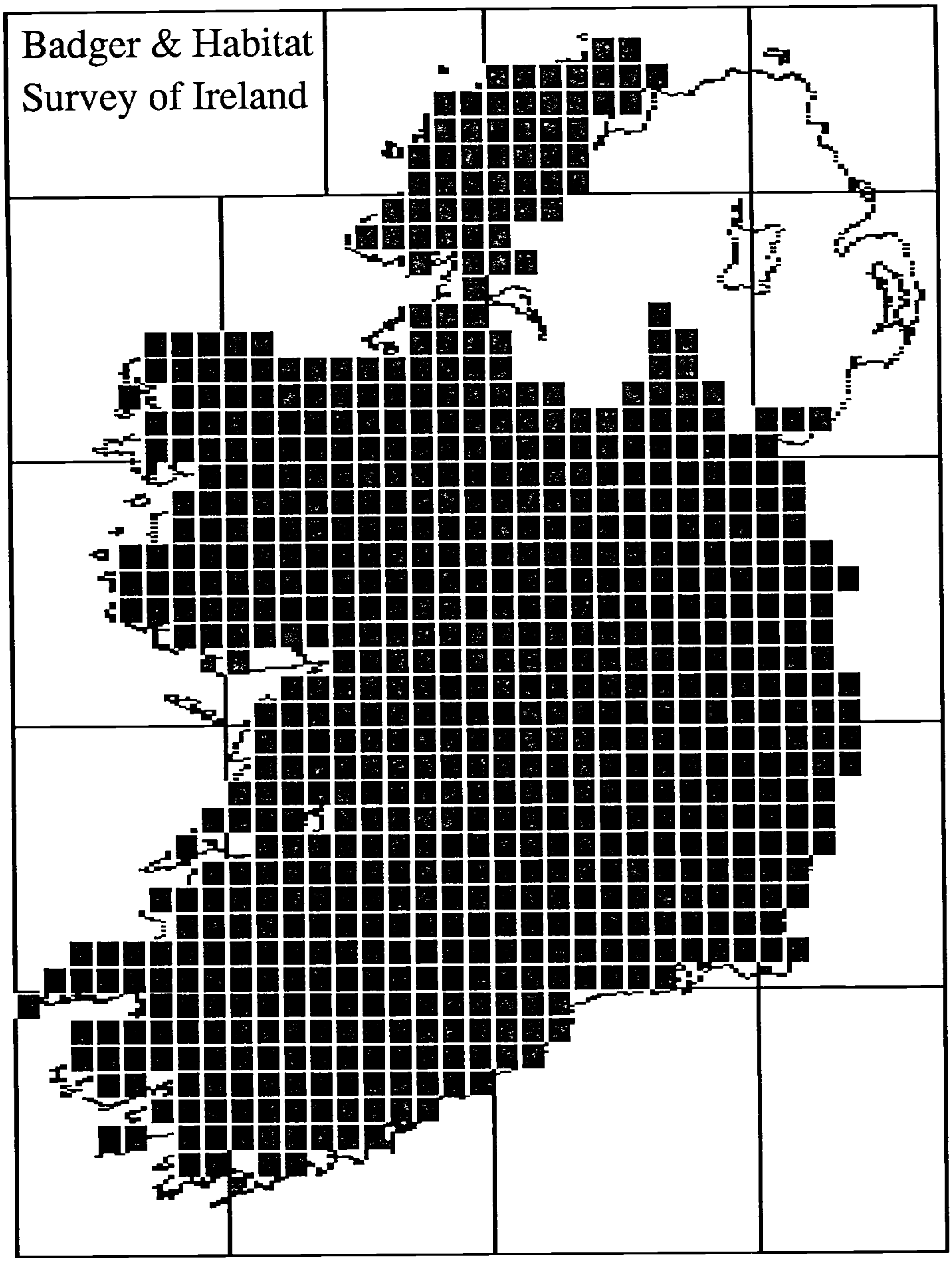


Figure 1. Completion of badger and habitat survey for the Republic of Ireland, given by the 10km squares in which each 1km survey square was located. Survey progress in Northern Ireland is not included.

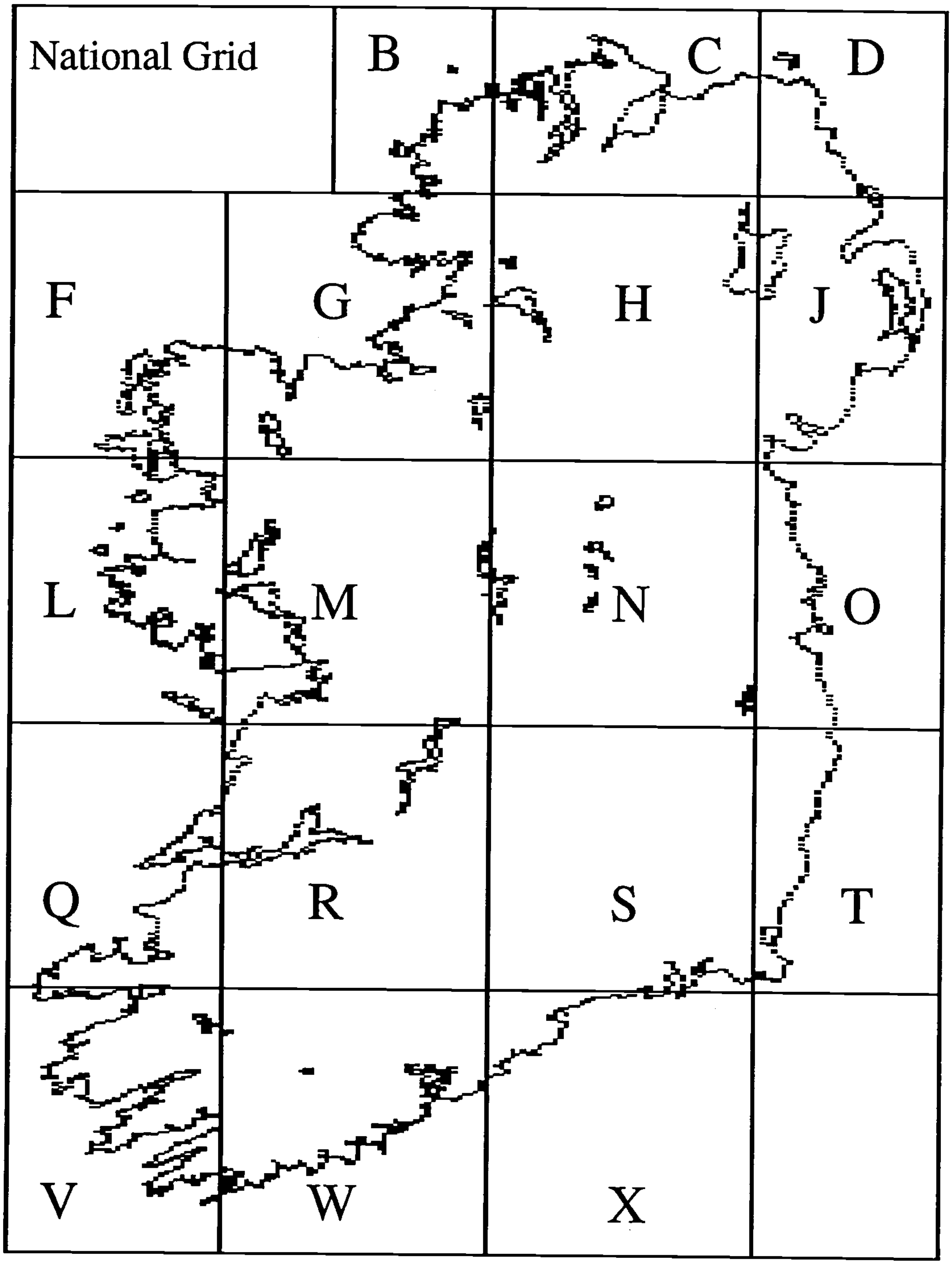


Figure 2. Lettering of the Irish National Grid

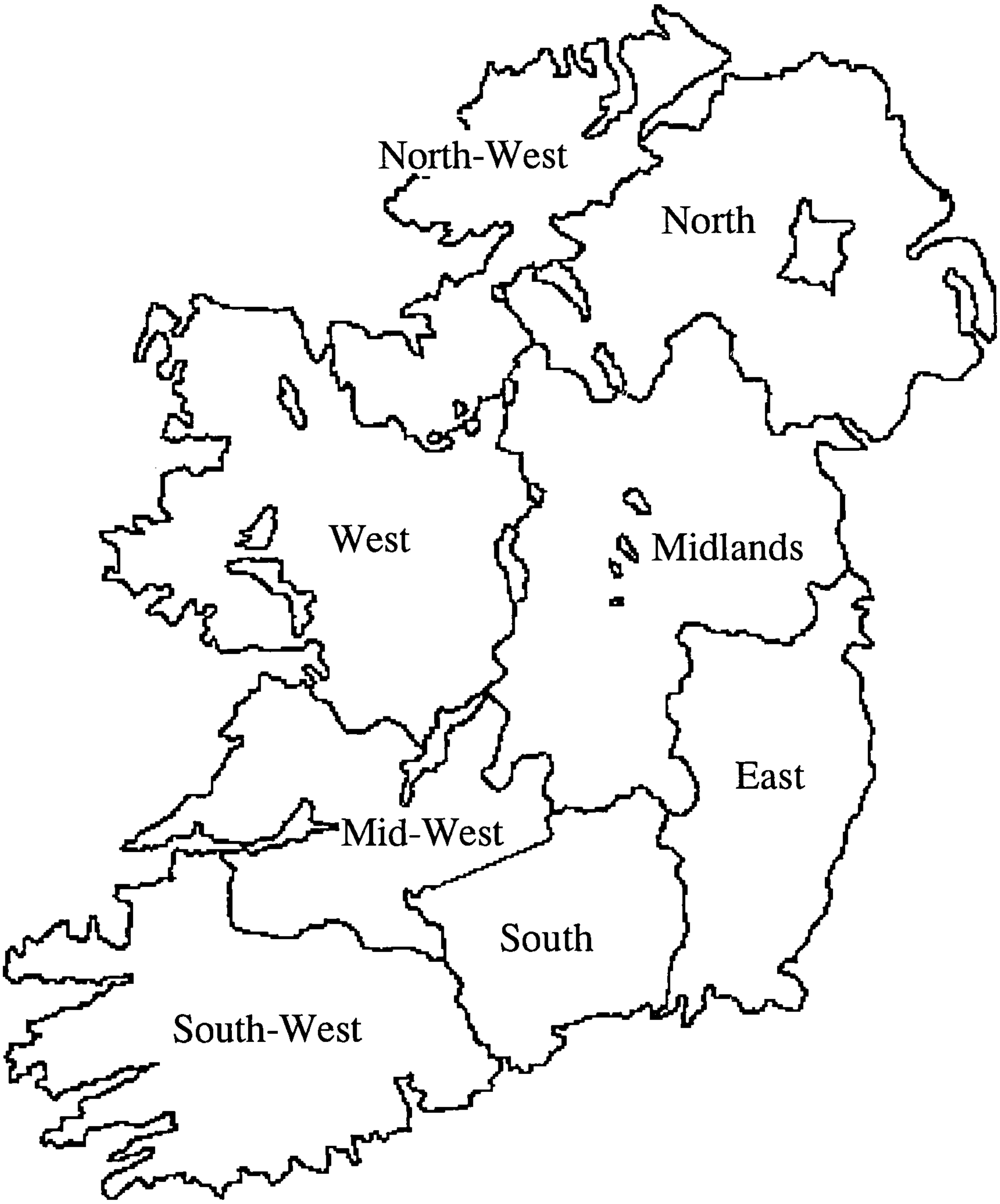


Figure 3. Administrative regions in Ireland as utilised in the badger and habitat survey.

Figure 4. Map of Ireland showing locations of Irish counties in the Republic.

Table 1. Number of survey squares in each county and region.

County	Total no. of survey squares allocated	No. of squares surveyed	No. of squares unsurveyed	Percentage of total surveyed
Carlow	8	8	0	100.0
Cavan	18	16	2	88.9
Clare	36	36	0	100.0
Cork	78	78	0	100.0
Donegal	56	55	1	98.2
Dublin	10	10	0	100.0
Galway	65	64	1	98.5
Kerry	54	54	0	100.0
Kildare	17	17	0	100.0
Kilkenny	20	20	0	100.0
Laois	19	19	0	100.0
Leitrim	16	16	0	100.0
Limerick	27	27	0	100.0
Longford	11	11	0	100.0
Louth	8	8	0	100.0
Mayo	63	62	1	98.4
Meath	28	28	0	100.0
Monaghan	13	12	1	92.3
Offaly	18	18	0	100.0
Roscommon	24	24	0	100.0
Sligo	18	18	0	100.0
Tipperary	45	45	0	100.0
Waterford	22	22	0	100.0
Westmeath	17	17	0	100.0
Wexford	25	25	0	100.0
Wicklow	19	19	0	100.0
TOTALS BY REGION				
South-West	132	132	0	100.0
Mid-West	85	85	0	100.0
West	152	150	2	98.7
North-West	82	81	1	98.8
Midlands	140	137	3	97.9
South	65	65	0	100.0
East	79	79	0	100.0
TOTALS				
Republic	735	729	6	99.2
Northern Ireland	144			
All Ireland	879			

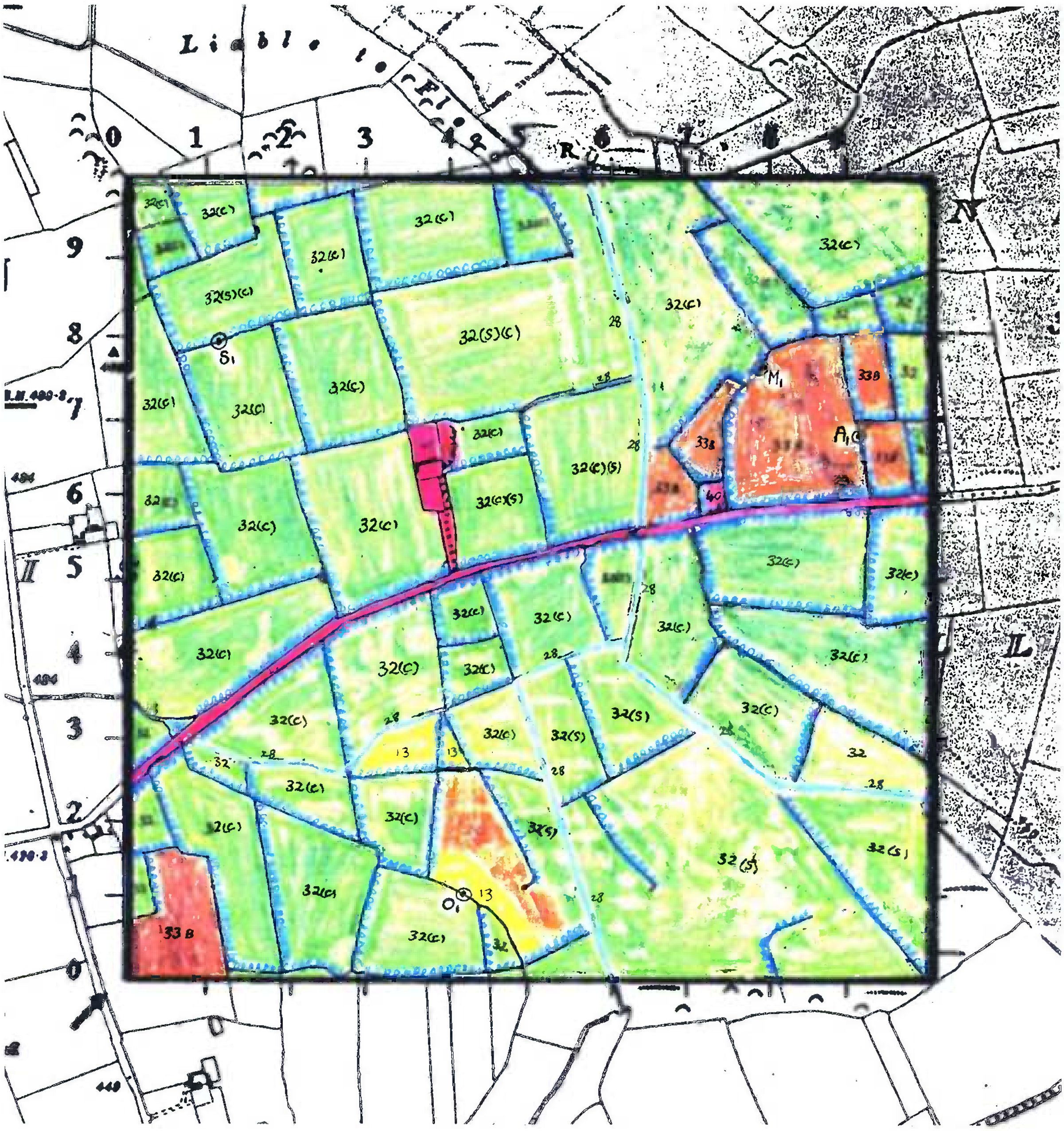


Figure 5. Example of a completed survey of a 1km square, with habitats and setts marked. Note that in order to reproduce the map here, it is laser photocopy reduced in size from the original which was on an A4 sheet with an approximate scale of 9":1 mile. Marked present in this square are 1 main sett, 1 annexe sett, 1 subsidiary sett and 1 outlier sett. The square is located on the border of Cos. Kilkenny and Tipperary.

Numbers of setts and sett types

Overall results

Of the 735 squares designated in the Republic, 729 were surveyed and a total of 1,378 setts was recorded. This compares with a total of 2,078 setts recorded from 2,455 squares in the British survey (Cresswell *et al*, 1990). The number of setts found in any 1km square varied from zero to 35. The latter high sett density was observed in a square in Co. Meath, the high density of setts resulting from a 1km boundary between peat and grassland, the combination of which provided ideal sett digging terrain in dry bog edge with feeding in the grassland adjacent. In this case, high sett disturbance resulted in only an average social group density.

The mean number of setts observed was 1.9 per km^2, which was found to vary considerably on a regional and on a county basis. The highest densities were found in the Midlands, the Mid-West and the South (>2.0 setts per km^2), and substantially fewer setts were found in the West and North-West (<1.2 setts per km^2). Low sett densities were reported from Cos. Donegal, Galway, Mayo and Waterford. A high proportion of squares revealed no setts at all, though many of these squares did possess some signs of badger activity, principally feeding signs. Many of the squares with zero setts were located in Ireland's western, upland, or raised/blanket bog areas, which are extensive.

The overall information on sett type and regional distribution is given in Table 2, and on a county-by-county basis in Table 3. The frequency of occurrence of all setts within squares is illustrated in Figure 6.

Table 2. Summary of badger sett data on a regional basis.

Region	No. of squares	Total no. of setts	Mean no. of setts	Totals				Mean density per km^2			
				Main	Annx.	Subsd.	Outl.	Main	Annx.	Subsd.	Outl.
South-West	132	275	2.08	78	35	81	81	0.59	0.27	0.61	0.61
Mid-West	85	222	2.61	57	29	90	46	0.67	0.34	1.06	0.54
West	150	108	0.72	46	20	21	21	0.31	0.13	0.14	0.14
North-West	81	96	1.19	33	15	30	18	0.41	0.19	0.37	0.22
Midlands	137	363	2.65	96	31	124	112	0.70	0.23	0.91	0.82
South	65	160	2.46	46	17	56	41	0.71	0.26	0.86	0.63
East	79	154	1.95	46	20	43	45	0.58	0.25	0.54	0.57
Republic	729	1378	1.89	402	167	445	364	0.55	0.23	0.61	0.50

Table 3. Summary of badger sett data on a county by county basis.

County	No. of squares	Total no. of setts	Mean no. of setts	Totals				Mean density per km²			
				Main	Annx.	Subsd.	Outl.	Main	Annx.	Subsd.	Outl.
Carlow	8	18	2.3	6	1	7	4	0.75	0.13	0.88	0.50
Cavan	16	20	1.3	6	2	5	7	0.38	0.13	0.31	0.44
Clare	36	110	3.1	23	21	48	18	0.64	0.58	1.33	0.50
Cork	78	197	2.5	53	23	54	67	0.68	0.29	0.69	0.86
Donegal	55	56	1.0	21	11	13	11	0.38	0.20	0.24	0.20
Dublin	10	22	2.2	5	4	5	8	0.50	0.40	0.50	0.80
Galway	64	45	0.7	18	6	7	14	0.28	0.09	0.11	0.22
Kerry	54	78	1.4	25	12	27	14	0.46	0.22	0.50	0.26
Kildare	17	32	1.9	11	5	6	10	0.65	0.29	0.35	0.59
Kilkenny	20	111	5.5	27	12	38	34	1.35	0.60	1.90	1.70
Laois	19	40	2.1	11	4	12	13	0.58	0.21	0.63	0.68
Leitrim	16	19	1.2	6	2	7	4	0.38	0.13	0.44	0.25
Limerick	27	78	2.9	22	7	28	21	0.81	0.26	1.04	0.78
Longford	11	13	1.2	3	1	7	2	0.27	0.09	0.64	0.18
Louth	8	22	2.8	8	1	8	5	1.00	0.13	1.00	0.63
Mayo	62	36	0.6	19	6	8	3	0.31	0.10	0.13	0.05
Meath	28	122	4.4	27	8	50	37	0.96	0.29	1.79	1.32
Monaghan	12	17	1.4	8	2	4	3	0.67	0.17	0.33	0.25
Offaly	18	65	3.6	16	7	21	21	0.89	0.39	1.17	1.17
Roscommon	24	27	1.1	9	8	6	4	0.38	0.33	0.25	0.17
Sligo	18	23	1.3	7	2	11	3	0.39	0.11	0.61	0.17
Tipperary	45	64	1.4	22	6	24	12	0.49	0.13	0.53	0.27
Waterford	22	19	0.9	9	0	8	2	0.41	0.00	0.36	0.09
Westmeath	17	62	3.6	16	6	16	24	0.94	0.35	0.94	1.41
Wexford	25	39	1.6	12	3	11	13	0.48	0.12	0.44	0.52
Wicklow	19	43	2.3	12	7	14	10	0.63	0.37	0.74	0.53
Totals	729	1378	1.9	402	167	445	364	0.55	0.23	0.61	0.50

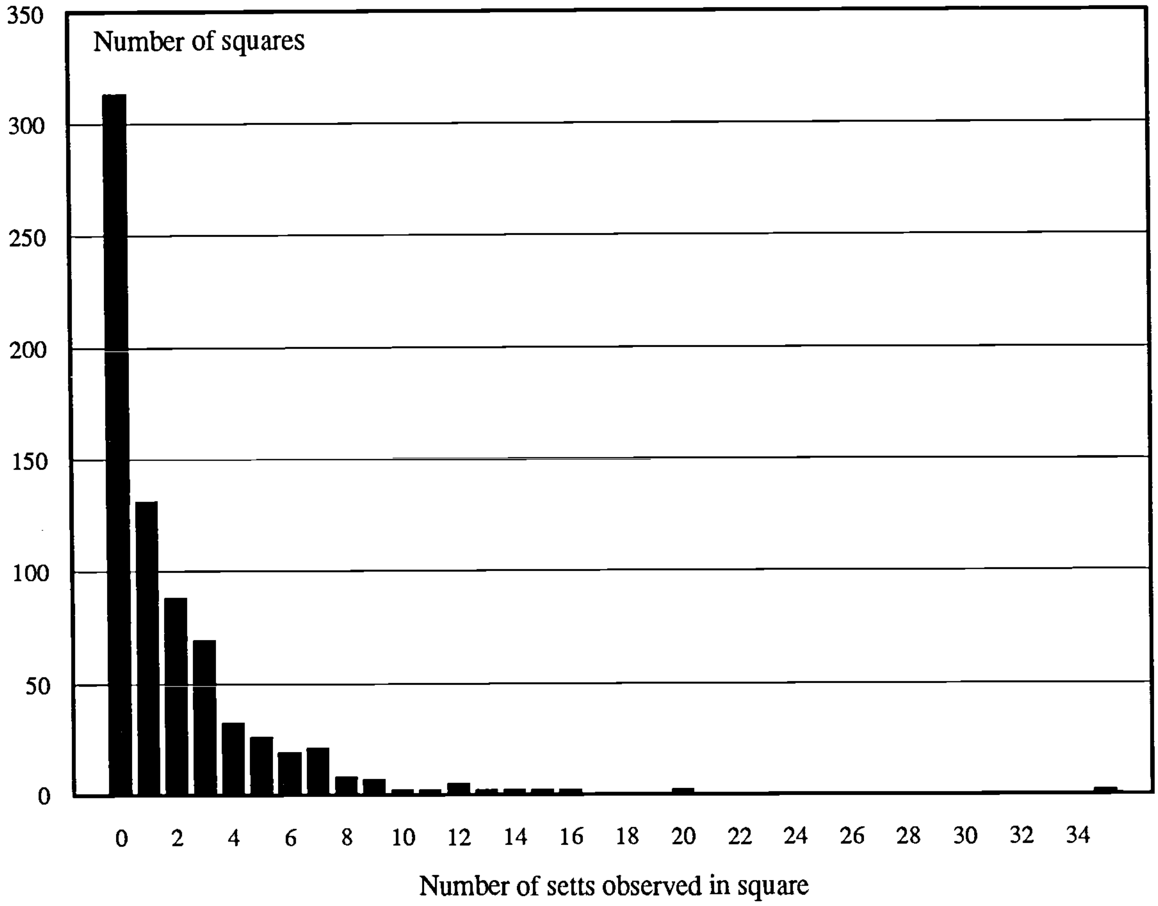


Figure 6. Frequency of occurrence of setts (all classes) in 1km squares in the Republic.

Summaries, for active setts only, are given in Table 4 on a regional basis and in Table 5 for individual counties. The density distribution is similar to that for all setts, but the proportions of the setts enumerated that were active does vary substantially, with only 42% of setts located in Co. Wicklow being designated as active but 95% of setts in Co. Cavan were found to be active, with an overall mean for the Republic of 72.7%. This variation is reduced on a regional basis, with a minimum of 60% setts active in East Ireland and a maximum of 83% setts active in the South. The means given in Tables 4 and 5 have not been corrected for areas of lake or sea: refined estimates for main sett densities are given in a later section summarising badger population estimates for Ireland.

The frequency of occurrence of active setts is illustrated in Figure 7 and that of active main setts only in Figure 8. Both figures demonstrate that the distribution is similar to a negative binomial or Poisson distribution, with a substantial proportion of squares with zero occurrence. The maximum number of active main setts located within any square was 3 (in the previous preliminary report, only 1 square had been identified with 4 main setts). The exceptional densities of up to 6 social groups per km^2 reported from areas such as the Cotswolds in Gloucestershire in the UK have not been observed in Ireland.

Table 4. Summary of active badger setts, on a regional basis.

Region	No. of squares surveyed	Total no. of active setts	% of setts active	Totals Main	Totals Annx.	Totals Subsd.	Totals Outl.	Mean density per km² Main	Mean density per km² Annx.	Mean density per km² Subsd.	Mean density per km² Outl.
South-West	132	185	67.3	65	27	56	37	0.49	0.20	0.42	0.28
Mid-West	85	179	80.6	53	25	75	26	0.62	0.29	0.88	0.31
West	150	85	78.7	38	19	15	13	0.25	0.13	0.10	0.09
North-West	81	67	69.8	30	12	16	9	0.37	0.15	0.20	0.11
Midlands	137	261	71.9	81	24	82	74	0.59	0.18	0.60	0.54
South	65	133	83.1	38	14	45	36	0.58	0.22	0.69	0.55
East	79	92	59.7	32	15	25	20	0.41	0.19	0.32	0.25
Totals	729	1002	72.7	337	136	314	215	0.46	0.19	0.43	0.29

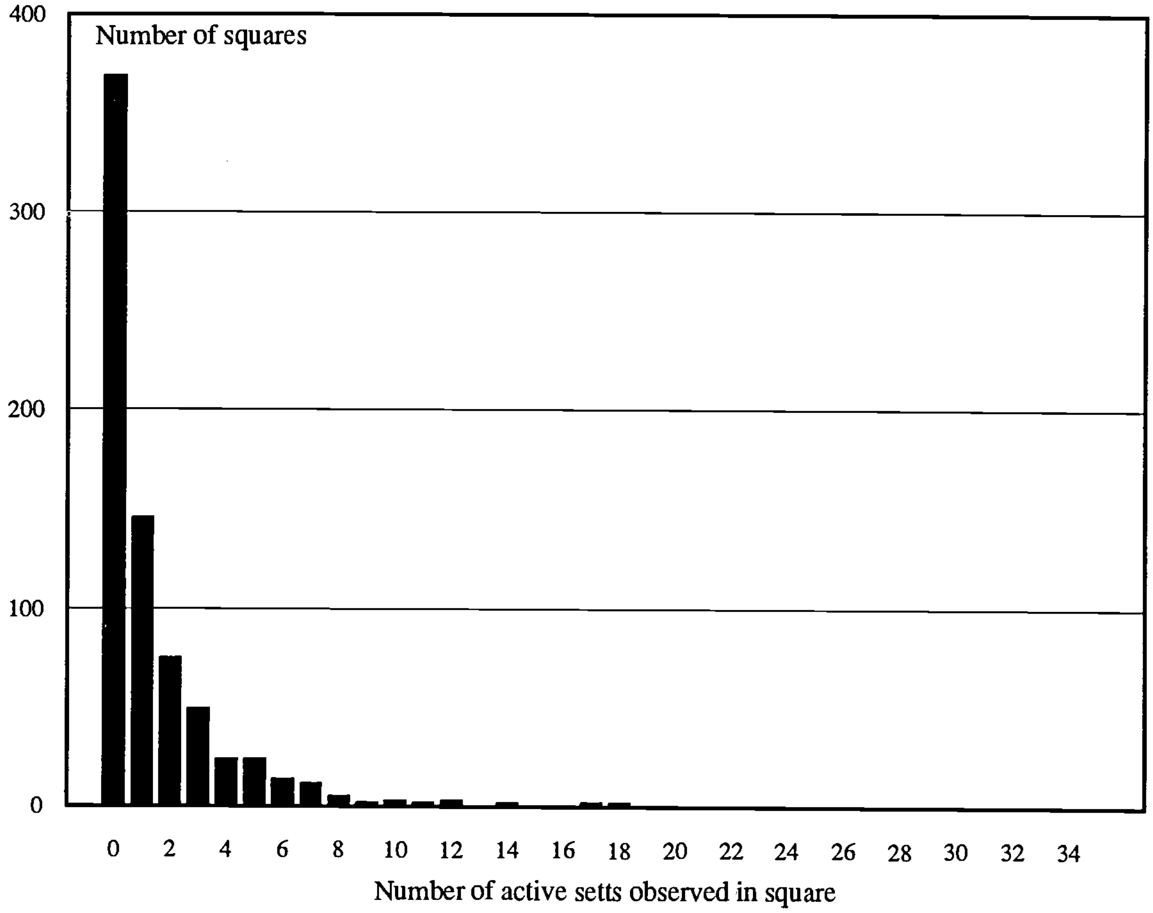


Figure 7. Frequency of occurrence of all active setts observed in the 1km squares surveyed.

Table 5. Summary of active badger sett data, given by individual counties.

County	No. of squares surveyed	Total no. of active setts	% of setts active	Active setts Main	Annx.	Subsd.	Outl.	Mean density per km^2 Main	Annx.	Subsd.	Outl.
Carlow	8	11	61.1	5	1	3	2	0.63	0.13	0.38	0.25
Cavan	16	19	95.0	6	2	5	6	0.38	0.13	0.31	0.38
Clare	36	88	80.0	21	18	40	9	0.58	0.50	1.11	0.25
Cork	78	139	70.6	45	17	45	32	0.58	0.22	0.58	0.41
Donegal	55	34	60.7	18	8	4	4	0.33	0.15	0.07	0.07
Dublin	10	19	86.4	5	4	3	7	0.50	0.40	0.30	0.70
Galway	64	35	77.8	14	6	6	9	0.22	0.09	0.09	0.14
Kerry	54	46	59.0	20	10	11	5	0.37	0.19	0.20	0.09
Kildare	17	14	43.8	7	2	3	2	0.41	0.12	0.18	0.12
Kilkenny	20	99	89.2	25	11	34	29	1.25	0.55	1.70	1.45
Laois	19	29	72.5	9	2	9	9	0.47	0.11	0.47	0.47
Leitrim	16	16	84.2	6	2	6	2	0.38	0.13	0.38	0.13
Limerick	27	63	80.8	21	6	25	11	0.78	0.22	0.93	0.41
Longford	11	8	61.5	2	0	5	1	0.18	0.00	0.45	0.09
Louth	8	20	90.9	8	1	7	4	1.00	0.13	0.88	0.50
Mayo	62	25	69.4	15	5	4	1	0.24	0.08	0.06	0.02
Meath	28	81	66.4	22	7	31	21	0.79	0.25	1.11	0.75
Monaghan	12	12	70.6	6	1	2	3	0.50	0.08	0.17	0.25
Offaly	18	48	73.8	13	6	12	17	0.72	0.33	0.67	0.94
Roscommon	24	25	92.6	9	8	5	3	0.38	0.33	0.21	0.13
Sligo	18	19	82.6	7	2	7	3	0.39	0.11	0.39	0.17
Tipperary	45	46	71.9	16	4	15	11	0.36	0.09	0.33	0.24
Waterford	22	16	84.2	8	0	6	2	0.36	0.00	0.27	0.09
Westmeath	17	42	67.7	14	5	10	13	0.82	0.29	0.59	0.76
Wexford	25	30	76.9	10	2	9	9	0.40	0.08	0.36	0.36
Wicklow	19	18	41.9	5	6	7	0	0.26	0.32	0.37	0.00
Totals	729	1002	72.7	337	136	314	215	0.46	0.19	0.43	0.29

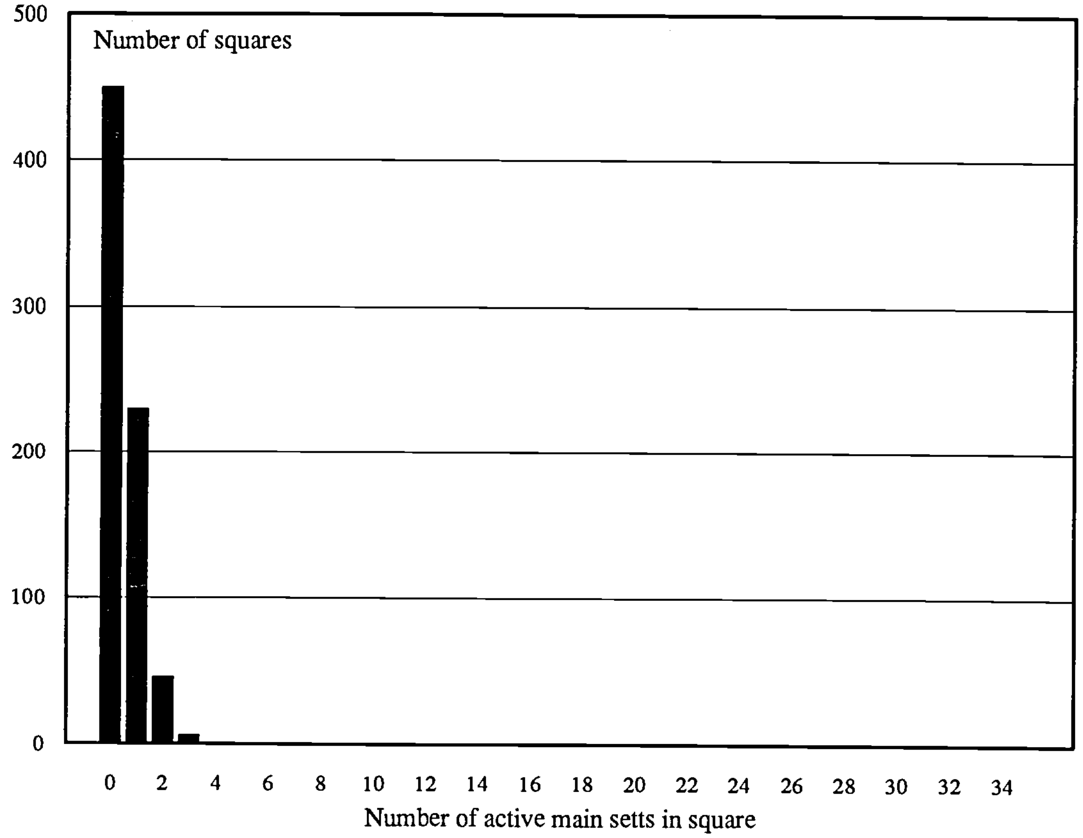


Figure 8. Frequency of occurrence of active main setts in the 1km squares surveyed.

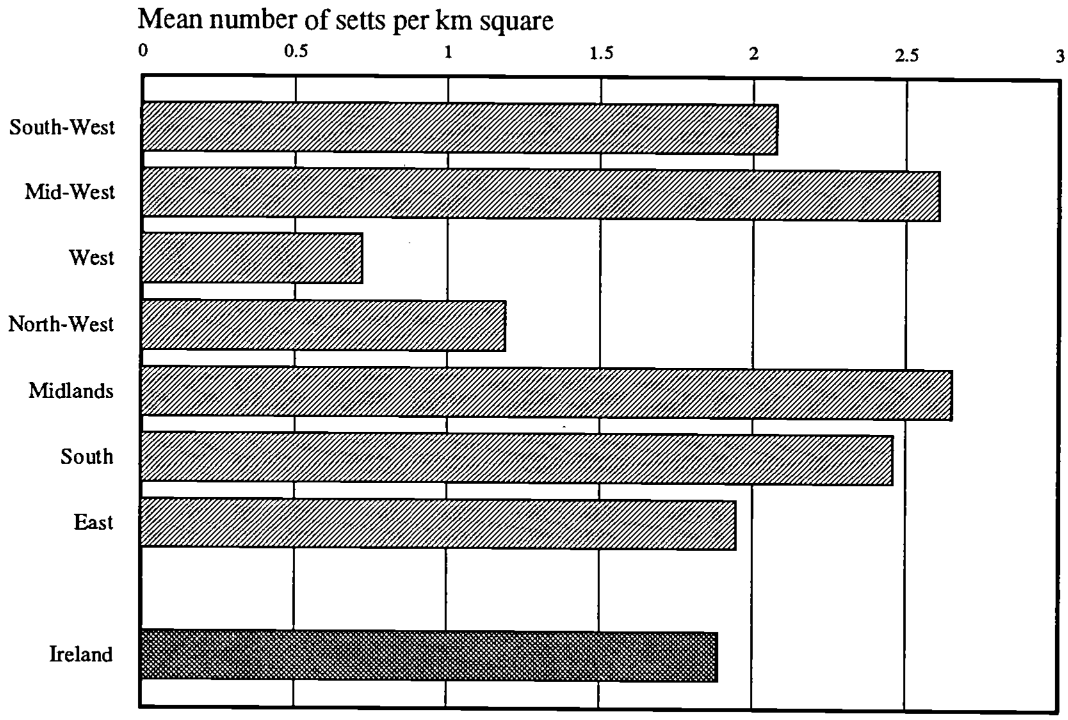


Figure 9. Mean number of setts located, given on a regional basis.

Figure 9 illustrates the mean number of setts on a regional basis. The mean number of active main setts per km^2 is given in Figure 10, again on a regional basis. The overall density of active main setts, each representing a badger social group is 0.46 social groups km^2. There is marked regional variation. The lowest densities are to be found in the West of Ireland, with 0.25 social groups per km^2 and highest in the Mid-West, with 0.62 social groups per km^2, but densities are almost equally high in the Midlands and the South. The North-West is low (0.37) and the other two regions - the East and the South-West are intermediate (0.41 and 0.49). Preliminary analyses would suggest that densities in Northern Ireland are very similar to those found in the higher badger densities in the Republic, at around 0.6 social groups per km^2.

Within regions, county variation is high (Figure 11). The highest densities of badger social groups were found in Cos. Kilkenny (at 1.25 active main setts per km^2) and Co. Louth (at 1.00 active main setts per km^2). Several counties had moderately high densities (between 0.5 and 1.0 social groups per km^2), namely, Cos. Carlow, Clare, Cork, Limerick, Meath, Offaly and Westmeath. Counties with low densities were Donegal, Galway, Longford, Mayo and Wicklow.

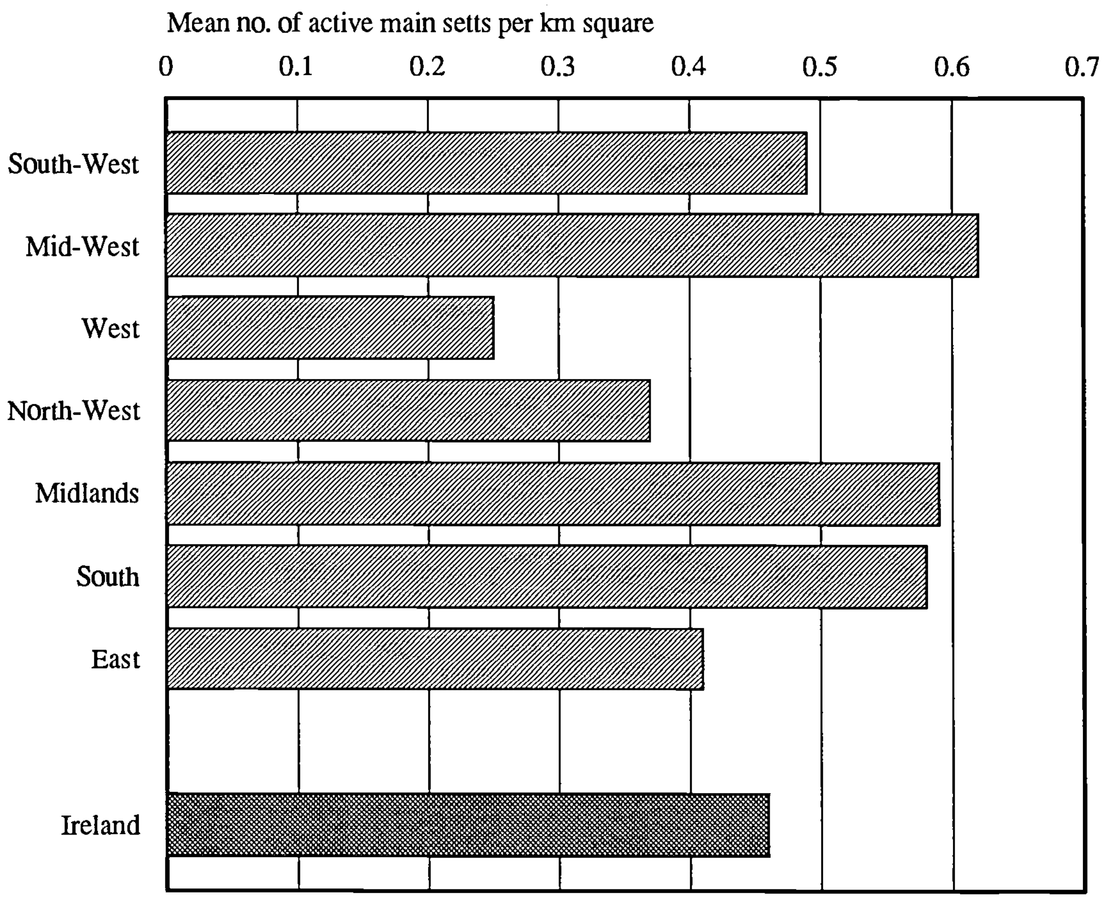


Figure 10. Mean number of active main setts per km square surveyed, on a regional basis.

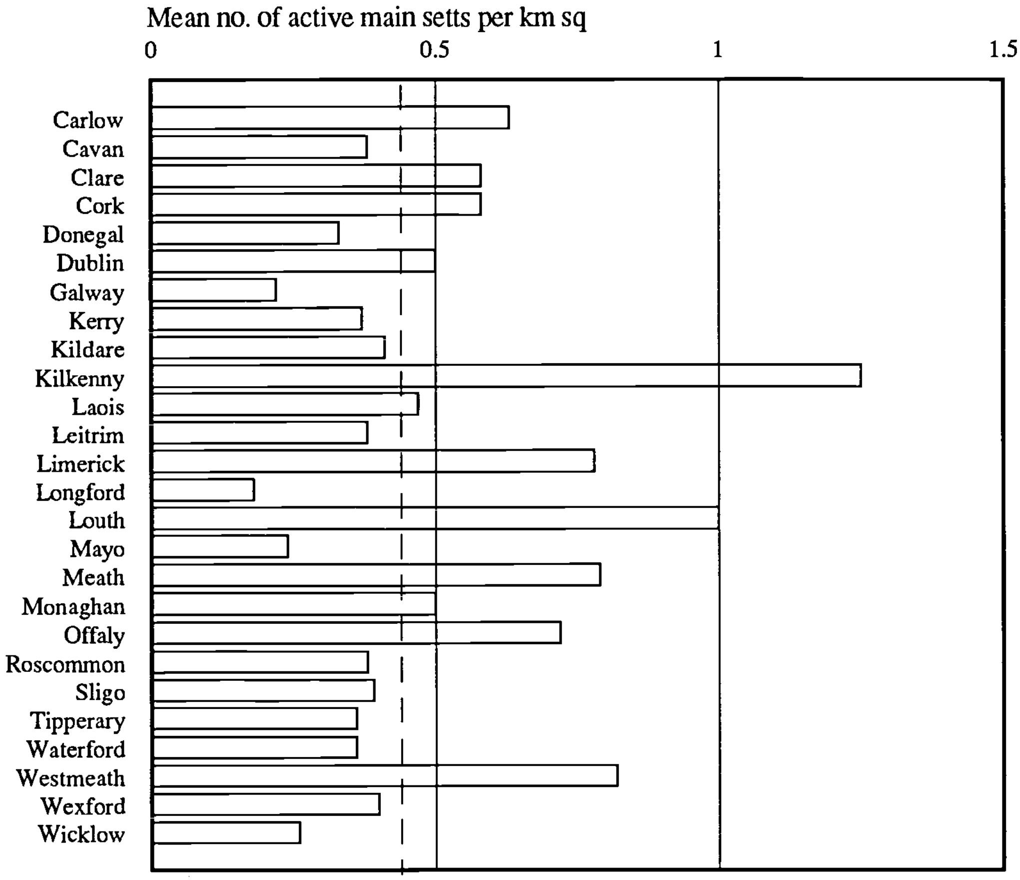
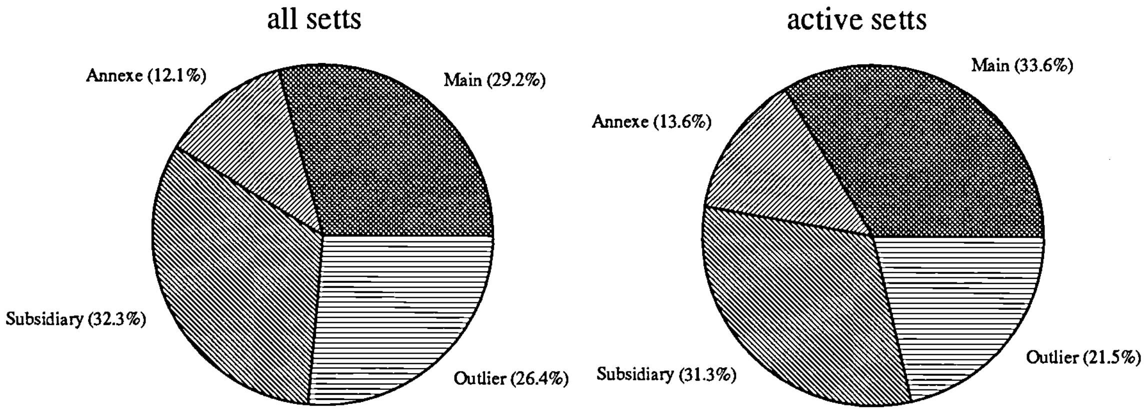


Figure 11. Variation in density of social groups on an individual county basis, based on the mean number of active main setts located. The overall mean of 0.46 social groups per km^2 is illustrated as a dashed line.

Proportions of sett classes

Overall, the proportions of sett classes were 1 active main sett (baseline, total number 337 setts) to: 0.19 disused main setts (n=65), 0.50 annexe setts (n=167), 1.32 subsidiary setts (n=445) and 1.08 outlier setts (n=364). Thus each active main sett was, on average, accompanied by 3.09 other setts, and each badger social group thus possessed 4.09 setts on average (this compares with 4.10 setts per group in Britain [Cresswell *et al*, 1990]). Undoubtedly, because of the difficulty of finding the small setts, especially so if these are unused, the number of setts associated with social groups is likely to be an underestimate - whereas, because main setts and larger setts are generally easy to locate, the estimate is likely to correspond to reality much more closely. The proportions of each sett type are illustrated in Figure 12. Regional and county variations in proportions of setts by type are given in Appendix A1. These reveal substantial variation in the number of setts per social group, from 2.4 in Waterford to 8.6 in Wicklow. On a regional basis, there are fewer setts per social group in regions of lower badger density (*e.g.* West and North-West) than elsewhere.

Figure 12. Pie-charts showing the proportions of sett classes.



Sett size

The largest main sett located comprised 44 entrances and the smallest 1 entrance: the histogram of main sett sizes is shown in Figure 13. The mean size of main setts was 6.9 entrances (unchanged since the preliminary report). Annexe setts were found to be smaller, with a mean size of 4.0 entrances (histogram shown in Figure 14). Subsidiary setts averaged 3.0 entrances (Figure 15) and outlier setts 1.3 entrances (Figure 16). In all sett classes, the minimum size was just 1 entrance but the maximum sett size for annexe setts was 19, for subsidiary setts 21 entrances and the largest outlier was found to have 7 entrances. These particular examples were, of course, the exception rather than the rule, and subsidiary and outlier setts were usually relatively small. Mean sett sizes for each class are shown in Figure 17.

Active setts were found to be slightly larger on average in the case of main and annexe setts but subsidiary setts and outlier setts were, on average, the same size. Thus the mean size of active main setts was 7.2 entrances and of annexe setts 4.1 entrances.

The means and statistical data on sett size are given on a regional basis in Table 6, and on a county basis in Appendix A2. As might be expected, there was some regional variation in the mean size of active main setts (Figure 18), but this was less than might have been anticipated, given that main setts are generally smaller in poorer badger habitats, *e.g.* upland and moorland areas. Thus the regions with smallest main setts were the North-West and East (at 6.2 entrances) and the regions with the largest main setts were the South-West and Mid-West (at 7.8 entrances and 7.4 entrances respectively). Considering active main setts only, the differences are comparable, with the smallest main setts being located in the North-West (at 6.3 entrances) and the largest in the South-West (at 8.0 entrances). The variation in sizes of the other sett types tended to follow the regional variation observed with main setts.

Table 6. Mean size of setts on a regional basis, as given by the number of entrances.

Region		**All setts**				**Setts in use**			
		Main	**Annx.**	**Subsd.**	**Outl.**	**Main**	**Annx.**	**Subsd.**	**Outl.**
South-West	N	78	35	81	81	65	27	56	37
	Mean sett size	**7.8**	**4.7**	**3.2**	**1.2**	**8.0**	**5.0**	**3.3**	**1.2**
	s.e.	0.66	0.58	0.22	0.05	0.77	0.72	0.30	0.06
	max. no. entrances	36	14	12	3	36	14	12	2
	min. no. entrances	1	1	1	1	1	1	1	1
Mid-West	N	57	29	90	46	53	25	75	26
	Mean sett size	**7.4**	**4.2**	**2.7**	**1.4**	**7.5**	**4.2**	**2.7**	**1.3**
	s.e.	0.80	0.42	0.18	0.09	0.86	0.45	0.20	0.10
	max. no. entrances	44	12	11	3	44	12	11	3
	min. no. entrances	3	2	1	1	3	2	1	1
West	N	46	20	21	21	38	19	15	13
	Mean sett size	**6.5**	**4.4**	**3.1**	**1.5**	**7.1**	**4.5**	**3.3**	**1.5**
	s.e.	0.47	0.28	0.28	0.11	0.52	0.28	0.32	0.14
	max. no. entrances	18	6	6	2	18	6	6	2
	min. no. entrances	1	3	1	1	1	3	1	1
North-West	N	33	15	30	18	30	12	16	9
	Mean sett size	**6.2**	**2.5**	**2.4**	**1.4**	**6.3**	**2.4**	**2.2**	**1.4**
	s.e.	0.85	0.47	0.17	0.14	0.93	0.58	0.24	0.23
	max. no. entrances	23	8	4	3	23	8	4	3
	min. no. entrances	1	1	1	1	1	1	1	1
Midlands	N	96	31	124	112	81	24	82	74
	Mean sett size	**6.8**	**4.1**	**3.2**	**1.4**	**7.0**	**4.0**	**3.2**	**1.5**
	s.e.	0.39	0.55	0.22	0.08	0.46	0.71	0.32	0.11
	max. no. entrances	29	19	21	7	29	19	21	7
	min. no. entrances	1	1	1	1	1	1	1	1
South	N	46	17	56	41	38	14	45	36
	Mean sett size	**6.7**	**4.4**	**3.4**	**1.3**	**6.8**	**4.5**	**3.4**	**1.3**
	s.e.	0.43	0.35	0.21	0.09	0.49	0.41	0.25	0.10
	max. no. entrances	17	9	9	3	17	9	9	3
	min. no. entrances	4	2	1	1	4	2	1	1
East	N	46	20	43	45	32	15	25	20
	Mean sett size	**6.2**	**3.1**	**2.7**	**1.3**	**6.8**	**3.2**	**2.6**	**1.2**
	s.e.	0.49	0.37	0.19	0.09	0.68	0.46	0.30	0.11
	max. no. entrances	16	8	6	4	16	8	6	3
	min. no. entrances	2	1	1	1	2	1	1	1
Totals (Republic)	Number	402	167	445	364	337	136	314	215
	Mean sett size	**6.9**	**4.0**	**3.0**	**1.3**	**7.2**	**4.1**	**3.0**	**1.3**
	s.e.	0.23	0.20	0.09	0.03	0.27	0.24	0.12	0.05
	max. no. entrances	44	19	21	7	44	19	21	7
	min. no. entrances	1	1	1	1	1	1	1	1

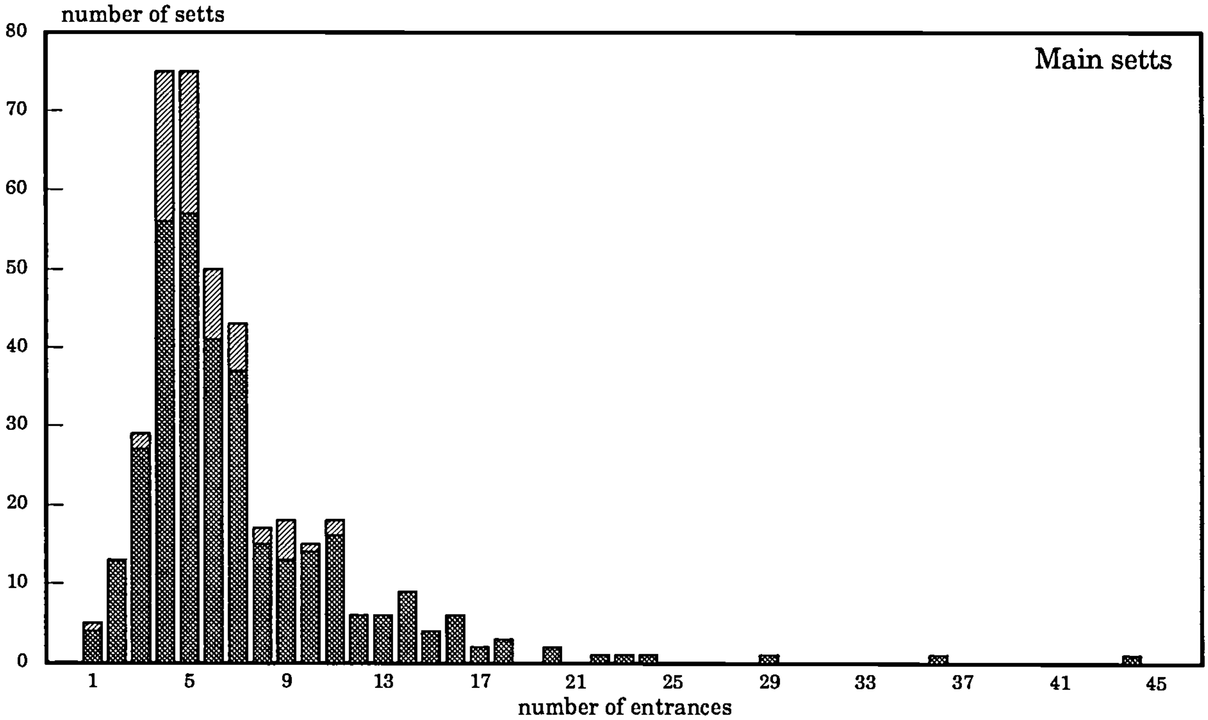


Figure 13. Frequency histogram of main setts according to size as given by the total number of entrances. Double-hatch: active setts; single-hatch: inactive setts.

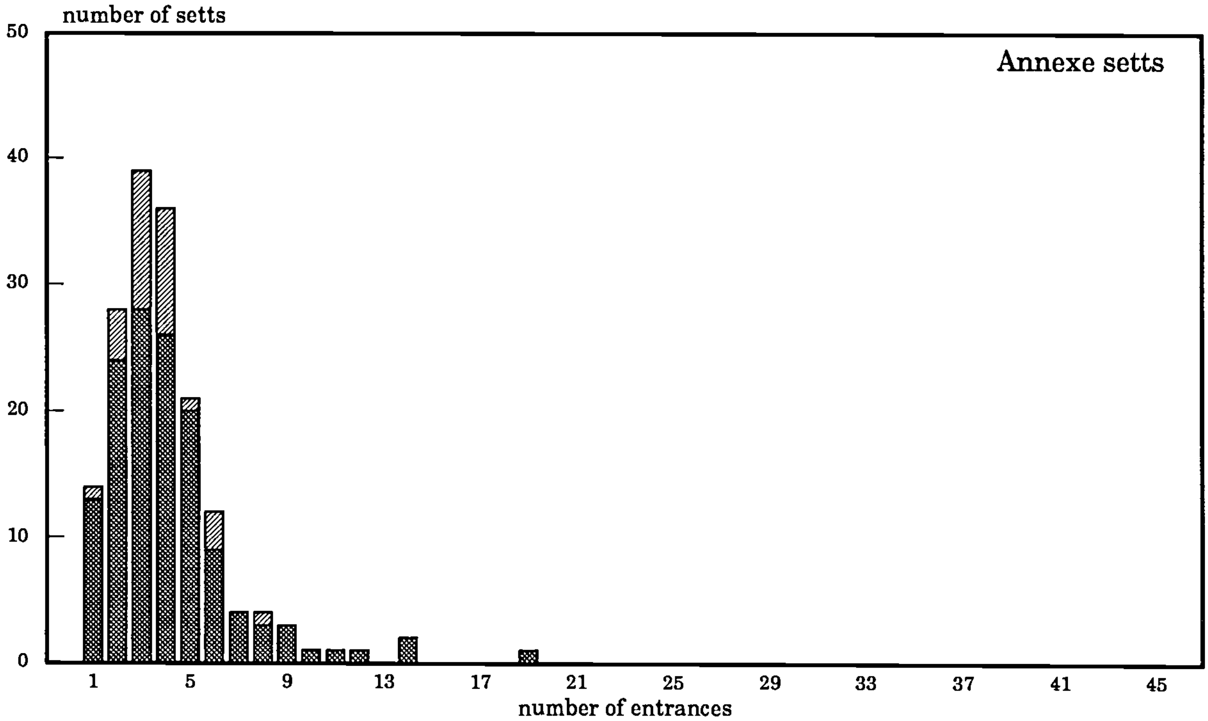


Figure 14. Frequency histogram of annexe setts according to size as given by the number of entrances. Cross-hatch: active setts; single-hatch: inactive setts.

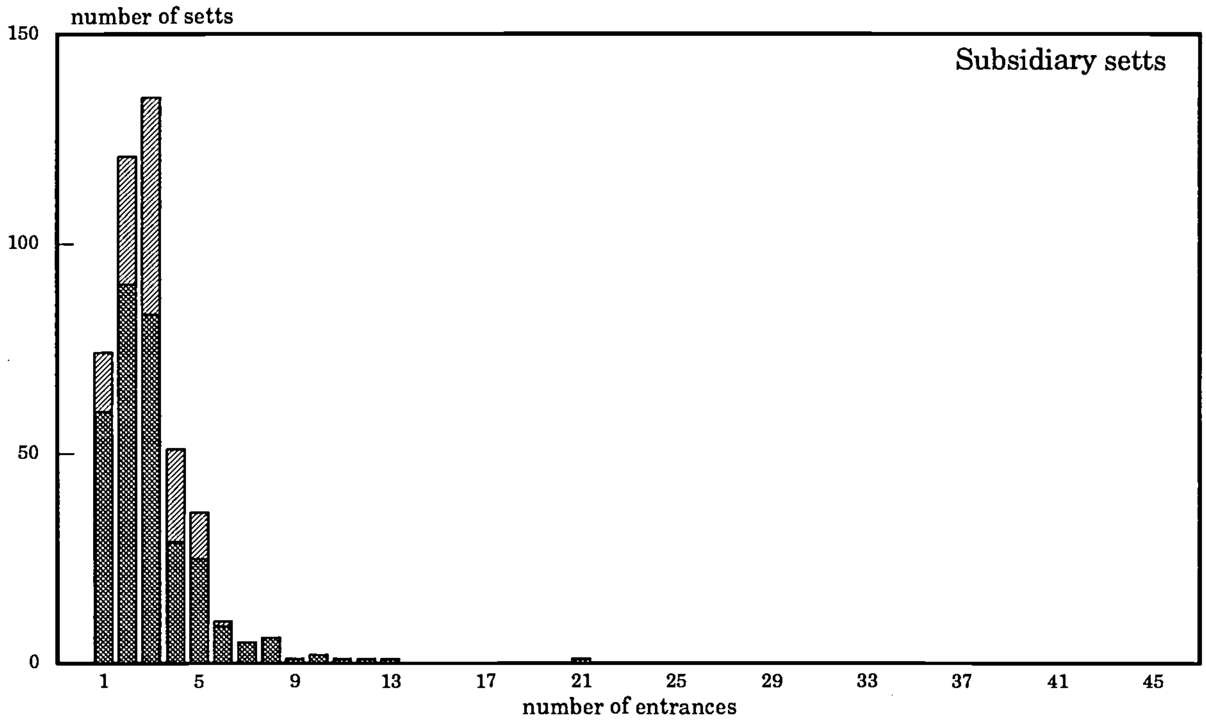


Figure 15. Frequency histogram of subsidiary setts according to size as given by the number of entrances. Cross-hatch: active setts; single-hatch: inactive setts

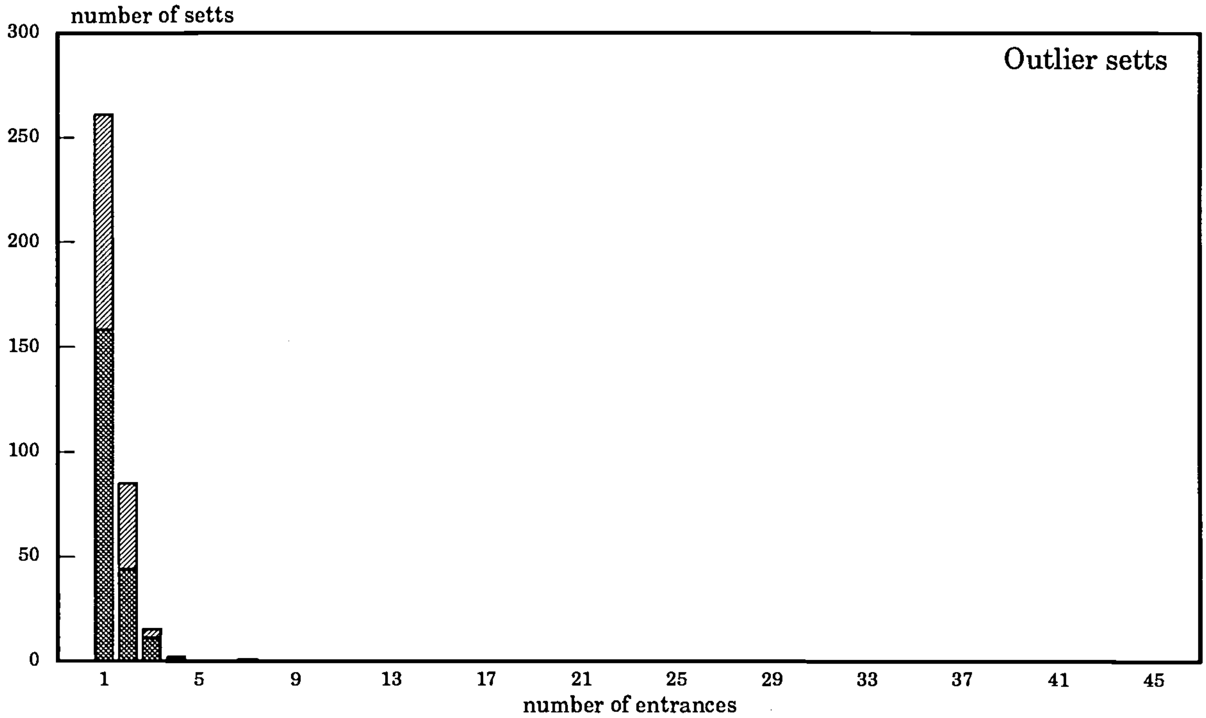


Figure 16. Frequency histogram for outlier setts, according to size as given by the number of entrances. Cross-hatch: active setts; single-hatch: inactive setts.

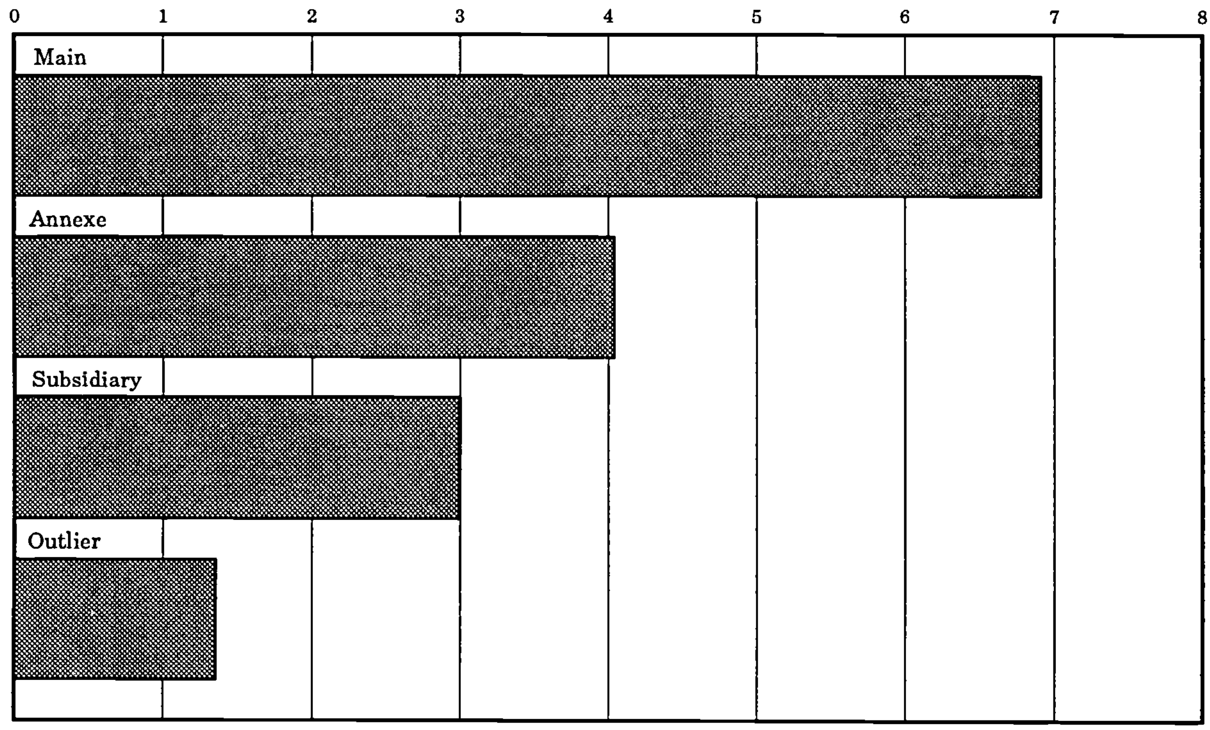


Figure 17. Mean size of the four classes of setts, as given by the number of entrances: means derived using totals of active and inactive setts.

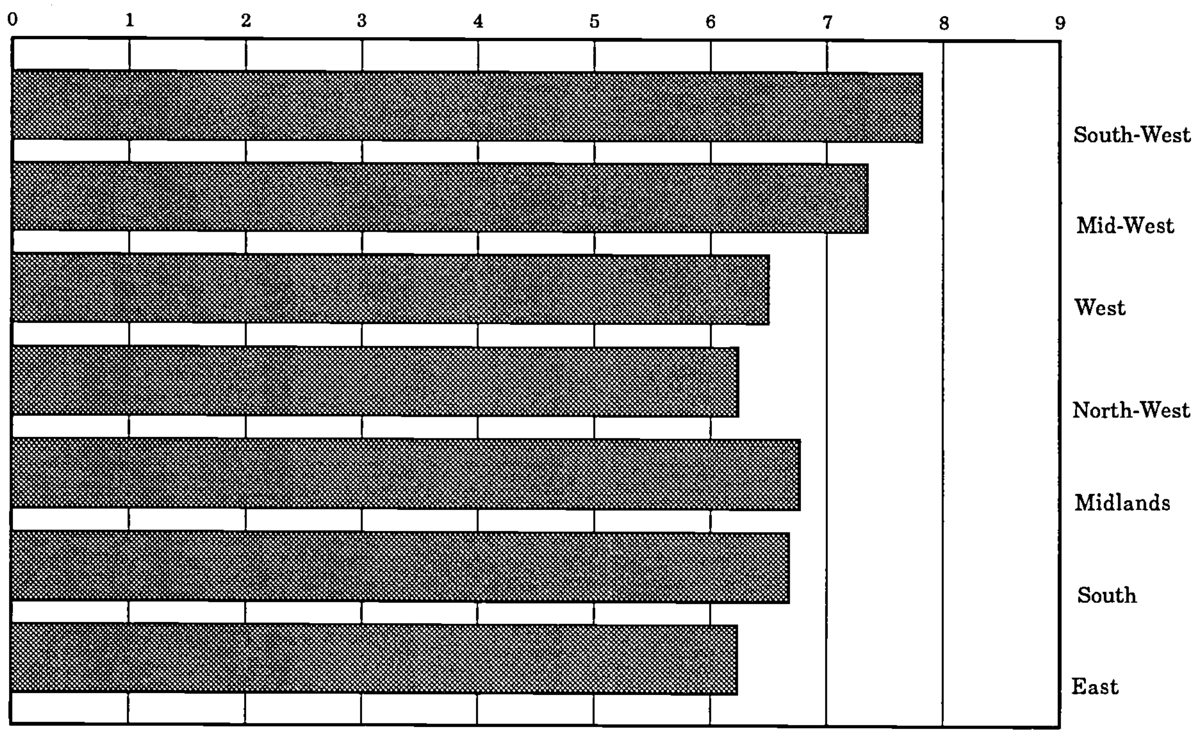


Figure 18. Regional variation in main sett size, as given by the total number of entrances.

Sett activity

Not all entrances to an active sett are as well used as others, and, of course, many setts recorded no active use. Overall, 83.8% of all main setts were active, 81.4% of annexe setts, 70.6% of subsidiary setts and 59.1% of outlier setts.

It is likely there were differences in interpretation of entrance use by different observers. Particularly well-used entrances were obvious, being entirely clear of vegetation, perhaps newly cleared with fresh spoil. However, prior field experience in the area studied by P. Sleeman in West Cork clearly showed that vegetation was often present in very active main and annexe setts, though such vegetation showed signs of being trodden and trampled, with the entrance remaining quite clear. Rangers were thus requested not to classify entrances as partially used on the basis of vegetation being present alone but to observe the type of debris and the degree of trampling. In the recording of unused entrances, this was clear if such entrances were collapsed, partially collapsed or blocked, but some confusion between its classification as a disused entrance and as a partially-used entrance could arise when an entrance was disused for some time and large amounts of leaves or debris had accumulated. It was made clear to observers that the classification of any entrance of a sett as partially-used would result in the sett being classed as in use by badgers, and that the interpretation should bear this in mind. On this basis, Figure 19 shows the proportions of entrances according to

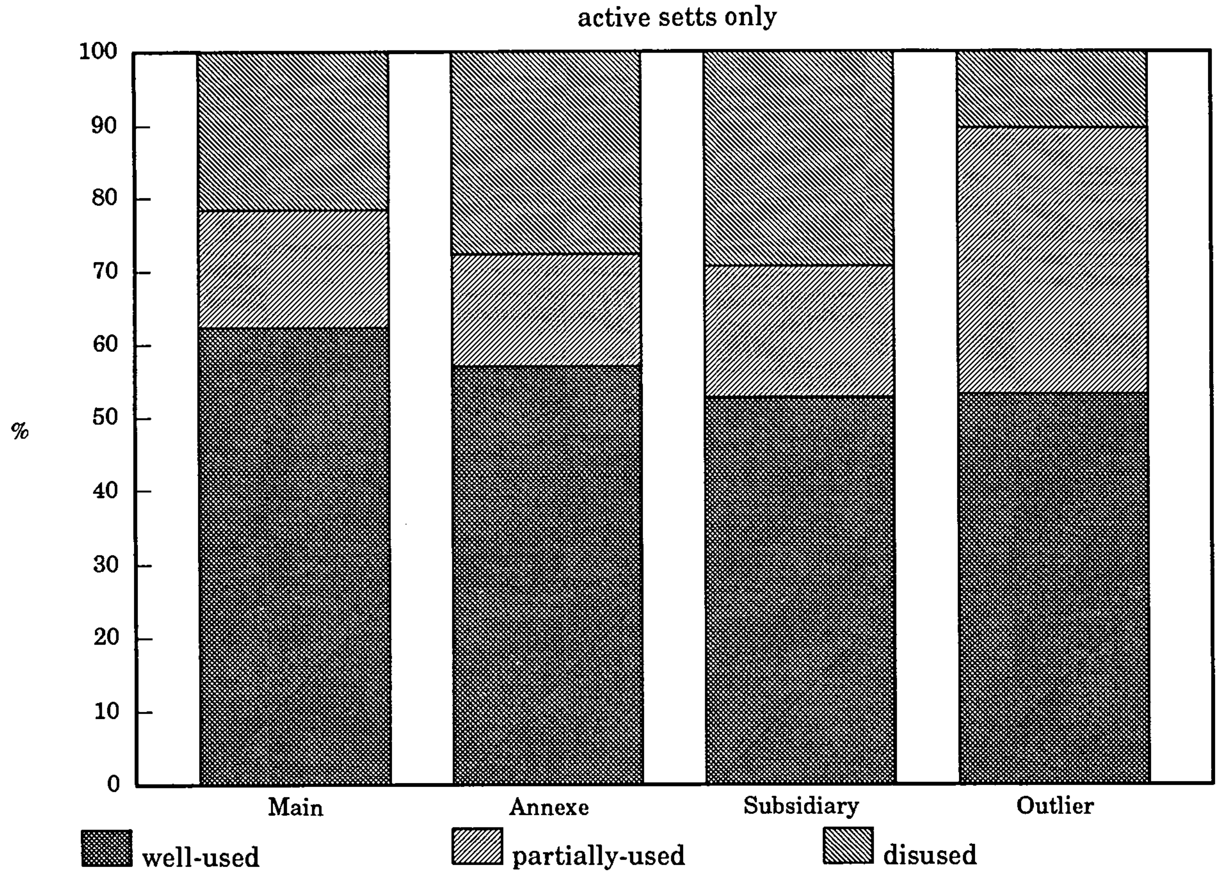


Figure 19. Sett activity, as given by the proportion of entrances active.

whether they were well-used, partially-used or inactive. Only active setts are considered, as disused setts would have possessed only disused entrances. Values are given in Table 7.

Signs of activity

Where setts were recorded as being active, tracks were the most frequent indicator and noted as being present at the majority of active setts (Table 8). Bedding was noted as the next most frequent indicator with 50%, overall, of setts possessing some bedding remains around the sett entrances. Since active main setts are in continuous use and are breeding setts, most setts identified as main setts had bedding (81%). The presence of bedding was also frequent at annexe setts (50%) and less so at subsidiary and outlier setts. Latrines were found in the vicinity of most active main setts (59%) but less so at the other sett categories. Other indicators such as hairs and scratching posts were common but less frequent than tracks, bedding and latrines.

Cattle presence in the vicinity of setts

Table 8 also gives the proportions of setts that had cattle grazing in their vicinity. In these cases, cattle were either able to access and nose sett entrances, or the sett was located very close to a boundary/field where cattle were present, so that it could be reasonably considered that cattle would be in regular contact with or highly likely to come into contact with contaminated pasture, badger carcasses or active badgers. The majority of active setts (78%) were found to be located within cattle grazing or immediately adjacent to it. The proportion varied only slightly with sett category.

Table 7. Entrance use for the four sett categories, given by the mean number of entrances classed as well-used, partially-used or disused.

	Main	Annexe	Subsidiary	Outlier
All setts				
Well-used	3.74	1.92	1.13	0.42
Part-used	0.97	0.51	0.40	0.29
Disused	2.17	1.59	1.46	0.63
Active setts only				
Well-used	4.47	2.35	1.60	0.72
Part-used	1.16	0.63	0.54	0.49
Disused	1.55	1.15	0.89	0.14

Table 8. Signs of occupation observed at active badger setts, only, and presence of cattle in the general vicinity of these active setts, given by the percentage of setts observed with signs.

	Latrines	Bedding	Hairs	Posts	Tracks	Other signs	Cattle
Main setts	59.4	81.0	39.5	10.4	86.9	6.5	75.4
Annexe setts	34.6	50.0	22.8	5.2	83.8	3.7	75.0
Subsidiary setts	27.1	35.4	24.8	8.6	77.7	5.7	79.3
Outlier setts	17.2	18.1	22.3	4.7	71.2	9.3	80.9
All setts	36.8	49.0	28.9	7.9	80.2	6.5	77.7

Other occupants

Many setts were found to be used by foxes or rabbits, even in the presence of badgers. It was not a rare occurrence to find evidence of foxes breeding within an active main sett. Setts not in use by badgers were, however, much more likely to have other occupants. The overall frequency of foxes and rabbits utilising all badger setts and only disused setts is given in Table 9. The only other mammalian species recorded as inhabiting a badger sett was the brown rat *Rattus norvegicus*: it is probable that this species was under-recorded as signs of its presence at setts would generally not be obvious.

Table 9. Use of sett by foxes and rabbits.

Sett category	Foxes %	Rabbits %
All main setts	6.0	16.7
Disused main setts	10.8	36.9
All annexe setts	3.0	17.4
Disused annexe setts	12.9	45.2
All subsidiary setts	7.4	18.2
Disused subsidiary setts	15.3	28.2
All outlier setts	3.6	19.2
Disused outlier setts	5.4	23.5

Further details of sett use by other species, and of sett sharing between species, are given in Table 10. In total, there were 33 setts recorded as being shared by badgers and foxes - and, of these, 7 setts also had rabbits recorded as being present. Rabbits and foxes were also recorded at 9 further setts, which were disused by badgers. In total, 140 setts were shared by badgers and rabbits.

Human disturbance to setts and badgers

A summary of disturbance to setts reveals (Table 11) regional variation, with few setts being disturbed in the Mid-West (3.6%) but a high proportion in the East (26.0%). Apart from the South-West at 10.6%, all other regions showed sett disturbance at around 15-20% of setts affected. Generally, as might be expected, main setts were more likely to be disturbed than other sett types. In total, 14.8% of setts were disturbed, and the breakdown according to sett type was: 20.6% of main setts, 16.2% of annexe setts, 14.8% of subsidiary setts, and 8.0% of outlier setts. Figures given in Table 12 reveal that disused setts were more likely to show signs of disturbance: this was to be expected as common forms of disturbance, such as digging, would often, though not always, lead to abandonment of the sett or destruction of an entire social group.

Table 10. Details of sett use and sett sharing by two or more species.

Species present	Sett category: Main	Annexe	Subsidiary	Outlier
Sett totals	402	167	445	364
Foxes alone				
No. of setts	5	3	19	6
%	1.2	1.8	4.3	1.7
Rabbits alone				
No. of setts	22	11	32	33
%	5.5	6.6	7.2	9.1
Foxes and badgers				
No. of setts	11	1	9	5
%	2.7	0.6	2.0	1.4
Rabbits and badgers				
No. of setts	37	17	44	35
%	9.2	10.2	9.9	9.6
Badgers, Foxes and Rabbits				
No. of setts	4	0	2	1
%	1.0	0.0	0.5	0.3
Rabbits and foxes, no badgers				
No. of setts	4	1	3	1
%	1.0	0.6	0.7	0.3

Table 11. Overall disturbance levels to setts, on a regional basis. Percentages given are those of the proportion of setts disturbed within the regional total recorded within each sett category.

	Main		**Annx.**		**Subsd.**		**Outlier**		**Totals**	
	no.	**%**	**no.**	**%**	**no.**	**%**	**no.**	**%**	**no.**	**%**
South-West	13	16.7	4	11.4	7	8.6	5	6.2	29	10.6
Mid-West	6	10.5	0	0.0	2	2.2	0	0.0	8	3.6
West	11	23.9	4	20.0	2	9.5	2	9.5	19	17.6
North-West	5	15.2	3	20.0	10	33.3	1	5.6	19	19.8
Midlands	20	20.8	4	12.9	27	21.8	13	11.6	64	17.6
South	13	28.3	4	23.5	6	10.7	2	4.9	25	15.6
East	14	30.4	8	40.0	12	27.9	6	13.3	40	26.0
totals	82	20.4	27	16.2	66	14.8	29	8.0	204	14.8

The sample sizes on a county by county basis are small for some counties (Table 12) and thus statistically unreliable. The figures would suggest that disturbance to setts is particularly high in Cos. Carlow, Cavan, Galway, Kildare, Laois, Longford, Offaly, Sligo and Wicklow. In these cases, over 20% of setts have been affected by disturbance of one form or another: it should be noted that surveyors were requested to note any signs of such disturbance, even if such appeared old, and it is not possible to estimate an annual rate of disturbance. Some signs were those of digging in the past - these signs may persist for many years, though in almost all cases it was believed that digging occurred within the previous 2 years.

The types of disturbance observed were varied and included digging, blocking, burning, official removal, snaring, land development, slurry and others. Some of these are deliberate activities and others 'accidental' or incidental, occurring as a result of agricultural improvement or other land development. A summary of the types of disturbance occurring to setts is shown in Figure 20. This reveals that digging is the main cause of disturbance, with blocking and land development also being frequent causes of disturbance to setts. On some occasions, setts had been dug and then blocked: in such cases, damage was noted in one category only - as digging. Burning, snaring, official removal and dumping of slurry were noted but each of these activities constituted a small proportion of overall sett disturbance. The category 'other' includes evidence of disturbance such as cartridges and badger carcasses, evidence of poisoning or gassing, reliable local reports or knowledge of badgers being killed at setts, and disturbance such as digging by dogs (not by spade).

Regional variation in type of sett disturbance is given in Table 13. The sample sizes are small for three regions (<20). Land development is a major cause of sett disturbance in the East (37.5%) and a common cause in the West and South-West (21.1% and 17.2%). Digging was the major disturbance to setts in 5 regions. Sett blocking contributed to more than 30% of disturbance to setts in 3 regions (South-West, Mid-West and South). In the North-West, setts known to have been affected by official removal comprised 31.6% of all disturbed setts in that region.

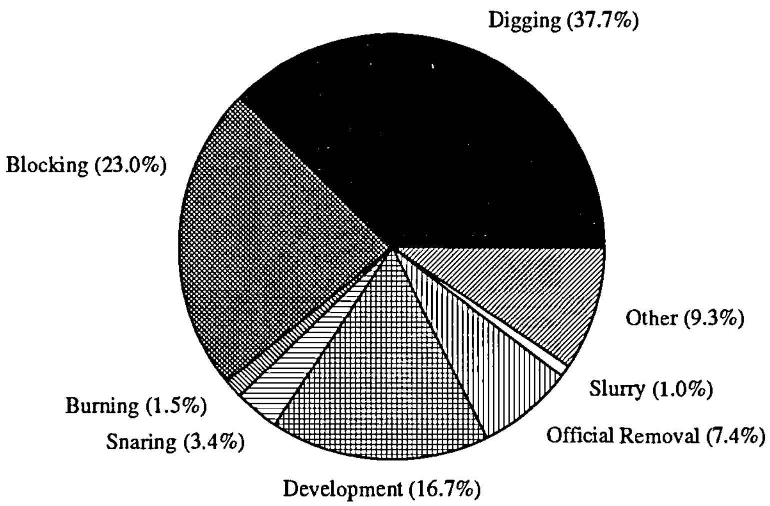


Figure 20. Pie chart showing types of disturbance to setts: summary for all regions in the Republic.

Table 12. Overall disturbance levels to setts, on an individual county basis. The number of setts disturbed is given and the percentage disturbed of the total setts in the sett category.

County	Main	Annx.	Subsd.	Outl.	Total disturbed and % of all setts	Number of active setts disturbed and % of total active setts	Number of disused setts disturbed and % of total disused setts
Carlow							
n	3	0	3	1	7	4	3
%	50.0	0.0	42.9	25.0	38.9	36.4	42.9
Cavan							
n	1	2	1	2	6	6	0
%	16.7	100.0	20.0	28.6	30.0	31.6	0.0
Clare							
n	2	0	1	0	3	1	2
%	8.7	0.0	2.1	0.0	2.7	1.1	9.1
Cork							
n	11	3	5	5	24	10	14
%	20.8	13.0	9.3	7.5	12.2	7.2	24.1
Donegal							
n	3	1	6	0	10	2	8
%	14.3	9.1	46.2	0.0	17.9	5.9	36.4
Dublin							
n	0	0	2	1	3	1	2
%	0.0	0.0	40.0	12.5	13.6	5.3	66.7
Galway							
n	9	3	2	0	14	10	4
%	50.0	50.0	28.6	0.0	31.1	28.6	40.0
Kerry							
n	2	1	2	0	5	2	3
%	8.0	8.3	7.4	0.0	6.4	4.3	9.4
Kildare							
n	2	4	1	4	11	3	8
%	18.2	80.0	16.7	40.0	34.4	21.4	44.4
Kilkenny							
n	8	3	5	2	18	12	6
%	29.6	25.0	13.2	5.9	16.2	12.1	50.0
Laois							
n	3	0	4	2	9	6	3
%	27.3	0.0	33.3	15.4	22.5	20.7	27.3
Leitrim							
n	0	1	0	0	1	1	0
%	0.0	50.0	0.0	0.0	5.3	6.3	0.0
Limerick							
n	3	0	1	0	4	3	1
%	13.6	0.0	3.6	0.0	5.1	4.8	6.7

Table 12 contd.

County	Main	Annx.	Subsd.	Outl.	Total disturbed and % of all setts	Number of active setts disturbed and % of total active setts	Number of disused setts disturbed and % of total disused setts
Longford							
n	1	0	2	0	3	1	2
%	33.3	0.0	28.6	0.0	23.1	12.5	40.0
Louth							
n	0	0	3	0	3	2	1
%	0.0	0.0	37.5	0.0	13.6	10.0	50.0
Mayo							
n	2	1	0	1	4	0	4
%	10.5	16.7	0.0	33.3	11.1	0.0	36.4
Meath							
n	9	0	8	2	19	9	10
%	33.3	0.0	16.0	5.4	15.6	11.1	24.4
Monaghan							
n	1	0	0	0	1	1	0
%	12.5	0.0	0.0	0.0	5.9	8.3	0.0
Offaly							
n	4	1	7	5	17	5	12
%	25.0	14.3	33.3	23.8	26.2	10.4	70.6
Roscommon							
n	0	0	0	1	1	1	0
%	0.0	0.0	0.0	25.0	3.7	4.0	0.0
Sligo							
n	2	1	4	1	8	7	1
%	28.6	50.0	36.4	33.3	34.8	36.8	25.0
Tipperary							
n	3	1	1	0	5	1	4
%	13.6	16.7	4.2	0.0	7.8	2.2	22.2
Waterford							
n	3	0	0	0	3	3	0
%	33.3	0.0	0.0	0.0	15.8	18.8	0.0
Westmeath							
n	1	1	2	2	6	4	2
%	6.3	16.7	12.5	8.3	9.7	9.5	10.0
Wexford							
n	3	2	2	0	7	5	2
%	25.0	66.7	18.2	0.0	17.9	16.7	22.2
Wicklow							
n	6	2	4	0	12	5	7
%	50.0	28.6	28.6	0.0	27.9	27.8	28.0

Table 13. Regional variation in disturbance to setts, by type of disturbance.

i) percentage of total setts in each region

Region	Blocking	Digging	Burning	Snaring	Development	Official Removal	Slurry	Other	Totals
South-West	3.6	4.0	0.0	0.0	1.8	0.4	0.0	0.7	10.5
Mid-West	1.4	0.9	0.5	0.0	0.0	0.0	0.0	0.9	3.6
West	2.8	8.3	0.0	1.9	3.7	0.0	0.0	0.9	17.6
North-West	4.2	7.3	0.0	0.0	2.1	6.3	0.0	0.0	19.8
Midlands	4.4	7.4	0.6	0.6	1.7	2.2	0.3	0.6	17.6
South	6.3	7.5	0.0	0.0	1.3	0.0	0.0	0.6	15.6
East	0.6	5.8	0.0	1.9	9.7	0.0	0.6	7.1	26.0
Totals	**3.4**	**5.6**	**0.2**	**0.5**	**2.5**	**1.1**	**0.1**	**1.4**	**14.8**

ii) type of disturbance to setts by number of setts affected and by percentage of each disturbance type

Region	Blocking	%	Digging	%	Burning	%	Snaring	%	Development	%
South-West	10	34.5	11	37.9	0	0.0	0	0.0	5	17.2
Mid-West	3	37.5	2	25.0	1	12.5	0	0.0	0	0.0
West	3	15.8	9	47.4	0	0.0	2	10.5	4	21.1
North-West	4	21.1	7	36.8	0	0.0	0	0.0	2	10.5
Midlands	16	25.0	27	42.2	2	3.1	2	3.1	6	9.4
South	10	40.0	12	48.0	0	0.0	0	0.0	2	8.0
East	1	2.5	9	22.5	0	0.0	3	7.5	15	37.5
Totals	**47**	**23.0**	**77**	**37.7**	**3**	**1.5**	**7**	**3.4**	**34**	**16.7**

Region	Official Removal	%	Slurry	%	Other	%	Totals	%
South-West	1	3.4	0	0.0	2	6.9	29	100.0
Mid-West	0	0.0	0	0.0	2	25.0	8	100.0
West	0	0.0	0	0.0	1	5.3	19	100.0
North-West	6	31.6	0	0.0	0	0.0	19	100.0
Midlands	8	12.5	1	1.6	2	3.1	64	100.0
South	0	0.0	0	0.0	1	4.0	25	100.0
East	0	0.0	1	2.5	11	27.5	40	100.0
Totals	**15**	**7.4**	**2**	**1.0**	**19**	**9.3**	**204**	**100.0**

Descriptions of modern 'sporting' activity concerning badgers (*i.e.* badger-baiting and digging) are given by Anon (1985) and Griffiths (unpublished); see also Griffiths (1991).

[Additional data on disturbance levels to setts are presented at a later stage (in Table 29), when disturbance to setts recorded in the National Badger Survey is compared with disturbance levels recorded to setts surveyed in areas licensed for badger removal operations. Disturbance levels to setts in use and disused are also compared].

Soil types at setts

Figure 21 illustrates the soil types (as given by texture) in which setts are located in the Republic. The soil types are of a general nature, identified in the field by texture, with a sample of soil being taken from the spoil heap or from within the walls of the sett's entrances. On occasion, two soil types may be associated with one sett, but surveyors were asked to identify one principal type only, and note any others in sett record notes. The soil types were determined from a key adapted from that given by Harris *et al* (1989): the key is described on the following page.

Badgers build setts in a wide range of soil types. However, over 70% of setts were located in 7 of the 15 soil categories. Whilst silts and peats are generally avoided, this is to be expected in view of lower badger densities in peat, moorland, and upland areas of Ireland, including the West and North-West. Whether these soil-sett associations arise from a positive preference or relate merely to distribution of soil types cannot be determined without data on the abundance/occurrence of soil types in the survey squares. This matter is to be addressed in the project proposals submitted by Smal (November 1992). Distributions according to soil type are illustrated in Figures 22 to 28 for each region and tabulated in Appendices A3 and A4.

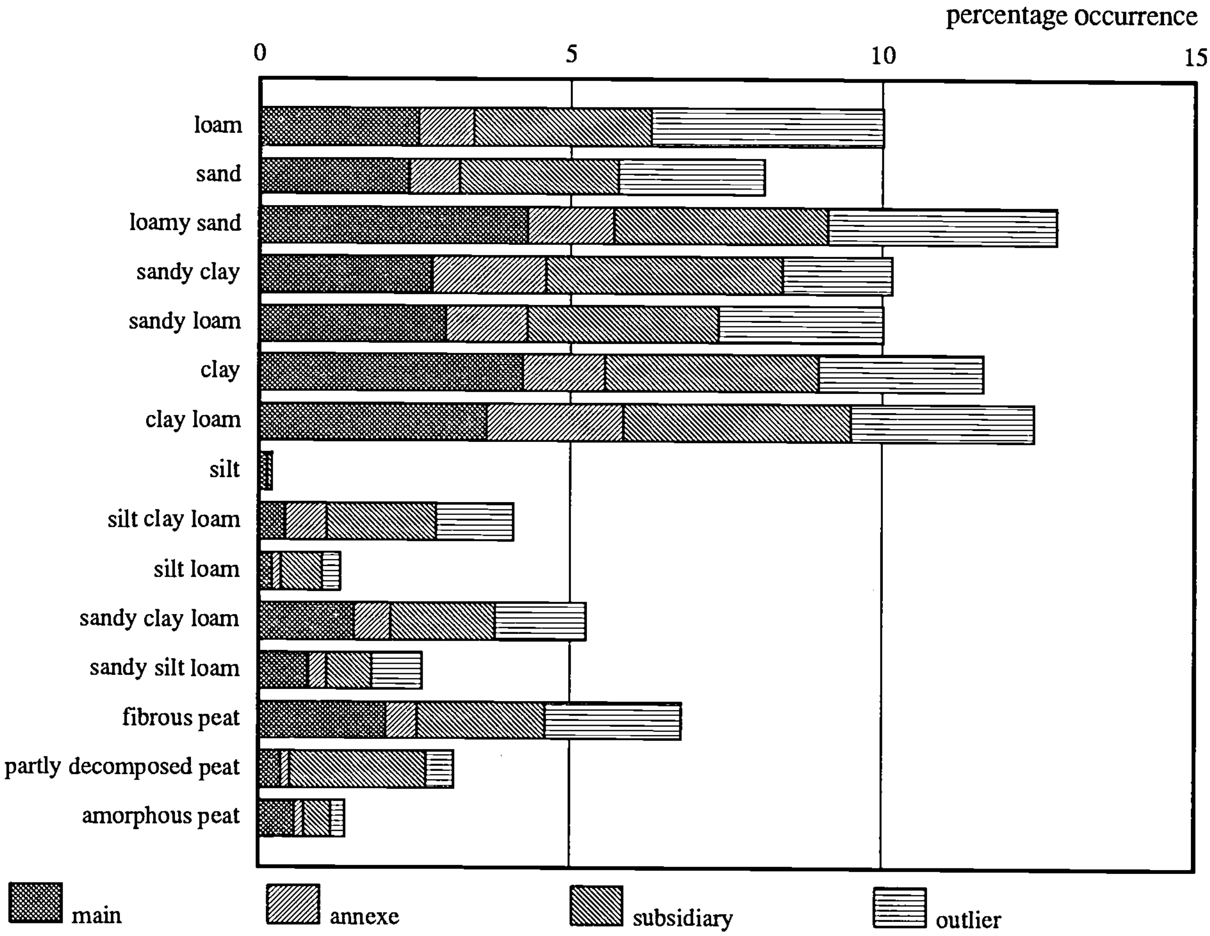


Figure 21. Sett distribution according to soil types observed at sett sites.

SOIL CLASSIFICATION KEY

A: Rub between fingers

1 Gritty >B
2 Sticky >C(i)
3 Silky >C(ii)
4 Sticky and gritty >C(iii)
5 Silky and gritty >C(iv)
6 None of these, but black >D
7 None of these, nor black = LOAM (1)

B: Try to mould into a roll

i cannot; does not stick or mark the skin = SAND (2)

ii roll formed and marks skin
a) roll breaks when bent double = LOAMY SAND (3)
b) roll does not break
1) surface can be polished with thumb
= SANDY CLAY (4)
2) surface cannot be polished
= SANDY LOAM (5)

C: Roll soil into ball and polish with thumb

i sticky
a) ball resists deformation = CLAY (6)
b) ball fairly resistant to deformation
= CLAY LOAM (7)

ii silky
a) ball fairly resistant to deformation
= SILT (8)
b) ball has little or no cohesion = SILT CLAY LOAM (9)
c) ball smooth; fairly resistant to deformation
= SILT LOAM (10)

iii sticky and gritty; can be balled and polished = SANDY CLAY LOAM (11)

iv silky and gritty; can be balled but not polished = SANDY SILT LOAM (12)

D: Peat

i firm, coherent, tough, not plastic, plant structures visible, often spongy
= FIBROUS PEAT (13)

ii may appear fibrous, soft, becoming paste-like under pressure
= PARTLY DECOMPOSED PEAT (14)

iii plastic when wet, powdery when dry, no plant remains visible
= AMORPHOUS PEAT (15)

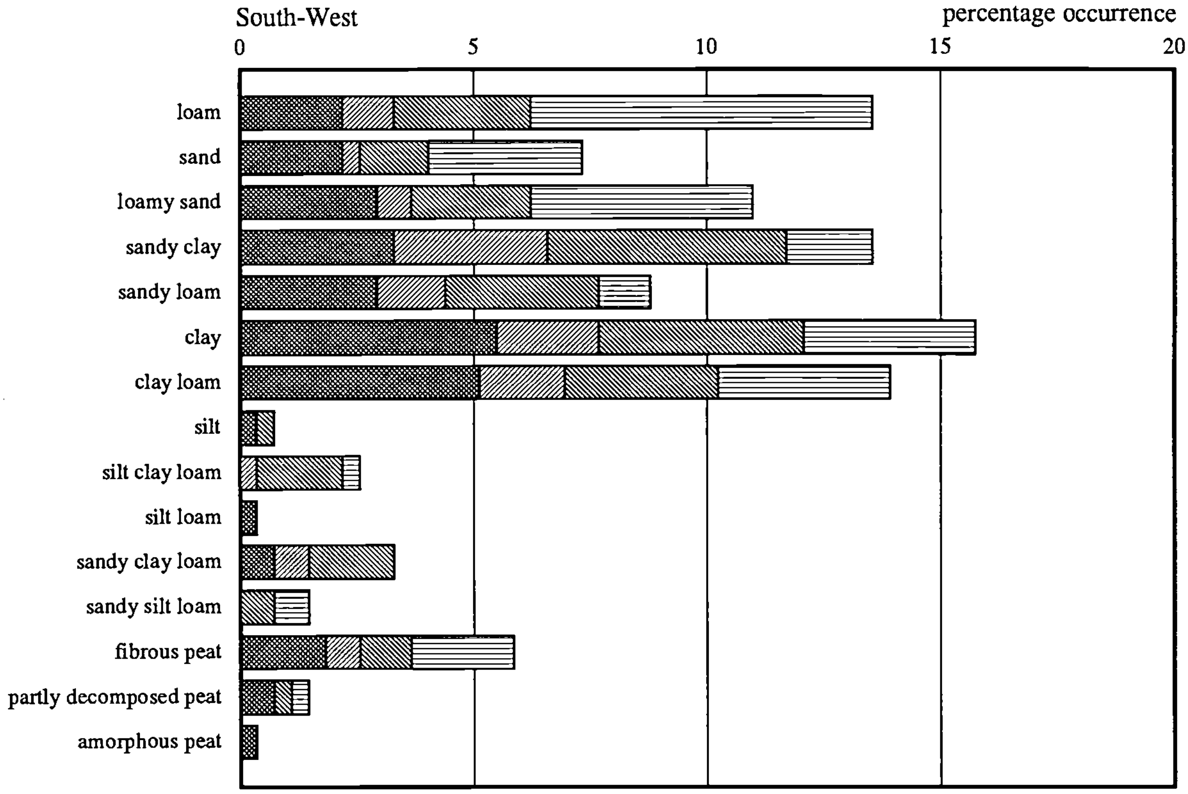


Figure 22. Sett distribution by soil type: South-West Region. Key as in Figure 21.

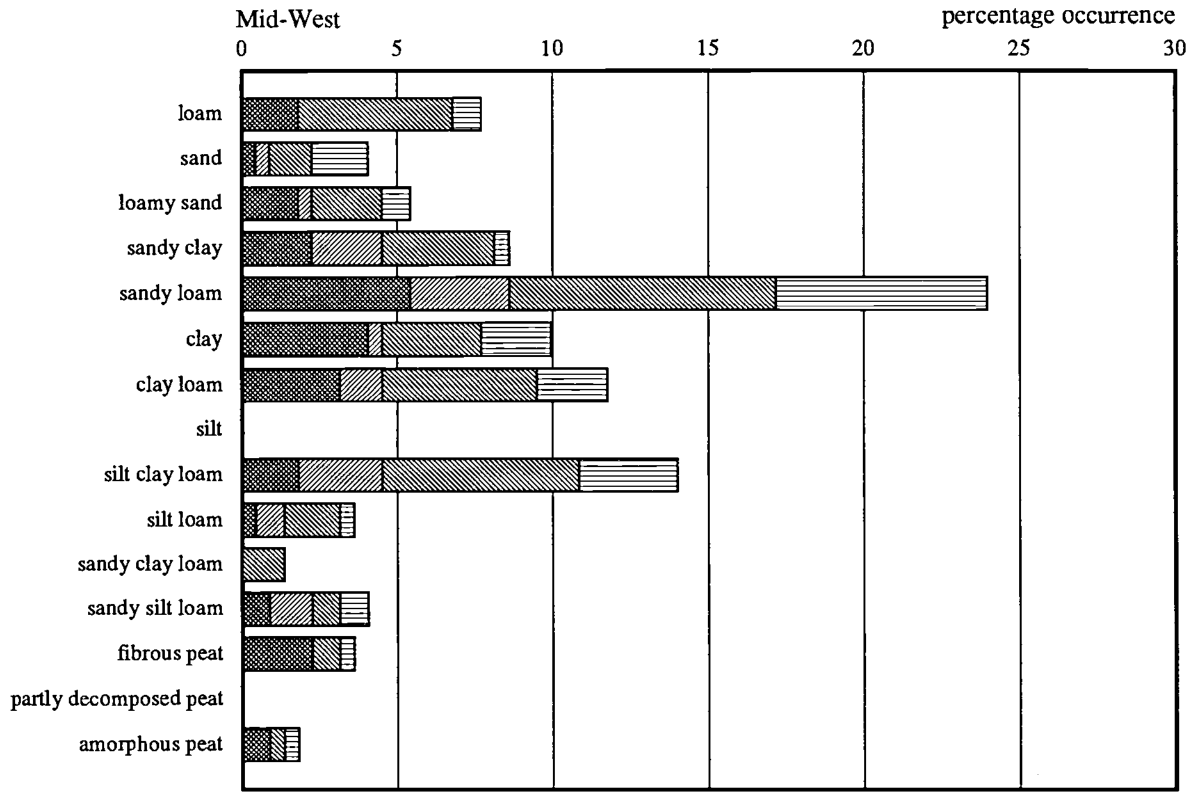


Figure 23. Sett distribution by soil type: Mid-West Region. Key as in Figure 21.

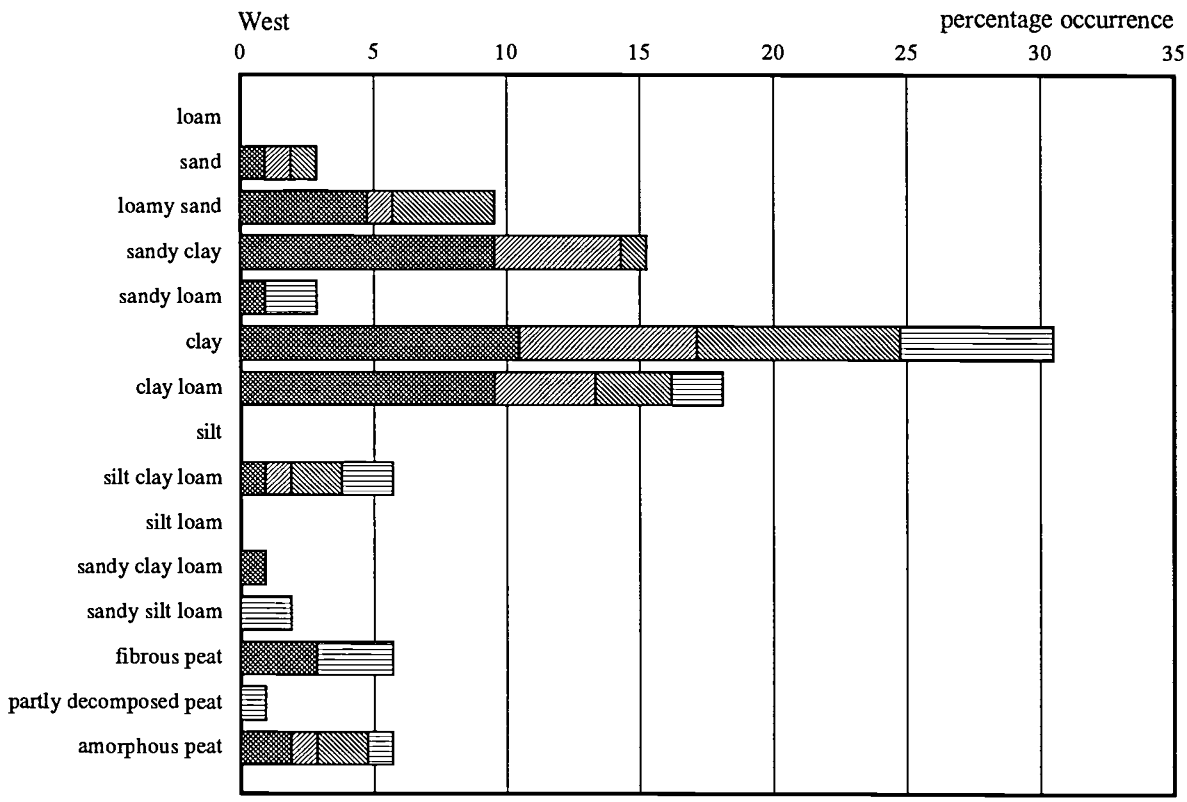


Figure 24. Sett distribution by soil type: West Region. Key as in Figure 21.

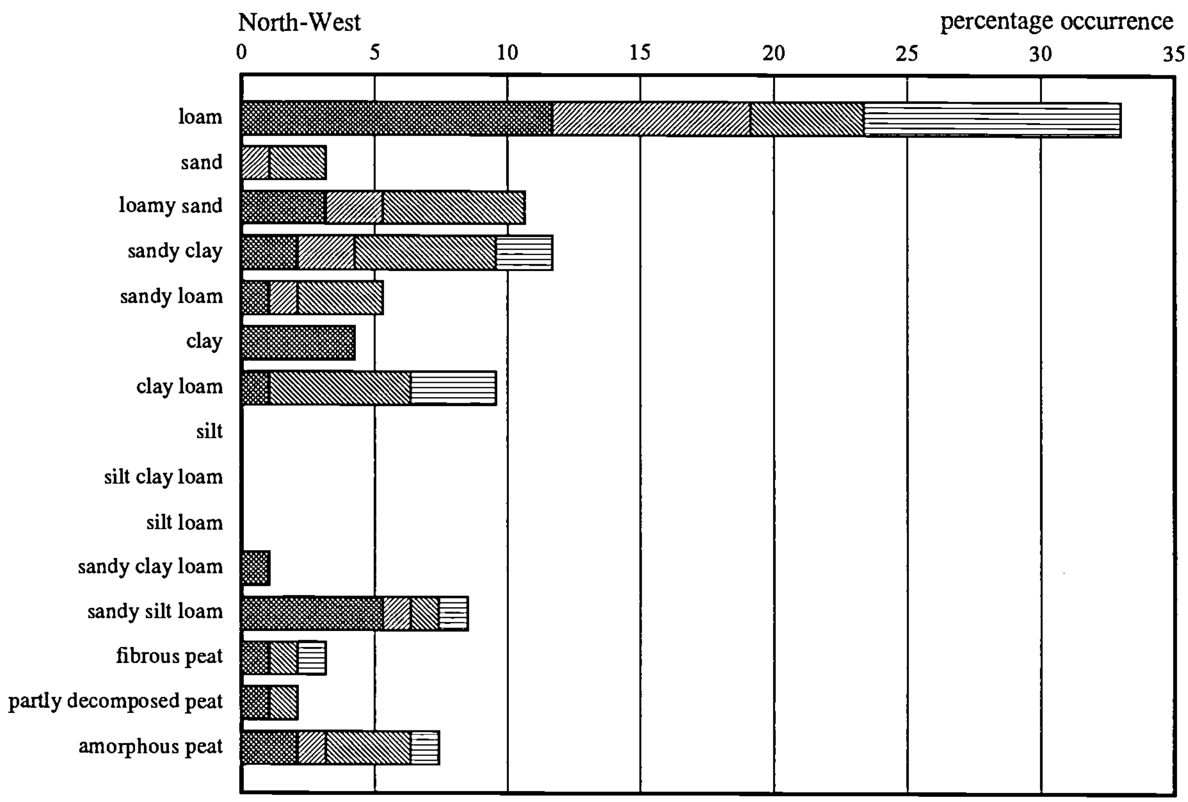


Figure 25. Sett distribution by soil type: North-West Region. Key as in Figure 21.

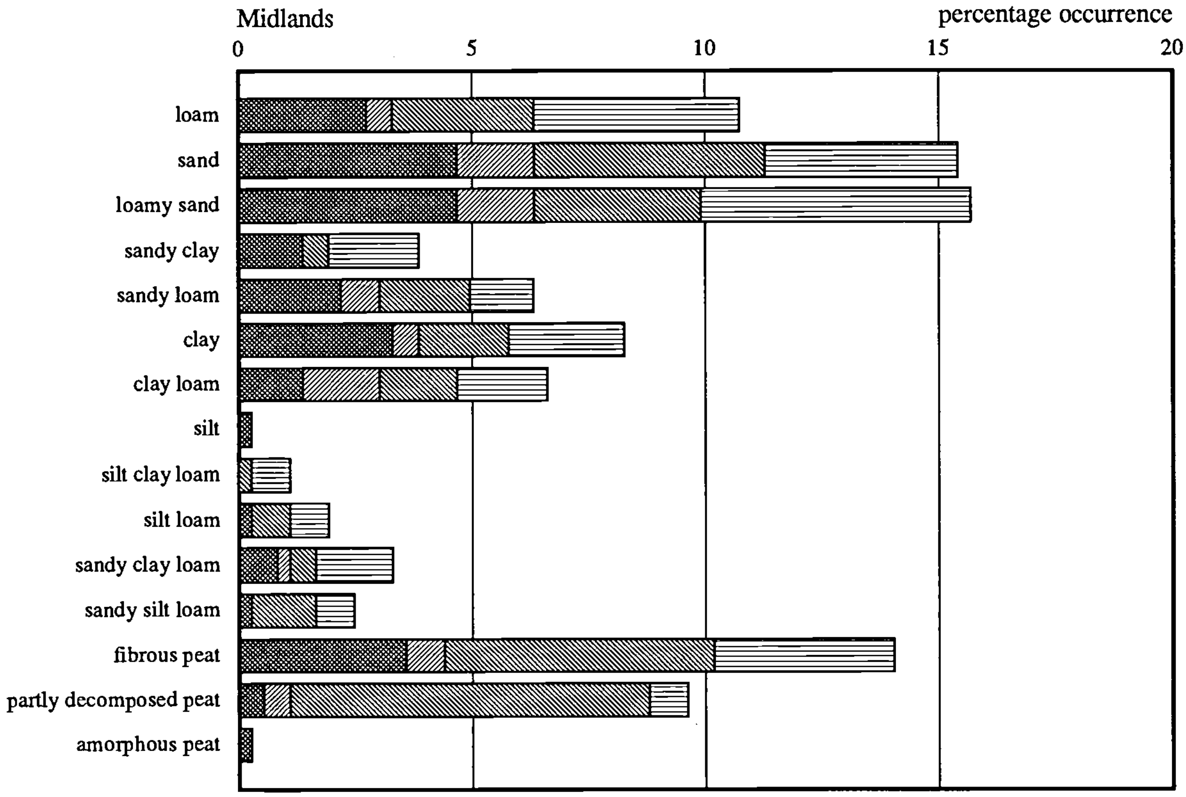


Figure 26. Sett distribution by soil type: Midlands Region. Key as in Figure 21.

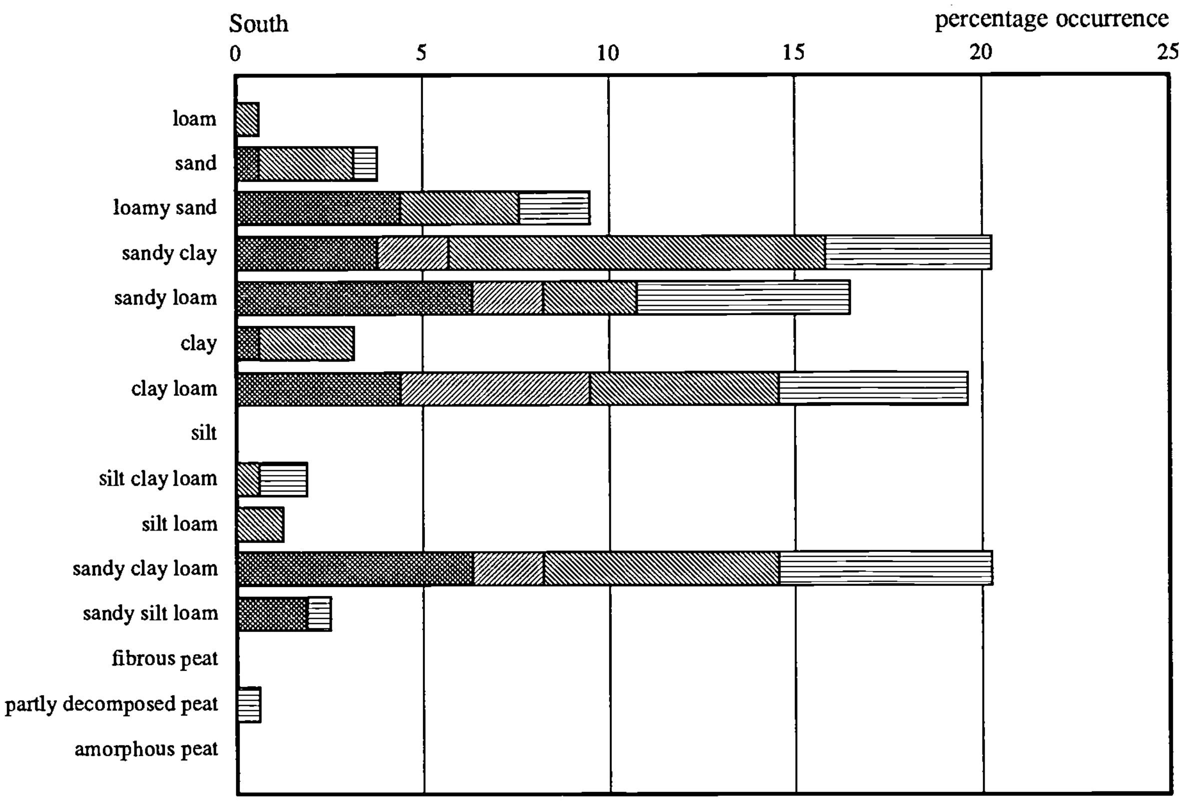


Figure 27. Sett distribution by to soil type: South Region. Key as in Figure 21.

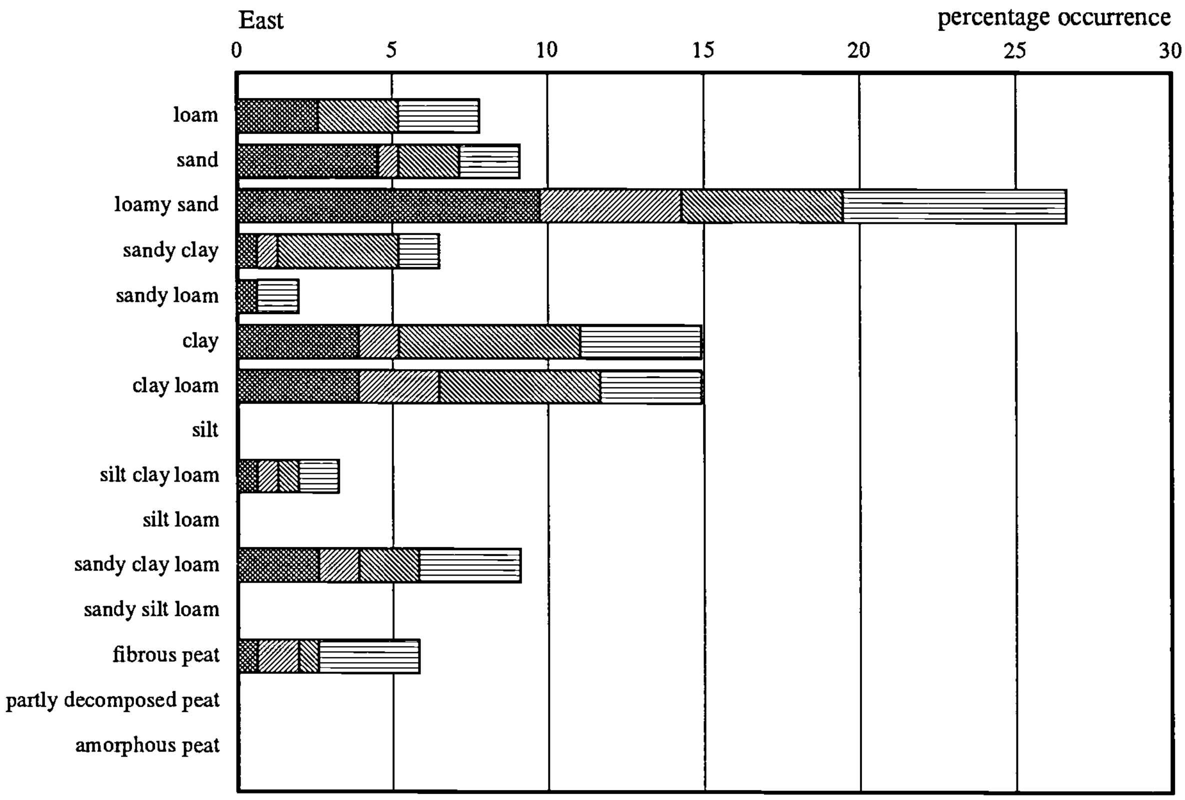


Figure 28. Sett distribution by soil type: East Region. Key as in Figure 21.

The figures illustrate marked regional differences between soil types in which setts were located, which must largely arise from the regional distribution of soil types. In the Midlands, setts in peat are more frequent than in any other region: given that badger density is higher than in other regions with large areas of peat, this is to be expected. Raised bog edges, often adjoining grazing or arable land are ideal sett sites for badgers (as the 1km square with 35 setts exemplified): such edges, usually with adjoining drains, result in dry peat soils, extremely easy to dig. In the West and North-West, where peats are often blanket bogs and overall badger density is low, badgers are more frequent and construct setts where sandy or clay soils occur. In the West, over 30% of setts were located in clay soils. The high proportion of setts identified in loams in the North-West is unexpected, however, though partially mirrored in the in the South-West, where the second highest frequency of setts in loams was found. The general lack of setts in peat in the South and East indicates a lack of peat soils in these regions. In the South-West, there is a fairly even distribution of setts across soil types, reflecting the wide range of soil types found in this region - from the prime grazing and arable areas of East Cork to the poorer badger habitats of the extreme west and upland areas.

Without reference to the proportions of soil types occurring in the surveyed squares, it is only possible to generally conclude that sett distribution according to soil type is determined by a combination of overall badger density and the types of soils that occur within a region.

Badger density and sett location according to habitat and landscape

The badger sett survey also noted the habitat in which each sett was located. Additionally, the overall landscape of each 1km square was described by reference to a land classification guide, which had been developed for Britain at the Institute of Terrestrial Ecology.

Setts were found to be more frequent in certain habitat types, such as hedgerow, and the size of setts also varied according to the habitats in which they were found. The mean density of setts in an area also varied with the landscape of the area.

The results for sett location according to habitat type and landscape class are presented in a later section (# *Abundance and distribution of badgers in Ireland*, page 192), following a description of the methodology involved in the habitat survey of each square (# *Habitat survey*, next page).

Mean badger social group densities for each county were re-calculated to take into account areas of sea, lake, coastal mudflats and beaches, with analyses of badger density according to habitat type then being performed upon these corrected data sets. This conforms with the approaches adopted by Cresswell *et al* (1990) and Thornton (1988). The badger sett survey has limitations in that it does not directly assess badger numbers, but indirectly through an enumeration of badger setts only. Some of these limitations have been addressed through the studies of badger removal areas (# *Studies involving badger removal areas*, page 129), but these studies were not sufficiently detailed to allow for refinements to the sett data on a county by county or regional basis.

HABITAT SURVEY

Methods

Mapping of habitats

Along with the survey of setts, detailed maps of the habitats occurring in each square were prepared, as illustrated in Figure 5. On the basis of the habitats used by Harris *et al* (1989), 40 principle habitat types were identified by surveyors. These can be related to the Nature Conservancy Council's National Vegetation Classification (Rodwell, quoted in Cresswell *et al*, 1990). Additionally, some habitat subdivisions were added in these studies:

Habitat 2 (treeline) was sub-divided into bare treeline [2B] (with little ground cover or 'hedge') and treeline (which differs from hedgerow principally in height only). Habitat 6 (coniferous plantation) was subdivided into young [6Y] and mature plantation [6]. Habitat 40 (built land) was later separated into two categories in the laboratory: labelled 40 for areas of built land comprising buildings, dwellings and gardens, *etc.*) and 41 (areas of road and laneway), and also re-totalled in a category named 40/41. Category 42 identified areas of sea. In early stages of the habitat surveys, it was noted that, because of the large areas of commercially exploited (worked) peat in Ireland (unlike Britain), surveyors were recording cut or bare areas of peat separately from the categories 20 (blanket bog), 21 (raised bog) or bare ground [39]. Since such cut areas are vegetationally identical, a new category labelled 20/21W was added to the analyses. The arable category [33] was subdivided according to crop, namely, arable seedcrops [33B], arable rootcrops [33R], arable horticultural crops [33H] and arable grassland keys [33G]; the totals were given within the category labelled 33.

In total, therefore, the Irish habitats have been grouped within 49 principal categories. These are listed below. In many respects, the habitat survey work proved a more daunting task to surveyors than the badger sett survey: different habitat types often form a continuum and the categorisation of many vegetation zones requires a subjective decision as to their nature and into which category they may best be included. Patchwork habitats (*e.g.* a neglected grass field with substantial areas of gorse) proved awkward.

The identification of many habitats according to the numbered list also depends on the detail in which they are examined, as in the case of patchwork habitats. Only habitats of a certain size were to be marked on the habitat maps. Any habitat greater than 50 m in length or 500 m^2 was to be recorded. Whilst the degree of detail recorded by observers did vary, most surveyors did, in practice, record habitat details with a greater degree of precision than these size requirements, with features of about 25 m in length being included and habitats such as roads and buildings, rivers, *etc.* were marked quite accurately, given that their boundaries were usually clearly already defined on the OS maps. Surveyors occasionally resorted to marking areas difficult to categorise with 2 habitat numbers.

Surveyors were all provided with sets of 12 colouring pencils. Most 1km squares did not possess more than seven or eight habitat types, so there were usually sufficient colours to separately identify the habitats within each square. It was not considered practical to suggest a colouring scheme involving 45 different colours, and surveyors were requested to adopt their own colouring schemes, but following general guidelines.

With the exception only of hedgerows, each habitat had to be numbered clearly on the map. Some observers used keys accompanying the map to identify the colours used. Hedgerows had to be marked in clearly as curly or zig-zag dark blue lines and treelines in black straight lines, with an identifying label to distinguish them as either habitat 2 or 2B. All waterways (fresh water) were marked in light blue and identified with a label to distinguish categories 27 (natural water courses) from 28 (canalised watercourses, including field drains with running water). Woodlands were to be usually marked in dark green, and pastureland in light green. Areas of scrub or bracken were usually to be marked in brown, orange or yellow, as were areas of moorland and bog (usually dark brown), with the surveyor choosing colours appropriate to the colour types of adjacent habitat categories. Arable land was generally marked in light brown. Cliffs, quarries and bare ground were usually marked in grey or purple. All built land had to be coloured in red only.

Tippex was supplied to surveyors, which was to be used for correcting errors and deleting extinct field boundaries. Alternatively, extinct field boundaries could be clearly marked as such with a cross-hatch on the map. New boundaries were to be marked in with a pencil and coloured or enumerated appropriately.

In certain areas of the country, stone walls commonly distinguished field boundaries, as did bare fence lines in others. Some surveyors marked these in with a key or annotation, but these boundaries were not taken into consideration in subsequent analyses, as there would have been lack of uniformity in their recognition by different surveyors. These boundary delineations were usually left uncoloured if they also appeared on the OS map, or drawn in as a pencil or biro line, again uncoloured and not numbered.

Certain difficulties were encountered in completion of habitat maps, as outlined below.

Many Irish field boundaries consist of overgrown stone walls or dykes, which could be confused with 'hedgerows'. This vegetation is often composed of a dense growth of bramble (Rubus sp.), gorse (or furze *Ulex europaeus*) or a mixture of species comprising low or tall scrub, perhaps including hawthorn (whitethorn) *Crataegus mongyna*, blackthorn *Prunus spinosa*, ash *Fraxinus excelsior*, elder *Sambucus nigra*, hazel *Corylus avellana* or other tree species. Surveyors were requested to categorise such boundaries appropriately: thus, boundaries primarily consisting of bramble and other scrub species were to be marked as low scrub or tall scrub. The hedgerow category overlapped to some extent, but would usually consist of hedge and tree species, and would often be planted or maintained through pruning or cutting-back. Depending upon the frequency and height of trees within such boundaries, they could also be designated as treelines. The bare treelines category was created to account for those boundaries in which the treeline was maintained not allowing any substantial scrub growth or any hedgerow beneath it.

There were found to be difficulties in the designation of grazing land also, the majority of which arose from the historical and ecological backgrounds of different counties and regions in Ireland. Thus, pasture that was considered to be unimproved in eastern and southern Ireland (that is, basically of a low quality) might be considered as semi-improved in the western regions. Whilst it was made clear to all surveyors that such regional biases should be avoided and the definitions strictly adhered to, each surveyor would tend to have a locally biased interpretation of the pasture classes. These biases were noted but could not be eliminated in the final analyses, and regional interpretation of the results requires some realistic understanding that high quality grazing identified in western Ireland would not necessarily correspond with high quality pasture in eastern or southern Ireland.

There was also a tendency, amongst some surveyors, particularly in western regions but also elsewhere, to grade pastures on a continuum from category 29 (upland unimproved grassland) through 30 (lowland unimproved grassland) and 31 (semi-improved grassland) to 32 (improved grassland) regardless of altitude. Whilst lowland pasture in the extreme west of Ireland might, in one interpretation, be considered as equivalent to upland pasture, it was considered in the analyses that altitude should be maintained as a major consideration. Therefore, in analyses, any squares that included areas of both categories 29 and 30 were identified and scrutinised. In some cases, the extremes of elevation present would have confirmed the surveyor's interpretation. Otherwise, the pastures were re-classified, using a general minimum 100 m elevation as a guideline to distinguish the classes.

Another difficulty with pasture was the identification of grassland leys, which are classed within the arable category 33(G). The definition requested followed that of Harris *et al* (1989), in which grassland leys were defined as short-term grasslands having been re-seeded within the previous 5 years and characterised by evidence of ploughing, bare soil between the plants, a scarcity of broad-leaved plants and usually dominated by a single grass species. Confusion arose from Harris *et al's* definition of habitat 32 (improved grassland) in which it is clearly stated that category 32 should *'not include monoculture grassland, i.e. grassland leys'*. It was noted that some surveyors tended to class improved, ploughed and re-seeded grasslands, as in grasslands of the west where land improvements are common as a result of EEC headage payments for cattle and sheep, in this category. Despite the pasture improvements, such grasslands, even if the land was ploughed and re-seeded recently, are essentially long-term grasslands, and do not realistically constitute arable land. Such grasslands should reasonably be considered as permanent pasture, to be used only for cattle or sheep grazing in the future.

Whilst these problems were noted, it proved unreasonable to request correction for all survey results submitted, given the initial requirements and weak definitions. Some surveyors had strictly followed the initial definitions and classified some areas of intended permanent pasture as 33(G). Reference was made to surveyors for clarification in certain cases and obvious mis-classifications altered, with annotation for future reference.

In the identification of waterways, some surveyors were observed to have different criteria in the classification of waterways as either 27 (running natural water) or 28 (running canalised water). Where a waterway had been canalised or re-routed many years previously, the growth of vegetation along its banks and amelioration of the effects of canalisation would, often, indicate a vegetationally natural watercourse. Regardless, natural watercourses usually adopt a meandering route. Thus, if any watercourses were noted to have a straight course, associated with straight field boundaries, they were re-classified as category 28 in analyses, even if the surveyor had classed them as 27.

Although some detailed attention has been paid to some of the difficulties entailed in classifying areas within the 49 principal habitat categories, problems associated with mis-classification of these habitats, habitat 33(G) for example, are, in practice, relatively minor - because these categories comprise a very small proportion of the habitats found to be present in the surveys. Nevertheless, the habitat distribution maps produced in this report should be considered in light of the difficulties experienced by observers in the field. Appropriate corrections have been made wherever such was considered satisfactory or by written reference to the surveyor.

Grazed habitats

In addition to habitats being marked and identified on the enlarged 1km square map (scale at approximately 9": 1 mile), surveyors were also required to mark in the stock utilising any habitats for grazing. No colouring scheme was allowed for these sub-divisions, with surveyors requested to add C, S, CS or O to the habitat numbers marked on any field or area. These capitals designated the land as grazed by cattle (C), sheep (S), cattle and sheep (CS) or by others, *e.g.* horses or goats (O). Some surveyors designated land as CO, SO or CSO, in which case the other category (O) was ignored and the land re-designated within the C, S, or CS categories only.

Surveyors were informed that stock would not necessarily be present on each parcel of land at the time of the survey, but the land's use for a stock type could be determined from obvious signs such as cowpats, sheep droppings, *etc.*

The database fields constructed allowed for separate inclusion of areas of land designated according to stock types present for certain habitat categories, namely 11 (parkland), 18 (lowland heath), 19 (heather moorland), 20 (blanket bog), 21 (raised bog), 24 (wet ground), 29 (upland unimproved grassland), 30 (lowland unimproved grassland), 31 (semi-improved grassland), 32 (improved grassland) and 33 (arable land). If a surveyor recorded land as being used for grazing in any of the other habitat categories, such areas were totalled and grouped within a category labelled as Other (and subdivided into C, S, CS, or O data fields). Areas of scrub (categories 12 and 13) were not assessed for stocks present.

In analyses, therefore, habitat categories were calculated independently of areas of land devoted to grazing within the 4 stock categories, so that there was no confusion between assessed areas and ensured that calculated areas assessed totalled 100 ha (*i.e.* the area of a 1km square). Subdivisions according to grazing rarely added up to the total area assessed for a particular habitat as surveyors would not always indicate stock use on all parcels of land. The totals for a category incorporate these areas in which grazing was 'unknown' or undesignated.

In total, habitat surveys entailed evaluation of 49 principal habitat categories, with grazing sub-divisions totalling 48 in number. Hedgerows and treelines were assessed in length only, whereas low and tall scrub were evaluated in terms of length and area, as were waterways (27 and 28). Roads were also assessed in length as well as area. The total number of database fields describing the habitats and land use of a 1km square totalled 103. A number of fields were added to note the total calculated area, whether the survey was adequate to incorporate subdivision into areas of cattle/sheep/other grazing, lengths and areas of low and tall scrub, and areas of roads and housing land considered separately. Any notes on the habitat survey were included within an additional field. The map scales were also measured (along X and Y axis, to account for slight changes in scales produced by different photocopiers) so that 113 fields were required for the entry of habitat data for each 1km square, totalling over 82,000 data computations and entries.

Description of habitat at sett sites

The habitat description of the location of each badger sett was also given by reference to the principal habitat categories. Stock use at the site was not included, though a separate indication was to be made of cattle or deer presence near the sett, as already reported.

Even if a sett was considered to straddle two or more habitat categories, surveyors were requested to give only one value for the habitat description at each sett, the habitat being the main habitat in which the sett was located. Checks were made in the laboratory to ensure correspondence between values given for sett location against the habitat map at the marked location of each sett. Changes, if such were suggested by a discrepancy, were not always made: only habitats of a certain size were mapped, so it was quite possible for a sett to be located within a habitat not identified on its accompanying map. In cases where the habitat description seemed unlikely, it was referred to the surveyor for clarification.

In line with Harris *et al* (1989), setts were also noted as being present within some additional habitat categories, namely: woodland edge, riverbank, railway banks, roadside, dry ditches and other man-made embankments. These were strictly *additional* to the sett having been identified as being located within one of the 49 habitat types

Laboratory analysis of habitat maps

In the laboratory, each habitat map was scrutinised in relation to the various difficulties reported above. Following clarification or amendment, if required, the areas of each habitat category were assessed using a planimeter. Lengths of certain habitats were measured using a map measuring wheel, against the map scale.

In order to calibrate the planimeter, each map's X and Y scales were measured in millimetres and inputted. It was found that photocopying of the OS 6": 1 mile scale maps produced alterations in the percentage enlargement of the original along the X and Y axis, which varied slightly according to the photocopier used. The planimeter therefore required calibration for each map.

With some practice, the planimeter proved to be an accurate instrument. Following initial experimentation, it was concluded that the precision with which a 1km square could be assessed according to the sum of its habitats was *c.* 0.4% - *i.e.* the estimates for all habitat totalled between 99.6 ha and 100.4 ha. A digitising pad was found to be more difficult to use, especially with narrow habitats such as roadways and rivers. In order to assess habitat areas, the best procedure was found to entail a preliminary sub-division of the square into 4 or 5 zones, usually sub-divided by major geographical features such as roads or rivers. The areas of these zones were measured and their total checked to conform within the overall 0.4% error guideline. The habitats within each zone were then assessed and then totalled and checked to ensure that the totals also accumulated to the value for that zone. If not, the areas were re-measured. As a planimeter reading line taken along a habitat boundary was not likely to be exactly repeated on a re-measurement, any area measured was correspondingly likely to vary slightly from an earlier measurement. If necessary, all areas were measured three times and the average calculated area was determined. Where the zones consisted of reasonably uniform habitat types (*e.g.* mainly pasture), the overall area of that pasture was calculated by estimation of all other habitat features and subtraction from the total for that zone. If a surveyor had marked an area with two habitat numbers, representing a mix of habitats that they felt was best represented in this way, the area was measured and an allocation made equally to each of the two habitat categories.

Each habitat's area was measured to 0.1 ha: over a 100 ha area; the minor deviations from accuracy for each portion of habitat measured could result in error up to around 2 ha (2%). By pre-division of the 1km square into zones and ensuring that all estimates compute to the total for that zone, these cumulative errors were avoided, ensuring the overall precision of 0.4%. Upon completion of the measurements, the estimate for each habitat was totalled and the data then transferred to a database.

The lengths of certain habitat categories were measured, using the map wheel, to 0.01 km. Hedgerows and treelines were measured in length only. In later analyses, approximate area estimates of hedgerow and treeline were calculated by applying a width of 2.5 m to the length measurements; this value is based on that given by O'Corry-Crowe *et al* (1993). This survey was unable to assess mean hedgerow widths on a geographical basis, though there is undoubtedly variation by county or region. The mean width of 2.5 m is indicative of the larger hedgerow widths in Ireland compared to Britain, where a value of 1.5 m was used (Cresswell *et al*, 1990). Where field boundaries had been alternatively marked as consisting of, for example, low scrub, then the area of scrub marked in an entire square was measured and the boundary length comprised of scrub was also measured in terms of length: this applied to categories 12 and 13. Hedgerow poses a difficulty in assessing overall areas as it was, of necessity, measured as a length, with the area of surrounding fields measured to the map boundary: thus field areas are overestimated, as they ignore the hedge width.

The lengths and areas of natural watercourses (generally referred to as rivers in this report) and canalised waters (generally referred to as drains in this report) were both measured. In initial analyses, areas had been neglected and lengths only measured. A particular number of 1km squares prompted a reappraisal because of the a substantial cumulative area of drains in some areas. Consequently all previously assessed maps were re-analysed and areas of these habitats assessed for all remaining 1km square habitat maps. However, the area measurement of these habitats was confined to those portions represented as having been both marked by the surveyor and also marked as a width on the OS map, *i.e.* where a watercourse was delineated as a channel and not as a single line. In awkward cases, the length of these portions was measured and the area calculated by multiplication of its mean width, which was given by an arbitrary figure based on general field experience (*e.g.* 2 m for many small drains and up to 4 m for large drains). Later OS maps used finer pen lines for demarcating drains and small streams. A planimeter-assessed area was used where such maps were available. Lengths and areas of roads were measured (areas by use of the planimeter). In some urban areas, road area could not reliably be distinguished from the overall area of built land.

Once the databases were complete, the habitat measurements were re-checked to ensure that they totalled between 99.6 ha and 100.4 ha. A number of keyboard entry errors were detected and corrected by reference to the original habitat maps and habitat measurements. Various checks were also performed to ensure that sums of sub-divided categories added up to the total of each category and that (as mentioned above) areas of habitats 29 and 30 did not occur within 1km square without good reason. A sample habitat database is given in Appendix B.

LIST OF HABITAT CATEGORIES

1 Hedgerows

These are less than 4 m (12 ft) high and less than 5 m wide. Drawn as continuous lines if any gaps are less than 10 m wide. See also Category 2.

2 Treelines

A line of single trees (minimum of 3) greater than 4 m high and less than 2 canopy widths apart. A hedgerow or substantial scrub cover is associated with the treeline.

2B Bare treelines

As for treelines, but with no hedgerow or scrub cover.

3 Semi-natural broad-leaved woodland

Predominantly broad-leaved trees more than 5 m high with a semi-natural or natural growth.

4 Broad-leaved plantation

Predominantly broad-leaved trees of any height that may or may not be native to the site and are of even age. Orchards are included in this category.

5 Semi-natural coniferous woodland

Predominantly coniferous trees more than 5 m high with semi-natural or natural growth.

6 Coniferous plantation
Predominantly coniferous trees more than 3 m high which have been planted.

6Y Young coniferous plantation

Predominantly coniferous trees under 3 m high, which have been planted.

7 Semi-natural mixed woodland

At least 25% broad-leaved and at least 25% coniferous trees over 5 m high with semi-natural or natural growth.

8 Mixed plantation

At least 25% broad-leaved and at least 25% coniferous trees which have been planted.

9 Young mixed or broad-leaved plantation

Young trees, up to 3 m high, which have been planted. (More than 75% conifer is 6Y - young conifer plantation).

10 Recently felled woodland

Areas for which there is evidence that woodland has been recently felled.

11 Parkland

Areas where tree cover is less than 30%, the majority of the trees are between 30 and 70 m apart, and a minimum number of 10 trees.

12 Tall scrub

Between 3 and 5 m high, *e.g.* thickets of blackthorn *Prunus spinosa*, old hazel coppice *Corylus avellana*, *etc.* Stands of trees more than 5 m high should be classified as woodland, not scrub.

13 Low scrub

Woody vegetation less than 3 m high, *e.g.* young coppice, bramble thickets (Rubus sp).

14 Bracken

Land dominated by bracken *Pteridium aquilinum* with at least 75% cover.

15 Coastal sand dunes

Includes all stages of succession where the vegetation is grass-dominated or wet dune slacks.

16 Coastal sand or mudflats

Bare areas of sand or mud.

17 Coastal shingle or boulder beaches

Includes shingle and boulder beaches and outcrops of bare rock on foreshores.

18 Lowland heath

Lowland heath with at least 25% dwarf shrubs such as heaths (Erica sp.) or heather *Calluna vulgaris*.

19 Heather moorland

Upland heath with at least 25% dwarf shrubs such as heather and bilberry *Vaccinium myrtilis.*

20 Blanket bog

Areas of peat, dominated by heather, bog cotton (Eriophorum sp.) or Sphagnum sp.

21 Raised bog

At least half the peat area raised into a shallow dome, and drier than blanket bog.

20/21W Worked peat

Any areas of bare or worked peat or areas of peat being stripped and prepared for commercial extraction on large or small scale.

22 Marginal inundations

Swamps or fens but not coastal marshes.

23 Coastal marsh

Consists predominantly of salt marsh vegetation, such as Spartina sp., sea aster *Aster tripolium, etc.*

24 Wet ground

Areas of wet land found in association with other habitats, *e.g.* wet area in a grassland field or flushes in upland areas.

25 Standing natural water

No evidence of damming.

26 Standing man-made water

Artificially created reservoirs and impoundments.

27 Running natural water

No evidence of canalisation.

28 Running canalised water

A water course that has been artificially confined to flow in a certain channel.

29 Upland unimproved grassland

In upland areas, and will include some areas used for rough grazing and poor quality grassland such as purple moor grass *Molinia caerulea.* They have not been improved by the application of fertilisers, herbicides or by drainage.

30 Lowland unimproved grassland

May be regularly grazed or mown, or totally neglected. Should not have been improved by the application of fertilisers or herbicides to significantly alter the composition of the sward. Includes herb-rich grassland such as downland, cliff-tops, *etc.* Neglected grassland that had reverted from categories 31 and 32 was included in this category.

31 Semi-improved grassland

Grassland which has been slightly modified by fertiliser or herbicide application, or by heavy grazing pressure and/or drainage.

32 Improved grassland

Grassland that has had regular treatments of artificial fertilisers and herbicides: this category should NOT include monoculture grassland, *i.e.* grassland leys (see 33G below).

33 Arable

All classes of arable land, including grassland leys and horticulture. A grassland is defined as short-term grassland, and will usually have been re-seeded less than five years previously. It is characterised by evidence of ploughing, bare soil between the grass plants, a scarcity of broad-leaved plants, and is usually dominated by a single grass species, often rye grass. There are usually fewer than 5 - 10 plant species per square metre. Category 32 consists of longer term grassland with a higher density of grass and broadleaf species, usually in enclosed land.

Sub-divisions:

33B Arable seedcrops

Arable land that is being used or has recently been used for seedcrops such as barley or wheat.

33R Arable rootcrops

Arable land that is being used or has recently been used for rootcrops such as potatoes, beet.

33G Arable grassland leys

As already defined above (see 32 and 33).

33H Arable horticulture and other crops

34 Amenity grassland

This includes well-maintained non-agricultural grass, such as playing fields, recreation grounds and golf courses.

35 Unquarried inland cliffs

Unvegetated rock over 5 m in height and at an angle of at least 60 degrees. It includes scree.

36 Vertical coastal cliffs

As above but in coastal areas and mostly unvegetated.

37 Sloping coastal cliffs

At an angle of less than 60 degrees and mostly vegetated.

38 Quarries and open-cast mines

Any excavation (gravel pits, chalk pits, *etc.*) including unvegetated spoil heaps.

39 Bare ground

Bare soil or bare ground not covered by vegetation and which does not fall into categories 35 - 38 or 40. Areas of worked peat were included in category 20/21W.

40 Built land

Any urban areas including gardens and transport corridors, and will include roads, buildings, *etc.*

Later subdivided into:

40 Built land (not including roads)

41 Roads only

40/41 total all built land

42 Sea

Land classes

A classification of Ireland's principal landscape types is not available, though one has recently been completed for Northern Ireland (Murray *et al*, 1992). In Britain, Cresswell *et al* (1990) made substantial use of land classes in their research on the abundance and distribution of the badger there. It is anticipated that the present survey reported here will be enlarged to incorporate environmental variables with the development of a preliminary land classification for the country. In the interim, the survey adopted the land classes defined by Bunce, Barr & Whittaker (1981, 1983) for Britain, and requested that surveyors attempt to *visually* assess the overall landscape of each 1km square surveyed and place it within one of the broad definitions: these are given below.

It should be noted that such visual assessments are quite subjective, and, additionally, a land classification developed for Britain will not include some land classes present in Ireland but not in Britain. Also, the environmental variables distinguishing a land class in Britain are unlikely to correspond accurately to a land class in Ireland, even though such areas may appear physically similar on a subjective basis.

The results obtained from these visually assessed land classes are of some interest because they have identified the overall nature of a 1km square, but it is not intended, nor would it be valid, to use these values in the manner adopted by Cresswell *et al* (1990).

LAND CLASSIFICATION GUIDE

Land classes: the main categories (after Bunce, Barr & Whittaker, 1981) obtained from an analysis of principal environmental variables

1	undulating country, varied agriculture, mainly grassland
2	open, gentle slopes, often lowland, varied agriculture
3	flat arable land, mainly cereals, little native vegetation
4	flat, intensive agriculture, otherwise mainly built-up
5	lowland, somewhat enclosed land, varied agriculture and vegetation
6	gently rolling enclosed country, mainly fertile pasture
7	coastal with variable morphology and vegetation
8	coastal, often estuarine, mainly pasture, otherwise built-up
9	fairly flat, open intensive agriculture, often built-up
10	flat plains with intensive farming, often arable/grass mixture
11	rich alluvial plains, mainly open with pasture or arable
12	very fertile coastal plains with very productive crops
13	somewhat variable land forms, mainly flat, heterogeneous land use
14	level coastal plains with arable, otherwise often urbanised
15	valley bottoms with mixed agriculture, predominantly pasture
16	undulating lowlands, variable agriculture, and native vegetation
17	rounded intermediate slopes, mainly improvable permanent pasture
18	rounded hills, some steep slopes, varied moorlands
19	smooth hills, mainly heather moors, often afforested
20	midvalley slopes, wide range of vegetation types
21	upper valley slopes, mainly covered with bogs
22	margins of high mountains, moorland, often afforested
23	high mountain summits, with well drained moorland
24	upper, steep, mountain slopes, usually bog covered
25	lowlands with variable land use, mainly arable
26	fertile lowlands with intensive agriculture
27	fertile lowland margins with mixed agriculture
28	varied lowland margins with heterogeneous land use
29	sheltered coasts with varied land use, often crofting
30	open coast with low hills dominated by bogs
31	cold exposed coasts with variable land use and crofting
32	bleak undulating surfaces mainly covered with bogs

RESULTS: HABITAT SURVEYS

Overall habitat data were computed for each county, region, and for the country, as means of values per square for each habitat type. Those squares that had inadequate or incomplete habitat maps within certain habitat categories were excluded from computations for those habitat categories. Thus, it was considered that 87 of the 729 squares (10.7%) had inadequate data for obtaining statistical data on grazing by stocks: some observers failed to note stock types on lands altogether, or marked in small proportions of the identified grazing areas. In 9 squares (1.2% of total), it proved impossible to differentiate areas devoted to roads from areas of buildings: all of these squares were located in urban areas, where such differentiation was too complex. All other habitats were found to have been assessed fully.

Summaries of habitat data are, firstly, presented on this basis in order to present an account of the overall habitat/landscape characteristics of each geographical unit, and will include areas of sea, lake or coastal mudflats, *etc.*, though these should be excluded from overall analyses involving badger densities and sett location preferences. Corrections for terrestrial areas (see section below) are also presented and were used for analyses involving the badger sett data.

In view of the large number of habitat categories and the number of counties and regions, habitat data is unwieldy. To express the principal findings in a meaningful manner, data is presented by region in Table 15, with means only presented. The standard errors of these means are presented in Appendix A6, and the maximum values observed for any habitat within the regions in Appendix A5. Minimum values are not presented, as zero values were observed as having occurred for almost all habitats in each of the regions (*i.e.* squares were present in every region in which even virtually ubiquitous habitats such as roads, built land, waterways or hedges were recorded as absent). Regional results corrected for sea and lake, *etc.* are presented in Table 16: no standard errors are applicable to corrected values (see below). Habitat summaries for each county (uncorrected and corrected) are given in appendices and no tables are presented of the standard errors of these means or maximum values.

Some of the principal habitat groups (such as total areas of grassland, woodland, *etc.*) are also included in the tables and appendices. Since the county data (Appendix A7) is of especial interest in the variation in habitat types that have a particular bearing on badger numbers, cattle and TB, some of these habitats and habitat groupings have been mapped on figures appearing below, allowing greater clarity in presentation. In the text, values corrected for areas of sea, lake, coastal mudflats and beaches are given in square brackets where they differ from uncorrected values. The mapped values are based on the corrected means for each county.

Correction factors for areas of sea, lake and coastal mud and shingle

The habitat means have been corrected for areas of sea and lake or associated mudflats and coastal shingle. Uncorrected values are also presented since uncorrected habitat survey results reflect the overall ecological landscape differences of the regions or counties, with their considerable variation in areas of sea, shore and lake. Corrections are based on the mean total areas of these habitats and can thus only be applied to the means for a geographical zone (county or region) and not to individual squares, so that standard errors cannot be computed for habitat data on a county or regional basis.

The choice of habitats to be excluded from the re-evaluation of survey data to calculate 'terrestrial land area' values only are, to some extent, subjectively based: from a badger's perspective, wet ground, marsh and river and drain areas are not suitable habitat. In compiling overall terrestrial information, it was considered appropriate only to exclude areas of sea and lake, and coastal mudflats and shingle. In particular survey squares, a large river and its tributaries may have comprised a substantial portion of their total area; consideration was given as to whether such areas should also be excluded. However, the area analyses do not distinguish rivers by size and the adoption of criteria for inclusion or exclusion would be arbitrary. Overall, the inclusion of rivers and freshwater habitats (other than lakes), and wet areas (marshes and wet ground) seemed reasonable in the analyses.

Corrections to habitat data were made by simple proportional multiplication of the mean habitat data for each county by the mean area of 'firm ground' contained within that county.

In summary, the following habitats have been excluded:

42 (sea), 25 (lake), 26 (reservoir or similar), 16 (coastal sand or mudflats) and 17 (coastal shingle or boulder beaches).

Although Cresswell *et al* (1990) excluded urban areas from their calculations pertaining to badger density, such exclusion was not considered appropriate for the Irish habitat data: firstly, because urban areas were a very small proportion of total land area (except in the immediate vicinity of Dublin, Cork and Limerick cities), and secondly, there could not be defined reasonable criteria for exclusion (*i.e.* how much of a 1km survey square should be covered in 'built land' to merit its exclusion? - very few squares proved to be wholly 'urbanised').

The correction factors are given for each county, and for the Republic as a whole, in Table 14. They are employed simply as multiplicatory factors for further analyses which incorporate habitat data on the basis of means for each region or county. The factors were calculated to sum corrected areas to the total derived primarily and not to 100 ha precisely. Largest corrections were required for western seaboard counties (Cork, Galway, Donegal, Mayo and Sligo) where excluded area comprised 9-12% of the totals. Cos. Dublin (15%) and Waterford (9%) also had high proportions of sea, lake and shore.

Some degree of precision of the 1% land area survey employed here may be estimated from the overall results. Using the overall figure for 93.4% firm land for the 735 chosen squares, an estimate of a total land area for the Republic of 68,649 km^2 is obtained. This differs from an atlas estimate of 68,900 km^2 by only 0.37%. Estimates may therefore be obtained for the *total* area - in the Republic - of *any* of the habitat types assessed in this survey by multiplication of the *uncorrected* mean value per km square by 73,500. The confidence limits for the means will vary with habitat type, with means for less common or clustered habitats (*e.g.* woodland or plantation) having much wider confidence limits than common or ubiquitous habitats (*e.g.* grassland).

Table 14. Correction factors for habitat summaries for each county, which allow for exclusion of sea, coastal zones and areas of lake (see text for details).

County/Region	area of sea, lake, *etc.* (ha)	area of firm land (ha)	multiplication factor
Carlow	0.03	99.99	1.0003
Cavan	5.35	94.68	1.0565
Clare	6.81	93.25	1.0730
Cork	9.91	90.10	1.1100
Donegal	11.05	88.97	1.1242
Dublin	15.55	84.48	1.1841
Galway	11.39	88.64	1.1285
Kerry	11.16	88.88	1.1256
Kildare	0.04	99.98	1.0004
Kilkenny	0.04	99.97	1.0004
Laois	0.05	99.96	1.0005
Leitrim	1.80	98.21	1.0183
Limerick	0.83	99.21	1.0084
Longford	3.61	96.35	1.0375
Louth	0.03	100.07	1.0002
Mayo	12.18	87.84	1.1387
Meath	0.04	99.96	1.0004
Monaghan	2.19	97.86	1.0224
Offaly	1.28	98.77	1.0129
Roscommon	5.63	94.39	1.0597
Sligo	11.24	88.77	1.1266
Tipperary	1.25	98.78	1.0126
Waterford	8.85	91.15	1.0971
Westmeath	0.22	99.84	1.0022
Wexford	0.20	99.80	1.0020
Wicklow	6.71	93.31	1.0719
South-West	10.50	89.52	1.1173
Mid-West	3.86	96.19	1.0402
West	10.80	89.23	1.1210
North-West	10.00	90.01	1.1111
Midlands	1.53	98.50	1.0155
South	3.01	97.00	1.0310
East	3.74	96.27	1.0389
Republic	6.63	93.40	1.0709

Overall results

The habitat survey has revealed examples of habitat variation by region that would be anticipated (uncorrected means - Table 15; corrected means - Table 16) [*n.b.* a 1km square contains 100 ha, and percentage areas of cover are equivalent to hectares per km square]. In a consideration of mean values for habitats across regions, the extreme values occurring in individual squares should be borne in mind - the maximum values observed are included in Appendix A5. Each region of Ireland possesses considerable geographical and ecological variation, the means only reflecting broad differences between the regions.

Areas of peat and moorland are almost completely absent in the South but comprise around one-third of the habitat area of the North-West (30% [33%]) and about one-quarter in the West (25% [28%]). The South-West also has considerable areas of peat and moorland (16% [18%]). The other regions are in the range 6-8% [6-9%], with an overall average for the Republic of 14.7% [15.8%]. These values obscure the variation in peat areas alone, with the West having a higher area of peat than the North-West, where moorland predominates. Worked peat was found to comprise 2.8% [2.8%] of total area in the Midlands (43% of total peat area in the Midlands). Several squares in various regions consisted almost entirely of peatlands (>97% of the area of the survey squares).

Similar expected differences were observed with regard to built land. The East of Ireland has the highest proportion of land built upon (mean 6.9 [7.1] ha km^{-2}; the highest values recorded were 84 ha in the South, 74 ha in the East) and the least was found in the West (2.1 [2.4] ha km^{-2}), though the Mid-West and North-West are also low. The overall average for the country is 3.4% [3.7%] of surveyed area. Most of these differences arise from the amount of built land, and areas of 1km squares devoted to roads showed less variation, being 1.2% - 1.8% of total area in the seven regions [1.3% - 1.9%].

Total woodland in Ireland averaged 5.4 [5.8] ha km^{-2} - highest in the Mid-West (8.7 [9.1] ha km^{-2}) and least in the West (3.1 [3.4] ha km^{-2}) and in the range 5-7 ha km^{-2} elsewhere [5-7.3]. Most of this woodland was coniferous plantation (mean 4.5 ha km^{-2} [4.9]) and the remainder other woodland categories (not including recently felled woodland, {which might be or might not be replanted in future}). Individual squares on occasion consisted almost entirely of woodland - up to 98.7%. Ireland's principal natural climax vegetation - deciduous woodland - comprises no more than 0.5% of the landscape (represented at a maximum by category 3, semi-natural broad-leaved woodland, and category 7, semi-natural mixed woodland). The West and South possess least of such areas, but the highest value recorded, in an individual square, for category 3 was 6.9% in the West.

The bulk of Ireland's landscape comprises grassland and arable land, these categories totalling 62.7% [67.2%] of the total. Of this, only 7.0% [7.5%] was noted as arable, and 55.8% [59.7%] as grassland pasture of various categories, varying from unimproved grasslands, often comprising poor feed species such as *Molinia,* to improved grasslands of high quality. As expected, there was considerable regional variation, but in every region of Ireland, grasslands comprised the largest proportion of the land area. Least was observed in the North-West (40.6% [45.1%]) and most in the Mid-West (68.3% [71.1%]). With the inclusion of arable lands, 4 regions have exceptionally high proportions of land devoted to grass and tillage:

Midlands (75.9% [77.1%]), South (72.8% [75.0%]), Mid-West and East (71.1%, 70.1% [73.9%, 73.5%]), with 59.4% [66.4%] in the South-West, 51.1% [57.3%] in the West, and 42.7% [47.4%] in the North-West. The highest recorded proportion of grassland observed in any square was 99.2% in the West: however, it should be noted that all grassland and arable areas are overestimated, as areas of hedges or treeline are not excluded. Other habitat categories, where hedges and treelines are frequent boundaries, will also tend to be overestimated.

In all regions, the principal type of grassland was improved grassland, with semi-improved grasslands generally the next highest proportion. Unimproved grasslands averaged 10.7 [11.5] ha km^{-2}: 8 ha km^{-2} and over in five regions, but only 1.4 [1.7] ha km^{-2} in the South, with an average of 5.1 [5.2] ha km^{-2} in the East.

Other habitat types comprising noteworthy areas of the Irish landscape were scrub (2.4% [2.5%]), wet ground (1.3% [1.4%]), standing natural water [lakes] (1.9% of total surveyed squares; but 4.6% in the West of Ireland), rivers and streams (0.5% [0.5%]), drains (0.3% [0.3%]), amenity grasslands (including golf courses, but not gardens, 0.4% [0.4%]), bracken (0.4% [0.4%]) and inland cliffs (0.2% [0.2%]). On average, each square was found to contain 2.1 km [2.1 km] of river, stream, drains or canals. One Midlands square contained 22.6 km of river/stream, and a square in the South-West had 10.4 km of drain/canal.

Lastly, hedgerows and treelines constitute an important habitat in most areas of Ireland. The mean length for the Republic was found to be 5.7 km [6.5 km] length per 1km square, but one square contained a total of 22.3 km (in the Midlands) and high values were observed in squares in every region. Scrub boundary length was determined at 0.4 km [0.5 km], the total for boundaries of a hedge/scrub nature thus being 6.1 km [6.5 km]. The calculated mean area for hedge and treeline (excluding bare treeline) is 1.4 [1.5] ha km^{-2}. This combined habitat area was highest, interestingly, in the Mid-West (1.8 [1.9]), Midlands (2.0 [2.1]) and the South (2.3 [2.4]). As would be anticipated, it was least in the West and North-West. The inclusion of assessed scrub length, almost all of which was boundary scrub, to hedge and treeline length is perhaps more realistic in consideration of boundaries: results for regional variations in the means are similar, however. Evaluating total areas of hedge, treeline and scrub, reveals proportionately smaller differences between regions, which is to be expected as scrub areas include general areas of scrub as well as boundaries so marked. Overestimation of grassland and arable areas (mean 62.8 ha [67.2]) through assessment of hedge areas by length and not by planimeter-assessed areas may be estimated at 1.4 [1.5] ha over 62.8 [67.2] ha maximum (as some hedges bound other habitats) = 2.2% overall. Overestimation within particular individual squares would have been much higher (up to *c.* 7%).

Area of sea constituted 3.7% of the overall area of 1km squares surveyed, but 8.1% in the South-West and *c.* 5% in the West and North-West: these high values reflect the high indentation of the coast by the sea, many peninsulas, and many islands, in these regions. Any squares with land above tidal limits were included in the surveys. The corrected values, naturally, exclude these categories (habitat numbers 16,17, 25, 26 and 42) in Table 16.

Briefly, initial indications from the Northern Ireland data suggest that there are no apparent major differences in overall habitat proportions as compared to the Republic as a whole. Northern Ireland data would correspond most closely with the East and the Midlands of Ireland (rather than the West, South-West or South), but grazing areas are a little less in view of a higher proportion of upland and moorland/peat areas in the North than in the East and the Midlands - suggestive of North-West type habitats being also common in the North. However, the overall initial interpretation does not suggest that the North is atypical of the island as a whole, and its habitat variables fall within the range exhibited in the Republic, with the exception of built land; on initial analyses, the mean area of built land is almost double that noted in the Republic (but similar to the East region).

County results

Means and corrected means for the habitat types and habitat groups are given in Appendix A8. Examination of the habitat data for counties, as opposed to regions, reveals a greater range of differences, as would be expected, since each county possesses a smaller range of landscape types and ecological zones than a region. The regional variations of the major habitat types were outlined above, and an account for the 26 counties is limited to an outline of the principal differences. Nevertheless, the data has been presented fully for each county since these differences lend themselves readily to statistical interpretation in connection with county TB levels in cattle. Additionally, these (corrected) means were applied on a county basis in examination of badger densities.

For an overview, the county means for the major habitat types/groups have been mapped, as follows:

1. combined area of peat, moorland and lowland heath (Figure 29)
2. area of built land including roads and transport corridors (Figure 30)
3. combined area of woodland habitats (Figure 31)
4. total length of rivers/streams and drains/canals (Figure 32)
5. total area of grassland (Figure 33)
6. area of unimproved grassland [upland and lowland] (Figure 34)
7. area of improved grassland (Figure 35)
8. total area of arable land (Figure 36)
9. total length of hedgerow and treeline (Figure 37)
10. total length of hedgerow, treeline and scrub boundary (Figure 38)

(list continues following tables)

Table 15. Habitat summaries on a regional basis, given by the mean length or area per km² of each habitat type and principal habitat groups. Data is uncorrected.

		South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
1	Hedgerow length (km)	4.49	6.91	1.89	2.35	6.58	8.47	5.26	**4.82**
2	Treeline length (km)	0.50	0.18	0.36	0.76	1.51	0.82	1.43	**0.79**
2B	Bare treeline length (km)	0.15	0.01	0.01	0.03	0.07	0.00	0.01	**0.05**
3	Semi-natural broad-leaved woodland	0.58	0.35	0.02	0.63	0.63	0.27	0.57	**0.42**
4	Broad-leaved plantation	0.04	0.16	0.07	0.37	0.41	0.39	0.22	**0.22**
5	Semi-natural coniferous woodland	0.01	0.09	0.05	0.00	0.08	0.00	0.07	**0.04**
6	Coniferous plantation	2.54	5.90	1.42	4.53	2.35	2.68	3.03	**2.94**
6Y	Young coniferous plantation	1.74	1.65	1.45	0.89	1.75	1.52	2.23	**1.61**
7	Semi-natural mixed woodland	0.00	0.04	0.05	0.12	0.07	0.00	0.04	**0.05**
8	Mixed plantation	0.03	0.44	0.00	0.03	0.15	0.17	0.09	**0.11**
9	Young mixed or broad-leaved plantation	0.00	0.07	0.00	0.00	0.00	0.02	0.08	**0.02**
10	Recently felled woodland	0.00	0.03	0.12	0.17	0.10	0.00	0.04	**0.07**
11	Parkland	0.13	0.03	0.00	0.18	0.05	0.00	0.07	**0.06**
12A	Tall scrub (area)	0.42	1.37	0.72	0.90	0.92	0.39	0.30	**0.72**
12L	Tall scrub (length km)	0.10	0.03	0.04	0.19	0.10	0.05	0.02	**0.08**
13A	Low scrub (area)	1.76	1.42	1.28	2.09	1.45	2.35	1.56	**1.65**
13L	Low scrub (length km)	0.56	0.08	0.19	0.83	0.25	0.23	0.51	**0.36**
14	Bracken	0.44	0.73	0.06	0.54	0.11	0.37	0.64	**0.37**
15	Coastal sand dunes	0.00	0.00	0.35	0.77	0.00	0.00	0.23	**0.18**
16	Coastal sand or mudflats	1.09	1.24	0.53	0.24	0.00	0.71	0.96	**0.64**
17	Coastal shingle or boulder beaches	0.24	0.10	0.43	0.73	0.00	0.08	0.15	**0.25**
18	Lowland heath	0.81	0.96	0.15	2.29	0.35	0.00	0.00	**0.60**
19	Heather moorland	7.96	2.20	6.41	16.02	0.44	8.00	1.26	**5.73**
20	Blanket bog	6.08	3.07	12.60	10.33	1.13	0.00	2.65	**5.68**
21	Raised bog	0.95	0.47	4.70	0.63	2.62	0.00	0.66	**1.83**
20/21W	Worked peat	0.00	0.00	0.74	0.30	2.78	0.22	1.34	**0.87**
22	Marginal inundations	0.03	0.18	0.07	0.01	0.29	0.13	0.09	**0.12**
23	Coastal marsh	0.05	0.00	0.05	0.02	0.21	0.69	0.05	**0.13**
24	Wet ground	1.36	0.95	1.40	1.10	1.37	1.53	1.10	**1.28**
25	Standing natural water	1.10	1.27	4.56	3.35	1.51	0.03	0.02	**1.94**
26	Standing man-made water	0.00	0.01	0.00	0.08	0.02	0.03	1.03	**0.13**
27A	Running natural water (area)	0.37	0.79	0.39	0.54	0.48	0.40	0.40	**0.47**
27L	Running natural water (length km)	0.95	0.65	0.66	1.37	0.49	0.48	0.64	**0.74**
28A	Running canalised water (area)	0.08	0.36	0.41	0.16	0.51	0.11	0.26	**0.29**
28L	Running canalised water (length km)	0.66	1.22	1.29	0.88	2.51	0.44	0.91	**1.23**
29	Upland unimproved grassland	3.44	4.95	3.44	6.38	1.44	1.08	2.40	**3.23**
30	Lowland unimproved grassland	5.52	9.31	9.78	7.38	11.84	0.61	2.65	**7.48**

Table 15 contd.

		South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
31	Semi-improved grassland	9.66	18.64	15.05	12.00	21.00	5.54	7.38	**13.58**
32	Improved grassland	31.42	35.44	22.02	14.86	32.36	54.60	41.06	**31.48**
33 TOT	Arable (total)	9.39	2.74	0.79	2.08	9.30	10.93	17.25	**7.00**
33B	Arable (seedcrops)	3.28	1.72	0.32	0.55	5.75	4.96	9.00	**3.42**
33R	Arable (rootcrops)	1.34	0.53	0.15	0.35	0.79	0.79	1.98	**0.81**
33G	Arable (grassland leys)	3.91	0.28	0.13	1.05	1.25	3.46	2.51	**1.70**
33H	Arable (horticultural)	0.10	0.01	0.00	0.00	0.07	0.63	0.47	**0.14**
34	Amenity grasslands	0.38	0.23	0.22	0.49	0.41	0.34	0.91	**0.40**
35	Unquarried inland cliffs	0.02	0.00	0.78	0.38	0.00	0.00	0.00	**0.21**
36	Vertical coastal cliffs	0.12	0.00	0.08	0.01	0.00	0.00	0.08	**0.05**
37	Sloping coastal cliffs	0.06	0.00	0.00	0.03	0.00	0.06	0.00	**0.02**
38	Quarries and open-cast mines	0.03	0.09	0.16	0.06	0.15	0.36	0.10	**0.13**
39	Bare ground	0.41	1.03	2.22	1.01	0.11	0.13	0.48	**0.85**
40	Built land area (excl. roads)	1.67	0.84	0.95	1.14	1.66	1.09	3.61	**1.52**
41A	Roads (area)	1.36	1.57	1.20	1.41	1.69	1.62	1.81	**1.49**
41L	Roads (length km)	2.01	2.12	1.72	1.88	2.05	2.00	2.08	**1.97**
40/41-TOT	Total built land (roads and built land)	3.64	2.41	2.16	2.55	3.36	4.05	6.87	**3.41**
42	Sea	8.08	1.24	5.27	5.60	0.00	2.16	1.57	**3.67**
OTHER	Unspecified	0.04	0.09	0.03	0.19	0.24	0.08	0.11	**0.11**
TOTAL	Total area calculated (mean)	100.03	100.05	100.03	100.01	100.03	100.01	100.02	**100.03**
	Principal habitat groups								
	total hedge and treeline (km)	5.14	7.11	2.27	3.14	8.16	9.29	6.71	**5.66**
	total scrub length (km)	0.66	0.10	0.23	1.03	0.35	0.28	0.53	**0.44**
	total hedge, treeline and boundary scrub (km)	5.80	7.21	2.50	4.17	8.51	9.57	7.24	**6.10**
	total hedgerow/treeline area (est. 2.5 m wide)	1.29	1.78	0.57	0.79	2.04	2.32	1.68	**1.41**
	total hedgerow/ treeline/scrub area	3.47	4.57	2.56	3.78	4.41	5.06	3.54	**3.79**
	total grasslands (29-32)	50.04	68.33	50.28	40.62	66.64	61.82	53.49	**55.76**
	total grazing and arable (29-33)	59.43	71.08	51.07	42.69	75.94	72.76	70.74	**62.76**
	total woodland (3-9)	4.93	8.70	3.07	6.56	5.45	5.03	6.34	**5.41**
	total peat areas (20,21,20/21W)	7.03	3.53	18.04	11.25	6.54	0.22	4.65	**8.38**
	total peat, moorland and lowland heath	15.80	6.70	24.59	29.56	7.33	8.22	5.91	**14.71**
	hedge density: hedgerow area/area grazing and arable	0.0216	0.0250	0.0111	0.0184	0.0269	0.0319	0.0237	**0.0225**
	hedge/scrub density: hedge/scrub area/area grazing and arable	0.0584	0.0643	0.0502	0.0884	0.0581	0.0695	0.0500	**0.0604**

Table 16. Habitat summaries on a regional basis, given by the ***corrected*** *mean length or area per km^2 of each habitat type and principal habitat groups.*

		South-West	Mid-west	West	North-West	Mid-lands	South	East	Rep-ublic
1	Hedgerow length (km)	5.02	7.19	2.12	2.61	6.68	8.73	5.47	**5.17**
2	Treeline length (km)	0.56	0.19	0.40	0.84	1.54	0.84	1.49	**0.84**
2B	Bare treeline length (km)	0.17	0.01	0.01	0.04	0.07	0.00	0.01	**0.05**
3	Semi-natural broad-leaved woodland	0.65	0.36	0.02	0.70	0.64	0.27	0.60	**0.45**
4	Broad-leaved plantation	0.05	0.17	0.08	0.41	0.41	0.40	0.23	**0.23**
5	Semi-natural coniferous woodland	0.01	0.09	0.05	0.00	0.09	0.00	0.07	**0.05**
6	Coniferous plantation	2.84	6.14	1.60	5.03	2.39	2.76	3.15	**3.15**
6Y	Young coniferous plantation	1.94	1.72	1.63	0.98	1.77	1.57	2.32	**1.72**
7	Semi-natural mixed woodland	0.00	0.04	0.05	0.14	0.08	0.00	0.05	**0.05**
8	Mixed plantation	0.03	0.46	0.00	0.03	0.16	0.17	0.09	**0.12**
9	Young mixed or broad-leaved plantation	0.00	0.07	0.00	0.00	0.00	0.02	0.09	**0.02**
10	Recently felled woodland	0.00	0.03	0.13	0.19	0.11	0.00	0.04	**0.08**
11	Parkland	0.14	0.04	0.00	0.20	0.05	0.00	0.07	**0.07**
12A	Tall scrub (area)	0.47	1.43	0.81	1.01	0.93	0.40	0.31	**0.77**
12L	Tall scrub (length km)	0.11	0.03	0.04	0.22	0.10	0.05	0.03	**0.08**
13A	Low scrub (area)	1.97	1.48	1.43	2.32	1.48	2.42	1.63	**1.77**
13L	Low scrub (length km)	0.62	0.08	0.21	0.92	0.26	0.24	0.52	**0.39**
14	Bracken	0.49	0.76	0.07	0.60	0.11	0.38	0.66	**0.40**
15	Coastal sand dunes	0.00	0.00	0.39	0.86	0.00	0.00	0.24	**0.19**
16	Coastal sand or mudflats								
17	Coastal shingle or boulder beaches								
18	Lowland heath	0.90	1.00	0.16	2.54	0.35	0.00	0.00	**0.65**
19	Heather moorland	8.90	2.29	7.18	17.80	0.45	8.25	1.31	**6.13**
20	Blanket bog	6.79	3.19	14.12	11.48	1.15	0.00	2.75	**6.09**
21	Raised bog	1.07	0.49	5.27	0.70	2.66	0.00	0.69	**1.96**
20/21W	Worked peat	0.00	0.00	0.83	0.33	2.82	0.23	1.39	**0.94**
22	Marginal inundations	0.04	0.19	0.08	0.01	0.30	0.14	0.10	**0.13**
23	Coastal marsh	0.06	0.00	0.06	0.02	0.21	0.71	0.06	**0.14**
24	Wet ground	1.52	0.99	1.57	1.22	1.39	1.58	1.14	**1.37**
25	Standing natural water								
26	Standing man-made water								
27A	Running natural water (area)	0.42	0.82	0.44	0.60	0.49	0.41	0.41	**0.50**
27L	Running natural water (length km)	1.07	0.68	0.74	1.53	0.49	0.49	0.66	**0.80**
28A	Running canalised water (area)	0.09	0.37	0.46	0.18	0.52	0.11	0.27	**0.31**
28L	Running canalised water (length km)	0.74	1.27	1.45	0.98	2.55	0.45	0.94	**1.32**
29	Upland unimproved grassland	3.84	5.15	3.86	7.08	1.46	1.12	2.49	**3.45**
30	Lowland unimproved grassland	6.17	9.68	10.96	8.20	12.02	0.63	2.75	**8.01**

Table 16 contd.

		South-West	Mid-west	West	North-West	Mid-lands	South	East	Rep-ublic
31	Semi-improved grassland	10.80	19.38	16.87	13.34	21.33	5.71	7.67	**14.54**
32	Improved grassland	35.10	36.86	24.68	16.51	32.87	56.29	42.66	**33.71**
33 TOT	Arable (total)	10.50	2.85	0.88	2.31	9.45	11.27	17.92	**7.50**
33B	Arable (seedcrops)	3.66	1.78	0.36	0.61	5.84	5.11	9.35	**3.66**
33R	Arable (rootcrops)	1.50	0.55	0.17	0.39	0.80	0.81	2.06	**0.86**
33G	Arable (grassland leys)	4.37	0.29	0.15	1.16	1.27	3.57	2.61	**1.82**
33H	Arable (horticultural)	0.12	0.01	0.00	0.00	0.07	0.65	0.49	**0.15**
34	Amenity grasslands	0.43	0.24	0.25	0.54	0.42	0.35	0.94	**0.43**
35	Unquarried inland cliffs	0.02	0.00	0.87	0.43	0.00	0.00	0.00	**0.22**
36	Vertical coastal cliffs	0.13	0.00	0.08	0.01	0.00	0.00	0.08	**0.05**
37	Sloping coastal cliffs	0.07	0.00	0.00	0.04	0.00	0.07	0.00	**0.02**
38	Quarries and open-cast mines	0.03	0.10	0.18	0.07	0.15	0.37	0.10	**0.13**
39	Bare ground	0.46	1.07	2.49	1.12	0.12	0.14	0.50	**0.91**
40	Built land area (excl. roads)	1.86	0.87	1.07	1.26	1.69	1.12	3.75	**1.62**
41A	Roads (area)	1.52	1.63	1.35	1.56	1.71	1.67	1.88	**1.60**
41L	Roads (length km)	2.25	2.21	1.93	2.09	2.08	2.07	2.16	**2.11**
40/41 TOT	Total built land (roads and built land)	4.07	2.50	2.42	2.83	3.41	4.18	7.14	**3.65**
42	Sea								
OTHER	Unspecified	0.04	0.09	0.03	0.21	0.24	0.08	0.11	**0.12**
TOTAL	Total area calculated (mean)	100.03	100.05	100.03	100.01	100.03	100.01	100.02	**100.03**
Principal habitat groups									
	total hedge and treeline (km)	5.75	7.40	2.54	3.49	8.29	9.57	6.97	**6.06**
	total scrub length (km)	0.73	0.10	0.26	1.14	0.36	0.29	0.55	**0.47**
	total hedge, treeline and boundary scrub (km)	6.48	7.50	2.80	4.63	8.65	9.87	7.52	**6.53**
	total hedgerow/treeline area (est. 2.5 m wide)	1.44	1.85	0.64	0.87	2.07	2.39	1.74	**1.52**
	total hedgerow/treeline/scrub area	3.88	4.75	2.87	4.19	4.48	5.22	3.68	**4.06**
	total grasslands (29-32)	55.91	71.08	56.37	45.13	67.67	63.74	55.57	**59.72**
	total grazing and arable (29-33)	66.41	73.93	57.25	47.44	77.12	75.02	73.49	**67.21**
	total woodland (3-9)	5.51	9.05	3.44	7.29	5.53	5.19	6.58	**5.79**
	total peat areas (20,21,20/21W)	7.86	3.68	20.22	12.50	6.64	0.23	4.83	**8.98**
	total peat, moorland and lowland heath	17.66	6.97	27.57	32.85	7.44	8.48	6.14	**15.76**
	hedge density: hedgerow area/area grazing and arable	0.0216	0.0250	0.0111	0.0184	0.0269	0.0319	0.0237	**0.0225**
	hedge/scrub density: hedge/scrub area/area grazing and arable	0.0584	0.0643	0.0502	0.0884	0.0581	0.0695	0.0500	**0.0604**

(continued list of mapped habitat variables)

11 hedgerow and treeline density (km per unit area grassland and arable) Figure (39)

12 hedgerow, treeline and scrub boundary density [km per unit area grassland and arable] (Figure 40)

13 total area of scrub (Figure 41)

These mapped summaries confirm and accentuate the observed regional differences. The above categories account for a total of *c.* 96% of the surface area of the surveyed 1km squares (excluding sea, lake and shore). Most of the remaining area is accounted for by the following habitats: quarries, cliffs, amenity grasslands, bracken, wet ground, marshes, felled woodland and parkland. Areas of deciduous woodland in Ireland have not been mapped, simply because they constitute such a small proportion of the overall area (<1%).

The maps illustrate the major differences between counties and are more revealing than a text-based account. They merit attention particularly in the context of mean badger densities for each county, and in relation to TB prevalence.

The predominance of moorland/peat habitats in western counties (particularly Kerry, Galway, Mayo, Sligo and Donegal) is shown (Figure 29) but high values are also observed through many of the Midland counties through to Wicklow. Co. Cork has below 7% in this habitat group, though the proportion of these habitat categories in the west of the county would be substantially higher.

Total built land is evenly distributed through the Irish counties (with the exception of Co. Dublin), as suggested by the regional results. Figure 30 reveals that the counties with the highest proportions of built land are Dublin, Kildare, Waterford and Wexford. Co. Mayo was observed to be the county with least land used for buildings or roads [2.16 ha km^{-2}] but Cos. Clare and Kerry were also very low [*c.* 2.2 ha km^{-2}].

Woodland [of all woodland types] (Figure 31) constitutes a high proportion of the landscape in Cos. Clare, Limerick and Wicklow (c 11% [Clare: 11.2%; Limerick: 10.6%; Wicklow: 11.8%]), with Cos. Offaly [9.6%], Westmeath [8.6%], Sligo [8.1%] and Leitrim [8.1%] also possessing substantial woodland areas. Counties with lowest woodland areas were Galway, Longford, Meath, Dublin, Carlow and Waterford (<3.5%).

The combined length of natural and canalised waterways (streams, rivers, drains and canals) was least in certain southern and south-eastern counties, which might be expected given the lower mean annual rainfall in the south-east: these counties are Waterford, Kilkenny and Wexford [<1.3 km of waterway km^{-2}] (Figure 32). Whilst western counties are noted for high rainfall, the counties with highest waterway lengths were found in the Midlands and adjoining eastern parts of the West region. In particular, Cos. Offaly, Laois, Westmeath, Longford and Roscommon have over 3.1 km of waterway km^{-2}. Adjoining these, with 2.5-3.1

km of waterway km^{-2} are Cos. Cavan, Monaghan, Louth and Meath. Much of this area is low-lying, quality grazing land, which has been substantially drained for grassland improvement.

That most of these counties have very high proportions of land devoted to grassland is illustrated in Figure 33. The proportion is high in all Irish counties, being lowest in Cos. Donegal and Mayo - principally because large portions of these counties are peat, moorland or mountain. Co. Offaly has, surprisingly, one of the lowest mean areas of grassland; nevertheless, 50.1% of the landscape is grassland. Counties with over 75% grassland cover are Kilkenny, Limerick and Monaghan.

Consideration of variation in density of unimproved grasslands and improved grassland shows that, as might be expected, unimproved grasslands form a larger proportion of the land in the west and north-west (with the highest proportion in Co. Leitrim) than in the south-eastern half of the country (Figure 34). A map of the improved grassland proportions (Figure 35) is almost a complete reverse of the county variation in unimproved grassland. In particular, Co. Kilkenny has over 70% of land area as improved grassland [73.8%]; Cos. Wexford, Waterford, Tipperary, Limerick and Meath have a high improved grassland cover (48-60%).

Similarly, highest proportions of land are given over to tillage (including grassland leys) in the south-eastern half of the country, with the highest proportions (>22%) in Cos. Carlow, Wexford and Louth (Figure 36).

Hedgerow, treelines and boundaries comprised of scrub are considered in Figures 37, 38, 39 and 40. The first figure shows county variation in the mean length of hedgerow and treeline, and the second includes lengths of scrub boundaries: these two figures differ little in overall geographical variation, the only county 'upgraded' by inclusion of scrub being Wicklow (*n.b.* the scales differ on the figures as the inclusion of scrub considerably raises the estimate of boundary vegetation). There are correlations between areas of pasture and areas/lengths of hedgerow and badger density. For this reason, hedgerow/treeline and boundary scrub have been examined in greater detail in this section.

The third and fourth figures (Figures 39 and 40) map hedgerow density (derived by division of the calculated length of hedgerow and treeline by the total area of primary 'farmland' (*i.e.* total area of grassland and arable land); Figure 40 adds scrub boundary to the total boundary length). Bare treelines have been excluded: their mean length was found to be small, and, also, they have little or no ground vegetation.

In summary, it is observable that many of the western counties (Kerry, Galway, Mayo, Donegal, Roscommon), and also Co. Wicklow in the east, have low hedgerow and treeline length. The country, as in consideration of unimproved and improved grassland as well as overall grassland and also arable areas, shows an overall division with regard to hedgerow/treeline - with mean values being generally higher in the eastern and southern portions of the country. Counties with high hedge density and high mean values for hedge and treeline are Kilkenny, Waterford, Tipperary, Cavan and Monaghan. These counties, and Cos. Wexford and Meath all have between 9.5 and 11.5 km of hedgerow or treeline per km^2.

The variation in hedgerow density (Figure 39) is similar to that for mean total areas of grassland habitats - though there are some differences in the pattern for some counties - which suggests that hedgerow density (*per unit grassland and arable not per 100 ha land survey*) increases in landscapes more suited to good pasture and arable land. Counties Cavan, Monaghan, Offaly, Tipperary, Kilkenny, Waterford and Wexford have between 115 and 139 m of vegetated boundaries per unit of farmed land. Some of these counties have the highest boundaries comprising hedgerow and treeline only, namely, Cavan, Monaghan, Tipperary, Kilkenny and Waterford, with between 115 and 135 m per ha grass and arable area.

Figure 40 is similar but takes into account scrub boundaries additionally: whilst this Figure shows less county by county variation in mean vegetated boundary length; thus proportionately more boundaries in counties such as Donegal, Westmeath, Clare, Kerry, Carlow and Sligo consisted of scrub. Nevertheless, the value for mean vegetated boundaries (per unit pasture and arable land) still shows marked geographical variation: landscapes more suited to agricultural activity - and pasture in particular - have more hedge per unit of agricultural land. Poorer landscapes probably possess less hedge type boundaries for several reasons: boundaries may consist of stone walls, of dykes with sparse or no scrub or hedge vegetation, or of fence lines. Poorer returns from farming may mean that overall boundary length is smaller (*i.e.* field size is larger - though one should note that unimproved grassland in much of the west is rough pasture which often has few boundaries); poorer farming returns may also result in less attention to maintenance of hedges.

Scrub areas (Figure 41) are most abundant in Clare, Donegal, Longford, Waterford and Laois. There is little pattern to the geographical variation in proportion of land covered by low or tall scrub: these categories include areas of scrub constituting boundaries.

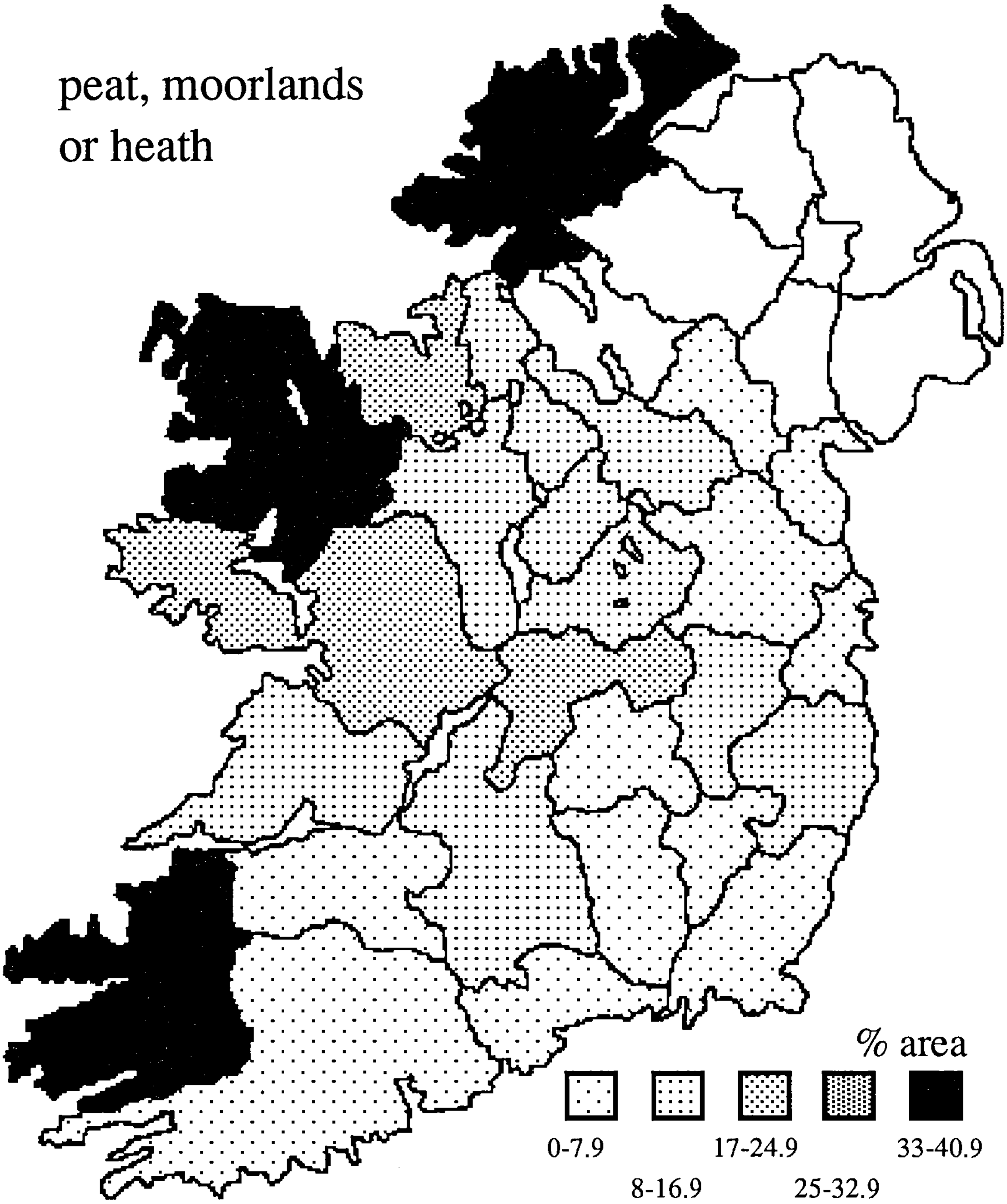


Figure 29. Variation in proportion of land with cover of the peat/moorland habitat group (comprising peat habitats, moorland and lowland heath) by county, given by the mean percentage of the total area surveyed within each county. The values are equivalent to density estimates expressed as ha km^{-2}.

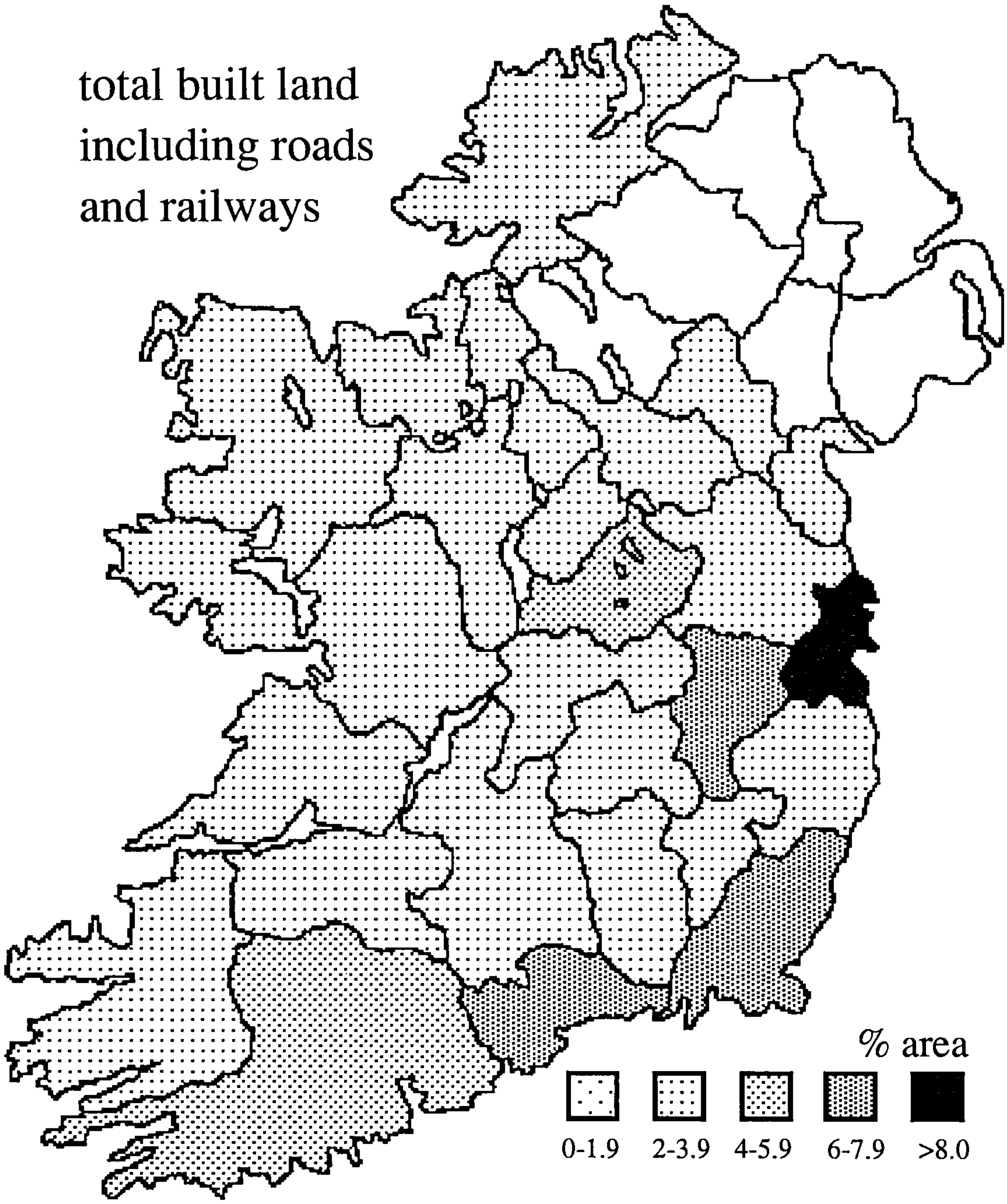


Figure 30. Variation in proportion of built land (comprising built land, roads, railways and urban gardens) by county, given by the mean percentage of the total area surveyed within each county. The values are equivalent to density estimates expressed as ha km^{-2}.

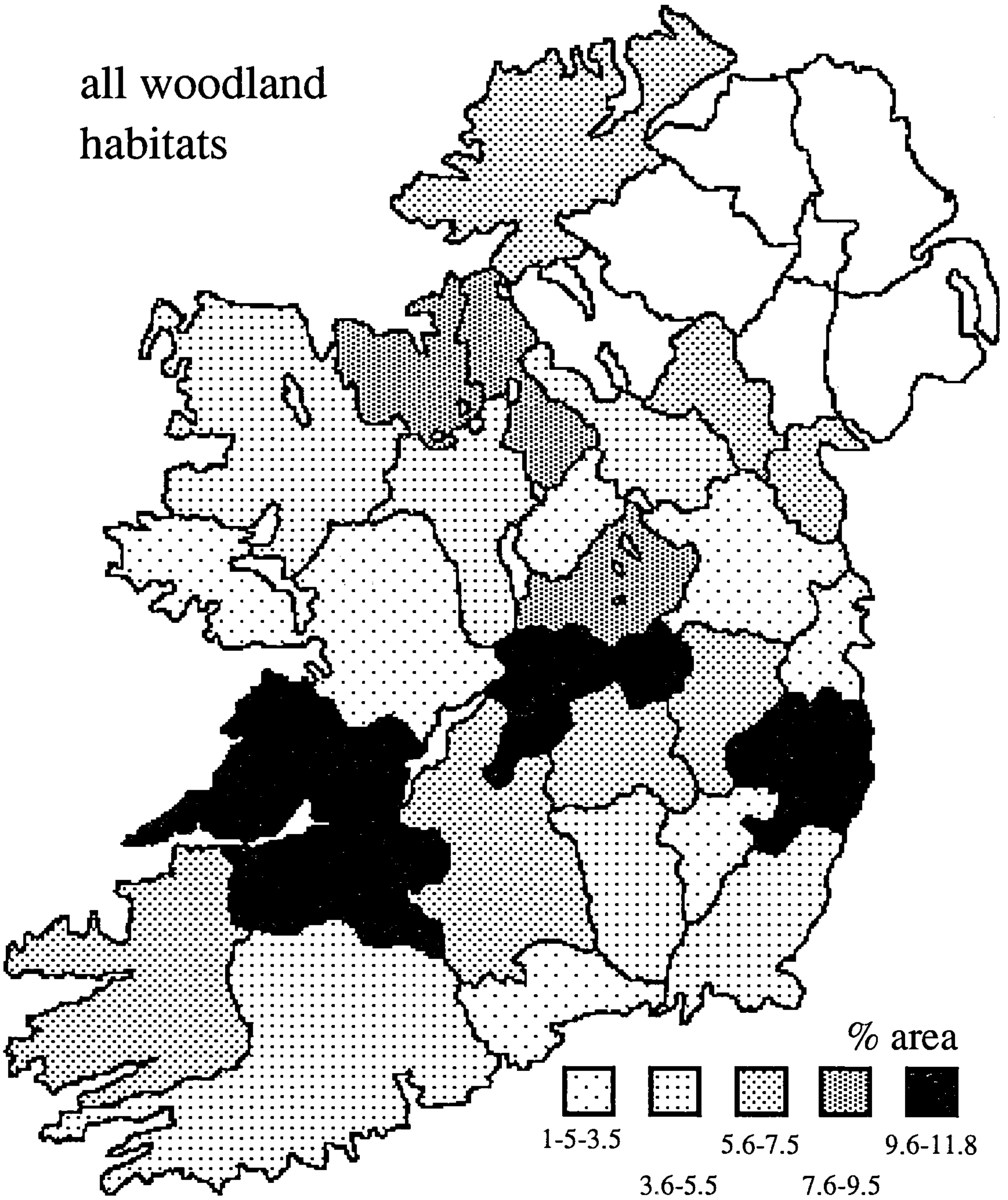


Figure 31. Variation in proportion of land with woodland cover (comprising all woodland types: semi-natural and plantations, deciduous and coniferous, and mixed) by county, given by the mean percentage of the total area surveyed within each county. The values are equivalent to density estimates expressed as ha km^{-2}.

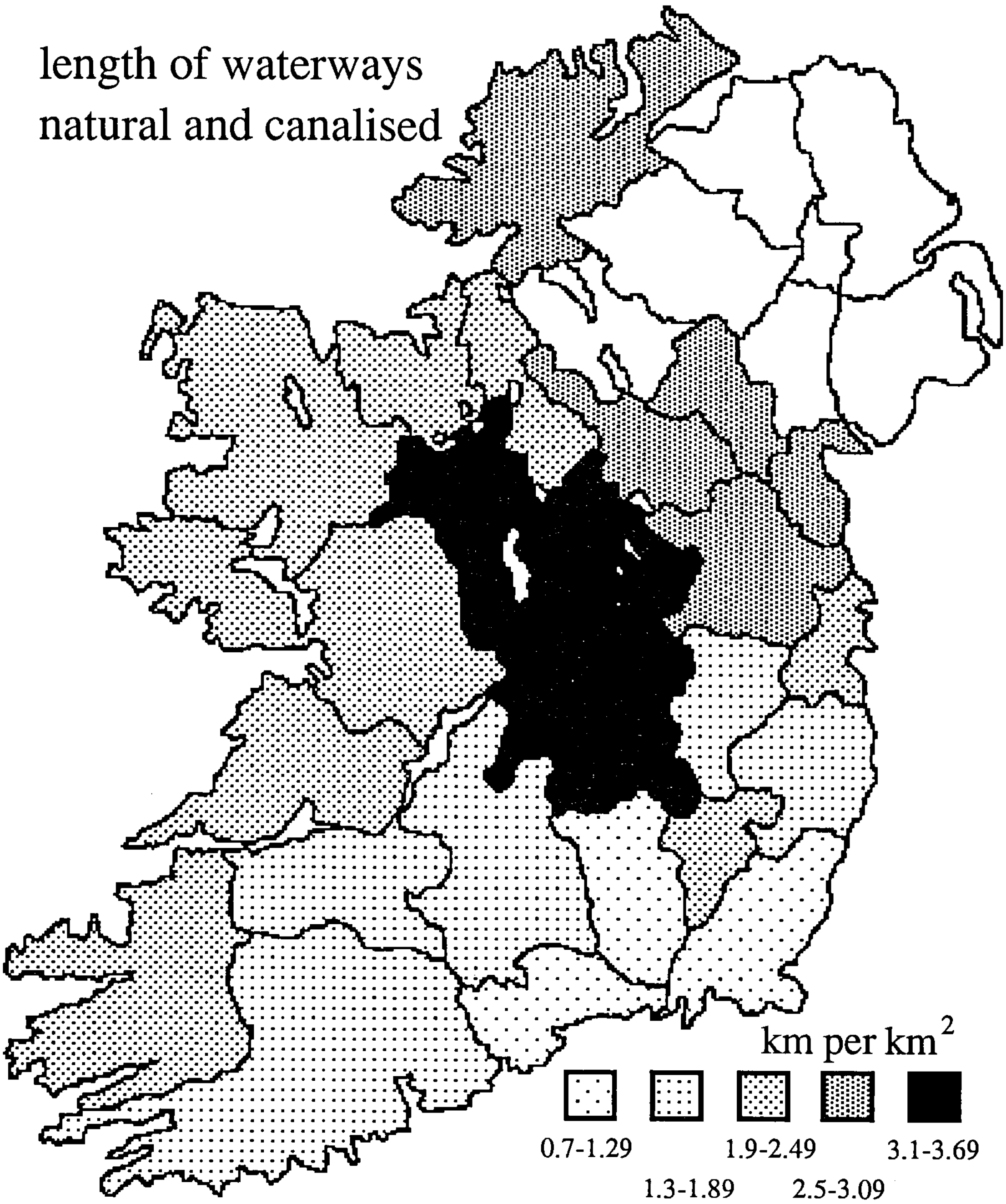


Figure 32. Variation in waterway length (comprising natural running water and canalised running water) by county, given as mean length (km) per km^2 observed in each county.

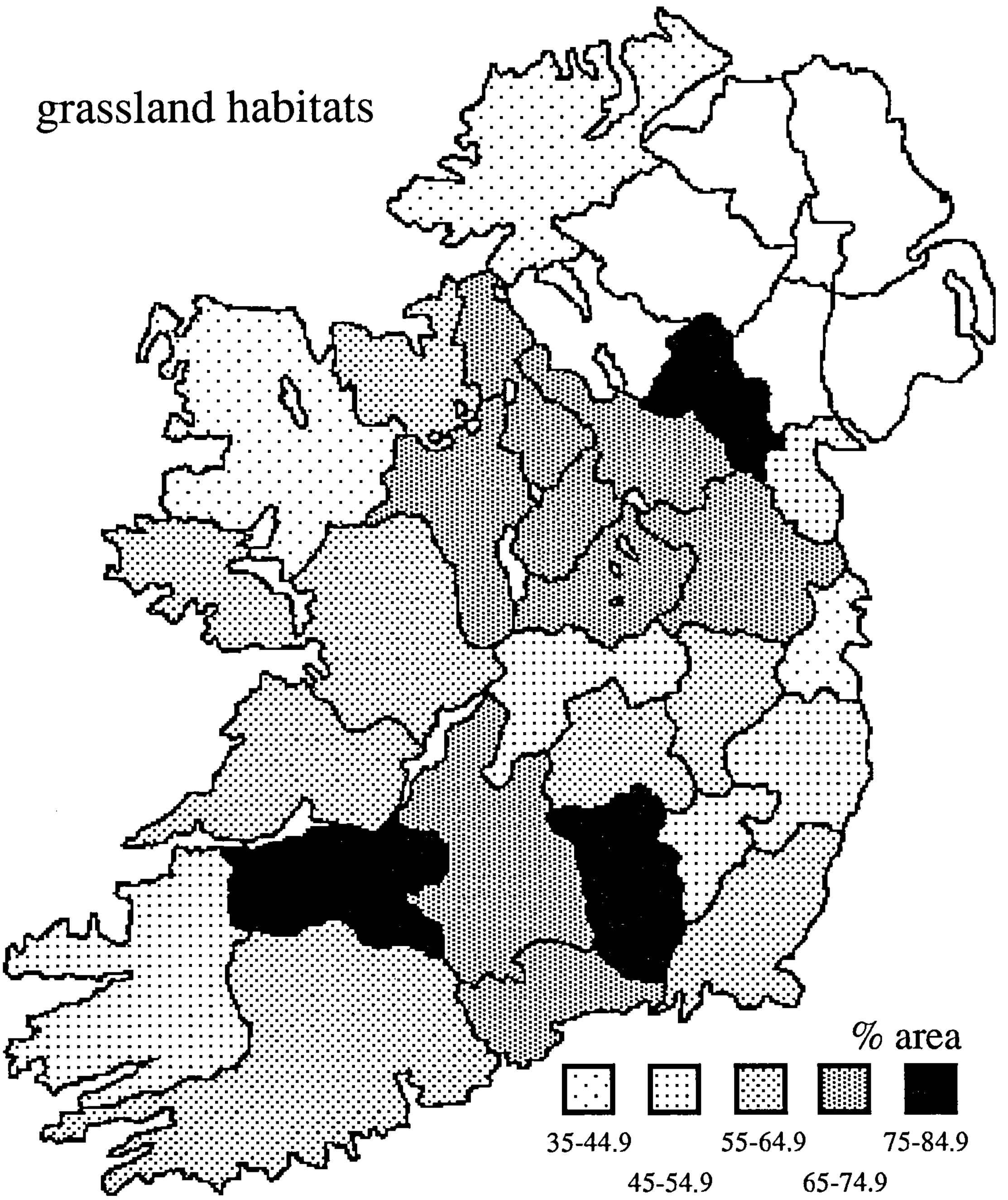


Figure 33. Variation in proportion of grassland (comprising unimproved upland and lowland grassland, semi-improved grassland and improved grassland) by county, given by the mean percentage of the total area surveyed within each county. The values are equivalent to density estimates expressed as ha km^{-2}.

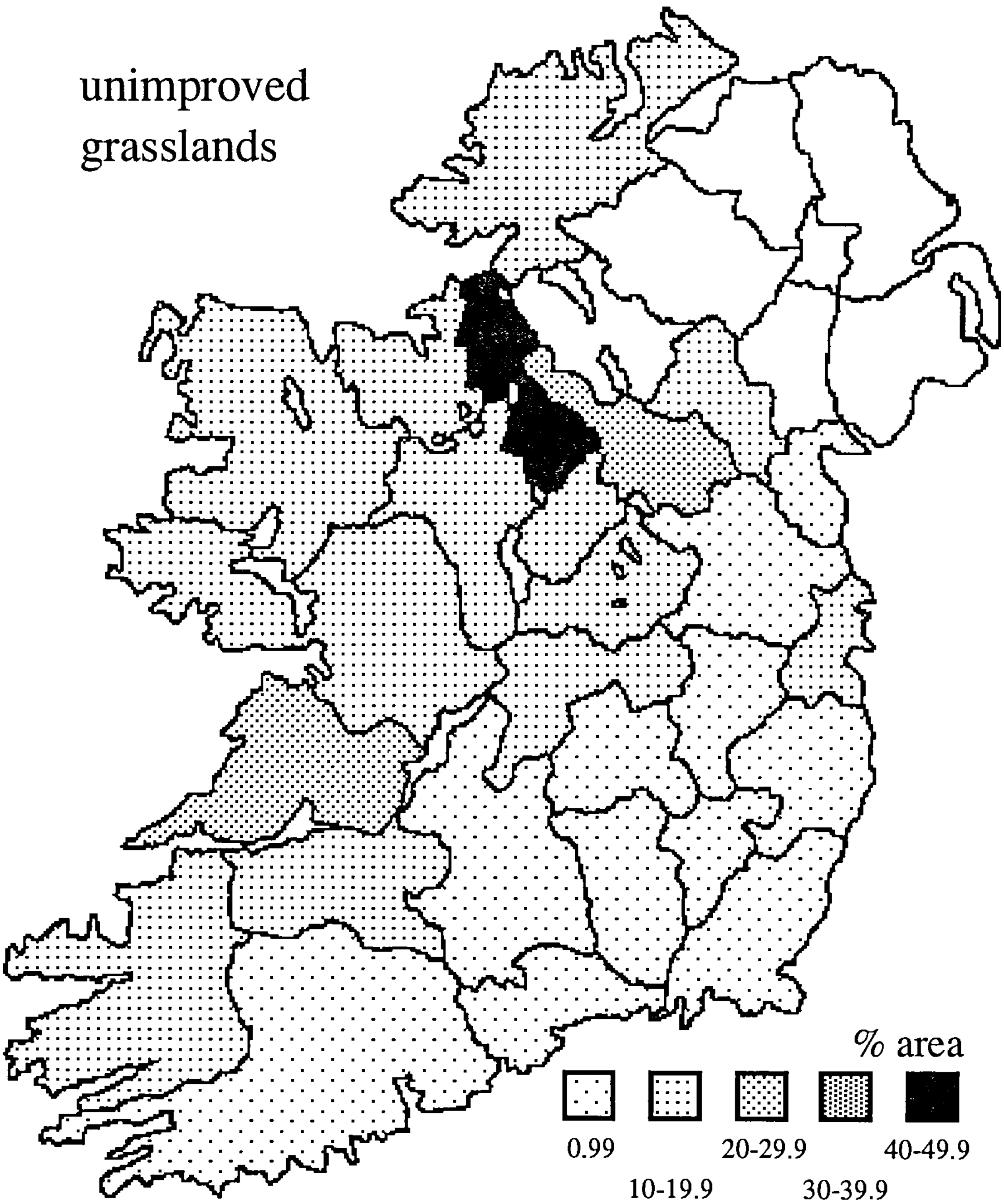


Figure 34. Variation in proportion of unimproved grassland (comprising unimproved upland and lowland grassland) by county, given by the mean percentage of the total area surveyed within each county. The values are equivalent to density estimates expressed as ha km^{-2}.

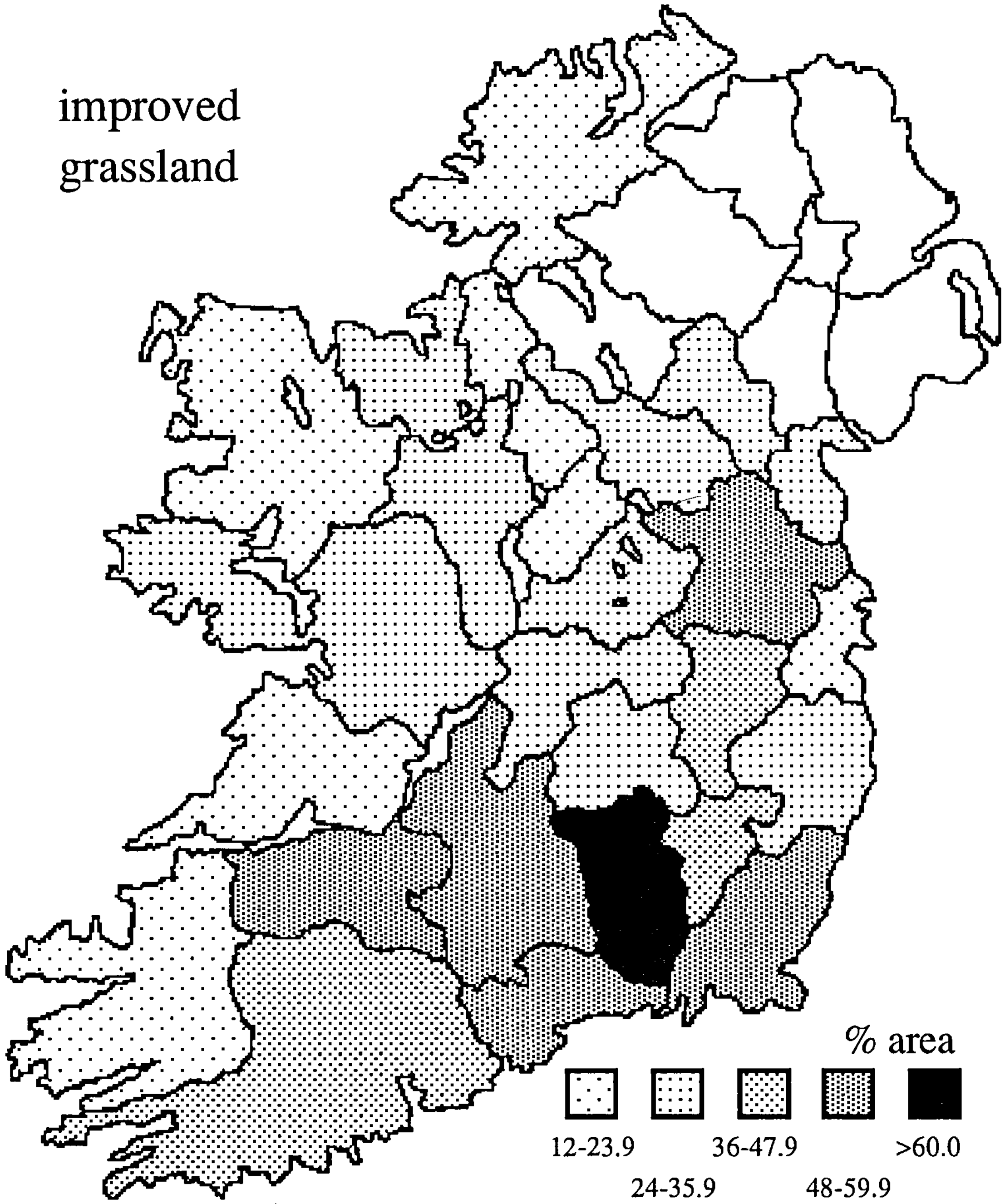


Figure 35. Variation in proportion of improved grassland by county, given by the mean percentage of the total area surveyed within each county. The values are equivalent to density estimates expressed as ha km^{-2}.

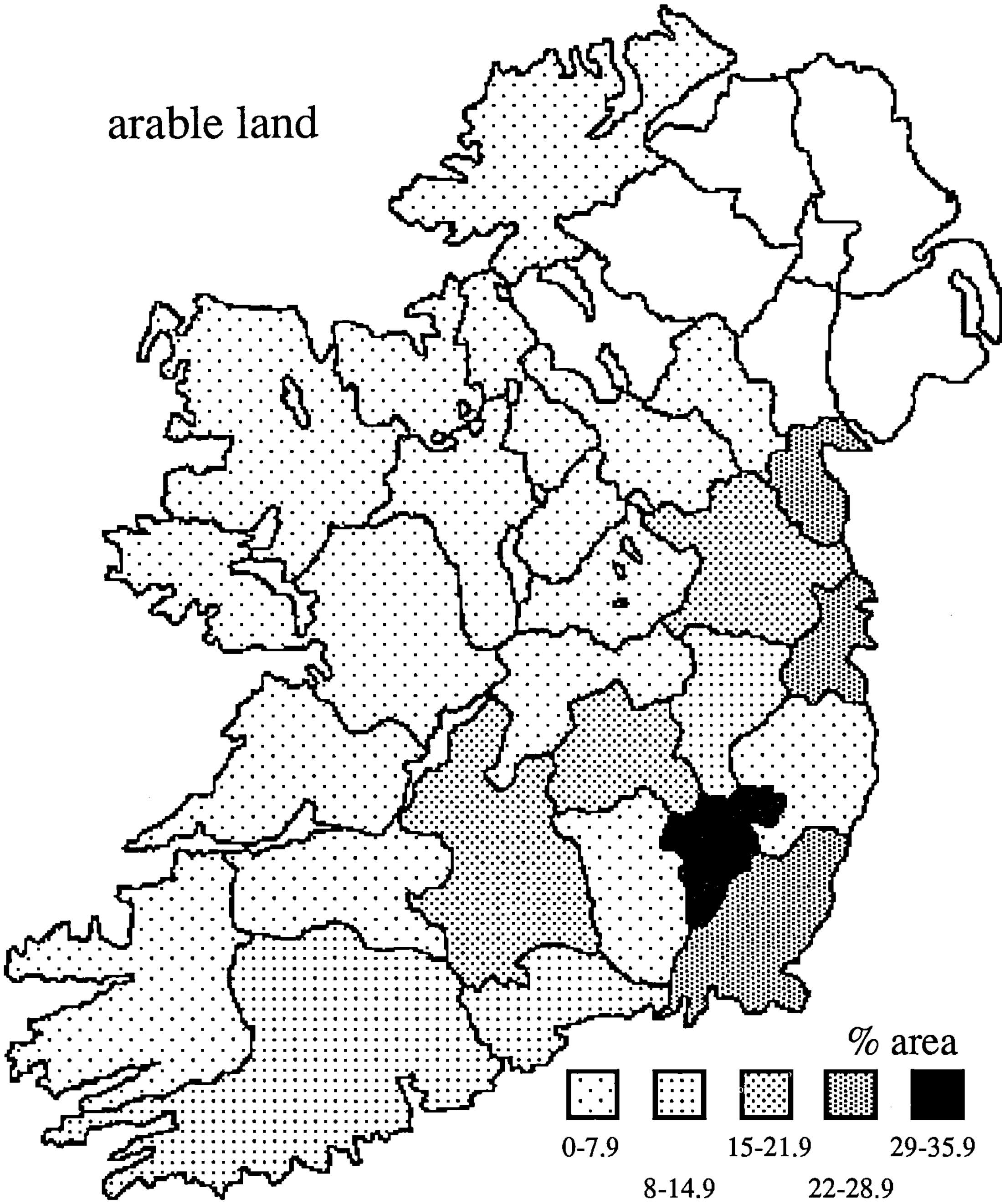


Figure 36. Variation in proportion of arable land (comprising all arable sub-categories, including grassland leys) by county, given by the mean percentage of the total area surveyed within each county. The values are equivalent to density estimates expressed as ha km^{-2}.

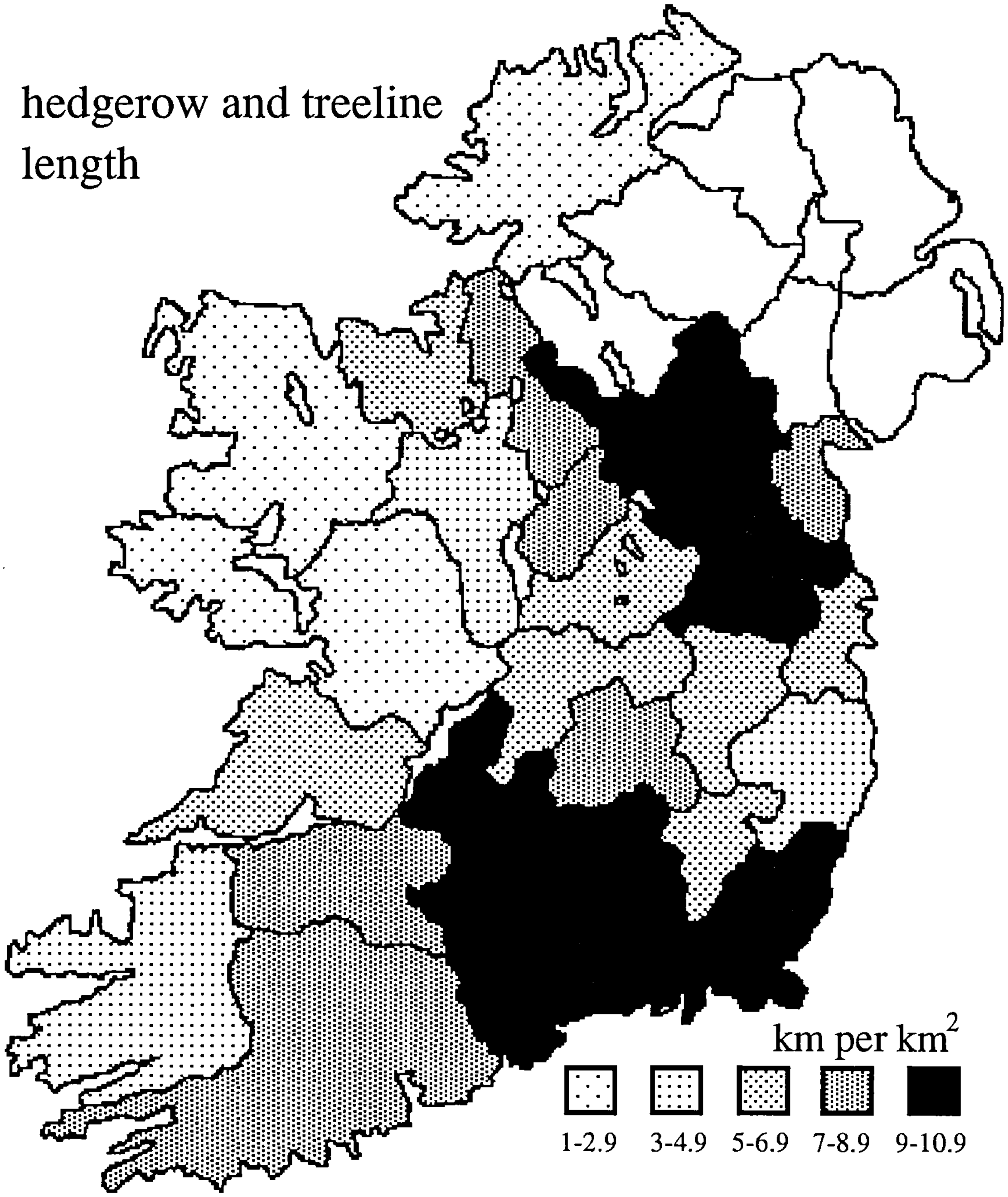


Figure 37. Variation in length of hedgerow and treeline (combined) by county, given by the mean combined length (km) observed in each county. Bare treeline is excluded.

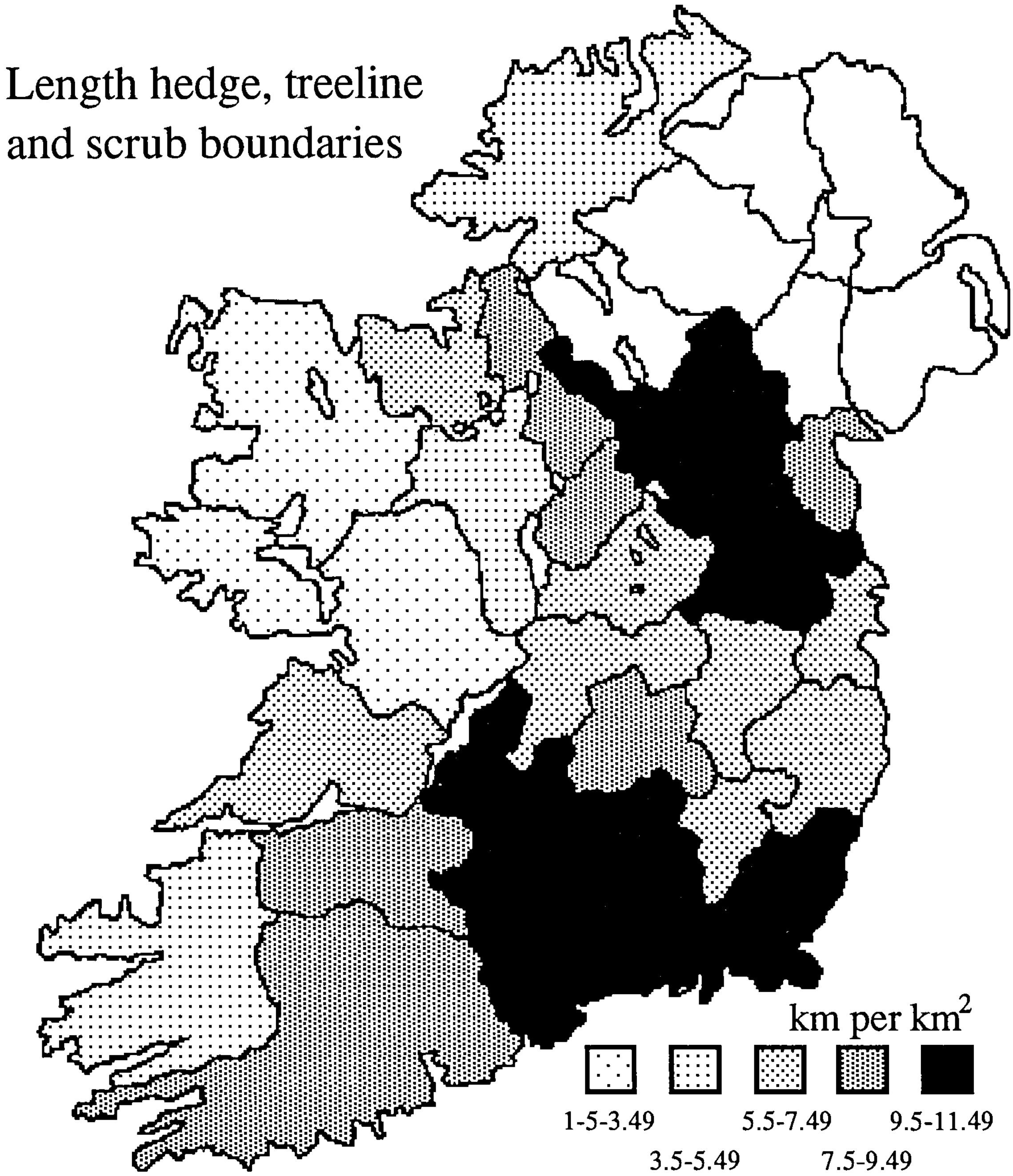


Figure 38. Variation in overall length of the hedge/scrub group (comprising hedgerow, treeline and scrub boundary length) by county, given as mean combined length (km) per km^2 observed in each county. Bare treeline is not included.

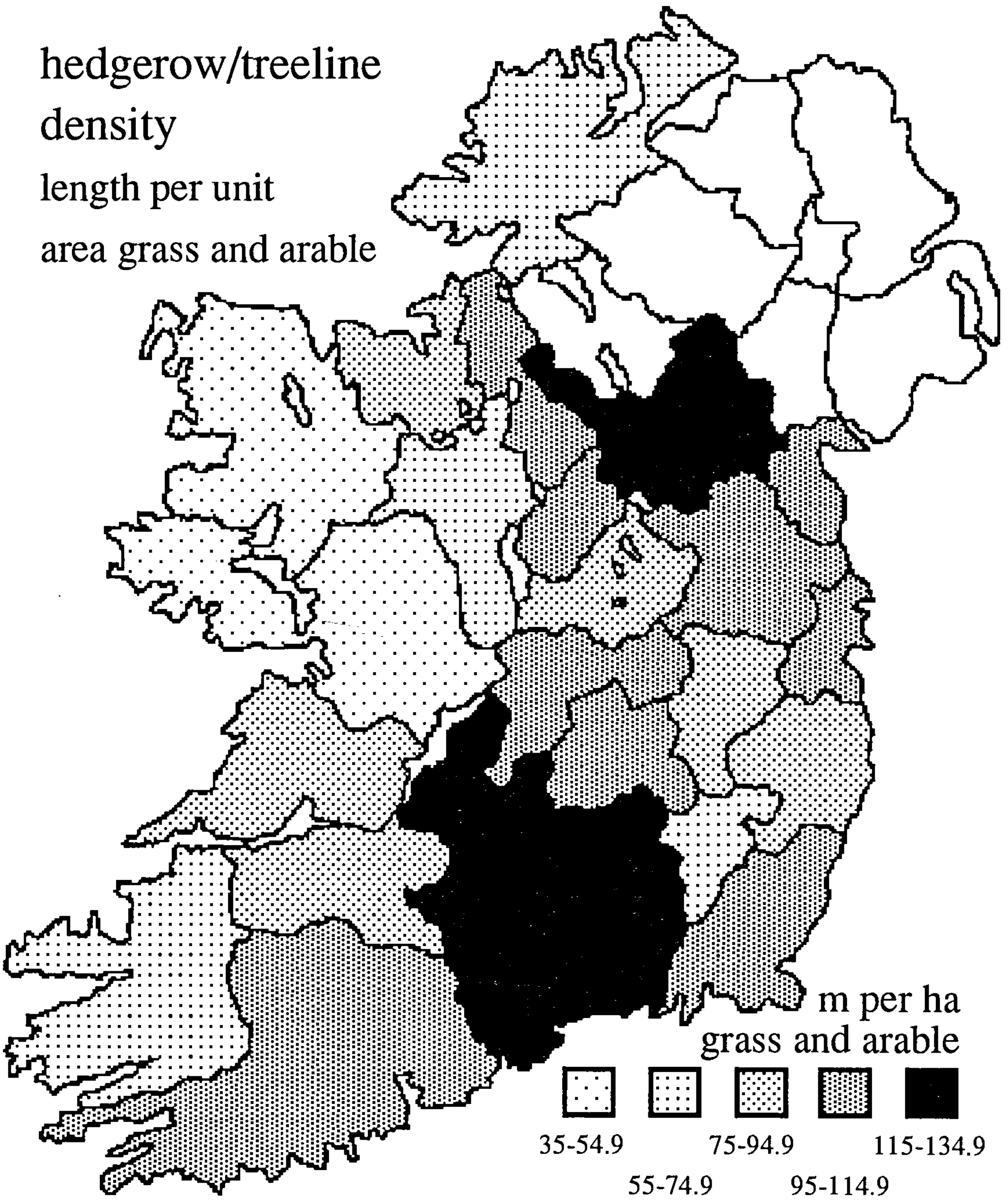


Figure 39. Variation in hedgerow density according to county. The density is given by the length of hedge and treeline (combined) per unit area of grassland and arable (combined). Bare treeline has not been included.

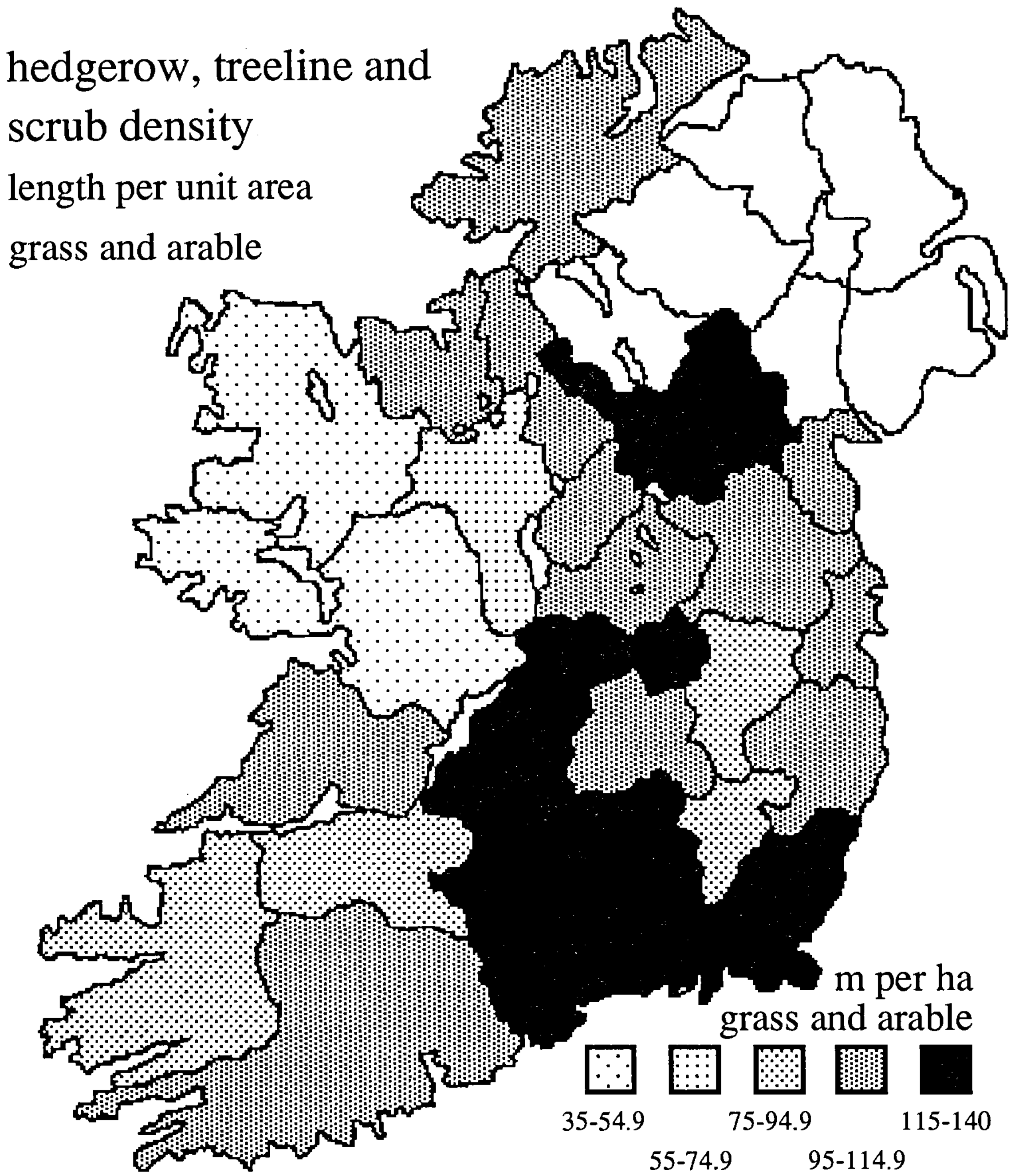


Figure 40. Variation in hedgerow density according to county. The density is given by the length of hedge, treeline and scrub boundaries (combined) per unit area of grassland and arable (combined). Bare treeline has not been included.

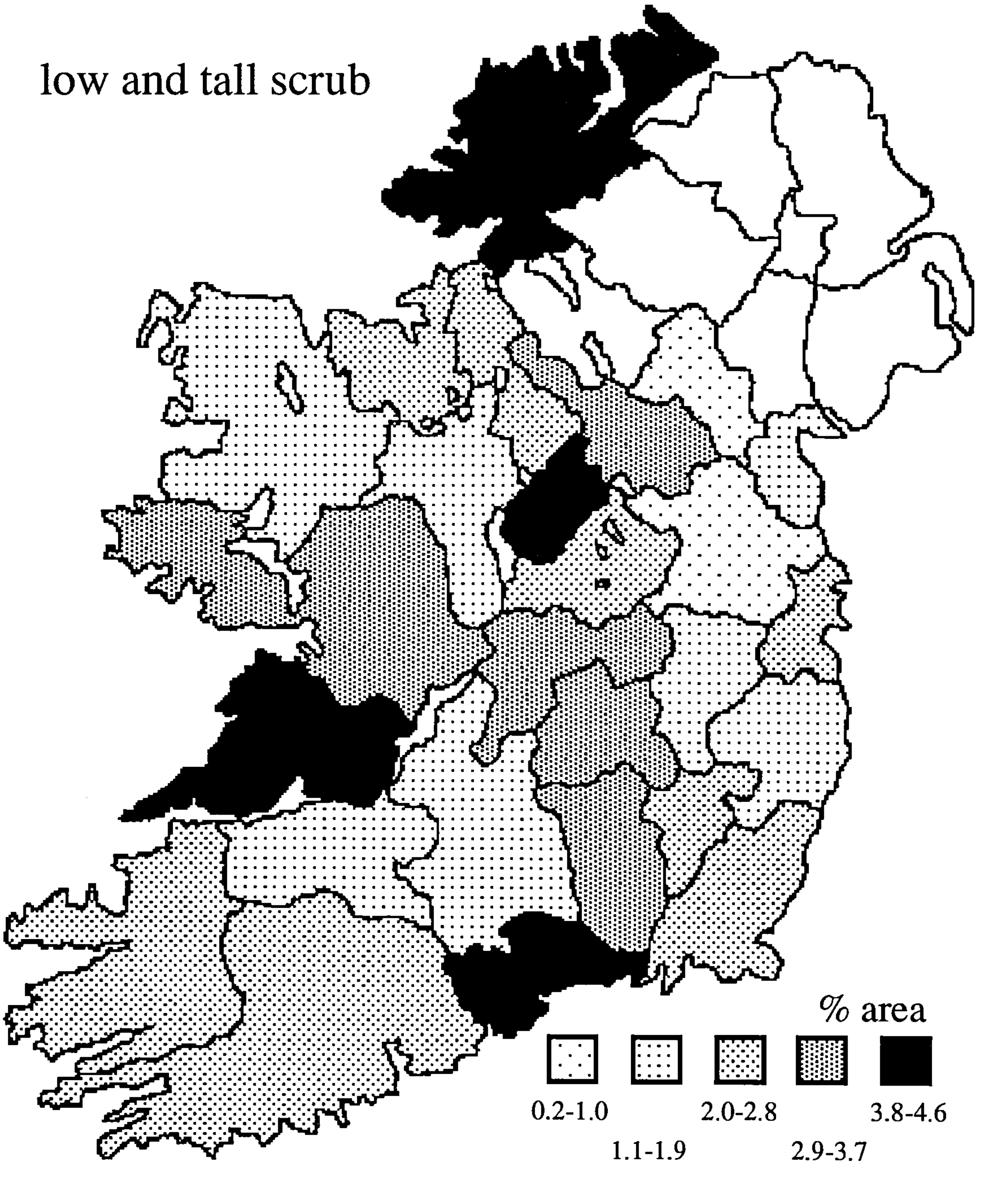


Figure 41. Variation in proportion of scrub land (comprising low and tall scrub) by county, given by the mean percentage the total area surveyed within each county. The values are equivalent to density estimates expressed as ha km^{-2}.

Grazing lands and stock types

The use of land areas by domesticated stock was assessed as part of the habitat survey of Ireland. Stock present, or signs of the use of the land for stock, were indicated by surveyors. Those squares that were not assessed satisfactorily for stock present were not included in analyses. In the squares that were subsequently considered for analysis, about 22% of grasslands had not been noted for stock use: throughout, this appears to be through oversight on the part of surveyors, and it may be reasonably assumed that the proportions of this unallocated grassland used for the different stocks would be similar to the areas recorded fully. The undesignated proportion varied with region and county and therefore with the observers primarily responsible.

A number of habitats were allocated database space for inclusion of stock type and, if stocks were grazing any of the other habitats, these areas were included in an extra database field which did not note habitat type. Surveyors were noted to have paid less attention to stocks that might be grazing habitats other than grassland pastures and grassland leys, so the results presented are likely to be slight underestimates of the total areas of land utilised, even marginally, for grazing. Areas of scrub were not usually noted for stock type: if they were, then the area of land involved was added to the extra database field referred to above.

Overall results

Table 17 presents the regional means (uncorrected means, with maxima and standard errors included in Appendix A9). Table 18 presents the corrected regional means. Values given below are means or percentages based on corrected values.

The overall mean for land used for grazing in Ireland is 60.4 ha km^{-2}, which includes all habitats and not grasslands alone. Although grassland leys had posed difficulties for some observers, total arable land devoted to grazing comprised a mean of only 1.6 ha km^{-2}. The total land assessed for grazing by all stocks on grasslands alone (habitats 29-32) averaged 48.3 ha km^{-2}. The recorded undesignated portion on grasslands was 11.0 ha km^{-2}, the estimates thus totalling 59.3 ha km^{-2}. The earlier assessed grassland mean area for the Republic was 59.7 ha km^{-2}: the discrepancy of 0.4 ha km^{-2} most probably consists of undesignated land, arising from the complexities of considering and entering the grazing data into the database files, where it was potentially easy to neglect undesignated areas in totalling stock types during planimeter-based assessments - the error is small (<2%). Some individual counties were observed to have higher proportions of grasslands undesignated as to stock type using them: as most surveyors were county based, these differences are due to variation in observer effort in this regard. Counties with high proportions of grasslands undesignated (*c.* 20-25%) were Cavan, Clare, Longford, Louth, Monaghan and Wexford.

The overall proportion of land devoted to cattle is high, at 43.5%, suggesting that avoidance of badgers or separation of cattle from badgers would be difficult to achieve. Regionally, the mean area used for grazing were very similar, varying from 54 to 67 ha km^{-2} across all regions, except the East where it was lower at 44%. Particular survey squares had very high proportions of the 100 ha area utilised for grazing: some squares were 100% grazed by sheep, other squares up to 98.6% grazed by cattle. Other stock type(s) grazed 50% of one survey square.

Land area specifically used for cattle grazing averaged 35.1% of the total area and for sheep 15.8%. Cattle pasture (excluding land shared by sheep) predominated in the Mid-West (51.9 ha km^{-2}; 2.6 ha km^{-2} for sheep) and in the South (46.6 ha km^{-2}). Only in the North-West, is more land grazed by sheep (30.7 ha km^{-2}) than cattle (16.1 ha km^{-2}). Some pastures were noted to be shared by cattle and sheep (at one time or another); if this is included in the totals for cattle pasture, then a total of 72.1% of stocked grazing land (all habitats) was utilised by cattle (overall, varying from 52.2% in the North-West to 93.7% in the Mid-West). Considering the grassland pastures (habitats 29-32) only, 80.6% of their area was grazed by cattle (varying from 59.7% in the East to 94.0% in the Mid-West).

Initial results for Northern Ireland suggest that there are significant differences between the Republic and the North. While grazing areas would appear to be, on average, the same proportion of total land area as in the Republic (*c.* 58%), less of this grazing is given over to cattle and much more given over to sheep in Northern Ireland. While the mean area devoted to cattle in the Republic is 43.5% of total area, only *c.* 31% is devoted to cattle in the North (where land areas utilised by cattle and sheep would appear to be virtually equal). This difference is less pronounced, considering pastures alone (39.0% of total land area in the Republic re. *c.* 30% in the North). Examining the proportions of grazed lands only, *c.* 53% of land assessed for grazing was utilised by cattle (re. 72.1% in the Republic); for grasslands alone, *c.* 55% of their area was grazed by cattle *cf.* 80.6% in the Republic.

County results

The data for county by county assessments of stock types present in the various habitats is given, in the same manner as for regions, in Appendix A10 (maximal values and standard errors are not included in the lengthy tables for counties). Means for areas corrected for sea, lake and shore are also given in the appendices (Appendix A11). As in the previous section on habitat distribution, some aspects of the grazing data have been mapped on a county basis for clarity of presentation (using the corrected means). Three figures are presented:

1. Mean hectarage per km^2 of land grazed by cattle (including land shared by cattle and sheep) - all habitats included (Figure 42).

2. Mean hectarage per km^2 of land grazed by sheep (also includes the land shared by cattle and sheep) - all habitats included (Figure 43).

3. Proportion (%) of pasture grasslands (habitats 29-32 only) grazed by cattle (Figure 44).

Figures 42 and 43 reveal the overall proportion of total land area apportioned to grazing either by cattle or by sheep and Figure 44 reveals the emphasis placed on stock type in grassland pastures (not including grassland leys) in different parts of the country.

The highest proportions of land area utilised for cattle grazing were found to be in Cos. Limerick and Waterford, and also in Cos. Tipperary, Roscommon and Sligo (Figure 42). In contrast, the highest proportions of total land area used for sheep grazing were clearly in the North-West (Figure 43), particularly Cos. Donegal, Mayo and Sligo, with high proportions also in some other western counties, including Cos. Kerry, Galway and Leitrim. Interestingly, high values were not observed in many counties bordering Northern Ireland, such as Cavan, Monaghan and Louth: this is suggestive of different farming policies or practices, which may be historical in origin, between the Republic and Northern Ireland, given the observations noted above, and that the initial results do not indicate any major habitat differences between the North and the Republic.

A central belt of Ireland, from Co. Cork to Co. Monaghan is observed to have the highest proportions of cattle grazing land, but high values were noted for some western counties also (Figure 44). Four adjoining counties, Cork, Limerick, Tipperary and Waterford, show over 90% of pastures being used for cattle. The East region (the south-eastern counties) is notably low. Some of these differences between counties result from a preference to make use of grazing land for cattle rather than sheep, presumably because of the land's capability to sustain cattle stocks.

However, it should be stressed that the bulk of grassland in all counties is used for cattle grazing (at least 50% - Figure 43). In addition to the high proportions noted in the south-west, very high pasture utilisation for cattle is also observable in Cos. Clare, Offaly, Meath, Cavan, Mayo, Roscommon, Sligo and Monaghan.

Grassland leys formed a small proportion of the land area in all counties. In Co. Carlow, the 3.9% mean area of leys was used mainly for sheep pasture; in Cos. Cork, Kerry, Kildare, Leitrim, Tipperary, Waterford and Wexford, where leys also comprised over 2% of land area, they were used principally for cattle.

Table 17. Summaries of data on the areas of land used for domestic grazing stock. Values are given in ha km^{-2}, being uncorrected means for each region.

	South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
Mean land area utilised for grazing - ha km^{-2}; all habitat categories								
Cattle	39.04	49.86	24.18	14.47	36.39	45.21	19.19	**32.74**
Sheep	16.50	2.48	19.80	27.60	8.60	10.36	16.37	**14.74**
Cattle and sheep	3.30	3.80	13.60	16.13	5.78	7.76	5.28	**7.89**
Other	0.68	1.11	0.61	0.43	2.00	0.99	1.38	**1.01**
Total land with cattle grazing on it	42.33	53.66	37.78	30.60	42.17	52.97	24.47	**40.63**
Overall total grazing land	59.51	57.24	58.19	58.63	52.77	64.33	42.22	**56.38**
percentage of total with cattle	71.1	93.7	64.9	52.2	79.9	82.3	58.0	**72.1**
Mean land area utilised for grazing in specified 'grazing' habitats (see text)								
Cattle	38.94	48.91	23.72	14.14	36.24	44.94	19.19	**32.42**
Sheep	16.05	2.45	19.39	26.40	8.37	10.36	16.22	**14.38**
Cattle and sheep	3.26	3.80	13.30	15.54	5.78	7.69	5.22	**7.75**
Other	0.68	0.89	0.32	0.43	1.91	0.99	1.38	**0.92**
Total land with cattle grazing on it	42.20	52.71	37.02	29.68	42.02	52.63	24.42	**40.16**
Overall total grazing land	58.94	56.04	56.73	56.50	52.30	63.98	42.01	**55.46**
percentage of total with cattle	71.6	94.0	65.3	52.5	80.3	82.3	58.1	**72.4**
Total area undesignated in specific 'grazing' habitats								
Total undesignated	18.71	22.96	19.67	16.73	29.31	18.32	35.90	**22.77**
Total area of grazing recorded on pastures only (habitats 29-32)								
Cattle	35.79	47.53	22.84	9.67	35.81	41.78	17.73	**30.42**
Sheep	5.20	2.44	11.07	8.13	8.05	6.28	14.05	**7.92**
Cattle and sheep	2.50	3.72	8.44	11.42	5.65	6.02	5.15	**5.97**
Other	0.55	0.81	0.24	0.05	1.90	0.99	1.38	**0.82**
Total land with cattle grazing on it	38.28	51.25	31.28	21.08	41.46	47.80	22.88	**36.39**
Overall total grazing land	44.03	54.51	42.59	29.26	51.41	55.07	38.31	**45.13**
percentage of total with cattle	86.9	94.0	73.4	72.0	80.6	86.8	59.7	**80.6**
Total area undesignated in pasture lands only (habitats 29-32)								
Total undesignated	7.04	13.35	7.30	8.65	14.89	6.75	16.04	**10.26**
Total area of land grazed in arable land (including grass leys)								
Cattle	2.10	0.29	0.00	0.75	0.13	2.83	1.30	**0.98**
Sheep	0.37	0.01	0.00	0.41	0.28	0.53	0.73	**0.30**
Cattle and sheep	0.37	0.08	0.00	0.04	0.12	0.75	0.04	**0.18**
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Overall total grazing land	2.83	0.38	0.00	1.20	0.53	4.11	2.06	**1.46**

Table 18. Summaries of data on the areas of land used for domestic grazing stock. Values are given in ha km^{-2}, being ***corrected*** *means for each region.*

	South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
Mean land area utilised for grazing - ha km^{-2}; all habitat categories								
Cattle	43.62	51.86	27.10	16.08	36.96	46.62	19.94	**35.06**
Sheep	18.43	2.58	22.20	30.67	8.74	10.68	17.01	**15.78**
Cattle and sheep	3.68	3.95	15.25	17.92	5.87	8.00	5.48	**8.45**
Other	0.76	1.15	0.68	0.47	2.03	1.02	1.43	**1.09**
Total land with cattle grazing on it	47.30	55.81	42.35	34.00	42.83	54.62	25.42	**43.51**
Overall total grazing land	66.50	59.54	65.23	65.14	53.59	66.33	43.86	**60.38**
percentage of total with cattle grazing	71.1	93.7	64.9	52.2	79.9	82.3	58.0	**72.1**
Mean land area utilised for grazing in specified 'grazing' habitats (see text)								
Cattle	43.51	50.88	26.59	15.71	36.81	46.33	19.94	**34.72**
Sheep	17.94	2.55	21.74	29.33	8.50	10.68	16.85	**15.40**
Cattle and sheep	3.65	3.95	14.91	17.27	5.87	7.93	5.42	**8.30**
Other	0.76	0.93	0.36	0.47	1.94	1.02	1.43	**0.98**
Total land with cattle grazing on it	47.15	54.82	41.50	32.98	42.67	54.26	25.36	**43.01**
Overall total grazing land	65.85	58.30	63.59	62.78	53.11	65.96	43.64	**59.39**
percentage of total with cattle grazing	71.6	94.0	65.3	52.5	80.3	82.3	58.1	**72.4**
Total area undesignated in specific 'grazing' habitats								
Total undesignated	20.90	23.88	22.05	18.59	29.77	18.89	37.29	**24.38**
Total area of grazing recorded on pastures only (habitats 29-32)								
Cattle	39.99	49.44	25.61	10.74	36.37	43.08	18.41	**32.58**
Sheep	5.81	2.54	12.41	9.04	8.18	6.48	14.60	**8.48**
Cattle and sheep	2.79	3.87	9.46	12.69	5.74	6.21	5.35	**6.39**
Other	0.61	0.85	0.27	0.05	1.93	1.02	1.43	**0.88**
Total land with cattle grazing on it	42.78	53.31	35.07	23.43	42.10	49.28	23.77	**38.97**
Overall total grazing land	49.20	56.70	47.75	32.52	52.21	56.78	39.80	**48.33**
percentage of total with cattle grazing	86.9	94.0	73.4	72.0	80.6	86.8	59.7	**80.6**
Total area undesignated in pasture lands only (habitats 29-32)								
Total undesignated	7.86	13.89	8.18	9.61	15.12	6.96	16.67	**10.99**
Total area of land grazed in arable land (including grass leys)								
Cattle	2.34	0.31	0.00	0.84	0.13	2.92	1.35	**1.05**
Sheep	0.41	0.01	0.00	0.46	0.29	0.55	0.76	**0.32**
Cattle and sheep	0.41	0.08	0.00	0.04	0.12	0.77	0.04	**0.20**
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Overall total grazing land	3.16	0.39	0.00	1.33	0.54	4.24	2.14	**1.56**

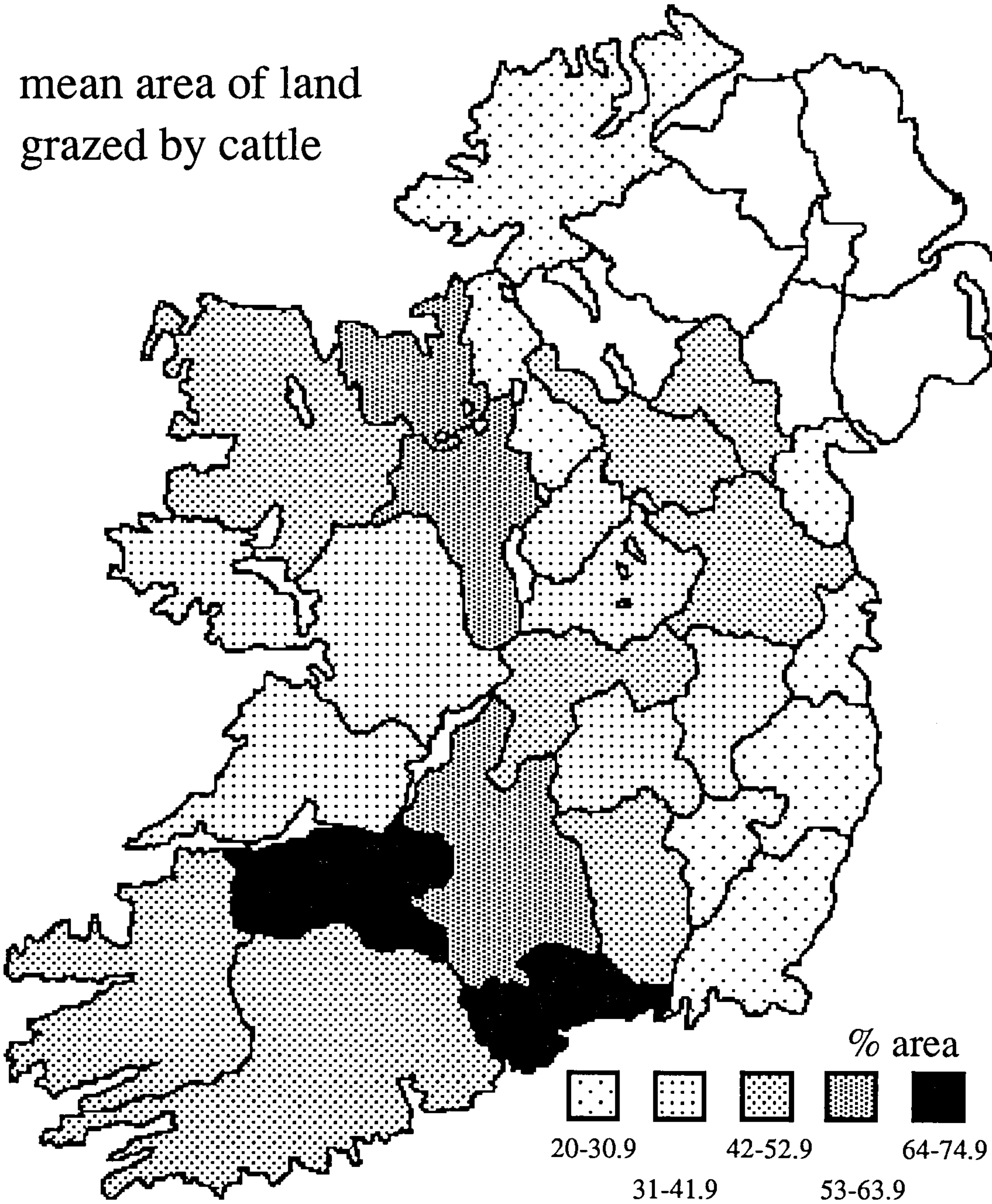


Figure 42. Variation in the mean area of land grazed by cattle in different counties. Values are given by percentages, which are equivalent to ha km^{-2}. Derived from corrected means.

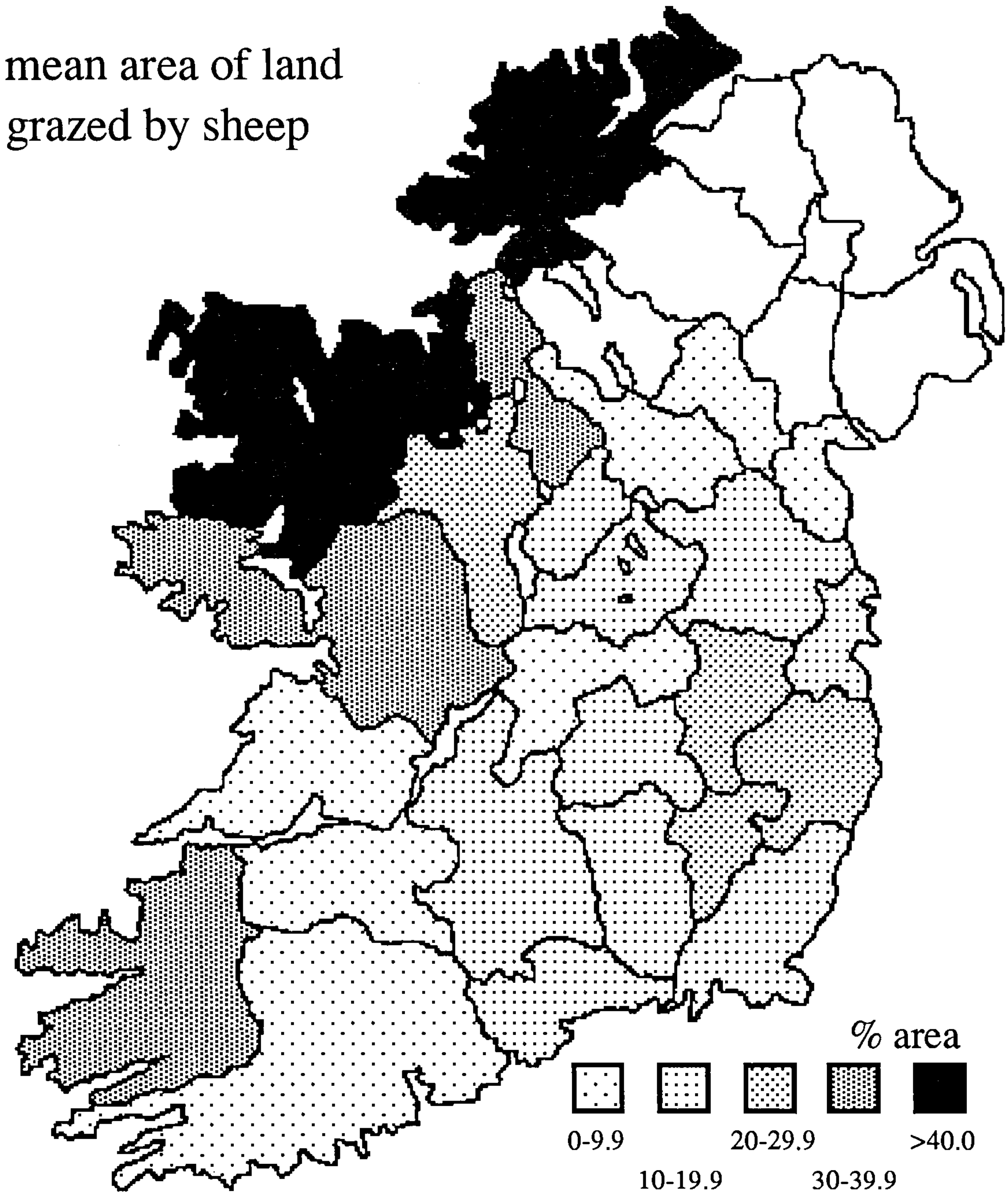


Figure 43. Variation in the mean area of land grazed by sheep in different counties. Values are given by percentages, which are equivalent to ha km^{-2}. Derived from corrected means.

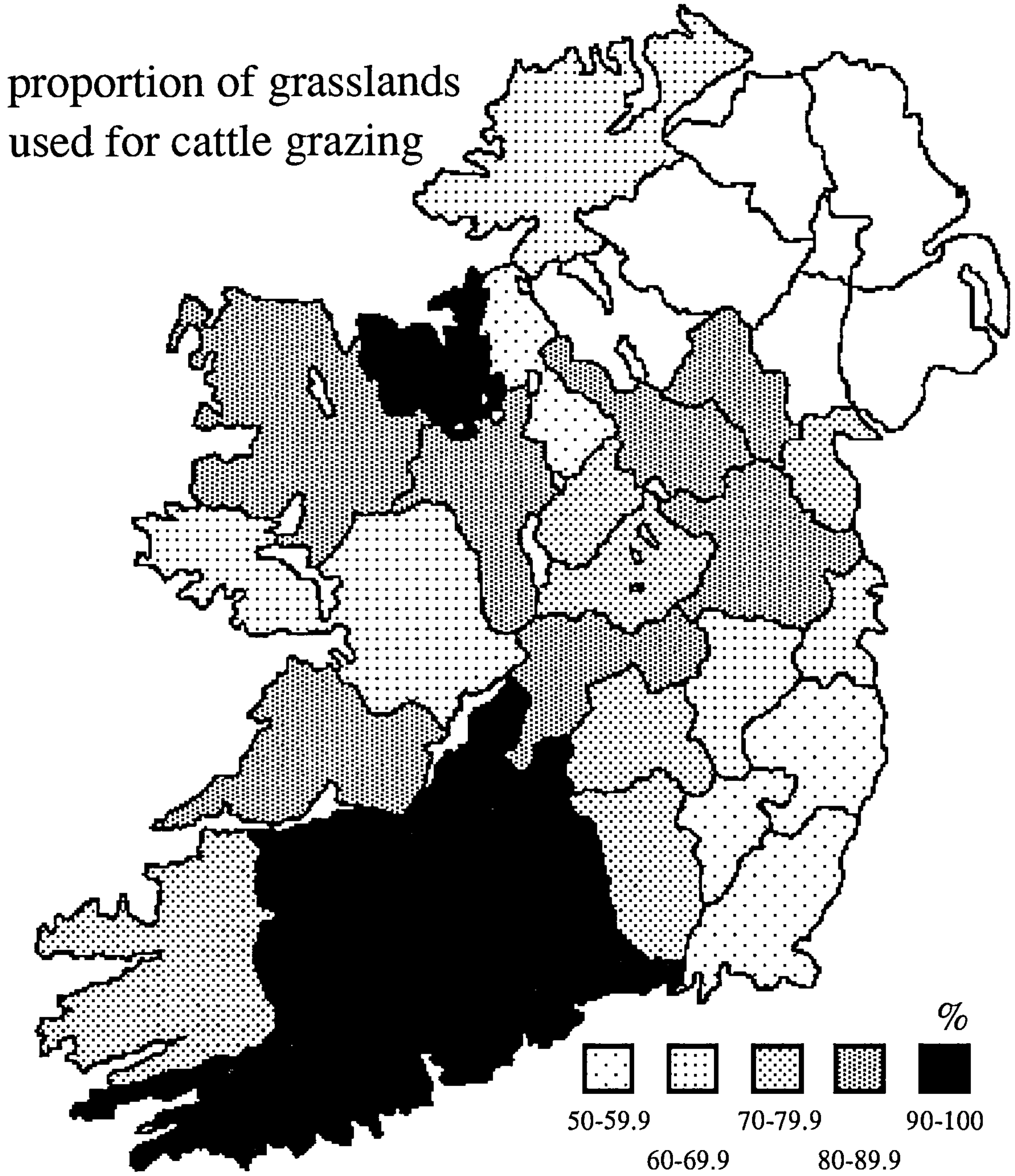


Figure 44. Variation in the proportion of grassland pastures grazed by cattle in different counties. Values are given by percentages of mean grassland pasture present in each county. Derived from corrected means.

Land classes

The habitat data has, so far, been summarised on a regional or county basis, but the limitations of such analyses are apparent. The data for Co. Cork, for example, are affected by the county's essential sub-division into east (more pasture and arable) and west (poorer grasslands, more bog and uplands) of the county: habitat averages for the county as a whole are not particularly meaningful. The lower mean area of grassland in Co. Offaly than in surrounding counties results from the large proportion of bog, worked peat and coniferous plantation (most of which would be located on drained bog or on commercially exhausted worked peat areas).

The land classes group landscapes into ecologically meaningful strata, rather than the arbitrary county or regional areas. Ireland's landscape has not been classified, and the results presented here are of an entirely tentative and preliminary nature, based on visually assessed and subjective classes. The need for appropriate ecological stratification is to be addressed in future research.

Results

Not all squares were placed in a landclass by surveyors. The occurrence of each class according to region is given in Table 19. The national distributions of each land class, as given by square surveys, have been mapped individually in figures presented below, with two landclasses mapped per figure (Figures 45 to 60).

In all, 669 squares were given a land class number using the guidelines (page 66). Landclass 1 was the most frequently observed (Figure 45), and landclasses 6 and 17 were also common. These three classes tend to have a high proportion of grasslands.

The overall habitat descriptions of the classes, by uncorrected means only, have been presented in Appendix A12 in the same manner as for counties. These values represent merely preliminary indications of the habitat distribution according to each land class and should not be considered as in any way definitive, given that they are based on visually assessed landscape descriptions. To apply corrections for areas of sea, lake and coastal margins, factors need to be calculated for each landclass. As compared to county data, correction factors will be much reduced in most landclasses but will be greatly increased in landclasses common in coastal areas (*e.g.* landclasses 7, 8, 14, 29, 30 and 31). Areas of sea, lake, *etc.* amounted to 44% of survey area in squares falling in landclass 7, 17% in landclass 8, 18% in landclass 14, 83% of landclass 29, 35% of landclass 30 and 50% of landclass 31. Given the preliminary nature of this data, it is presented without correction factors applied at this stage.

The landclass guidelines used by surveyors gave some indication of the overall habitat types to be expected. Accordingly, therefore, the habitat means for each landclass were found to be consistent with the guidelines. In landclasses 1, 3, 25, 26 and 27, the area of grass pastures and arable exceeded 85% of the total surveyed area. Landclasses 19,21, 22, 24, 30 and 32 had under 25% grass and arable land. These latter landclasses are moorland, mountain or exposed coasts, and consequently total peat and moorland area was high (respectively, 41%, 65%, 50%, 62%, 35% and 67%).

Table 19. Occurrence of each landclass by region.

Landclass	South-West	Mid-West	West	North-West	Mid-lands	South	East	Republic
1	26	18	15	5	45	19	20	**148**
2	3	2	5	3	3	6	3	**25**
3	2	1	0	0	1	1	1	**6**
4	2	0	1	0	0	0	2	**5**
5	4	3	7	0	8	1	5	**28**
6	11	8	15	7	34	8	9	**92**
7	5	3	1	2	0	3	2	**16**
8	4	0	3	1	1	0	3	**12**
9	1	0	0	0	1	0	2	**4**
10	1	1	2	0	4	0	4	**12**
11	1	0	0	0	0	0	1	**2**
12	1	3	0	0	0	0	0	**4**
13	2	1	3	1	1	0	2	**10**
14	2	0	1	0	0	0	0	**3**
15	1	1	2	1	4	0	3	**12**
16	3	1	4	2	1	3	3	**17**
17	13	9	26	7	6	10	4	**75**
18	6	3	10	8	3	1	2	**33**
19	7	5	8	9	1	3	1	**34**
20	4	1	2	7	0	0	1	**15**
21	2	1	1	5	1	1	1	**12**
22	3	0	0	5	0	1	0	**9**
23	1	0	0	1	0	1	0	**3**
24	6	2	8	2	0	1	2	**21**
25	3	0	1	0	0	1	1	**6**
26	0	1	0	0	0	0	2	**3**
27	0	1	0	0	0	0	0	**1**
28	2	0	1	0	0	1	0	**4**
29	1	0	1	0	0	0	0	**2**
30	5	0	1	3	0	0	0	**9**
31	4	0	3	4	0	0	0	**11**
32	4	1	20	1	8	0	1	**35**

Other landclasses with high proportions of peat and moorland included 18 (46%), 20 (26%) and 23 (68%). Many lowland landclasses had zero peat or moor areas (namely, 3, 4, 9, 11, 12, 14, 26, 27 and 29).

Some landclasses have high proportions of woodlands: 15 (15%), 19 (28%) and 22 (19%). Hedge and treeline length was generally higher in those landclasses with high proportions of grassland pastures and arable land. Thus means of 5.5-9 km km^{-2} of hedge and treeline were noted in landclasses 1, 2, 3, 4, 5, 6, 10, 11, 16, 17, 25, 26 and 27. The single landclass with over 8.8 km of hedgerow per km square was landclass 9 (with 11.0 km of hedgerow and treeline). This landclass was identified in only 4 squares, well scattered in the south-eastern part of the island (Figure 49). Landclasses with very low average lengths of hedge and treeline were 19, 21,22, 30, 31 and 32. Hedgerows and treelines were found to be absent in landclasses 23, 24 (mountains), 29 (coasts, crofting).

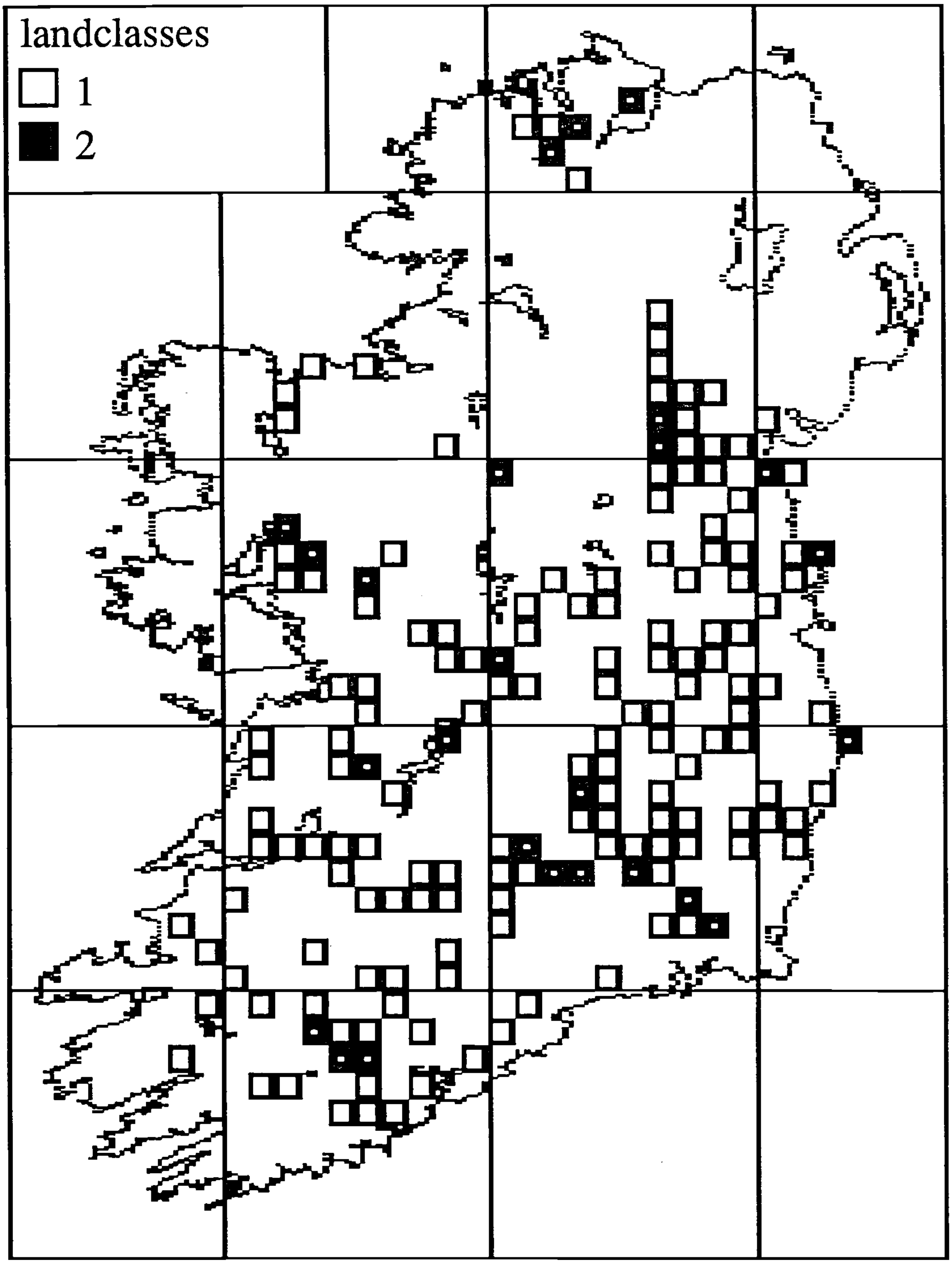


Figure 45. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 1 and 2.

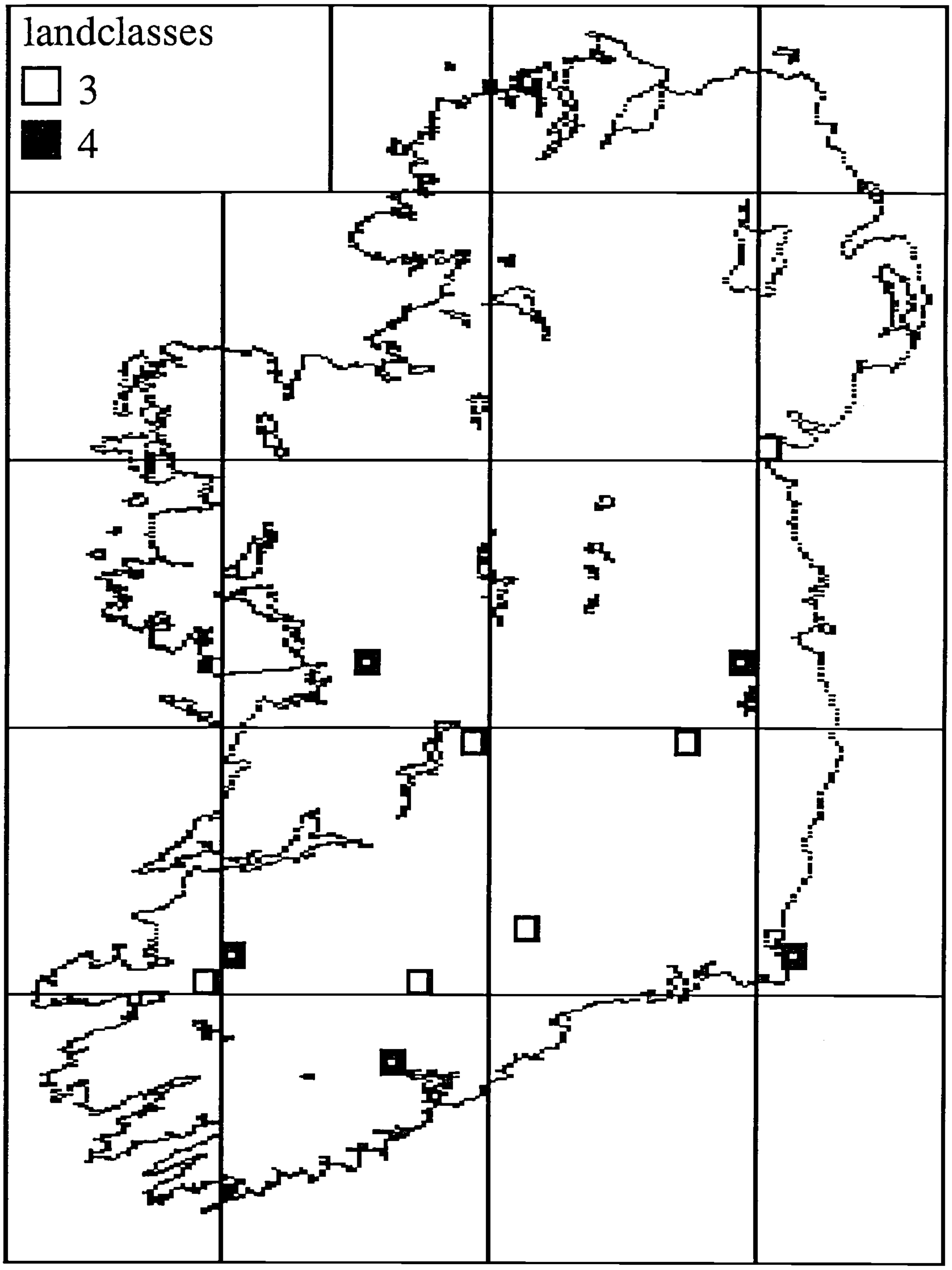


Figure 46. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 3 and 4.

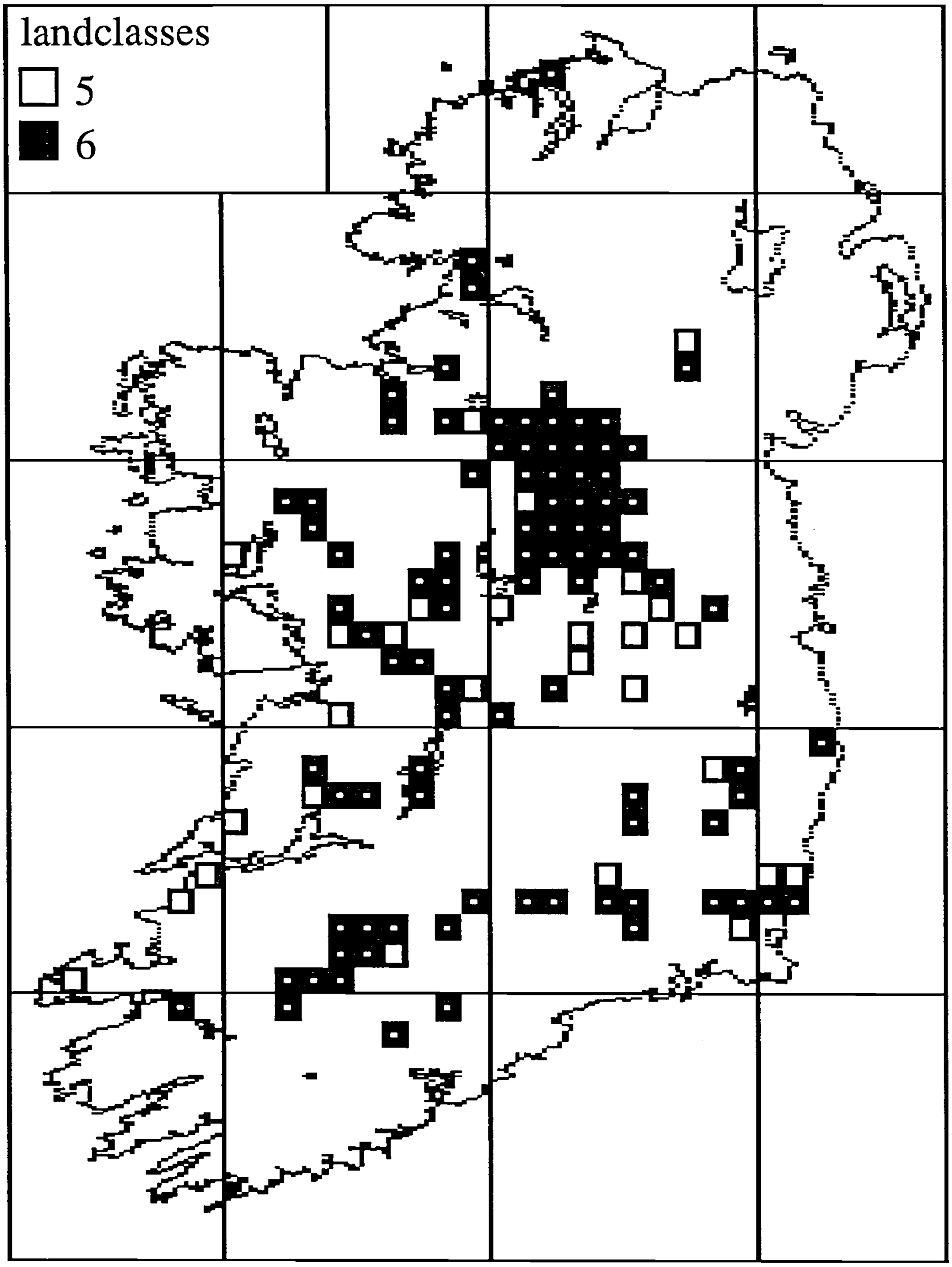


Figure 47. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 5 and 6.

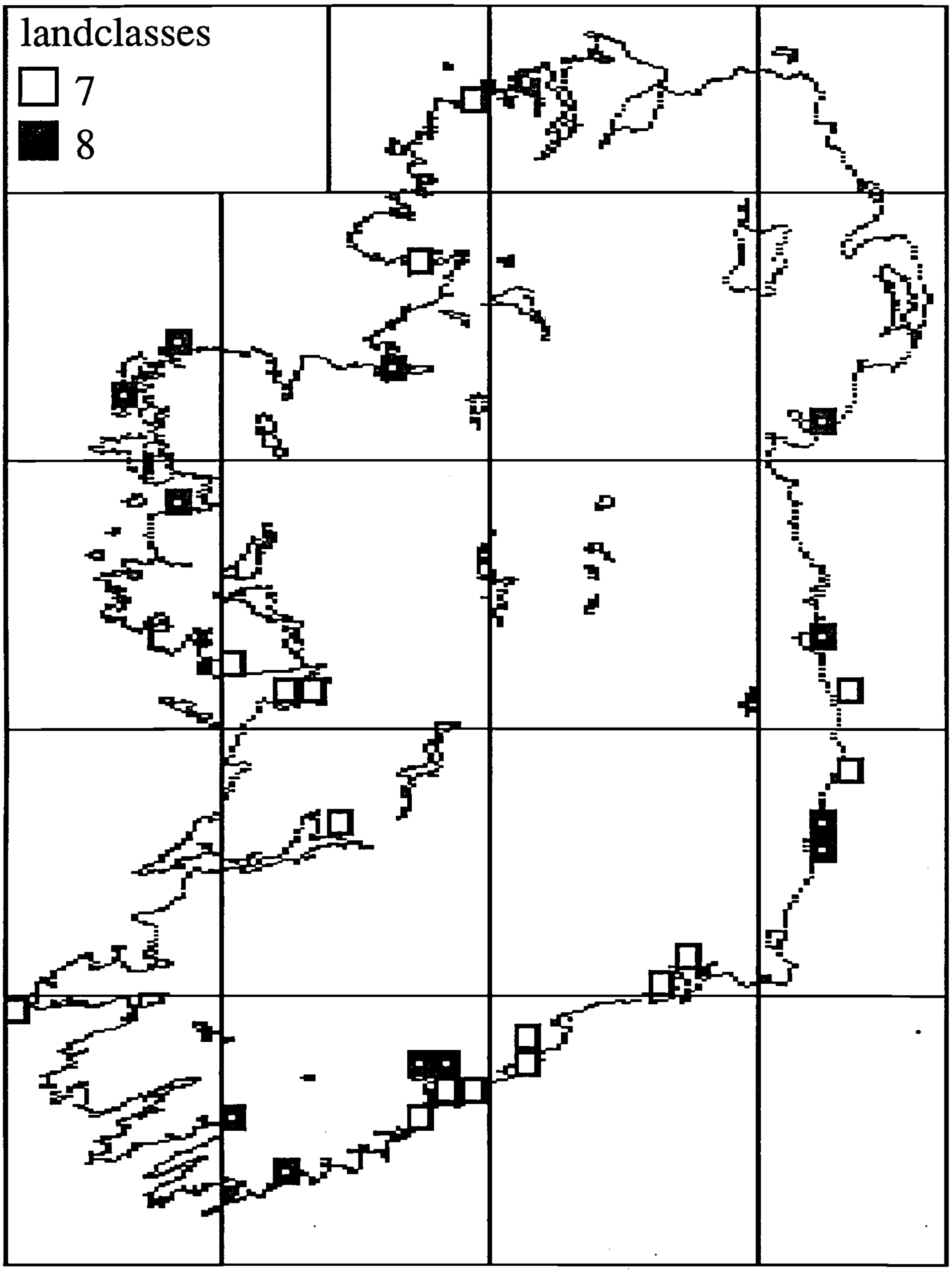


Figure 48. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 7 and 8.

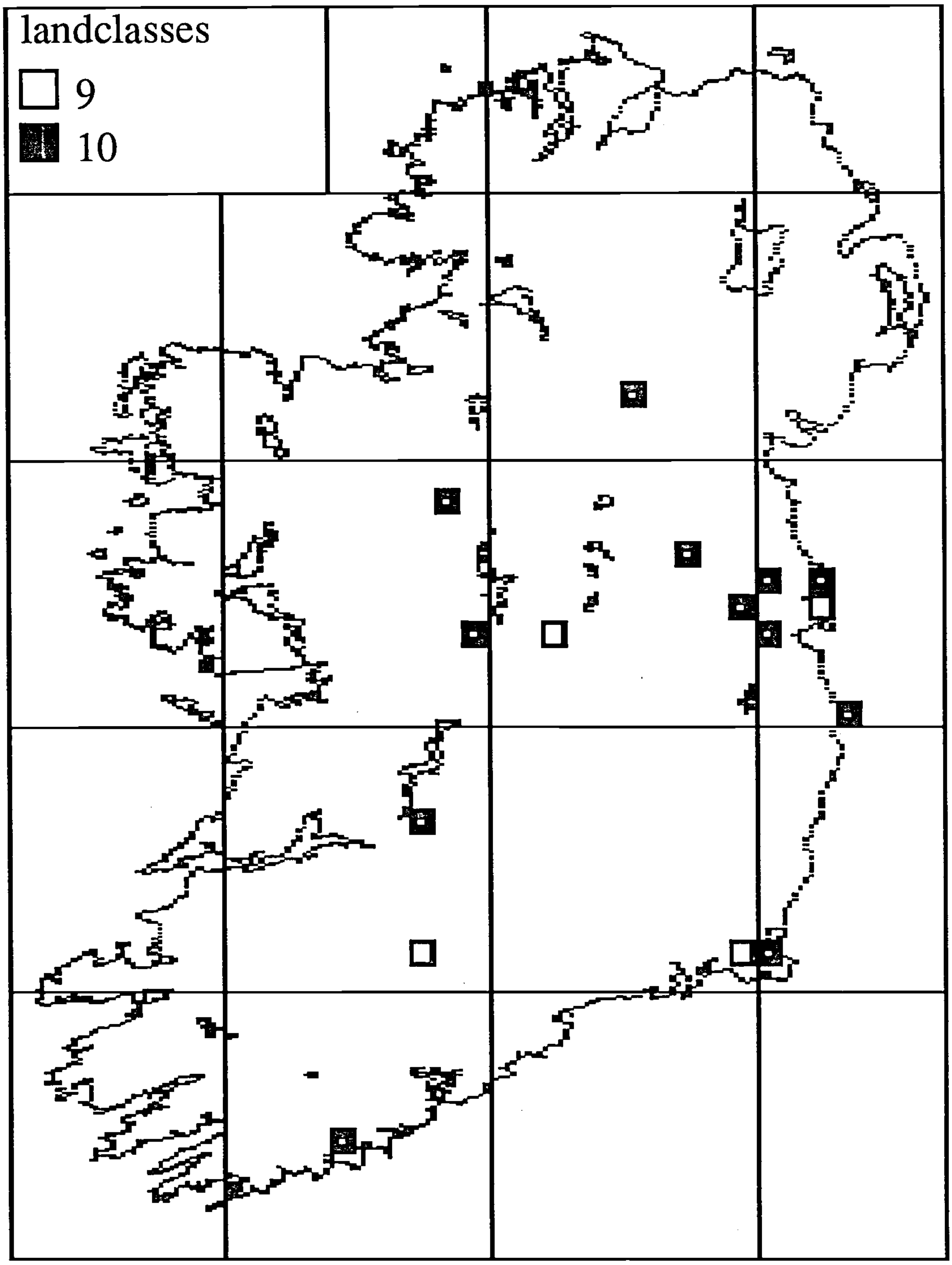


Figure 49. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 9 and 10.

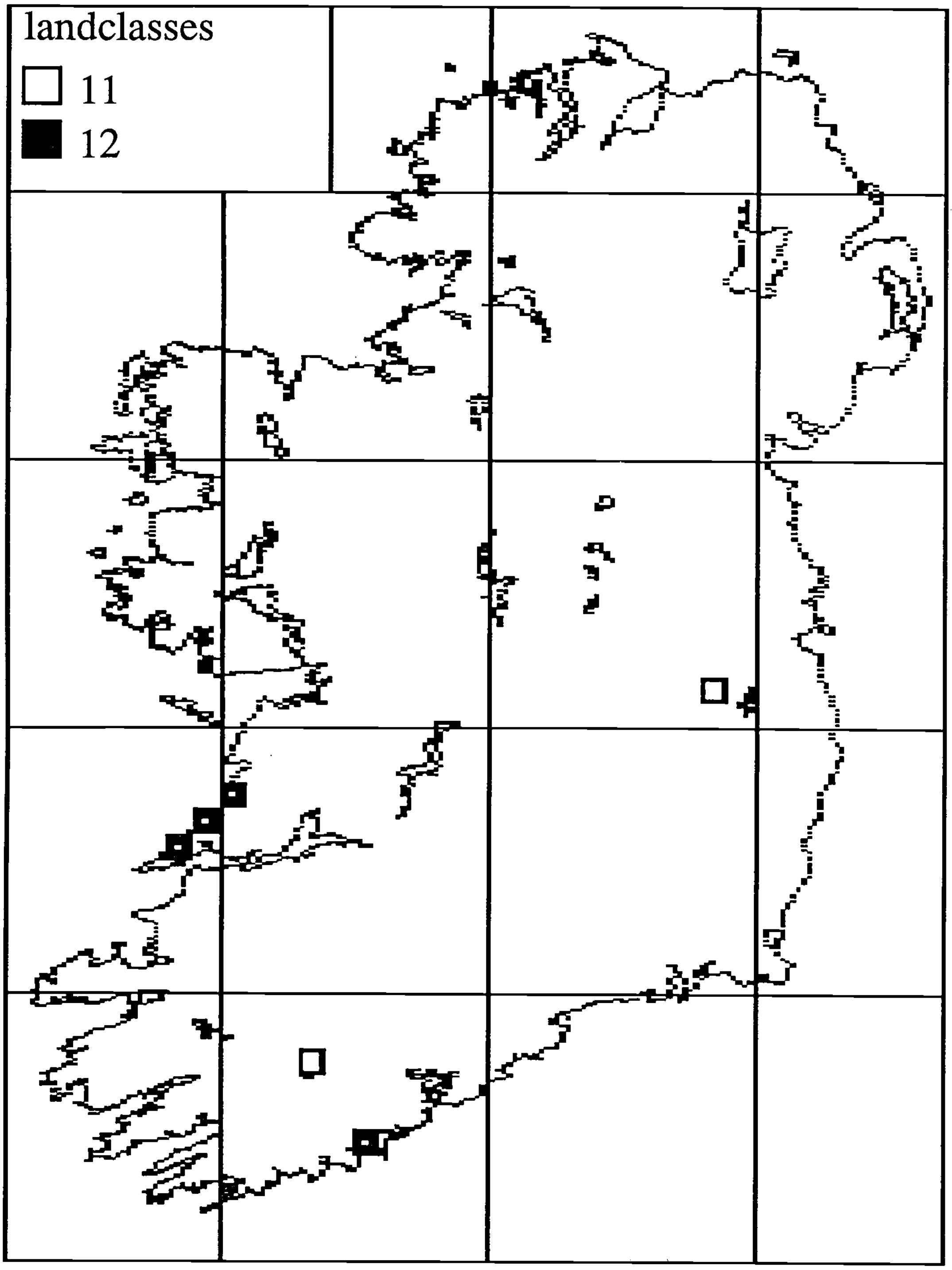


Figure 50. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 11 and 12.

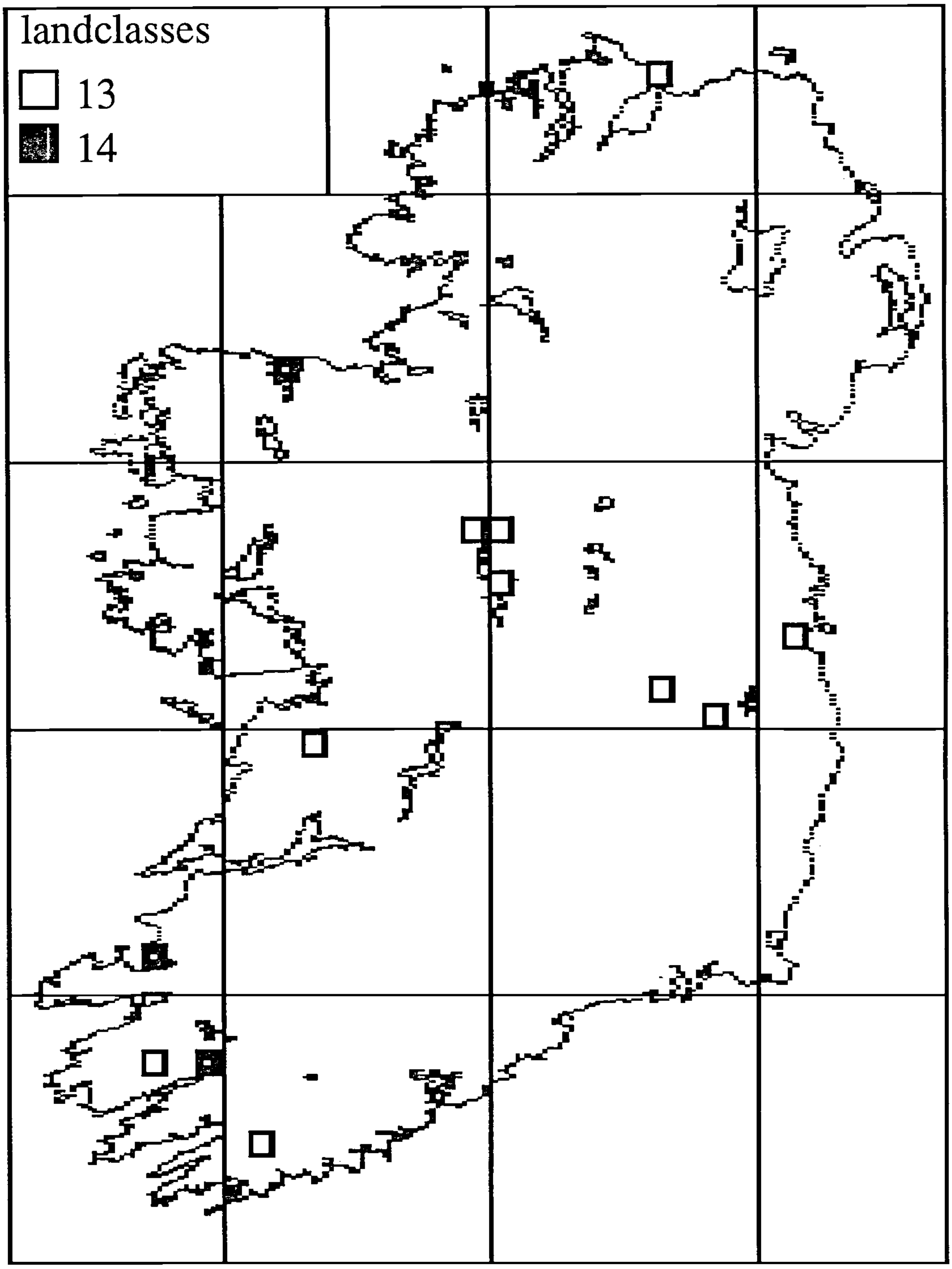


Figure 51. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 13 and 14.

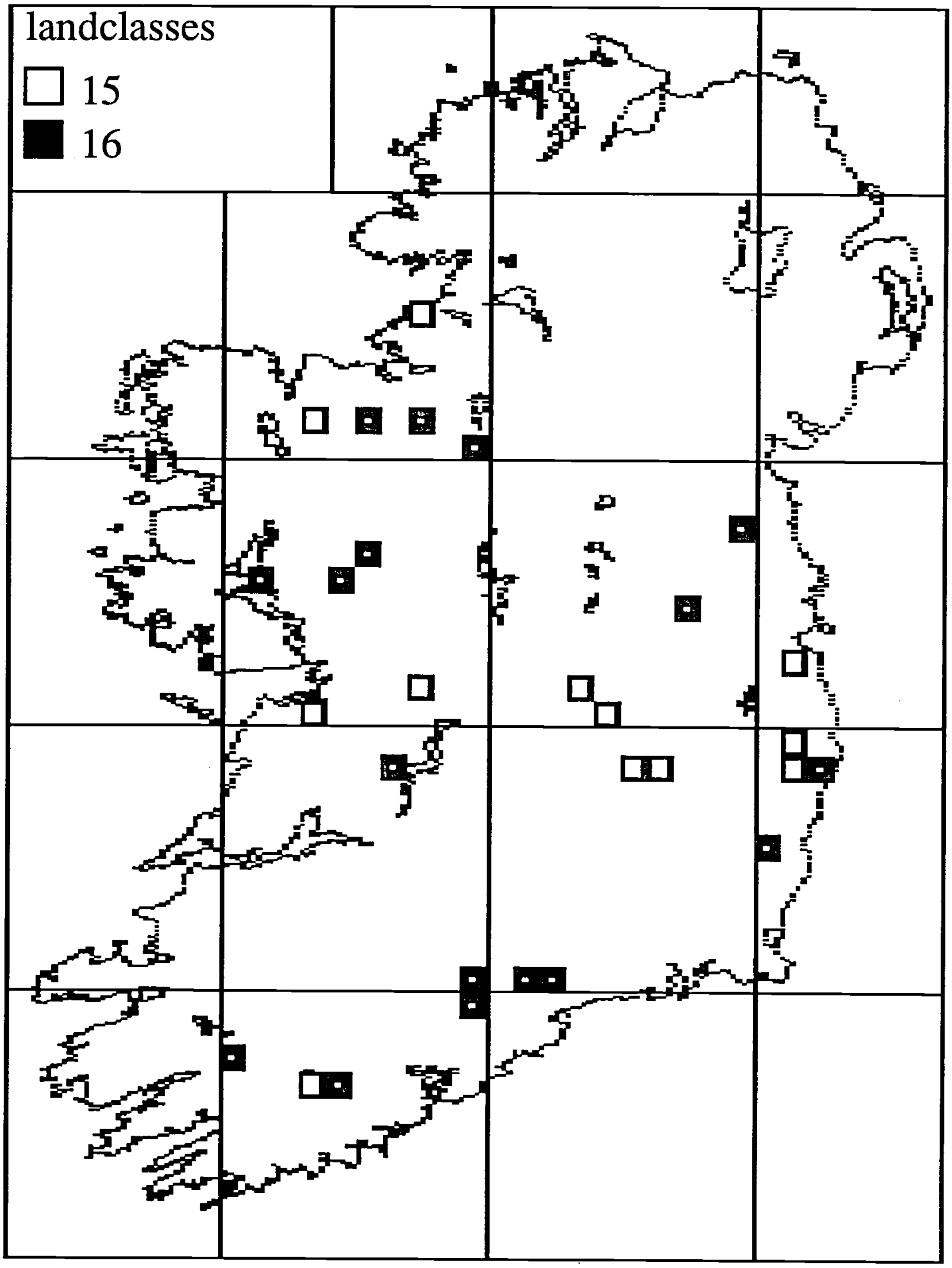


Figure 52. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 15 and 16.

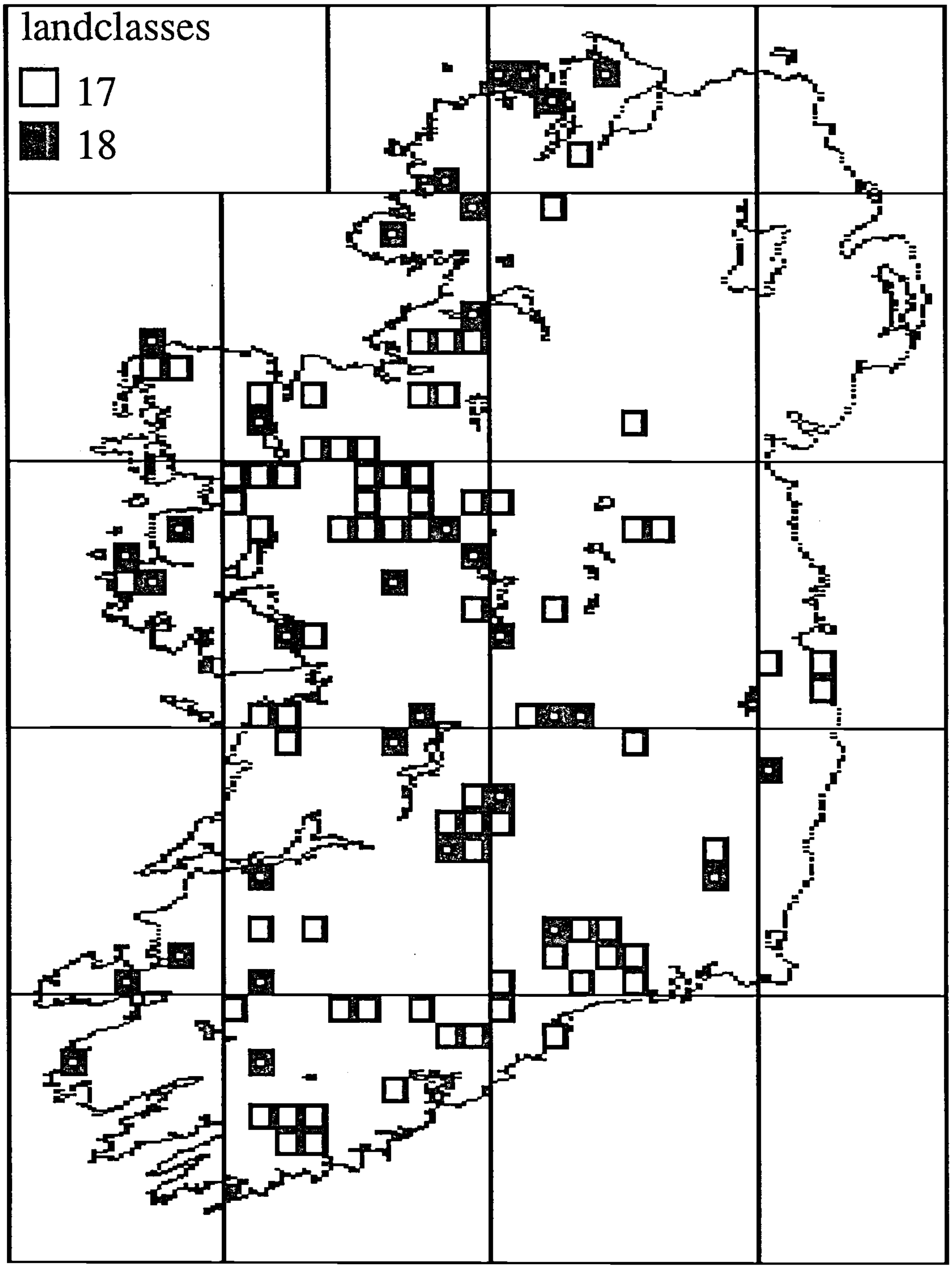


Figure 53. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 17 and 18.

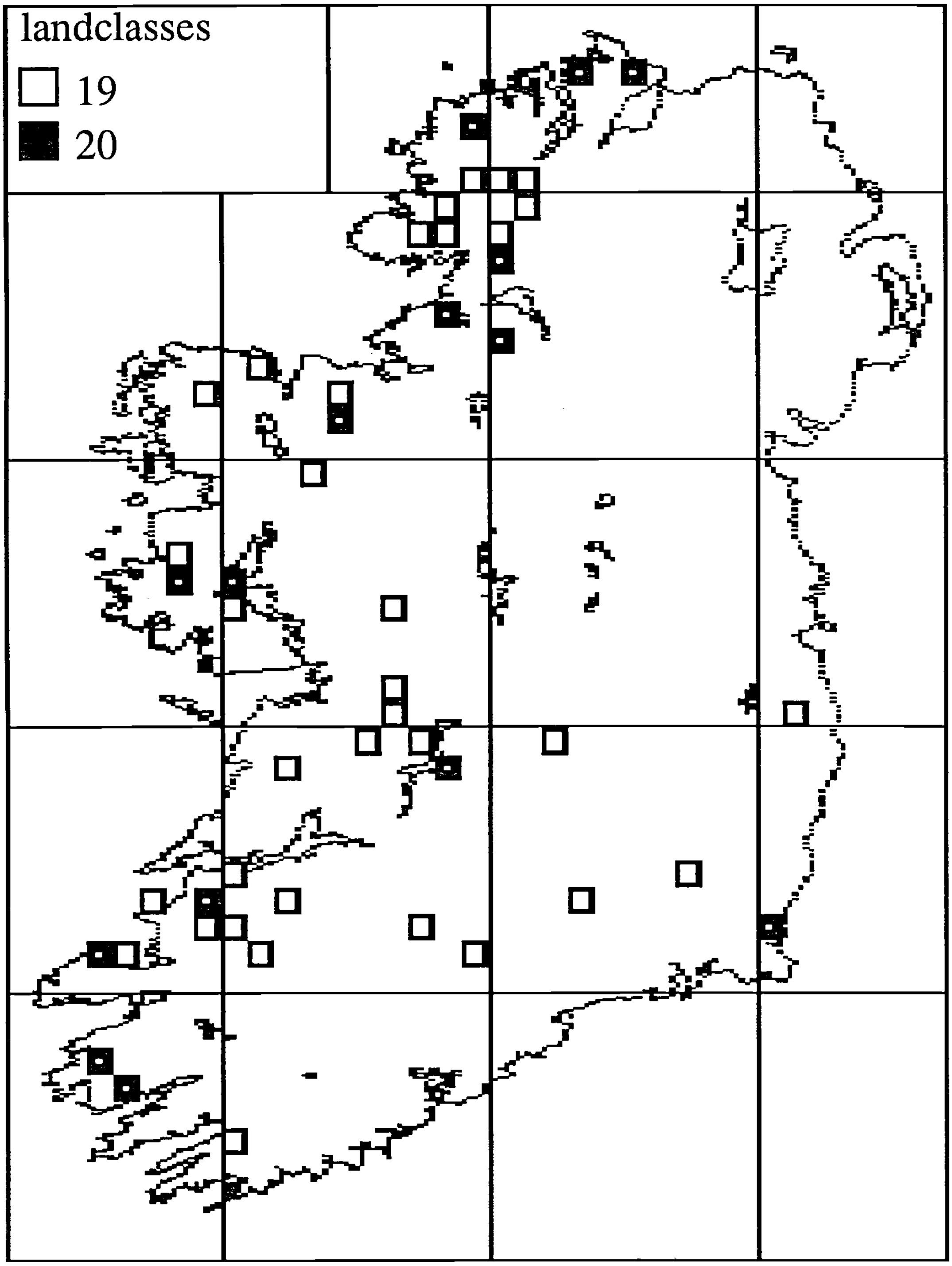


Figure 54. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 19 and 20.

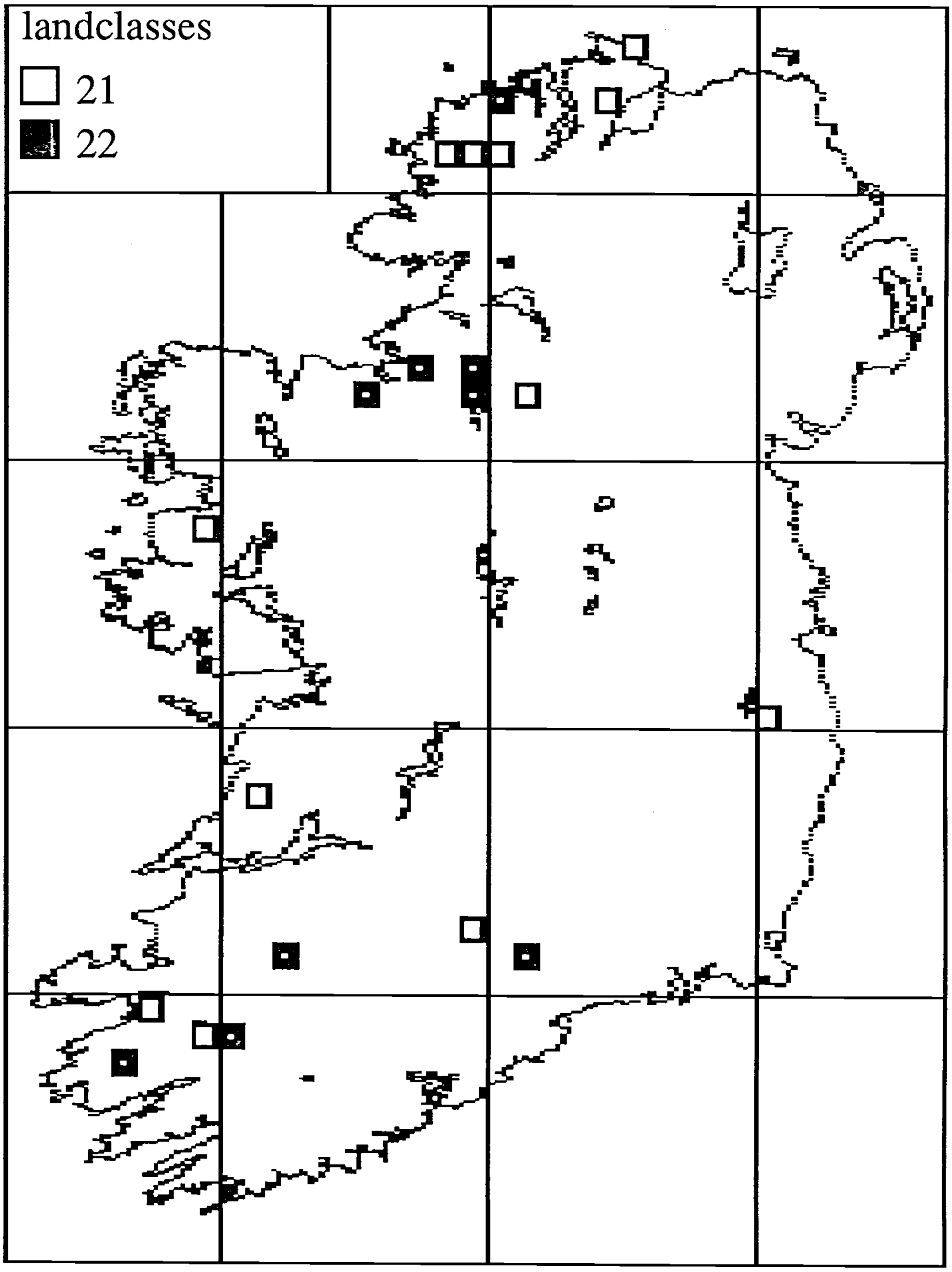


Figure 55. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 21 and 22.

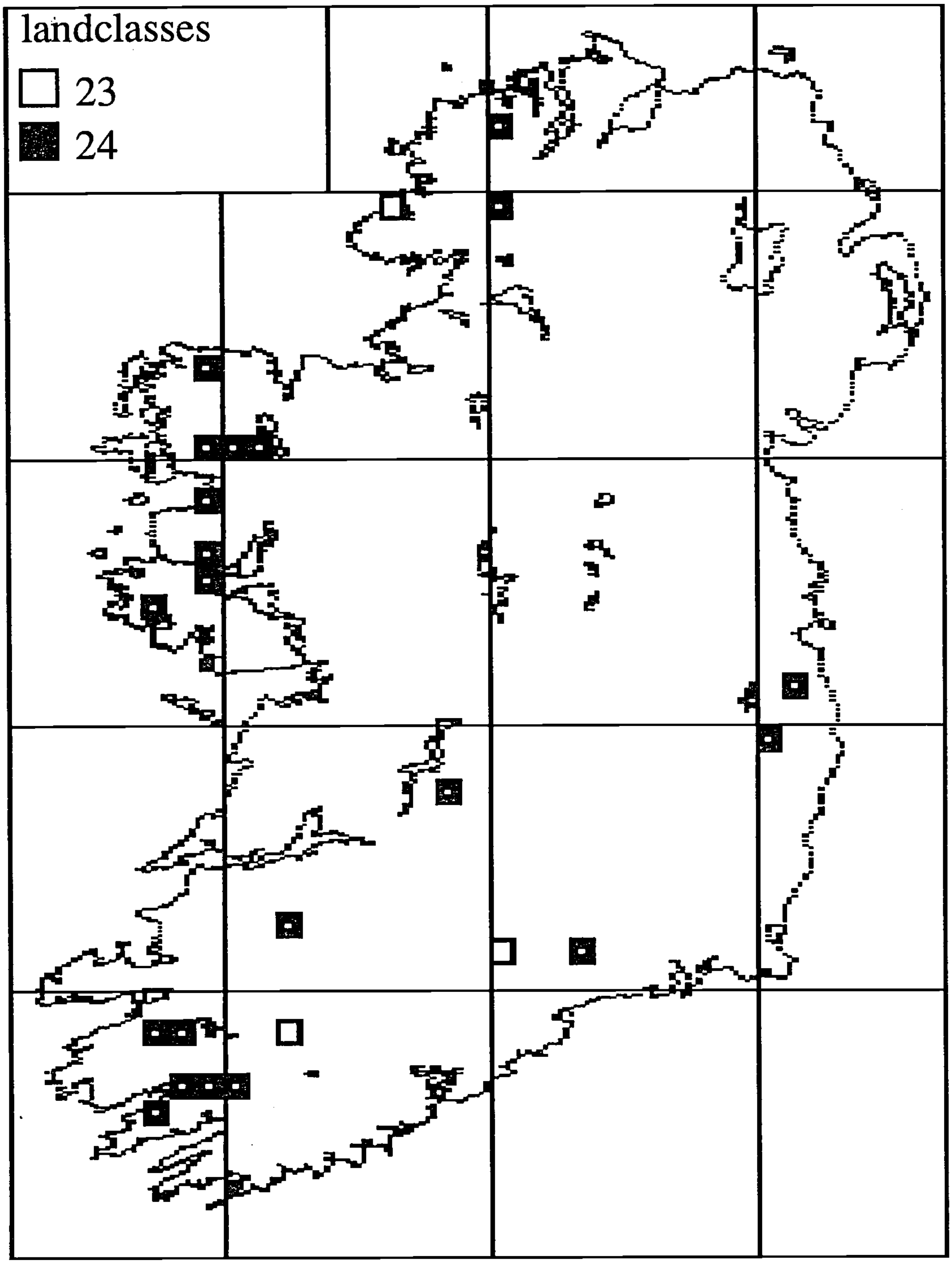


Figure 56. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 23 and 24.

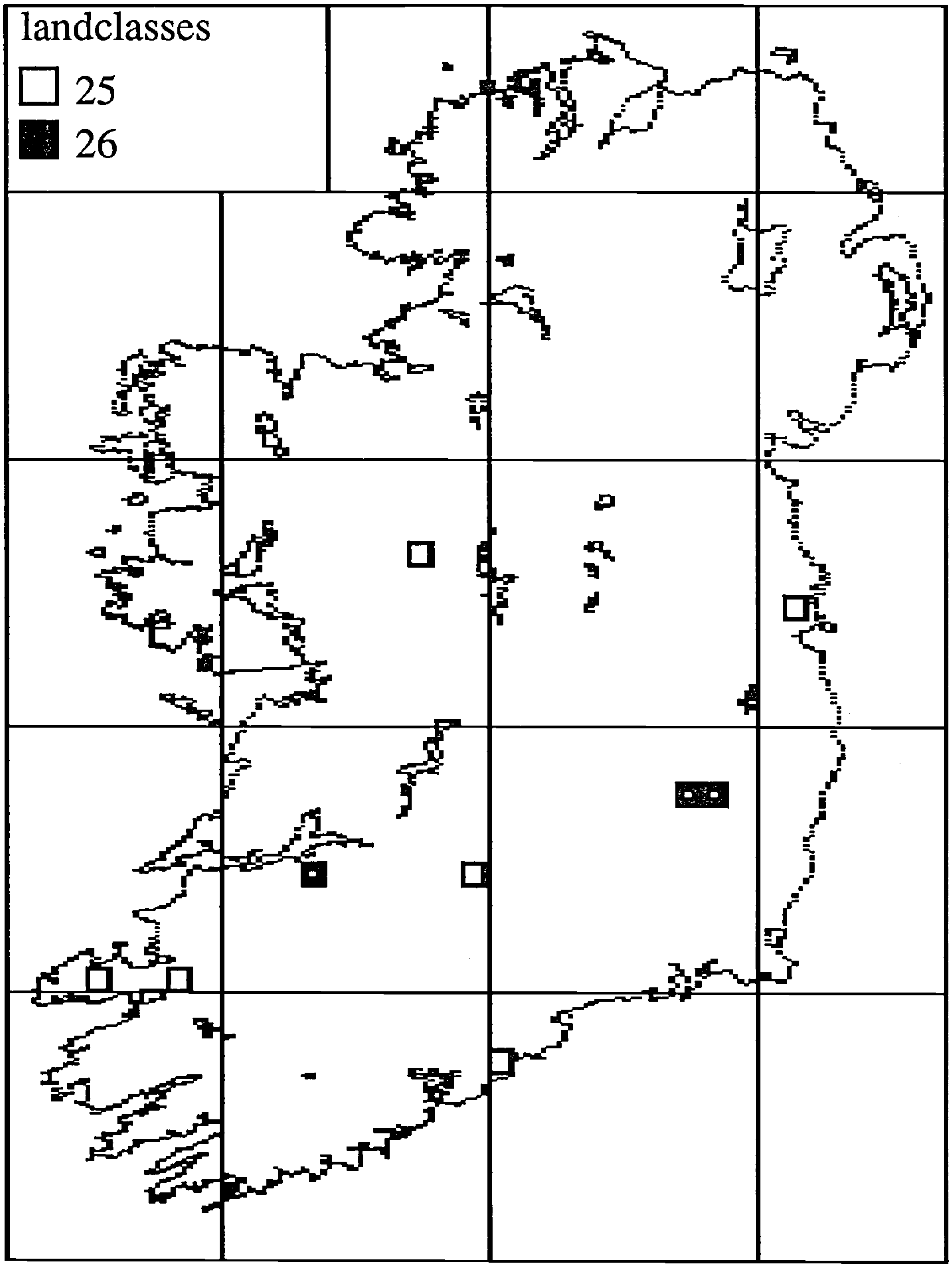


Figure 57. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 25 and 26.

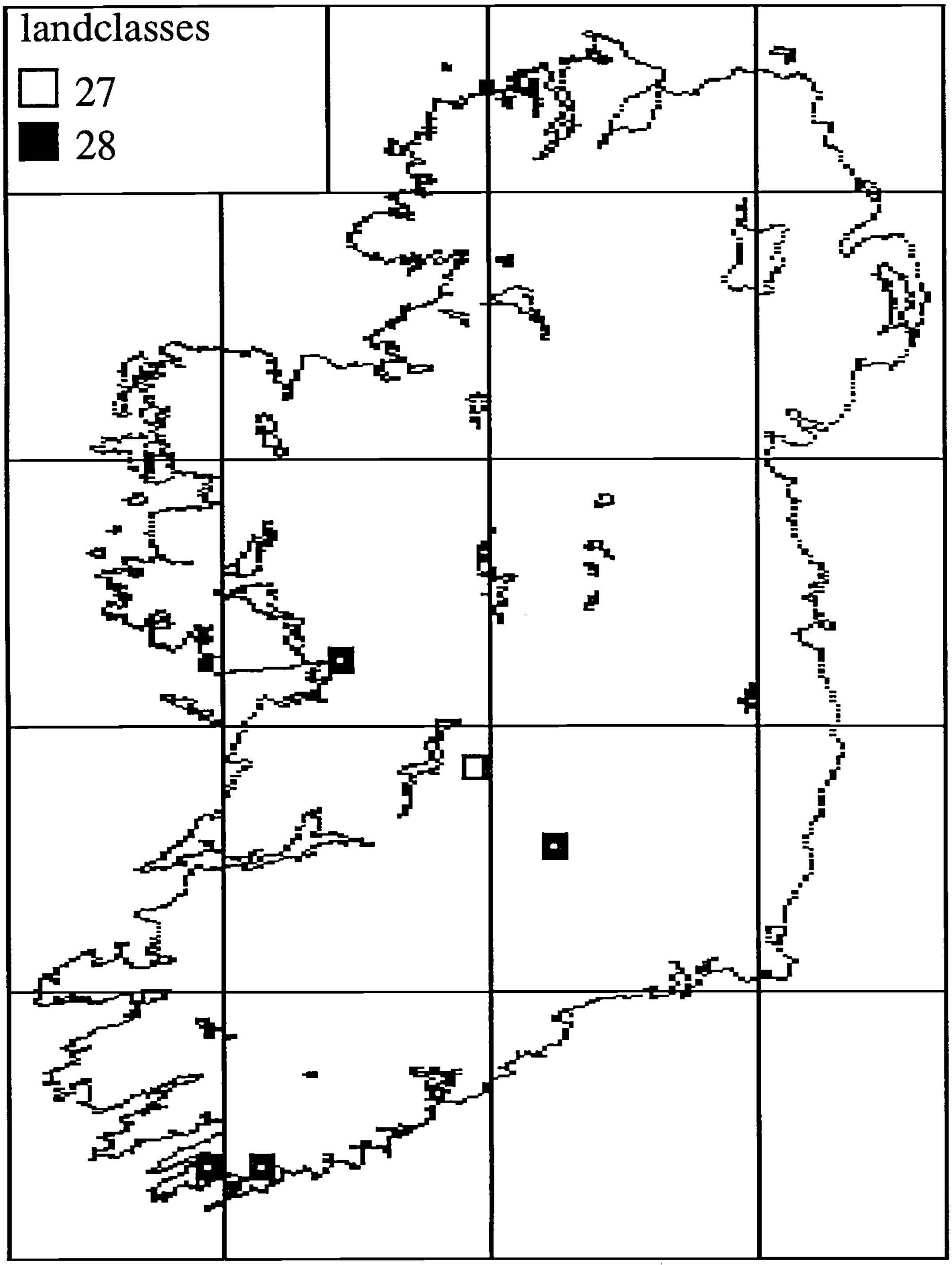


Figure 58. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 27 and 28.

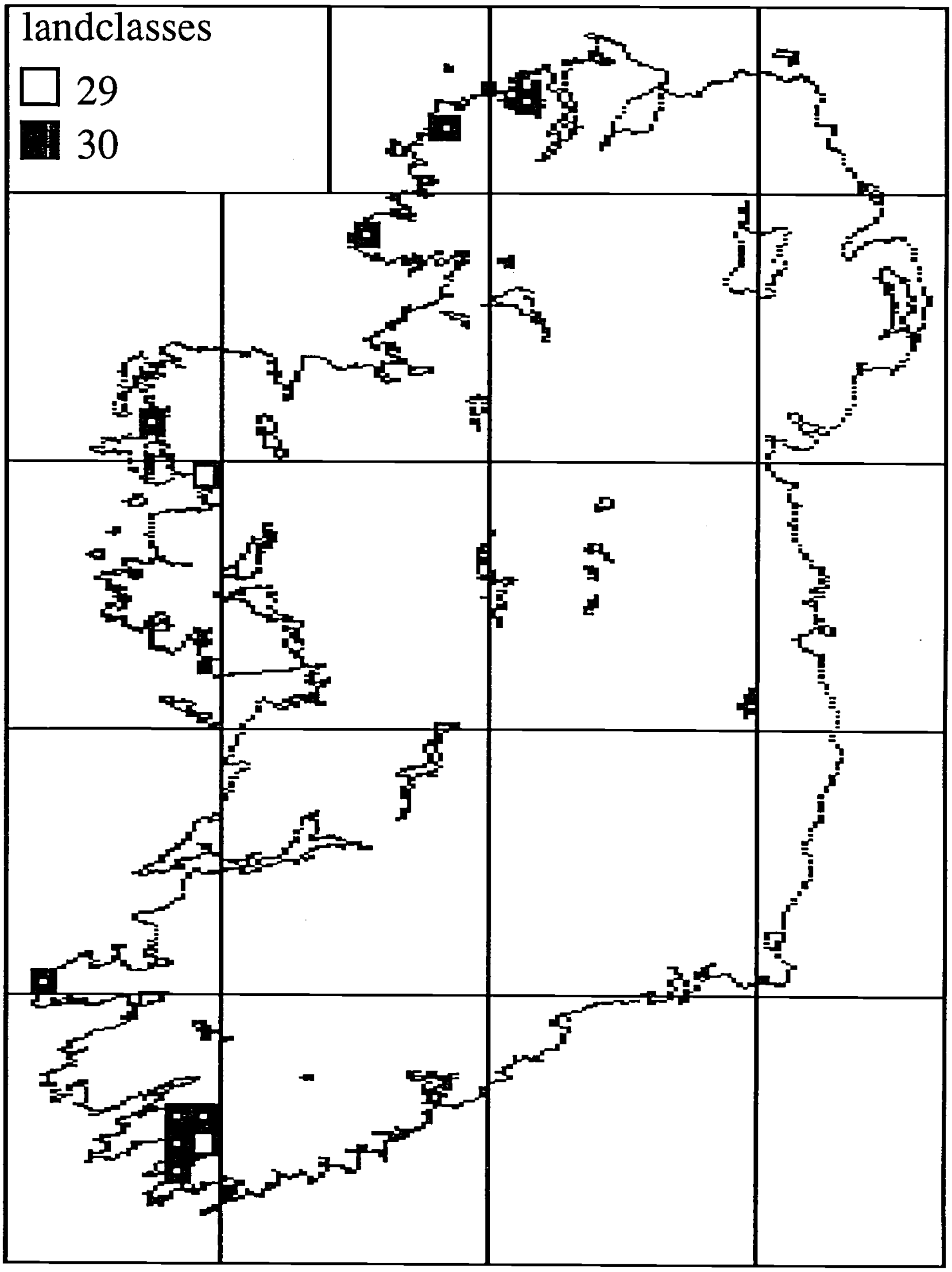


Figure 59. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 29 and 30.

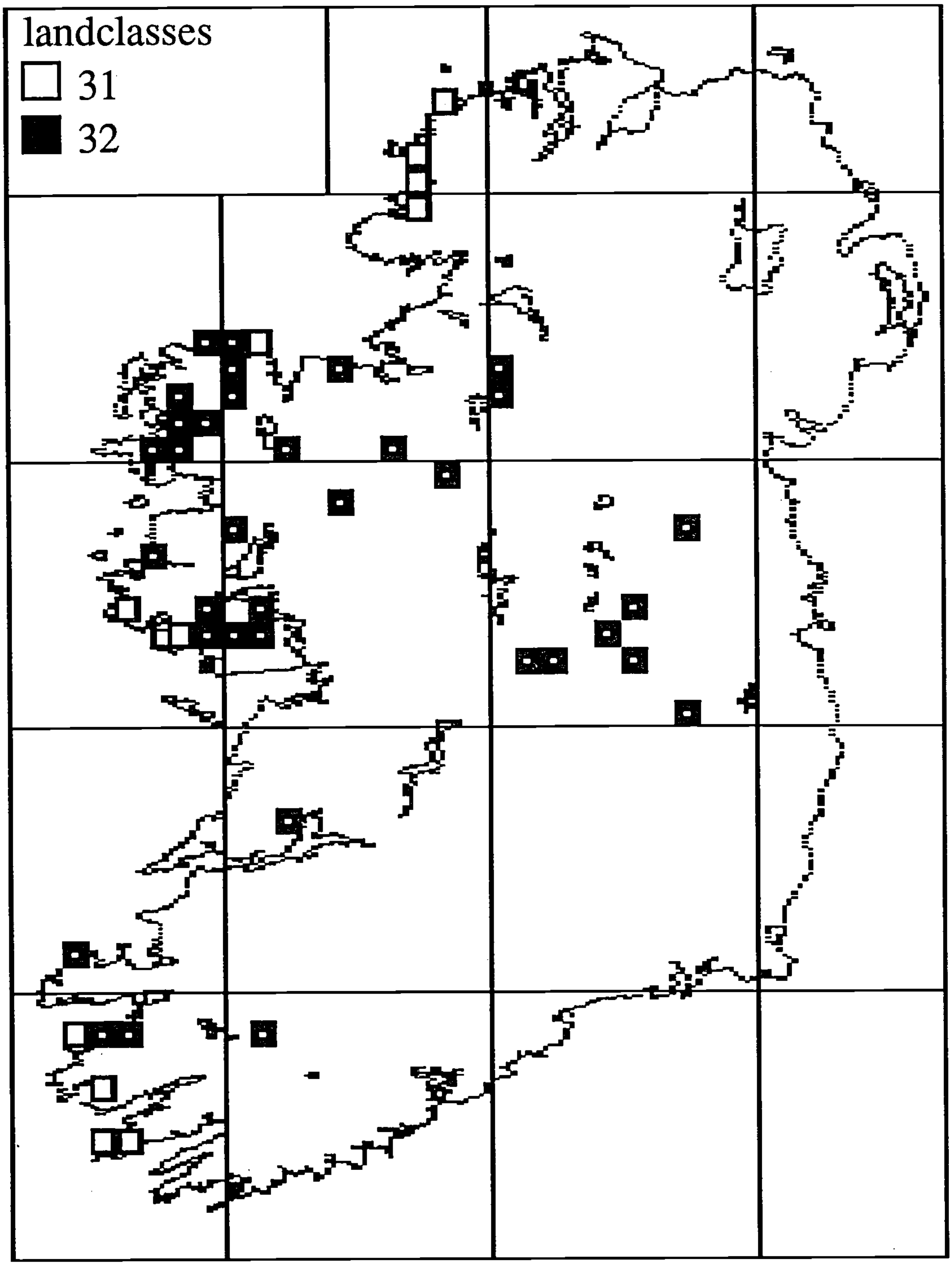


Figure 60. Visually assessed landclasses (the landclass of each 1km survey square is given by the 10km square in which it falls). Landclasses 31 and 32.

Use of land for domestic grazing stocks is given for each landclass in Appendix A13 and presented in the same form as for counties. Landclasses are ecologically more uniform than counties, so as, with the overall habitat data above, differences between landclasses are more pronounced than between counties.

The total amount of land devoted to grazing stocks was high (>60%) in landclasses 1 (65%), 6 (64%), 9 (78%), 11 (64%), 17 (66%), 18 (62%), 20 (61%), 21 (69%), 23 (65%), 24 (61%), 25 (67%) and 27 (79%). It was least in landclasses 7 (17%) and 29 (5%).

In several landclasses, the proportion of grazing lands used for cattle was low, with sheep being the principal grazing stock: principally landclasses 18, 19, 21, 22, 23, 24 and 29. These landclasses are all upland or moorland areas, with the exception of 29 (coastal, crofting). Some other landclasses also had more total area of land grazed by sheep alone than by cattle alone (*i.e.* excluding sums of shared pasture): landclasses 20, 31 and 32.

MAMMAL SURVEY

Methods

Field survey

During the badger and habitat surveys of each 1km square, surveyors were requested to note any signs indicating presence of other mammals within the square. Badger signs, such as latrines, hairs on fences, *etc.* were also noted and would have indicated presence of badgers within a square, or the area's use by badgers, even if no active setts were located. As well as noting presence of mammal species within a square, notes were also kept of the type of field signs observed. Signs or observations of the more common larger mammals were encountered frequently during a survey and surveyors were not expected to divert attention from the principal aims of the badger and habitat survey, particularly in the case of the smaller mammalian fauna that leave more obscure field signs.

Wildlife Rangers and other surveyors often had previous knowledge of the general areas in which 1km squares were located. In particular, surveyors were asked to note presence of mammal species within the 10km square in which the 1km survey square was located, also giving details of the type and date of the observations. Every positive record for a 1km survey square automatically indicated that species' presence within the 10km square, but additional records could be added to a database for the 10km squares based on previous experience. Since knowledge of the 10km squares area varied widely between observers, the results can be used only to add to a mammal distribution atlas based on 10km squares.

The data for 1km squares is of more pertinence as it allows for future analyses of distribution of the more common mammalian species in relation to habitats. However, it should be noted that for no species, other than badgers, was an attempt made to objectively assess the abundance of mammal species within any square. In individual notes, observers usually noted the number of hares *Lepus timidus* observed for example, and might indicate whether rabbits *Oryctolagus cuniculus* were particularly abundant. These accounts and those for the presence/absence of other mammals such as foxes *Vulpes vulpes*, deer, feral American mink *Mustela vison*, otters *Lutra lutra, etc.* were not intended for assessment of their densities.

The general ecology and behaviour of each mammal species also determined the likelihood of its presence being observed and the nature of the observations. Thus, hares were usually sighted rather than observations made of other signs, such as forms or pellets. Rabbits were commonly sighted, but the majority of records resulted from observation of active burrows and pellets. Deer were usually observed or their presence known from prior experience: droppings confirmed deer presence on occasion, but in these cases species was unrecorded. Foxes were observed in some surveys, but their active use of land within a square was usually indicated by scent, scats or den use. Mink and otter presence were, except for one or two instances, noted by spraints/scats alongside waterways.

Every Irish land mammal (and also seal species) was recorded in one or more squares of the survey, with the exception of some bat species. Common Irish species, such as longtailed field mice *Apodemus sylvaticus*, brown rats *Rattus norvegicus*, bank voles *Clethrionomys glareolus*, pygmy shrews *Sorex minutus*, and hedgehogs *Erinaceus europaeus* were not usually recorded by surveyors: their signs, such as tracks or droppings, would not be normally noted without extra attention to detail that would have been disruptive to the badger survey.

Laboratory analysis

The presence/absence data on the 1km Square Field Record Sheet and on the 10km Mammal Record Sheet from each survey square were checked to ensure correspondence. For badger data, if disused setts only were located within a 1km square, and there were no other indications of active badger presence, then badgers were recorded as absent. The data from these two record sheets were logged together onto one database, with separate presence fields being constructed only for the more common large mammals. Other mammals were recorded in 'Other species' fields.

Results

The numbers of squares in which the more common larger mammals were recorded are given in Table 20. For all mammals, surveyors' prior knowledge of presence in the 10km square, as well as observations noted outside the 1km square during the badger survey, has resulted in an increase in the number of 10km squares recording presence compared to the 1km squares. This is particularly marked for mink, probably as a result of a national survey of the species which had been undertaken some years previously (1983-1985: Smal, 1991). Wildlife Service Rangers also have a knowledge of deer over substantial areas of Ireland, so that 10km square records were noticeably more numerous than records obtained during the badger survey.

Badger presence was recorded in 454 1km squares, whilst the number of squares in which active setts (of any type) was recorded was 359, the difference being accounted for by other signs such as latrines, hairs, digging, or other observations. Some signs of badgers were thus noted in over 62% of squares surveyed, with badgers known to be present in 75% of the corresponding 10km squares.

The most commonly recorded mammal was the fox, with its presence being observed in 85% of 10 km squares (80% of all survey 1km squares). Rabbits were almost as frequent (82% of `10km squares, 77% of 1km survey squares). Irish hares were, perhaps unexpectedly, observed to be present in 75% of the 10km squares - and they were either sighted or signs observed in 69% of all survey squares. Hares are a particularly obvious species, as a result of their behaviour, but this survey would indicate that this somewhat controversial species is very widespread and common - though its densities cannot be directly compared with their rabbit relatives, where the survey data is composed of burrow observations rather than sightings.

Rabbits may play some minor rôle as carriers of bovine tuberculosis (Sleeman, pers. comm.), but deer are known carriers of the disease and believed to have been causal in cattle herd breakdowns. The various species of deer were recorded as present, or using, over 10% of all survey squares, and present in 19% of all 10km squares. Whilst these frequencies are well below those of the other major carrier of bovine tuberculosis, the badger, deer species do merit additional attention in an examination of the rôle that they may play in the transfer of the disease to cattle. Analysis of the presence/absence data may reveal that deer are more likely to be found in those areas in which cattle are not the principal stock, *e.g.* moorland and uplands (see above), so that contact between cattle and deer may not, in practice, be as likely to occur as this initial data would suggest.

Mammal distribution maps are presented (in Figures 61 to 66) for the above common larger land mammals using data for 10km squares: this data shows the national distribution of these species, but in anticipated future research projects, the data would be analysed for the 1km squares in relation to the habitats and landclasses of the 1km survey squares.

Table 20. Numbers of squares recording presence of common larger Irish mammals

species and record type	**no. of squares**	**percentage of all survey squares**
Presence of badgers: 1km squares	454	62.3
Presence of badgers: 10km squares	550	75.4
Presence of mink: 1km squares	136	18.7
Presence of mink: 10km squares	225	30.9
Presence of foxes: 1km squares	586	80.4
Presence of foxes: 10km squares	619	84.9
Presence of deer (all species): 1km squares	75	10.3
Presence of deer (all species): 10km squares	138	18.9
Presence of rabbits: 1km squares	560	76.8
Presence of rabbits: 10km squares	599	82.2
Presence of hares: 1km squares	503	69.0
Presence of hares: 10km squares	547	75.0

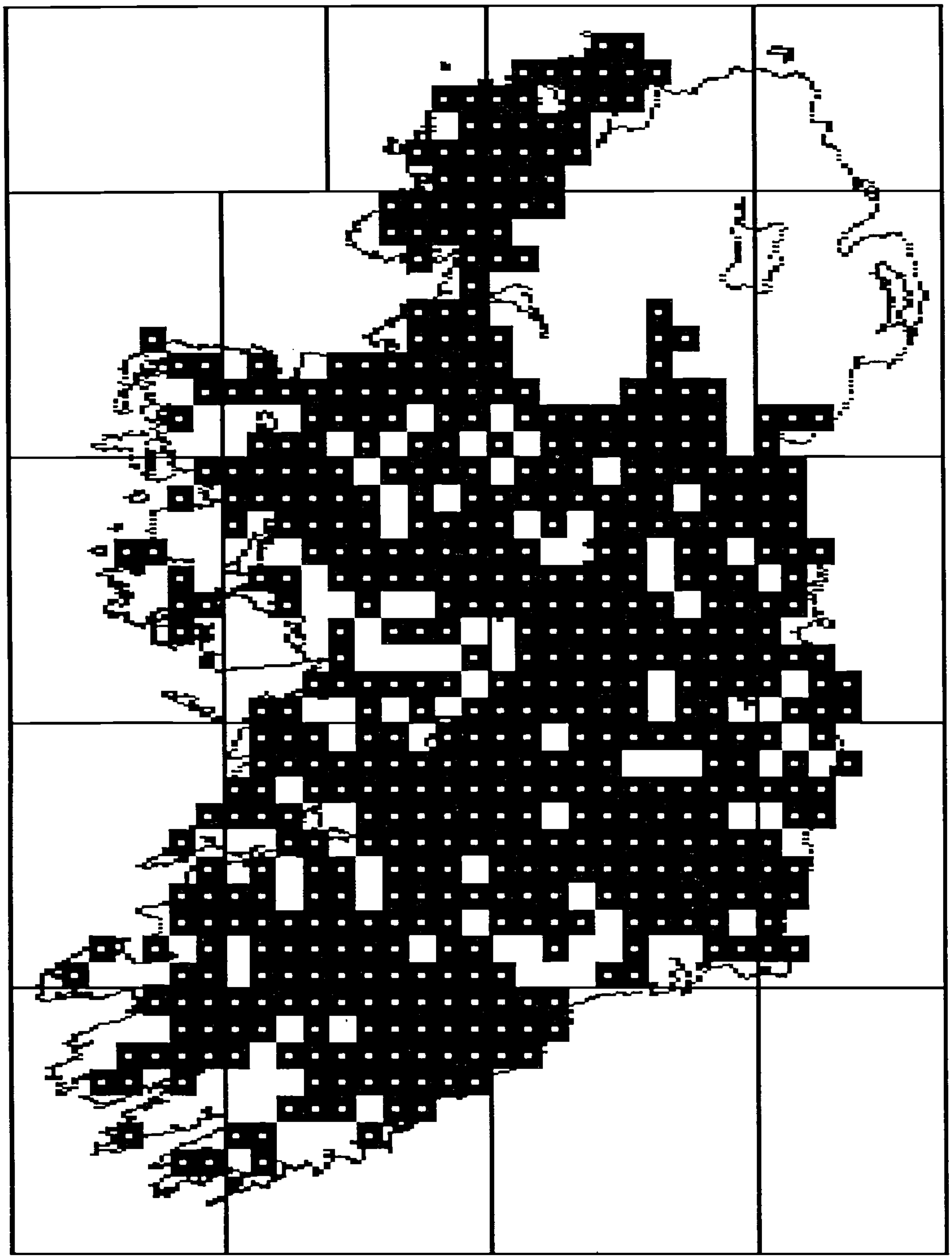


Figure 61. Badger distribution in the Republic according to presence of field signs in 10km squares.

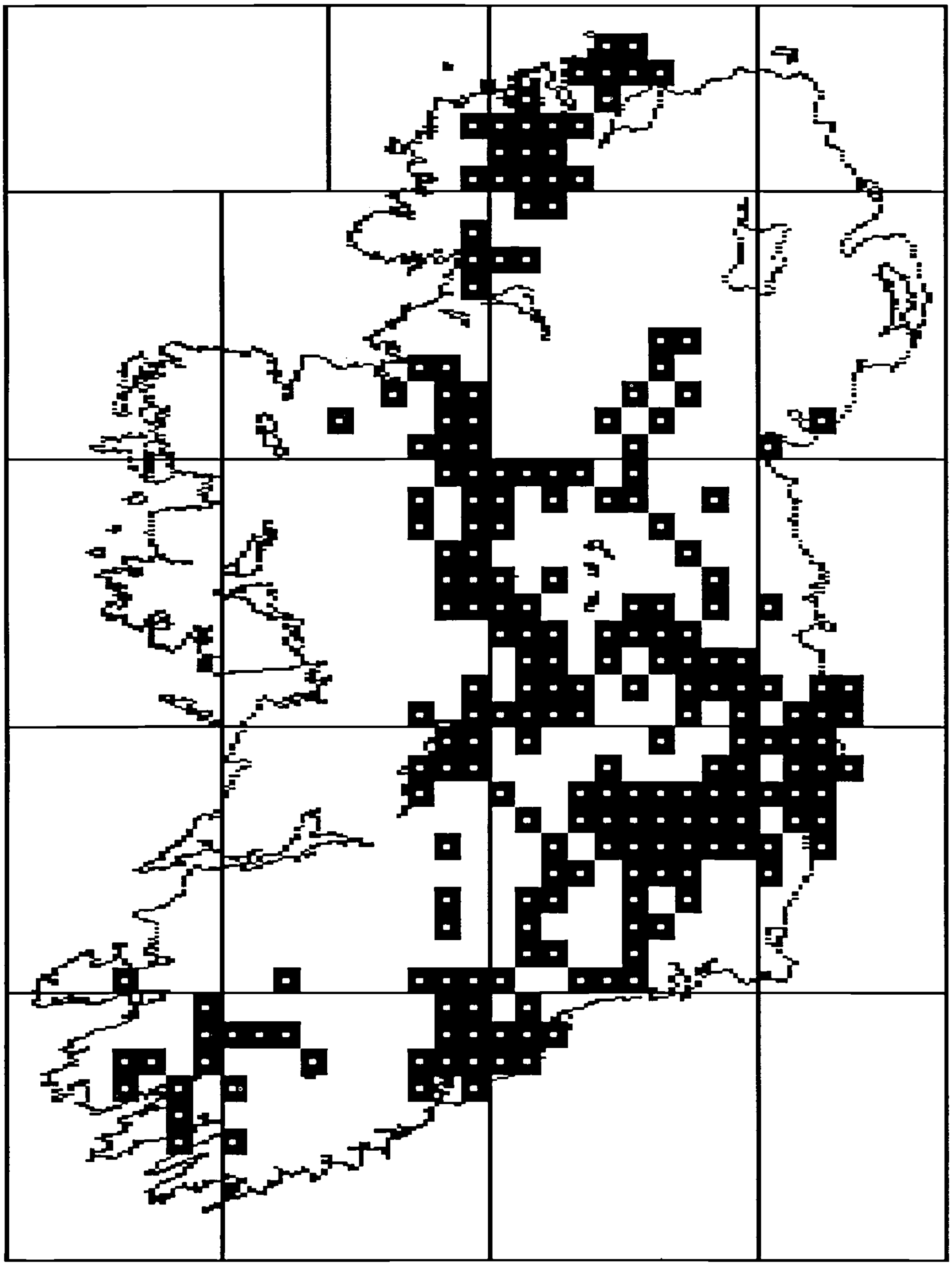


Figure 62. Distribution of feral American mink in the Republic according to presence of field signs in 10km squares, as recorded in the present survey.

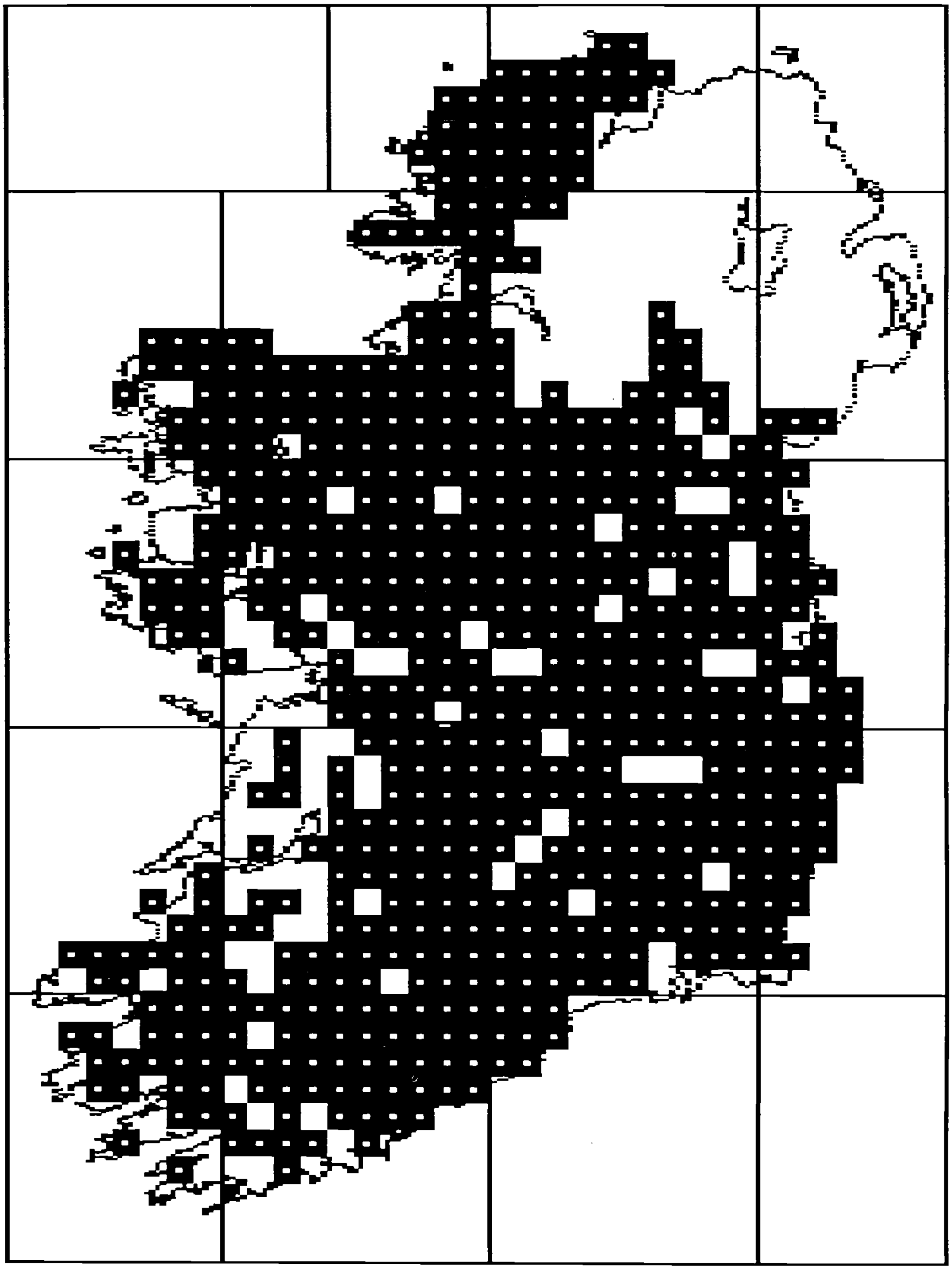


Figure 63. Distribution of the fox in the Republic according to presence of field signs in 10km squares, as recorded in the present survey.

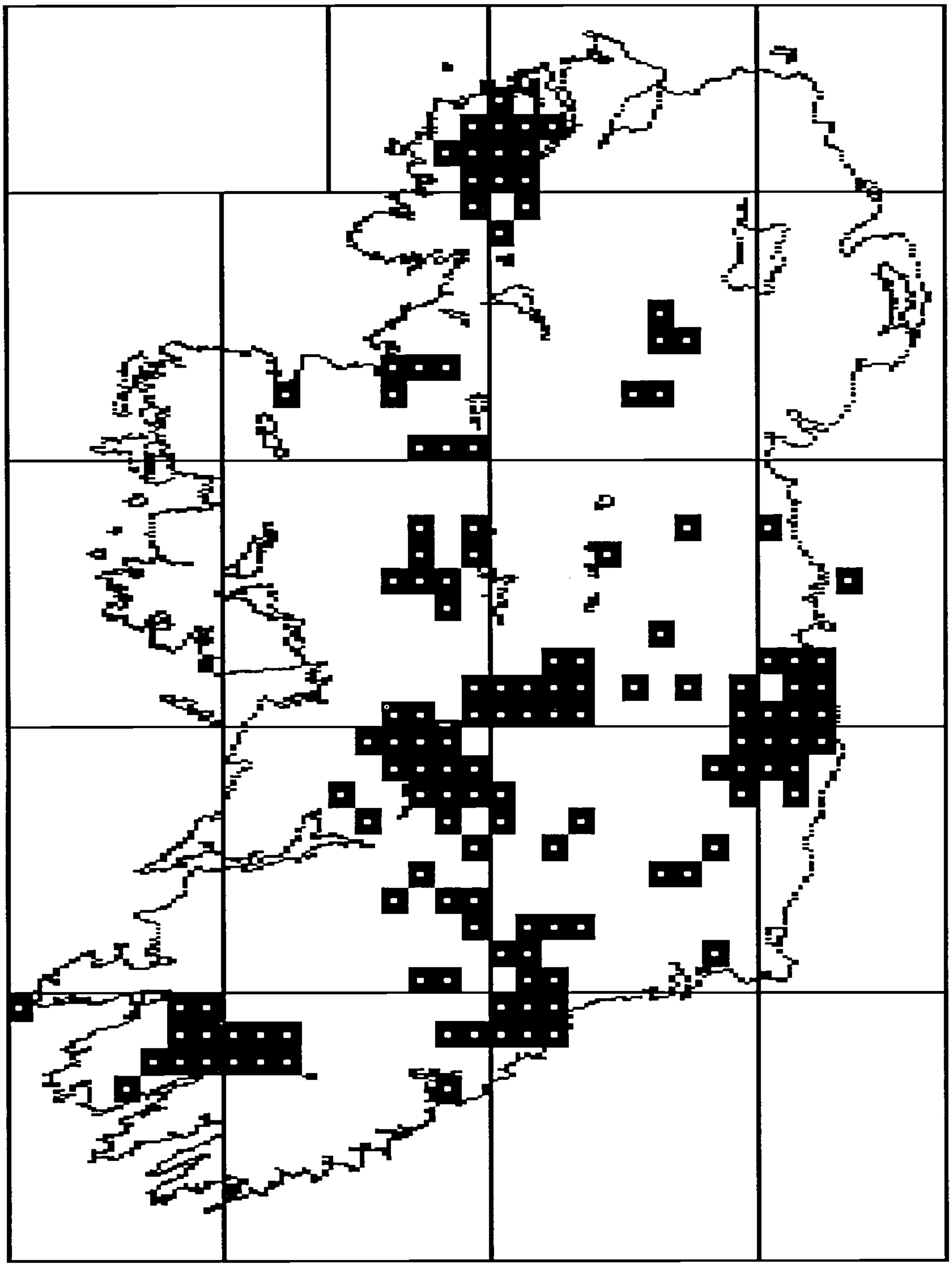


Figure 64. Distribution of deer (all species) in the Republic according to presence of field signs in 10km squares, as recorded in the present survey.

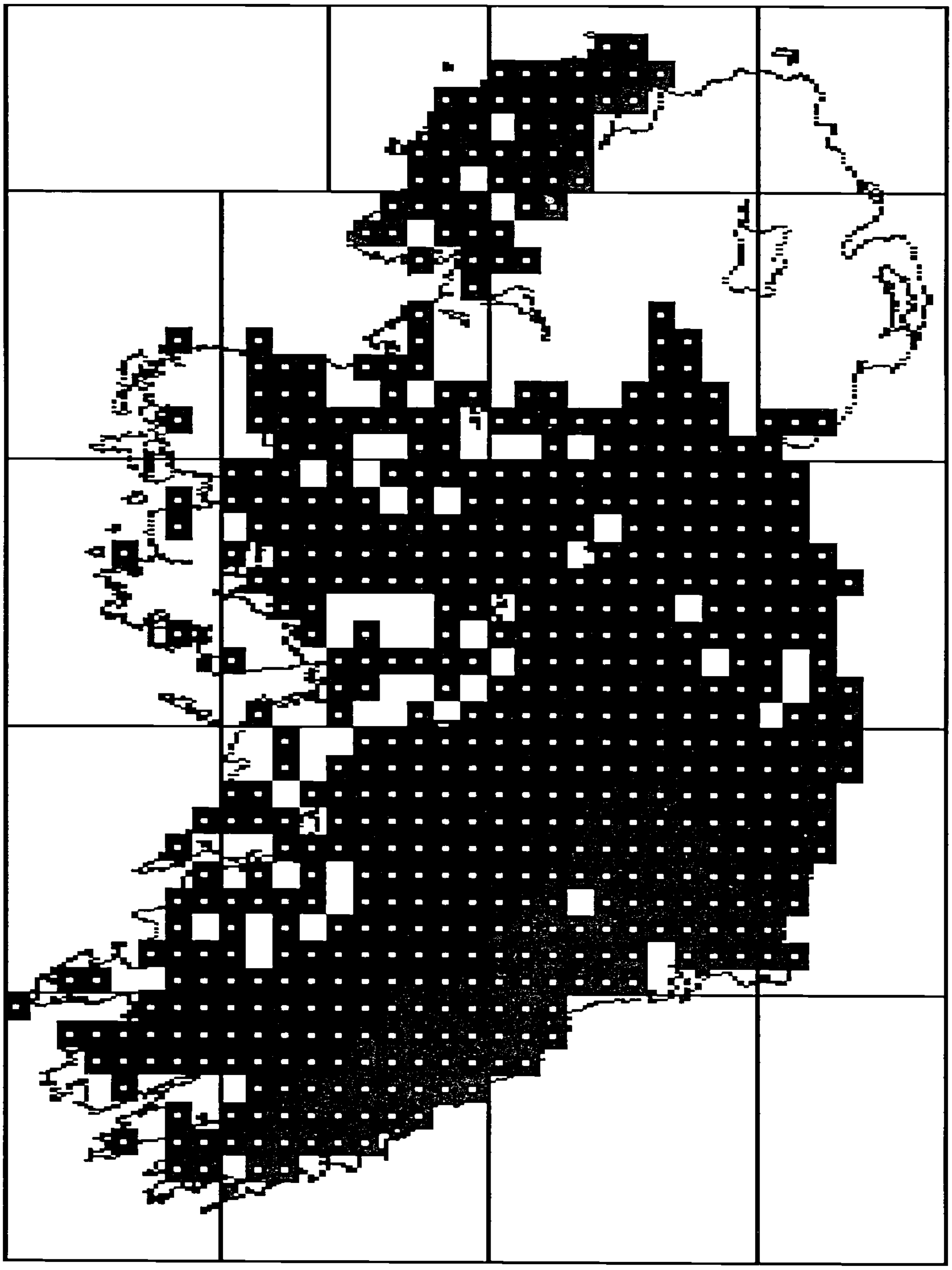


Figure 65. Distribution of rabbits in the Republic according to presence of field signs in 10km squares, as recorded in the present survey.

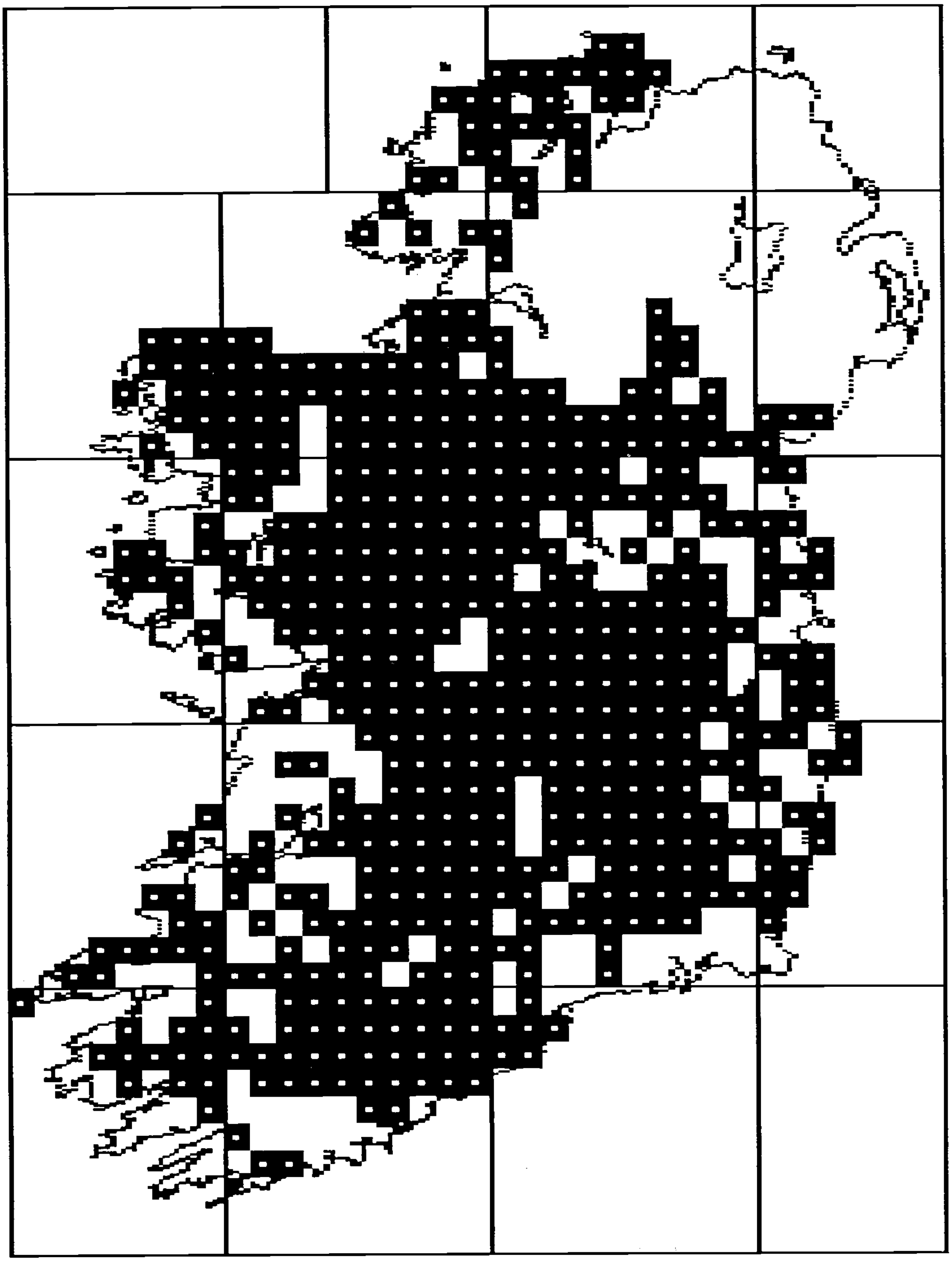


Figure 66. Distribution of the Irish hare in the Republic according to presence of field signs in 10km squares, as recorded in the present survey.

STUDIES INVOLVING BADGER REMOVAL AREAS

Introduction

The Department of Agriculture, Food & Forestry arranges the removal of badgers, under licence from the Office of Public Works (National Parks & Wildlife Service), from areas in which the cause of a TB breakdown in cattle has been attributed to badgers. The licences are granted under sections 9 and 23 of the Wildlife Act, 1976 for the purpose of badger/bovine TB research. Licences usually permit only the use of snares (in accordance with the Wildlife Act [Approved traps and snares] Regulations, 1977). The licence may stipulate a period in which snaring may take place.

Each application for a removal operation is made by the District Veterinary Office: grant of licence for badger removal is conditional upon the wildlife source having been implicated in the breakdown. Because it is has not been possible to *prove* that badgers were responsible for a particular breakdown, attribution of the cause to wildlife is usually based on elimination of all other likely sources of infection, such as lack of hygiene, importation of infected stocks, or lateral transmission from neighbouring infected herds - though there usually were circumstantial reasons for implicating badgers.

The licence allows for removal of badgers - by snaring - from the affected farm and adjoining areas within a 2 km radius of the farm. Captured animals are killed humanely and carcasses sent for laboratory testing for gross visible lesions. On occasion, blood samples are also taken and tested and/or tissues cultured. The 2 km radius covers a substantial area and snaring of all active setts throughout this zone is rarely carried out. In practice, it is usually the area of the affected farm and some adjoining lands from which badgers are removed. The licence does not stipulate numbers of snares to be applied or any intensity of snaring or trapping.

The expenditure involved and snaring intensity employed in dealing with a permit for badger removal varies considerably from licence to licence and the quantity and quality of data obtained from captured badgers was also found to be variable in the present studies.

Aims

It was considered that useful results could be obtained for the National badger survey from the snaring results obtained at a sample of licence areas. In particular, if setts could be classified according to the techniques adopted in the National survey before snaring, the subsequent snaring operations could yield data on the validity of survey techniques. Through identification of social groups, the data would also yield preliminary information on badger group size. Ideally, of course, validation exercises and estimates of group size would be obtained from population studies of badgers, involving capture-mark-recapture and bait-marking. Such studies lead to a correct sett classification based on usage by badgers and a correct determination of the extent of each social group's territory, and, preferably, should be carried out in a reasonable large sample in various geographical regions of the country. This was outside the scope of the present project. The badger removal areas have instead been used to provide validation and preliminary data on group size, but have limitations of subjective interpretation of the data, as in sett classification.

To allow the integration of badger data from these removal areas into the National survey, a consistent approach was required both for the survey of setts and for subsequent snaring operations. Thus, a co-operative study was launched in which National Parks & Wildlife Service Rangers from the Office of Public Works surveyed pre-selected portions of the licence area, and the setts identified were snared by operatives under the direction of the District Veterinary Office, adopting advised snaring guidelines and data sheets.

The surveys of setts and the badger data have yielded additional information not only on mean group size and survey validity but on sex ratios and TB status of badgers, as well as identifying some difficulties with the present licensing arrangements.

One ancillary study was carried out, with its goals similar to those given above. This was a 'semi-blind' survey by Wildlife Rangers of badger setts in an area in which badgers had been studied for some time (P. Sleeman's [UCC] study in West Cork) - the principal purpose here being to evaluate sett survey techniques, surveyors not being informed of the numbers of setts or sett locations in an area beforehand. It had been hoped to carry out a similar operation in East Co. Offaly in the area intensively studied by O'Corry-Crowe (1992) and which was subsequently thoroughly snared by ERAD (Dolan *et al*, 1993). However, shortage of National Parks & Wildlife Service personnel in the Midlands made a similar survey impossible before the badger removals started there.

Methods

Choice of study areas

The initial aim of the study was to obtain information on *c*. 50 licence areas spread throughout the country. Since these areas were all ones in which badgers were considered likely sources of a particular TB breakdown in cattle, it was expected that studies of these licences would also yield information on about 50 social groups of badgers.

To obtain a wide geographical spread of information, each District Veterinary Office (DVO) was requested to submit 2 licences. In the main, there is one DVO for each county, but two of the largest counties (Cork and Tipperary) have 2 DVOs each, and East Wicklow is adjoined to the Dublin DVO, with West Wicklow in the Kildare administrative region. The initial licences for study were submitted in 1991, and further licences considered in 1992. For the majority of these licences, a survey prior to badger snaring was undertaken by National Parks & Wildlife Service staff. In 1993, because insufficient data had been received, further licences were selected for study, and, for these, survey and snaring was carried out by staff of the Department of Agriculture, Food & Forestry alone: the methodologies pertaining to these licence areas are described below. Results submitted to July 1993 have been incorporated into this report.

In a number of cases, licences submitted for the studies were deemed unsuitable immediately: this was either because the area had already been snared under licence in the previous few years or because no suitable OS maps were readily available sources in the OPW.

It was also required that the DVO locate on a map any setts identified in a wildlife survey that was carried out by them before submission of a licence application. Since badgers were considered as a source of infection in an application, it was the norm for a map accompanying the application to identify at least one active sett.

In total, 72 licences were initially considered for study, but for a variety of reasons, some of which have been referred to above, many did not provide information that was usable in the studies, and some were only partially usable for some aspects of the studies only. These matters are considered further below.

Preparation of survey maps and procedural arrangements

Licence areas for inclusion in these studies were chosen by each DVO and full details were submitted to the author either directly or through Department of Agriculture, Food & Forestry HQ. The information required for inclusion of the licence into the studies comprised a copy of the licence issued by the National Parks & Wildlife Service (with licence number), the name of the farmer on whose behalf the licence had been issued, his address and farm address, and an accompanying map (preferably 6":1 mile OS) clearly indicating the farm's location and any badger setts identified in the area or within the 2 km radius of the farm. The licence application form was usually submitted, giving the reasons for the application and details of previous applications for the farm.

The licence area was identified on half-inch:1 mile OS maps and 6":1 mile maps obtained for the licence area principally from OPW archives. From the designated 2 km zone, an area of approximately 1km square was chosen for survey by Wildlife Rangers: this usually centred on the farm and included as many setts identified by the DVO as possible. Where major physical boundaries, such as large rivers, would have made it fruitless to consider areas on both sides (as each would containing discontiguous badger social groups), the square was moved to one side only or, instead, an irregular area of about 1 km^2 was identified for survey on one side of the boundary only. The surveys were not intended for assessment of badger densities and the exact size of each designated area was not assessed accurately where it formed an irregular shape or rectangle. The choice of an area to be surveyed of about 1 km^2 was to ensure that survey could be completed within much the same time as surveys conducted within the National badger survey.

As for the National badger surveys, Rangers were supplied with several copies of the survey area at a scale of 6":1 mile and also enlargements of approximately 9":1 mile on which habitats and sett locations could be marked.

Full details of each licence, the DVO's maps, the prepared OS copies, and full instruction sheets were sent to National Parks & Wildlife Service District Officers, co-ordinating surveys carried out by Rangers in their district. At the same time, the DVO was informed that the licence area was being surveyed and that snaring operations should not be carried out until the surveys had been completed.

Once the surveys had been received by the author and checked, maps giving sett locations (each marked with a number) and snaring instructions were issued to the DVO concerned. Subsequently, DVOs submitted snaring results through Department of Agriculture, Food & Forestry HQ. Clarification was sought from DVOs and Rangers where snaring was found to be inadequate or if there were discrepancies between results submitted by Rangers and those submitted by DVO field operatives. In a number of instances, snaring was repeated at a later stage on request, either to include setts that had not been snared but had been identified for snaring, because the numbers of snares laid had been too few, or the trapping period was too short.

In view of the nature of the Government Departments involved and the overall perceived priorities of badger research or TB control by individual staff, close co-operation at field level was not always possible. For this reason, the two chains of communication described above were used - with sett surveys being co-ordinated through the National Parks & Wildlife Service Management and badger removal operations through the DVOs, co-ordinated by Department of Agriculture, Food & Forestry HQ. This entailed some delays in processing applications. In some cases, Rangers and DVO staff co-operated in the studies, staff jointly assessing areas and Rangers monitoring removal operations. In other instances, some Rangers refused to carry out sett surveys in the knowledge that these would be subsequently snared. Meetings were held in various districts to emphasise that, as these were areas licensed for badger removal, such removal would go ahead irrespective of whether Wildlife Ranger surveys were carried out, and that the surveys would increase the information obtainable from these operations. Nevertheless, certain of the licence areas could not be included in the studies as no staff were available for survey work.

In 1993, with a need to obtain more information from certain counties, the difficulties noted above were avoided by requesting that DVO staff carry out sett surveys and give full sett information along with snaring results. Of necessity, as DVO staff were not trained in the methodologies employed in the National Badger Survey, the data thus obtained have required assessment different from the earlier studies; however, adequate data was obtained from a number of licence areas, with sett classifications being amended according to the guidelines given earlier (*Sett survey*, pages 12 - 16).

Sett survey and sett classification

Rangers carried out surveys of licence areas in the same manner as for National sett survey squares, marking in habitats on the maps, and providing full sett details for each sett observed as well as other information for the area on the data sheets used in the National survey.

The aim of the these surveys, unlike the National surveys, was to attempt to identify all setts belonging to at least one social group. Rangers were thus requested to survey outside the designated area whenever this was considered necessary to include all setts that might form part of the territorial area of an identified social group. Additional instructions/notes were therefore issued to Rangers involved in these surveys.

The mapped habitats have not been assessed in these studies, but assisted in the correct classification of setts.

Setts were classified by Rangers and sett classifications were checked and revised where necessary. Once a number of snaring results had been received from DVOs, it was recognised that there were instances in which the sett classifications did not correspond with snaring results, and that there was a tendency to overestimate the number of active main setts in an area. Close scrutiny of the data and maps resulted in the additional criteria for sett classification reported earlier (see *Sett survey*, pages 15 - 16). Consequently, all data from the National Badger Survey were re-evaluated using the revised criteria, and all survey data from licence areas were similarly evaluated using these criteria. Correspondence between sett classifications using the revised criteria with the number of badgers captured at each sett is considered in the results below.

Snaring operations

Maps of sett locations identified by surveys were forwarded to DVOs. Brief notes on recommended snaring levels were issued; data sheets were provided for each badger snared and each sett snared (Appendix B). For licence areas surveyed by the DVOs in 1993, additional notes were sent and revised data sheets were issued (Appendix B).

Following work carried out by O'Corry-Crowe and Hayden (pers. comm.) in East Offaly, *c.* 500 snare nights per social group was recommended to obtain adequate snaring results. As operatives would not necessarily be aware of the extent of a social group, a snaring effort of 10 snares per sett entrance was recommended around each sett. This density was not usually achieved and was highly variable between areas and even within areas. In some instances, only data from the setts of one social group within a square were found to be adequate, and those for another group in the area excluded.

In order for the results to be fully used in validating the National sett survey, it was requested that *all* setts be snared, regardless of badger activity - to assess the accuracy of field identification of degree of sett activity. In practice, however, snaring was usually not carried out at setts considered inactive by the DVO field staff; the main reason for this seems to have been consideration of the effort and time involved in snaring where the field staff considered that badgers would not be captured. Given the undoubted field experience of the staff involved in regular snaring operations, it was accepted that these setts would have yielded zero captures, providing that sett information was supplied. However, in the case of several licences, lack of any information on the snaring operations at all the setts resulted in a request either for more information and re-examination of the setts or for snaring to be carried out at the other setts.

There was a time-lag between surveys carried out by Rangers and the snaring operations that followed. It was thus quite feasible for some setts to have become disused and others come into use by badgers in the intervening period. Again, where an obvious discrepancy occurred in the observations, clarification was sought from both the Ranger and the DVO field staff. Repeat visits to the area either confirmed the change in sett status or snaring at the sett was requested.

STUDIES OF BADGER REMOVAL AREAS: RESULTS

General account

The principal aim of the present studies was to estimate badger numbers removed from setts previously surveyed by Rangers, and to use these results to estimate social group size. In practice, about 36 of 72 licence areas yielded data, and information for some counties is lacking. Some information on TB status of badgers was also obtained from an additional 6 areas. A brief summary is given in Table 21, and full details in Appendices A14-A19. Many of these data sets were incomplete and the quality of data presented variable.

Table 21. County summaries of numbers of licence areas considered for study.

County	No. of licences considered	No. of data sets utilised
Carlow	3	1
Cavan	2	0
Clare	2	2
Cork	5	2
Donegal	4	3
Dublin	0	0
Galway	2	2
Kerry	3	2
Kildare	2	0
Kilkenny	3	1
Laois	2	2
Leitrim	4	1
Limerick	3	0
Longford	3	3
Louth	0	0
Mayo	5	4
Meath	2	0
Monaghan	3	0
Offaly	2	1
Roscommon	2	1
Sligo	3	1
Tipperary	4	3
Waterford	3	3
Westmeath	3	2
Wexford	4	2
Wicklow	3	0
Totals	**72**	**36**

The reasons for excluding certain licence areas from these studies were as follows:

1) for a number of licence areas, sett surveys were not received from National Parks & Wildlife Service staff (number = 5)
2) no maps were available (n = 1)
3) no snaring operations took place in the designated area (n = 7) or no results were submitted
4) the sett survey or the snaring did not take place because of prior destruction of setts or disturbance to badgers that was believed to be severe (n = 5)
5) badgers had been removed under previous licence in the last few years (n = 8)
6) inadequate snaring, or inadequate sett information, or major inconsistencies in data (n = 6)
7) no active badger setts were found in the square; no snaring took place and the available data was insufficient to confirm the sett survey (n = 3)
8) no setts were located in one survey (n = 1)

Within the remaining 36 licences, there were a number of discrepancies, incomplete data sheets and variation in snaring intensity. For a number of areas, sett sizes reported by Wildlife Rangers and DVO personnel did not correspond; usually, this was because DVO staff counted active entrances only, not all entrances to a sett. Where such differences in field techniques were inadequate to provide an explanation or no clarification was obtained, the data was used in part only.

With quality of surveys and snaring varying substantially from area to area, the data was used in whole where it was adequate or in part only. In some areas, data appeared inadequate to provide reasonable data on validation or group size, but the data for individual badgers captured was made use of. Badgers were not captured in all of these 36 areas, but the data in most (34) of these licence areas was adequate for examination of sett survey validity.

No active setts were identified in 4 licence areas and no setts in one of the areas (in at least three areas, setts identified on the licence application could not be located and apparently did not exist). However, the areas surveyed were only *c.* 1 km^2 of the licence area so active setts would probably have been present within a 2 km radius; nevertheless, attribution of the source of TB infection to badgers (under a licence application) when no active badger setts are present in a 1 km^2 area around the farm area would appear questionable.

The findings of these studies must be considered as of a preliminary nature because of the nature of the database: the sample of setts studied is not representative of setts in Ireland as all are located, by definition, in cattle grazing areas. Additionally, there are the remaining inconsistencies in the data. Some licence areas were re-snared and thus the snaring periods not only differ in duration but were carried out over two periods. In one area, a snaring duration of 16 days was employed and in others under 10 days at some setts. For a number of setts, no snaring intensity data sheets were returned.

The consideration of whether licence areas in which setts had been disturbed should be included posed some difficulty. To estimate the mean size of badger groups nationally, a random selection of setts for snaring would be an appropriate sampling method. Alternatively, it might be possible to assess mean group size at undisturbed setts and at disturbed setts, and apply this to the national estimates, but group size in disturbed groups will be highly variable depending on the degree of disturbance and the time elapsed since it took place.

Because of limitations of time and manpower available, it was considered that, initially at least, surveys that revealed no active setts and thus no badger captures for estimation of group size, would be wasteful of resources, even though some of these results might have been used for validation studies. Similarly, there was a risk that setts in areas which had had a TB outbreak were more likely to have been interfered with than elsewhere. Certainly, areas that had already been serviced under a previous licence had to be excluded, and if setts were destroyed between survey and snaring then the area's results were of no use. Thus, 7 licence areas were cancelled by Rangers or by DVO staff once it was realised that serious sett interference had taken place in the areas. In these cases, no data was submitted either from the survey or snaring.

Nevertheless, in preparation of summaries for the 36 licence areas, it became clear that disturbance to setts was common. It occurred in many of the areas studied, paralleling the widespread disturbance to badger setts observed in Ireland as a whole (pages 40-45). All these areas have therefore been included in analyses, with estimates being calculated for disturbed and undisturbed groups, where possible.

Validation of sett survey social group estimates

Methods

One of the principal goals of the National badger sett survey was to determine the number of social groups present in Ireland, which was determined from enumeration of active main setts (see page 13). In the sett classification procedure for a 1km square survey, active main setts and other sett types were identified using the criteria given earlier: from examination of the habitat maps, sett locations and activity patterns, the extent of each social group's territory and the setts within that territory could be estimated. However, providing that there was reasonable confidence in the classification of the active main sett, it was only incidental to the survey whether any subsidiary or outlier sett was contained within the territory of the group being examined (though in particular cases of sett classification, appraising which group a sett probably belonged to was instrumental in the correct classification of the sett).

Setts found in surveys of licence areas were classed in the same manner, but, additionally, all setts were grouped according to which social group territory they belonged.

Snaring data also required subjective interpretation, because badgers captured at setts not too far from each other may or may not belong to the same social group. The normal expectation would be that most badgers captured within a territory would be captured at the main sett or its immediate vicinity, including the annexe (if there is one). Fewer badgers would be captured at subsidiaries, and badgers would only occasionally be captured at an outlier.

Thus, if, of a group of badgers captured, most were captured at a sett other than a main sett, the sett classification would have been erroneous. Also, if no badgers were captured at a main sett, then its classification would be erroneous. Additionally, if badgers were captured at a sett previously designated as inactive, then its classification as an inactive sett at the time of survey would be in doubt.

In practice, few badgers were captured at outliers. In almost all cases, more badgers were captured at the main sett and annexe sett rather than at all subsidiaries present in the territory. However, it was not feasible to use the number of captures to distinguish between subsidiaries and outliers: the numbers of captures were used principally to confirm whether setts classed as the active main sett and its annexe for a social group had been classed correctly.

Conversely, the snaring data could be interpreted to suggest numbers of social groups present. For example, two setts, each with *c.* 5 badgers, and separated by 500 m would be indicative of two separate social groups. This would require that the survey had classed these setts as active main setts and any discrepancy would indicate a survey error.

In addition to validating the classification of individual setts, the overall number of social groups assessed by survey was compared with that assessed by snaring. For the purposes of the National badger survey, whilst misclassifications may occasionally occur, the overall mean may remain similar, with errors being made that would increase the estimate for some squares and would decrease the estimate in other squares.

Results

The results of sett surveys carried out by Wildlife Rangers (revised using the criteria outlined earlier) proved to be correct in the majority of surveys (Table 22 gives details of licence areas and reasons for failure of sett surveys where such occurred). Surveys carried out by DVO staff only did not always provide adequate sett information for assessment of sett type independently of the number of badgers known to have been snared at the setts.

In summary, 12 of the 34 areas with adequate data suggested actual or possible errors in estimates of numbers of social groups or of sett classifications, although estimates obtained of the total number of groups by survey and that obtained by snaring were identical at 42 groups. An examination of the details of these surveys shows that the survey methods employed were possibly inadequate in only a few of these instances, and certain examples reveal that it would be difficult to improve upon the sett criteria adopted to take such specific instances into account.

The principal reason for sett survey errors appears to have arisen from movement of social groups in the interval between sett survey and snaring. In some cases, this interval was long and would certainly account for the errors (interval details and dates are given in Appendix A15).

Examples are as follows:

a) in area 32/92 (Co. Donegal), no badgers were captured at a sett classed as an active main sett with 5 well-used entrances, but 5 badgers were captured at a single-entrance outlier. Clearly the main sett was now the one-entrance sett, which would not normally be classed as a main sett. The estimate of badger groups for the area remained correct, and the error seems to have resulted from movement of the group from the large sett to the smaller one. The period between survey and snaring was 6 weeks.

b) in area 107/92 (Co. Laois), a group of 6 badgers was captured at a main sett and its annexe, both of which had been classified as disused, but no badgers were caught at the main sett and subsidiaries identified as active. Again, the total group count for the area remained correct, but the group appears to have vacated an active sett and occupied a disused one. In this case, the period between survey and snaring was very long: 12 months.

c) in area 80/92 (Co. Kerry), a disused main sett yielded 3 badgers. Ranger checks confirmed that the group had moved into this sett in the period between survey and snaring. The period between survey and snaring was 6 weeks.

d and e) in two areas in Co. Mayo (575/91 and 610/91), single disused main setts in each area yielded 4 (3 adults and 1 cub) and 5 badgers, respectively. Again, groups would appear to have moved into these setts. In the first area, the period between survey and snaring was 5 weeks, but in the latter it was longer, at 14 weeks.

f) a 4-entrance sett classed as a subsidiary with low activity in Co. Westmeath (area 18/91) yielded 7 badgers (the active main sett in the area had another badger group present, of which 6 were captured). The interval between survey and snaring was quite long, at 12 weeks.

Conversely, there was apparent abandonment of main setts in some areas, additionally to those just mentioned above:

g) no badgers were taken at an active main sett in area 202/92 (Co. Waterford). This discrepancy is probably accounted for by the fact that snaring did not take place until 43 weeks after the survey.

h) only one badger was captured at a 14 entrance sett in Co. Cork (area 574/91), which had had 11 active entrances. There was no evidence of disturbance at this sett and no revision of survey techniques would be appropriate. The interval before snaring was *c.* 1 month. The group may have moved as the snaring results confirmed 2 other main setts in the area.

i) an active main sett of 7 active entrances with bedding and latrines yielded no captures in area 48/92 (Co. Wexford). The period between survey and snaring was 11 weeks.

Disturbance may have caused some of these movements. In area A51/92 (Co. Sligo), the capture of a single individual in an area in which 2 active main setts were present could be attributed entirely to sett interference.

Of course, some of the above misclassifications may have arisen from observer error rather than the result of group movements: the sett in area 202/92 consisted of only 3 active entrances (of a total of 5), and the outlier mentioned above (area 32/92) may have been misclassified. In another example, 3 badgers were captured at a single-entrance outlier in area 45/92 (Co. Leitrim).

Generally, however, given the above examples in which several badgers were captured at a sett, field observer error in classing a main sett's status as active or disused is somewhat unlikely and was probably caused by movement of groups in most instances. The long intervals between survey and snaring probably accounted for many of the discrepancies above.

As snaring data also requires subjective interpretation in difficult cases, confirmation of sett surveys for some licence areas was tentative. Thus for licence areas 596/91 (Co. Westmeath) and 45/92 (Co. Leitrim), it was possible that the sett survey did underestimate the number of social groups, but without population studies on these badger groups, whether this was the case cannot be determined. For area 23/92 (Co. Clare; fair to good grazing mainly), the snaring data appeared to yield 3 social groups (each separated by about 1 km), each comprising just two adults. Such small groups are unusual in lowland grazing areas, and the result may have been brought about by various factors: a) that there are, in reality, 3 groups of this size; b) that the social groups have been reduced by previous snaring or human disturbance; c) that the individuals comprise just one or two social groups not 3, or d) that snaring did not capture many of the badgers present. Again, this cannot be confirmed without behavioural studies on these badgers. Given that the 3 main setts were all large active setts with considerable separation, a revision of sett survey methods would not be possible.

Notwithstanding the difficulties posed by certain of the data sets in Table 22, a total count for the licence areas gives an estimate by sett survey of 42 social groups and, derived from interpretation of snaring results, also of 42 social groups.

The density of badger groups estimated from these licence areas is approximately 1.24 social groups per km^2. This is well above the national mean because the licence area data are not representative of 1km squares in the country, with few areas possessing zero badger groups. This is to be expected because, firstly, a licence is applied for removal of badgers and badgers were therefore usually present in the areas studied, and, secondly, licence areas in which no active setts could be located were mainly excluded from DVO snaring.

Survey of a known population of badgers

In a 'semi-blind' check on survey techniques, three Wildlife Rangers participated in a survey of part of the established badger population study area in west Cork (UCC project; Sleeman, 1992; Sleeman & Mulcahy [1993]). For reasons of limited resources, only 3 1km squares could be surveyed, each by one Ranger, with all Rangers from the Cork/Kerry region. Though the Rangers were informed that they were re-surveying a known area, they were not informed of sett locations, and informed that this was to ensure that additional setts might be found by this means. In all other respects, survey of the areas was the same as that for the National sett survey.

In the first square (A), six setts were identified by survey, all of which had been located by the population studies. A disused sett of 13 entrances was located at a distance of 250 m from the main sett was classed as a disused main sett. Population studies showed that this was a sett that was in use as a subsidiary in summer. Any activity at this sett would have allowed for its inclusion as subsidiary but it was noted as disused by the surveyor. 4 small setts near the main sett were classed as subsidiaries but have been included within the main sett complex by Paddy Sleeman.

In the second square (B), 2 setts were located by survey, an annexe and an outlier. The annexe is close to the main sett in the first square and Paddy Sleeman had included this complex as part of the main sett complex rather than a separate sett. In all, with the main sett in the centre, there was a (mapped) distance of 200 m from the extreme subsidiary to the annexe. For practical purposes, this is considered as a main sett complex by the population studies, but survey has separated these into a main sett, annexe and smaller setts. A main sett (present 100 m outside the survey area, with 2 badgers located within it) was not found in the survey.

The third square (C), was complex. Survey located 2 large setts and an outlier within the square and 2 large setts within *c.* 125 m of the square. A known disused subsidiary was missed and an active outlier on the periphery of the square. In all there were 4 large setts located, 3 of which were active (referred to here as S1, S4, S5), the other classed as a disused main sett. 2 of these large setts were within the square (S1, S4), separated from each other by 525 m, with the large sett (S5) outside the square 325 m further and separated from the others by a small river. As one of the 2 setts was not very active (S1, 6 entrances, 1 active but bedding, latrines, tracks, *etc.* were present), the revised sett classifications described in # *Methods* would yield a result of the active sett (S4) being a main sett and the sett (S5), 325 m distant from it and separated by a river, also being a separate main sett. The sett sizes were, for S4, 10 entrances with 5 active (with bedding, latrines, *etc.*), and, for S5, 5 entrances with 5 active, with bedding (no latrines noted). For the survey square, there is no option other than to class the 10 entrance sett (S4) as a main sett. It transpired that S5 was the main sett with badgers crossing the river to the remainder of the territory, and with badger movements taking place over a distance of 1,150 m from this main sett to an active outlier. S4 was a subsidiary. The survey overestimated badger abundance in this square by one group, but the social behaviour of badgers in this area has a history: disturbance to setts has disrupted 2 groups that occupied this large territory, and now the 7 adults present in the 1 group remaining included various 'wanderers' (Sleeman, pers. comm.).

The surveys would indicate that, occasionally, smaller setts will not be found within the survey areas. This is inevitable, given the time that can reasonably be devoted to sett survey. All active setts were located. Behavioural studies did yield different results for one area, for which it is not possible to suggest revision of survey techniques. As mentioned earlier, disturbance to setts causes great difficulty for surveyors, due to the unusual pattern of badger activity that results.

Conclusions

Overall, estimates of numbers of badger social groups from sett survey corresponded with estimates obtained from snaring data. Where difficulties did arise, revision of survey techniques by alteration of sett definitions used for sett classification was not a logical consequence. The studies of licence areas and the surveys in the UCC study area have, however, highlighted the fact that sett surveys cannot achieve the same degree of accuracy in the correct classification of setts as do behavioural studies or surveys backed by snaring data.

The results do suggest that the sett survey techniques employed were adequate to allow derivation of estimates of badger social group density for counties and regions that would, in practice, be confirmed by snaring of setts.

However, data for any particular survey square is prone to error resulting in underestimation or overestimation of groups present in the area, certainly over any significant period - due to main sett relocation by badgers in *c.* 10 - 20% of the groups observed here. The apparent high mobility of groups was not anticipated, and, there is some possibility that such badger group mobility may be higher in licence areas than elsewhere, due to one form or other of disturbance to setts; overall disturbance levels were slightly higher (page 158).

Finally, it must be recognised that the value of conducting studies of licence areas led, initially, to the revised criteria for sett classification which were adopted for all surveys in the National sett survey. This resulted in a downward revision of social group density in Ireland of *c.* 15%. These revised criteria have been used in assessment of licence areas and have been validated in the above studies.

Table 22. Comparison of estimates of social groups given by sett survey and given by DVO snaring results.

Licence	County	Estimates of social groups present in survey area			Comments
		corrected WS survey	estimate from snaring operation	sett survey confirmed ?	
102/92	Carlow	0	0	Y	Sett survey confirmed by snaring in area, but the 1 disused main sett not snared by DVO (inactive).
24/92	Clare	3	3	Y	Sett survey confirmed.
23/92	Clare	3	3	Y	Sett survey probably confirmed. The sett survey identified 3 active main setts with no other interpretation possible. Snaring revealed 2 badgers at each of these setts, with possibility therefore that there were fewer than 3 social groups or that numbers had been underestimated by snaring.
574/91	Cork	3	2	N?	WS sett classification uncertain; 1 main sett yielded only 1 capture.

Table 22 contd.

Licence	County	Estimates of social groups present in survey area: corrected WS survey	estimate from snaring operation	sett survey confirmed ?	Comments
598/91	Cork	1	1	Y	Sett survey confirmed.
32/92	Donegal	1	1	N/Y	The sett survey totals proved correct, but zero badgers captured at the main sett, and 5 at an outlier sett with 1 entrance.
618/91	Donegal	0	0	Y	Sett survey confirmed.
142/93	Donegal	2	2	Y	Sett survey confirmed. 4 of 5 setts disturbed.
532/91	Galway	1	1	Y	Sett survey confirmed.
571/91	Galway	2	2	Y	Sett survey confirmed.
80/92	Kerry	0	1	N	Disused main sett yielded 3 badgers. Sett classification correct, but activity in error. Possible reason: badgers moved in between survey and snaring.
33/93	Kerry	1	1	Y	DVO sett survey. Sett information was sufficient to demonstrate that sett classification would have been confirmed by snaring results.
522/91	Kilkenny				Data not included in validation.
44/92	Kilkenny	1	1	Y	Sett survey confirmed.
107/92	Laois	1	1	N/Y	Group totals confirmed, but previously active main sett yielded no captures, and a previously disused main sett yielded 6 badgers.
108/92	Laois	1	1	Y	Sett survey confirmed.
45/92	Leitrim	1	2	N?	One group confirmed survey. Also 3 badgers captured at an outlier but confused snaring data and location data. 'Second group' (?) data unsuitable for inclusion in validation.

Table 22 contd.

Licence	County	Estimates of social groups present in survey area			Comments
		corrected WS survey	estimate from snaring operation	sett survey confirmed ?	
15/92	Longford	0	0	Y	Sett survey probably confirmed. 2 adults captured at separate subsidiary setts; no full group?
16/92	Longford	1	1	Y	Sett survey confirmed.
166/92	Longford	2	2	Y?	DVO survey only. DVO operative labelled captures as 1 social group. Snaring results would confirm a WS sett interpretation of 2 groups.
575/91	Mayo	1	2	N	Sett survey underestimate. Sett types correctly classified, but disused main sett proved to be an active sett, with 4 badgers captured. Reason: time interval between survey and snaring?
610/91	Mayo	0	1	N	Sett survey underestimate. Sett types correctly classified but disused main sett proved to be active main sett, with 4 badgers captured. Reason: Ranger stated that badgers had clearly re-occupied sett by time of DVO snaring. Error caused by time interval between survey and snaring.
31/93	Mayo				Data not included in validation.
140/93	Mayo	1	1	Y?	DVO sett survey only. Interpretation would confirm sett survey techniques.
8/92	Offaly	2	1	N?	Possible sett survey overestimate. No other sett survey interpretation possible, but snaring revealed one social group to be too small: however, some of the snaring was very inadequate. Snaring estimate: 1+ groups.

Table 22 contd.

Licence	County	Estimates of social groups present in survey area: corrected WS survey	estimate from snaring operation	sett survey confirmed ?	Comments
569/91	Roscommon	1	1	Y	Sett survey confirmed, but snaring results below recommendation.
A51/92	Sligo	2	1	N?	Only 1 badger from 2 main setts: all setts appear interfered with.
514/91	Tipperary	2	2	Y?	Sett survey found 3 main setts, but no snaring data for this and minor setts.
581/91	Tipperary	1	1	Y	Sett survey confirmed, but snaring data below recommendation.
112/93	Tipperary	1	1	Y	Sett survey confirmed. Snaring results revealed part capture of additional social group (but not another main sett).
544/91	Waterford	1	1	Y?	Results tend to confirm sett survey, but only 1 badger was captured at a main sett that had suffered considerable disturbance by digging.
47/92	Waterford	1	1	Y?	Results tend to confirm sett survey, but only 1 badger was captured at a main sett that had suffered considerable disturbance by digging.
202/92	Waterford	1	0	N	Sett survey overestimate. No badgers captured at 3 setts (of which 2 active). Inadequate snaring information from DVO. Possible reasons: 1) sett group incorrectly classified 2) badgers may have vacated main sett since survey.
18/91	Westmeath	1	2	N	Sett survey underestimate. A subsidiary of low activity yielded 7 adults.

Table 22 contd.

Licence	County	Estimates of social groups present in survey area			Comments
		corrected WS survey	estimate from snaring operation	sett survey confirmed ?	
596/91	Westmeath	1	1	Y?	Sett survey probably confirmed. Possibility that 3 badgers at a subsidiary constitute a separate social group.
48/92	Wexford	2	1	N?	Sett survey confirmed for one group, but other main sett not snared because DVO considered it inactive.
174/93	Wexford				Data not included in validation.
Totals	**34**	**42**	**42**		
mean		**1.24**	**1.24**		
s.e.		**0.12**	**0.11**		

Estimation of the mean size of badger social groups

Estimates of social group size were derived from the snaring data. Most badgers were captured at the main sett and its annexe, but badgers captured at subsidiary and outlier setts were included where these were considered to fall within the territory of that social group. The estimates given below are based on revisions of territories following snaring and, where the sett survey did not correspond with snaring results, the estimates are derived from *corrected* sett classifications (see page 148, # *Numbers of badgers according to sett type* and Appendix A16) and territory assessments. A later section provides estimates of group size corrected by estimates of the numbers of untrapped individuals, as obtained by catch-effort analyses (pages 161-177).

Most badgers were captured at the main sett. In a few instances, as referred to above, it was not clear whether badgers captured at a subsidiary belonged to the group at the main sett or comprised a separate social group. Inclusion of such badgers within estimates for a group has been based on the criteria adopted for the National sett survey and an overview of sett distribution and habitats within the areas studied. Results are given in Table 23.

A total of 40 badger social groups were assessed for group size within 32 of the licence areas. In a few instances, the sex of badgers captured was not recorded. In total, 171 yearlings and adults were captured, and also 5 cubs. All but a few of the licence areas were snared from February to June: there was, therefore, no confusion in distinguishing the young of the year with those of the previous year. One licence area was snared in August, one in October, two in November, and two in January. In these cases, the data clearly distinguished between young born earlier that year from older animals.

Table 23. Estimates of size of badger social groups, as ***obtained from*** ***actual*** ***captures****.*

Licence	County	Social group	Captures Male adult	Female adult	Male cub	Female cub	Totals adults	Group disturbed?	Comments
24/92	Clare	A	2	4	0	0	6	N	-
		B	3	3	0	0	6	N	-
									Third group insufficient data.
23/92	Clare	A	0	2	0	0	2	Y	Inadequate captures?; annexe sett blocked with stones.
		B	1	1	0	0	2	N	Inadequate captures?
		C	1	1	0	0	2	N	Inadequate captures?
574/91	Cork	A	2	1	0	0	3	N	
		B	3	2	0	0	5	N	
598/91	Cork	A	2	2	0	0	4	N	Insufficient snaring?
32/92	Donegal	A	1	6	0	0	7	N	Majority female.
142/93	Donegal	A	2	1	0	0	3	Y	Main sett dug; subsidiary disturbed.
		B	4	2	0	0	6	Y	Disturbed main and subsidiary setts.
532/91	Galway	A	4	2	0	0	6	Y	Outlier blocked: report of 2 badgers killed.
571/91	Galway	A	3	2	0	0	5	N	
		B	3	1	0	0	4	N	
80/92	Kerry	A	?	1	0	0	3	N	No details of badger sex for 2 individuals.

Table 23 contd.

Licence	County	Social group	Capt-ures Male adult	Female adult	Male cub	Female cub	Totals adults	Group dist-urbed?	Comments
33/93	Kerry	A	2	2	0	0	4	N	No sett disturbance data.
522/91	Kilkenny	A							No social group identifiable although 6 adults captured.
44/92	Kilkenny	A	3	4	0	0	7	N	
107/92	Laois	A	3	3	0	0	6	N	Sett recorded as disturbed prior to this group moving in.
108/92	Laois	A	1	3	0	1	4	Y	
45/92	Leitrim	A	1	7	0	0	8	N	
		B							Group excluded: insufficient data on group territory.
15/92	Longford	A							No full social group captured.
16/92	Longford	A	3	4	0	0	7	N	
166/92	Longford	A	1	2	0	0	3	N	DVO operative suggest these 2 groups are 1 but sett survey indicates otherwise; no sett disturbance data.
		B	1	2	0	0	3	N	No sett disturbance data.
575/91	Mayo	A	2	1	0	1	3	N	
		B	0	3	0	1	3	N	No males.
610/91	Mayo	A	2	2	0	0	5	Y	Evidence of sett being dug some years ago. No sex data for 1 adult.

Table 23 contd.

Licence	County	Social group	Captures Male adult	Female adult	Male cub	Female cub	Totals adults	Group disturbed?	Comments
140/93	Mayo	A	3	2	0	0	5	N	No sett disturbance data.
8/92	Offaly	A	3	2	0	0	5	N	
		B							1 adult male captured; snaring data inadequate for estimation of group size.
569/91	Rosc-ommon	A	2	0	0	0	2	N	Snaring results unsatisfactory? DVO says they estimate 2 badgers not snared.
A51/92	Sligo	A							All group setts interfered with.
		B	0	1	0	0	1	Y	All group setts interfered with.
514/91	Tipperary	A	2	2	0	0	4	N	Insufficient snaring.
		B	1	3	0	0	4	N	Insufficient snaring.
581/91	Tipperary	A	3	1	0	0	4	Y	Subsidiary sett snared.
112/93	Tipperary	A	2	2	0	0	4	N	No data on sett disturbance.
		B							Only partially snared group.
544/91	Waterford	A	0	1	0	0	1	Y	Disturbed main sett: digging.
47/92	Waterford	A					1	Y	Disturbed main sett: digging; no sex data for badger.

Table 23 contd.

Licence	County	Social group	Captures					Group disturbed?	Comments
			Male adult	Female adult	Male cub	Female cub	Totals adults		
18/91	Westmeath	A	4	2	0	0	6	N	
		B	4	3	0	0	7	N	
596/91	Westmeath	A	4	3	1	0	7	Y	Signs of digging.
48/92	Wexford	A	1	2	0	1	3	N	
Totals	**32**	**40**	**79**	**88**	**1**	**4**	**171**		

In ageing badgers, DVO field staff employed differing degrees of categorisation, some staff ageing adults by year (*e.g.* 1 year old, 3 years old, 4 years old); other staff distinguished juveniles (*c.* 1 year old) from adults only (*c.* 2 years old and older). There was not sufficient consistency between reports from the various areas to consider juveniles separately from adults in summaries. The term adult in Table 23 and following tables therefore includes juveniles.

The overall mean group size, as given by actual captures (without correction for untrapped individuals) was 4.28 adults (±0.61 [95% conf.]); normal approximation to a Poisson distribution, see page 207), comprising a mean of 2.03 males and 2.26 females (Table 24). Group size varied from 1 to 8 adults: frequency of occurrence of groups by size is illustrated in Figure 67. If the groups that suffered disturbance are excluded (n = 11, 34% of groups), then the mean social group size derived from snaring data is 4.52 adults (±0.61 [95% conf.]). This is composed of a mean of 2.03 males and 2.41 females (a few individuals had no sex data recorded).

As would be expected, groups where setts had been disturbed were smaller (though one main sett which was classed as disturbed because of previous digging did consist of 7 adults and two other setts each of 6 adults). The mean group size for disturbed groups was 3.64 (±1.23 [95% conf.]), with more males than females present on average: 2.00 males : 1.80 females. The difference in mean group size of disturbed and undisturbed groups was not significant (t=1.19, P=0.25) as sample sizes were small and group size variable.

The application of this data to national estimates is considered following an evaluation of data by sett type and proportions of setts showing disturbance, as well as re-calculating group size to take into account estimates of untrapped animals.

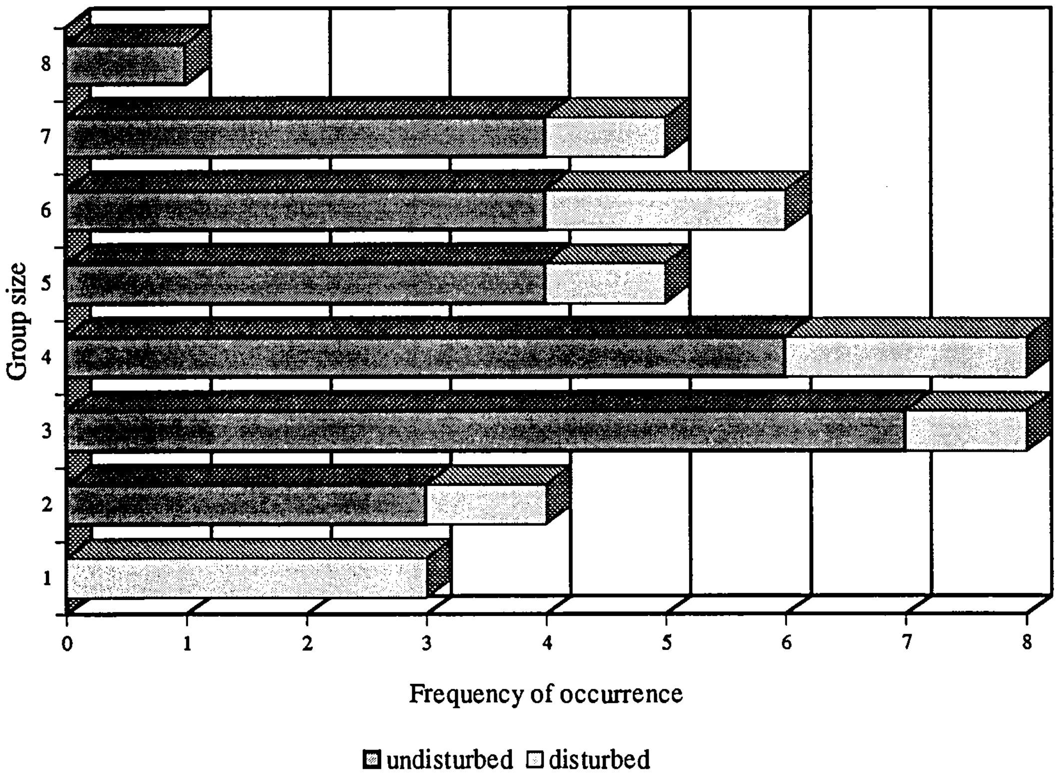


Figure 67. Histogram illustrating frequency of occurrence of social groups by size (from Table 23). n.b. *social group sizes given by* ***actual*** *captures only.*

Sex ratios observed in badger groups

Of the badgers captured, ratio of females to males was close to unity: for all areas included in Table 23, the sex ratio observed was 1 male : 1.11 females (does not differ from 1:1; $\chi^2_1 = 0.49$, P = 0.49). In undisturbed groups only, there were more females to males: 1 male : 1.19 females. In disturbed groups, males predominated: 1 male : 0.90 females. The difference in sex ratio between disturbed and undisturbed groups was not significant ($\chi^2_1 = 0.32$, P = 0.57). No sex data had been recorded for 4 individuals from the licence areas in Table 23. Further information on the individual badgers captured from these and additional licence areas (where group data was not assessed but some badger data is available) is given later.

Although the sex ratio was close to parity overall, individual groups sometimes possessed very unbalanced sex ratios, and it is possible that some of these results arose from incomplete snaring of the groups. However, groups with unbalanced sex ratios identical or similar to those observed in these studies were reported by O'Corry-Crowe (1992).

Particular examples of groups exhibiting unbalanced sex ratios were: a) area 32/92 (Co. Donegal) with group A consisting of 6 adult females and 1 adult male, b) area 45/92 (Co. Leitrim) with group A consisting of 7 adult females and 1 male, c) area 108/92, Co. Laois, with 3 adult females and 1 female in group A, d) area 575/91 (Co. Mayo) with group B consisting of 3 adult females and no males. One group in area 23/92 (Co. Clare) consisted of 2 females. Males outnumbered females by 2 individuals or more in a number of areas: a) areas 142/93 (Co. Donegal) and area 18/91 (Co. Westmeath) where groups comprised 4 males and 2 females, b) area 532/91 (Co. Galway) with group A also consisting of 4 males and 2 females, c) areas 571/91 (Co. Galway) and 581/91 (Co. Tipperary) with groups consisting of 3 males and 1 female, d) area 569/91 (Co. Roscommon) where the group was comprised of just 2 males.

Table 24. Summary data for estimates of social group size (uncorrected for untrapped animals). If any of the setts present within a group's territory were disturbed, the group was considered as a disturbed group.

	Male adult	Female adult	Male cub	Female cub	Total adults
All groups					
max.	4	7	1	1	8
min.	0	0	0	0	1
total captures	79	88	1	4	171
mean group size	**2.03**	**2.26**	**0.03**	**0.10**	**4.28**
s.e.	0.20	0.22	0.03	0.05	0.31
n (groups)	39	39	39	39	40
Disturbed groups					
max.	4	3	1	1	7
min.	0	1	0	0	1
total captures	20	18	1	1	40
mean group size	**2.00**	**1.80**	**0.10**	**0.10**	**3.64**
s.e.	0.51	0.24	0.09	0.09	0.63
n (groups)	10	10	10	10	11
All undisturbed groups					
max.	4	7	0	1	8
min.	0	0	0	0	2
total captures	59	70	0	3	131
mean group size	**2.03**	**2.41**	**0.00**	**0.10**	**4.52**
s.e.	0.20	0.27	0.00	0.06	0.31
n (groups)	29	29	29	29	29

Numbers of badgers captured according to sett type

An alternative to the assessment of badgers captured per social group (which requires some subjective assessment of the extent of a group's territory and assessment of which setts 'belong' to each badger group) is to assess the mean number of captures according to sett classification. The badger capture results for every sett found in the 36 licence areas are given in full in Appendix A16 (some setts included are additional to those considered for group estimates: they had been excluded from group estimates because either the groups could not be assessed accurately, or the setts yielded no captures).

In order to present as complete an assessment as possible and to use the data for extrapolation to the national estimates, all setts observed by Rangers in surveys of licence areas were included even though data on the snaring of these setts was not always obtained from DVOs. However, snaring data sheets were usually incomplete when the sett had been deemed inactive and no snaring had, therefore, taken place.

As discussed above, setts were classified in the same manner in licence areas as in the National badger sett survey. A number of misclassifications did occur, but most of these resulted from the time interval between survey and snaring and badger group movements. It would be unrealistic to use the data uncorrected for these observations: *e.g.* the uncorrected data shows 2.68 adults being captured at active main setts and 1.50 at *disused* main setts. The detailed assessment above showed that such large badger groups would have been obvious in field surveys had they been present. The data were corrected for 11 main setts by alteration to reflect their status as revealed by snaring (Appendix A16). Summary data (Table 25) for corrected and uncorrected data shows that these results differ little; application of the data to national survey results produced values for badger numbers that differed only by 0.05%.

The corrected data shows that, overall, 3.19 adults were captured at active main setts, 0.69 at active annexes, 0.70 at active subsidiary setts and 0.16 at active outlier setts. No badgers were captured at inactive setts.

The mean number of badgers captured at undisturbed setts in comparison with disturbed setts is given in Table 26. As would be expected, fewer badgers were snared at disturbed setts - except for subsidiary setts, but small sample sizes and variability in group size account for this latter observation (diff. insign.; $t = 0.97$, $P = 0.34$; active setts only). For main setts, the mean number of adults captured at a disturbed sett was 68% of the number captured at an undisturbed sett (diff. sign.; $t = 1.98$, $P = 0.06$; active setts only). No badgers were captured at disturbed annexe setts, whilst 1.0 on average were captured at undisturbed annexe setts (diff. sign.; $t = 2.34$, $P = 0.04$; active setts only).

Application of estimates to national data

Mean group sizes were calculated in Table 24, and estimates for badger numbers according to sett type in Tables 25 and 26. To estimate national badger populations, a correction for badgers not snared is required (below), but consideration is paid, firstly, to whether the data from licence areas are representative of the country as a whole. The licence areas were not randomly selected with respect to geography and habitats, though as wide a geographical spread was obtained as possible. As compared to 729 1km squares for the national sett survey, *c.* 36 licence areas have been considered to obtain badger data, numerically thus entailing a database of about 5% in size by comparison. There is a possibility that, with licence areas being all located in cattle grazing areas, the use of this data might lead to overestimation of badger numbers. However, as most badger setts in Ireland are located in hedgerow and treeline (see later section) and because so much land in Ireland is devoted to cattle grazing (43.5%, Table 18), the data might, in practice, be applied with little error. An additional difficulty is the incorporation of badger estimates for disturbed setts: the sample size for disturbed groups and setts is small.

Comparison with overall National sett survey data

Whether the data setts are compatible may be judged by comparing various sett attributes, such as habitat location, sett size, activity, proportions of sett types present, and sett disturbance, against the data from the National sett survey.

One principal difference between the licence squares and the National sett survey squares has been mentioned already: the mean density of social groups in the licence areas is considerably above the national mean (1.24 groups km^{-2} *cf.* 0.46). This is to be expected as the 1 km squares for survey *within* licence areas were chosen *deliberately* to maximise the probability that a main sett/social group would be present (usually based on the preliminary map submitted by the DVO). This being the case, consideration of this sampling approach would predict, firstly, that, because a group *is* present, a higher proportion of the setts found in an area surrounding that group might be active, and, secondly, fewer small inactive subsidiaries and outliers might be located in the survey area than in a random sampling approach (because outlying areas of a group's territory will not be sampled as often as in a random survey). Also, it is possible that disturbance to setts might be higher - though, since disturbance can lead to sett abandonment, this is not clear. These various possibilities were tested.

The mean number of setts per active main sett was observed to be 3.62 setts in the licence areas (Table 27) and 4.09 in the National sett survey: almost all of this difference is accounted for by fewer outlier setts (0.69 *cf.* 1.08; diff. sign., $\chi^2_1 = 3.49$, P = 0.06). The sett ratios for the other sett types were similar: for annexe setts - 0.45 *cf.* 0.50 (licence areas and national survey respectively) [diff. not sign.]; for subsidiary setts - 1.29 *cf.* 1.32 (diff. not sign.) and 0.19 *cf.* 0.19 for disused main setts.

For these *overall* sett categories, the two data setts do not differ significantly ($\chi^2_3 = 3.97$, P = 0.27), but consideration of the data for all 8 sett types (class of sett and activity; Table 27) shows that the difference is greater ($\chi^2_7 = 11.46$, P = 0.12) which arises from a higher proportion of active setts being present in the licence area sample. Comparison of active total against total disused is significant ($\chi^2_1 = 5.09$, P = 0.02). In fact, comparing licence areas with the National sett survey, the finding is that there is no significant difference in activity levels for a) main setts, b) annexe setts and c) outlier setts. The *similarity* in activity levels is high for annexe setts ($\chi^2_1 = 0.00$, P = 0.99). The observed difference between the two sets of data arises almost entirely from the difference in activity of subsidiary setts, with 87.0% active compared to 70.6% in the national data ($\chi^2_1 = 5.74$, P = 0.01).

Table 25. Numbers of adults captured at setts according to sett type. Sett ratios are given according to number per active main sett, as for the National sett survey. Number of licence areas considered was 33.

Uncorrected data		**Active setts**				**Disused setts**		
	Main	**Annexe**	**Subsi-diary**	**Outlier**	**Main**	**Annexe**	**Subsi-diary**	**Outlier**
N	41	16	49	19	8	3	6	10
Total captures	110	7	40	3	12	4	0	5
Mean	**2.68**	**0.44**	**0.82**	**0.16**	**1.50**	**1.33**	**0.00**	**0.50**
s.e.	0.26	0.22	0.17	0.15	0.56	1.09	0.00	0.47
Sett ratios	*1.00*	0.39	1.20	0.46	0.20	0.07	0.15	0.24
Sett ratios (setts other than main setts grouped regardless of activity)	*1.00*	0.46	1.34	0.71	0.20	**Total:**	**3.71**	
% disturbed	19.51	31.25	12.24	5.26	37.50	0.00	0.00	20.00
% disturbed (setts grouped regardless of activity)	22.45	26.32	10.91	10.34				

Corrected data		**Active setts**				**Disused setts**		
	Main	**Annexe**	**Subs-idiary**	**Outlier**	**Main**	**Annexe**	**Subsi-diary**	**Outlier**
N	42	16	47	19	8	3	7	10
Total captures	134	11	33	3	0	0	0	0
Mean	**3.19**	**0.69**	**0.70**	**0.16**	**0.00**	**0.00**	**0.00**	**0.00**
s.e.	0.23	0.30	0.12	0.15	0.00	0.00	0.00	0.00
Sett ratios	*1.00*	0.38	1.12	0.45	0.19	0.07	0.17	0.24
Sett ratios (setts other than main setts grouped regardless of activity)	*1.00*	0.45	1.29	0.69	0.19	**Total:**	**3.62**	
% disturbed	21.43	31.25	12.77	5.26	25.00	0.00	0.00	20.00
% disturbed (setts grouped regardless of activity)	22.00	26.32	11.11	10.34				
National survey sett ratios	***1.00***	**0.50**	**1.32**	**1.08**	**0.19**	**Total:**	**4.09**	
National survey disturbance %	**20.4**	**16.2**	**14.6**	**8.0**				

Table 26. Data from licence areas: a) mean sett sizes and b) numbers of badgers captured at different sett types, differentiated by occurrence of disturbance to setts. Based on corrected data only (re. Table 25 and Appendix 16).

	Active setts				**Disused setts**			
	Main	**Annexe**	**Subsidiary**	**Outlier**	**Main**	**Annexe**	**Subsidiary**	**Outlier**
Mean sett size								
No. of entrances	7.1	3.1	3.2	1.8	6.1	3.7	2.6	1.6
s.e.	0.54	0.71	0.22	0.26	0.65	0.27	0.40	0.21
Disturbed setts								
N	9	5	6	1	2	0	0	2
Total captures	21	0	6	0	0	0	0	0
Mean	2.33	0.00	1.00	0.00	0.00	-	-	0.00
s.e.	0.42	0.00	0.33	0.00	0.00	-	-	0.00
Undisturbed setts								
N	33	11	41	18	6	3	7	8
Total captures	113	11	27	3	0	0	0	0
Mean	3.42	1.00	0.66	0.17	0.00	0.00	0.00	0.00
s.e.	0.26	0.41	0.12	0.16	0.00	0.00	0.00	0.00

The results confirm that, in addition to licence areas having a higher mean density of badger groups, the proportion of setts active is higher than that obtained from the National sett survey. Additionally, significantly fewer outliers, and slightly fewer subsidiary setts were observed in the licence areas. Sett sizes (Table 26 above) were similar to those observed in the National survey (Table 6), particularly for active main setts (overall mean 7.0 entrances) and subsidiary setts (overall mean 3.1 entrances). Annexe setts were found to be smaller in the data from licence areas (overall mean 3.2 *cf.* 4.0) and outlier setts slightly larger (overall mean 1.7 *cf.* 1.3. These results are of particular interest as they are derived from sett classifications verified by badger capture studies and would support the use of extrapolations to determine national badger estimates from a count of active main setts.

Comparison with selected data from the National sett survey

As the sampling method adopted for choosing licence survey areas usually resulted in a badger group being present, a comparison with similar data from the National sett survey is more appropriate than the comparisons above, where all of the national data was included. Thus, in Table 27, information is presented from the national data giving results for sett types present in all squares that contained a minimum of one active main sett (referred to hereafter as *active squares* for brevity: active setts other than main setts were present in the other squares). Data is also given for the remaining squares that contained no active main setts.

Examining the data from the National sett survey alone, it is observed that sampling only active squares results, obviously, in a higher badger group density: the mean for these 280 squares was 1.30 badger groups per km^2, quite similar to the mean of 1.24 groups km^{-2} observed in the 37 licence areas. In active squares, a higher proportion of setts are active: 79.8% of all setts present in these squares are active as compared with 72.7% for all surveyed squares. The proportions increase for all sett classes: from 83.8% to 92.3% for main setts, from 81.4% to 86.3% for annexe setts, from 70.6% to 75.6% for subsidiary setts, and from 59.1% to 64.5% for outlier setts.

The ratios of each sett type to each active main sett also differ substantially. In particular, the mean number of outliers observed per active main sett drops from 1.08 to 0.79 (27% fewer). There are also fewer subsidiaries and annexes: subsidiaries decrease from 1.32 to 1.03 (22%), and annexes from 0.50 to 0.45 (10%). There were markedly fewer disused main setts - a decrease from 0.19 per active main sett to 0.08 (57.9%). The total number of setts associated with each badger group thus drops from 4.09 in the national data to 3.35 for the active squares alone.

Of the total of 1378 setts observed in the National sett survey, 1131 (82%) were located in the 280 active squares, which constituted only 38% of the total number of squares surveyed (mean = 4.04 setts km^{-2}) . Only 247 setts were located in the remaining 449 survey squares (mean = 0.55 setts km^{-2}). 59.9% of these setts were disused.

Thus, in comparing the overall data from the licence areas with the active squares of the national sett surveys, it is observed that sett ratios and activity levels are more similar than in the previous comparisons to the overall national data. To complete the comparison, similar data has been derived for the licence areas, since not all of these had active main setts present either (also in Table 27). There were 30 active areas (of a total of 34 areas), indicating the bias of the sample relative to the national survey (where the majority had no active main setts).

The mean badger density in this licence area sample was 1.40 badger groups km^{-2} compared to 1.30 in the national data for active squares (diff. not sign.). The total number of setts associated with each group was also very similar: 3.33 *cf.* 3.35 in the national active squares. Sett ratios were also similar, though there were still relatively few outliers. The observations were: 0.12 disused main setts in licence areas *cf.* 0.08 in national data; 0.45 annexe setts per active main sett in both data sets; 1.19 subsidiaries in the licence areas *cf.* 1.03 in the national data (diff insign., $\chi^2_1 = 1.20$, $P = 0.27$); 0.57 outliers *cf.* 0.79 (no sign. diff, $\chi^2_1 = 2.46$, $P = 0.12$). The overall sett ratios did not differ statistically, nor did a breakdown by sett activity ($\chi^2_3 = 3.20$, $P = 0.36$; $\chi^2_7 = 8.89$, $P = 0.26$).

However, comparison of overall sett activity, showed that a higher percentage of setts were active in the licence areas (active squares) than in the national data (active squares): 85.7% *cf.* 79.8%. This difference was not significant ($\chi^2_1 = 2.38$, $P = 0.12$). As in the prior comparisons, the difference is accounted for mainly by subsidiary setts, with 88.0% active *cf.* 75.6% in the national data: this difference *remains* high ($\chi^2_1 = 3.15$, $P = 0.08$). No statistical differences existed between activity levels in the samples of the other sett categories.

In conclusion, whilst some small differences do exist between data sets obtained from active squares in the licence areas and active squares in the national sett surveys, given that the licence area sample was relatively small, there was a high degree of correspondence between these data sets. The estimation of badger numbers in Ireland through use of the National sett data, coupled with estimates of badger group size (based on a count of active main setts), has been supported by the data on mean sett size in licence areas.

Table 27. Summaries of sett types found in the National sett survey and in licence areas.

	Active				Disused			
	Main	**Annx.**	**Subs.**	**Outl.**	**Main**	**Annx.**	**Subs.**	**Outl.**
Sett survey: all squares								
number of setts	337	136	314	215	65	31	131	149
% of each sett type	24.5	9.9	22.8	15.6	4.7	2.2	9.5	10.8
Sett ratio per active main	*1.00*	0.40	0.93	0.64	0.19	0.09	0.39	0.44
Sett ratio (grouped regardless of activity)	*1.00*	0.50	1.32	1.08	0.19	**Total:**	**4.09**	
% active	*83.8*	*81.4*	*70.6*	*59.1*				
Licence areas								
number of setts	42	16	47	19	8	3	7	10
% of each sett type	27.6	10.5	30.9	12.5	5.3	2.0	4.6	6.6
Sett ratio per active main	*1.00*	0.38	1.12	0.45	0.19	0.07	0.17	0.24
Sett ratio (grouped regardless of activity)	*1.00*	0.45	1.29	0.69	0.19	**Total:**	**3.62**	
% active	*84.0*	*84.2*	*87.0*	*65.5*				
Sett survey: squares with at least 1 active main sett present (n=280)								
number of setts	337	132	263	171	28	21	85	94
% of each sett type	29.8	11.7	23.3	15.1	2.5	1.9	7.5	8.3
Sett ratio per active main	*1.00*	0.39	0.78	0.51	0.08	0.06	0.25	0.28
Sett ratio (grouped regardless of activity)	*1.00*	0.45	1.03	0.79	0.08	**Total:**	**3.35**	
% active	*92.3*	*86.3*	*75.6*	*64.5*				
Sett survey: squares with no active main setts (n=449)								
number of setts	0	4	51	44	37	10	46	55
% of each sett type	0.0	1.6	20.6	17.8	15.0	4.0	18.6	22.3
Sett ratio per active main								
Sett ratio (grouped regardless of activity)								
% active	*0.0*	*28.6*	*52.6*	*44.4*				
Licence areas: squares with at least 1 active main sett present (n=30)								
number of setts	42	16	44	18	5	3	6	6
% of each sett type	30.0	11.4	31.4	12.9	3.6	2.1	4.3	4.3
Sett ratio per active main	*1.00*	0.38	1.05	0.43	0.12	0.07	0.14	0.14
Sett ratio (grouped regardless of activity)	*1.00*	0.45	1.19	0.57	0.12	**Total:**	**3.33**	
% active	*89.4*	*84.2*	*88.0*	*75.0*				

Comparison of disturbance levels

The manner in which data for the large data sets of the National sett survey was logged did not allow calculation of disturbance levels for the data sub-set of 280 squares, without considerable expenditure of time. A comparison of disturbance levels is restricted to a comparison of the full licence area data with the full national sett survey data as before.

A total of 16.4% of setts were disturbed in licence areas as compared to 14.8% in the National survey (insign. diff.; $\chi^2_1 = 0.18$, $P = 0.68$). Disturbance to main setts was very similar in both the sett survey and the licence areas (20.4% *cf.* 22.0%), considerably higher in licence areas for annexes, marginally higher for outliers, and lower for subsidiary setts (Table 28). There were no statistically significant differences between disturbance levels within any sett type (high similarity was noted in the case of main setts and outliers) but significant differences were revealed in a breakdown by sett activity (Table 29).

Overall, disturbance levels were similar in licence areas and in the national data, but proportionately more active setts were disturbed in the licence areas than in the National sett survey. This difference was significant only for active annexe setts ($P<0.10$) and, for **all** *active* setts (excluding disused setts), more were disturbed in licence areas (16.9%) than in the National sett survey data (10.5%) [diff. sign.; $\chi^2_1 = 5.95$, $P = 0.02$].

Table 28. Summaries of disturbance levels to setts found in the National sett survey and in licence areas.

	Main	Annexe	Subsidiary	Outlier	Totals
Sett survey					
Disturbed	82	27	66	29	204
Undisturbed	320	140	379	335	1174
Total	402	167	445	364	1378
% disturbed	**20.4**	**16.2**	**14.8**	**8.0**	**14.8**
Licence areas					
Disturbed	11	5	6	3	25
Undisturbed	39	14	48	26	127
Total	50	19	51	30	152
% disturbed	**22.0**	**26.3**	**11.1**	**10.3**	**16.4**
Difference between disturbance levels					
χ^2_1	0.01	0.62	0.28	0.01	0.18
P	0.94	0.43	0.60	0.92	0.68

Table 29. Summaries of sett types found in the National sett survey and in licence areas, and differences in disturbance levels in active and disused setts.

	Active Main	Annx	Sub.	Outl.	Disused Main	Annx	Sub.	Outl.
Sett survey								
Disturbed	54	16	24	11	28	11	42	18
Undisturbed	283	120	290	204	37	20	89	131
% disturbed	**16.0**	**11.8**	**7.6**	**5.1**	**43.1**	**35.5**	**32.1**	**12.1**
Licence areas								
Disturbed	9	5	6	1	2	0	0	2
Undisturbed	33	11	41	18	6	3	7	8
% disturbed	**21.4**	**31.3**	**12.8**	**5.3**	**25.0**	**0.0**	**0.0**	**20.0**
Difference between disturbance levels								
χ^2_1	0.45	3.07	0.82	0.26	0.36	0.37	1.89	0.06
P	0.50	**0.08**	0.37	0.61	0.55	0.54	0.17	0.81

Although some differences exist between licence areas and national data in the disturbance levels, given the small sample sizes for disturbed setts, estimation of national badger numbers from separate calculations for disturbed setts and undisturbed setts in the national sett survey may be unreliable. As disturbance levels to main setts (where most badgers are captured) were very similar, it is appropriate to use the *overall* values obtained from the licence area studies for data on badger group size and mean numbers of badgers captured per sett type. Qualification of results may be applied to those individual counties and regions where disturbance levels varied substantially from the national mean.

Conclusions regarding use of badger estimates derived from licence areas

The analyses confirm that the sampling method employed for selection of the surveyed portions of licence areas resulted in a sample that differed from the National sett survey in terms of badger group density, proportions of sett types, activity of setts sampled, and disturbance levels.

Nevertheless, these differences were anticipated from an evaluation of the sampling methods. They result, primarily, from the selection of survey areas around active main setts rather than at random. There were fewer observations of minor setts, mainly of outlier setts, but also of subsidiary setts. Activity levels and disturbance levels were higher in the licence areas.

Further analysis of the data showed that there was a high degree of correspondence between the data obtained from active squares in the licence areas with active squares in the national surveys, though a greater proportion of subsidiaries were active. In the main, these two data sets were comparable: the differences remaining may result from the licence area sample being located in cattle grazing areas, so extrapolation to the national survey data must be tentative.

In a consideration of the use of the data for national estimates, the following matters are addressed:

1) the numbers of badgers present in a group have been estimated (by snaring). The methods employed have attempted to catch all badgers present in that group, with the large majority of badgers being captured at the main sett and its annexe. Badgers were also captured at subsidiary setts and outliers, in relatively small proportions. Captures at subsidiaries and outliers located outside the square and at a distance from the main sett might be expected to be substantially fewer - but mean group size may be slightly underestimated through non-inclusion of *some* of such outlying setts.

2) as inactive setts yield no badgers, the neglect of the unobserved setts, most of which would consist of inactive setts, would be of no consequence. In non-active squares, 59.9% of setts were disused.

3) in application of the overall mean for captures according to sett data to the national estimates, it is likely that the means obtained for active subsidiaries and active outliers here *will* lead to overestimation. This observation is based on the assumption that, at those subsidiaries and outliers that have been missed in the licence area surveys, the likelihood of badgers being captured is less than in the surveyed portions of the licence areas. As mentioned in items 1 and 2 above, these 'unobserved' setts will have possibly been missed in outlying parts of a group's territory and therefore less likely to yield any captures. Application of the data for numbers of badgers per sett type will, therefore, result in overestimation for these types of setts.

4) conversely, the slightly higher disturbance levels observed in licence areas would suggest that application of the means will tend to underestimate national badger estimates, in that, if fewer disturbed groups are present generally, the group size would be expected to be larger. In view of the small sample sizes available for disturbed groups, estimation of national means by use of separate figures for disturbed and undisturbed setts is unreliable, and, generally, the overall values (including both data sets) will be applied. Thus, a mean group size of 4.28 adults is generally more applicable rather than the value for undisturbed groups alone, of 4.52 adults.

5) as referred to earlier, the licence areas are, by definition, in cattle grazing areas, and in such areas, badger populations were slightly higher (1.40 groups *cf.* 1.30 groups km^{-2}) and group size may also be larger than in national surveys, the latter including a higher proportion of main setts in 'poor' habitats, such as mountainous areas and areas devoted mainly to sheep grazing. Resolution of this question requires a random sampling of badger setts and their populations.

To conclude, the data for active squares may be applied to the national data with reasonable confidence, but with the above qualifications. The correspondence between the data derived from licence areas and from the sett survey is high for active squares, but the analyses revealed some discrepancies between licence area data and data from national sett survey squares. Estimates for the remaining squares (*i.e.* squares without an active main sett) may lead to slight overestimation of badger numbers. Although these squares are numerous, they contain a small proportion of setts, so errors associated in application of the overall means are reduced correspondingly.

In summary, the data available cannot indicate whether, for the 'non-active' squares, there would be an expectation of fewer badgers per active subsidiary sett or outlier. It would appear that group estimates are more reliable, in an overall context, than captures per sett type.

Revision of group size data and number of badgers per sett type according to snaring success

The data for analysis of snaring success is inherently weak because of the different snaring intensities employed in each of the licence areas. An analysis is undertaken here because the only other data available for snaring success is that of O'Corry-Crowe (1992) [analysis of snaring results in his study area in East Co. Offaly], which may not apply to the data here.

Principally utilising Leslie's model for catch-effort analyses, O'Corry-Crowe determined that, in a population where 38 badgers were snared (over four sessions in two years), the total population present had been 51. The overall snare success rate was thus 74.5%, but the result was complicated by mortality, recruitment and possible movement into the area studied over a 15 month snaring period. In the first snaring period, O'Corry-Crowe *et al* (1993) estimate only a 51% trapping success. Hayden (1993) estimates that the snaring programme (of several sessions), coupled with natural mortality, removed 80 - 90% of the population from setts snared (but less overall, given that all setts may not have been located).

Methods

Krebs (1989) described two principal methodologies for dealing with catch-effort methods of population estimation. These are Leslie & Davis (1939) and Ricker (1975). Both rely on the population being closed, that the probability of each individual being captured remains a constant throughout the experiment, and that all individuals have the same probability of being caught. Variation in snaring techniques will affect some of these assumptions. If the catch per unit effort is plotted against accumulated catch, there should be a clear linear relationship between these parameters, indicative of a proportionately declining catch per unit effort. The same applies to Ricker's model, which plots the log of catch per unit effort against accumulated effort.

The day by day snaring success has been compiled for all the setts referred to specifically in the Appendices (re. above section # *Numbers of badgers captured according to sett type,* page 152). Some of these were additional to those used for group estimates and separate analyses are performed on those that were included for group estimates.

Inclusion of the areas in which repeat snaring took place results in inflation of catch-effort figures, as fewer badgers would be expected in repeat snaring. Data on snaring effort on a day by day basis was missing for several areas, or for badger groups and setts, so these have been excluded from the calculations. It is thus not possible to arrive at the same value of mean badger group size as estimated in an earlier section because the data set differs from that employed earlier. Instead, an estimate is obtained by catch-effort analysis for the number of badgers present at the setts/groups (for which data is available) and this is compared against the actual total number of captures for those setts: an estimate is thus obtained of the *overall* snaring success.

Initial plots using all the data revealed that the inclusion of the second snaring sessions and also any data for snaring days after the first 10 produced aberrant results: such data was from few of the licence areas, and most data was from areas in which snaring took place over a 10 day period; the data from the additional 6 days snaring was incompatible with the initial 10 days. Analyses were therefore confined to the values available for the first 10 days snaring. Only adults were included. Overall results on a daily basis are given in Table 30.

The total number of adult badgers captured within the setts (for which snaring data was adequate) was 167, with 7 of these being captured in a repeat snaring operation. The number of setts possessing snaring data was 115: thus, of the 152 setts considered for analyses previously, 37 submissions had no snaring intensity data. The day by day total captures for the first 16 days are plotted in Figure 68. The plot shows a decline in snaring success in succeeding days, though there is a rise over days 8, 9 and 10. The linear regression line fitted is of the form: $y = 24.0 - 1.6x$.

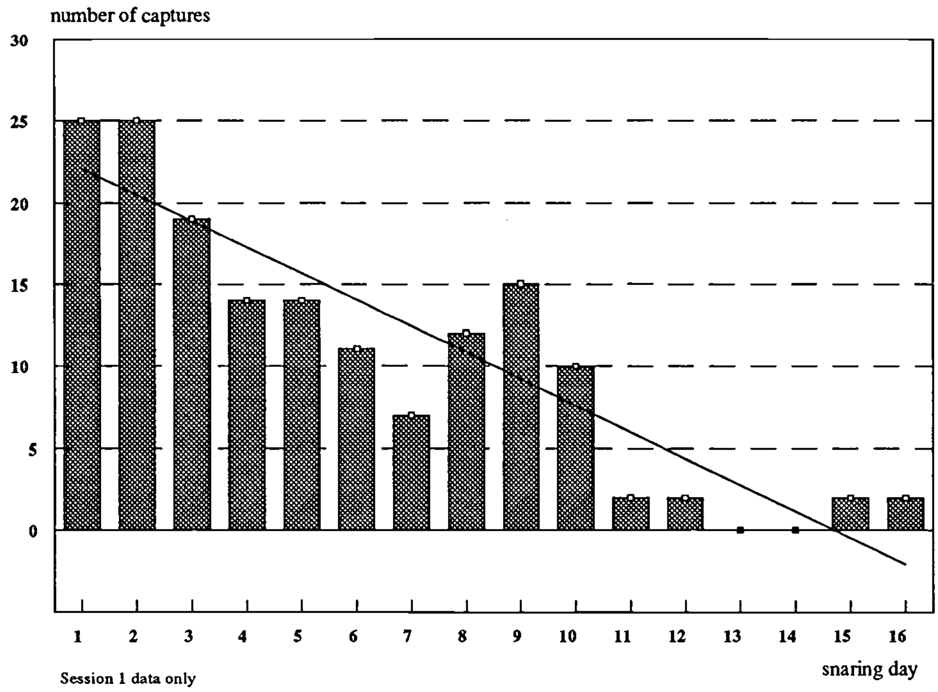


Figure 68. Plot of total number of captures against day of capture (adults only; repeat snaring operations not included).

Table 30. Snaring summaries, on a daily basis.

Day	Catch First snaring session	Catch Repeat snaring session	Effort First session	Effort Repeat session
1	25	1	1924	574
2	25	1	1930	574
3	19	1	1933	574
4	14	0	1932	574
5	14	1	1941	574
6	11	0	1940	574
7	7	0	1949	574
8	12	2	1949	574
9	15	0	1949	574
10	10	1	1895	573
11	2	0	243	573
12	2	0	243	20
13	0	0	142	0
14	0	0	92	0
15	2	0	92	0
16	2	0	92	0
Totals	**160**	**7**	**20246**	**6332**
Overall totals	**167**		**26578**	
Means			**1265.38**	**395.75**

Results

The mean snaring effort for the first 10 days was 1934.2 snare nights, but for the following 6 days, it was only 150.7 snare nights. This low snaring effort on days 11-16 yielded some captures resulting in the aberrant values observed for that period. Captures in the first 10 days are considered in further calculations, totalling 152 badgers not 160, the other 8 having been captured on the last 6 days.

Initial catch-effort analyses applied were those of Leslie & Davis (1939, after Krebs 1989). The plot of badgers captured per snare night against the cumulative catch is shown in Figure 69. The fitted regression line, with 95% confidence limits for the mean y values and for actual y values, is shown in Figure 70. The effect of excluding the aberrant data may be compared with similar plots which includes the data for the 11-16 day period - Figures 71 and 72. Figure 69 shows that there still remains marked variation in catch success, with deviations from the regression line particularly noticeable for captures on days 8 to 10. This indicates that application of the data for catch-effort analyses will still yield unreliable results, even though the regression of y against x was significant ($t = 4.24$, $P = 0.003$).

The regression is of the form $y = a + bx$, where the slope b is an estimate of the catchability of the badgers:

$$y = 1.4136\text{x}10^{-2} - 6.4804\text{x}10^{-5}x$$

[s.e. of constant: $1.5909\text{x}10^{-3}$; s.e. of coefficient: $1.5275\text{x}10^{-5}$]

- the equation may be used to estimate the population by extrapolation along the x axis to where $y = 0$. The estimate thus derived is 218.1 badgers, as opposed to 152 caught over this period, and 167 caught in all. These results suggest that 76.5% of the population was snared. Incidentally, incorporation of the data for days 11-16 yields a population estimate, derived in exactly the same way (Figures 71 and 72) of 722.2 badgers. One may judge from this and from Figure 69, that the extra weight given by the occurrence of more than expected captures in the 8-10 day period is likely to lead to overestimation of the badger population, at least in comparison to estimates that would be obtained from using the first 7 days results only.

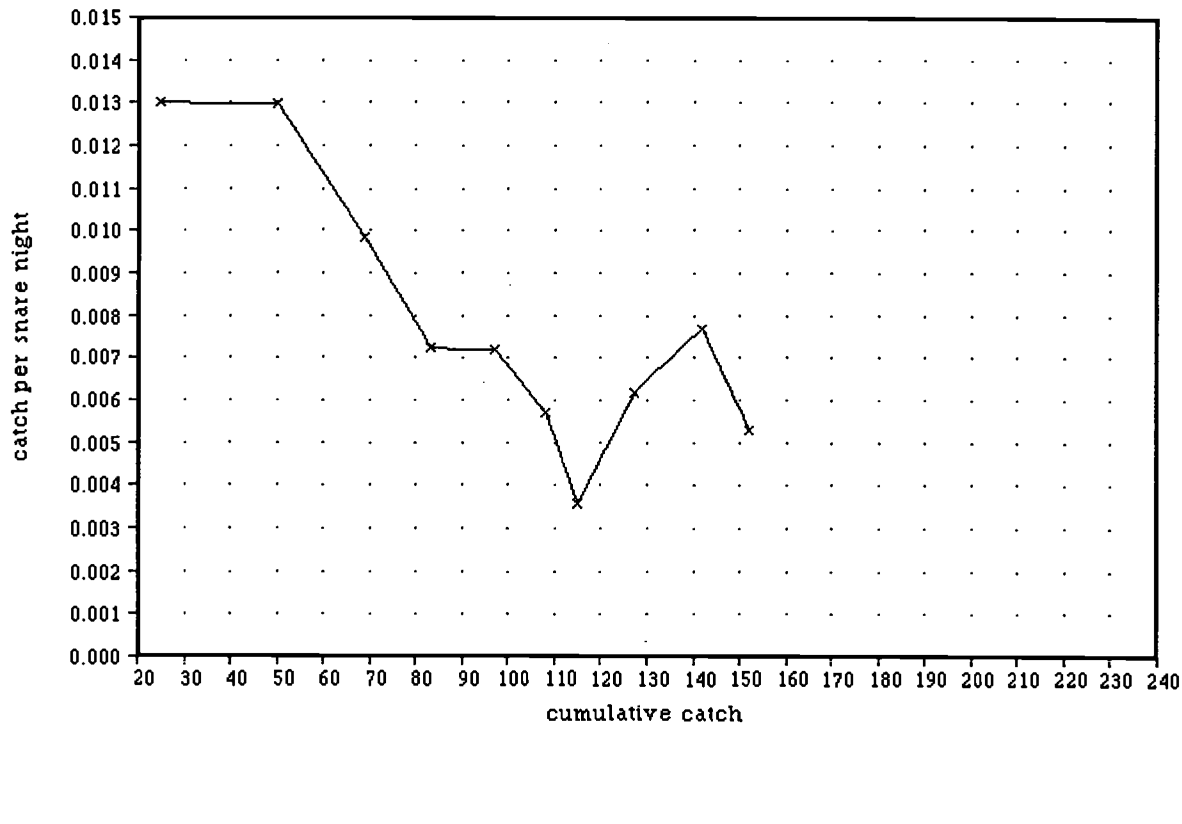


Figure 69. Leslie line plot of catch-effort data, utilising data from first snaring sessions only for the first 10 days only.

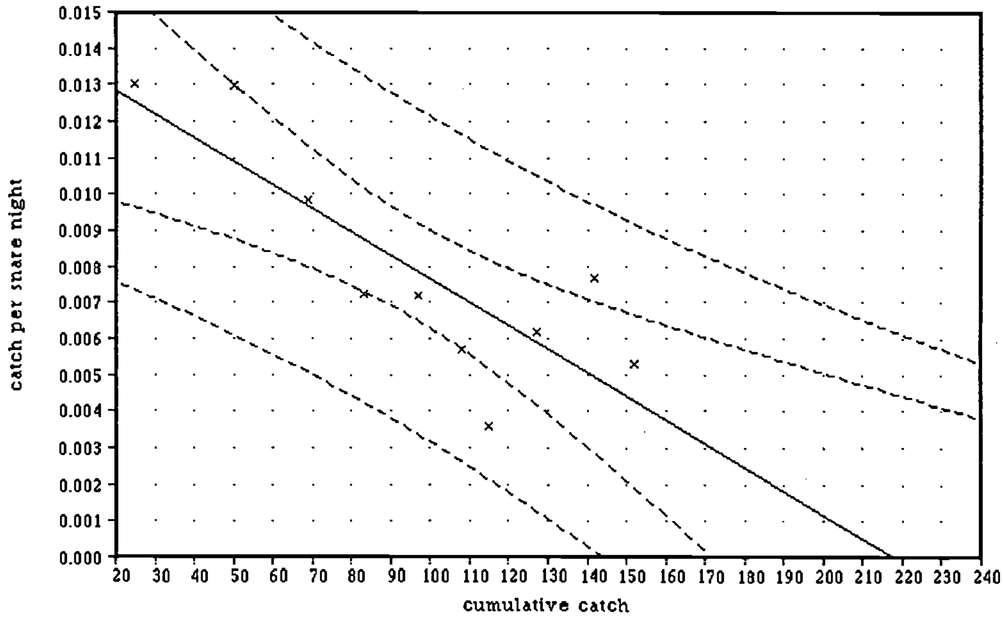


Figure 70. Leslie plot of catch-effort data, as in Figure 69, with trend and 95% confidence limits for mean values of y *and actual* y *values.*

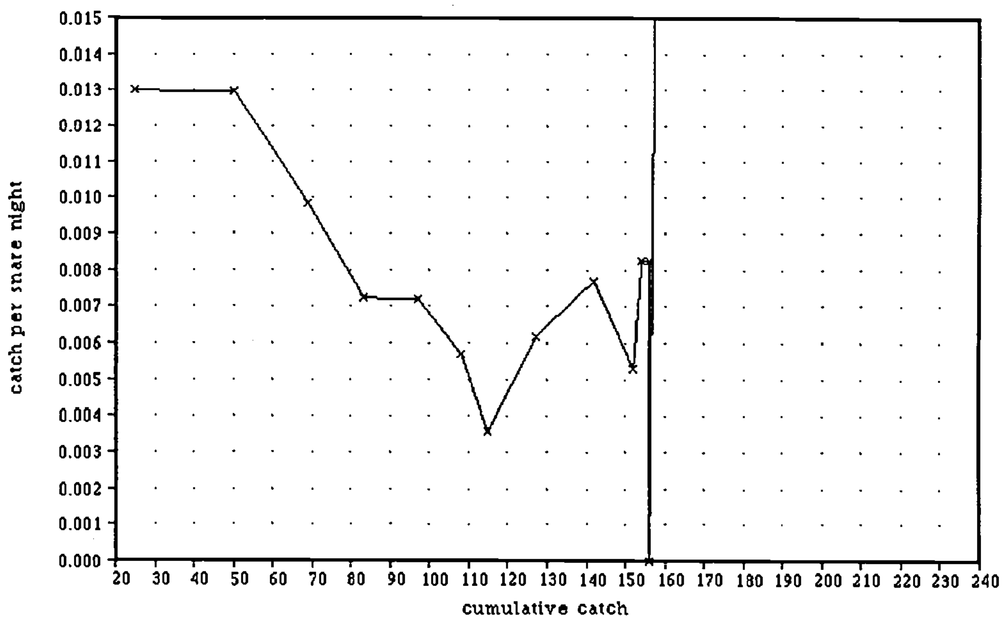


Figure 71. Leslie plot of catch-effort, as in Figure 70, but utilising the data from all 16 days (first snaring session only).

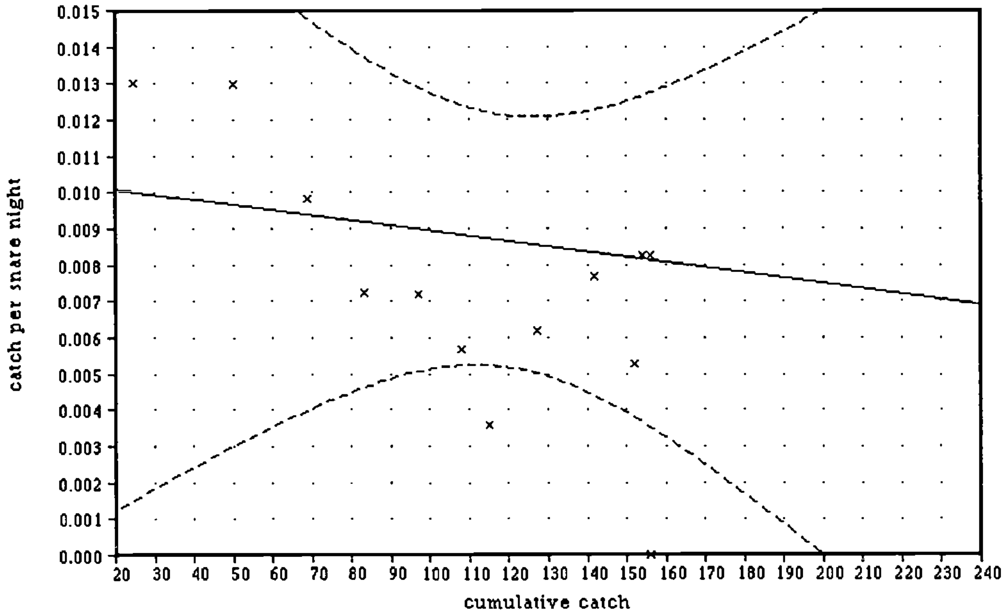


Figure 72. Leslie plot of catch effort, as in Figure 71, utilising data from all 16 days snaring (first snaring session only).

It is not at all clear why badgers' catchability was not equal over the snaring period. Some of the results were examined by differentiating areas where high snaring effort was utilised as against low snaring effort, but this revealed that the rise in catchability over the 8-10 day period occurred regardless of snaring intensity. Details are given below.

Ricker (1975, after Krebs, 1989) applied a semi-logarithmic model to catch-effort analyses. As the methods of Leslie and Ricker differ, it is worthwhile to plot both, in order to gauge whether the underlying assumptions are violated - as suggested above. In these plots, only the 10 day snaring period is used, and a plot is obtained of the log of catch per unit effort against accumulated effort. These are shown in Figures 73 and 74, in the same manner as for the Leslie plots. In this case, an extrapolation does not apply, and population estimates are derived separately. The linear regression takes the form

$$y = -1.8984 - 2.2302 \times 10^{-5} x$$

[s.e. of constant = 0.0835; s.e. of coefficient = 6.9549×10^{-6}; sign. $b = 0.013$, $t = 3.21$, d.f. = 8].

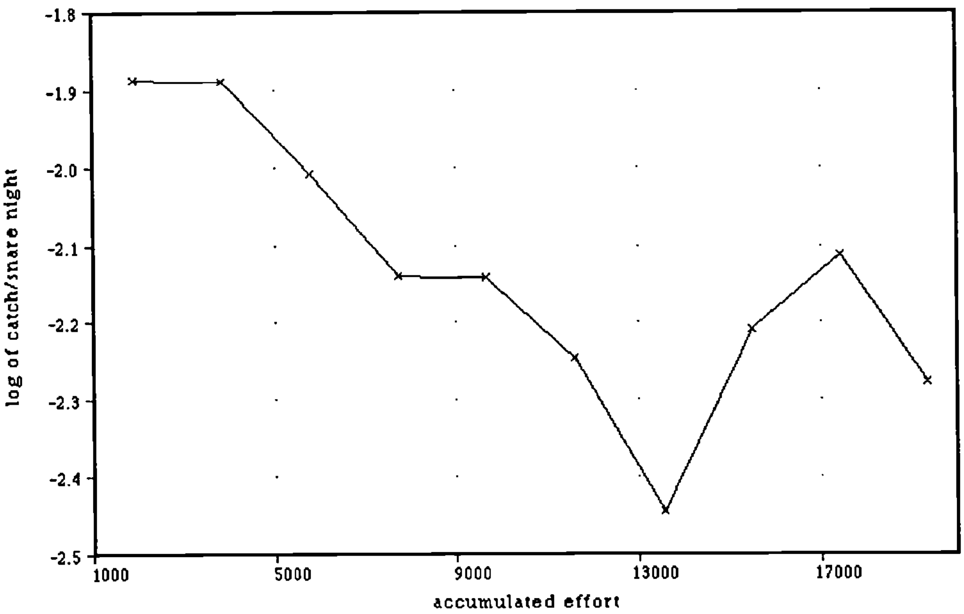


Figure 73. Ricker line plot of the catch-effort data, utilising only the data for the first 10 snaring days and from the first snaring session only.

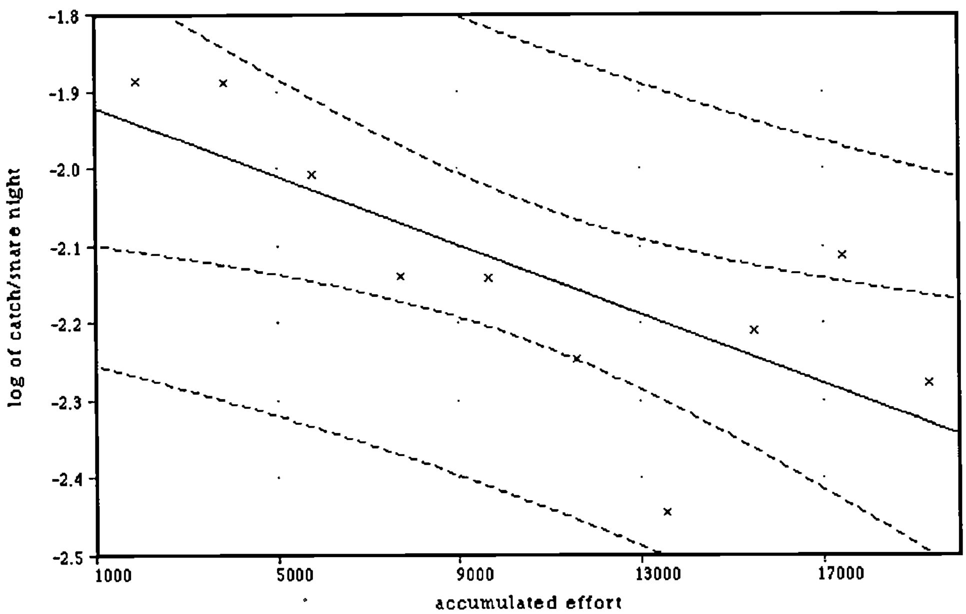


Figure 74. Ricker plot of the catch-effort data, as for Figure 73, including 95% confidence limits for mean y *values and for actual* y *values.*

Whilst there is evidence of variation in catchability, the models were utilised for population estimates, using the FORTRAN programs given by Krebs (1989). The estimates differ slightly from those obtained above.

The estimate obtained by the Leslie method was 212.35, with 95% confidence limits of 158.4 to 266.3.

The estimate obtained from the Ricker method was 222.9, with 95% confidence limits of 204.3 to 241.5, which are much tighter than those derived from the Leslie method.

Given the snared population of 167, overall, it may be estimated that the snaring success for these setts was **78.6%** and **74.9%**, derived from Leslie and Ricker analyses respectively (averaged **76.8%**).

Snare success may be used for correction of population estimates which are derived using the *Numbers of badgers captured per sett type* data, but it is based on the entire data set irrespective of snaring intensity. It is likely that, where snaring intensity was low, the captures were not comparable to those areas in which snaring intensity was high.

Catch-effort analyses for badger groups

From an identification of the setts that 'belonged' to each group (as carried out earlier), the above types of analyses have also been conducted on badger groups. These have been differentiated by those groups in which the total number of snare nights per group was greater than 400 snare nights over the snaring period, and those that had less than this (this is a little more lenient than the 500 snare nights per group suggested by O'Corry-Crowe and Hayden [pers. comm.]).

There were snaring data available for 36 of the 40 groups examined earlier (Table 23). Of these, only 19 had been snared at a high intensity, and 17 at a low intensity. Summary snaring intensity data are given in Table 31: over 16 days, the high intensity groups averaged 45.7 snares per night, but the low intensity groups averaged only 11.0 snares per night. For the first 10 snaring days, high snaring groups averaged 69.0 snares per night and low snaring groups 17.0 only. Snare-night totals (first snaring session only) for each group, identified by location, are given in Appendix A17.

[A number of groups were re-snared, but these repeat snaring sessions are not included in the summaries, and, where the snaring intensity was low on the first snaring session, these badger groups have not been included in high snare groups but in low snare groups, even though snaring effort was adequate in total; this is because the analyses have been restricted to the first 10 days of snaring, as above].

Table 31. Snaring intensities for badger groups, with results of captures per day of snaring session.

Day	Groups > total 400 snare nights				Groups < total 400 snare nights			
	Captures session 1	Captures session 2	Total snare nights session 1	Total snare nights session 2	Captures session 1	Captures session 2	Total snare nights session 1	Total snare nights session 2
1	11	0	1299	21	11	1	290	501
2	14	1	1299	21	11	0	296	501
3	11	0	1304	21	7	1	294	501
4	9	0	1303	21	3	0	294	501
5	8	1	1312	21	5	0	294	501
6	6	0	1311	21	5	0	294	501
7	4	0	1320	21	3	0	294	501
8	3	1	1320	21	9	1	294	501
9	8	0	1320	21	6	0	294	501
10	7	1	1320	20	2	0	240	501
11	1	0	223	20	1	0	20	501
12	2	0	223	20	0	0	20	0
13	0	0	122	0	0	0	20	0
14	0	0	72	0	0	0	20	0
15	1	0	72	0	1	0	20	0
16	1	0	72	0	1	0	20	0
Totals	**86**	**4**			**65**	**3**		
Mean			**868.2**	**15.6**			**187.7**	**344.4**
10 days			**1310.8**				**288.4**	

The plots confirm the aberrant nature of results for the period 8-10 days for high and low snaring groups, but also that the data is weaker for low intensity groups, with much more variation away from the regression line. The Leslie plots for high and low snaring groups are shown in Figures 75 and 76 (line plots) and in Figures 77 and 78 (trend plots).

The regressions were as follows:

High snaring groups, Leslie plot: $y = 1.0711\text{x}10^{-2} - 8.8082\text{x}10^{-5}x$ [t = 3.22, P = 0.01]

Low snaring groups, Leslie plot: $y = 3.6149\text{x}10^{-2} - 3.7769\text{x}10^{-4}x$ [t = 1.97, P = 0.08].

The Leslie plots for all groups (this data differs slightly from that given for all setts earlier, due to exclusion of some data) are shown in Figures 79 and 80.

The regression was:

All badger groups, Leslie plot: $y = 1.5694\text{x}10^{-2} - 7.4402\text{x}10^{-5}x$ [t= 3.77, P = 0.05].

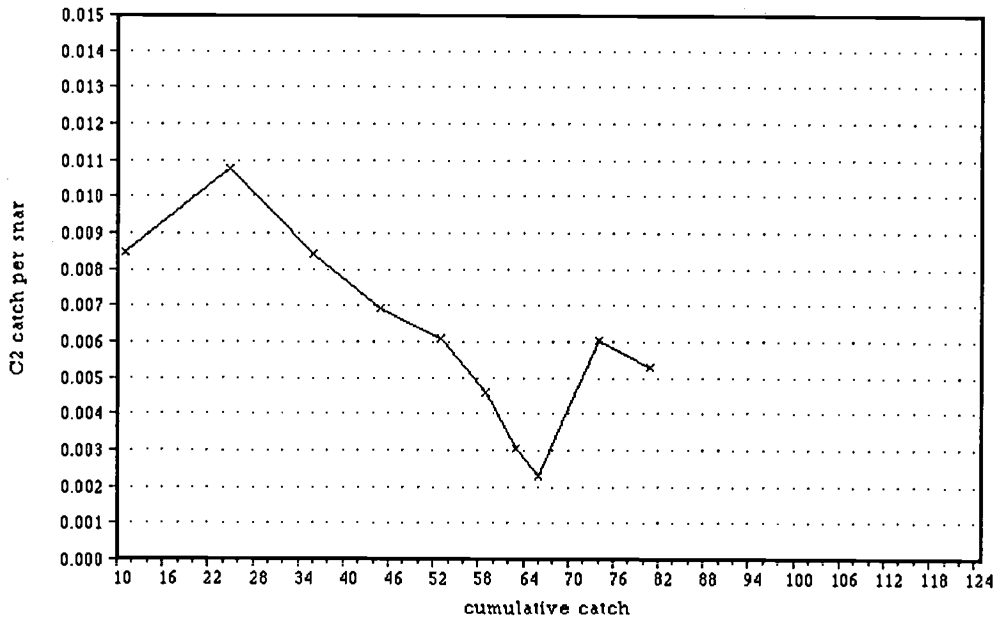


Figure 75. Leslie plot of data for groups where snaring intensity was high. Data is included for the first 10 days only, with only first snaring sessions included.

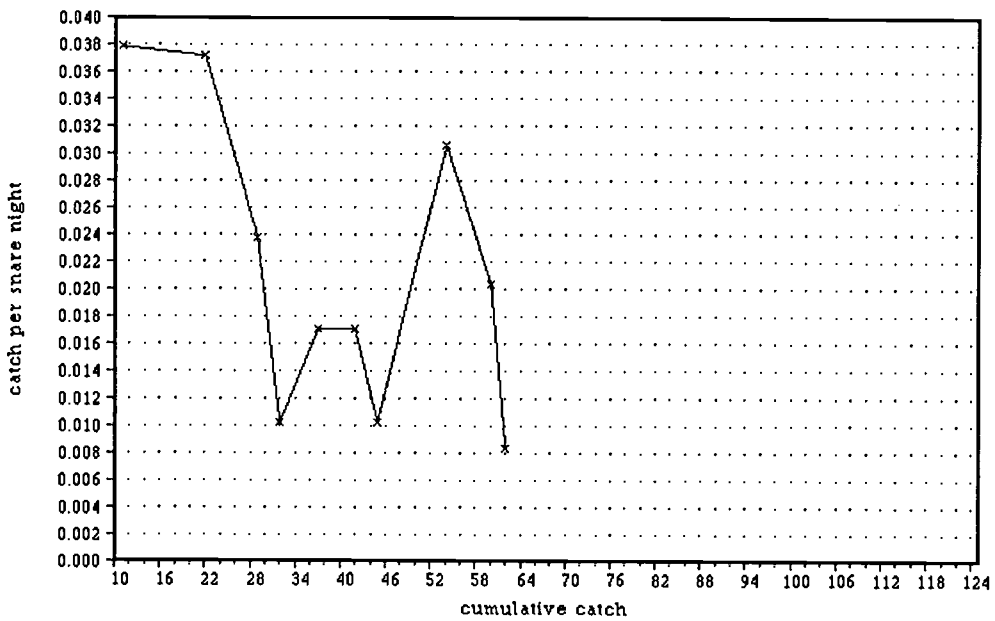


Figure 76. Leslie plot of data for groups where snaring intensity was low. Data is included for the first 10 days only, with only first snaring sessions included.

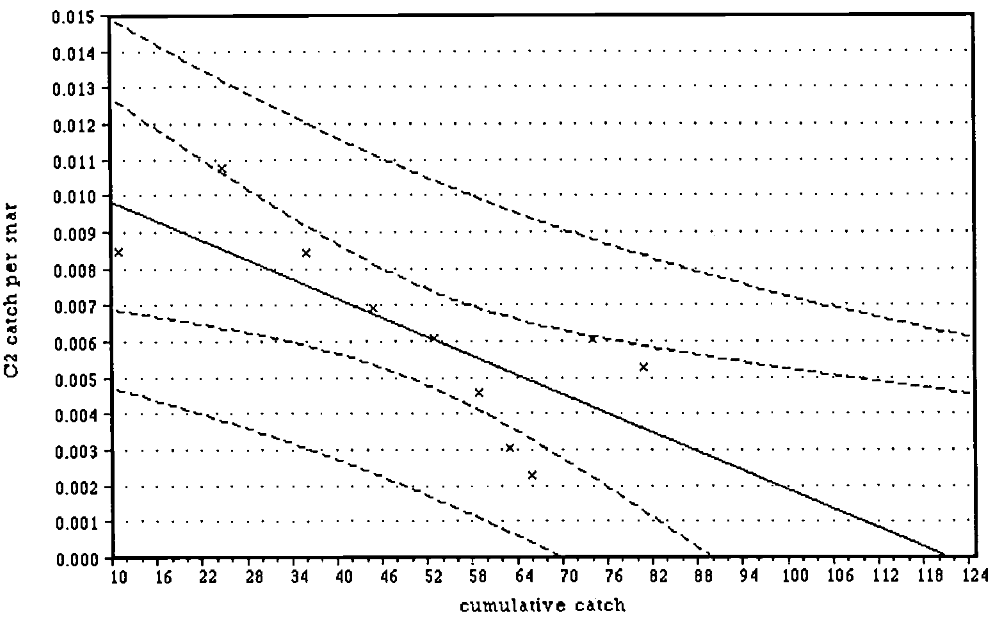


Figure 77. Leslie plot of data for groups where snaring intensity was high: as in Figure 75, with trend and 95% confidence limits.

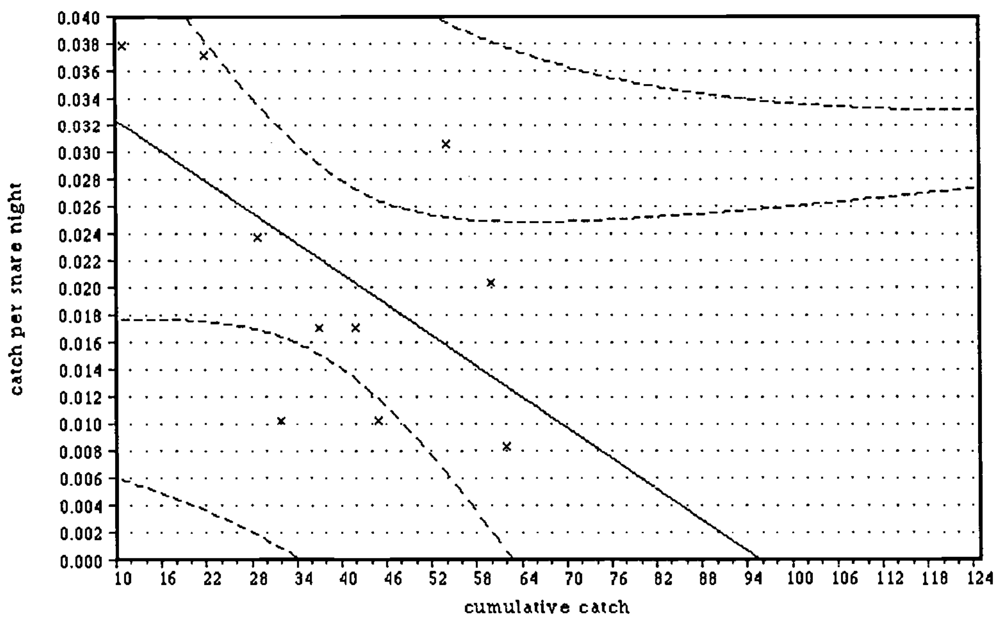


Figure 78. Leslie plot of data for groups where snaring intensity was low: as in Figure 76, with trend and 95% confidence limits.

Figure 79. Leslie plot of data for all badger groups. Data is included for the first 10 days only, with only first snaring sessions included.

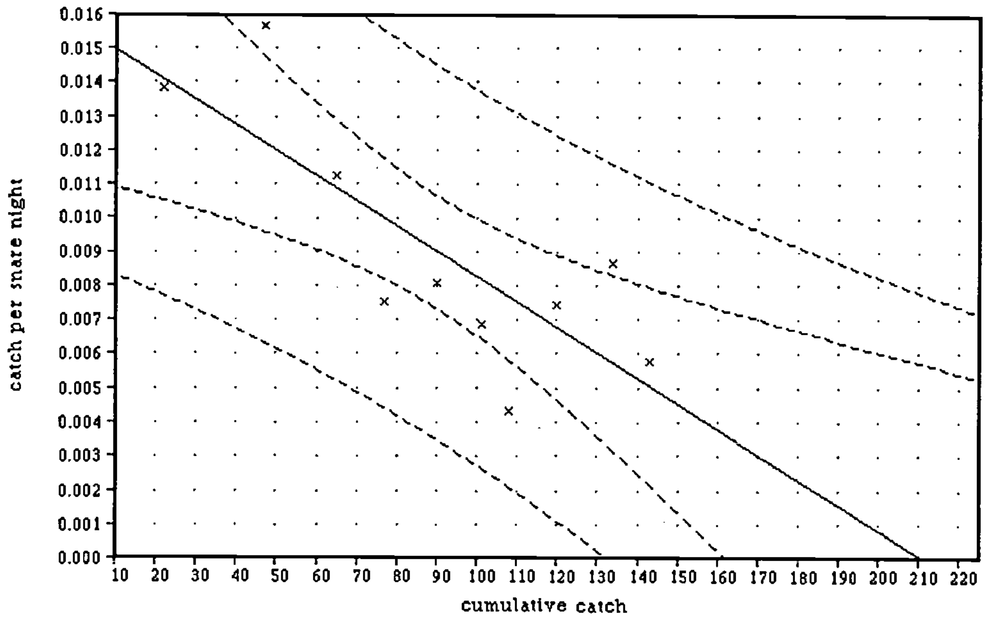


Figure 80. Leslie plot of data for all badger groups, with trend and 95% confidence limits.

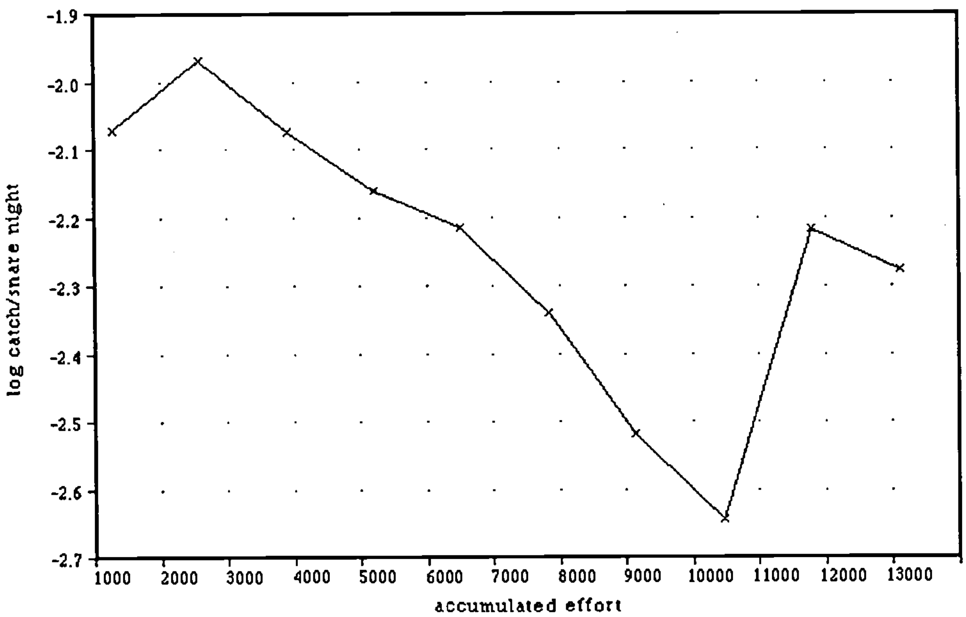


Figure 81. Ricker plot of data for groups where snaring intensity was high. Data is included for the first 10 days only, with only first snaring sessions included.

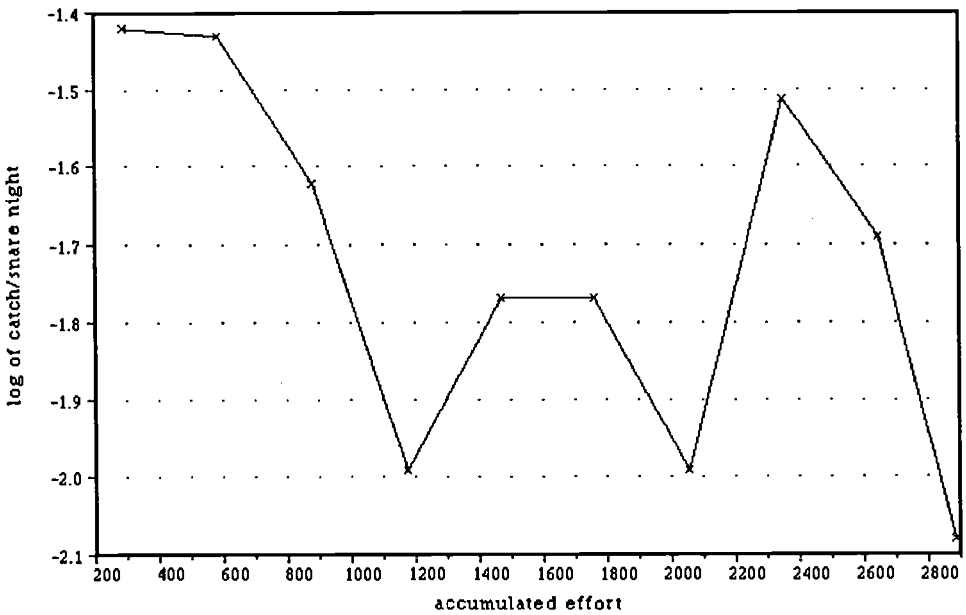


Figure 82. Ricker plot for groups where snaring intensity was low. Data is included for the first 10 days only, with only first snaring sessions included. Scales differ from Figure 81.

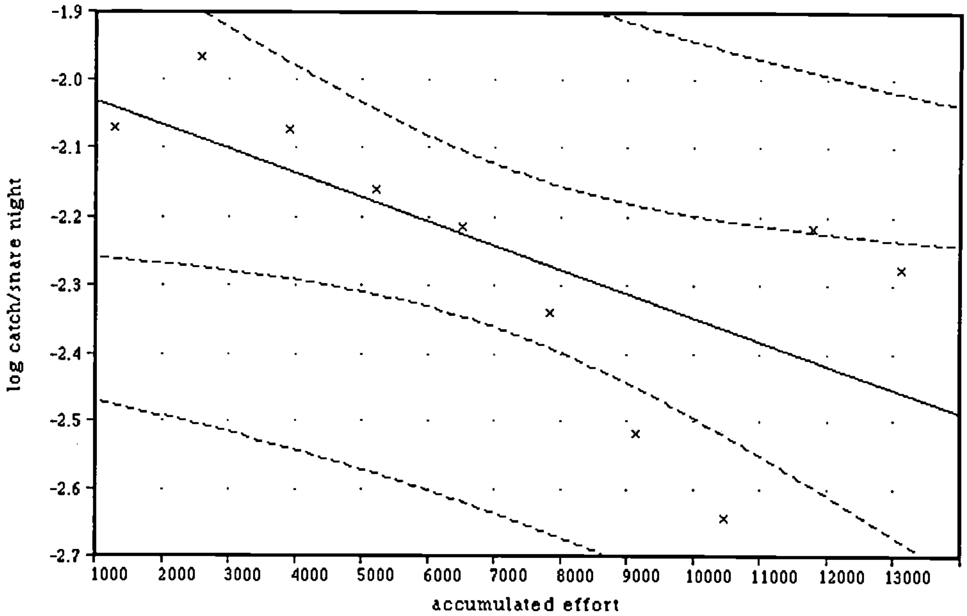


Figure 83. Ricker plot of data for groups where snaring intensity was high, as in Figure 81, with trend and 95% confidence limits. Data is included for the first 10 days only, with only first snaring sessions included.

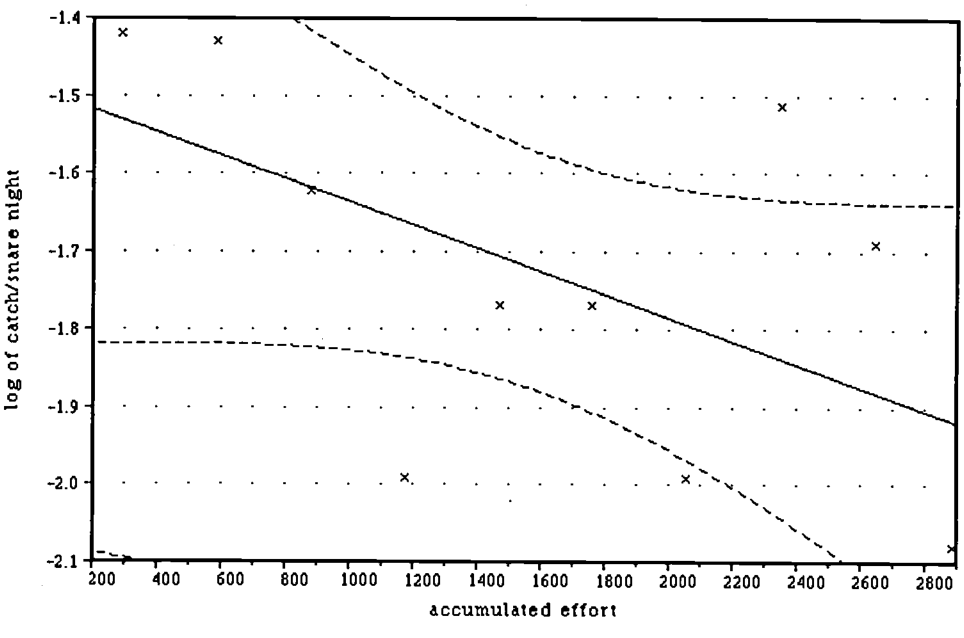


Figure 84. Ricker plot of data for groups where snaring intensity was low, as in Figure 82, with trend and 95% confidence limits. Data is included for the first 10 days only, with only first snaring sessions included. Scales differ from Figure 83.

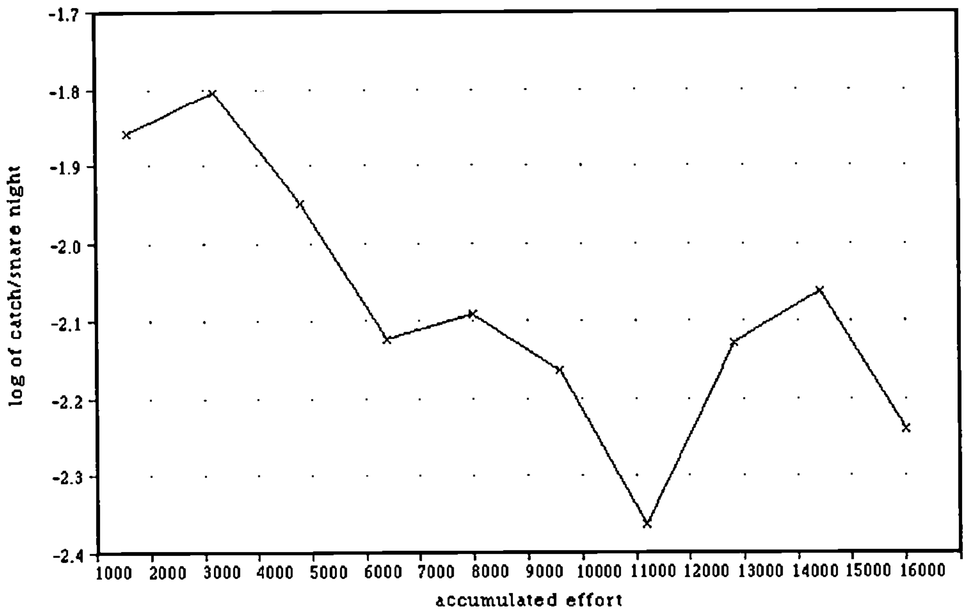


Figure 85. Ricker plot of data for all badger groups. Data is included for the first 10 days only, with only first snaring sessions included.

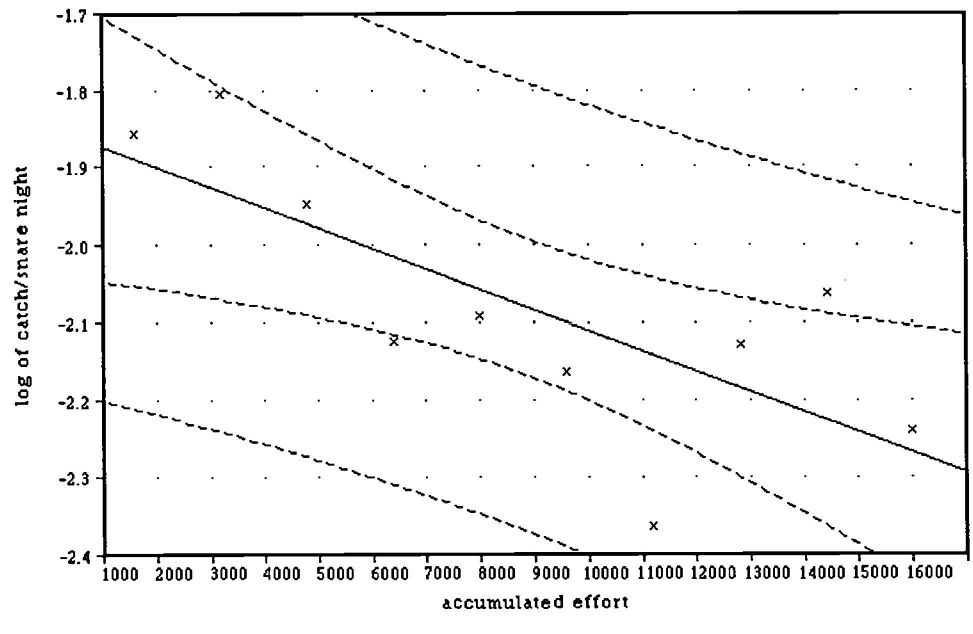


Figure 86. Ricker plot of data for all badger groups, as in Figure 85, with trend and 95% confidence limits. Data is included for the first 10 days only, with only first snaring sessions included.

The equivalent plots based on the Ricker method are shown in Figures 80 to 86. The regressions were as follows:

Badger groups in high snaring areas: $y = -1.9957 - 3.5164\times10^{-5}x$ [t = 2.57, P = 0.03]

Badger groups in low snaring areas: $y = -1.4886 - 1.4866\times10^{-4}x$ [t = 1.87, P = 0.10]

All badger groups: $y = -1.8489 - 2.6088\times10^{-5}x$ [t = 3.17, P = 0.01]

For the groups in low snaring areas, the regression is barely significant at the 10% level, indicating that the relationship between captures and snaring effort is weaker.

Results - badger groups

For the 19 groups where snaring was high, 90 badgers were actually captured in total, the mean group size being 4.74 adults (±0.80, s.e. 0.41); this is compared with a total of 68 badgers captured in the low snaring areas, the mean group size being 4.00 (±0.90, s.e. 0.46). The difference is not significant (t = 1.18, P = 0.25). The overall mean for the 36 groups was 4.39 adults (±0.61, s.e. 0.31), with 158 adults snared.

The mean group size differs a little from the previously derived one of 4.28 adults, as some of the data had to be excluded from present calculations. The difference in group size between the high and low snaring areas indicates that low intensity snaring results in an average of 0.74 fewer badgers being captured per group (15.6%).

Populations estimates were calculated using the programs given by Krebs (1989), as above, for a) all badger groups, b) groups in areas with high snaring intensity, and c) groups in areas with low snaring intensity. The population estimates are given in Table 32, which also includes the previous estimates and estimates for group size. The latter have been calculated by simple division of the group size (as revealed by snaring) by the snare success rate.

The values obtained from the low snaring areas are clearly unreliable and the estimated mean for group size in these areas differs little from the group size derived by snaring alone (5.1 *cf.* 4.7), which is improbable, given the overall results and previous work (*e.g.* O'Corry-Crowe, 1992). Figures 71 and 82 demonstrated that there was a very poor (almost absent) linear relationship between captures and catch-effort.

The values of mean group size of 5.90 adults, given by the use of the Ricker method for groups snared with a minimum of 400 snare nights, and 6.12 adults given by the Leslie method, are the most reliable of the estimates. O'Corry-Crowe arrived at a figure of 5.8 adults per social group and Cresswell *et al* (1990) utilised a figure of 5.9 adults per group, which was obtained from 11 field studies in the UK, totalling 73 badger groups. There is, then, much similarity between these sets of observations and the estimates obtained here.

The overall snaring success, using Ricker's data, is 80.3% with a high snare density. If the (reasonable) assumption is made that the *real* mean group size in low snaring areas was also *c.* 5.90, then the snaring success in these areas may be estimated at 67.8%.

Table 32. Summaries of population estimates N_e, actual badgers snared C, estimated group size, group size as revealed by snaring, and estimated snaring success rates (%).

	N_e	Lower conf.	Upper conf.	C	Group size^{N_e}	Group size^{C}	Snaring success %
All setts							
Leslie	212.4	158.4	266.3	167			78.6
Ricker	222.9	204.3	241.5	167			74.9
All groups							
Leslie	204.1	145.3	262.9	158	5.67	4.39	77.4
Ricker	214.2	196.0	232.4	158	5.95	4.39	73.8
High snaring groups							
Leslie	116.3	77.4	155.1	90	6.12	4.74	77.4
Ricker	112.1	102.0	122.2	90	5.90	4.74	80.3
Low-snaring groups							
Leslie	86.3	44.9	127.7	68	5.08	4.00	78.8
Ricker	86.0	76.4	95.6	68	5.06	4.00	79.1

In applying these studies to estimate badger numbers nationally, a mean group size of 5.9 will be adopted, being the average number of *adult* badgers found at an active main sett. The data set is too small to consider any geographical variation in mean group size.

The *Number of badgers by sett type* data can also be used for badger population estimates. In this case, an estimate is obtained by multiplication of the mean number of badgers captured at each sett type, and, from the above data, ***a figure of 74.9% snare success will apply overall (based on Ricker analysis for all setts).*** Of the choice between the estimates given by Ricker and Leslie, the Ricker value is used for consistency with the use of Ricker's estimate for badger group size. Additionally, it is possible to estimate average snare success from the values for high snare groups and low snare groups. The number of sample groups was almost equal (19 *cf.* 17); actual snaring success for low snare areas was *c.* 67.8% (as calculated above), the snare success for high snare areas was 80.3%, thus the weighted average snare success rate is *c.* 74.4%, rather than the higher value of 78.6% derived from the Leslie estimates. As the data to be used for estimating badgers at each sett type differs from the group estimate, this is only a guide, which indicated the choice of the Ricker model in this instance.

The studies and analyses have been performed to obtain a means of estimating badger numbers in Ireland or in counties or regions, and with the data that is available, values have been obtained for mean group size and numbers per sett. The confidence limits for group size are wide: mean 5.90 adults, 95% lower value 5.37, 95% upper value 6.44 adults; these values were calculated using only 19 social groups. There remain weaknesses in the data used to derive these and previous estimates: a larger set of observations would be desirable.

TB STATUS OF SNARED BADGERS, AND OTHER OBSERVATIONS

Methods

All snaring and physical measurement of badgers was undertaken by DVO staff, who were requested to fill in the supplied data sheets for each badger captured. Details requested, in addition to sett location, *etc.*, were tag number, sex, age, weight, body length, tail length, colour, notes on condition and TB status. The latter item was entered onto data sheets by DVO staff after post-mortem investigation at the Department of Agriculture's Veterinary laboratories. In the main, TB status was determined from gross visible lesions, and on occasion this was confirmed by additional histopathological examination or culture of tissue samples.

To maximise the information from all of the licence areas, every badger recorded as being captured, and for which any data were available, within *all* of the 72 licence areas was entered onto a database with a record of whether the badger had been included in any of the above studies appended. Badgers which had not been snared within the 1km square areas but within the greater 2 km radius zone of the licence were therefore also included (submissions were not always made for badgers captured outside the 1km^2 survey area, so the results do *not* constitute total captures for the 2 km radius zones of the 72 licence areas). Details of every badger captured are included in Appendices A18 and A19.

Data for each badger was entered onto a database only *after* completion of all the analyses undertaken above, and the TB status of individuals had not been given any consideration previously. This point is of some relevance because the results revealed an overall difference between the frequency of occurrence of TB in badgers present in the identified badger social groups and that of badgers in areas that had been excluded from calculations for groups. There was a higher frequency in areas excluded.

The decision whether an area was included or excluded from the analyses performed earlier was made according to the quality of the snaring data and/or sett information and whether this data was adequate either for estimation of group size or for the observations of badger numbers per sett type (see # *General account*, page 134, details in Appendix A14). Nevertheless, the differences in TB prevalence prompted not only a re-examination of why each of the areas had been excluded in prior analyses [which suggested no reconsideration] but also that the badger TB data be examined in far more detail than had been anticipated. Therefore, high snaring and low snaring groups were also compared, and badgers that were included in *Numbers per sett type* calculations. These analyses pertain chiefly to TB status and sex ratios, as variation in physical variables of badgers did not reveal any other differences of note - physical data is summarised briefly for all the badger data submitted.

Results

In total, data for 262 badgers were entered onto the database, from 42 licence areas, with no badgers being captured or no details being available in the other 30 areas. Data is incomplete for many of these badgers, with some badgers having no sex data recorded, or no physical measurements. Of the 262 badgers, there were 235 adults and 9 cubs, the remainder having no age or weight statistics. The overall sex ratio was 129 adult females to 102 adult males - 1 male : 1.26 females.

The mean weight of an adult male badger was 8.85 kg (± 0.30, s.e. = 0.16) and that of an adult female was 7.85 kg (± 0.25, s.e. = 0.13).

Male badgers with TB were lighter in weight than clear males, and the reverse held for females - samples were small, so there were found to be no significant differences between diseased and clear individuals. For males, TB+ve, mean weight was 8.43 kg (n = 10, s.e. 0.58), and for males, TB-ve, mean weight was 8.91 kg (n = 71, s.e. 0.16) [diff. insign., P = 0.44]. For females, TB+ve, mean weight was 8.18 kg (n = 8, s.e. = 0.54), and for females, TB-ve, mean weight was 7.84 (n = 106, s.e. 0.13) [diff. insign., P = 0.50].

The mean body length of an adult male badger was 69.3 cm (± 1.72, s.e. = 0.88) and that of a female 71.5 cm (± 1.49, s.e. = 0.76). The mean tail length of an adult male badger was 14.9 cm (± 0.71, s.e. = 0.36) and that of a female 14.2 cm (± 0.53, s.e. = 0.27). Tail length varied substantially and it is not clear whether some of the data had been measured incorrectly (Appendix A19).

Initial observations

The number of badgers (including cubs) confirmed with TB was only 21, with 240 negative, the individuals with lesions thus constituting 8.1% of all badgers examined. TB data for one badger awaits laboratory confirmation. The 9 cubs are included in all summaries, shown in Table 33. There are several initial observations to be made from the data presented in Table 33.

Firstly, although mean TB prevalence in badgers was 8.1%, the prevalence for badgers in the data sets used earlier (*i.e.* badger groups, and badgers included in *Numbers per sett type analyses*) was lower - at *c.* 6%, with the 'excluded' data indicating a contrasting level of 14.5%.

Secondly, TB rates were higher in males than in females, for all data sets above, except for high snaring groups. The difference was evident for all data (with 10.6% of males infected as opposed to 5.9% of females) and for 'excluded' data (with 18.2% of males infected as compared with 13.9% of females).

Thirdly, the sex ratios clearly reveal that wherever a low snaring effort was employed, snaring resulted in a disproportionate sex ratio indicating that females were much more likely to be snared than males. The sex ratios observed were *c.* 1 male to 1.6 - 1.7 females. Within the high snaring groups, sex ratio was close to parity. The similarity between the sex ratio for the low snaring groups and that for the 'excluded' data shows that there was probably much similarity in the snaring intensities employed, if this was the sôle reason for the difference arising, as would appear to have been the case.

Table 33. Prevalence of TB in badgers, assessed from different sets of data. Sex ratios observed are also included.

	Totals	**Males**	**Females**	**Sex ratio** *Females/males*
All data				
TB+ve	21	11	8	*0.73*
TB-ve	240	93	127	*1.36*
Totals	45	104	135	*1.30*
% TB positive	**8.1**	**10.6**	**5.9**	
all badgers in *Numbers per sett type*				
TB+ve	10	7	3	*0.43*
TB-ve	175	75	96	*1.28*
Totals	185	82	99	*1.21*
% TB positive	**5.4**	**8.5**	**3.0**	
all social groups				
TB+ve	10	7	3	*0.43*
TB-ve	165	73	88	*1.21*
Totals	175	80	91	*1.14*
% TB positive	**5.7**	**8.8**	**3.3**	
all high snaring groups				
TB+ve	6	3	3	*1.00*
TB-ve	86	45	41	*0.91*
Totals	92	48	44	*0.92*
% TB positive	**6.5**	**6.3**	**6.8**	
all low snaring groups				
TB+ve	4	4	0	*0.00*
TB-ve	66	21	42	*2.00*
Totals	70	25	42	*1.68*
% TB positive	**5.7**	**16.0**	**0.0**	
all excluded data				
TB+ve	11	4	5	*1.25*
TB-ve	65	18	31	*1.72*
Totals	76	22	36	*1.64*
% TB positive	**14.5**	**18.2**	**13.9**	

Fourthly, sex ratios observed amongst diseased animals differ from those of clear animals, with more males infected than females. The exception to this, again, is the data for the high snaring groups.

It is reasonable to suggest, from the previous catch-effort analyses on the badger groups, that high snaring effort samples badger populations more uniformly than does a low snaring procedure. Thus, the *real* sex ratio of badgers in Ireland (as assessed from the 19 social groups) is close to parity but low intensity snaring efforts have resulted in an unbalanced sex ratio.

On the basis that high intensity snaring samples the populations uniformly, the data on TB observed in the high snaring groups should be regarded as approximating to the *true* TB situation for badgers in Ireland. Thus, in the high snaring groups, it is observed that the prevalence of TB in males and females is virtually identical - in contrast to the remaining data (*though sample sizes are far too small to place substantial confidence in these results*).

The number of badgers with TB in the data here is very small; nevertheless, the observed differences are potentially of substantial importance, and require some consideration. The overall sample of 261 badgers, and the 40 badger groups may be considered to be a representative sample from which to suggest possibilities for recommendations and for further research.

Various means of testing the hypotheses are considered below, following a detailed evaluation of some of the above statements.

General

The figure of 8.1% is substantially below the mean value reported by Dolan & Lynch (1992) of 17.0% for the country (n = 3,909, n^{TB+ve} = 664). The difference between these means is highly significant (χ^2_1 = 13.60, P = 0.0002). Figures made available by the Department of Agriculture, Food & Forestry for badger post-mortems (for 1991, 1992, and 1993 [to August 1993]) are much closer to those obtained here - 10.3% of badgers snared were recorded as TB+ve in 1991 (n = 2443), 12.7% in 1992 (n = 1392), and 10.8% in 1993 (n=955) [Table 34]. There was no statistical difference between the overall value obtained in this study (8.1%) and either the 1991 or 1993 values (P = 0.30, P = 0.24, respectively) but there was a significant difference between the overall value obtained here (most of the studies here were carried out in 1992) and the national figure for 1992 (P = 0.04).

Overall differences in TB rates between data sets

The data for all badgers, with a mean of 8.1% TB+ve badgers, is composed of several data sets. The occurrence of TB in badgers was, therefore, further examined by comparing levels in all badger groups (n = 40, as before), badger groups of high intensity snaring ($n^{[highsnaregroups]}$ = 19), low intensity snaring ($n^{[lowsnaregroups]}$ = 17), and data included in the *Numbers per sett type* analyses, against data from the badgers added to the database from areas previously excluded from analyses (Table 33). Badgers present within each of these data sets are identified as such in Appendix A19.

Table 34. National data for badgers snared under licence (Department of Agriculture, Food & Forestry preliminary data). Annual totals (1993 to August only) are given, followed by breakdown for each year according to whether badgers were obtained from a new licence or from a renewed (repeat) removal operation.*

Year/ period	males % of males TB+ve	males	females % of females TB+ve	females	sex ratio	sex ratio	overall sex ratio	over-all TB rate	totals
	TB+ve	TB-ve	TB+ve	TB-ve	TB+ve	TB-ve			
1991	99 9.3%	966	152 11.0%	1226	1.54	1.27	1.29	10.3%	2443
1992	83 12.7%	569	94 12.7%	646	1.13	1.13	1.13	12.7%	1392
1993 (to Aug.)	62 12.7%	428	41 8.8%	424	0.66	0.99	0.95	10.8%	955
1991 new	43 9.23%	423	64 11.5%	491	1.49	1.16	1.19	10.5%	1021
1991 renewed	26 13.0%	174	31 10.7%	258	1.19	1.48	1.45	11.7%	489
1992 new	29 16.0%	152	31 17.5%	146	1.07	0.96	0.98	16.8%	358
1992 renewed	48 11.9%	356	54 10.9%	441	1.13	1.24	1.23	11.3%	899
1993 new (to Aug.)	31 12.9%	209	18 7.6%	219	0.58	1.05	0.99	10.3%	477
1993 renewed	30 12.2%	215	21 9.9%	191	0.70	0.89	0.87	11.2%	457

* this data is preliminary and unpublished. Differences between annual totals and totals derived from 'new' and 'renewal' operations exist. Only preliminary observations are derived from these data sets and this report does not purport to contain a detailed analysis of the observations.

There are close similarities in TB levels between the data sets for all badgers in *Numbers per sett type* and that for all social groups (5.4% *cf.* 5.7%); as these were virtually similar data sets, this is not unexpected: only 10 badgers more are included in the first of these data sets. TB levels were actually slightly lower in low snaring groups (5.7%) than in high snaring groups (6.5%), but the lack of any TB+ve females in the former is anomalous. The difference in TB rates was not significant (P = 0.91). Note that the capture rate had previously been estimated at 80% in high snaring groups and *c.* 68% in low snaring groups.

The difference in TB levels between high snaring groups (6.5%) and 'excluded' data (14.5%) was substantial but not significant (χ^2_1 = 2.09, P = 0.15) and a comparison across sexes showed no significant difference (χ^2_3 = 3.49, P = 0.32). However, the TB rate for all badgers in *Numbers per sett type* data (5.4% infected) differed statistically from the 'excluded' data (14.5%) [χ^2_1 = 4.82, P = **0.03**).

Compared to the 17% value reported by Dolan & Lynch, the values for groups differ significantly (high snare groups 6.5% *cf.* 17%: χ^2_1 = 6.33, P = **0.01**; low snare groups 5.7% *cf.* 17%: χ^2_1 = 5.47, P = **0.02**; all groups 5.4% *cf.* 17%: χ^2_1 = 14.64, P = **0.0001**).

However, compared to the Department's of Agriculture, Food & Forestry's figures for 1991-1993, the differences were less, being insignificant when compared to high or low snaring groups but *significant* when compared to all groups (high snare groups: 1991 P = 0.32, 1992 P = 0.11, 1993 P = 0.27; low snare groups: 1991 P = 0.30, 1992 P = 0.12, 1993 P = 0.26; but for all groups: 5.7% *cf.* 10.3% - 1991 P = **0.07,** 5.7% *cf.* 12.7% 1992 P = **0.01,** 5.7% *cf.* 10.8% 1993 P = **0.055**). The overall TB rate from 1991-1993 was 11.1%: this differs statistically from the rate of 5.7% observed here in the badger groups (χ^2_1 = 4.48, P = **0.03**). In contrast the 'excluded' data (TB rate 14.5%) did not differ from the overall TB rate given by the national figures for 1991-1993 (11.1%) [χ^2_1 = 0.56, P = 0.45].

Thus the groups studied here showed a significant difference in prevalence of TB in badgers (*c.* 6%) compared to badgers not included in these groups (14.5%), and compared to the national average over 3 years (*c.* 11.1%).

The national rate in 1992 (12.7%) is a significant increase upon 1991 (10.3%) [χ^2_1 = 5.09, P = **0.02**], and the subsequent decrease from 1992 (12.7%) to 10.8% in 1993 is large but not significant (χ^2_1 = 1.83, P = 0.18).

Comparison of TB infection rates between sexes

The results suggest that TB lesion rates were higher in male badgers than in females, with 10.6% of males infected and 5.9% of females overall, but the difference is not significant (χ^2_1 = 1.16, P = 0.28).

For the high snaring groups, the TB levels in males and females were virtually identical at 6.3% and 6.8% respectively (P = 0.75). For all social groups and in the *Numbers per sett type* data, there were more males infected than females (8.5% *cf.* 3.0%, diff. not sign., P = 0.20). For the low snaring groups, the data is unreliable in view of unacceptably small sample size of infected badgers (P = 0.03). There was *no* difference between the infection rate in males of 18.2% and that of females 13.9% in 'excluded' data (P = 0.95). There was a substantial difference between the proportions of each sex infected in high and low snare groups, which would tend to substantiate the hypothesis that there is a higher prevalence of TB in males than females ($\chi^2_3 = 6.84$, P = 0.08).

The totals given by the Department of Agriculture, Food & Forestry's figures for 1991-1993 are, for males 11.1% (287 TB+ve, 2583 TB-ve) and, for females 11.1% (244 TB+ve, 1963 TB-ve). The data for 1991-1993 reveals a higher prevalence in female badgers in 1991 (11.0% *cf.* 9.3%, P = 0.18), equivalence in 1992 (12.7%, P = 0.95), and higher in males in 1993 (12.7% *cf.* 8.8%, P = 0.07). These differences are not statistically significant, but the higher prevalence of TB in males than in females in 1993 is close to significance.

The *increase* in TB prevalence in males from 1991 (9.3%) to 12.7% in both 1992 and 1993 is significant ($\chi^2_2 = 6.48$, P = **0.04**). The *decrease* in TB prevalence in females from 1991 (11.0%) to 1993 (8.8%) is substantial ($\chi^2_2 = 4.38$, P = 0.11). The changes in TB prevalence for the sexes from 1991 to 1993 are significant ($\chi^2_5 = 10.87$, P = **0.054**). This reversal in susceptibility of each sex over this 3 year period is bewildering, especially as there appears to be a trend involved.

In summary, there would appear to be indications that males are more susceptible to infection by TB in the data for 'licence' areas here (except for high snare groups) and for national data for 1993, but this is not proven (significance at 10% level only). There has been a significant change in the prevalence of TB in each sex since 1991 in national data. That these observations may have arisen from differences in trappability rather than real differences in TB prevalence between sexes is considered below.

Sex ratios

Sex ratios in Table 33 include data for the 9 cubs. Sex ratios had not been investigated in the previous section on badger groups and snaring success. These perhaps require re-evaluation at a later stage to refine the group size estimates based on separate catch-effort analyses for each sex. However, the conclusion to that section was to make use of group size estimates from high snare groups only: the fact that the sex ratio was virtually at parity in this sample indicates that refined estimates would differ little, if at all, from those obtained earlier. However, the use of *Numbers per sett type* data may need refining as females are revealed to be far more trappable, overall, than males, and the multiplication factor involved (74.9% snare success rate) and captures per sett type are based on the overall data rather than the more reliable set of data from high snare groups alone.

The overall data here indicates that the sex ratio of captures in all data sets other than high snare groups differs from unity (low snare groups, 1 male : 1.68 females [P = **0.04**], and 'excluded' data, 1.64 females to each male [P = 0.07]) (*n.b.* published data on sex ratios in badger populations is considered in the *Discussion*). The sex ratio differs from that in the high snare groups though not significantly (*cf.* low snare groups $\chi^2_1 = 2.88$, P = 0.09; *cf.* 'excluded' data $\chi^2_1 = 2.36$, P = 0.12). The sex ratio of clear (TB-ve) animals was compared between low and high snaring groups, and this difference *was* significant ($\chi^2_1 = 4.57$, P = **0.03**). Thus, high snaring captures an equal sex ratio of clear animals, but in low snaring areas, clear females are more susceptible to capture than clear males. When diseased animals are included, the difference becomes less significant, as there were more diseased males captured than females in low snaring areas.

The observed sex ratios were compared with the Department of Agriculture's snaring results for 1991-1993, which were: for 1991, 1 male : 1.29; for 1992, 1 male : 1.135; for 1993, 0.95; overall 1991-1993, 1 male : 1.17 females [there appears to be a trend, with an annual decline in this ratio from 1991-1993]. Sex ratios in high snare groups did not differ from the national data (1991 $P = 0.13$, 1992 $P = 0.38$, 1993 $P = 0.96$, overall $P = 0.29$). For low snare groups, there is a difference in 1993 but not for other years (1991 $P = 0.37$, 1992 $P = 0.16$, 1993 $P =$ **0.04**, overall $P = 0.19$).

The national sex ratios have altered very significantly over the 3 year period ($\chi^2_2 = 16.91$, $P =$ **0.0002**). This is because the sex ratio in 1991 had more females than males (ratio 1 : 1.29, which differs significantly from unity, $\chi^2_1 = 40.10$, $P <$ **0.0001**) but by 1993, the sex ratio had reversed with more males being captured than females (1 male : 0.95 females; $P = 0.42$). In 1992, the sex ratio was intermediate 1 male : 1.135 females (also differs from parity, $\chi^2_1 = 5.56$, $P = 0.02$).

Sex ratios of diseased badgers

The sex ratio of diseased badgers was compared with that observed for clear badgers within the data sets. The data indicates that more diseased males are captured than diseased females, in comparison with clear animals, where more females are captured than males. This is observed for *Numbers per sett type* data where the sex ratio for diseased animals was 1 male : 0.43 females and that for clear animals 1 male : 1.28 females, and in the case of low snaring groups, where 0 diseased females were captured in contrast with a sex ratio of 2 females to each male for clear animals. The difference was not significant in the former case ($P = 0.20$) but significant in the latter ($P = 0.03$), but the very small numbers involved render this observation unsatisfactory.

In the Department of Agriculture, Food & Forestry's figures for 1991-1993, proportionately more diseased males than females were snared in 1993, but for 1991 and 1992, the reverse was the case, with more females TB+ve than males (sex ratios for TB+ve badgers: 1991 1 male : 1.54 females; 1992 1 male : 1.13 females; 1993 1 male : 0.66 females; overall 1 male : 1.18 females). Again, a trend over time is indicated in line with the observations above, and the change in sex ratio over time is significant ($\chi^2_2 = 12.76$, $P =$ **0.002**). This indicates that diseased males are more likely to be captured than diseased females - in 1993.

The sex ratio of diseased animals is observed to differ from the sex ratio of clear animals in the national data. Thus in 1991, the sex ratio of clear animals was 1 male : 1.27 females, but for diseased animals, it was 1 male : 1.54 females. This suggests that diseased females are more likely to be captured than healthy females but the difference is not significant ($\chi^2_1 = 1.78$, $P = 0.18$). In 1992, the sex ratio of infected and clear animals was equal (at 1 male : 1.13 females, $P = 0.95$). In 1993, the sex ratio of healthy animals was 1 male : 0.99

females, and that of diseased animals 1 male : 0.66 females - this difference approaches significance ($\chi^2_1 = 3.26$, $P = 0.07$).

Examination of these differences between 'new' and 'renewal' areas in the national data again reveals a more complicated picture. In 1991, diseased females appear to be more trappable only in 'new' areas and quite the reverse holds for the renewal areas, where diseased males appear much more trappable than diseased females. The same pattern holds in 1992, though the differences are smaller. In 1993, diseased males appear slightly more trappable than diseased females in renewal areas, and, unlike the previous years, also in 'new' areas.

Trends

The national data reveals opposing trends: a significant increase in prevalence of TB in males from 1991 to 1993, a substantial decrease in prevalence of TB in females from 1991 to 1993, and a significant change in the sex ratio of animals captured. There is one additional trend: the numbers of badgers captured per year have fallen from 1991 to 1993 (2443, 1392, 955, respectively, with 1993 data to August 1993 only).

There would appear to be matters of some importance underlying these trends, but no explanation is immediately apparent. Preliminary discussion of these matters is included here as the possibilities may be tested against the data presented from the studies here.

Firstly, one may accept that the national data represents reality, and that there has been a genuine change, over 3 years, in TB prevalence amongst sexes, and also a genuine change in sex ratios. Acceptance of this is to infer that TB infection affects each sex differentially and that the nature of such differential epidemiology alters for each sex over time. If this is the case, then the change in sex ratio might come about because more of one sex die in the population (perhaps leading to a change in TB prevalence in each sex over time) or that each sex is more susceptible to trapping if diseased.

The alternative hypothesis is that there has been no real change in sex ratios over time, and that TB prevalence in the sexes is roughly equal, but that the observations over 1991-1993 have been brought about sôlely by changes in the trapping methodology over the 3 year period. As shown above, females are more susceptible to snaring than males when snaring intensity is low: perhaps the 1991 data was derived from snaring at a low intensity and the intensity of snaring has been increased in 1992 and 1993. The fact that almost twice as many badgers were snared in 1991 than 1992 might point in this direction. One way to test this, in a rudimentary manner, is to evaluate the mean number of badgers removed per licence in 1991 as compared to 1992 and 1993.

There is one other possible explanation for the observed trends. Major efforts were made from the end of 1990 to increase the number of badger removal operations, but in 1992 and 1993, more of these operations consisted of repeat snarings in the same areas. The data presented from groups studied here suggests that the observed changes, year by year, in the national data, would in fact be brought about by the inclusion of many licences which were 'repeat snarings'. The hypothesis would remains that there has been no real change in the sex ratio of badgers in Ireland as a whole over this period and that the TB prevalence in each sex is close to parity and has not altered from 1991-1993 for Ireland. The changes observed would be considered to be an artefact resulting from repeat snaring of the same populations.

Thus, the sex ratio in 1991 was 1.29, surprisingly close to the entire data set here: 1.26 [*n.b.* the licence areas selected for study here were specifically chosen *not* to include areas that had been snared previously]. As females are caught disproportionately, each repeat snaring results in the surviving population consisting of fewer females than males. Each repeat snaring also, obviously, results in fewer captures than before. If this hypothesis is correct, then the overall methodology of snaring nationally appears to resemble a mix of high snaring and low snaring operations, as in the overall data here. The effects of repeat snaring may be simply modelled, confirming that sex ratios would be obtained much as observed (such a model has been constructed but is not detailed in this report).

Table 34 gives initial data on sex ratios and TB prevalence in badgers captured in 'new' areas and in repeat removal operations (renewals). Unfortunately, this data suggests an even more complicated scenario with the hypothesis that the trend observed over the period 1991-1993 is a result of repeat snaring operations apparently negated. In 1991, the sex ratio for new areas was 1 male : 1.19 females, compared to a sex ratio of 1 : 1.45 for renewals - this is the opposite of that predicted. The same pattern is followed in 1992 (sex ratio in new areas: 1 male : 0.98 females, and in renewals 1 male : 1.23 females). The position was reversed in 1993 (new areas: 1 male : 0.99 females, renewals 1 male : 0.87 females).

Conversely, examination of the data for repeat operations alone does show that the overall sex ratio has declined from 1 male : 1.45 females in 1991 to 1 : 1.23 in 1992 and 1 : 0.87 in 1993 as would be predicted. The data also suggests that diseased males are more trappable than clear males in these areas - which would support the data from the badger social groups here; this would tend to support the hypothesis also. However, as the overall sex ratio gives a greater proportion of females in renewal areas than in 'new' areas, the 'model' is not supported overall.

These results, and those for the sex ratios of diseased animals, given above, suggests that explanation of the national data from snaring data obtained here from high-snaring and low-snaring groups is not at all straightforward. There are reasonable grounds for considering that explanation of the national data *should* be straightforward. The differences between the 'new' and 'renewal' operations in the national data require further investigation. The difficulty with the renewal areas is that it is not clear whether such operations are concentrated upon the same social groups.

Re-evaluation of low and high snaring groups

Comparison of high and low snaring groups would suggest that snaring intensity was not involved in producing results of TB rates in badgers below the national average. However, some of the additional data were from areas in which snaring intensity was so low as to merit exclusion from the analyses entirely; some of the data from sett survey was insufficient to merit inclusion of the data also - and, in these cases, snaring effort was probably lower also, without all setts being surveyed and snared. Since the data for badgers in all these 'excluded' areas showed a high TB prevalence, the 'excluded' data was reconsidered.

Every badger was designated as *probably* either coming from a high snaring operation or from a low snaring operation: this was as before for the social groups but, for much of the additional material, this classification was tentative, as few snaring details were included. In the case of at least two licences previously excluded, all badgers were designated as from a high snaring operation (the reason for their exclusion previously was lack of sett information in one case, and the fact that all badgers were captured outside the designated 1 km^2 area in the other). The revised list of badgers according to intensity of snaring is included in Appendix A19. All 262 badgers were classed in this manner in an exploratory exercise. The results are given in Table 35.

Table 35. A comparison of TB levels in badgers for all badgers from 42 licence areas, classed according to whether they were snared at high or low intensity. The classes are tentative.

	Totals	**Totals by sex**	**Males**	**Females**	**Sex ratio** *Females/males*
High snare groups					
TB+ve	9	7	3	4	*1.33*
TB-ve	110	96	49	47	*0.96*
Totals	119	103	52	51	*0.98*
% TB positive	**7.6**	**6.8**	**5.8**	**7.8**	
Low snare groups					
TB+ve	12	12	8	4	*0.50*
TB-ve	130	124	44	80	*1.82*
Totals	142	136	52	84	*1.61*
% TB positive	**8.5**	**8.8**	**15.4**	**4.8**	

The initial observations from Table 35 are:

1) that chance exclusion, earlier, of several areas that had some TB+ve badgers, resulted in a slightly higher TB incidence value for high snare groups. The overall prevalence of TB in high snare groups has risen to 7.6% *cf.* 6.5% in Table 33. Nevertheless the estimate for high snare groups remains well below the national average. Perhaps unusual badger behaviour or movement of diseased badgers, especially male, is creating a different pattern of TB prevalence in these high-snare groups than in groups/badgers sampled in a different way for the national data.

2) that the difference between sex ratios of diseased and clear animal in low snaring groups has been increased by addition of the data from 'excluded' areas (sex ratio 1 : 0.50 for diseased animals *cf.* 1 : 1.82 for clear animals; $\chi^2_1 = 3.28$, $P = 0.07$). The sex ratio of diseased animals and clear animals in high snare groups has remained close to unity.

3) previously, there were zero captures of TB+ve females in low snaring groups. This has altered with the addition of data from 'excluded' areas, but the considerably higher apparent prevalence of TB in males remains (15.4% *cf.* 4.8%). As the data for high snare

groups indicates equal prevalence of TB in the sexes, the data would suggest that diseased males are more trappable than clear males.

4) the overall sex ratio in high snare groups approaches unity more closely than before (1 male : 0.98 females).

A general observation is that the entire data set is derived from the licence area studies, the conditions for which were outlined earlier. The data for badgers that had not been included in Table 35 is from just a few licence areas excluded previously. For most of the low snare groups, data on snaring intensity and methodology employed in catching badgers was assessed. Even for the additional licence areas included, some evaluation was made as to the probability that entire groups might have been snared by judging badger sett distributions on a map against captures and sett descriptions. Full snaring details had been submitted for some of these areas.

Detailed observations are as follows:

The overall prevalence was 7.6% in badgers snared at high intensity *cf.* 8.5% in badgers snared at low intensity. The difference is not significant (P = 0.97). For the badgers with sex data, the difference between 6.8% in high snare groups *cf.* 8.8.% in low snare groups is also not significant (P = 0.74). The 7.6% value for high snare groups did not differ from the national data for 1991, 1992, and 1993 (P =0.42, P = 0.13, P = 0.35, respectively) nor did the 8.5% value for low snare groups (P = 0.58, P = 0.18, P = 0.48, respectively). However, most of the data here was obtained in 1992, so the difference between the data from the groups here and the national value in that year is worth noting.

Again, the difference between the proportion of males observed as infected in high snare groups (5.8%) does not differ statistically from that in low snare groups (15.4%) [P = 0.20], in view of the low sample sizes.

Although 1 more diseased female was captured than diseased males in high snare groups, the difference is not significant (P = 0.98). But in low snare groups, the difference is significant at the 10% level (χ^2_1 = 3.28, P = 0.07) - *i.e.* the sex ratio of diseased animals differs significantly from that of clear animals, with more diseased males being captured than anticipated.

The overall sex ratio differs between high snaring and low groups, with sex ratio at unity in high snare groups and at 1.61 females per male in low snare groups (χ^2_1 = 3.10, P = 0.08).

There is no significant difference between the sex ratios of infected animals of high and low snaring groups (1 : 1.33 and 1 : 0.50; P = 0.59) but that of clear animals differs significantly between the two data sets (1 : 0.96 and 1 : 1.82; χ^2_1 = 4.75, P = **0.03**).

Summaries for group prevalence of TB and occurrence of TB in licence areas

Of the 40 badger social groups, one or more tuberculous badgers were snared in 9 of them (22.5% of groups). In 8 of these infected groups, one badger was tuberculous, and in the remaining TB+ve group, 2 badgers had the disease. None of the 9 cubs had TB. A summary for each group is presented in Table 36. The maximum TB prevalence in a group was 50%, and in each of these cases the group consisted of 2 adults, with 1 tuberculous. There was no significant difference in mean group size between clear groups (4.29 adults) and groups which had an infected individual (4.22 adults).

In all, 21 TB+ve badgers were snared in 41 licence areas (one area had only one capture and that badger had no data recorded for TB). Of these 41 areas, 16 areas had tuberculous badgers (39%). The mean number of badgers captured per licence area was 6.37, and the overall means were 0.51 tuberculous badgers per licence area and 5.85 clear badgers per area. The maximum number of TB+ve badgers captured in any of the licence areas was 3. As noted previously, the figures for licence areas are not representative of most normal snaring operations as the snaring was usually confined to the 1 km^2 areas requested, and in many cases badgers snared outside these areas were not reported. Nevertheless, the average number of tuberculous badgers returned per licence area from the vicinity of breakdown farms appears to be a low return for the effort involved.

Conclusions

There is evidence that differential trappability exists, with females being more trappable than males overall and diseased males being more trappable than healthy males. The national data appears to differ, in several respects, from that obtained in the studies conducted here. Whilst trappability of infected animals appears to differ from that of healthy badgers, between sexes at least, the data is not sufficient to confirm there has been considerable overestimation of badger TB through tuberculous badgers as a whole being more trappable than healthy ones. A direct comparison between the TB prevalence in the badger groups and in the national data might suggest that there has been overestimation of TB in badgers of the order of 2-3% (1991 - 1993). A larger sample of badgers snared at high intensity would be required to confirm this. Overestimation of the real TB prevalence in badgers possibly results from snaring at a low intensity which is not sufficient to uniformly sample the badger population.

There is contradictory information from badger groups and from national data as to whether males are more susceptible to disease and capture than females, which affects the nature of these conclusions. The national data is extremely difficult to interpret without considerably more attention being paid to the manner in which the data was obtained. Thus, it is possible that 'renewal areas' (repeat operations) are in some cases not repeat snarings of the badger groups initially snared, but merely additional snaring operations in the same 2 km radius zone. The fact that there are differences between these repeat snaring areas and 'new' areas does merit further investigation, in the light of the studies undertaken here. The various trends in TB levels in badgers nationally over a 3 year period are hard to comprehend.

There would appear to be little question that high snaring operations will yield samples of the badger populations that more closely correspond to reality than do low intensity operations, and, therefore, it is recommended that more attention be paid to consistency in the operation of badger removal licences, which would allow for a greater degree of confidence being placed upon resultant data as being representative of the country. These matters are addressed further in the *Discussion* but, briefly, the use of the snaring methods adopted for high snare groups here, upon the original recommendation of O'Corry-Crowe and Hayden (pers. comm.), is considered as a guideline that merits adoption universally to eliminate most of the difficulties associated with incomplete sampling of badger populations for research purposes.

Table 36. Numbers of infected badgers captured within each of the 40 badger social groups.

group no.	group size	badgers TB+ve	% TB+ve	high snaring group?
1	6	0	0.0	N
2	6	1	16.7	N
3	2	0	0.0	N
4	2	1	50.0	N
5	2	0	0.0	N
6	3	0	0.0	
7	5	0	0.0	
8	4	0	0.0	
9	7	2	28.6	Y
10	6	0	0.0	Y
11	3	0	0.0	Y
12	6	0	0.0	Y
13	5	1	20.0	Y
14	4	0	0.0	Y
15	3	0	0.0	N
16	4	0	0.0	Y
17	7	0	0.0	Y
18	6	1	16.7	Y
19	4	0	0.0	Y
20	8	0	0.0	N
21	7	0	0.0	Y
22	3	0	0.0	Y
23	3	1	33.3	N
24	3	0	0.0	N
25	3	0	0.0	N
26	5	0	0.0	N
27	5	0	0.0	N
28	5	0	0.0	Y
29	2	1	50.0	Y
30	1	0	0.0	Y
31	4	1	25.0	N
32	4	0	0.0	N
33	4	0	0.0	Y
34	4	0	0.0	N
35	1	0	0.0	N
36	1	0	0.0	
37	6	0	0.0	Y
38	7	0	0.0	N
39	7	0	0.0	Y
40	3	1	33.3	Y
Totals	**171**	**10**	**5.8**	

ABUNDANCE AND DISTRIBUTION OF BADGERS IN IRELAND

This final chapter of the *Results* section of this report brings together the data obtained from the Badger Survey, the Habitat Survey, and the data on social groups obtained from studies of 'licence' areas. Estimates are provided of the densities and total number of badger social groups in Ireland, corrected for areas of sea, lake, *etc.* Also presented are estimates of the numbers of badgers present in Ireland, as determined from the data on social group size and numbers of badgers per sett type. The distribution of badgers in Ireland is considered (in the second part of this chapter) by analyses of badger habitat preferences for sett location. The density of active main setts (*i.e.* badger social groups) and other sett types is evaluated with regard to the overall habitat composition of survey areas and counties.

THE ABUNDANCE OF BADGERS IN IRELAND

Confidence limits for estimates of active main setts and other active setts

Estimation of the number of badger groups relies upon assessment of the density of active main setts, given in Table 4. Estimation of badgers in Ireland from mean captures at each sett type also requires estimates of mean density of active annexe setts, active subsidiary setts, and active outlier setts (also in Table 4). Confidence limits for these estimates are required to provide limits for national estimates of numbers of badger groups or individuals.

The frequency of occurrence of active main setts follows a Poisson distribution (Figure 87; overall data for the Republic). A negative binomial distribution may also be fitted to the data. The Poisson distribution is a random one (*i.e.*, without inferring a biological interpretation, active main setts are randomly distributed with respect to sampling squares), in which the variance is equal to or similar to the mean (in this case the variance : mean ratio = 0.91, with the variance being slightly *less* than the mean).

This is in contrast to the frequency distributions of the other sett types, which follow a negative binomial distribution, with significant clumping - *i.e.* non-random distribution (see Figures 88, 89 and 90 for frequency distributions of other active sett types). In these cases the variance is always *greater* than the mean. However, there is not much difference in the overall shape of these statistical distributions for the data here, with a predominance, in all cases, of squares with no setts present, followed by most with 1 sett present, and fewer with 2 present, *etc.* However, the different distribution of active main setts probably has a biological explanation, which is not profound. Once one active main sett occurs in a square, the chance that another is also present is reduced, as there is, by definition, a distance between such setts. The chance that another main sett also falls in the square, at some distance, is quite random (though variable according to overall sett density). In contrast, several annexe setts may be grouped around an active main sett, leading to significant clumping. The same holds for the other minor sett types.

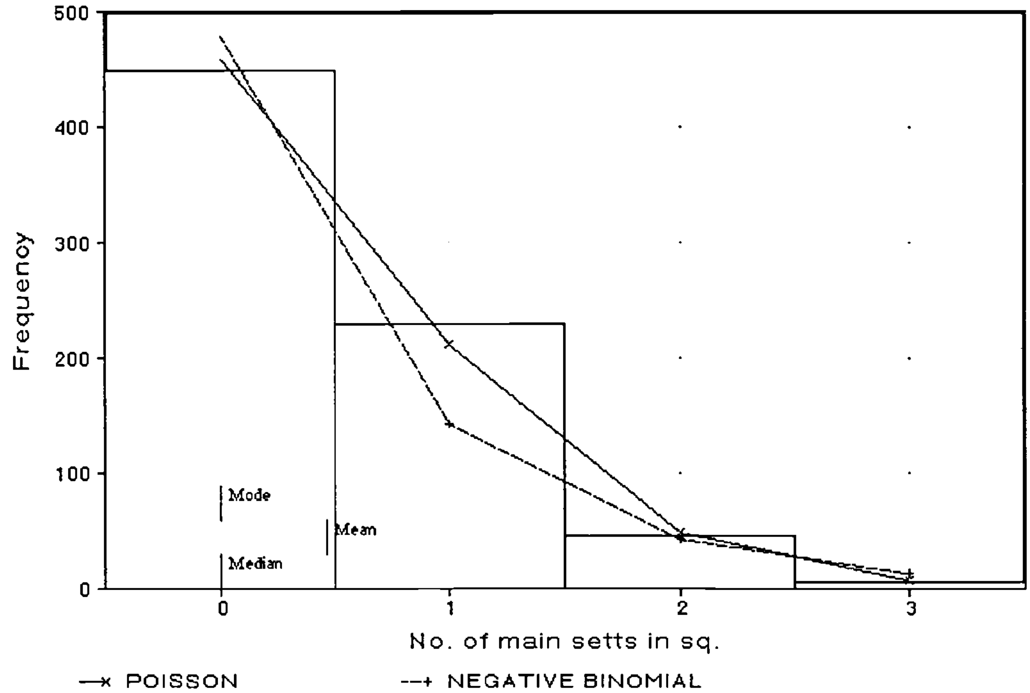


Figure 87. Histogram of occurrence of active main setts in 1km squares in Ireland.

95% confidence limits for the Poisson distribution were obtained by normal approximation where the total number of active main setts observed (x) was >100, as follows:

lower limit = x - 0.94 -1.96$\sqrt{(x\text{-}0.02)}$

upper limit = x + 1.94 +1.96$\sqrt{(x\text{+}0.98)}$

and for smaller samples, confidence limits were obtained from Poisson distribution tables (Krebs, 1989). A χ^2 test of fit for a Poisson distribution was carried out for all regions, giving a reasonable fit (Table 37); a Poisson distribution was therefore used for all confidence intervals. Conversely, U and T tests for the fit of data to the negative binomial rejected the fit for some regions - though it was an acceptable fit for the total Republic data and for several regions. For the larger samples, a normal approximation may be used to calculate confidence limits for both the Poisson and negative binomial, and the confidence limits are very similar. Since variance : mean ratios were close to or below unity, the Poisson fit was adopted for all regions. These matters and those of degrees of freedom are considered further in Appendix 20. Cresswell *et al* (1990) did not refer to the distribution of their data, but their data for active main setts (Table 4 in Cresswell *et al*, 1990) reveals a negative binomial (Appendix 22).

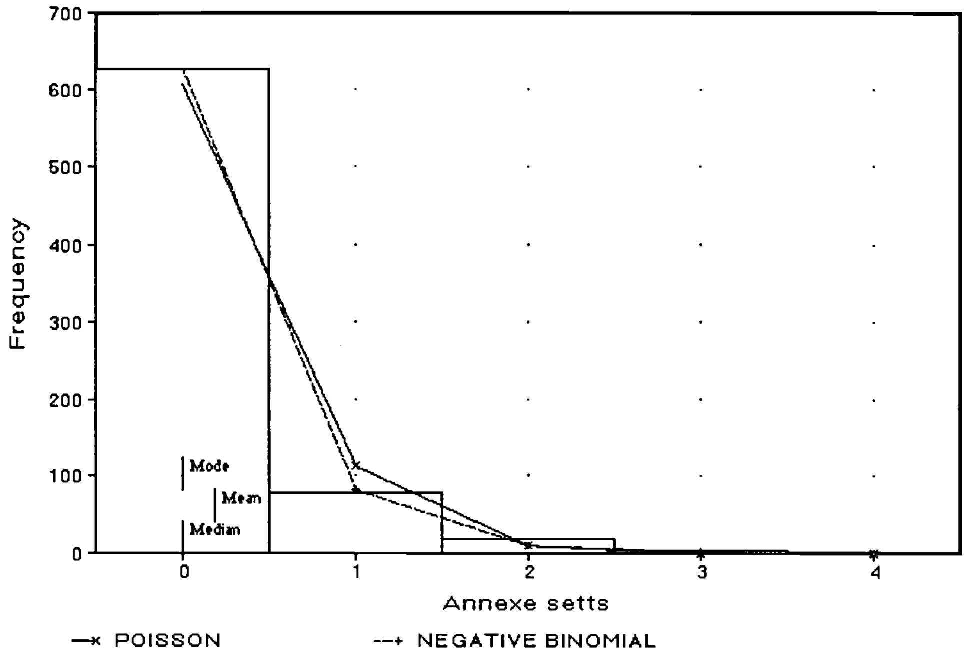


Figure 88. Frequency of occurrence of active annexe setts (all Republic data), with fitted distribution curves.

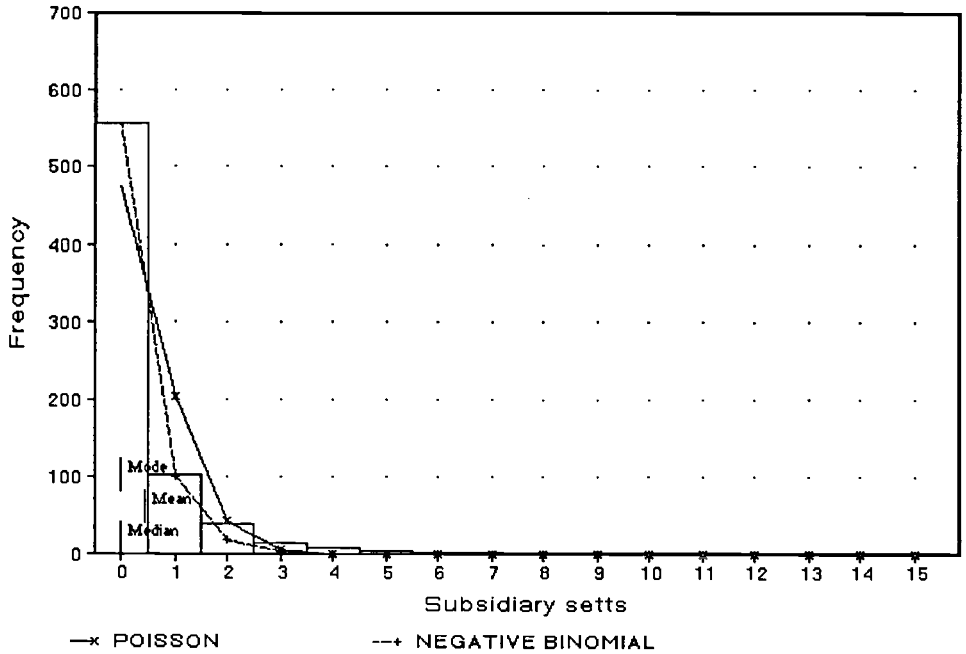


Figure 89. Frequency of occurrence of active subsidiary setts (all Republic data), with distribution curves fitted.

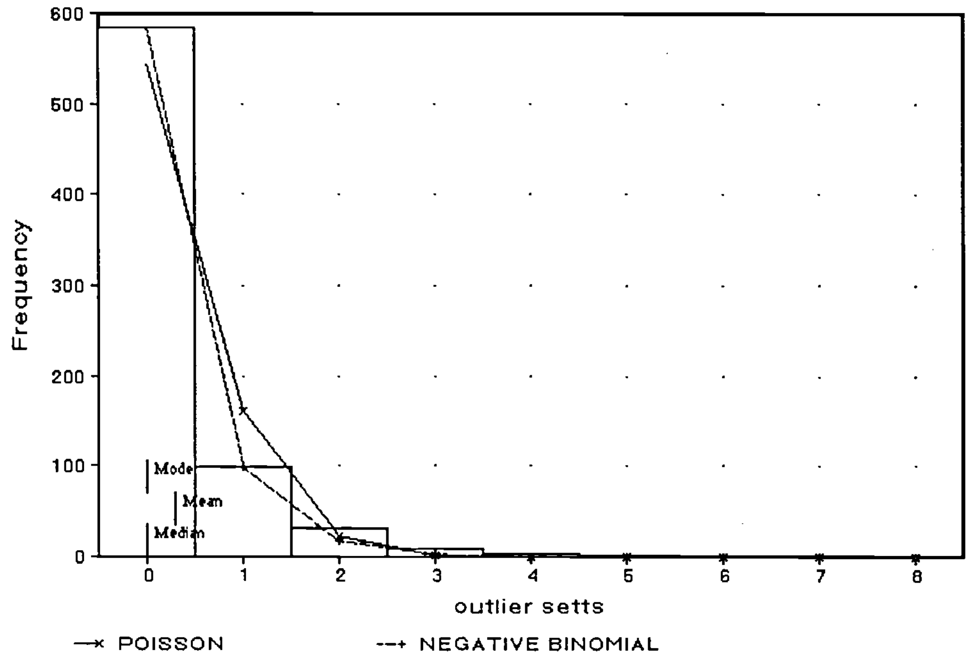


Figure 90. Frequency of occurrence of active outlier setts (all Republic data), with distribution curves fitted.

Table 37. Goodness of fit tests for the active main sett distribution data for a Poisson distribution - for each region. P values show a reasonable fit between the observed and expected distributions (poor for Mid-West only).

Region	**S-W**	**M-W**	**W**	**N-W**	**Midl.**	**S**	**E**	**Ireland**
χ^2	2.62	3.31	0.36	1.01	0.59	0.82	0.57	2.63
P	0.11	**0.07**	0.55	0.32	0.44	0.36	0.45	0.27
d.f.	1	1	1	1	1	1	1	2
Variance :mean ratio	0.88	0.74	1.02	0.84	0.81	1.12	0.86	0.91

For negative binomial distributions, the variance is always larger than the mean, indicating distributional clumping. For the distributions for active annexes, subsidiaries and outliers, the ratio of variance to means was 1.45, 2.11, and 1.70 respectively. Whether the data could possibly be fitted to a Poisson distribution was tested for the three data sets. In each case, the observed distribution differed from an expected Poisson distribution very significantly (goodness of fit test, in every case, $P < 0.0001$; annexe setts: $\chi^2_1 = 28.45$; subsidiary setts: $\chi^2_2 = 153.9$; outlier setts: $\chi^2_2 = 91.2$), which contrasts sharply with the P values for this test for active main setts (range P = 0.07 - 0.55, Table 37).

χ^2 goodness of fit tests were performed to test the fit to the negative binomial distribution. In all cases, the fit was close (annexe setts: $\chi^2_1 = 0.12$, $P = 0.73$; subsidiary setts: $\chi^2_4 = 1.33$, $P = 0.86$; outlier setts: $\chi^2_2 = 0.19$, $P = 0.39$) and in all cases, presence of clumped distribution was significant ($P < 0.0001$). The more sensitive U test (Evans, 1953) confirmed the negative binomial for annexe, subsidiary and outlier setts (annexe setts: $U = 0.4*s.e._u$; subsidiary setts: $U = 0.6*s.e._u$; outlier setts: $U = 0.4*s.e._u$; for additional information, refer to Appendix 20). As the sample was large, confidence limits are obtained by normal approximation.

The values for Morisita's Index of Dispersion (Krebs, 1989) were, in the same order as before: 3.42, 3.69 and 3.39. The values for the Standardised Morisita Coefficient were: 0.50, 0.50 and 0.50 (indicating 95% probability of clumped distribution in the data in each case).

Densities of badger groups in Ireland

The overall density of social groups in Ireland was determined initially at 0.46 groups km^{-2} (Table 4) for the Republic, with preliminary results indicating a density of *c.* 0.6 social groups km^{-2} for Northern Ireland. These densities, and the corresponding county and regional data, require correction for areas of sea and lake, *etc.* which were evaluated in Table 14.

The uncorrected and corrected means for each county, region, and for the island, are given in Table 38. Regional means and the national mean are shown with their confidence limits in Figure 91. The county means are illustrated in Figure 92 and regional means in Figure 93. Most of the county means have wide confidence limits due to small sample sizes and the predominance of squares with zero active main setts.

The overall corrected density of badger social groups in Ireland is estimated at 0.50 groups km^{-2} (to 3 decimal places: 0.495 groups km^{-2} with 95% lower and upper confidence limits of 0.44 and 0.55 - *i.e.* ± 11%).

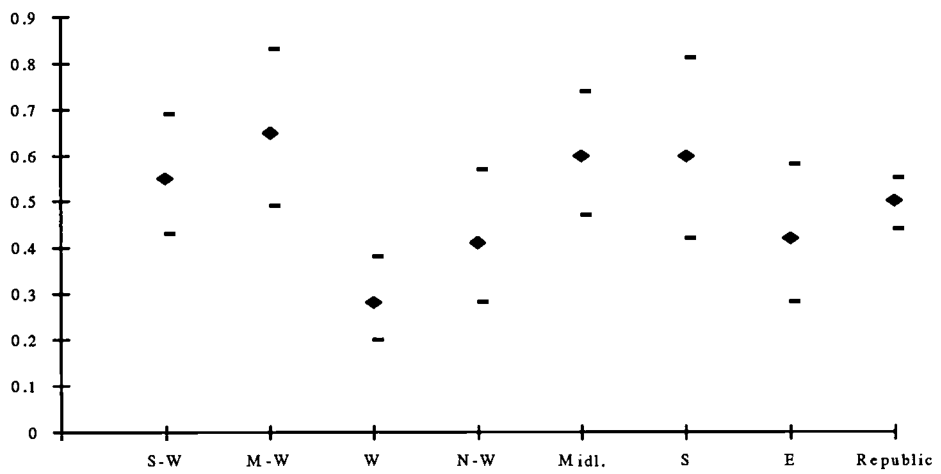


Figure 91. Regional variation in badger social group density (corrected values), with 95% confidence limits.

Table 38. Density of badger social groups (as given by density of active main setts) in each Irish county and region, corrected for areas of sea and lake, etc. *Confidence limits obtained from the Poisson distribution in all cases (see text):* n.b. *confidence intervals are not equal in each direction.*

County/region	Uncorrected values			Correction factor	Corrected values		
	mean main sett density	lower 95% cf.l.	upper 95% cf.l.		mean main sett density	lower 95% cf.l.	upper 95% cf.l.
Carlow	0.63	0.25	1.40	1.0003	**0.63**	0.25	1.40
Cavan	0.38	0.16	0.80	1.0565	**0.40**	0.17	0.85
Clare	0.58	0.36	0.88	1.0730	**0.63**	0.38	0.94
Cork	0.58	0.41	0.75	1.1100	**0.64**	0.46	0.84
Donegal	0.33	0.20	0.50	1.1242	**0.37**	0.23	0.57
Dublin	0.50	0.20	1.12	1.1841	**0.59**	0.23	1.32
Galway	0.22	0.13	0.36	1.1285	**0.25**	0.14	0.40
Kerry	0.37	0.24	0.56	1.1256	**0.42**	0.27	0.63
Kildare	0.41	0.19	0.81	1.0004	**0.41**	0.19	0.81
Kilkenny	1.25	0.84	1.80	1.0004	**1.25**	0.84	1.80
Laois	0.47	0.23	0.88	1.0005	**0.47**	0.23	0.88
Leitrim	0.38	0.16	0.80	1.0183	**0.38**	0.17	0.82
Limerick	0.78	0.47	1.17	1.0084	**0.78**	0.48	1.18
Longford	0.18	0.03	0.61	1.0375	**0.19**	0.03	0.63
Louth	1.00	0.41	1.87	1.0002	**1.00**	0.41	1.87
Mayo	0.24	0.13	0.38	1.1387	**0.28**	0.15	0.44
Meath	0.79	0.49	1.15	1.0004	**0.79**	0.49	1.15
Monaghan	0.50	0.22	1.07	1.0224	**0.51**	0.22	1.09
Offaly	0.72	0.37	1.19	1.0129	**0.73**	0.38	1.20
Roscommon	0.38	0.19	0.70	1.0597	**0.40**	0.20	0.74
Sligo	0.39	0.18	0.76	1.1266	**0.44**	0.21	0.86
Tipperary	0.36	0.21	0.56	1.0126	**0.36**	0.22	0.57
Waterford	0.36	0.15	0.68	1.0971	**0.40**	0.16	0.74
Westmeath	0.82	0.48	1.35	1.0022	**0.83**	0.48	1.35
Wexford	0.40	0.21	0.71	1.0020	**0.40**	0.21	0.71
Wicklow	0.26	0.10	0.59	1.0719	**0.28**	0.11	0.63
South-West	0.49	0.38	0.62	1.1173	**0.55**	0.43	0.69
Mid-West	0.62	0.47	0.80	1.0402	**0.65**	0.49	0.83
West	0.25	0.18	0.34	1.1210	**0.28**	0.20	0.38
North-West	0.37	0.25	0.52	1.1111	**0.41**	0.28	0.57
Midlands	0.59	0.46	0.72	1.0155	**0.60**	0.47	0.74
South	0.58	0.40	0.79	1.0310	**0.60**	0.42	0.81
East	0.41	0.27	0.56	1.0389	**0.42**	0.28	0.58
Republic	0.46	0.41	0.51	1.0709	**0.50**	0.44	0.55
N. Ireland (preliminary estimates)	0.62	0.47	0.78	1.0538	**0.65**	0.49	0.83

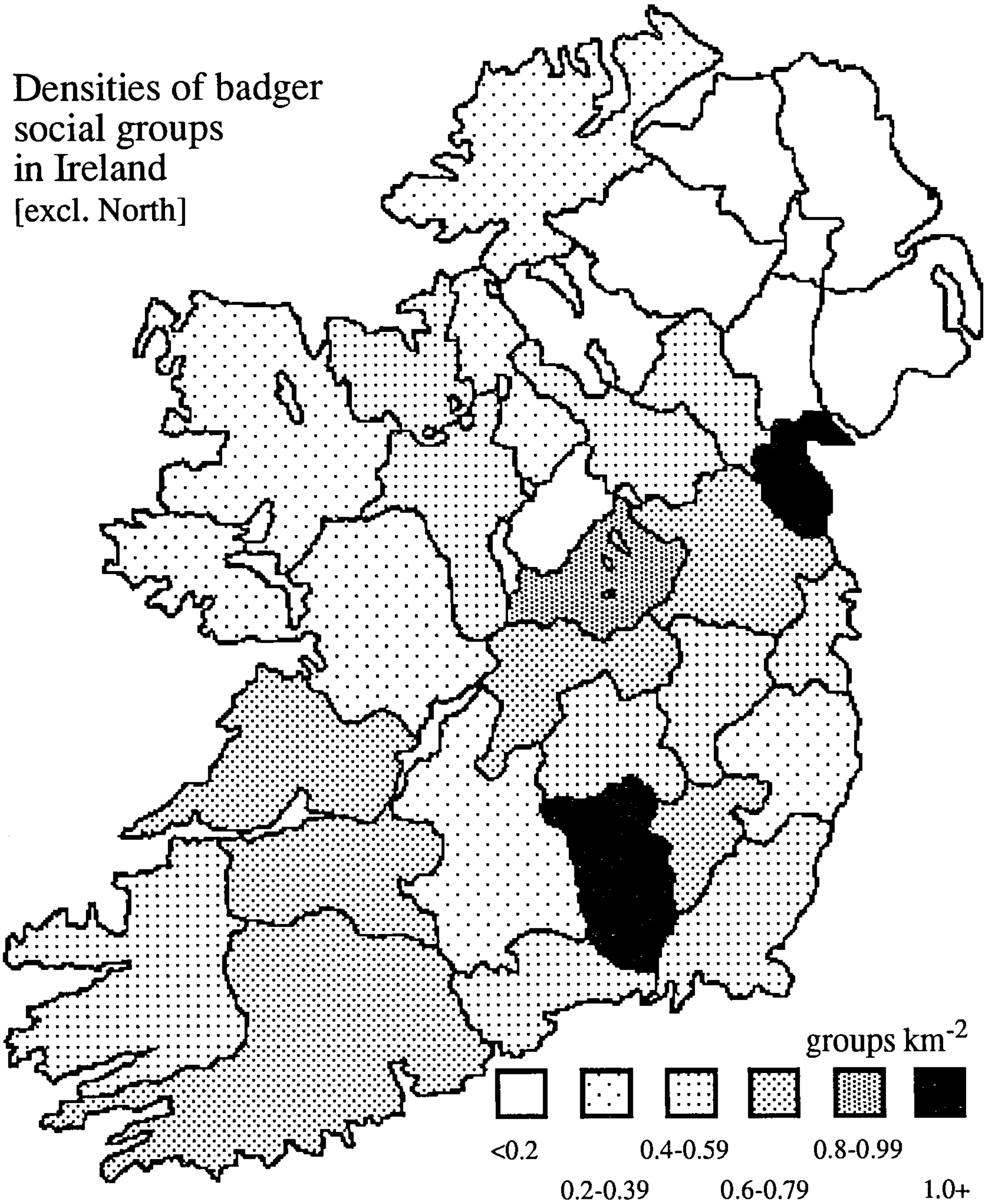


Figure 92. Mean density of badger social groups in Ireland, given by county. For actual values and confidence limits refer to Table 38.

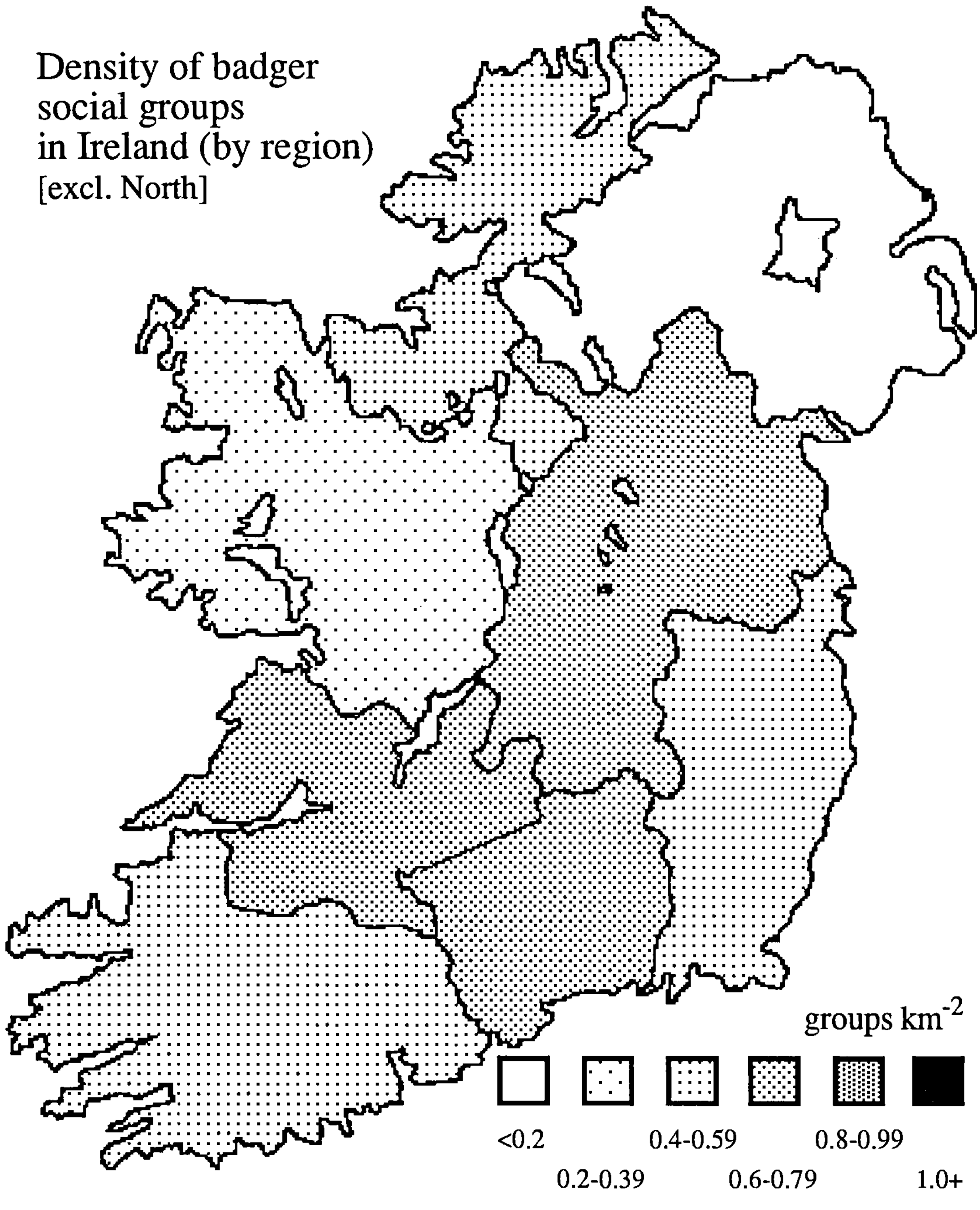


Figure 93. Mean density of badger social groups in Ireland, given by region. For actual values and confidence limits, refer to Table 38.

Comparison of group densities between regions was carried out using non-parametric statistical techniques on data for each 1 km square transformed by correction for areas of sea and lake. Tabulation of differences revealed by the Mann-Whitney U test for unmatched samples is given in Table 39. Note that the technique compares medians and not means - some observed differences even where means are similar suggest that clustering of main setts is occurring bringing about differences between regions.

Means are compared in Table 40 using the *t* test (equivalent to *z* test for large samples, which allows for non-normal distributions; comparisons were made using either pooled or separate variance *t* tests, depending on an initial F test). Given the very small sample sizes and wide confidence limits of most county data, a comparison between counties has not been considered at this stage. Principal observed differences were between the low mean value observed in the West with most other regions. All observed differences given in Table 40 (*t* -test) are confirmed by examination of means and 95% confidence levels in Figure 91.

Table 39. Comparison of median badger group density between regions. Differences at the 5% level (*), 1% level (**) and 0.1% level (***) are marked next to P values.

	S-W	**M-W**	**W**	**N-W**	**Midl.**	**S**
S-W	-					
M-W	0.52	-				
W	0.03*	0.001***	-			
N-W	0.006**	0.39	0.45	-		
Midl.	0.37	0.01**	0.001**	0.47	-	
S	0.35	0.03*	0.03*	0.74	0.35	-
E	0.02*	0.0002***	0.28	0.39	0.76	0.99

Table 40. Comparison of mean badger group density between regions. Differences marked as above (see Table 39). Compare with Figure 91.

	S-W	**M-W**	**W**	**N-W**	**Midl.**	**S**
S-W	-					
M-W	0.33	-				
W	0.0009***	0.0001***	-			
N-W	0.14	0.02*	0.12	-		
Midl.	0.57	0.62	0.0000***	0.05*	-	
S	0.65	0.72	0.006*	0.13	0.98	-
E	0.17	0.03*	0.09	0.92	0.06	0.006*

Numbers of social groups in Ireland

The estimated number of social groups in Ireland may be determined from the above estimates of density for county, region, or the Republic by multiplication of the land area by the appropriate estimates of group density. In practice, as the estimates of land area proved to correspond well with atlas estimates (refer page 71), a simpler approach to determination of actual numbers of groups present, rather than densities, is given by simple multiplication of the *uncorrected* means * 100 * number of sample squares (the sample having been a 1% area sample).

This results from the estimates being derived as follows:

Number of groups in region $=$ total land area $\times$ overall badger social group density

$$= \text{total land area of region} \times \frac{\text{no. of setts observed in survey squares}}{\text{land area of survey squares}}$$

$$= 100 \times \text{no. of survey squares} \times \frac{\text{land area of survey squares}}{\text{total area of survey squares}} \times \frac{\text{total no. of active main setts observed in survey squares}}{\text{land area of survey squares}}$$

$$= 100 \times \text{no. of survey squares} \times \frac{\text{total no. of active main setts observed in survey squares}}{\text{total area of survey squares}}$$

$$= 100 \times \text{no. of survey squares} \times \text{uncorrected group density}$$

Estimates of badger groups, thus obtained, present in each county and region of Ireland are given in Table 41. Confidence limits may be obtained directly from Table 38, by multiplication * 100 * number of survey squares. The total land area of the Republic is given by 735 squares rather than 729 actually surveyed; the assumption is made that the proportion of 'firm land' is similar in the unsurveyed 6 squares and that badger densities are also similar. As mentioned previously, the 735 squares represent an area marginally larger than the Republic, as all squares falling on the border were included within the Republic. The discrepancy is very small. Given the small number of samples in some counties, land area estimates for the counties, as well as actual estimates of social group densities, and thus estimates of badger group numbers are unreliable.

The number of badger social groups estimated in Ireland is thus 0.46 * 735 * 100

= 33,977 social groups (±11%) [computed using 6 decimal places]

(95% confidence limits: 30,255 to 37,806 groups).

Values for each region are given in Table 41.

Cresswell *et al* (1990) obtained an estimate, for Britain, of 43,000 ± 9% social groups, giving a very similar range of confidence intervals as that obtained here.

Table 41. Estimates of numbers of badger groups present in each county and region of Ireland, with 95% confidence limits derived from the Poisson distribution as before. Estimates for counties with less than c. *50 samples are unreliable.*

County/region	**Uncorrected mean main sett density**	**total squares**	**estimate of number of groups**	**lower 95% cf.l.**	**upper 95% cf.l.**
Carlow	0.63	8	**500**	197	1,118
Cavan	0.38	18	**675**	294	1,442
Clare	0.58	36	**2,100**	1,282	3,167
Cork	0.58	78	**4,500**	3,228	5,884
Donegal	0.33	56	**1,833**	1,138	2,824
Dublin	0.50	10	**500**	197	1,118
Galway	0.22	65	**1,422**	823	2,330
Kerry	0.37	54	**2,000**	1,282	3,002
Kildare	0.41	17	**700**	328	1,376
Kilkenny	1.25	20	**2,500**	1,677	3,603
Laois	0.47	19	**900**	446	1,677
Leitrim	0.38	16	**600**	261	1,282
Limerick	0.78	27	**2,100**	1,282	3,168
Longford	0.18	11	**200**	36	669
Louth	1.00	8	**800**	328	1,492
Mayo	0.24	63	**1,524**	823	2,415
Meath	0.79	28	**2,200**	1,376	3,228
Monaghan	0.50	13	**650**	283	1,389
Offaly	0.72	18	**1,300**	669	2,136
Roscommon	0.38	24	**900**	446	1,677
Sligo	0.39	18	**700**	328	1,377
Tipperary	0.36	45	**1,600**	960	2,540
Waterford	0.36	22	**800**	328	1,492
Westmeath	0.82	17	**1,400**	810	2,294
Wexford	0.40	25	**1,000**	533	1,763
Wicklow	0.26	19	**500**	197	1,118
South-West	0.49	132	**6,500**	5,042	8,161
Mid-West	0.62	85	**5,300**	3,976	6,810
West	0.25	152	**3,851**	2,666	5,197
North-West	0.37	82	**3,037**	2,058	4,227
Midlands	0.59	140	**8,277**	6,488	10,134
South	0.58	65	**3,800**	2,631	5,129
East	0.41	79	**3,200**	2,136	4,426
Republic	0.46	735	**33,977**	30,255	37,806
N. Ireland (preliminary estimates)	0.62	144	**8,894**	6,733	11,291

Numbers of badgers in Ireland, as given by estimates of mean group size

Extreme care must be placed upon estimates of total numbers of adult badgers present in Ireland, as derived from mean social group size. This is because the mean group size was obtained from studies carried out in 'licence' areas, which have been shown to be atypical of Ireland as a whole. However, it was also shown that few setts were present outside of areas typical of 'licence' areas, so that the degree of error should not be exaggerated, though it is unknown.

It would be a reasonable assumption, based on biological information, that the mean group size used here slightly overestimates actual mean group size for the island as a whole.

Given these qualifications, mean group size was estimated earlier at 5.90 adults per group (95% confidence limits: 5.37 to 6.44 adults).

Utilising the extremes of 95% confidence limits, the number of adult badgers in Ireland (Republic), estimated in this survey, was

200,470 adults

with lower limit of 162,470

and upper limit of 243,470 (values rounded to 10).

These limits correspond to a 90% confidence interval. It must be stressed that the upper limit is biologically unlikely, as mentioned above, and must be considered as an overestimate. Final analyses of data for Northern Ireland have not been completed, but a preliminary assessment of badger numbers on the island of Ireland is of interest. The data presented in Table 38 suggests a mean density of 0.62 groups km^{-2} in Northern Ireland, with 144 1km survey squares there.

The preliminary estimate for Northern Ireland is thus 0.62 * 144 * 100 social groups

= 8,894 social groups

= 8,894 *5.90 adults (mean) = 52,474 adults

The total for the island of Ireland is thus estimated at 200,470 + 52,470

= 252,940 adults (to nearest 10),

with a total of 42,871 social groups.

The above estimates of badger groups and numbers are virtually identical to those suggested by Smal (1992; Smal, 1993; also in Griffiths & Thomas, 1993; Griffiths, Griffiths & Thomas, 1993; Smal, Feore & Montgomery, 1992) of *c.* 250,000 badgers. However, this result is somewhat fortuitous, the original estimates having been altered by a downward estimate of group density of *c.* 15% (as reported earlier [page 136]), due to revision of sett classification criteria, which have been accompanied by an upward revision of mean group size (from 5.0, used as a 'guesstimate', to 5.90 based on calculated estimates from actual captures in 'licence' areas).

The estimate of 42,871 groups for the island is very similar to the estimate of 43,000 social groups for Britain obtained by Cresswell *et al* (1990), and has very similar confidence limits. In view of these similarities, but given the much larger land area of Britain, there is the extreme likelihood that a simplistic judgement may be made that badger densities are much higher in Ireland than in Britain. It must be stressed that this has ***not*** been found to the case: badgers in Britain are largely restricted to the south, the south-west, and to parts of Wales - a total area equivalent to that of Ireland. Overall badger densities in these regions and Ireland are very similar and in the approximate range 0.4 - 0.6 social groups km^{-2}. Moreover, high densities such as those observed in the Cotswolds in Gloucestershire - of *c*. 5-6 groups km^{-2} - have *not* been observed in Ireland.

Estimates of badger numbers in Ireland given by badgers captured at each sett type

An alternative to the above assessments, based on mean group size and active main setts, is given by the mean number of badgers captured at each sett type multiplied by the estimate of the capture rate at each sett type (of *c*. 74.9%, page 180). For various reasons, as already referred to in the earlier sections, there are grounds for considering that these estimates are likely to be less reliable than estimates obtained from the group means, as given above. The results will differ from estimates obtained from social group size for the following reasons: mean group size was assessed from 19 social groups, which it was considered had been snared at a high intensity. Data on captures at each sett type were determined from *all* data, regardless whether snaring had been carried out at high or low intensity. Whilst a snaring success rate of 74.9% was estimated for this data set, compilation of this corrective statistic was derived from a poor data set in terms of snaring effort, and is not as reliable as that obtained for the 19 groups.

Estimation of badger numbers in Ireland from the mean captures at each sett type requires the following data:

a) mean captures at each sett type (Table 25)

b) overall snaring success (value of 74.9% - Table 32)

c) estimates of total numbers of each sett type present in Ireland. The methodology for this has already been described in assessing numbers of active main setts (= number of social groups - page 199). As in that estimation, correction factors for areas of sea and lake can be avoided. Mean sett densities (Table 4) are multiplied by total number of survey squares (735 for the Republic) times 100 (as above).

Estimates are then obtained by multiplying elements a and c and dividing by snare success - b - (= 0.749). National badger numbers are estimated by adding together the values obtained for each sett type.

Extreme limits for the estimates are derived by obtaining the above estimates using firstly all lower estimates and then all upper estimates for i) sett density, ii) mean captures at each sett type, and iii) snare success. As before, this process exaggerates the degree of error associated with the estimate and it is not a 95% confidence interval but *c.* 86%.

i) confidence limits for the mean sett densities for annexe, subsidiary and outlier setts were not given in Table 4, and were obtained from the negative binomial distribution. The values for regions, and nationally, are given in Table 42 (on the next page).

ii) Confidence limits for mean captures at each sett type have been calculated according to the data distribution. Most badgers were captures at main setts; the frequency of captures by number of animals caught had a Poisson distribution, reflecting the range of badger group sizes (χ^2 goodness of fit test, $\chi^2_5 = 2.56$, $P = 0.87$, Figure 94). The large majority of badgers were captured at main setts, so the lack of precision of estimates for the other sett types is not critical. Badger captures at other sett types were apparently largely randomly distributed: Poisson curves were adopted to estimate confidence limits for captures at subsidiary ($\chi^2_1 = 0.07$, $P = 0.80$) and outlier setts (sample too small to test for goodness of fit), and a negative binomial distribution to captures at annexe setts (confirmed by U test, $P<0.05$; sample too small for χ^2 test), with a log transformation performed to obtain confidence limits. The distributions are illustrated in Figures 94, 95, 96 and 97, and the confidence limits given in Table 43 (below).

iii) the confidence limits for snare success were given in Table 32, but require simplification: the snare success rate was estimated at 0.749, with 95% confidence limits of: lower 0.817, upper 0.692 (*n.b.* because snare success is a divisor, upper estimates of badger numbers are given by the lower snare success value).

Table 43. Revised confidence limits for mean captures at each sett type.

	Main	Annexe	Subsidiary	Outlier
Mean	3.19	0.69	0.70	0.16
Lower limit	2.63	0.04	0.49	0.04
Upper limit	3.78	0.90	0.96	0.43
Variance:mean ratio	0.72	2.27	0.92	(3.00)

Results

The estimates of badger populations present in each region of Ireland and national totals are given in Table 44. These have been derived by multiplication of mean sett density * 100 * number of survey squares * mean captures at each sett type/snaring success. The 6 unsurveyed squares result in minor differences between the overall total and the total summed for regions.

Table 42. Means and confidence limits of (uncorrected) mean densities for active annexe, subsidiary and outlier setts, by region. Confidence limits were obtained by normal approximation. The variance:mean ratio indicates clumped data, and Standardised Morisita Coefficients above 0.5 are significant at the 95% level (*). All positive values of the coefficient indicate clumping (+).

Region	mean	95% cf. l. lower	95% cf. l. upper	variance:mean ratio	Morisita coeff.
Annexe setts (active)					
South-West	0.20	0.11	0.30	1.40	0.50 *
Mid-West	0.29	0.13	0.46	1.93	0.51 *
West	0.13	0.05	0.20	1.73	0.51 *
North-West	0.15	0.05	0.24	1.20	0.30 +
Midlands	0.18	0.10	0.25	1.08	0.16 +
South	0.22	0.09	0.34	1.23	0.31 +
East	0.19	0.08	0.30	1.36	0.50 *
Totals	0.19	0.15	0.23	1.45	0.50 *
Subsidiary setts (active)					
South-West	0.42	0.25	0.60	2.42	0.51 *
Mid-West	0.88	0.55	1.22	2.74	0.51 *
West	0.10	0.04	0.16	1.31	0.50 *
North-West	0.20	0.08	0.31	1.32	0.48 '*'
Midlands	0.60	0.36	0.84	3.38	0.51 *
South	0.69	0.37	1.01	2.43	0.51 *
East	0.32	0.16	0.47	1.50	0.50 *
Totals	0.43	0.35	0.51	2.11	0.50 *
Outlier setts (active)					
South-West	0.28	0.15	0.41	2.03	0.51 *
Mid-West	0.09	0.03	0.15	1.54	0.51 *
West	0.31	0.17	0.44	1.25	0.38 +
North-West	0.11	0.03	0.19	1.13	0.19 +
Midlands	0.54	0.39	0.69	1.44	0.50 *
South	0.55	0.29	0.82	2.09	0.51 *
East	0.25	0.12	0.39	1.36	0.50 *
Totals	0.29	0.24	0.35	1.70	0.50 *

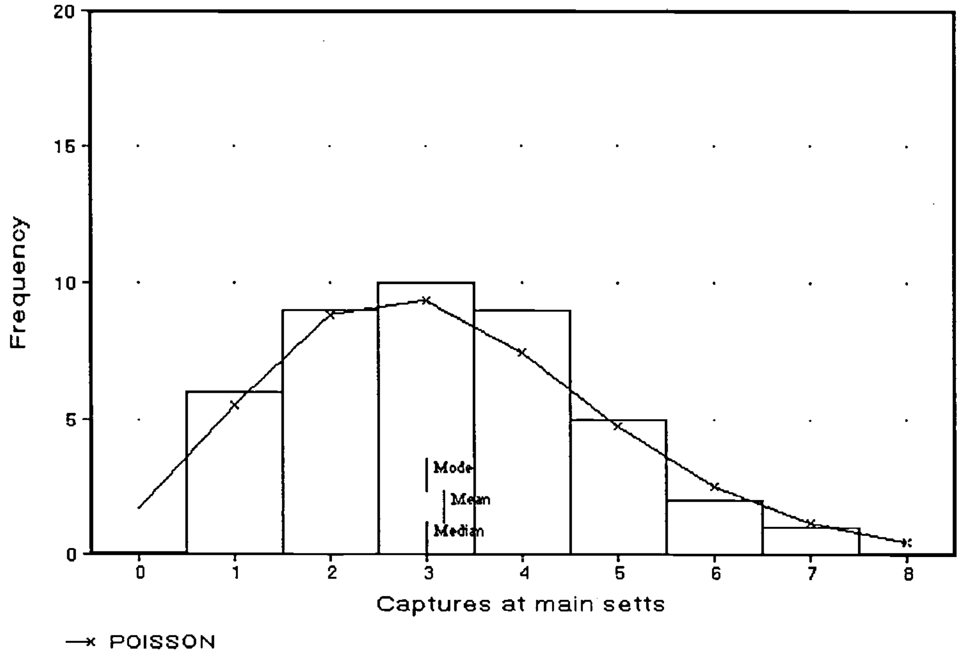


Figure 94. Badger captures at active main setts: the histogram is of frequency of occurrence of setts according to number of badgers captured at each sett.

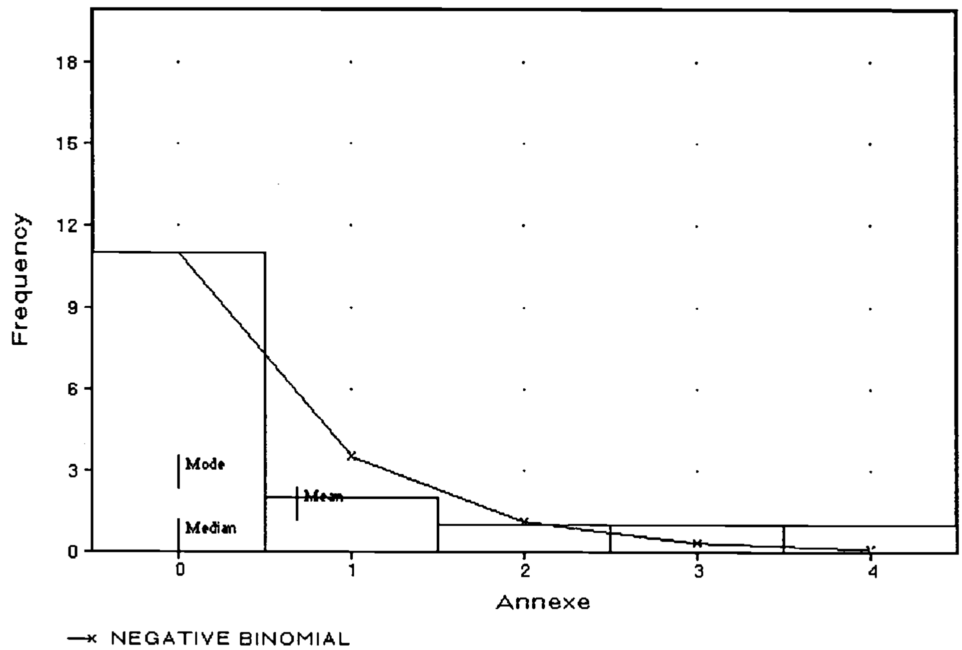


Figure 95. Badger captures at active annexe setts: the histogram is of frequency of occurrence of setts according to number of badgers captured at the sett.

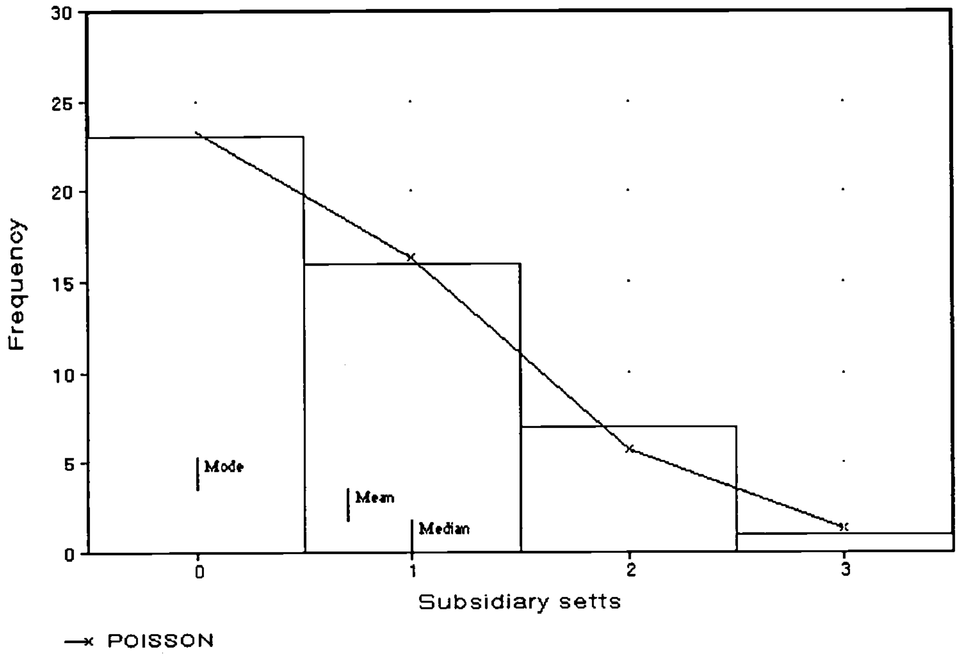


Figure 96. Badger captures at active subsidiary setts: the histogram is of frequency of occurrence of each sett according to number of badgers captured at the sett.

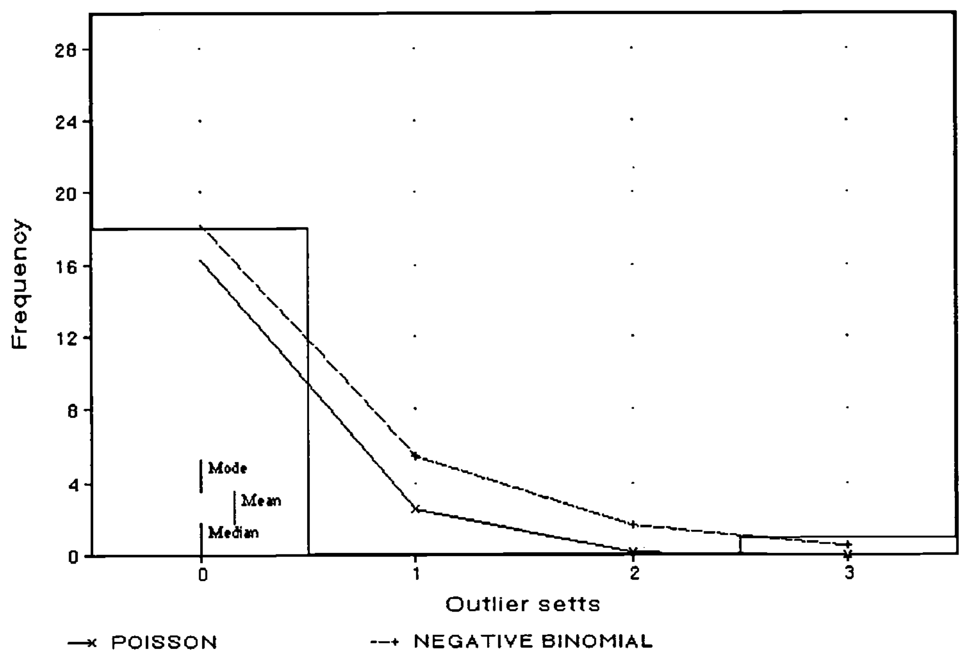


Figure 97. Badger captures at active outlier setts: the histogram is of frequency of occurrence of each sett according to number of badgers captured at the sett.

Table 44. Estimates of badgers present in Ireland, as derived from data on captures at each sett type. The final column corrects for snaring success.

Region	estimates of setts present in Ireland				estimates of badgers present				total	Corr-ected
	main	annx.	subs.	outl.	main	annx.	subs.	outl.		
South-West	6500	2700	5600	3700	20738	1856	3932	584	27110	36196
Mid-West	5300	2500	7500	2600	16910	1719	5266	411	24305	32450
West	3851	1925	1520	1317	12285	1324	1067	208	14884	19872
North-West	3037	1215	1620	911	9690	835	1137	144	11806	15762
Midlands	8277	2453	8380	7562	26409	1686	5884	1194	35172	46959
South	3800	1400	4500	3600	12124	962	3160	568	16814	22449
East	3200	1500	2500	2000	10210	1031	1755	316	13312	17773
Totals	33965	13693	31619	21690	108365	9414	22201	3425	143404	191461
Overall	33977	13712	31658	21677	108404	9427	22228	3423	143482	**191565**

The overall estimate for Ireland (Republic) is 191,565 adult badgers

which corresponds reasonably well with the earlier estimate of *c.* 200,450, but is lower as anticipated (by 4.4%).

Calculated lower and upper limits (which do not correspond to 95% confidence intervals are approximately a 85.7 % confidence interval - see Appendix 21) are:

lower estimate: 114,240

upper estimate: 296,310

The average of the two estimates (by social group size and by badger captures at each sett type) is 196,015. There are grounds for considering that the higher estimate, derived from mean badger social group size is a slight overestimate, and, likewise, there are grounds for considering that the estimate derived from mean captures at each sett type is an underestimate. **It may be reasonably concluded, given the ecological aspects of the data (and without any emphasis on the statistical limits), that a logical *approximation* of the badger population in Ireland (Republic) is *c.* 196,000 ≈ 200,000, and *c.* 250,000 for the island.**

THE DISTRIBUTION OF BADGERS IN IRELAND

Sett location according to habitat

The habitat in which each sett was located was entered on the badger sett record sheets in the field. The habitat was given by the habitat number as listed earlier, corresponding with the habitat survey proper. Often a sett of any size might be located in two habitat types, *e.g.* hedgerow and grassland. Surveyors were requested to only enter one value for a sett, with the habitat in which most of the sett was located being the more important. Data was missing for some setts. Additional habitat categories were also included and these were noted if present at the sett: namely, woodland edge, riverbank, roadside verge, dry ditch, and other man-made embankments (common examples were ring-forts or hill-forts).

The results for all setts (all regions) are given in Table 45 and for active setts only in Table 46. The data is presented graphically in Figures 98 to 102. The habitat categories numbered in the graphs are described in Table 45.

The data show that setts were located primarily in several of the habitat categories, principally hedgerow and treeline, in woodlands, in areas of scrub, bracken, or in grassland. (*n.b.* as described earlier, some of these areas of scrub consisted of field boundaries, best described as having a low scrub vegetation rather than a hedgerow type vegetation).

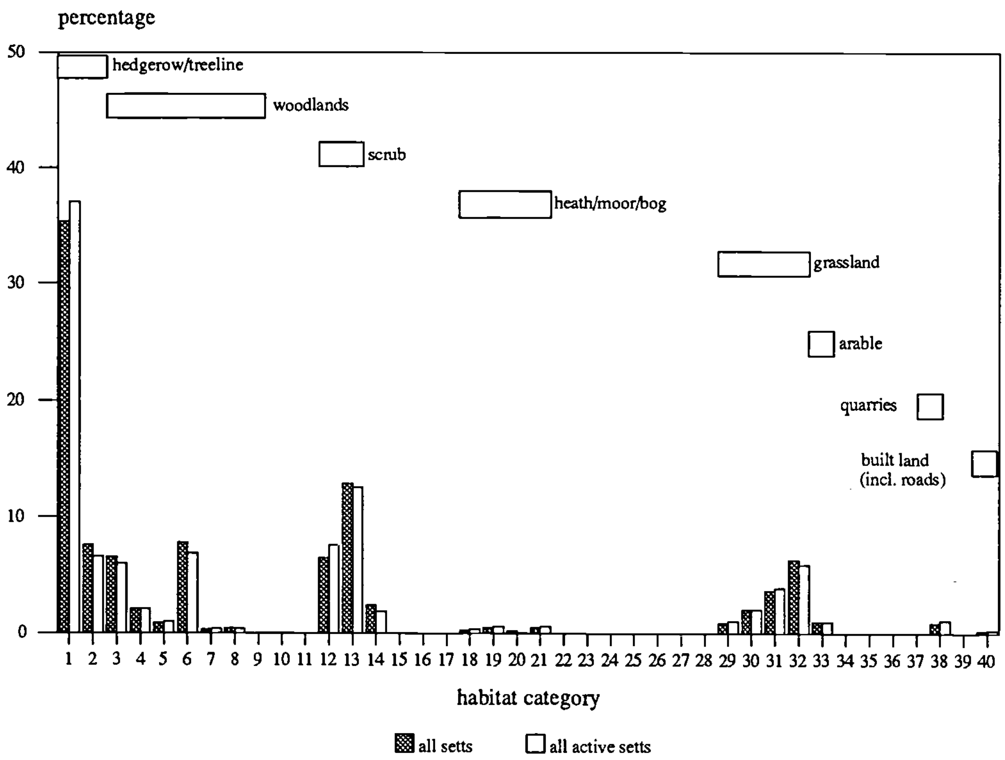


Figure 98. Sett distribution (all setts) according to habitat categories in which they were located.

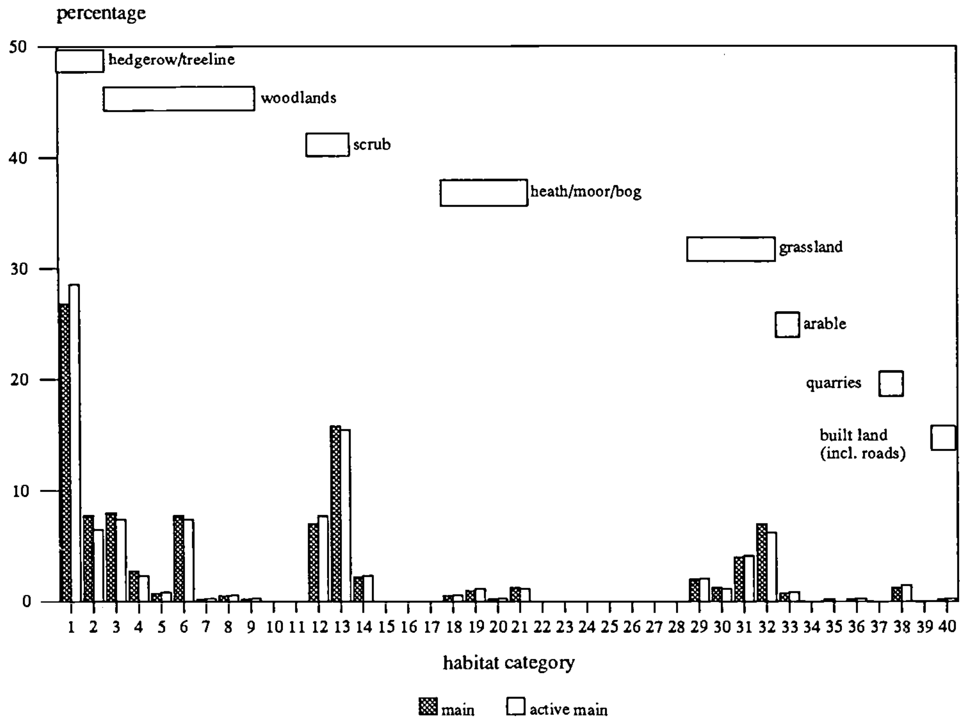


Figure 99. Distribution of main setts according to habitat type in which they were located.

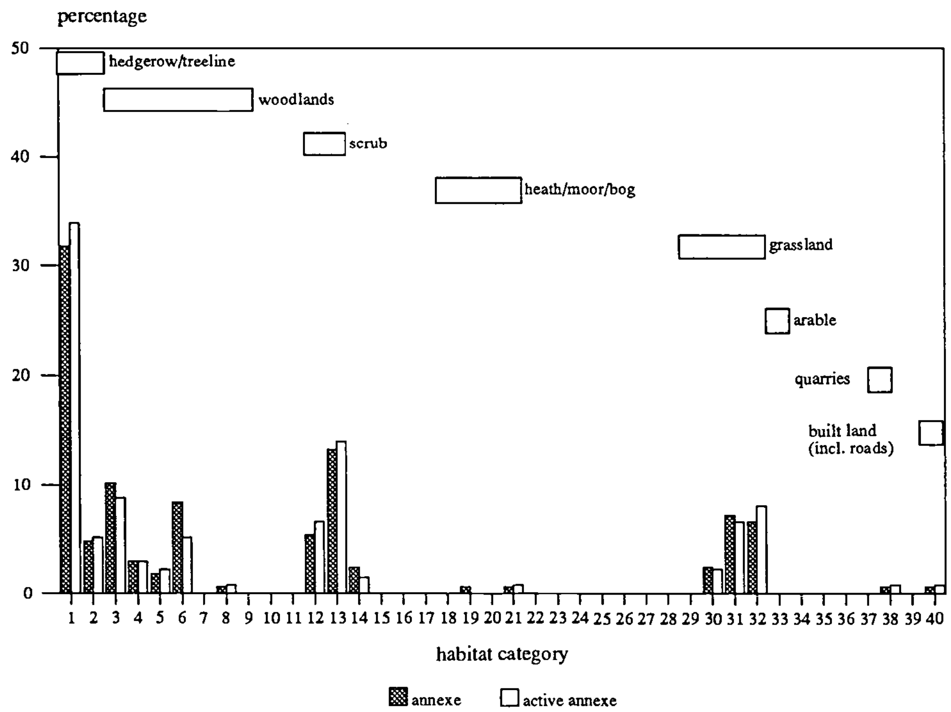


Figure 100. Distribution of annexe setts according to habitat type in which they were located.

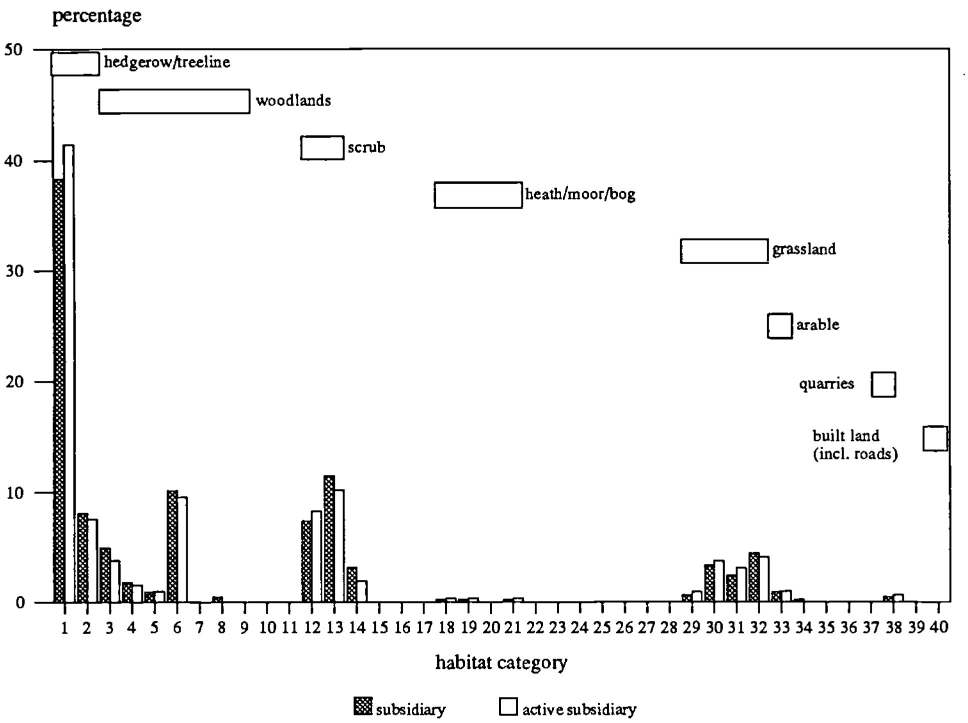


Figure 101. Distribution of subsidiary setts according to habitat in which they were located.

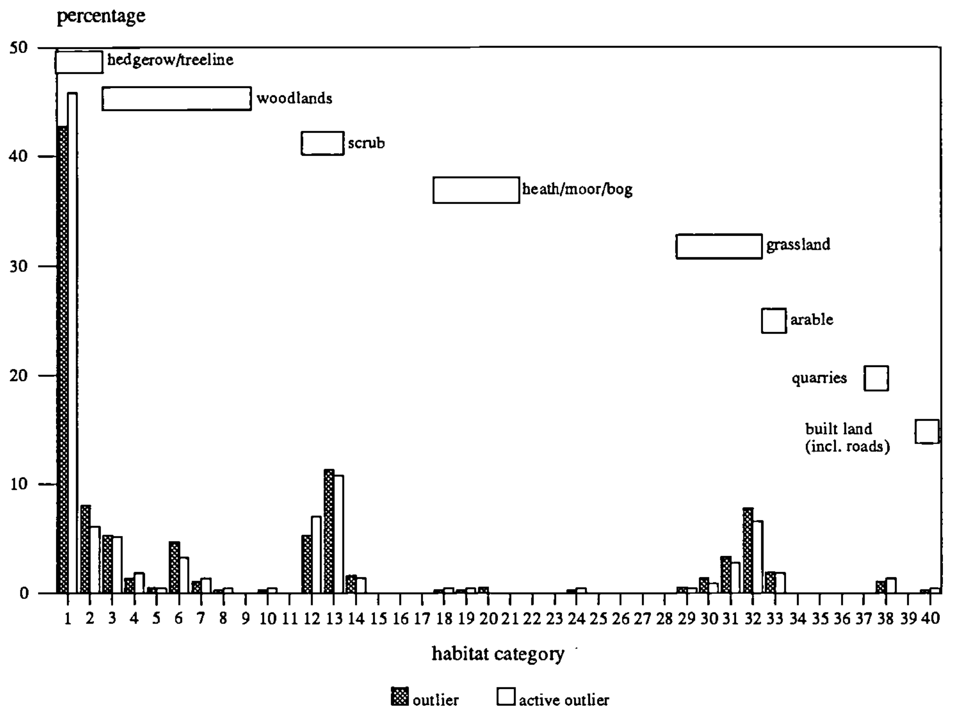


Figure 102. Distribution of outlier setts according to habitat in which they were located.

Table 45. Frequency of occurrence of badger setts in each of the 40 principal habitat types.

habitat number	habitat description	numbers				
		all setts	main	annexe	subsd.	outlier
1	hedgerow	485	107	53	170	155
2	treelines	104	31	8	36	29
3	semi natural broad-leaved woodland	90	32	17	22	19
4	broad-leaved plantation	29	11	5	8	5
5	semi-natural coniferous woodland	12	3	3	4	2
6	coniferous plantation	107	31	14	45	17
7	semi-natural mixed woodland	5	1	0	0	4
8	mixed plantation	6	2	1	2	1
9	young mixed/broad-leaved plantation	1	1	0	0	0
10	recently felled woodland	1	0	0	0	1
11	parkland	0	0	0	0	0
12	tall scrub	89	28	9	33	19
13	low scrub	177	63	22	51	41
14	bracken	33	9	4	14	6
15	coastal sand dunes	0	0	0	0	0
16	coastal sand or mudflats	0	0	0	0	0
17	coastal shingle or boulder beaches	0	0	0	0	0
18	lowland heath	4	2	0	1	1
19	heather moorland	7	4	1	1	1
20	blanket bog	3	1	0	0	2
21	raised bog	7	5	1	1	0
22	marginal inundations	0	0	0	0	0
23	coastal marsh	0	0	0	0	0
24	wet ground	1	0	0	0	1
25	standing natural water	0	0	0	0	0
26	standing man-made water	0	0	0	0	0
27	running natural water	0	0	0	0	0
28	running canalised water	0	0	0	0	0
29	upland unimproved grassland	13	8	0	3	2
30	lowland unimproved grassland	29	5	4	15	5
31	semi-improved grassland	51	16	12	11	12
32	improved grassland	87	28	11	20	28
33	arable	14	3	0	4	7
34	amenity grassland	1	0	0	1	0
35	unquarried inland cliffs	1	1	0	0	0
36	vertical coastal cliffs	1	1	0	0	0
37	sloping coastal cliffs	0	0	0	0	0
38	quarries and open-cast mines	12	5	1	2	4
39	bare ground	0	0	0	0	0
40	built land	3	1	1	0	1
	Totals	**1373**	**399**	**167**	**444**	**363**

Table 46. Frequency of occurrence of active badger setts according to the habitat type in which they were located.

habitat number	habitat description	numbers				
		all setts	main	annexe	subsd.	outlier
1	hedgerow	370	96	46	130	98
2	treelines	66	22	7	24	13
3	semi natural broad-leaved woodland	60	25	12	12	11
4	broad-leaved plantation	21	8	4	5	4
5	semi-natural coniferous woodland	10	3	3	3	1
6	coniferous plantation	69	25	7	30	7
7	semi-natural mixed woodland	4	1	0	0	3
8	mixed plantation	4	2	1	0	1
9	young mixed/broad-leaved plantation	1	1	0	0	0
10	recently felled woodland	1	0	0	0	1
11	parkland	0	0	0	0	0
12	tall scrub	76	26	9	26	15
13	low scrub	126	52	19	32	23
14	bracken	19	8	2	6	3
15	coastal sand dunes	0	0	0	0	0
16	coastal sand or mudflats	0	0	0	0	0
17	coastal shingle or boulder beaches	0	0	0	0	0
18	lowland heath	4	2	0	1	1
19	heather moorland	6	4	0	1	1
20	blanket bog	1	1	0	0	0
21	raised bog	6	4	1	1	0
22	marginal inundations	0	0	0	0	0
23	coastal marsh	0	0	0	0	0
24	wet ground	1	0	0	0	1
25	standing natural water	0	0	0	0	0
26	standing man-made water	0	0	0	0	0
27	running natural water	0	0	0	0	0
28	running canalised water	0	0	0	0	0
29	upland unimproved grassland	11	7	0	3	1
30	lowland unimproved grassland	21	4	3	12	2
31	semi-improved grassland	39	14	9	10	6
32	improved grassland	59	21	11	13	14
33	arable	10	3	0	3	4
34	amenity grassland	0	0	0	0	0
35	unquarried inland cliffs	0	0	0	0	0
36	vertical coastal cliffs	1	1	0	0	0
37	sloping coastal cliffs	0	0	0	0	0
38	quarries and open-cast mines	11	5	1	2	3
39	bare ground	0	0	0	0	0
40	built land	3	1	1	0	1
	Totals	**1000**	**336**	**136**	**314**	**214**

Table 47. Frequency of occurrence of setts in the other habitat types.

habitat description	**numbers all setts**	**main**	**annexe**	**subsd.**	**outlier**
All setts					
woodland edge	169	60	27	51	31
riverbank	95	40	13	18	24
railway embankments	25	7	3	10	5
roadside verges	13	7	1	2	3
dry ditches	497	125	60	178	134
other man-made features	98	40	11	24	23
Totals	897	279	115	283	220
none of the above	481	123	52	162	144
Active setts					
woodland edge	121	43	21	36	21
riverbank	81	38	13	12	18
railway embankments	20	6	3	6	5
roadside verges	9	6	0	1	2
dry ditches	375	109	51	138	77
other man-made features	66	32	8	14	12
Totals	672	234	96	207	135
none of the above	330	103	40	107	80

The graphs illustrate that there were no differences between the habitat location of all setts as opposed to active setts only (for all main setts *vs.* active main setts χ^2_{39} =2.59, P = 1.00). The distribution of main and annexe setts is quite similar, with a slightly higher proportion of the latter in hedgerow and grassland. Whilst the overall distribution of minor setts is similar to that of main setts and annexes, a greater proportion of minor setts are found in hedgerow (*c.* 40% *cf. c.* 30%). The occurrence of setts in the ancillary habitat types (Table 47) is illustrated in Figure 103 for all setts, and in Figure 104 for each of the sett types.

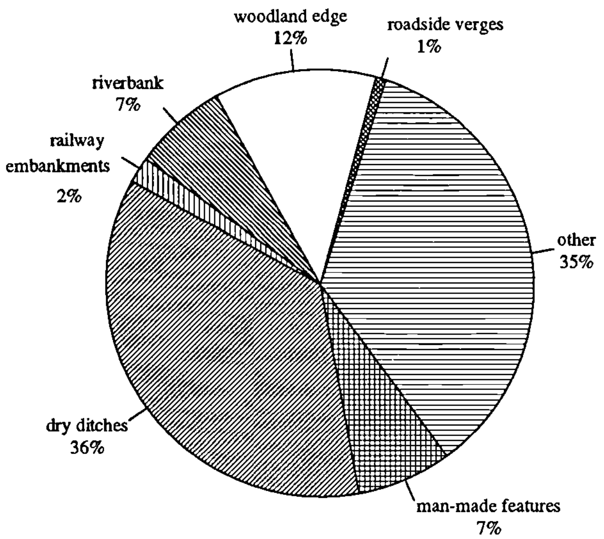


Figure 103. Occurrence of setts (all types) in the ancillary habitat categories (listed in Table 47).

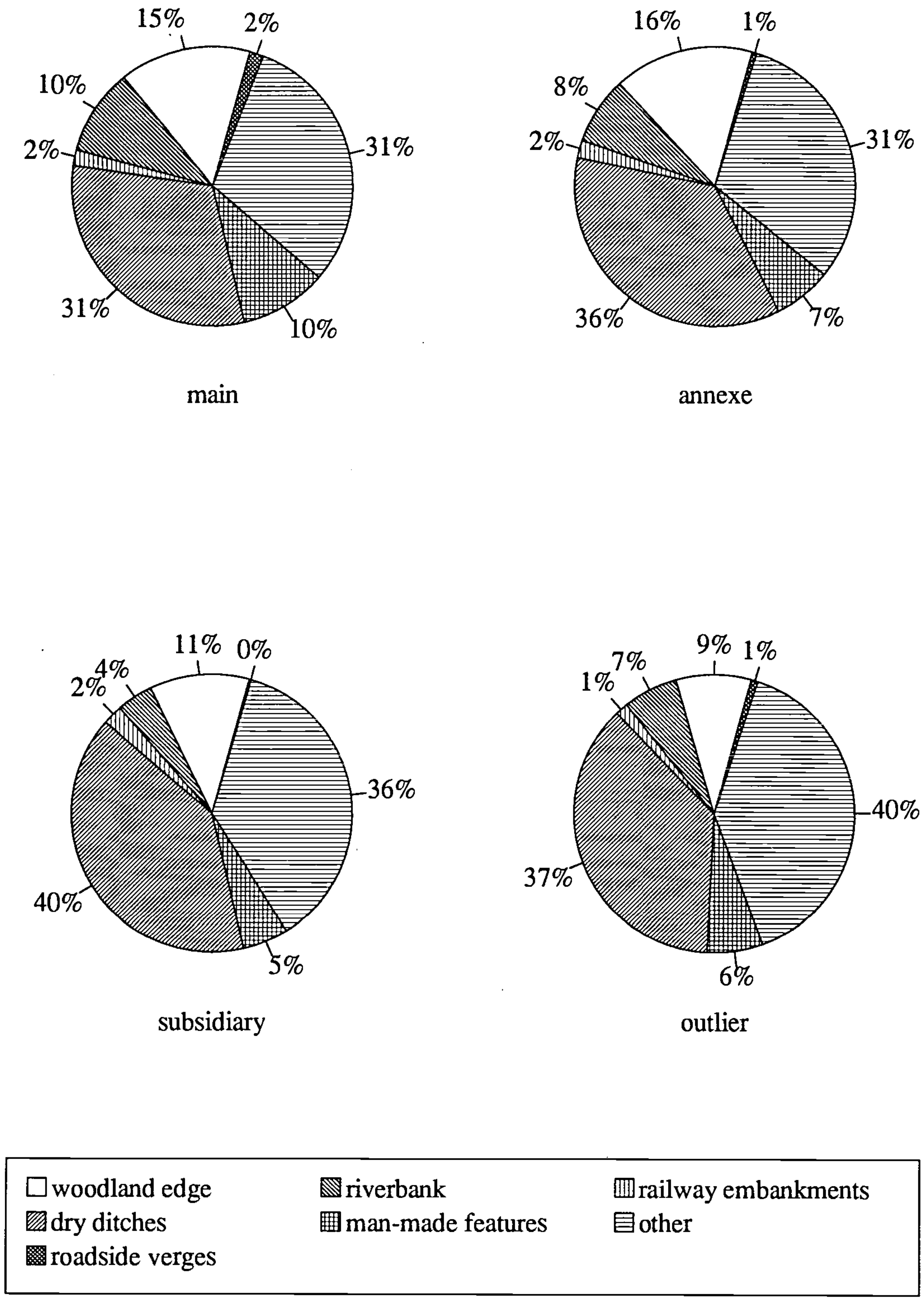


Figure 104. Frequency of occurrence of setts in the ancillary habitat categories (Table 47).

The pie charts show that a greater proportion of minor setts were recorded in dry ditches (*c.* 38.5%) than were main or annexe setts (31-36%), though this was the category where most setts were located (*n.b.* only 897 of 1378 setts were placed in one of these additional categories, the remaining setts being classed in these pie charts as 'other'). Many setts were also recorded in woodland edge (12%) - in this case, main and annexe setts were recorded as being located in this habitat more frequently (*c.* 15%) than the minor setts (*c.* 10%). In combination with the previous bar charts, although most setts of any type were located in hedgerow (often synonymous with dry ditch), a greater proportion of main and annexe setts would be found in woodland than would minor setts. Many setts were also located along riverbanks (7% of all setts) and railway embankments (2% of all setts).

The fore-going charts and tables essentially describe the habitats in which setts of various kinds (by sett type or by sett activity) were located in Ireland. A regional breakdown would be likely to reveal differences between regions, which would have resulted from the overall geographical differences between the regions and variation in the overall habitat composition of the regions, as well as being affected by any preference of some habitat over another in choice of location of sites for setts by badgers. Therefore, rather than presenting more graphics of sett location in each region, it is necessary to examine whether badgers actively select certain habitats for sett location. Certainly, given the relatively small average area of hedgerow in most 1km squares, the high proportion of setts in hedgerow suggests that hedgerows are habitats that are actively selected by badgers.

Habitat preferences for sett location: analyses

The habitat data recorded for each badger sett consisted of a numeric descriptor for each of the 40 categories listed in Table 45 - which do not include a breakdown of some of the categories as indicated in # *Habitat Survey: Methods*. The categories here, exclude, for example, a breakdown of built land into roads and land built upon. An assessment is made here, therefore, of the expected numbers of setts in each of the *40* principal habitat categories.

If there was no habitat selection by badgers, in location of setts, the expected number of setts is given by the proportion of the land area of each habitat type. The difference between this and the proportion of setts observed in each habitat type suggests a preference for, or an avoidance of, location of setts in that habitat. The overall national proportions of each habitat type are given in Table 16, where the percentage cover of each habitat type has been corrected for areas of sea and lake, *etc.* These habitat types have been grouped into 15 principal groupings, and their proportions and the proportion of setts observed are given in Table 48. Area of hedgerow is included, with the observation that hedgerow area was initially measured as a linear feature, which gives rise to a slight overestimation of the total land area for most squares. This was demonstrated to be of the order of 1.5% nationally (page 71), and, therefore, unlikely to be an error of substantial significance in the following calculations.

Statistical tests

There is some debate in the literature about the most appropriate means of statistically examining the use of resources by individuals or species in relation to the availability of that resource: *i.e.* resource selection. This is a general debate, involving several different approaches, each having its pitfalls (Alldredge & Ratti, 1986, 1992; Thomas & Taylor, 1990;

Johnson, 1980; Kincaid & Bryant, 1983). Krebs (1989) describes a number of preference indexes (*e.g.* Manly's alpha, Johnson's rank preference). The selection of the technique to adopt depends on an assessment of how the data was collected and how the data is likely to be statistically distributed.

The area of research into resource utilisation by species, populations, or individuals, is one of substantial importance in wildlife management - for very obvious reasons. The matter concerns resource use and resources available to any species, and how these may be managed (by humans), either when the species is a pest and requires some management (this might be considered to be the case here), or when the species is under threat, and requires conservation. It is thus unfortunate that the statistical approaches remain diverse, so that results obtained from one method may give overall results that differ substantially from another.

The simplest approach is to conduct a χ^2 goodness of fit test, of observed proportions against expected proportions for each habitat type. Some reasonable care has to be taken not to include too many habitat categories, and also to group habitat categories that may be largely considered to be of essentially the same value to the species. Thus, it is reasonable to group all deciduous woodland habitats together, and also to create another group, for examination, which might be *all* woodland habitats. But to group woodlands and grasslands together would not make ecological sense, in terms of the species' *known* preferences or its ecology; nor would it make sense, from the viewpoint of making practical assessments about whether that species is more likely to be found in that habitat group or not. However, these judgements for grouping imply *a priori* assessments of which habitats should be considered similar habitat types.

Perhaps the most important difference in the various techniques adopted by different researchers is whether emphasis should be placed on the individual or the overall means. In Table 48, *means* are utilised, *i.e.* the overall proportions are given of expected and observed values in each habitat. It is possible, instead, to evaluate the habitat choices available to each individual or group, in relation to the habitats available in its locality or its range (territory). In this report and from the data available, it is the overall count of setts, rather than habitat use by any particular badger group or individual that was the basis of assessments, so that the other option is effectively ruled out, for all practical purposes. The study here falls into the category designated as *Design 1* by Thomas & Taylor (1990).

However, the problem of aggregation, or clumping, of setts then arises: if setts are clumped for any biological (/ecological) reason, then a simplistic approach to the data yields unreliable conclusions. Thus, it has already been determined (and *known* that, *by definition*) that annexes and subsidiaries (for example) tend to be grouped around the main sett. Thus, these are *quite* likely to occur in the same habitat type as each other - this leads to an unreliable inference from a simple χ^2 test, as these groupings exaggerate differences. It may be concluded that the grouping of ancillary or minor setts around a main sett will yield biased results with regard to habitat/resource use. It is, therefore, intended, within this report, to concentrate on main setts only - as these are separated by distance, and are more randomly distributed ('randomly' not suggesting purely random choice of habitat - but a statistical distribution). In any case, it is of more consequence that main setts relate directly to numbers of social groups [*n.b.* all main setts are considered here, rather than only active main setts, because the data has shown no apparent differences between habitat selection between active and inactive main setts, so the basis for inclusion of all the main setts holds true, and adds data to the analyses performed].

Various methods of analysis have been referred to above. Given the particular circumstances of main badger sett location relative to habitat type, the use of the approach first suggested by Neu, Byers & Peek (1974), appears appropriate. The method was adopted, originally by Neu *et al* (1974), and further described by Alldredge & Ratti (1986, 1992) and Byers, Steinhorst & Krausman (1984). World-wide, this method has been used by Singer *et al* (1981), Ringleman & Longcore (1982), Steventon & Major (1982), Servheen (1983), Jenkins & Starkey (1984), Baber & Coblentz (1986) and others. Within the immediate context of badger ecology in Europe, this method was also adopted by Cresswell *et al* (1990) [for the UK] and by O'Corry-Crowe (1992) [in an Irish study - in Co. Offaly]. Another technique, Johnson's rank preference (1980) is also considered, but only briefly, as the method, in this case, does not allow a statistical analysis of the data.

It might also be considered appropriate, since the same method was adopted in the UK for the badger survey there, and, in Ireland (by O'Corry-Crowe), that the technique be applied in this report. This would allow similar conclusions to be drawn based on similar data sets and on similar analytical techniques.

Unfortunately, comparisons cannot not be easily made. Cresswell *et al* (1990) *and* O'Corry-Crowe (1992) would both appear to have failed to correctly apply the statistical formulae to the data - each, apparently, for different reasons. The basis of the statistical technique is simple but substantial confusion has nevertheless arisen, apparently through lack of reference to the original work. It is anticipated that a short publication examining and describing the technique (generally, and not only with regard to badgers) is necessitated. Attention, here, is drawn to the fact that the statistical conclusions drawn by these badger researchers are invalid, though the errors are not of substantial consequence. Details of the methodology (and its misuses) are given in Appendix 21.

For the Neu *et al* method, there are a number of limitations (Alldredge & Ratti, 1986, 1992):

firstly, the number of habitats under consideration should not be large, as the analysis depends on normal approximation to the binomial in each case (in this case, a preliminary analysis is carried out on 40 habitat groups, for the sake of completeness [and this analysis includes far too many sub-divisions], but these were then grouped into 12 principal habitat groups, a number of habitat groupings which is acceptable [Byers, Steinhorst & Krausman, 1984).

and secondly, that all observations are independent (which precludes the analysis of aggregated animals, and makes analysis of individual animals tenuous because locations may not be independent) [this matter has already been considered by restricting analyses to main setts only - which have been shown not to be aggregated, unlike annexe and subsidiary setts].

Following a simple χ^2 goodness of fit test: whether a particular habitat is selected for or against is determined by examination of the expected value (proportion) against the observed value (proportion), the *former's* confidence limits having been calculated by use of an adjusted z statistic.

The area of each habitat type determines the *expected* proportion of setts. The basis for calculating the confidence intervals for the *observed* values in each habitat type was given by Neu *et al* (1974) and is based upon Bonferroni adjustments to the confidence limits, as given in Miller (1966). These adjust the z values according to the number of (in this case) habitats that are included (details in Appendix 21)

Results

Table 48 presents results for the country, including 39 habitat types (with values corrected for areas of sea, lake, *etc*.). The areas of the habitat types are given, along with the observed number of main setts located in that habitat type, and the expected number of main setts, as given by the proportion of the area. The area of hedgerows and of treelines (which included the value for bare treelines) was calculated as before, by assuming a mean hedgerow width of 2.5 m. As these habitat types were measured by length, the total mean area (per 1km square) of habitats estimated rises above 100% to 101.5 ha km^{-2}.

A χ^2 goodness of fit test showed that selection or avoidance of habitats was occurring in the location of setts by badgers:

$$\chi^2_{30} = 4612.8, P<0.0001.$$

Table 49, repeats the results given in Table 48, but on the basis of proportions observed and expected, and the Neu *et al* method applied. With 39 habitats, the z statistic is given by

$$z_{(1-0.2/[2*39])} = z_{(0.9974)} = 2.80$$

where $\alpha = 0.2$, giving 80% family confidence intervals for the observed values. Since k is large and the size of some of the observations small (*e.g*. only 9 main setts observed in bracken), this preliminary analysis set α at a high value, giving a relatively narrow width for the confidence interval.

Where the expected value falls outside the range of the confidence intervals for the observed values, then the habitat has been selected for or avoided. In Table 49, there is active selection for location of main setts in hedgerow, treeline, semi-natural broad-leaved woodland, broad-leaved plantation and areas of tall and low scrub. Young coniferous plantation, heather moorland, blanket bog, lowland unimproved grassland, semi-improved grassland, improved grassland and arable land were actively avoided. Clearly, other habitat types were also being selected or avoided, but these observations were not statistically significant given the wide confidence intervals. Habitats where no setts at all were found are excluded from calculations. An examination of the ratios of observed : expected values is quite revealing (Table 49). Thus main setts are 21 times more likely to be located in hedgerow than expected, 36 times more often than expected in treelines, 18 times more often than expected in semi-natural broad-leaved woodland, 16 times more often than expected in semi-natural coniferous woodland, 12 times more often than expected in broad-leaved plantation, and 13 times more often in young mixed or broad-leaved plantation. Other habitat categories in which setts were found much more often than expected were semi-natural mixed woodland (x5), mixed plantation (x4), tall scrub (x9), low scrub (x9), bracken (x6), quarries (x9) and vertical coastal cliffs (x5).

Some habitats were avoided, so the ratio of observed to expected was a fraction: in particular, for heather moorland (0.2), lowland unimproved grassland (0.2), semi-improved grassland (0.3), improved grassland (0.2), arable land (0.1), and built land (0.1).

The habitat groups and occurrence of main setts in Table 49 were examined and 12 principal habitats and habitat groupings were included in further analyses, and their areas and main setts re-calculated as before. The area of these 12 habitat types comprises *c.* 96% (97.0 ha) of the total corrected land area (101.5 ha), so that almost every main sett observed (397 of 399, 99.5%) occurred in these 12 habitat groups. It was considered statistically appropriate to lump the remaining habitat types together and to include this is as one habitat type (labelled 'other') in the calculations, rather than to arbitrarily exclude this component of the total area surveyed. The total number of principal habitat groups was, thus, 13. [Means for these habitat groupings were obtained by summing the individual means observed for each habitat type].

For the estimation of 99% family confidence intervals, decreasing α to $\alpha = 0.01$ (with $1 - \alpha = 0.99$):

$k = 13$

$\alpha = 0.01$

$z_{(0.99962)} = 3.37$ (z value obtained from Afifi & Azen [1979] giving tables for the z statistic to 9 decimal places).

The smaller number of habitat groupings and the larger sample size of each group (number of badger setts recorded) allowed the habitat preferences to be examined at a much greater confidence level (though the calculations were repeated with 10% and 20% confidence intervals to check changes in habitat preference at different confidence levels). The results are given in Table 50, and are much clearer than those presented in Table 49, with statistically significant selection or avoidance being indicated for almost every one of 12 habitat groups ($P<0.01$). Hedgerows and treelines are actively selected for, as are semi-natural woodlands and also plantations, and areas of scrub. All these habitats provide cover. Bracken was found to be selected for at the 80% level ($P<0.20$) but not at the 10% level ($P<0.10$). Actively avoided are moorland and bog, unimproved grassland and improved grasslands (including semi-improved grassland), built land, and 'other' habitats. These habitats tend to be open or liable to disturbance/interference.

As noted above, far more main setts were observed than in hedgerow (x21) and in treelines (x36); of the groupings, in semi-natural woodlands (x16), in plantations (x2), in bracken (x5) and in scrub (x9) and also in quarries (x9) but this latter figure was not significant ($P>0.20$). Fewer main setts than expected were observed in heath, moorland and bog (x0.2), unimproved grassland (x0.3), improved grassland (x0.2), arable land (x0.1), built land (x0.1) and 'other habitats' (x0.1).

Table 48. Areas of each habitat type (corrected values for the Republic), and observed numbers of main setts in each habitat type, followed by the expected number of main setts, as determined by the proportion of the habitat's area.

habitat no.	habitat type	corrected area (ha km^{-2})	main setts observed	main setts expected
1	hedgerow (area)	1.29	107	5.1
2	treelines (area, incl. bare treeline)	0.22	31	0.9
3	Semi-natural broad-leaved woodland	0.45	32	1.8
4	Broad-leaved plantation	0.23	11	0.9
5	Semi-natural coniferous woodland	0.05	3	0.2
6	Coniferous plantation	3.15	31	12.4
6Y	Young coniferous plantation	1.72		6.8
7	Semi-natural mixed woodland	0.05	1	0.2
8	Mixed plantation	0.12	2	0.5
9	Young mixed or broad-leaved plantation	0.02	1	0.1
10	Recently felled woodland	0.08	0	0.3
11	Parkland	0.07	0	0.3
12A	Tall scrub (area)	0.77	28	3.0
13A	Low scrub (area)	1.77	63	6.9
14	Bracken	0.40	9	1.6
15	Coastal sand dunes	0.19	0	0.8
16	Coastal sand or mudflats			0.0
17	Coastal shingle or boulder beaches			0.0
18	Lowland heath	0.65	2	2.5
19	Heather moorland	6.13	4	24.1
20	Blanket bog	6.09	1	23.9
21	Raised bog	1.96	5	7.7
20/21W	Worked peat	0.94		3.7
22	Marginal inundations	0.13	0	0.5
23	Coastal marsh	0.14	0	0.5
24	Wet ground	1.37	0	5.4
25	Standing natural water			0.0
26	Standing man-made water			0.0
27A	Running natural water (area)	0.50	0	2.0
28A	Running canalised water (area)	0.31	0	1.2
29	Upland unimproved grassland	3.45	8	13.6
30	Lowland unimproved grassland	8.01	5	31.5
31	Semi-improved grassland	14.54	16	57.1
32	Improved grassland	33.71	28	132.5
33 TOT	Arable (total)	7.50	3	29.5
34	Amenity grasslands	0.43	0	1.7
35	Unquarried inland cliffs	0.22	1	0.9
36	Vertical coastal cliffs	0.05	1	0.2
37	Sloping coastal cliffs	0.02	0	0.1
38	Quarries and open-cast mines	0.13	5	0.5
39	Bare ground	0.91	0	3.6
40/41TOT	Built land area	3.65	1	14.3
Other	Unspecified	0.12		0.5
TOTAL	Totals	101.54	399	399.0

Table 49. Selection or avoidance of habitats by badgers in the location of badger main setts. 80% family confidence intervals are given.

habitat no.	description	proportion of area	proportion of main setts observed	lower cf.l.	upper cf.l.	actively selected? Yes=1	actively avoided? Yes=1	ratio obs/exp
1	hedgerow (area)	0.013	0.268	0.206	0.330	1	0	21.1
2	treeline (area)	0.002	0.078	0.040	0.115	1	0	35.5
3	Semi-natural broad-leaved woodland	0.004	0.080	0.042	0.118	1	0	18.0
4	Broad-leaved plantation	0.002	0.028	0.005	0.051	1	0	12.0
5	Semi-natural coniferous woodland	0.000	0.008	-0.005	0.020	0	0	15.9
6	Coniferous plantation	0.031	0.078	0.040	0.115	1	0	2.5
6Y	Young coniferous plantation	0.017	0.000	0.000	0.000	0	1	0.0
7	Semi-natural mixed woodland	0.000	0.003	-0.005	0.010	0	0	5.0
8	Mixed plantation	0.001	0.005	-0.005	0.015	0	0	4.2
9	Young mixed or broad-leaved plantation	0.000	0.003	-0.005	0.010	0	0	12.6
10	Recently felled woodland	0.001	0.000					
11	Parkland	0.001	0.000					
12A	Tall scrub (area)	0.008	0.070	0.034	0.106	1	0	9.2
13A	Low scrub (area)	0.017	0.158	0.107	0.209	1	0	9.1
14	Bracken	0.004	0.023	0.002	0.043	0	0	5.7
15	Coastal sand dunes	0.002	0.000					
16	Coastal sand or mud flats							
17	Coastal shingle or boulder beaches							
18	Lowland heaths	0.006	0.005	-0.005	0.015	0	0	0.8
19	Heather moorlands	0.060	0.010	-0.004	0.024	0	1	0.2
20	Blanket bogs	0.060	0.003	-0.005	0.010	0	1	0.0
21	Raised bogs	0.019	0.013	-0.003	0.028	0	0	0.7
20/21 W	Worked peat	0.009	0.000					
22	Marginal inundations	0.001	0.000					
23	Coastal marsh	0.001	0.000					
24	Wet ground	0.013	0.000					
25	Standing natural water							
26	Standing man-made water							
27A	Running natural water (area)	0.005	0.000					
28A	Running canalised water (area)	0.003	0.000					
29	Upland unimproved grassland	0.034	0.020	0.000	0.040	0	0	0.6
30	Lowland unimproved grassland	0.079	0.013	-0.003	0.028	0	1	0.2
31	Semi-improved grassland	0.143	0.040	0.013	0.068	0	1	0.3
32	Improved grassland	0.332	0.070	0.034	0.106	0	1	0.2
33 TOT	Arable (total)	0.074	0.008	-0.005	0.020	0	1	0.1
34	Amenity grasslands	0.004	0.000					

Table 49 contd.

habitat no.	description	proportion of area	proportion of main setts observed	lower cf.l.	upper cf.l.	actively selected? Yes=1	actively avoided? Yes=1	ratio obs/exp
36	Vertical coastal cliffs	0.000	0.003	-0.005	0.010	0	0	5.1
37	Sloping coastal cliffs	0.000	0.000					
38	Quarries and open-cast mines	0.001	0.013	-0.003	0.028	0	0	9.4
39	Bare ground	0.009	0.000					
40/41 TOT	Built land area (incl. roads)	0.036	0.003	-0.005	0.010	0	1	0.1
Other	Unspecified	0.001	0.000					
Total	Totals	1.000	1.000					

Table 50. Selection or avoidance of habitat types in sett location by badgers. The habitats have been grouped into 12 principal groupings (plus one grouping = all other habitats). 99% family confidence intervals are given (P<0.01), and also the ratio of observed : expected values.

habitat type or grouping	corrected area	proportion of area	main setts observed	proportion of main setts observed	obs/exp. ratio	low. cf.l.	upp. cf.l.	active selection? Yes=1	active avoidance? Yes=1
hedgerow area	1.29	0.013	107	0.268	21.1	0.193	0.343	1	0
total treeline area	0.22	0.002	31	0.078	35.5	0.033	0.123	1	0
semi-natural woodlands	0.55	0.005	36	0.090	16.6	0.042	0.139	1	0
plantations (coniferous, broad-leaved, mixed)	5.24	0.052	45	0.113	2.2	0.059	0.166	1	0
total scrub area	2.54	0.025	91	0.228	9.1	0.157	0.299	1	0
bracken	0.40	0.004	9	0.023	5.7	-0.002	0.048	0	0
heath, moorland, bog	15.76	0.155	12	0.030	0.2	0.001	0.059	0	1
total unimproved grassland	11.46	0.113	13	0.033	0.3	0.003	0.063	0	1
total improved grassland	48.26	0.475	44	0.110	0.2	0.057	0.163	0	1
arable land	7.50	0.074	3	0.008	0.1	-0.007	0.022	0	1
quarries	0.13	0.001	5	0.013	9.4	-0.006	0.031	0	0
built land (incl. roads)	3.65	0.036	1	0.003	0.1	-0.006	0.011	0	1
other	4.54	0.045	2	0.005	0.1	-0.007	0.017	0	1
total area	101.54	1.000	399	1.000					

Table 51. Johnson's ranking of preferences, compared with values of habitat composition (ranked), and ranked preferences obtained from ratios of observed/expected and also by order of elimination by raising confidence intervals in the Neu et al *method.*

habitat type or grouping	**Rank by proportion of land area**	**Johnson's rank**	**Rank by ratio of obs/exp**	**Rank by 'confidence' interval**	**P**	**Adjusted preference rank**
		Order of preference for sett location				
hedgerow area	*9*	1	2	1	P too small	2
total treeline area	*12*	6	1	1	P too small	1
semi-natural woodlands	*10*	5	3	1	P too small	3
plantations (coniferous, broad-leaved, mixed)	*5*	3	7	5	P=0.0014	5
total scrub area	*8*	2	5	1	P too small	4
bracken	*11*	9	6	6	P=0.148	6
heath, moorland, bog	*2*	8	10	13	P too small	10
total unimproved grassland	*3*	7	8	13	P too small	8
total improved grassland	*1*	4	9	13	P too small	9
arable land	*4*	11	12	13	P too small	12
quarries	*13*	10	4	7	P=0.436	7
built land (incl. roads)	*7*	13	13	13	P too small	13
other	*6*	12	11	13	P too small	11

Johnson's Rank Preference Index (1980)

This method is generally used to determine a species' habitat preferences from observations on several individuals: the use of each resource is given a ranking for each individual, and the availability of each resource type in the environment is also ranked. When this kind of data is available, there are benefits of this method over the Neu *et al* method.

In this study, the badger population of Ireland is considered as a unit utilising the habitat resources of Ireland for location of badger setts (*i.e.* the study is concerned with resource selection at the population level). In this approach, no statistical analysis can be performed to demonstrate whether the resultant ranks differ from each other statistically or from the null hypothesis of nil preference by badgers. However, whilst the Neu *et al* method was used to show which habitats were preferred, it did not give the order of preference: this might be computed for that method from simple observation of observed : expected ratios (as in Table 50) or, alternatively, by stepwise elimination of habitat variables one at a time by raising the confidence interval (*e.g.* as in the case of bracken).

Johnson's preference rank was computed as described by Krebs (1989). The maximal value of z is $\approx$4, so that the confidence interval (Neu *et al*) will not contain the expected value if the ratio of observed/expected is too large or too small, and it is not possible to rank these habitats by order. Note that the ranked habitats by proportion of area show that the largest component of the Irish landscape is improved grassland and the second is heath/moorland/bog.

There are substantial differences between Johnson's rank preference and values obtained from the other methods (Table 51). That Johnson's method is unreliable when used in this way is shown by the ranking of some habitats that were avoided above some of those that were selected (*e.g.* total improved grassland above bracken).

It is suggested that the use of P levels to obtain an order of preference (rank) may be applied to the results obtained from the use of the Neu *et al* method. Beyond $z = \pm 4.0$, the habitats are known to be either preferred or avoided *absolutely* (*i.e.* there is no other statistical possibility), and ranking at this stage might be achieved by reference to the observed/expected ratios. This adjusted ranking is given in the final column of Table 51.

The results are: in order of preference as habitats for main sett location - treelines, hedgerow, semi-natural woodland, low and tall scrub, plantations, bracken, quarries. In order of avoidance for sett location (with the most avoided first) - built land, arable land, 'other habitats', heath/bog/moorland, improved grassland and unimproved grassland. Most of these results were highly significant (Table 51).

Other preference indexes

In view of the observation that methods to determine habitat preference may yield different results with the same data set, it was, finally, decided to check some other commonly used indices of preference. The values presented in Table 51 were compared with several indexes of preference suggested by Krebs (1989), namely the forage ratio (Savage, 1931; Williams & Marshall, 1938), electivity index (Ivlev, 1961) and Manly's alpha (Manly, Miller & Cook, 1972). The preferences have been ranked but no statistical analyses performed, though such may be computed for Manly's alpha. The results show (Table 52) that the ranking order is identical to that obtained from the ratios of observed/expected given in Table 51 (except that Manly's alpha ranked several habitats equally on two occasions, as did the forage ratio on one occasion).

The overall conclusion from analysis of a substantial number of techniques is that the simple observed/expected ratio yields results that are supported by the majority of techniques, yet this easily derived ratio is not commonly used. Giffin, Scott & Mountainspring (1987) termed the ratio HAR (habitat association ratio) and determined the statistical significance for each observation by measuring its deviation from unity (at HAR = 1, there is zero habitat selection or avoidance) by a χ^2 test, as did Storaas & Wegge (1987). Where there are several samples of habitat preferences, Hobbs & Bowden (1982) gave means for computation of the confidence interval for the ratio, termed a preference index. Given the attributes of the HAR, in that it is both simple and would appear to give results conforming to several other techniques, a methodology for placing confidence limits upon the ranking order obtained by its use should be practical. Confidence limits for each HAR might be estimated by jack-knife or bootstrap techniques.

The badger data, when grouped into the 13 habitat groupings examined here, has shown remarkable resilience in the face of a variety of techniques, probably because the location of badger setts in relation to overall habitat areas available is *very* selective. The very nature of the construction of badger setts rules out the majority of them being located within an arable field or within an improved grassland (for example). If there was no human disturbance to setts (including the use of machinery), then badgers might quite probably locate their setts in the midst of such habitats. The whole area of analyses of resource by species remains difficult especially should more complex resource use be examined, with the expectation of considerably more disparity between results obtained from different analyses.

Table 52. Comparison of habitat preference as given by a ratio of observed/expected frequencies with three other commonly used indices of preference.

habitat type or grouping	**Rank by ratio of obs/exp**	***Value by forage ratio***	**Rank by forage ratio**	***Value by electivity index***	**Rank by electivity index**	***Value by Manly's alpha***	**Rank by Manly's alpha**
hedgerow area	**2**	*20.57*	**2**	*0.907*	**2**	*0.190*	**2**
total treeline area	**1**	*38.92*	**1**	*0.950*	**1**	*0.359*	**1**
semi-natural woodlands	**3**	*17.96*	**3**	*0.895*	**3**	*0.166*	**3**
plantations (coniferous, broad-leaved, mixed)	**7**	*2.17*	**7**	*0.369*	**7**	*0.020*	**7**
total scrub area	**5**	*9.10*	**5**	*0.802*	**5**	*0.084*	**5**
bracken	**6**	*5.74*	**6**	*0.703*	**6**	*0.053*	**6**
heath, moorland, bog	**10**	*0.19*	**10**	*-0.676*	**10**	*0.002*	**9**
total unimproved grassland	**8**	*0.29*	**8**	*-0.549*	**8**	*0.003*	**8**
total improved grassland	**9**	*0.23*	**9**	*-0.625*	**9**	*0.002*	**9**
arable land	**12**	*0.11*	**11**	*-0.805*	**12**	*0.001*	**11**
quarries	**4**	*12.97*	**4**	*0.857*	**4**	*0.120*	**4**
built land (incl. roads)	**13**	*0.08*	**13**	*-0.846*	**13**	*0.001*	**11**
other	**11**	*0.11*	**11**	*-0.800*	**11**	*0.001*	**11**

Nîche Breadth

The preference of certain habitats for the location of badger setts is one means of defining part of the species' nîche in Ireland. The nîche is an *n*-dimensional hypervolume whose axes are critical physical and environmental factors determining the existence of a species (Hutchinson, 1957, from Smith, 1982). Other important measures of nîche for the badger in Ireland are, therefore, those of its dietary preferences and selective use of the available food resources, and the species overall use of or occurrence in the landscape (*i.e.* habitat and environmental factors). Sett location is limited in its use as a primary nîche-defining attribute, and, here, it remains incomplete as the sett locations have not fully been described in terms of soils types preferred, *etc.* Nevertheless, the application of some standard formulae for calculating nîche breadth for badger use of habitat resources for sett placement may be of some interest when this nîche breadth is compared to other populations.

One measure of nîche breadth that allows for the abundance of the available resources to be taken into account is Smith's *FT* measure (Krebs, 1989). Other measures such as Levin's measure are sensitive to the number of resources measured and how they are grouped and quite unreliable in this case.

Smith's measure (Smith, 1982) of nîche breadth varies from 0 to 1 and is a standardised measure. It is given by

$$FT = \sum_{j=1}^{n}\left(\sqrt{\left[p_j \cdot a_j\right]}\right)$$

where *FT* = Smith's measure of nîche breadth
p_j = proportion of setts found in habitat *j*
a_j = proportion of habitat *j* of total
n = total number of habitats

95% confidence limits are given at

$$\sin\left(x \pm \frac{1.96}{2 \cdot \sqrt{y}}\right)$$

where $x = \arcsin(FT)$
and y = total number of individuals studied

The results from the data in Tables 49 and in Table 50 were:

1) Smith's $FT = 0.646$, with $n = 39$ (Table 49; badger setts were not recorded in 14 of these); 95% confidence limits: 0.608, 0.683.

2) Smith's $FT = 0.665$, with $n = 13$ (Table 50), with 95% confidence limits of 0.626 and 0.701.

The measure was also calculated for data given by Cresswell (*et al*, 1990) for landclass 1 (Table 17).

Smith's $FT = 0.647$, with n = 14 (excluding total woodland as all woodland subdivisions were already included), confidence limits 0.571 and 0.717.

The Irish and UK data sets are slightly different with different habitat groupings but the similarity of the index for UK data for class 1 and the Irish data is evident.

The use of the nîche breadth measure for sett location according to habitat may allow for interesting comparisons between different landclasses, counties, or countries.

Variation in badger social group density by county, in relation to habitat composition: initial indications from density-habitat plots

The habitat preferences shown by badgers in the location of main setts may differ from county to county - because the counties differ in their overall habitat composition. It would be more appropriate to use landclasses (ecologically uniform strata) rather than counties to further investigate preferences for sett location.

The county variation in badger density relative to selected habitat types is of some interest. Thus, a plot of mean hedgerow area (ha km^{-2}) for each of the 26 counties against mean badger group density (active main setts km^{-2}) for each county reveals a roughly linear relationship (Figure 105), though increase in mean hedgerow area does not yield an increase in badger density in all counties (*e.g.* Cos. Wexford, Cavan, Waterford, Tipperary).

Most of the principal habitat types or groupings given in Table 50 have been plotted in this way, in Figures 105 to 117. Generally, the greater the area of the habitats shown to be selected above as suitable for main sett location, then also the greater the overall mean density of badger social groups. But the same does not hold for some of the habitats that had been shown to be avoided for sett location. Thus, badger density tends to increase with improved grassland area (Figure 114) - this is probably because area of grassland is correlated with area of hedgerow and/or treeline and/or woodland, so that an increase in badger density is observed even though the badgers will not locate their setts in the grasslands themselves.

The graphs suggest a positive relationship between area of hedgerow and badger density (Figure 105) and also for treeline, though this is less pronounced (Figure 106), and also for the combined area of hedgerow, treeline and low scrub (Figure 107). This combination was included as it represents all boundary areas (hedgerow boundaries, treeline boundaries and low scrub boundaries, but it also included non-boundary areas of low-scrub). The positive relationship expected between mean county badger density and woodland area is weak (Figure 108, semi-natural woodlands) or possibly non-existent (Figures 109 and 110, total plantation and total woodland respectively). Similarly, there is no relationship evident between badger density and mean area of scrub, possibly because scrub area may be high where overall habitat composition is good for badgers (*e.g.* Co. Kilkenny, see Figure 111) and also where it is poor (*e.g.* Co. Donegal).

Plots of mean badger density for each county against area of heath, moorland and bog (Figure 112) reveal a negative relationship, and the same trend is shown for unimproved grassland. These results are indicative of the poorer quality of overall habitat composition for badgers where these habitat types occur substantially. Conversely, badger density tends to increase as mean area of improved grassland and as arable land area increases (Figures 114 and 115).

A plot of built land against badger density is not very revealing (Figure 116), but a plot against road length suggests that there is an 'optimum' road length (Figure 117). Almost certainly, this observation arises from the fact that areas with very low road lengths will tend to be located in the remote, upland or moorland areas of the country. These will generally possess fewer good habitats for badgers, but, where there is substantial road length (urban areas), then badgers will be restricted in numbers, also, through disturbance and lack of suitable habitat.

The plots are useful in a preliminary visual assessment of the data that has been presented earlier in this report: the habitat composition of each county (given by corrected mean ha km^{-2}, Table 16 - regions and overall summary, county data in Appendices 7 & 8) and the mean badger group density (given by corrected density of active main setts, Table 38). For example, although there are clear differences between Co. Longford and Co. Galway in hedgerow length, many habitat attributes of these counties are very similar (*e.g.* combined areas of hedge, treeline and low scrub, area of plantation, total woodland area, overall scrub area, areas of moorland and bog, area of unimproved grassland and areas of improved grassland and arable land, as well as similarities in road length and area of built land). Some of these factors may contribute to the lower observed than expected badger densities in Co. Longford. Similarly, Cos. Louth and Kilkenny, with high badger densities, possess a number of similarities in the proportion of some of the habitat types, principally hedgerow area, treeline area, area of semi-natural woodland, area of plantation, total woodland area, low percentage of moorland or bog, and unimproved grassland, and a similarity in area of built land and length of roads. But these counties do differ in the mean area of improved grassland and that of scrub.

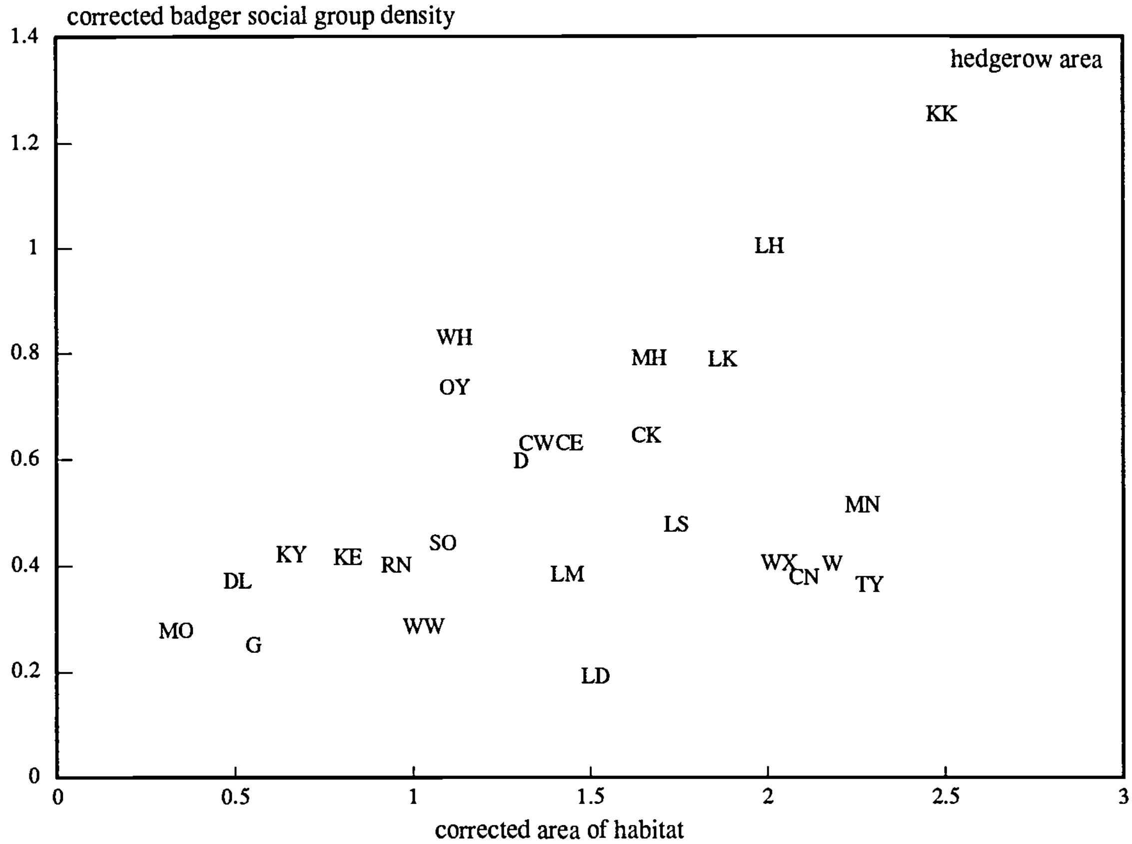


Figure 105. Plot of mean hedgerow area against mean badger group density for each county. Counties may be identified by the first and last letter of their name (thus adopting the vehicle licence plate identification code), except for *D (Dublin), G (Galway), KK (Kilkenny), W (Waterford), WX (Wexford) ([*n.b.*]Cork given by CK not C, being the only difference from vehicle plate codes).*

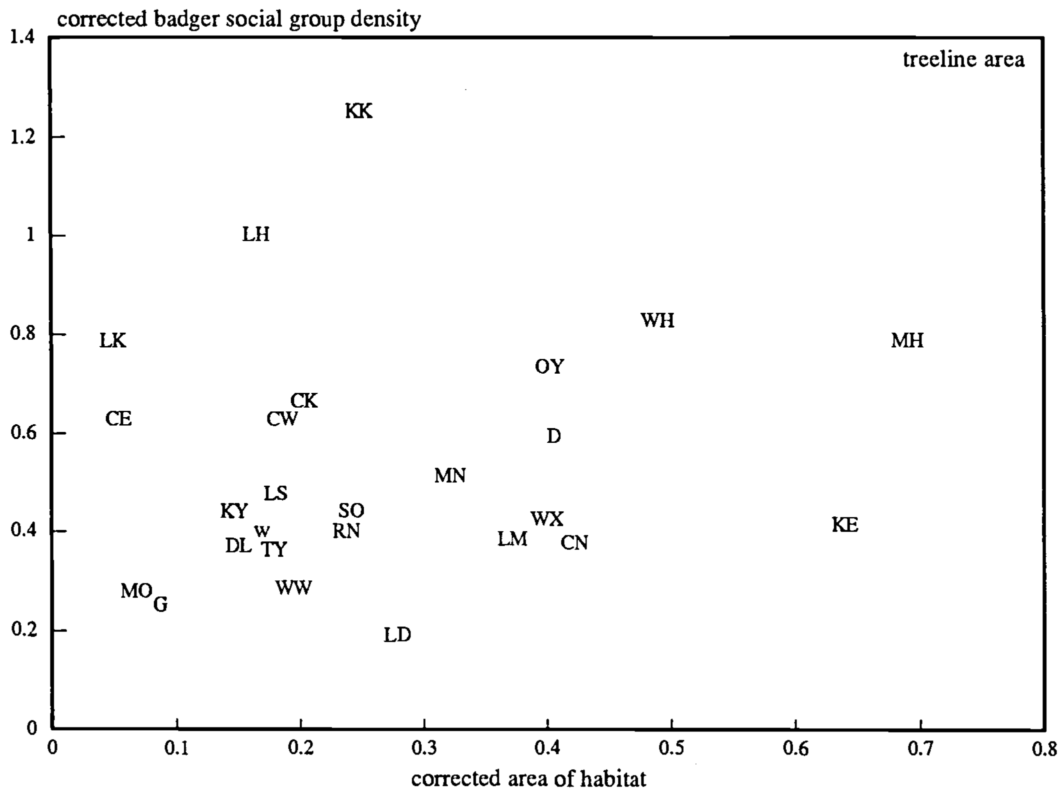


Figure 106. Plot of mean treeline area for each county against mean badger group density.

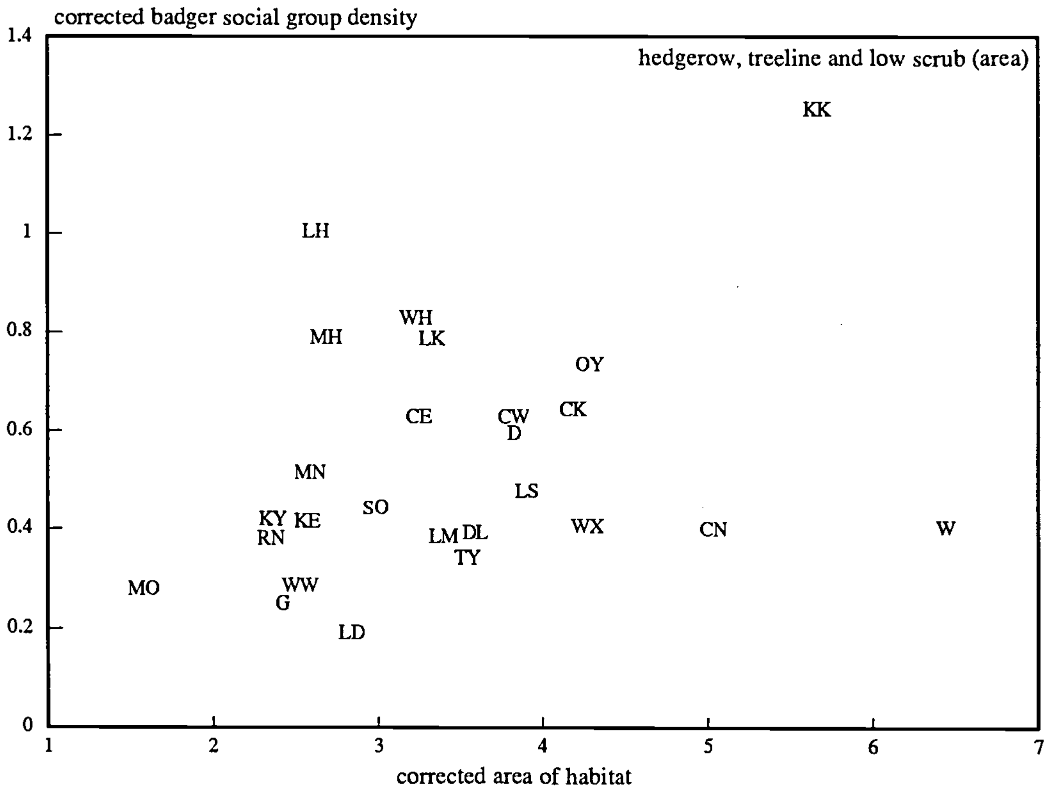


Figure 107. Plot of combined mean areas of hedge, treeline and scrub against mean badger group density.

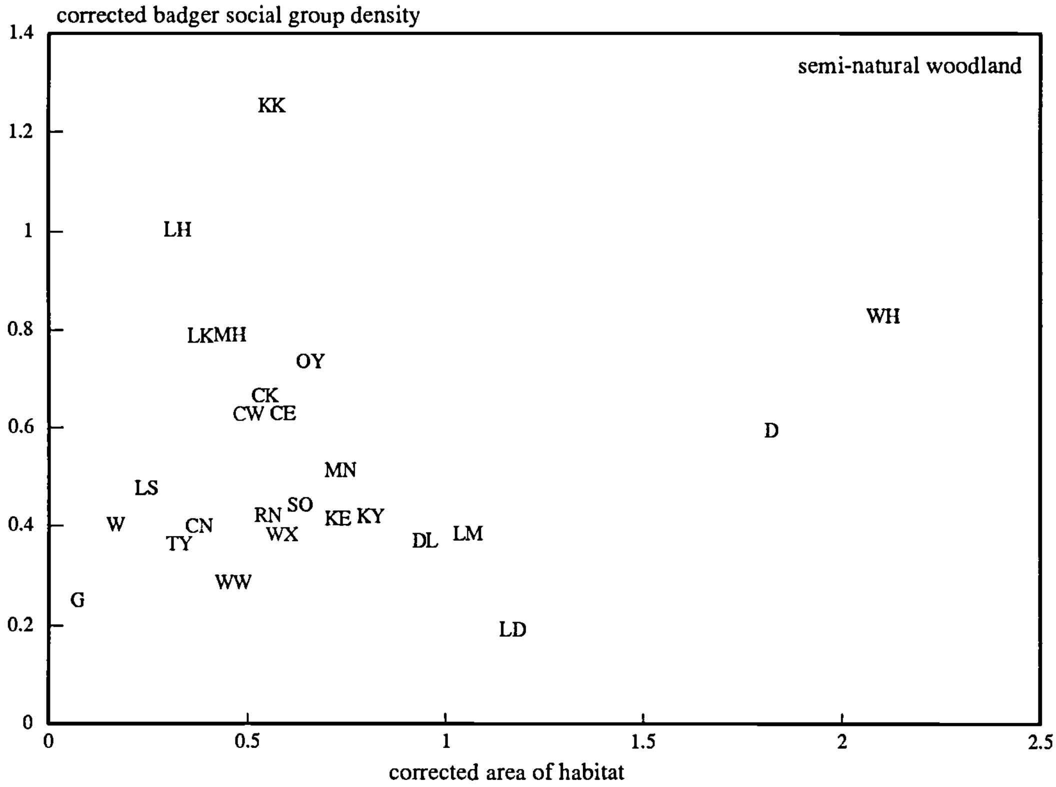


Figure 108. Plot of combined mean area of semi-natural woodland against mean badger group density.

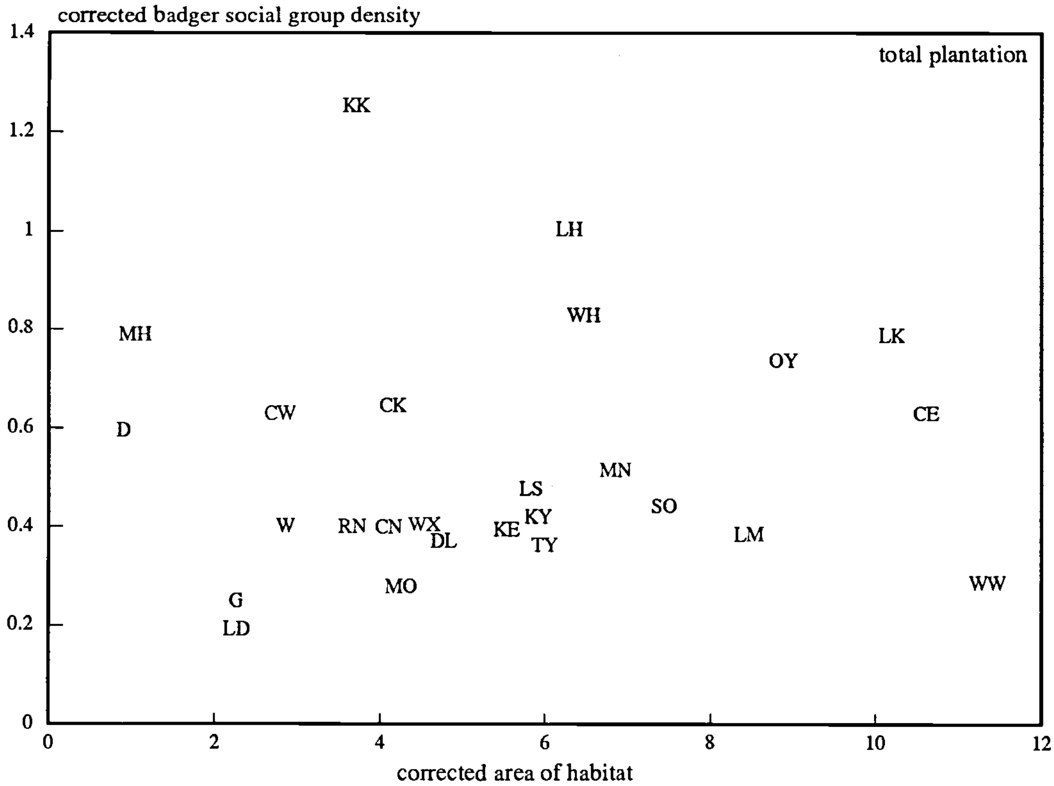


Figure 109. Plot of combined mean area of plantation (broad-leaved, coniferous and mixed) against mean badger group density.

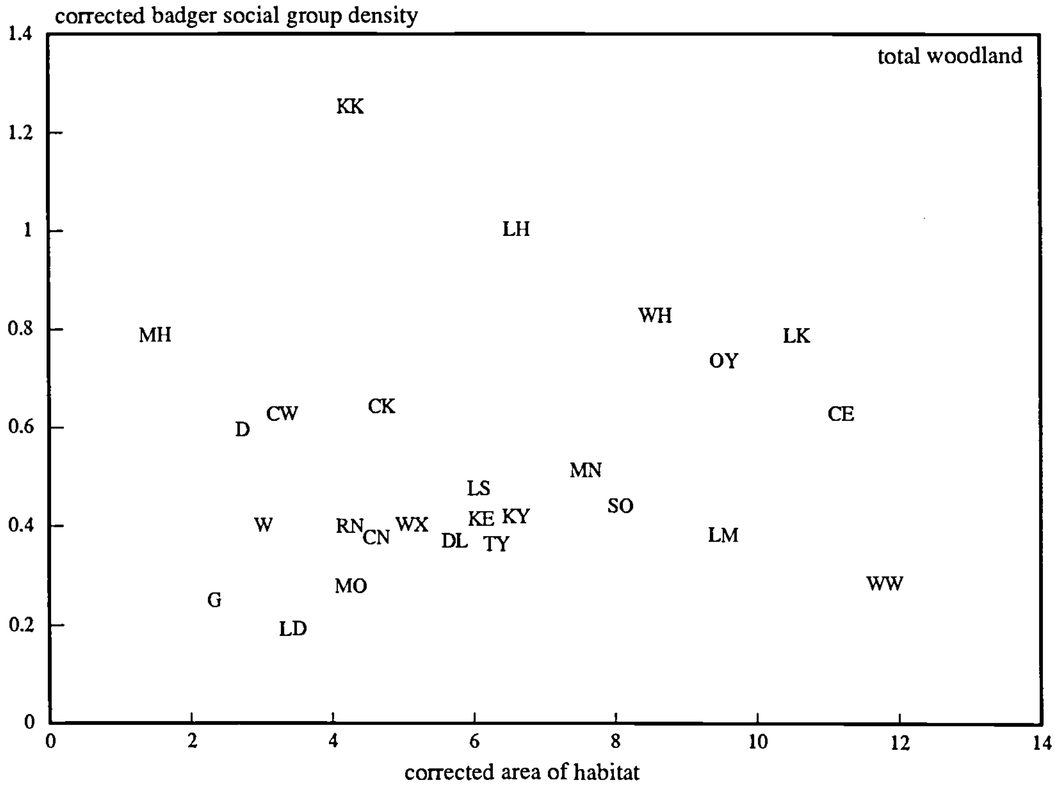


Figure 110. Plot of combined mean woodland area (all categories, excluding felled woodland) against mean badger group density.

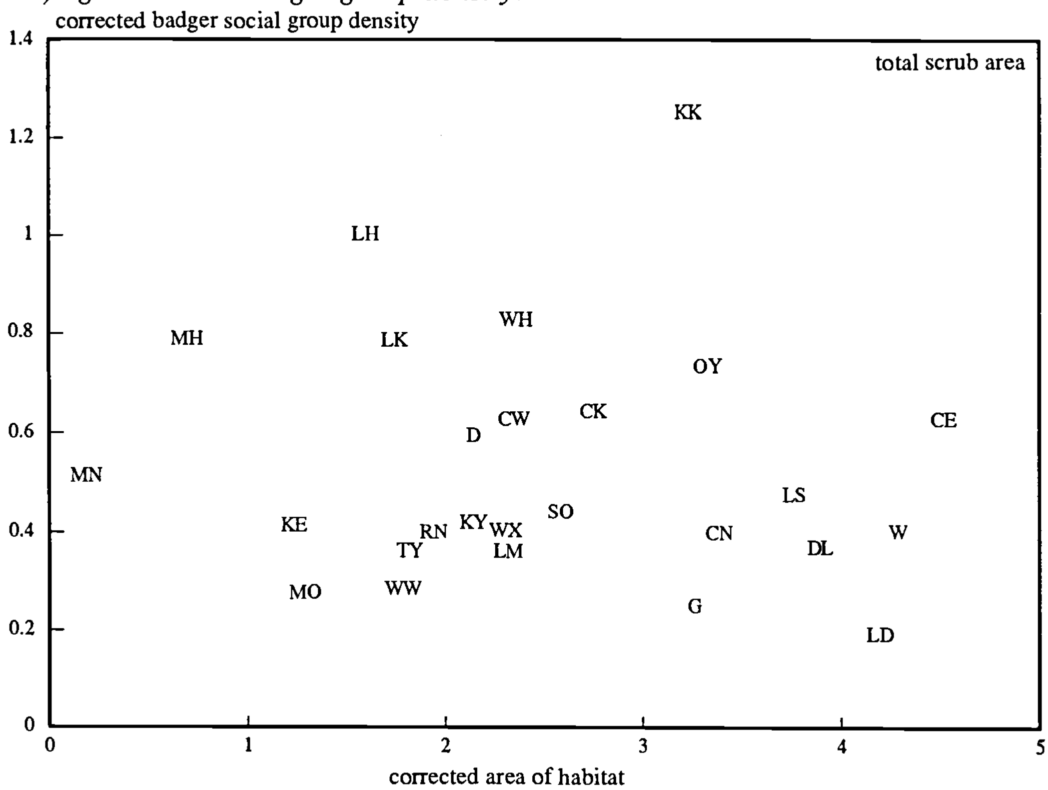


Figure 111. Plot of combined mean areas of scrub (low and tall scrub) against mean badger group density.

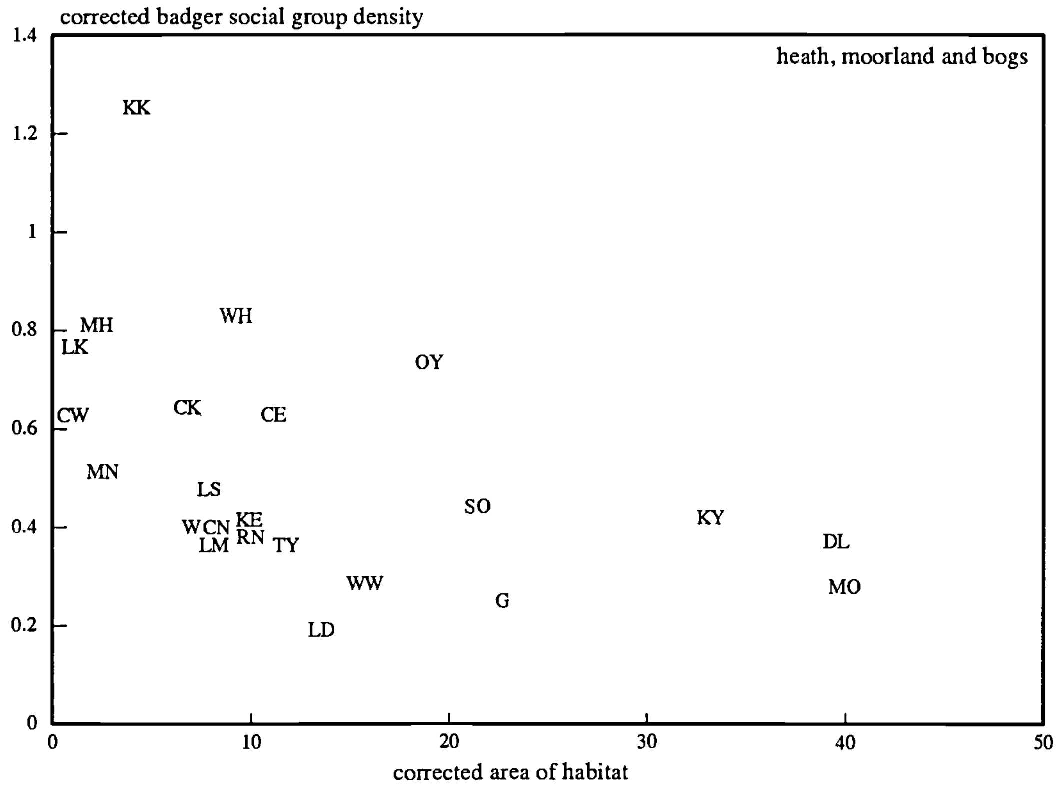


Figure 112. Plot of combined means of heath, moorland and bog *habitats against mean badger group density.*

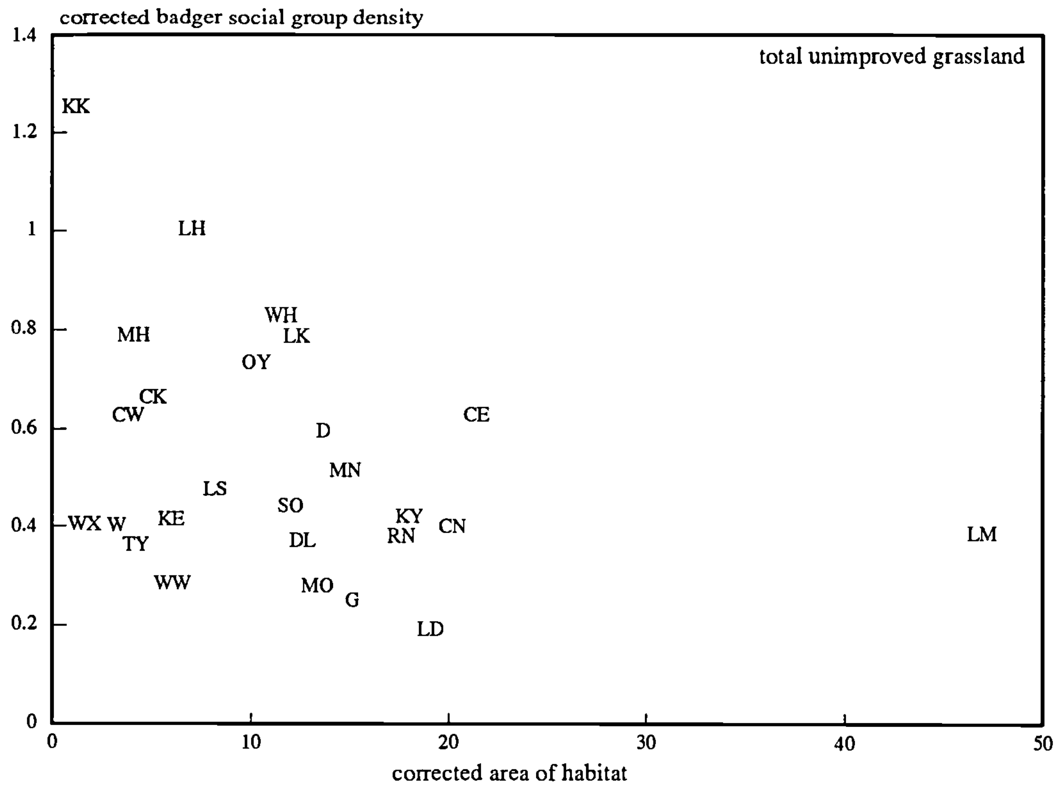


Figure 113. Plot of combined means of unimproved grassland habitat categories against mean badger group density.

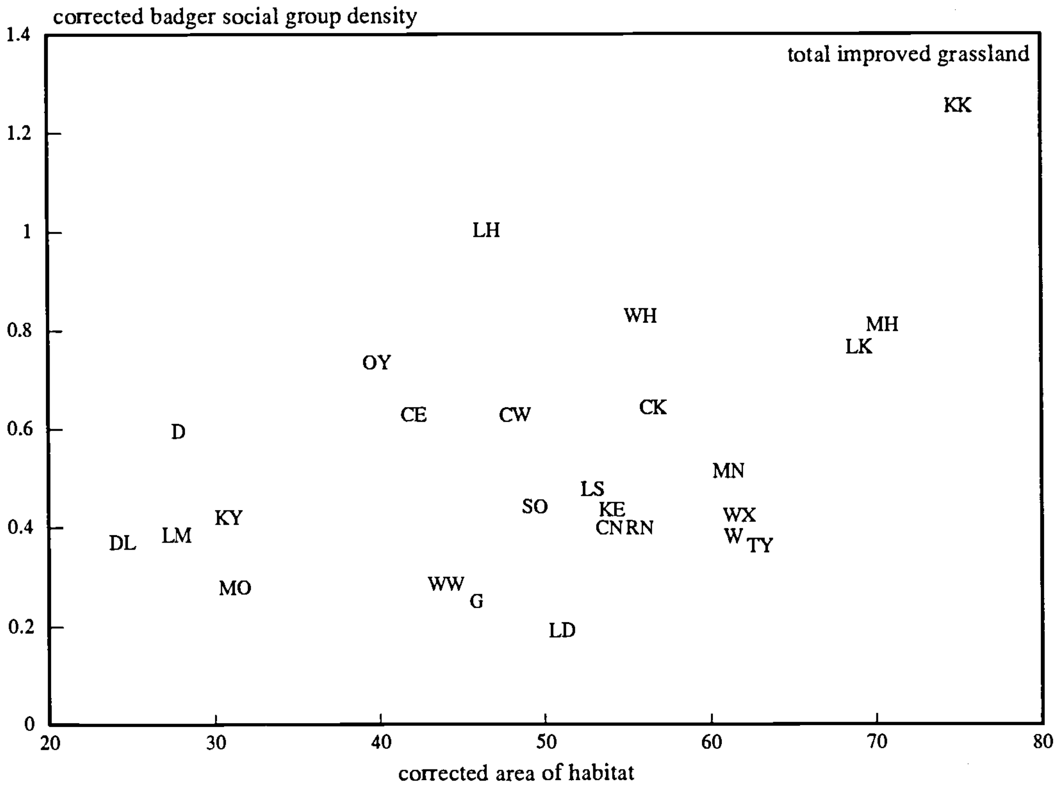


Figure 114. Plot of combined means of improved grassland categories against mean badger group density.

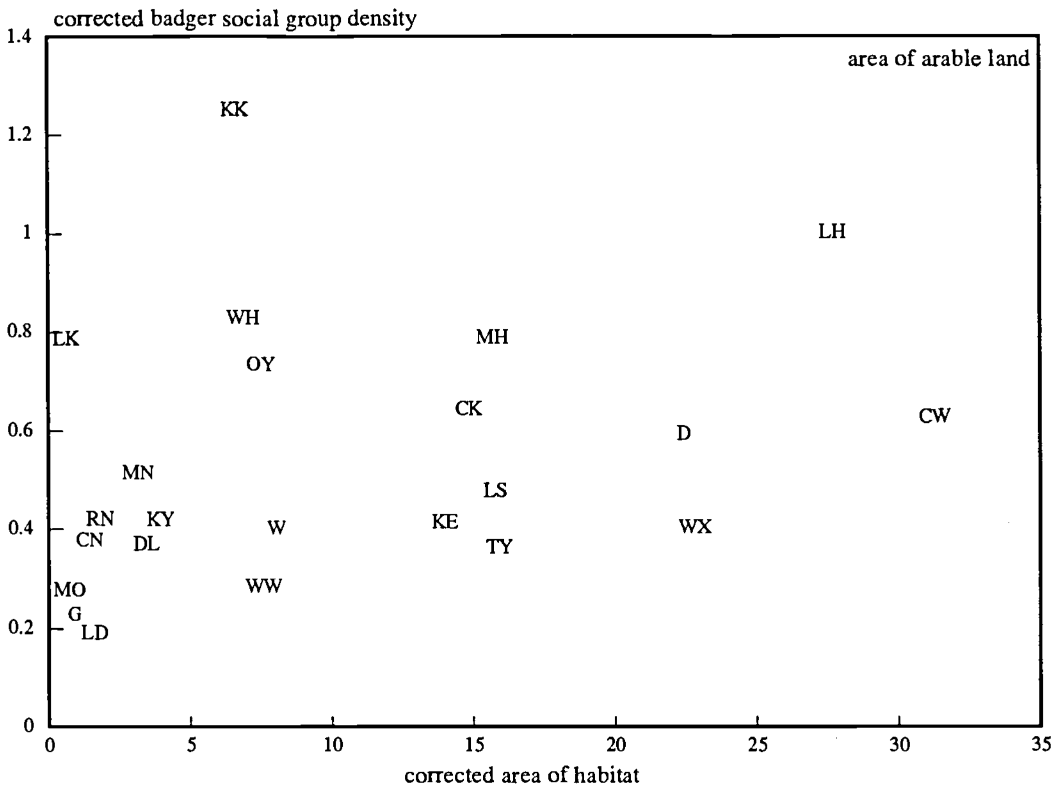


Figure 115. Plot of mean area of arable land against mean badger group density.

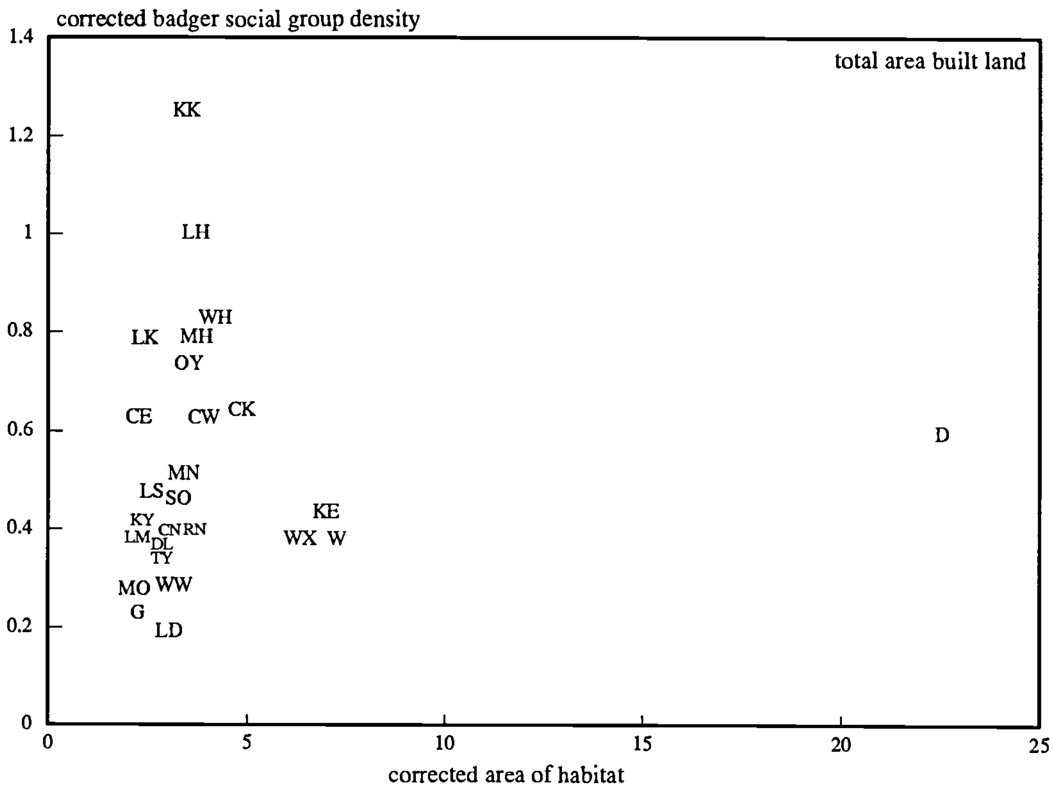


Figure 116. Plot of mean area of built land against mean badger group density.

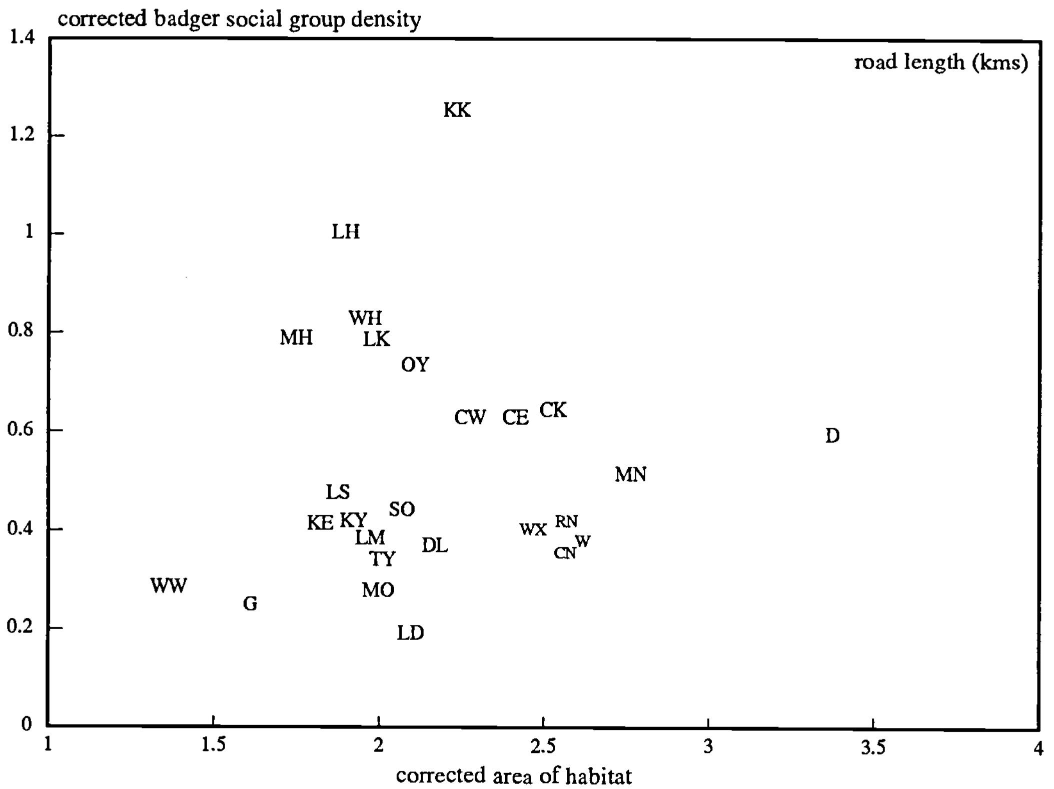


Figure 117. Plot of mean road length against badger group density.

Additional plots of badger density in relation to pasture and grazed habitats and some implications for research into TB prevalence in cattle

Similar county plots of mean badger group density against habitat attributes are shown in Figures 118 to 123, the habitat types considered being those of cattle and sheep grazing (using corrected values, given in Table 18, and in Appendices 10 & 11).

The plots of mean badger group densities against county grazing attributes reveal a clear separation of counties: in general, the Midlands counties tend to group together, and upland or western counties together also.

As the mean area of sheep grazing increases, a fall in badger densities is observed (Figure 118), but, in contrast, badger densities tend to show an increase as the area of land devoted to cattle increases (Figure 119). A plot of overall grazing land (Figure 120) is basically a combination of Figures 118 and 119, and, with the contrasting trends, this Figure shows no pattern at all.

Considering the total mean area of land with cattle grazing on it (Figure 121), which includes land shared with sheep, the trend is similar to that in Figure 119, showing a general tendency for badger group density to be higher in those counties where more land is grazed by cattle.

The latter two plots (Figures 122 and 123) produce a greater scatter of points, by considering not overall mean area, but the *percentage* of **pasture** or **grazing** land given over to cattle (rather than sheep, but including land shared with sheep). The two plots prove quite similar. The combination of higher percentages of pasture devoted to cattle coupled with higher badger densities in the Midlands is revealed by the Midland counties falling close together on the plot: Louth, Westmeath, Meath, Offaly - and counties such as Kilkenny, Limerick, Clare and Cork cluster near the Midland counties. Conversely, many of the upland and western counties are clustered, having both low percentage of pasture devoted to cattle and low badger densities: Wicklow, Donegal, Leitrim, Kerry, Galway, Mayo, but also Wexford and Carlow (where the low proportion of pasture given over to grazing appears to result from these counties being largely arable).

The implication of the various graphical presentations is that badger densities appear to be linearly related to the area of grazing land, and in particular cattle grazing. This is not to imply a causal relationship, but may suggest that the conditions that prove economically/environmentally conducive to use of land for cattle grazing (rather than for sheep pasture or for arable purposes, or for little human activity) are also those that tend to be attractive for badgers. There appear to be related habitat attributes brought about largely by human selection and modification of land areas used for cattle grazing that appear to provide a more attractive environment for badgers than do the land areas utilised for arable land or little used by man. Thus, hedgerow area and area of treelines tend to increase with mean area of cattle grazing - whereas, broadly, in the west, sheep grazing, because it tends to be concentrated in upland or moorland areas, is not accompanied by field boundaries composed of hedgerow (Figures 124 and 125).

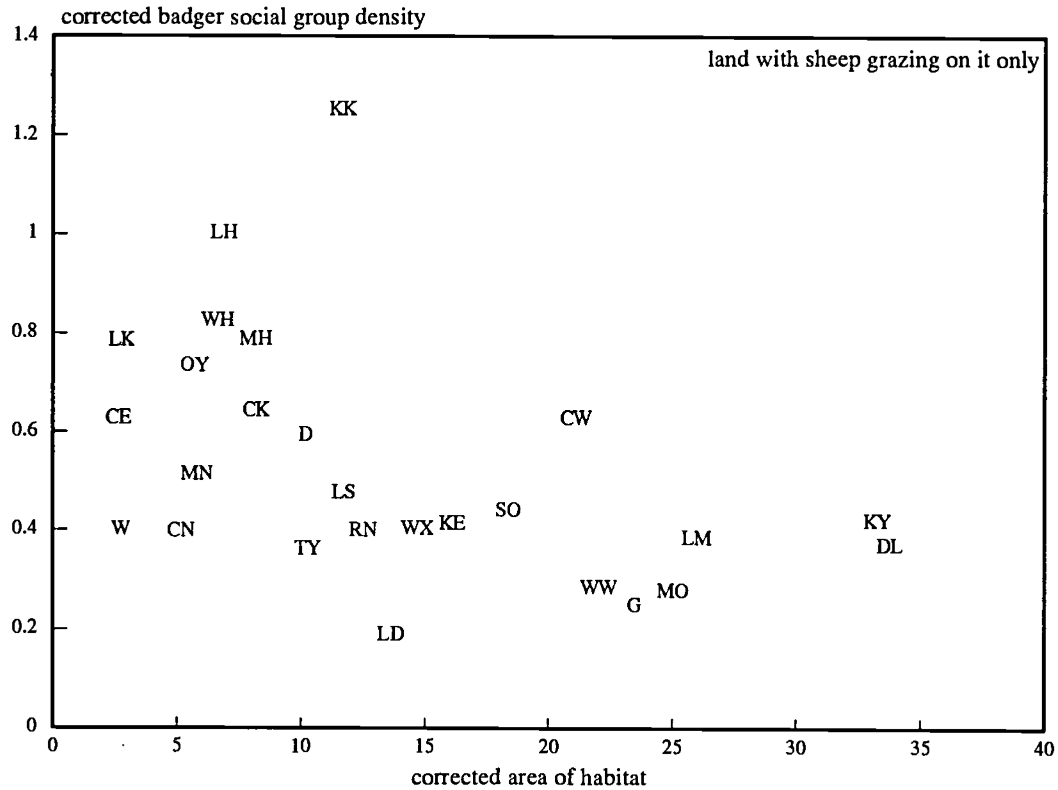


Figure 118. Plot of mean area of land with sheep grazing on it only (i.e. *not shared with cattle) against mean badger group density. Grazed land is all habitats, not only pastures.*

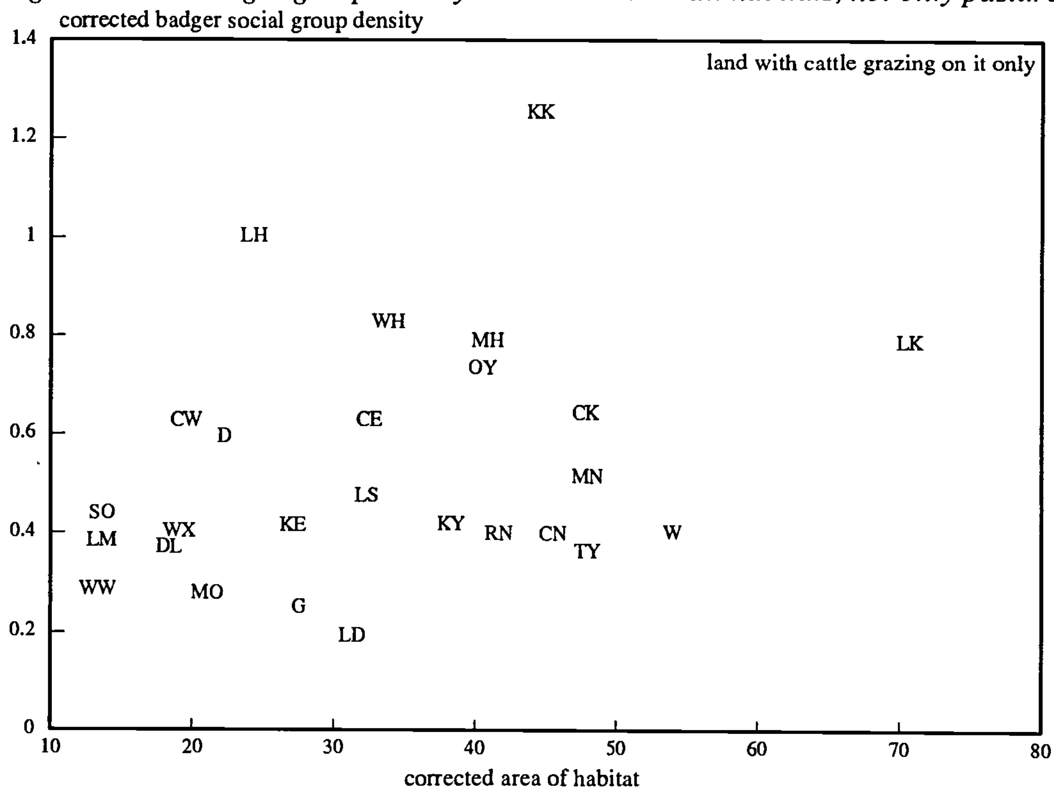


Figure 119. Plot of mean area of land with cattle grazing on it only (i.e. *not shared with sheep) against mean badger group density. Land is all habitats, not only pastures.*

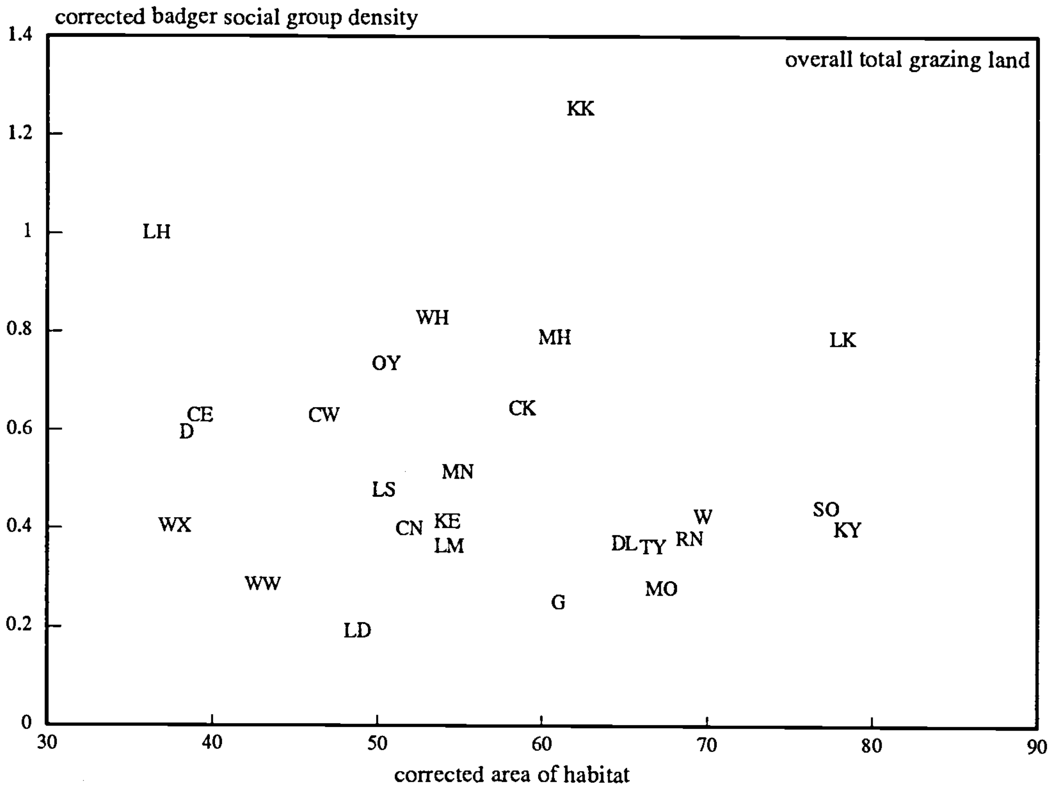


Figure 120. Plot of mean grazing land, ha km^{-2}(total land used for grazing in all habitat types) against mean badger group density.

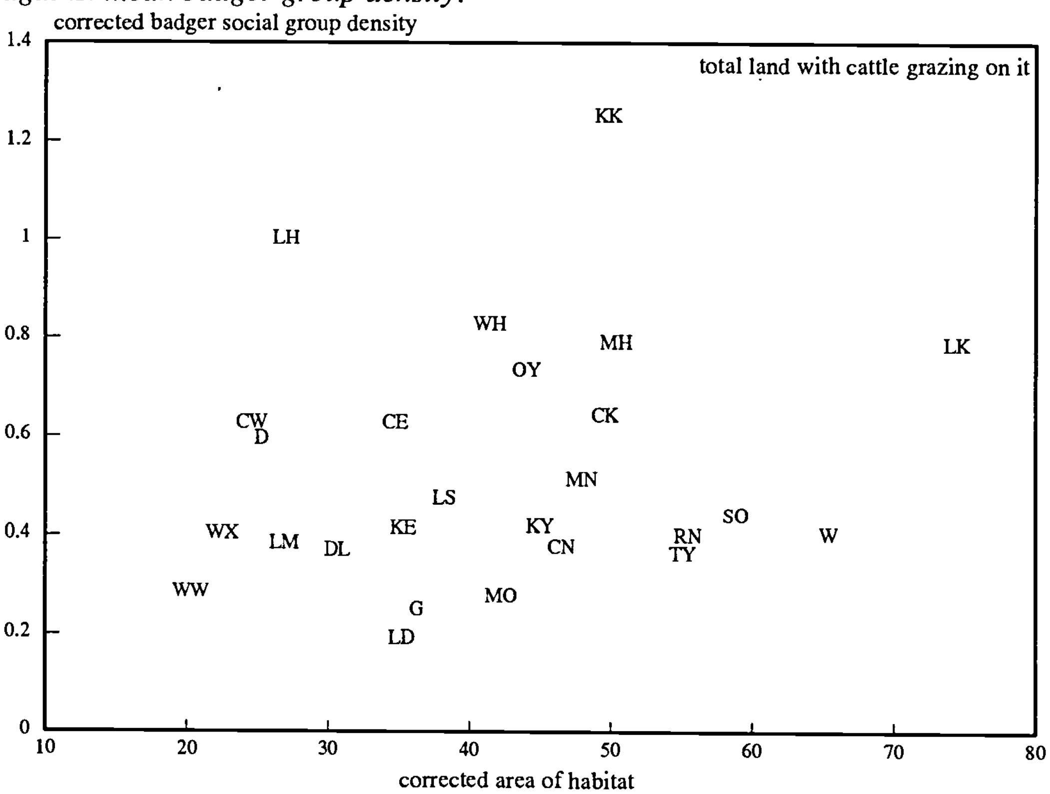


Figure 121. Plot of mean area of land with cattle grazing on it (all habitats, and including grazing shared with sheep) against mean badger group density.

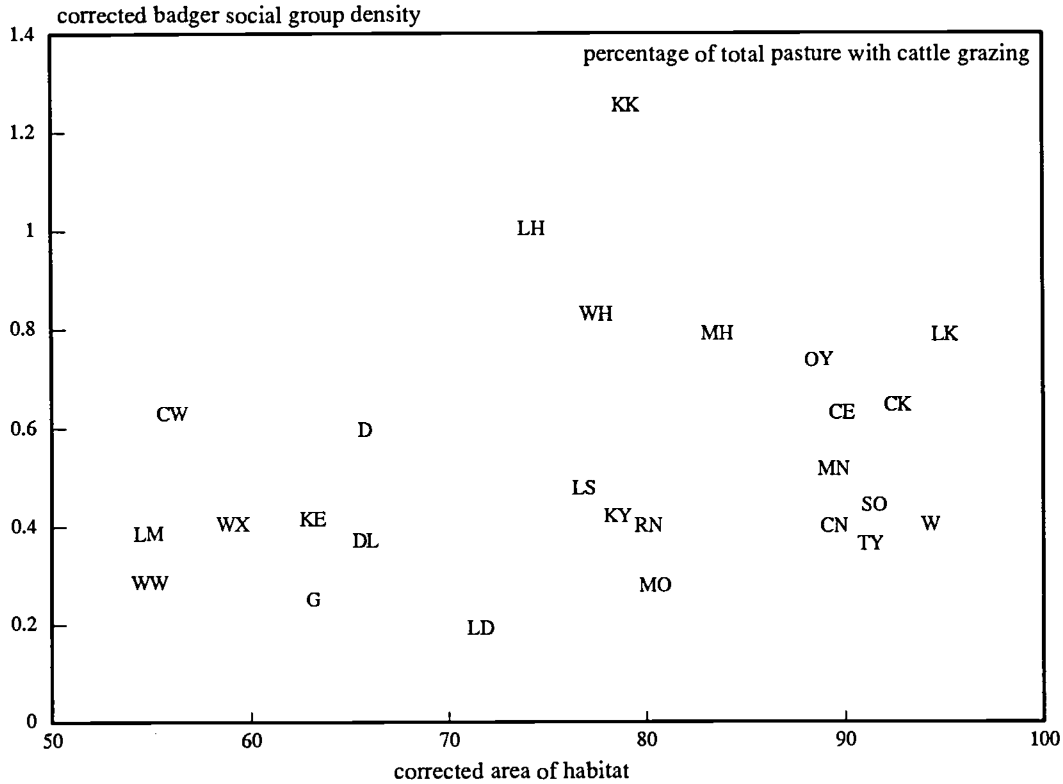


Figure 122. Plot of the percentage of all pastures (habitat categories 29, 30, 31 and 32) grazed by cattle (including pastures shared with sheep) against mean badger group density.

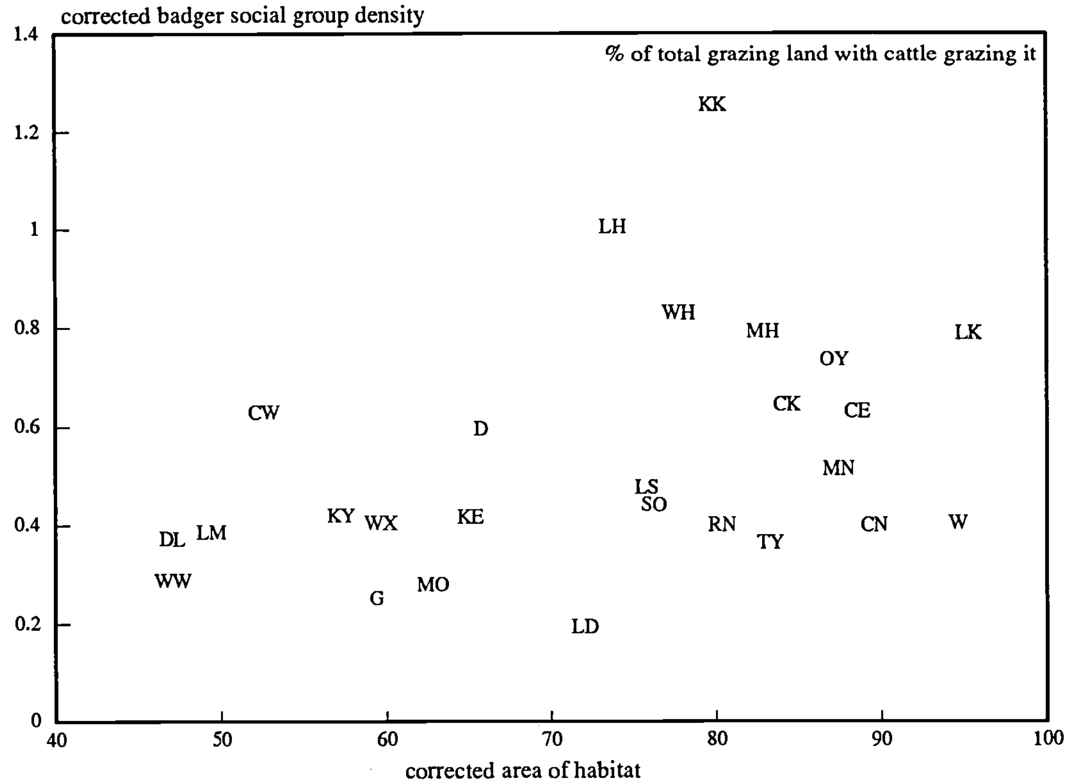


Figure 123. Plot of the percentage of total grazing land (all habitats) grazed by cattle (including grazing shared with sheep) against mean badger group density.

Land that is suited to cattle grazing rather than arable is often undulating and broken, and unsuitable for machinery: this land pattern may create a greater habitat diversity and more patches of scrub and woodland, again possessing a habitat composition that would tend to be conducive to larger badger densities.

Generally, the overall environmental characteristics of cattle grazing areas are conducive to greater badger densities: this is examined further later, but the likely consequence is that it seems improbable that a means of managing the habitat composition of the environment (with regard to reducing badger density) can be suggested that would not also have profound consequences for the largest part of the Irish agricultural sector and the overall Irish environment.

The complexities of inter-relationships between habitats and cattle grazing and badger densities may be inferred from the earlier plots and analyses and Figures 124 and 125. Figure 124 indicates that there is, as might be expected, an approximately linear relationship between the proportion of grazing land given over to cattle and the mean area of hedgerow in the county. Thus, if more of the land is suitable for cattle grazing, then the field boundaries will also tend to be of hedgerow (or treeline) - compared to land areas or counties where, if the land is more suitable for sheep, then, generally the boundaries will often be composed of materials other than hedgerows, *e.g.* stone walls, sheep fencing, *etc.* Figure 125 supports the basic relationship between cattle grazing and hedgerow, with a general tendency for counties with more land utilised for cattle having a higher area of hedgerow.

Whilst the relationship shown in Figures 124 and 125 is one that would be logically expected, the county clustering that arises from this sample plot is, again, of interest - with counties such as Kilkenny, Tipperary, Monaghan, Cavan, Louth, Waterford, Limerick, Meath, Cork and Laois clustered. Most of these counties are ones with TB problem areas (though Clare is excluded here (perhaps as a result of so many of its field boundaries composed of stone walls which were not measured separately in this study). Cavan and Monaghan, with slightly lower badger densities than some other Midlands counties, are included in these clusters, which may be suggestive of habitat/land use differences possibly playing a greater rôle in TB in cattle than do badgers. The preliminary observation that less grazing land is devoted to cattle than sheep in Northern Ireland (relative to the Republic) clearly requires further investigation in the matter of determining environmental aspects of TB in cattle.

The distribution of bovine TB in cattle is illustrated in Figure 126. The various graphs in this report have already revealed a broad range of similarities between habitat variables, including land use (mean area of cattle grazing, *etc.*) and TB levels in cattle. There have also been illustrated certain similarities between those areas prone to TB in cattle and aspects of badger or sett density. The cattle grazing environment would appear to be one that, in Ireland at least, is well suited to the badger, so that various factors that may enhance the spread or maintenance of the disease are correlated, without all necessarily being causal factors. A number of questions arise: is TB incidence in cattle correlated with cattle density? (or perhaps herd density?); is TB in cattle correlated with badger density?; is TB in cattle correlated with hedgerow density?; is boundary length/field size per unit of cattle grazing (with implications of herd-herd contact) a causal factor, or, if badger densities are correlated with hedgerow density, are the badgers implicated instead?

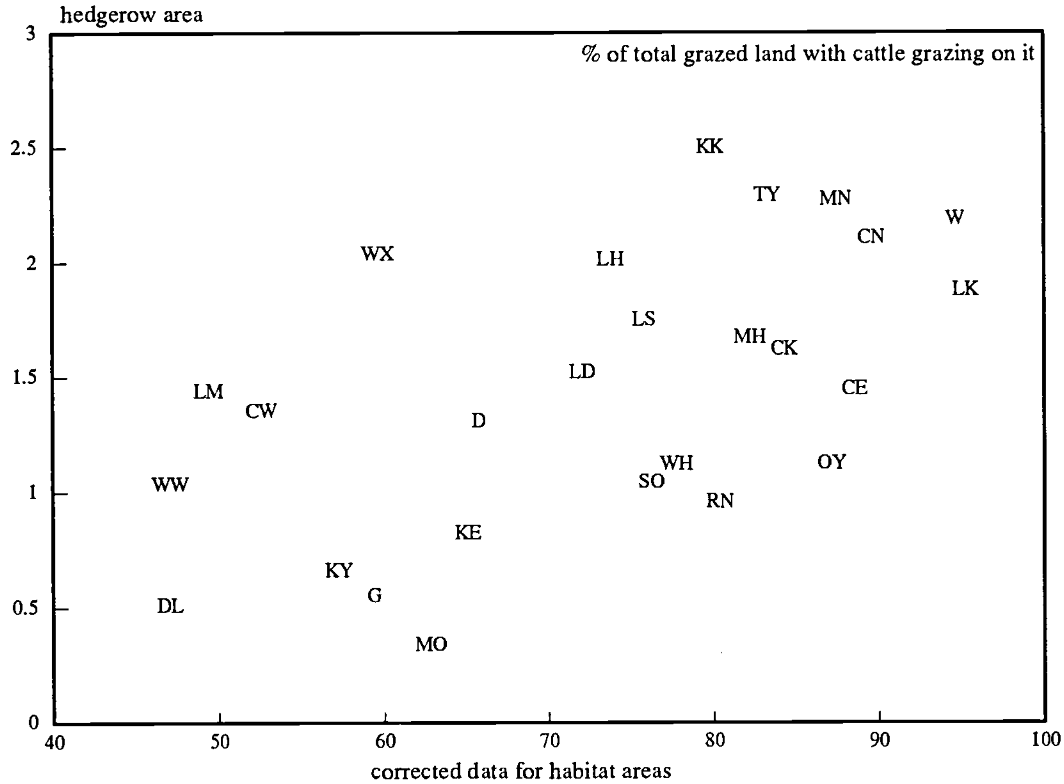


Figure 124. Plot of hedgerow area against the percentage of the total grazing land (all habitats) given over to cattle grazing (including areas shared with sheep).

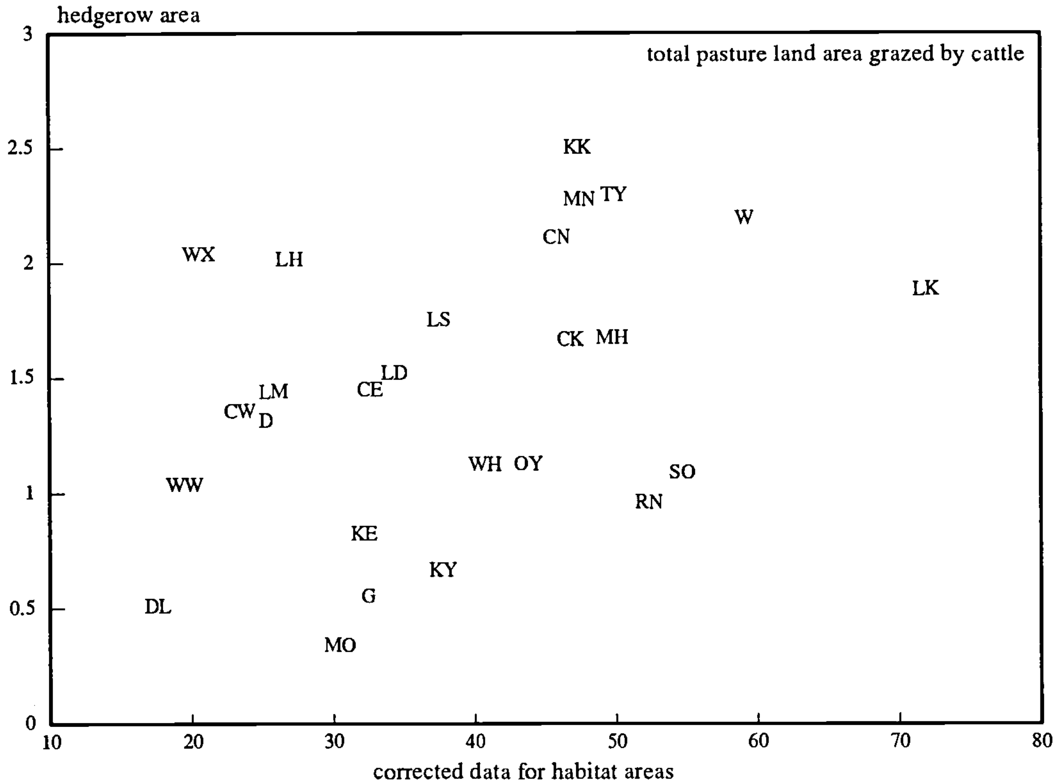


Figure 125. Hedgerow area plotted against mean area of pastures (habitat categories 29, 30, 31 and 32) grazed by cattle (including pastures shared with sheep).

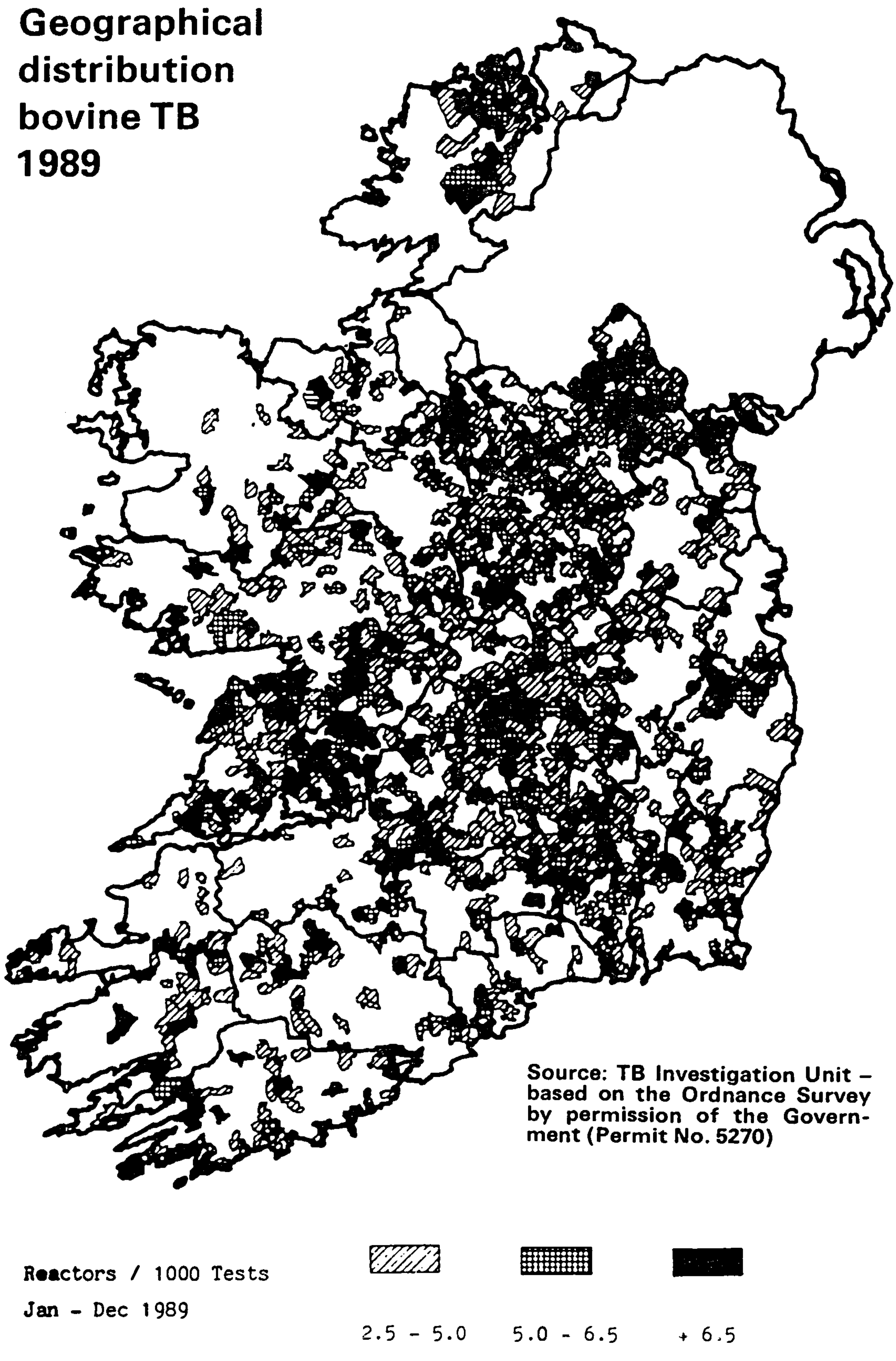


Figure 126. Geographical distribution of bovine TB in cattle in the Republic (in 1989, from Downey, 1990).

BADGER DENSITY IN RELATION TO HABITAT COMPOSITION:

ANALYSES AND MODELS

Whilst one of this study's principal aims was to determine overall badger distribution, numbers and densities in Ireland, the underlying motivation was to assemble the relevant portions of this data in a form that would be useful for further examination of the TB problem in cattle and thus concerning a major component of the Irish agricultural industry. The National Badger Survey, itself, was limited to 1% of Ireland's land area, and directly, therefore, the sett surveys are, of limited application. However, if basic relationships between badger density and habitat and environmental variables can be elucidated, then there are substantial ways in which relationships between badger densities, habitats, and TB, might be examined. It is the aim of future research to incorporate a series of environmental factors into the database, and also measures of TB incidence, but, presently, analyses are limited to the habitat variables that have been assessed as an integral part of the Badger & Habitat Survey of Ireland.

In the fore-going plots of badger density against some arbitrarily chosen habitat variables that appeared to be of interest, there is evidence that badger numbers are, to some extent at least, determined by, for example, the quantity of improved grassland and of hedgerow, and negatively correlated with areas of bog/moorland.

The results of various analyses below show that badger densities are substantially determined by the habitat composition of an assessed zone. For example, the mean badger density in counties may be predicted from the overall habitat composition of the county - a surprising result, perhaps, given that any Irish county possesses, within its bounds, a variety of landscapes. However, predictions for small areas such as 1km squares have been found to be poor - the mechanisms for this failure are examined in some detail below. Thus, whilst the predictive capability of the badger survey has a substantial potential, the best means of attaining this would be through assessing mean badger densities over areas larger than 1km squares - *e.g.* in similar landscapes (or land classes). The fact that badger densities appear to be predictable at the county level would indicate that far more reliable models might be built upon more ecologically uniform strata.

Initial evaluation, with reference to difficulties with the Irish data set

The various relationships indicated in the plots above, and other relationships, were examined using multiple regression techniques, initially for the individual survey areas (*i.e.* using badger densities and habitat values for each survey square) and then for data from the counties (using the corrected county means for habitat variables and for badger densities).

Thornton (1988) developed a predictive model for badger group densities using multiple regression, so that the density of active main setts in tetrads (2x2 km squares) could be reliably predicted from a relatively limited number of habitat and environmental variables. The various multiple regression models estimated that *c.* 60-70% of the variation in badger group density could be explained using between 6 and 15 habitat and environmental variables (which included a number of derived or measured indices, *e.g.* variability of soil index).

Cresswell *et al* (1990) developed similar predictive models for the 1km survey squares of the British survey, but this involved two steps. Firstly, the use of discriminant analysis to predict, within each landclass, whether a square contained an active main sett or not: this was predictively successful for most land classes. Then, excluding squares that had no main setts, multiple regression models similar to those constructed by Thornton were developed, which Cresswell *et al* note were able to explain *c.* 80% of the variation in sett density (for various sett categories).

Because of the lack of a land classification for Ireland, a discriminant analysis could not be carried out meaningfully here (for the same purpose), so, unlike Cresswell *et al*, data from all squares were examined initially by multiple linear regression of various sett categories against *c.* 95 initial habitat variables (or a sub-set of these). No additional environmental variables were available to be added, so, because some of these assist in the predictive capability of some models (as for disused main setts - Cresswell *et al*), some loss of predictive power was anticipated. Analyses were performed upon the entire data set of 729 squares - but in so doing, the data included some variables that were poor or incomplete for some of the squares. Thus (as referred to earlier), 9 squares did not have separate values measured for road area and built land area (excluding roads). This was probably inconsequential. Of more consequence, data was unavailable for 78 squares for use of habitats for grazing: however, this proved to be an interesting variable, and its importance, therefore, is certainly underestimated in the regressions below. Additionally, the regressions were carried out on the original data, which includes areas of sea and lake. These and minor (rare) habitat types were excluded from most of the regressions, but were found to yield a substantial negative correlation with badger density (which is not surprising, as areas of lake and sea were often substantial portions of individual squares, and would, of course, have contained far fewer, or zero, setts).

Regressions of active main sett density against principal habitat types were extremely poor in predicting badger density, with r^2 at *c.* 0.2 only. This was somewhat surprising given the highly predictive nature of the British studies. The relationships found useful are examined below, but a reconsideration of the overall nature of the Irish badger and habitat data would indeed suggest that there might be difficulties in obtaining good models for Ireland - on the basis of present data.

Firstly, Thornton (1988), studying the South-West of England, used tetrads, and her studies resulted in a mean badger group density of 2.33 groups per tetrad (0.58 groups km^{-2}), a density quite similar to that obtained in the Irish badger survey, for most regions (except the West). The number of main setts found in each tetrad varied from 0 to 6. The observations did not yield many tetrads with zero setts. In contrast, the use of 1km squares in the Irish survey has resulted in many of squares with zero setts, and the overall statistical distribution of observations - even in areas of moderate density - is that of a Poisson distribution, *i.e.* somewhat random. With main sett densities of around 0.5 km^{-2}, and, for the sake of argument, assuming a fairly uniform landscape (*e.g.* grazing lands of major parts of the Midlands), then a 1km square survey will, on average, sample either 0 main setts or 1 main sett, and, just occasionally, 2 or 3 setts. Even if the habitat characteristics of an area surrounding a sett would indicate the best location for a sett, this is masked by the measure of the entire 1km square surveyed, which is placed at random in relation to the sett's location. By chance, then, with an overall density of 0.5 groups km^{-2} many squares of *equal* habitat composition will still have a tendency to yield different results, *i.e.* either 1 sett or 0 setts (in the main).

That this might be a difficulty for the use of multiple regression techniques is suggested by the composition of large areas of the Irish landscape: grazing land dominates, and is accompanied by substantial lengths of hedgerow and treeline in most counties. It has been shown that most setts are located in hedgerow and treeline, so, as there is a considerable availability of these habitats in Irish landscapes, the landscape composition will tend to result in a rather 'uniform' distribution of main setts (such 'uniformity' over much of the country might explain the corresponding Poisson distribution of main setts). Since badgers tend to 'disperse' their main setts through territorial behaviour, then, provided that an indicator habitat is available in quantity (*e.g.* hedgerow), an increase in the total amount of that habitat would not necessarily lead to an increase in badger density. This would be especially so if that habitat serves one purpose for the species but not all. Hedgerows provide cover and a suitable location for setts, but, if the density of badgers is ultimately determined by food supply, then any increase in hedgerow length above a certain minimum is inconsequential to badger density.

Woodland habitats cover such a small proportion of the Irish landscape, that even when badgers select them preferentially, the net contribution to a linear regression of these setts, located there, tends to be minor. In contrast, overall British agricultural landscapes differ in, generally, having only a fraction of the hedgerow and treeline length of that commonly observed in Ireland; *e.g.* if we compare landclass 1 data (varied agriculture, mainly grassland, undulating) for the UK [Cresswell *et al*, 1990] with overall Irish data, the proportion of land area consisting of hedgerow in Britain is 0.0006, but 0.013 in Ireland, which is 21.7 times greater in area (and 13 times greater in length). Since hedgerows are also very actively selected as site locations for main setts in Britain, but, as the occurrence of hedgerows in the landscape will follow a different pattern, a linear regression might be expected to be more significant in Britain.

The hedgerow habitat was made use of above as an example. Interestingly, hedgerow length contributed to the regressions performed for the British badger survey, but were *negatively* correlated with badger density in South-West England (with $r = -0.299$, $P < 0.05$; Thornton, 1988) - and that region of Britain is perhaps more akin to many Irish landscapes than any other in Britain.

Whilst Cresswell *et al* do not explain their reasoning in full, it would be expected that the use of 1km squares for the British survey also created difficulties, as so many squares also had zero main setts present. Therefore, the use of land classes to allow discriminant analysis of squares with and without setts allows for a two-step predictive model to be constructed, as described above. Following this first step, the multiple regressions were obtained by using data from only those squares that had setts present.

The possibility that this approach might be useful in Ireland was tested by a multiple regression derived from data for squares with main setts present only. However, unlike the British model, the results indicated a *decreased* level (r^2) of variance explained. The root to this lack of a satisfactory regression would appear to result from the overall ubiquity of badgers in Ireland, coupled with a general uniformity of landscapes. The use of a small survey area (1 km^2) in these (Irish) circumstances compounds the problem by returning, in the main, a survey result of either 0 or 1 main sett.

However, the county means and plots of habitats given in this section have demonstrated a number of *clear* positive and negative relationships with mean badger density - indicating that regional/county/geographical differences *are* sufficiently pronounced to explain much of the observed variation in badger density.

Conclusions

Initial multiple regressions, using data from all 729 1km squares, accounted for an unacceptably low amount of variation in the density of main setts. Given the particular Irish circumstances of a tendency to uniformity of badgers and habitats, the incorporation of environmental variables, and a land classification, into the database should yield much-improved results (this work forms part of a current research programme).

Whilst 1km survey squares were an effective size for the British study, the Irish circumstances, in hindsight (or with some prior knowledge of the distribution of the badger in Ireland), would suggest that tetrads would have been more suitable. This is considered in the *Discussion*, but briefly, tetrads are somewhat impractical units to survey due to their size, and their use would have reduced the number of survey areas that could be surveyed to 182 rather than 729. This would have considerably reduced the value of the *habitat* survey as a representative survey of the island, with consequences for the study of geographical variation in sett density and in habitat composition. For example, the number of tetrads that could have been investigated would be merely 2 for Cos. Carlow and Louth.

In this context, it is interesting to consider the sampling size that would be required *if* the badger's overall distribution pattern had been known prior to this survey *and* an estimate of 0.46 groups per 1km^2 had been a known (or estimated) quantity. In order to obtain 10% confidence limits (*i.e.* ± 10% of the mean badger group density), the use of 1km squares with a Poisson distribution requires a minimum sampling size of *c.* 630 squares. This study surveyed 729, which gives an additional degree of confidence to the overall results. With the same guidelines, and surveying tetrads with a mean density of 4x0.46 badger groups km^{-2} (= 1.84) and anticipating a negative binomial distribution with a k value estimated at -6.5 (with a slightly higher overall mean of 2.0 groups per tetrad), *c.* 115 tetrads would be required (estimates obtained using methodology of Krebs, 1989). Tetrads would, therefore, have been relatively more efficient in use of resources, *if* the sôle purpose of the Irish Badger & Habitat Survey had been to assess the nation-wide mean badger group density. This was not the sôle purpose, and the parameters were *unknown* beforehand.

It is clear from the nature of the database, that 'means' of badger densities for zones identified by some overall ecological similarity will yield a substantially improved predictive capability of any models developed. The data from the individual squares requires grouping to obtain such means: they might be grouped into fours (*e.g.* 4 1km survey squares within a 20x20km square), thus eliminating the Poisson distribution and approximating more to the negative binomial. They may be grouped into land classes (subsequent research programme), or equally by some suitable or relevant environmental parameter, such as altitude (to be included as a component of future research). Alternatively, they may be grouped in somewhat arbitrary geographical zones, such as counties. This option is available here, and preceding graphs have already indicated that mean badger densities are indeed determined, to a large extent, by the overall habitat composition of those counties. The limitations are obvious for those counties possessing substantial variation in landscape types but, nevertheless, the graphs suggest that any predictive models that can be developed will be substantially enhanced following incorporation of additional environmental variables or by analyses following re-grouping according to landscape types.

Multiple regression analyses

Methodology

The result of a multiple regression analysis is an equation, which may be used to predict the number of main setts (for example) in an area according to chosen habitat variables. Even if the model thus obtained does not explain all the variation in sett density, the principal habitat components that determine sett density are suggested. These predictive models for badger group density should not be confused with earlier analyses of habitat preferences for main sett location.

In total there were about 42 principal habitat variables, but these were also grouped (as above) into ecologically relevant units (*e.g.* all natural woodland), and variables such as area of grazing land according to stock present were also included. About 95 habitat variables or groupings were thus available, and, of these, a useful sub-set was initially identified from a correlation matrix. This formed the basis of computations but various other habitat components or groupings were entered or removed from multiple regressions to improve the predictive model, following procedures suggested by Afifi & Azen (1979).

Because the habitat variables are linearly dependent (since together they must total 100 ha), a major habitat component must be excluded from the resultant regression equations (Thornton, 1988; Jeffers, pers. comm.). In the main, unimproved and semi-improved grasslands were excluded from the analyses below, as they were negatively correlated with improved grassland area, and, generally, their inclusion was shown not to be useful in improving the model.

Simpson's Index of Diversity (D) was determined for each square and added to the variables considered: it was calculated from the 42 principal habitat groupings only (including sea and lake) and was computed as described by Krebs (1989). The diversity index used here is given by 1 - D, so that higher values represent a greater diversity (all values fall between 0 and 1). County and regional means for the Diversity Index are given in Table 53 and illustrated as a plot against mean badger density for each county in Figure 127.

Figure 127 suggests that diversity alone is not a predictor of badger densities in counties (negative correlation, $r = -0.24$).

Additionally, several grazing variables or indices were considered. These are included in following tables; of interest is the ratio of hedgerow (and treeline) length to the grassland area. In other words, does badger sett density have a relationship not just with grassland area but with the density of hedgerow associated with the grassland habitat? There appears to be some relationship (Figure 128). These relationships require further evaluation, but, at this stage, the ratio concerns the length of hedgerow and treeline/area of all pasture plus arable land. The logical next step - that of considering the ratio of hedgerow and treeline length/**improved** grassland only, in relationship to badger densities requires attention.

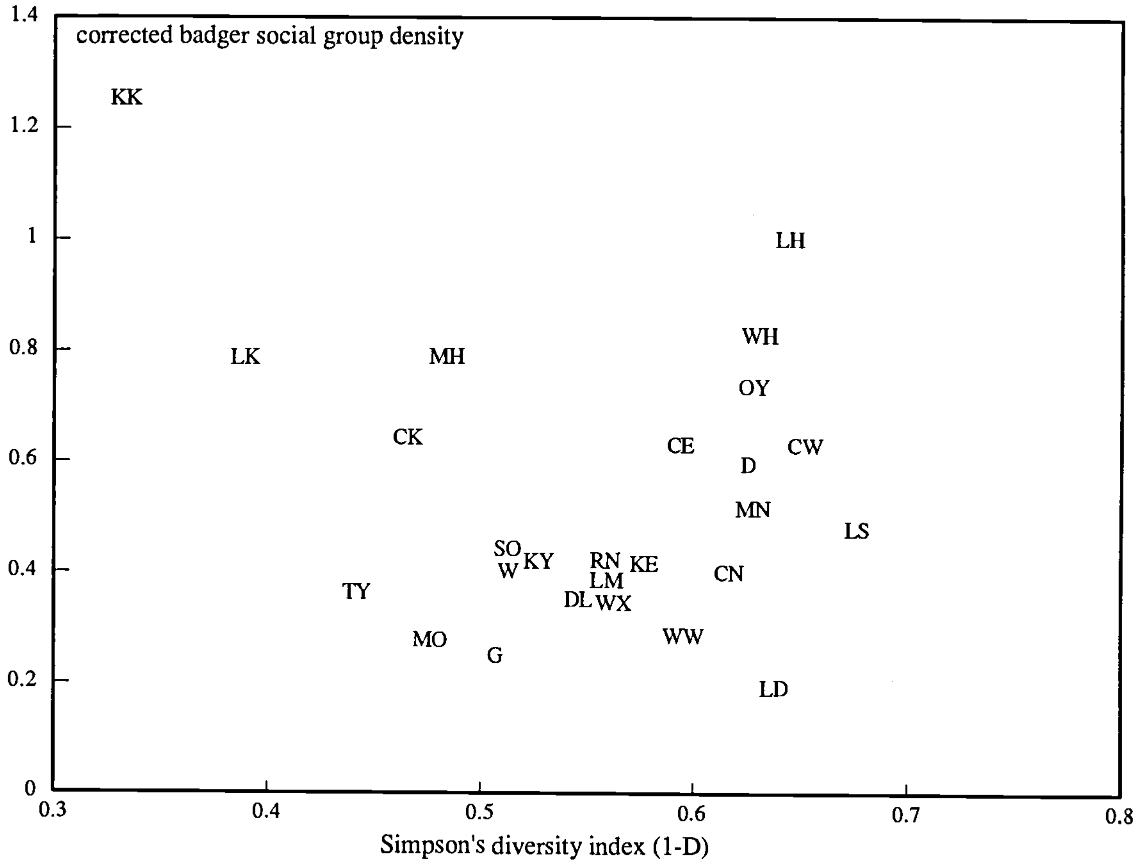


Figure 127. Plot of the county means of the Simpson's Index of Diversity (1-D) against corrected mean badger density.

In view of the *categorical* nature of much of the data available here, *i.e.* a 1km square tends to contain either 0 or 1 main sett, a logistic regression approach would be more suitable: it was not possible to consider this option within the present report.

Results: correlations between sett densities and habitat variables

The correlation matrix was used to determine the main habitat variables included in the regressions (Table 54 for active main setts, all setts, and disused main setts, and Table 55 for all ancillary sett types).

Table 53. Simpson's Diversity Index: means for the counties and regions.

	Simpson's Index given by 1-D *mean*	*minimum*	*maximum*
County			
Carlow	0.65	0.51	0.83
Cavan	0.62	0.01	0.84
Clare	0.59	0.04	0.81
Cork	0.47	0.03	0.88
Donegal	0.55	0.09	0.83
Dublin	0.63	0.43	0.96
Galway	0.51	0.00	0.85
Kerry	0.52	0.03	0.86
Kildare	0.58	0.12	0.88
Kilkenny	0.33	0.03	0.81
Laois	0.68	0.41	0.83
Leitrim	0.56	0.05	0.76
Limerick	0.39	0.03	0.78
Longford	0.64	0.43	0.82
Louth	0.65	0.51	0.80
Mayo	0.48	0.00	0.79
Meath	0.48	0.06	0.83
Monaghan	0.63	0.22	0.87
Offaly	0.63	0.16	0.81
Roscommon	0.56	0.19	0.80
Sligo	0.52	0.11	0.84
Tipperary	0.44	0.00	0.77
Waterford	0.51	0.01	0.99
Westmeath	0.63	0.05	0.85
Wexford	0.56	0.33	0.85
Wicklow	0.60	0.07	0.89
Region			
South-West	0.49	0.03	0.88
Mid-West	0.51	0.03	0.81
West	0.50	0.00	0.85
North-West	0.55	0.09	0.84
Midlands	0.60	0.01	0.87
South	0.40	0.00	0.99
East	0.59	0.07	0.96
Republic	0.52	0.00	0.99

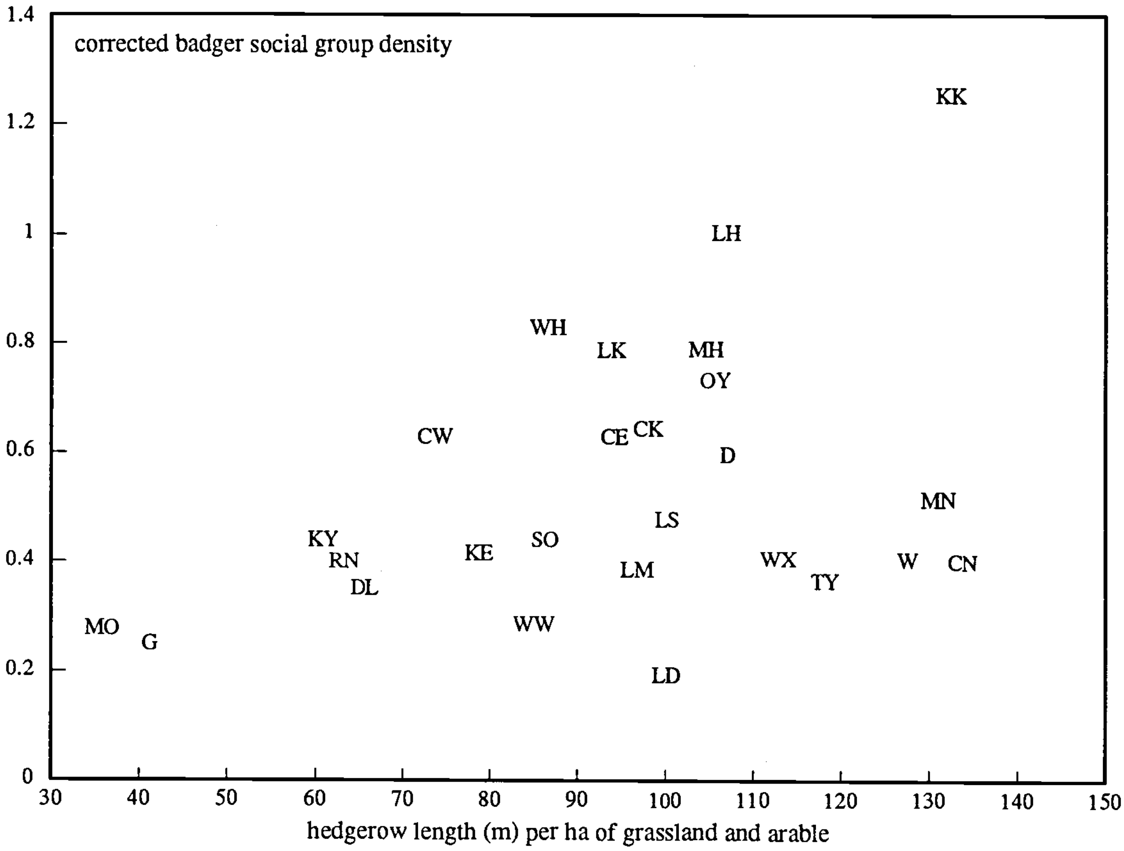


Figure 128. Plot of mean badger group density against an index of hedgerow intensity present on grassland and arable land. The index is the ratio of the length (m) of hedgerow and treeline to the area of grassland and arable land.

The density of active main setts is positively correlated with hedgerow and treeline length, with hedgerow being the major component. Subsidiary and outlier setts are also correlated with hedgerows and treelines, but disused main setts and annexe setts are not. Relationships between the area of woodland and sett density are generally positive but quite weak, with semi-natural woodland (principally deciduous and mixed rather than coniferous) being the main contributor. Disused main setts were found to be significantly correlated with young plantations, whether broad-leaved, mixed or coniferous: this is suggestive of sett abandonment following planting or maturation of such areas. Weak negative correlations of sett density (for some sett categories) exist relative to area of coniferous plantation and recently felled woodland.

For most sett categories, sett density was negatively correlated with tall scrub. There was a virtual absence of correlation with low scrub for all sett types, except for disused main setts, where area of low scrub was negatively correlated with density but low scrub length (boundaries) was positively correlated with the sett density. Adding scrub boundary length to the hedgerow and treeline category improved the positive correlation with sett density in all sett categories, but the contribution is rather small.

Table 54. Pearson's correlation matrix for sett density against habitat variables, habitat groupings, and habitat indices. These correlations are obtained from the corrected county means.

Significant correlations are indicated as follows: at the 10% level +, at the 5% level *, at the 2% level **, and at the 1% level ***.

Habitat no.	Habitat	Active main setts *r*	sign.?	All setts *r*	sign.?	Disused main setts *r*	sign.?
1	Hedgerow length (or area)	0.431	*	0.318	+	-0.103	
2	Treeline	0.133		0.272		0.231	
2B	Bare treeline	0.111		0.194		0.106	
	Total hedgerow and treeline length (or area)	0.444	*	0.375	*	-0.035	
3	Semi-natural broad-leaved woodland	0.125		0.236		0.000	
4	Broad-leaved plantation	0.192		0.089		0.152	
5	Semi-natural coniferous woodland	0.061		-0.001		-0.097	
6	Coniferous plantation	0.110		0.045		-0.054	
6Y	Young coniferous plantation	-0.154		0.070		0.467	**
7	Semi-natural mixed woodland	-0.006		-0.014		-0.174	
8	Mixed plantation	0.306		0.268		0.131	
9	Young mixed or broad-leaved plantation	-0.097		0.102		0.512	***
10	Recently felled woodland	-0.079		-0.123		-0.036	
	All natural woodland	0.133		0.208		-0.068	
	All plantation	-0.059		0.116		0.270	
	All deciduous and mixed woodland	0.302		0.299		0.178	
	All coniferous woodland	0.002		0.078		0.226	
11	Parkland	-0.151		-0.109		-0.282	
12A	Tall scrub (area)	-0.214		-0.102		-0.177	
12L	Tall scrub (length km)	-0.029		-0.061		-0.338	+
13A	Low scrub (area)	0.053		0.041		-0.214	
13L	Low scrub (length km)	-0.074		0.033		0.276	
	Total scrub area	-0.106		-0.038		-0.294	
	Total scrub length	-0.075		0.010		0.139	
	Total length of hedge, treeline and scrub	0.457	**	0.397	*	-0.017	
	Total area of hedge, treeline and scrub	0.135		0.160		-0.282	
	Total length of hedge, treeline and low scrub	0.457	*	0.399	*	-0.001	
	Total area of hedge, treeline and low scrub	0.304		0.254		-0.194	
14	Bracken	0.086		-0.007		-0.140	
15	Coastal sand dunes	-0.318	+	-0.239		0.280	
16	Coastal sand or mudflats	excluded		excluded		excluded	
17	Coastal shingle or boulder beaches	excluded		excluded		excluded	
18	Lowland heath	-0.073		-0.122		-0.188	
19	Heather moorland	-0.351	+	-0.383	*	-0.079	
20	Blanket bog	-0.402	*	-0.360	+	0.049	
21	Raised bog	-0.412	*	-0.289		-0.017	
20/21W	Worked peat	0.162		0.266		0.294	

Table 54 contd.

Habitat no.	Habitat	Active main setts r	sign.?	All setts r	sign.?	Disused main setts r	sign.?
	Total bog and moorland	-0.473	**	-0.405	*	0.065	
	Total heath, bog, moorland	-0.473	**	-0.414	*	0.035	
22	Marginal inundations	0.120		0.281		0.228	
23	Coastal marsh	0.272		-0.026		-0.275	
24	Wet ground	-0.165		-0.238		0.161	
25	Standing natural water	excluded		excluded		excluded	
26	Standing man-made water	excluded		excluded		excluded	
27A	Running natural water (area)	0.082		0.212		0.079	
27L	Running natural water (length km)	-0.276		-0.358	+	-0.146	
28A	Running canalised water (area)	-0.034		0.133		-0.060	
28L	Running canalised water (length km)	0.118		0.173		-0.017	
	Total stream and drain area	0.047		0.259		0.029	
	Total stream and drain length	0.001		0.025		-0.093	
29	Upland unimproved grassland	-0.259		-0.277		-0.286	
30	Lowland unimproved grassland	-0.278		-0.300		-0.365	
31	Semi-improved grassland	-0.252		-0.299		-0.135	
32	Improved grassland	0.492	***	0.512	***	0.214	
	Total unimproved grassland	-0.319	+	-0.344	+	-0.399	*
	Total improved grassland (incl. semi-improved)	0.398	*	0.391	*	0.157	
	Total grassland (habitats 29-32)	0.211		0.184		-0.132	
33 TOT	Arable (total)	0.308		0.234		0.126	
33B	Arable (seedcrops)	0.385	*	0.288		0.041	
33R	Arable (rootcrops)	0.207		0.075		0.116	
33G	Arable (grassland leys)	0.016		0.043		0.250	
33H	Arable (horticultural)	0.017		-0.024		-0.177	
34	Amenity grasslands	0.009		0.022		-0.174	
35	Unquarried inland cliffs	-0.268		-0.332	+	-0.119	
36	Vertical coastal cliffs	-0.303		-0.161		0.375	+
37	Sloping coastal cliffs	-0.085		-0.171		-0.090	
38	Quarries and open-cast mines	0.142		0.095		0.174	
39	Bare ground	-0.318	+	-0.209		0.126	
40	Built land area (excl. roads)	0.113		0.152		-0.125	
41A	Roads (area)	0.224		0.147		-0.284	
41L	Roads (length km)	0.075		-0.060		-0.469	**
40/41-TOT	Total built land (roads and built land)	0.065		0.074		-0.155	
42	Sea	excluded		excluded		excluded	
other	Unspecified	-0.144		-0.186		-0.049	
minor	Sum of minor habitat categories (10,11,15,16,17,22,23,24,25,26,34,35,36,37,39,42)	-0.242		-0.307		-0.018	

Table 54 contd.

Habi-tat no.	Habitat	Active main setts r	sign.?	All setts r	sign.?	Disused main setts r	sign.?
	Total grazing and arable area	0.420	*	0.341	+	-0.033	
	Hedgerow and treeline area/area of grazing and arable	0.390	*	0.357	+	-0.022	
	Hedgerow, treeline and scrub area/area of grazing and arable	-0.092		-0.028		-0.231	
	Hedgerow and treeline length/area of grazing and arable	0.390	*	0.357	+	-0.219	
	Hedgerow, treeline and scrub length/area of grazing and arable	0.370	(*)	0.357	+	0.013	
	summaries all habitats						
	Cattle grazing area (all habitats)	0.312	+	0.245		-0.072	
	Sheep grazing area (all habitats)	-0.461	**	-0.426	*	0.090	
	Cattle and sheep shared grazing area (all habitats)	-0.253		-0.299		-0.225	
	Grazing area of 'other' stock types (all habitats)	0.442	(**)	0.420	*	0.047	
	Total cattle grazing area (all habitats) incl. shared grazing	0.162		0.061		-0.222	
	Total area of land grazed (all stock types)	-0.116		-0.203		-0.175	
	% of total grazing areas grazed by cattle	0.379	*	0.309		-0.208	
	summaries all specified grazing habitats						
	Cattle grazing area (grazing habitats)	0.316	+	0.252		-0.063	
	Sheep grazing area (grazing habitats)	-0.464	**	-0.426	*	0.082	
	Cattle and sheep shared grazing area (grazing habitats)	-0.247		-0.292		-0.226	
	Grazing area of 'other' stock types (grazing habitats)	0.486	***	0.461	**	0.101	
	Total cattle grazing area (grazing habitats) incl. shared grazing	0.169		0.072		-0.213	
	Total area of land grazed (all stock types)	-0.101		-0.184		-0.168	
	% of total grazing areas grazed by cattle	0.378	*	0.310	+	-0.199	
	summaries all pastures (habitats 29 - 32)						
	Cattle grazing area (pastures)	0.337	+	0.273		-0.066	
	Sheep grazing area (pastures)	-0.294		-0.204		0.169	
	Cattle and sheep shared grazing area (pastures)	-0.170		-0.195		-0.205	
	Grazing area of 'other' stock types (pastures)	0.493	***	0.473	**	0.125	
	Total cattle grazing area (pastures) incl. shared grazing	0.253		0.171		-0.193	
	Total area of pastureland (all stock types)	0.219		0.160		-0.140	
	% of total pasturelands grazed by cattle	0.245		0.162		-0.231	

Table 55. Pearson's correlation matrix for density of minor setts against habitat variables, habitat groupings, and habitat indices. These correlations are obtained from the corrected county means.

Significant correlations are indicated as follows: at the 10% level +, at the 5% level *, at the 2% level **, and at the 1% level ***.

Habitat no.	Habitat	Annexe setts *r*	sign.?	Subsidiary setts *r*	sign.?	Outlier setts *r*	sign.?
1	Hedgerow length (or area)	-0.035		0.365	+	0.272	
2	Treeline	0.094		0.162		0.416	*
2B	Bare treeline	0.099		0.109		0.294	
	Total hedgerow and treeline length (or area)	-0.006		0.389	*	0.372	+
3	Semi-natural broad-leaved woodland	0.260		0.116		0.357	+
4	Broad-leaved plantation	0.038		0.061		0.027	
5	Semi-natural coniferous woodland	0.232		-0.155		0.063	
6	Coniferous plantation	0.068		0.121		-0.082	
6Y	Young coniferous plantation	0.297		0.031		0.046	
7	Semi-natural mixed woodland	0.048		0.082		-0.104	
8	Mixed plantation	0.288		0.267		0.146	
9	Young mixed or broad-leaved plantation	0.256		0.194		-0.066	
10	Recently felled woodland	-0.132		-0.201		-0.025	
	All natural woodland	0.325	+	0.064		0.323	+
	All plantation	0.256		0.149		-0.021	
	All deciduous and mixed woodland	0.306		0.230		0.256	
	All coniferous woodland	0.246		0.106		-0.035	
11	Parkland	-0.037		-0.041		-0.098	
12A	Tall scrub (area)	0.035		0.069		-0.206	
12L	Tall scrub (length km)	-0.109		0.060		-0.107	
13A	Low scrub (area)	0.071		-0.006		0.105	
13L	Low scrub (length km)	0.092		0.007		0.035	
	Total scrub area	0.081		0.043		-0.060	
	Total scrub length	0.047		0.026		-0.002	
	Total length of hedge, treeline and scrub	0.001		0.414	*	0.392	*
	Total area of hedge, treeline and scrub	0.070		0.240		0.139	
	Total length of hedge, treeline and low scrub	0.006		0.410	*	0.396	*
	Total area of hedge, treeline and low scrub	0.054		0.224		0.304	+
14	Bracken	-0.024		0.040		-0.073	
15	Coastal sand dunes	-0.015		-0.257		-0.253	
16	Coastal sand or mudflats	excluded		excluded		excluded	
17	Coastal shingle or boulder beaches	excluded		excluded		excluded	
18	Lowland heath	-0.086		-0.008		-0.215	
19	Heather moorland	-0.201		-0.312	(+)	-0.431	*
20	Blanket bog	-0.033		-0.359	+	-0.375	+
21	Raised bog	-0.199		-0.224		-0.246	
20/21W	Worked peat	0.216		0.118		0.373	+

Table 55 contd.

Habitat no.	Habitat	Annexe setts *r*	sign.?	Subsidiary setts *r*	sign.?	Outlier setts *r*	sign.?
	Total bog and moorland	-0.116		-0.391	*	-0.396	
	Total heath, bog, moorland	-0.127		-0.383	*	-0.420	*
22	Marginal inundations	0.251		0.291		0.256	
23	Coastal marsh	-0.278		0.018		-0.088	
24	Wet ground	-0.083		-0.256		-0.289	
25	Standing natural water	excluded		excluded		excluded	
26	Standing man-made water	excluded		excluded		excluded	
27A	Running natural water (area)	0.328	+	0.296		0.085	
27L	Running natural water (length km)	-0.132		-0.313	+	-0.416	*
28A	Running canalised water (area)	0.164		0.128		0.201	
28L	Running canalised water (length km)	0.077		0.144		0.230	
	Total stream and drain area	0.375	+	0.327	+	0.194	
	Total stream and drain length	0.025		0.013		0.063	
29	Upland unimproved grassland	-0.022		-0.240		-0.291	
30	Lowland unimproved grassland	-0.079		-0.235		-0.311	
31	Semi-improved grassland	-0.278		-0.213		-0.323	+
32	Improved grassland	0.170		0.475	**	0.513	***
	Total unimproved grassland	-0.071		-0.278		-0.358	+
	Total improved grassland (incl. semi-improved)	0.019		0.404	*	0.377	+
	Total grassland (habitats 29-32)	-0.034		0.251		0.157	
33 TOT	Arable (total)	-0.062		0.174		0.279	
33B	Arable (seedcrops)	-0.014		0.242		0.310	
33R	Arable (rootcrops)	-0.218		0.081		0.058	
33G	Arable (grassland leys)	-0.073		-0.050		0.138	
33H	Arable (horticultural)	0.016		-0.084		0.046	
34	Amenity grasslands	0.233		-0.114		0.127	
35	Unquarried inland cliffs	-0.187		-0.327	+	-0.320	+
36	Vertical coastal cliffs	0.160		-0.180		-0.212	
37	Sloping coastal cliffs	-0.237		-0.156		-0.151	
38	Quarries and open-cast mines	-0.049		0.109		0.047	
39	Bare ground	0.092		-0.194		-0.245	
40	Built land area (excl. roads)	0.289		-0.017		0.289	
41A	Roads (area)	0.161		0.037		0.234	
41L	Roads (length km)	0.141		-0.141		-0.012	
40/41-TOT	Total built land (roads and built land)	0.224		-0.078		0.199	
42	Sea	excluded		excluded		excluded	
other	Unspecified	-0.344	+	-0.067		-0.222	
minor	Sum of minor habitat categories (10,11,15,16,17,22,23,24,25,26,34,35,36,37,39,42)	-0.014		-0.355	+	-0.317	+

Table 55 contd.

Habitat no.	Habitat	Annexe setts *r*	sign.?	Subsidiary setts *r*	sign.?	Outlier setts *r*	sign.?
	Total grazing and arable area	-0.077		0.359	+	0.348	+
	Hedgerow and treeline area/area of grazing and arable	0.082		0.363	+	0.347	+
	Hedgerow, treeline and scrub area/area of grazing and arable	0.120		0.036		-0.060	
	Hedgerow and treeline length/area of grazing and arable	-0.082		0.363	+	0.347	+
	Hedgerow, treeline and scrub length/area of grazing and arable	0.100		0.366	+	0.341	+
	summaries all habitats						
	Cattle grazing area (all habitats)	0.090		0.228		0.233	
	Sheep grazing area (all habitats)	-0.223		-0.407	*	-0.409	*
	Cattle and sheep shared grazing area (all habitats)	-0.261		-0.188		-0.337	+
	Grazing area of 'other' stock types (all habitats)	0.333	+	0.248		0.506	***
	Total cattle grazing area (all habitats) incl. shared grazing	-0.075		0.116		0.025	
	Total area of land grazed (all stock types)	-0.214		-0.146		-0.223	
	% of total grazing areas grazed by cattle	0.142		0.337	+	0.265	
	summaries all specified grazing habitats						
	Cattle grazing area (grazing habitats)	0.0969		0.233		0.240	
	Sheep grazing area (grazing habitats)	-0.222		-0.407	*	-0.407	*
	Cattle and sheep shared grazing area (grazing habitats)	-0.258		-0.180		-0.331	+
	Grazing area of 'other' stock types (grazing habitats)	0.339	+	0.275		0.552	***
	Total cattle grazing area (grazing habitats) incl. shared grazing	-0.068		0.126		0.035	
	Total area of land grazed (all stock types)	-0.203		-0.128		-0.203	
	% of total grazing areas grazed by cattle	0.145		0.341	+	0.260	
	summaries all pastures (habitats 29 - 32)						
	Cattle grazing area (pastures)	0.096		0.254		0.267	
	Sheep grazing area (pastures)	-0.110		-0.235		-0.136	
	Cattle and sheep shared grazing area (pastures)	-0.201		-0.082		-0.237	
	Grazing area of 'other' stock types (pastures)	0.305		0.294		0.566	***
	Total cattle grazing area (pastures) incl. shared grazing	-0.019		0.218		0.133	
	Total area of pastureland (all stock types)	-0.044		0.183		0.164	
	% of total pasturelands grazed by cattle	0.064		0.226		0.088	

Whilst setts were preferentially located in bracken, the area of bracken was not correlated with sett density. Coastal sand dunes were negatively correlated with density of most sett types, except disused main setts.

One of the largest habitat groupings in Ireland is that of bog and moorland; lowland heath has been included in this grouping. There is a significant negative relationship between the area of heath, bog and moorland and sett density for all sett categories. However, the area of worked peat is positively correlated with sett density, particularly so for minor setts. Most moorland and bog areas are located in western and upland areas of the country which are generally unsuitable for badgers, but sizeable tracts of worked peat occur in the Midlands, where, together with the adjacent pastures and grasslands on reclaimed bog, worked bog edges actually provide a good overall environment for badgers.

Whilst the mean area of wet ground in a county is negatively correlated with sett density, marginal inundations are positively correlated with sett density, and coastal marsh also positively correlated with active main sett density.

The length of natural watercourses (rivers, streams) is negatively correlated with sett density - this relationship may arise from such watercourses being more common in western, upland, and hill areas. Where rivers and streams were large enough to be represented as features having a width on OS maps, the area was assessed, and in this case, there is a weak *positive* correlation of river/stream area with sett density - which, similarly, may arise from these *larger* watercourses being more often located in lowland areas. Thus, it may be anticipated that canalised waterways (drains and canals), being more frequent in improved agricultural areas and in lowland zones, would be positively correlated with badger sett density. This is the case, though the correlations are not substantial, perhaps because drains are also a prominent feature of many moorland and bog areas. It is shown later that drain length is a significant contributor to the linear regressions, through, apparently, adding a descriptor to the type or quality of improved grasslands present in a county.

Grasslands are the most important component of the Irish landscape - and their abundance and quality in any Irish county is an important determiner of mean badger density in the county. All sett categories were found to be negatively correlated with unimproved grassland, whether upland or lowland. In contrast, the most significant positive correlations observed here were of sett density with improved grassland. Use of pasture for sheep predominates on poorer grasslands, and cattle on improved grasslands. Thus, sett densities were found to be negatively correlated with the mean area of sheep pasture, and positively correlated with the area of cattle pasture. If grazing or grassland habitats are considered in terms of the proportion of these lands given over to cattle, then the higher the percentage of grazing land devoted to cattle, the higher the mean sett density. Similarly, when the 'density' of hedgerows and treelines was considered (mean length per ha of grassland), it was found that badger density is correlated with this index, probably as a result of this index being positively correlated with improved grassland [including semi-improved grassland] ($r = 0.52$) and negatively with unimproved grassland ($r = -0.17$).

Surprisingly, there is a strong correlation between the mean area of land given over to 'other' stock types and badger sett density, and this relationship is stronger than that between area of land used for cattle and sett density (accounting for 24% of variation in main sett density). The mean area of land grazed by 'other' stock types is very small overall (*c.* 1% overall in Ireland, 2% in the Midlands, refer Table 18). This item is one that merits further investigation in view of its predictive capability; undoubtedly, there are grassland productivity and historical factors involved. 'Other' stock types were, in the main, horses, goats, donkeys, and also pig and deer farming. Badger density was also correlated with the mean area of arable land (particularly seedcrops).

The above observations together indicate that badger density is correlated with the mean area (per km^2) of farming land of high productivity, where it is principally used for cattle grazing. Presence of suitable habitats for sett location such as hedgerow and woodland contribute to the relationship, though overall habitat diversity, *per se*, is not implicated. Aspects of overall land management, which may even have a historical basis, appear implicated, as a result principally of the relevance of land grazed by 'other stocks': this may be related to land productivity and farm size, with larger holdings (or 'estates') tending to be those with copses/woodlands, and a variety of additional land uses. The possibility that size of land-holdings, ownership type, land quality and management contribute to increased badger density requires additional data to confirm it.

The data from Northern Ireland should assist in further appreciation of these possibilities, especially because the area of pasture devoted to sheep is proportionately far greater there than in the Republic. Therefore, it might be anticipated that the relationship between badger density and area of land devoted to cattle would be considerably weaker. Given the reasonably high densities of badgers in the North, pasture and land management differences might be implicated instead. There exist, of course, political reasons, as well as environmental ones, for differences in land management between the North and the Republic.

Finally, badger densities were positively correlated with road area (but not length): this would be expected, because lowland areas of higher productive quality tend to have more large roads than upland areas, but the *length* of roads has been shown to be quite uniform over the country. Most of these correlations were not significant, but, interestingly, the one exception was that of disused badger setts, where the density of such setts was strongly negatively correlated with road length. It may be surmised that abandonment of many main setts might be the result of road fatalities and/or disturbance by traffic or through resultant ease of access by people (including badger-baiters) to setts.

The above correlations were used as guidelines in the construction of multiple regression models for the various sett categories.

Results: multiple regression analyses for county means

Active main setts (badger social groups):

A limited number of variables were needed to provide a significant regression, yielding an explanatory value of 78.3%, by county means. [*n.b.* sett densities and habitat means used for analyses, here and following, were corrected for areas of sea and lake]. No other model was recognised without the availability of an all possible sub-sets regression.

Active main sett density = 1.3001 + 0.1211(area of mixed and deciduous woodland) - 0.0110(total area of heath, moor, bog, excl. worked peat) + 0.1065(area of coastal marsh) + 0.2589(length of natural waterways) + 0.2511(length of canalised waterways) - 0.0169(area of semi-improved grassland) - 2.0110(Simpson's diversity index) [F(7,18) = 9.29; P = 0.0001].

The regression equation suggests that variation in badger density in any county may largely be explained by a limited number of habitat variables, with some of the inter-relationships between them difficult to understand. Thus habitat diversity has a negative coefficient, which may relate to the relative lack of diversity in good farming areas preferred by badgers. Similarly, badger densities are negatively correlated with areas of bog and moorland. However, in these models, the length of natural waterways provides a positive coefficient though the correlations were negative.

Two variables that contributed very substantially to the statistical significance of the models were the diversity index and the length of canalised waterway (drains and canalised streams mainly). With regard to the use of land classifications (future research), there is a need to develop useful models that rely upon rudimentary map-derived statistics for any area. The diversity index was obtained from detailed habitat surveys, and is, therefore, inappropriate in this regard, though important in the above models. Land classification allows the incorporation of environmental variables, such as altitude, so that variables that have presently been assessed by land survey might be excluded in future. At present, the predictive models of badger group density rely heavily upon habitat variables assessed in the field.

Disused main setts:

As with active main setts, a multiple regression yielded a good relationship between a limited number of variables and the density of disused main setts (explained variation = 68.3%). However, the variables involved were quite different, as follows.

Density of disused main setts = 0.2886 + 0.6547(area of young mixed or broad-leaved plantation) - 0.0246(total area of scrub) + 0.0086(area of worked bog/peat) - 0.0026(total area of unimproved grassland) - 0.0592(road length) [F(5,20) = 8.64; P = 0.0002].

An alternative model excluded the worked peat variable but included broad-leaved plantation, young plantation, and semi-natural mixed woodland. This model provided 70.1% of explanation but the regression was slightly less significant.

The variables utilised suggest that plantations may lead to sett abandonment, and, similarly, perhaps road casualties account for abandonment of setts where road length is high. Working of areas for peat may also affect sett faithfulness.

Annexe setts

As for main setts, only one suitable model was derived for annexe setts. Four variables accounted for 52.9% of variation, with the inclusion of a fifth (marginally insignificant) - *coastal marsh* - improving explanation to 59.8%.

Density of annexe setts = 0.0821 - 0.3501(area of recently felled woodland) + 0.2709(area of natural waterways) - 0.0067(area of arable land) + 0.1075(area of pastureland utilised by 'other' stock) [F(5,20) = 5.4; P < 0.002].

The variables utilised for the regression are not readily understandable.

Subsidiary setts

The best 'success rate' of regression analyses was for the mean density of subsidiary setts that may be predicted for a county from its habitat means.

The regression analysis yielded two alternative models, the best giving 83.3% explanation of variation:

Mean density of subsidiary setts = 0.1089 + 0.1636(area of mixed and deciduous woodland) - 0.0872(area of worked peat) - 0.2299(area of wet ground) + 1.2282(area of natural waterways) + 0.2133(length of canalised waterways) - 0.0309(area of lowland unimproved grassland) + 0.0112(area of improved pasture) - 0.3767(area of roads) + 0.2023(area of land utilised for grazing by 'other' stock) [F(9,16) = 8.84; P = 0.0001].

Whilst the alternative model yielded a lower explanation of variation of 70.3%, the variables employed differed:

Mean density of subsidiary setts = 1.5661 - 0.7112(area of recently felled woodland) + 0.2052(area of tall scrub) - 0.0122(total area of heath, bog, moorland) + 0.7702(area of natural waterways) + 0.2594(area of pastures grazed by 'other' stock) - 0.26814(Simpson's diversity index) [F(6,19) = 7.50; P = 0.0003].

The variables might suggest that subsidiary setts are more common in good grazing areas. As with the other sett types, the insignificance of hedgerow length as an indicator is puzzling.

Outlier setts

Only one model was derived for mean outlier sett density per county. This utilised just three variables, yielding an explanation of variation of 64.4%.

Mean outlier sett density = - 0.3995 + 0.5251(area of natural waterways) + 0.0131(area of improved pasture) + 0.2402(area of pasture utilised for 'other' stocks) [F(3,22) = 13.26; P < 0.0001].

The above models illustrate that habitat variables account for a substantial amount of variation in sett density, but some of the relationships, and habitat variables that contribute, are difficult to interpret in a biologically relevant manner. Given present constraints, logistic regression and all possible sub-sets regression have *not* been included in analyses. These matters need to be addressed, and, in a more general context, variables that might be computed from maps or satellite data alone would be more useful than variables that can only be assessed from detailed ground surveys, for predictive purposes.

Results: multiple regressions for 1km squares

As noted previously, regressions for 1km squares were not fruitful. Briefly, results are presented for badger density (active main setts) in regression against the most relevant habitat variables. Habitat data (areas) were log arcsine transformed or square root transformed (lengths).

The most pertinent variables were included in the following regression, which explained only 14.7% of the variance in main sett density:

Active main sett density = 0.9220 + 0.0923(total hedgerow, treeline and scrub length) + 0.1630(area of deciduous and mixed woodland) + 0.0683(total length of natural and canalised waterway) + 0.1808(total area of pasture grazed by cattle) [$F(4,724) = 31.29$; $P < 0.0001$].

n.b. values for log arcsine transformed data, length data square root transformed.

A multiple regression was attempted for those squares with main setts present only, to evaluate whether the methodology of Cresswell *et al* (1990) (as mentioned above) might be considered useful here. No meaningful result was obtained at all, with no variables contributing to more than 1% of variance. In this analysis, most of 280 sample squares had 1 main sett and a smaller number 2 or 3 setts.

As mentioned above, a logistic regression may yield improved results for the analyses for individual squares data, which is largely of a presence/absence type. It may reasonably be concluded that, whilst multiple linear regressions yield predictive equations (of some merit as they explain 50-83% of variation for county data) they do not readily lend themselves to an understanding of relationships. Discriminant analyses would appear to be far more useful in understanding underlying relationships. The following sections deal with predictive capability for badger density.

Habitat variables distinguishing squares or counties of differing badger density

Mean values for principal habitat variables were computed for squares with 0 active main setts and 1, 2 or 3 active main setts. Those variables that showed a trend, either negative or positive, over this range may be considered to be badger density indicators for the 1km squares. Essentially, this type of evaluation leads to discriminant analyses which may be used to identify squares that have main setts present. These analyses, in contrast with the linear regressions for 1km squares proved fruitful but remained unsatisfactory, in that only *c.* 64% of squares could be correctly categorised, in terms of badger density, by their habitat composition. As before, means over larger areas proved far more successful. In fact, discriminant analysis for counties correctly categorised over 90% of counties, when counties were classified into 5 categories (by badger density). The use of discriminant analysis has, therefore, more potential than linear regression, in a predictive capacity.

Those habitat variables expressing a trend in relation to badger density are presented in Table 56. Table 56 also presents correlation coefficients for the variables against active main sett density. These relationships suggested the variables that should be included in discriminant analyses. Table 56 marks those variables that showed a trend over the full range of social group density (as ++ or --) and those that showed a lesser trend, in that 3 of the 4 categories showed a trend (as + or -). As there were few squares having 3 active main setts, the habitat means for these high density badger squares are not reliable. It would be possible to statistically compare means of these habitat variables for each group (the groups comprising squares of differing active main sett density), but this analysis has not been included at present.

Table 56 may be compared with correlation coefficients obtained from county means given in Table 54. Most of the habitat variables that were correlated with badger density there, were also found to be correlated for the individual squares' data, but some variables, such as area of sea had been excluded from corrected habitat composition data available for counties.

From Table 56, badger density was significantly correlated with hedgerow and treeline length (+ve), with broad-leaved plantation (+ve) or total area of deciduous and mixed woodland (+ve), with low scrub (+ve), and area of coastal shingle (-ve), are of heather moorland or blanket bog (-ve), standing natural water (-ve), canalised water length or area (+ve), semi-improved and improved grassland (+ve), quarries (+ve), road length (+ve), sea (-ve), Simpson's diversity index (+ve). Here the latter was positive rather than negative.

As before, badger density was positively correlated with area of cattle pasture and negatively with sheep pasture.

Several habitat types showed clear positive trends with badger density: one example is semi-natural woodland, but the correlation between area of this habitat in individual squares with badger density in each square was not significant. Clearly, whilst the *mean* values for squares of each category do reveal a strong trend, the considerable variation that exists between squares in the area present of this woodland type reduces the statistical relationship.

*Table 56. Variation in mean habitat composition (ha or km as appropriate) of 1km squares with differing badger social group density (as expressed by number of active main setts surveyed). Trends are indicated by +. The correlation coefficient is also given, with significance levels (5% *, 1% **, <0.1% ***). Habitat groupings in italics.*

	active main setts					
habitat description	**0**	**1**	**2**	**3**	**trend**	***r***
hedgerow length	3.87	6.18	6.47	11.85	++	0.27 ***
hedgerow area	0.97	1.54	1.62	2.96	++	0.27 ***
treeline length	0.66	0.94	1.16	0.82	+	0.12 **
bare treeline length	0.05	0.04	0.13	0.00		0.02
total treeline length	0.71	0.98	1.29	0.82	+	0.12 **
total treeline area	0.18	0.24	0.32	0.20	+	0.12 **
total hedge and treeline length	4.58	7.16	7.76	12.66	++	0.28 ***
total hedge and treeline area	1.15	1.79	1.94	3.17	++	0.28 ***
semi-natural broad-leaved woodland	0.38	0.45	0.60	1.13	++	0.04
broad-leaved plantation	0.12	0.26	0.98	0.20	+	0.13 **
semi-natural coniferous woodland	0.04	0.03	0.23	0.00		0.06
coniferous plantation	2.76	3.27	3.36	0.12	+	0.01
young coniferous plantation	1.89	1.08	1.67	0.00		-0.04
semi-natural mixed woodland	0.04	0.04	0.20	0.00		0.06
mixed plantation	0.07	0.22	0.06	0.00		0.04
young mixed or broad-leaved plantation	0.01	0.03	0.00	0.00		0.01
felled woodland	0.09	0.04	0.00	0.00	-	-0.03
all natural woodland	0.45	0.51	1.03	1.13	++	0.06
all plantation	4.84	4.86	6.08	0.32	+	0.00
all deciduous and mixed woodland	0.62	1.00	1.85	1.33	+	0.11 **
all coniferous woodland	4.68	4.37	5.26	0.12		-0.01
parkland	0.02	0.08	0.37	0.00	+	0.08 *
tall scrub area	0.67	0.81	0.84	0.27	+	0.02
tall scrub length	0.06	0.08	0.14	0.32	++	0.07
low scrub area	1.37	2.12	1.88	2.67		0.10 **
low scrub length	0.31	0.41	0.61	0.32	+	0.07 *
total scrub area	2.04	2.93	2.72	2.93		0.09 *
total scrub length	0.38	0.50	0.75	0.64	+	0.09 *
total scrub, hedge, treeline length	4.96	7.65	8.51	13.30	++	0.30 ***
total scrub, hedge, treeline area	3.19	4.72	4.66	6.10	+	0.16 ***
total low scrub, hedge, treeline length	4.90	7.57	8.37	12.98	++	0.29 ***
total low scrub, hedge, treeline area	2.52	3.91	3.82	5.83	+	0.20 ***
bracken	0.32	0.48	0.39	0.17	-	0.02
coastal sand dune	0.29	0.00	0.00	0.00		-0.04
coastal sand or mudflats	0.97	0.13	0.00	0.00	--	-0.06
coastal shingle or boulder beaches	0.40	0.03	0.10	0.00	-	-0.10 *
lowland heath	0.49	0.84	0.59	0.00		0.02
heather moorland	8.14	2.17	0.31	0.00	--	-0.17 ***
blanket bog	7.70	2.95	0.05	0.00	--	-0.14 **
raised bog	1.87	1.60	2.69	0.00		-0.00
worked peat	1.30	0.22	0.00	0.00	--	-0.06
total heath, moorland, bog	19.51	7.79	3.64	0.00	--	-0.22 ***
marginal inundations	0.09	0.12	0.48	0.12	+	0.07 *
coastal marsh	0.14	0.14	0.00	0.00	-	-0.01
wet ground	1.28	1.35	0.80	1.67		-0.01

Table 56 contd.

habitat description	active main setts 0	1	2	3	trend	*r*
standing natural water	2.85	0.53	0.22	0.00	--	-0.10 **
standing man-made water	0.18	0.06	0.05	0.00	--	-0.02
running natural water area	0.48	0.41	0.68	0.23	-	0.00
running natural water length	0.74	0.72	0.95	0.62	-	0.02
running canalised water area	0.26	0.32	0.42	0.37	+	0.08 *
running canalised water length	1.03	1.53	1.66	1.49	+	0.14 **
total area streams and drains	0.74	0.74	1.11	0.60		0.03
total length streams and drains	1.76	2.25	2.61	2.11	+	0.14 **
upland unimproved grassland	3.34	3.23	2.45	0.00	--	-0.02
lowland unimproved grassland	6.91	8.52	7.72	7.03		0.04
semi-improved grassland	12.20	15.46	18.07	12.52	+	0.09 *
improved grassland	25.63	39.60	43.47	65.22	++	0.24 ***
total unimproved grassland	10.25	11.74	10.16	7.03	-	0.02
total improved grassland	37.83	55.06	61.54	77.73	++	0.29 ***
total grassland 29-32	48.08	66.80	71.70	84.77	++	0.30 ***
arable total	6.35	8.49	6.34	3.00	-	0.03
amenity grassland	0.53	0.19	0.27	0.00		-0.06
unquarried inland cliffs	0.33	0.01	0.00	0.00	--	-0.04
vertical coastal cliffs	0.07	0.00	0.00	0.00	--	-0.06
sloping coastal cliffs	0.03	0.01	0.00	0.00	--	-0.04
quarries	0.07	0.17	0.50	0.00	+	0.08 *
bare ground	1.03	0.59	0.20	1.48	-	-0.04
built land, excl. roads	1.44	1.60	1.42	2.18		0.02
road area	1.28	1.78	1.78	1.65		0.20 ***
road length	1.74	2.34	2.21	2.80	+	0.20 ***
total area built land	3.33	3.57	3.22	3.83	+	0.01
sea	5.87	0.32	0.68	0.00	-	-0.15 ***
unspecified	0.11	0.10	0.13	0.00		-0.00
'others'	14.18	3.59	3.18	3.27	-	-0.21 ***
diversity index	0.49	0.58	0.58	0.46	+	0.15 ***
Grazing: all habitats						
grazing area for cattle alone (C)	23.61	38.95	41.06	68.07	++	0.28 ***
grazing area for sheep alone (S)	16.30	9.99	6.94	1.32	--	-0.14 **
grazing shared by cattle and sheep (CS)	6.95	7.35	8.46	5.53	+	0.02
grazing by 'others' (O)	0.59	1.19	2.85	0.82	+	0.14 **
total land with cattle grazing	30.55	46.30	49.52	73.60	++	0.26 ***
Grazing: pastures						
cattle grazing in pastures 29-32 (C)	21.72	36.28	39.60	67.82	++	0.28 ***
sheep grazing in pastures 29-32 (S)	7.37	7.70	6.63	1.32	-	-0.02
total shared grazing in pastures 29-32 (CS)	4.75	6.46	7.16	5.53	-	0.06
total grazed by 'others' in pastures 29-32	0.47	0.95	2.48	0.82	+	0.14 **
total grazed by sheep in pastures (S+SC)	23.25	17.34	15.39	6.85	--	-0.11 **
total grazed by cattle in pastures(C+CS)	26.46	42.73	46.76	73.35	++	0.29 ***
total grazed by cattle in unimproved pasture	3.90	6.60	6.41	6.27	-	0.11 **
total grazed by cattle in improved pastures	22.57	36.14	40.35	67.08	++	0.27 ***
total grazed by sheep in unimproved pasture	2.81	2.15	2.52	0.00		-0.03
total grazed by sheep in improved pastures	9.31	12.00	11.28	6.85		-0.06

Discriminant analyses and classification: individual survey squares

Several different approaches were adopted to examine the use of discriminant analyses/classification of squares. The first concerns discrimination between 1km squares that had active main setts and those which none, *i.e.* distinguishing squares by presence or absence. The second approach allowed more categories for discrimination by consideration of main sett density. Categories adopted were a) zero active main setts present, b) 1 main sett present, and c) 2 or more main setts present. Thirdly, a machine rule-finding system (PC/BEAGLE: Forsyth, 1987) was utilised to test the variables suggested by standard statistical techniques and to search for alternative rules for classification.

Discriminant analysis successfully categorised 64% of 1km survey squares by presence/absence. The analysis was derived from just two habitat variables: total area of cattle pasture and hedgerow and treeline length (Table 57). A result of 60% was obtained by substituting the diversity index for hedgerow and treeline length (which may have a logical basis) and results of between 60 and 63% were obtained by making use of alternative grassland variables such as area of improved grassland or area of improved cattle pasture. Other variables were either insignificant or only improved the classification marginally. [Incidentally, results from use of transformed data to reduce skewness (principally use of a log arcsine transformation) differed little from untransformed data, and transformations are not a necessity (Lunn & McNeil, 1991)].

Prediction for 1km squares is likely to be relatively poor, because of the size of the squares relative to mean badger social group densities. However, the analyses not only indicate the most important environmental variables that assist in classification but a breakdown shows that the error appears to arise mainly from areas that are predicted to have a main badger sett present and which do not possess one. Areas predicted to have no setts did not, generally, possess one (Table 57). This thus confirms the earlier conclusion with regard to the sampling error of 1km squares relative to mean badger density. If the model is used predictively, then its results are quite good: over 81% of squares predicted to have no setts had no setts. However, only 51.5% of squares predicted to possess setts actually did so.

A prediction for 1km squares based on 0 badger groups present, 1 present, and 2 or 2+ present, was less successful, yielding a 52.4% correct classification based on three environmental variables. These were: hedgerow and treeline length, total cattle pasture, and area of mixed and deciduous woodland (Table 57). Again, other combinations of variables were not useful in improving the classification or the significance of discriminant functions. A breakdown of the classification table showed that presence/absence was again predicted with a 64% success rate.

Machine rule-finding classification procedure

Classification by machine rule-finding improved upon discriminant analysis, with an overall best score of 65%, in which the program used three variables - improved cattle pasture, hedgerow and treeline length, and area of mixed and deciduous woodland [*n.b.* the program utilises a learning data set (of approximately 65% of the data) which it tests against the remaining data]. However, a breakdown of the analysis reveals that classification was in fact producing a considerably better result (Table 58) - as was noted to be the case for multiple discriminant analysis above. This is a result of success in predicting squares with zero main setts present. The success rate here was 92% correct for 'definite' predictions, and 80% for 'probable' predictions, with an overall prediction rate for squares of zero sett presence of 86%.

Prediction for squares that have setts present was approximately 50/50 (49.4% correct, 50.6% incorrect). This is actually good, as with overall sett density being in the region of 0.5 setts per km^2, a 50% rate is unlikely to be substantially improved upon. Thus, with a prediction rate of 86% for areas that have no setts, the overall performance is satisfactory, and has a greater predictive capacity than discriminant analysis.

Of interest are the rules that were adopted, which used the three variables referred to above. Squares are distinguished by two simple rules:

1) area of improved cattle pasture $\geq$ 4.52 ha km^{-2}
[When an even simpler analysis was performed, this one variable alone (value 4.50 ha km^{-2}) accounted for a 60.4% success rate, principally with a 88.1% success rate in predicting squares with zero setts - Table 57].
2) total hedgerow and treeline length $\geq$ 1.725 km km^{-2} and deciduous/mixed woodland must be present in square.

Another set of rules was obtained using the variable *improved grassland* rather than improved cattle pasture. This was relatively poor, probably because much improved pasture is used for sheep, with a substantial portion of this being at higher elevations and not as suitable for badgers. 90% of squares predicted to have 0 setts were correctly predicted, but 57% of squares predicted to have setts did not do so. Because the analysis predicted presence in many more squares than it did for absence, the overall success rate was only 55%. However, the incorporation of indicator variables improved the success rate to 63%: these included road length, hedgerow and treeline length, length of tall scrub, area of sea, total area of bog, moor and heath (excluding worked peat), length of drains, total scrub area, the diversity index and area of wet ground. Prediction of zero sett squares were 72% correct and prediction of squares with setts was only 44% correct. Overall, the rules utilising area of improved cattle pasture were far more successful, but the variable is not the most reliable to assess in the field.

The construction of rules is a time-intensive procedure and the use of rule-finding systems will be explored further, as the potential is good.

The addition of land classes and environmental variables (*e.g.* elevation as noted above to allow an additional parameter for separating areas of improved pasture into separate categories) into the database should improve upon the present predictive capacity of discriminant analyses and of rule-learning systems. Earlier studies (on badger removal areas) have, however, shown that there *must* be a limit to the predictive capacity of such models due, simply, to movement of badger groups from one main sett to another within their territory. The size of the 1km survey squares places a limit on the potential to develop accurate models for relatively small areas. Logistic regression remains to be evaluated in terms of its success rate with the badger group presence/absence data.

Table 57. Classification of 1km survey squares by discriminant analysis. Correct predictions are marked with an asterisk in tables.*

Classification by presence/absence of main setts.

		predicted	predicted		
		0	1+	totals	
actual	0	237*	212	449	*52.7% success*
actual	1+	54	226*	280	*80.7% success*
	totals	291	438	729	
		81.4% success	*51.5% success*	*63.5% overall*	
	standardised coefficient			**discriminant function**	
variable	***function 1***			***function 1***	***function 1***
hedgerow and treeline length	0.426		group (0 setts)	-0.307	
improved cattle pasture ha	0.692		group (1, 2 or 3 setts)	0.491	
					d.f. 2
	eigenvalue	%	Λ	χ^2	**P**
1	0.1511	100.0	0.869	102.2	0.0000

Classification of 1km squares according to number of active main setts (3 categories: 0, 1, 2 or 3) by multiple discriminant analysis. Variables: hedgerow and treeline length, area of improved cattle pasture

		predicted	predicted	predicted		
		0	1	2 or 3	totals	
actual	0	235*	137	77	449	*52.3% success*
actual	1	42	123*	64	229	*53.7% success*
actual	2 or 3	4	23	24*	51	*47.1% success*
	totals	281	283	165	729	
		83.6% success	*43.5% success*	*14.5% success*	*52.4% overall*	
	standardised coefficient	**stndrdised coefficient**		**discr. function**	**discr. function**	
variable	***function 1***	***function 2***		***function 1***	***function 2***	
hedgerow and treeline length	0.438	0.172	group (0 setts)	-0.317	0.017	
total cattle pasture area	0.614	-0.570	group (1 sett)	0.450	-0.110	
decid/mixed woodland	0.279	0.913	group (2/3 setts)	0.769	0.350	
	eigenvalue	%	Λ	χ^2	**d.f.**	**P**
1	0.1674	93.0	0.846	121.3	6	0.0000
2	0.0013	7.0	0.988	9.1	2	0.0107

Table 58. Classification of 1km squares according to presence/absence of active main setts by rule-finding system. Correct predictions are marked with an asterisk in tables.*

Rules: 1) 4.522 < improved cattle pasture
2) NOT (area deciduous/mixed woodland > 0 AND total hedgerow and treeline length ≤ 1.725)
(χ^2 = 80.9; d.f. 3; P < 0.0001)

Results are for unseen testing sample of 298 squares. Classification rules derived from remaining 431 survey squares.

		predicted 0 likely	predicted 0 definite	predicted 1+ definite	totals	
actual	0	57*	51*	87	195	*55.4% success*
actual	1+	5	13	85*	103	*82.5% success*
	totals	62	64	172	298	
		91.9% success	*79.7% success*	*49.4% success*	*64.8% overall success rate*	

Rule: 1) improved cattle pasture > 4.500 (χ^2 = 72.9; d.f. 1; P < 0.0001)

		predicted 0 definite	predicted 1+ definite	totals	
actual	0	89*	106	195	*45.6% success*
actual	1+	12	91*	103	*88.3% success*
	totals	101	197	298	
		88.1% success	*46.4% success*	*60.4% overall success rate*	

Discriminant analyses: counties

Analysis of badger density by county, undertaken by grouping counties into 5 density classes, showed that the overall habitat composition of these large areas accounted for badger density present. The density classes are somewhat broad, in that there might be 50% or more badgers present in one county than another in the same group, as follows:

category 1	(a)	<0.30 social groups per km^2 (corrected density)		
category 2	(b)	0.30 - 0.399	"	"
category 3	(c)	0.40 - 0.499	"	"
category 4	(d)	0.50 - 0.699	"	"
category 5	(e)	>0.70	"	"

The categories were chosen to divide the 26 counties reasonably equally by number, which was the case, with four counties in categories 1, five in categories 2 and 4, and six in categories 3 and 5. The range was, therefore, 4 -6 counties in each category, with the counties falling into each category indicated in Table 41. Co. Waterford, with a badger group density of 0.399 was placed into category 3 (density range 4.0 - 4.999) rather than category 2. Discriminant analyses revealed that, otherwise, Co. Waterford was singled out as markedly misclassified according to its habitat composition (details below).

100% of counties were categorised correctly with 12 variables, namely, hedgerow length, area of deciduous and mixed woodland, total area of heath, bog, moorland (excluding worked peat), area of wet ground, length of natural waterway, length of canalised waterway, total area unimproved grassland, total area improved grassland (including semi-improved), percentage of land used for cattle grazing, area of arable land, length of road, and Simpson's diversity index. Three of four derived functions were significant, accounting for 97% of correlation (Table 59). The success in classification of counties had not been expected to be as clear cut given the wide range of landscape composition in some counties, *e.g.* Co. Cork.

The results from discriminant analyses draw upon habitat variables that would appear to have a greater logical consistency than many of those derived as useful for multiple regressions. It was noted that the 6 high badger density counties (social group density > 0.7 km^{-2}) were especially well-defined in discriminant analyses (Figures 129 to 132) but definition was good for all groups. Co. Waterford was markedly misclassified when grouped with category 2 counties (Figures 133 and 134).

Some evaluation of the contributing habitat variables was considered by examining trends in the same manner as in Table 56. These results, giving habitat composition for each group of counties are shown in Table 60. General trends (indicated by a trend over 3 of the 5 categories) are indicated by + or - , and if a trend was observed over all 5 categories, by ++ or -- (in keeping with Table 56). Additionally, any habitat variables that were markedly different between low and high badger density counties are indicated.

Interesting attributes of high badger density counties are that the hedgerow length is greater, area of broad-leaved woodland woodland greater (particularly semi-natural), and area of plantation greater also. The 6 counties have less scrub, less moorland, less blanket bog, but have more worked peat (Co. Offaly affects the mean for the 6 counties). The means for the counties reveal more marsh, less natural waterway (length) and more canalised waterway (length). The counties have less unimproved grassland and more improved grassland, and the area grazed by cattle is highest in this group of counties, as is the grazing area given over to 'other' stocks. The area grazed by sheep is lowest in these high badger density counties. Road length and area of built land are lower than in category 4 counties, as is the diversity index.

That there are certain habitats that contribute positively to badger density has been shown for a number of variables earlier. Not all are linear, however. There are, as is to be expected, a number of similarities between category 4 and category 5 counties. Category 5 counties differ in possessing, for example, greater treeline length, more plantation, more canalised waterways, more improved pasture, less road length and lower diversity.

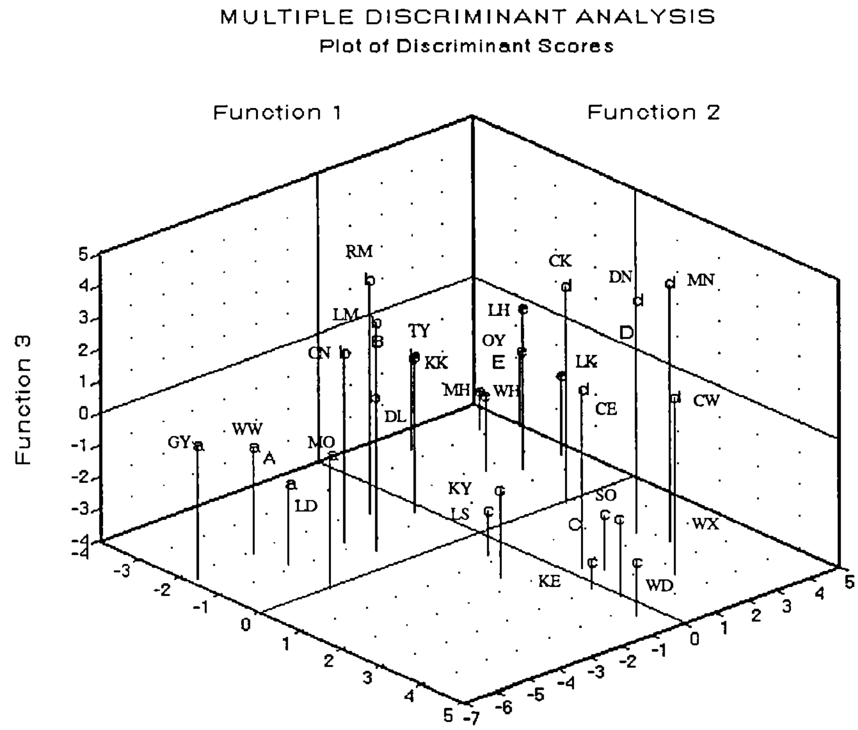


*Figure 129. Plot of functions 1, 2 and 3 in discriminant analysis for counties, using 12 habitat variables. Each county is marked by its category (a to e) and its name, given by first and last letter (*n.b. *Dublin DN, Cork CK, Waterford WD, Wexford WX, Galway GY, Kilkenny KK). Cluster centres are also marked (A to E).*

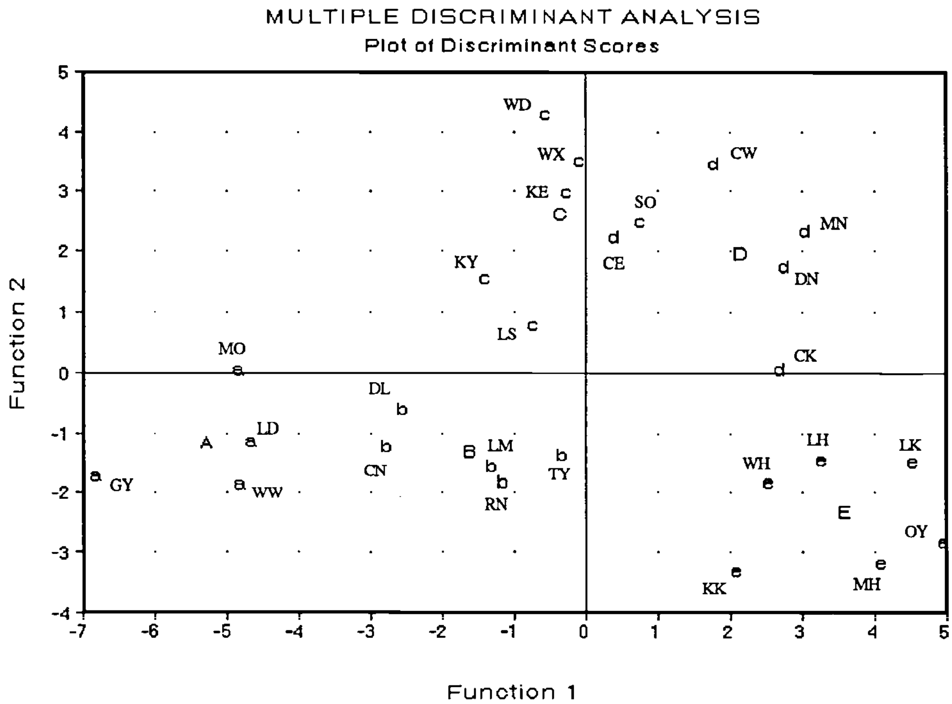


Figure 130. Plot of functions 1 and 2 in discriminant analysis for counties using 12 habitat variables.

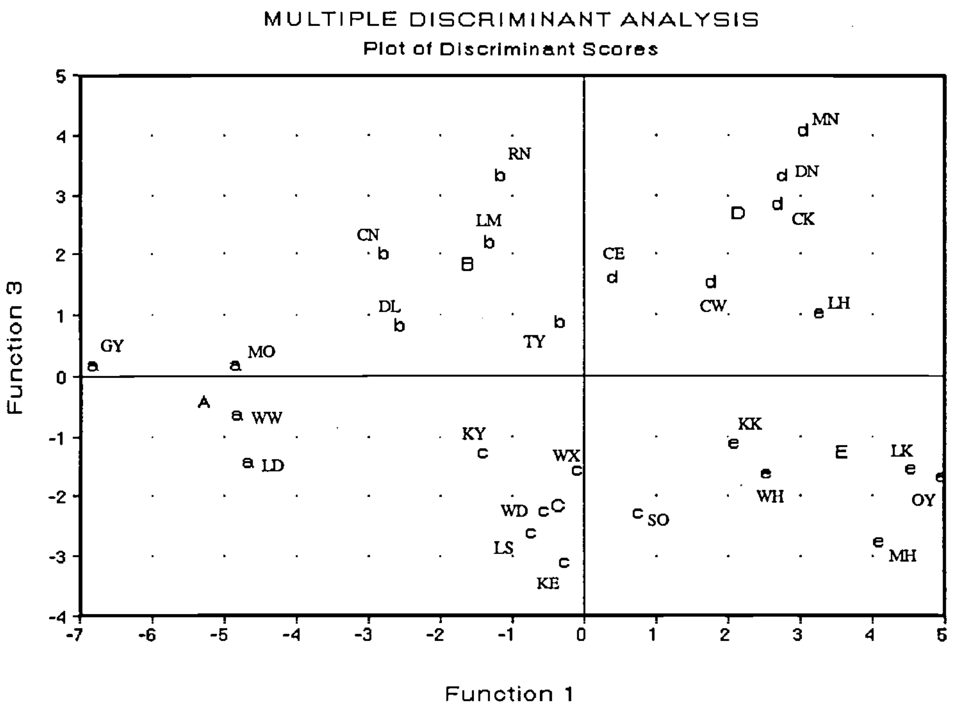


Figure 131. Plot of functions 1 and 3 in discriminant analysis for counties using 12 habitat variables.

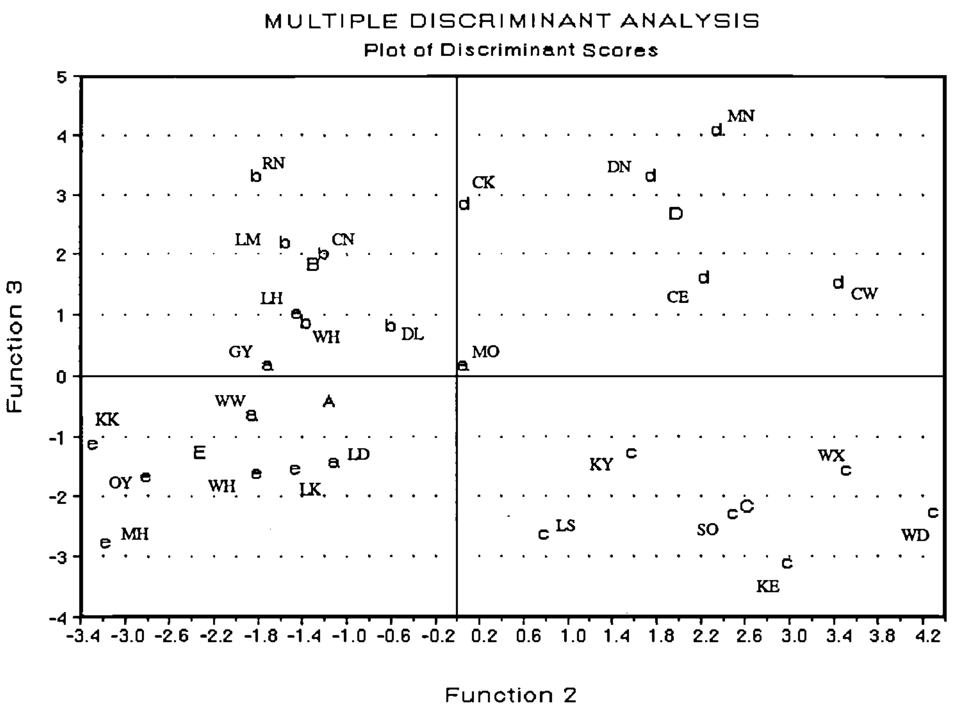


Figure 132. Plot of functions 2 and 3 in discriminant analysis for counties using 12 habitat variables.

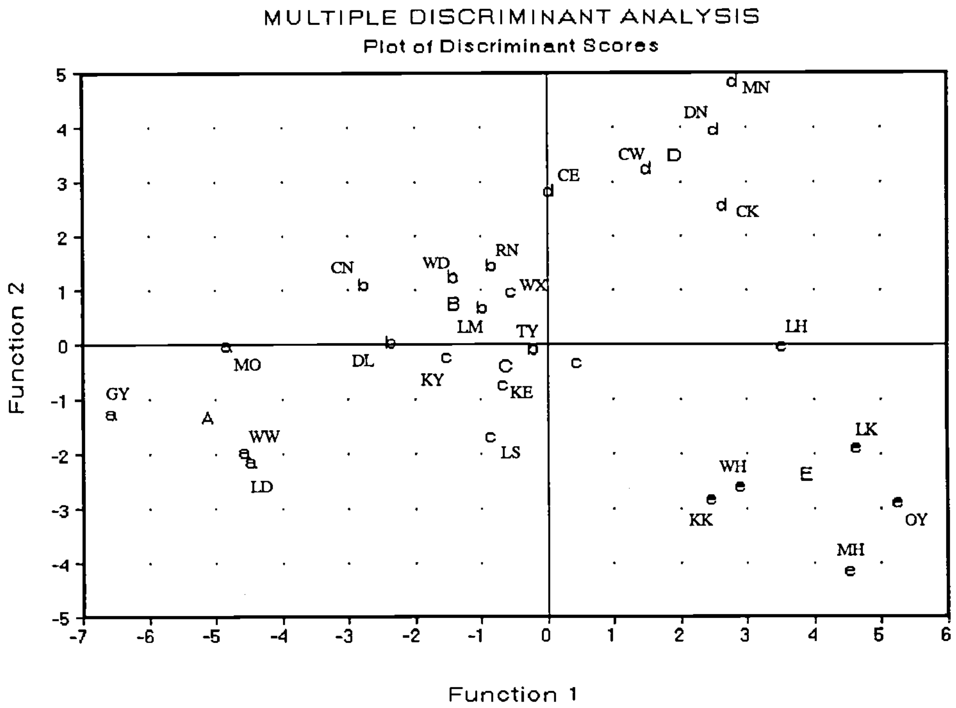


Figure 133. Plot of functions 1 and 2 in discriminant analysis for counties using 12 habitat variables. In this case, Co. Waterford is misclassified in Group 2 (b). This separates categories a, d, and e, but places b and c categories close together.

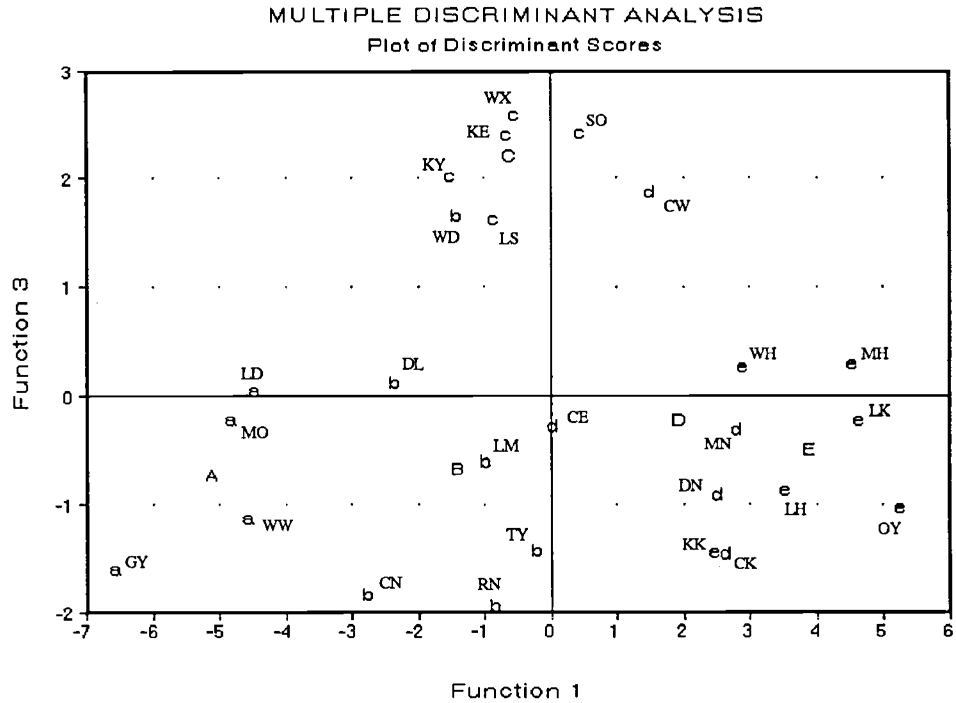


Figure 134. Plot of functions 1 and 3 in discriminant analysis for counties using 12 habitat variables. In this function, Co. Waterford is clearly misclassified and appears with category c not category b.

Table 59. Classification of counties according to active main sett density (5 categories: refer text) by multiple discriminant analysis. Correct predictions are marked with an asterisk.*

	category		predicted 1 a	predicted 2 b	predicted 3 c	predicted 4 d	predicted 5 e	totals
actual	1	a	4*	0	0	0	0	4
actual	2	b	0	5*	0	0	0	5
actual	3	c	0	0	6*	0	0	6
actual	4	d	0	0	0	5*	0	5
actual	5	e	0	0	0	0	6*	6
	totals		4	5	6	5	6	26
	success rate		*100%*	*100%*	*100%*	*100%*	*100%*	*100%*

standardised coefficients

variable	*function 1*	*function 2*	*function 3*	*function 4*
hedgerow and treeline length	-1.579	-1.504	-0.484	0.281
decid/mixed woodland	1.730	1.078	-0.057	-0.333
total bog, moor, heath, excl. worked peat	-1.418	2.472	-0.841	0.793
wet ground	-1.039	-0.851	1.631	-0.820
length of natural waterway	2.284	-1.073	0.165	1.384
length of canalised waterway	1.315	-3.592	0.540	0.513
unimproved grassland	-0.178	1.894	0.958	0.570
improved grassland (incl. semi-improved)	0.037	2.697	-0.722	1.824
arable land	2.490	2.463	0.582	0.385
length of roads	-0.183	0.353	0.788	0.309
percentage grazing land used for cattle	2.512	1.741	-0.402	-0.057
Simpson's diversity index	-1.085	3.626	-1.738	0.754

discriminant functions

		function 1	*function 2*	*function 3*	*function 4*
category 1	a	-5.307	-1.170	-0.431	-0.998
category 2	b	-1.652	-1.319	1.837	1.156
category 3	c	-0.403	2.598	-2.180	0.414
category 4	d	2.112	11.952	2.665	-0.629
category 5	e	3.558	-2.345	-1.284	-0.188

	eigenvalues	%	Λ	χ^2	d.f.	P
1	10.740	51.5	0.0016	106.5	48	0.0000
2	5.083	24.4	0.0185	65.9	33	0.0006
3	4.359	20.9	0.1123	36.1	20	0.0151
4	0.661	3.2	0.6020	8.4	9	0.4970

Table 60. Variation in mean habitat composition of counties (ha or km as appropriate) according to mean badger group density (categories given in text). Trends over 3 categories are indicated by + or -, and over all five categories by ++ or --. Habitat groupings in italics. The means given are derived from averages of county means of counties present in each group, corrected for areas of sea and lake. Category 1 (a) are lowest badger density counties and category 5 (e) are highest badger density counties.

habitat type	**category by badger density 1 a**	**2 b**	**3 c**	**4 d**	**5 e**	**trend**	**marked difference (factor >1.99)**
hedgerow length	3.43	5.83	5.68	6.42	6.85	+	1
hedgerow area	0.86	1.46	1.42	1.60	1.71	+	1
treeline length	0.60	1.06	1.12	0.91	1.29	+	1
bare treeline length	0.03	0.03	0.05	0.03	0.07		1
total treeline length	0.63	1.09	1.17	0.93	1.36	+	1
total treeline area	0.16	0.27	0.29	0.23	0.34	+	1
total hedgerow and treeline length	4.06	6.91	6.85	7.35	8.21	+	1
total hedgerow and treeline area	1.01	1.73	1.71	1.84	2.05	+	1
semi-natural broad-leaved woodland	0.42	0.50	0.44	0.51	0.64	+	0
broad-leaved plantation	0.07	0.20	0.34	0.55	0.39	+	1
semi-natural coniferous plantation	0.01	0.07	0.00	0.25	0.05		1
coniferous plantation	2.59	3.72	2.58	3.27	3.79	+	0
young coniferous plantation	2.28	1.46	2.30	0.85	1.67		1
semi-natural mixed woodland	0.00	0.09	0.08	0.07	0.06	-	1
mixed plantation	0.02	0.02	0.09	0.31	0.24	+	1
young mixed or broad-leaved plantation	0.07	0.00	0.01	0.07	0.00		1
felled woodland	0.08	0.18	0.03	0.07	0.09	+	1
all natural woodland	0.43	0.66	0.53	0.84	0.75		0
all plantation	5.03	5.40	5.33	5.06	6.10		0
all deciduous and mixed woodland	0.58	0.81	0.97	1.51	1.33	+	1
all coniferous woodland	4.88	5.25	4.88	4.38	5.51		0
parkland	0.13	0.02	0.14	0.17	0.00		1
tall scrub area	1.31	0.82	0.67	0.69	0.58	-	1
tall scrub length	0.08	0.11	0.14	0.03	0.10	+	1
low scrub area	1.33	1.86	2.05	1.70	1.58	+-	0
low scrub length	0.38	0.35	0.43	0.31	0.32		0
total scrub area	2.63	2.67	2.72	2.39	2.16	+-	0
total scrub length	0.46	0.47	0.58	0.33	0.42	+	0
total scrub, hedge, treeline, length	4.52	7.38	7.43	7.69	8.64	++	0
total scrub, hedge, treeline, area	3.65	4.40	4.43	4.23	4.21	+-	0
total low scrub, hedge, treeline, length	4.44	7.26	7.28	7.66	8.53	++	0
total low scrub, hedge, treeline, area	2.34	3.58	3.77	3.53	3.64	+	0
bracken	0.07	0.25	0.49	0.80	0.34	+	1
coastal sand dune	0.47	0.26	0.00	0.00	0.00	--	1
lowland heath	0.10	0.27	1.72	0.86	0.25	+-	1
heather moorland	5.54	7.73	6.61	0.96	0.71	-	1
blanket bog	10.86	5.80	2.16	2.37	0.12	-	1
raised bog	6.00	1.66	1.54	0.04	1.32	-	1
worked peat	0.49	0.17	1.21	0.00	3.46		1

Table 60 contd.

habitat type	category by badger density 1 a	2 b	3 c	4 d	5 e	trend	marked difference (>factor 1.99)
total bogs and moorland	22.89	15.36	11.52	3.37	5.61	-	1
total heath, bogs and moorland	22.99	15.64	13.24	4.24	5.86	-	1
total heath, bogs, moorland (excl. worked peat)	22.50	15.46	12.02	4.24	2.40	--	1
marginal inundations	0.09	0.11	0.10	0.10	0.29		1
coastal marsh	0.04	0.01	0.38	0.12	0.60		1
wet ground	1.65	1.78	0.69	2.17	0.81		1
running natural water - area	0.49	0.73	0.27	0.59	0.54		1
running natural water - length	0.70	1.09	0.65	0.78	0.45		1
canalised water - area	0.46	0.32	0.25	0.30	0.46	-+	0
canalised water - length	1.62	1.43	1.18	1.35	2.13	-+	0
total area streams and drains	0.95	1.04	0.51	0.89	1.00	+	1
total length streams and drains	2.32	2.52	1.83	2.13	2.58	+	0
upland unimproved grassland	3.35	4.81	2.87	3.90	1.37		1
lowland unimproved grassland	10.05	15.51	5.31	7.74	6.35		1
semi-improved grassland	19.31	17.89	12.84	16.40	15.08	-	0
improved grassland	23.68	27.07	38.97	30.76	44.37	+	0
total unimproved grassland	13.40	20.32	8.18	11.65	7.72		1
total improved grassland	42.99	44.96	51.82	47.16	59.45	+	0
total grassland	56.39	65.28	60.00	58.81	67.17	-	0
arable (total)	2.64	4.53	10.76	14.36	10.82	+	1
amenity grassland	0.22	0.51	0.41	1.36	0.38		1
unquarried inland cliffs	0.51	0.20	0.01	0.00	0.00	--	1
vertical coastal slopes	0.11	0.03	0.05	0.02	0.00	-	1
sloping coastal cliffs	0.00	0.01	0.04	0.02	0.00	-	1
quarries and open-cast mines	0.10	0.15	0.02	0.36	0.16		1
bare ground	1.95	0.36	0.11	0.76	0.07	-	1
built land area (excl. roads)	1.26	1.27	1.86	3.76	1.81	+	1
roads (area)	1.33	1.68	1.71	2.05	1.69	+	0
roads (length)	1.77	2.26	2.13	2.67	1.99		0
total built land area (incl. roads)	2.59	2.95	4.90	7.35	3.51	+	1
unspecified	0.16	0.11	0.26	0.13	0.14		1
'others'	5.25	3.49	1.96	4.80	2.26	-	1
diversity index	0.56	0.55	0.56	0.59	0.52	+	0

Boundary indices

hedge area/grazing and arable land	0.02	0.02	0.02	0.03	0.03		0
hedge & scrub area/grazing and arable land	0.06	0.07	0.06	0.06	0.06		0
hedge length (m)/grassland and arable (ha)	65.51	95.52	94.41	100.75	105.01	+	0
hedge, treeline, scrub length (m)/grassland and arable (ha)	73.25	104.45	103.55	105.18	110.93	+	0

Table 60 contd.

habitat type	category by badger density 1 a	2 b	3 c	4 d	5 e	trend	marked difference (>factor 1.99)
Grazing indices							
total grazing and arable land 29-33	59.03	69.81	70.75	73.17	77.99	++	0
grazing area for cattle alone (C)	23.28	33.41	30.71	33.99	42.43	+	0
grazing area for sheep alone (S)	21.02	17.54	16.13	9.56	6.96	--	1
grazing area shared by cattle and sheep (CS)	10.18	9.50	13.48	2.42	5.39		1
grazing by others (O)	0.52	0.83	0.86	1.62	2.16	++	1
total land with cattle grazing (C+CS)	33.46	42.91	44.19	36.41	47.82	+	0
total grazing land	55.00	61.28	61.19	47.59	56.93		0
percentage of total grazing land used for cattle	60.33	69.96	71.44	75.72	82.75	++	0
area grazed by cattle on pastures	22.13	30.73	27.97	32.80	41.30	+	0
area grazed by sheep on pastures	13.68	10.29	9.67	7.47	6.64	--	1
area grazed by cattle and sheep on pastures	7.03	7.57	12.30	2.29	5.31	+	1
area grazed by others on pastures	0.30	0.41	0.86	1.42	2.15	++	1
total grazed by cattle on pastures	29.17	38.31	40.27	35.09	46.62	+	0
total grazing on pastures	43.15	49.01	50.80	43.98	55.41	+	0
percentage of grazing pasture used by cattle	67.52	76.31	77.24	78.76	83.01	++	0

To place the category 5 counties in the broadest context, they are all counties within a broad midlands zone, from Co. Limerick in the west to Co. Louth in the east. The counties possess differences amongst themselves also, but they are all counties of high agricultural productivity. Most of the land is improved grassland, which is devoted mainly to cattle. They are 'rural' in character, having less developed road networks, and also possess much low-lying terrain, with extensive drainage systems. Whilst the overall habitat diversity is low, these counties have more deciduous woodland and plantation and a greater length of hedgerows and treelines.

The 6 counties (Meath, Westmeath, Offaly, Limerick, Kilkenny and Louth) differ in their overall habitat composition, therefore, from other counties. These 6 counties are, of course, *also* distinguished by having the highest badger densities. Despite the fact that counties are large units, defined as much by historical and administrative imperatives as geographical considerations, the analyses have shown that the overall characteristics of a county determine the prevailing badger densities recorded.

Stratification of Ireland according to its landscape types would clearly be even more revealing, a matter which is the subject of ongoing research.

Distribution of setts by land class

The visually assessed landclasses provide a weak foundation for investigation of badger density in relation to landscape types. Also, a number of landclasses had few squares fitting their description.

Results are given in Table 61. χ^2 goodness of fit tests indicated significant differences for 6 of the landclasses, with 3 landclasses having a higher badger density than expected and 3 having a lower density.

Higher than expected badger densities:

Landclass 1 (undulating country, varied agriculture, mainly grassland)

Landclass 6 (gently rolling country, mainly fertile pasture)

Landclass 17 (rounded intermediate slopes, mainly improvable permanent pasture)

Lower than expected:

Landclass 19 (smooth hills, mainly heather moors, often afforested)

Landclass 24 (upper, steep, mountain slopes, usually bog covered)

Landclass 32 (bleak undulating surfaces mainly covered with bogs)

The above results identify two of the major variables already reported influencing badger density: a positive relationship with grassland pastures and a negative relationship with moors, bog and uplands.

Table 61. Landclasses: numbers of squares in each landclass and observed numbers and density of badger setts. Values uncorrected *for area of sea, coastal fringes and lakes.*

landclass	no. of squares	total no. of setts	total no. of active main setts	main sett density observed	main sett density expected	ratio of obs/exp	χ^2	P
1	148	374	91	0.61	0.46	1.34	4.75	0.03
2	25	56	12	0.48	0.46	1.04	0.01	0.91
3	6	9	3	0.50	0.46	1.09	0.01	0.91
4	5	5	1	0.20	0.46	0.43	0.61	0.43
5	28	58	15	0.54	0.46	1.16	0.22	0.64
6	92	247	63	0.68	0.46	1.49	5.97	0.01
7	16	15	3	0.19	0.46	0.41	2.18	0.14
8	12	10	2	0.17	0.46	0.36	1.93	0.17
9	4	10	2	0.50	0.46	1.09	0.01	0.92
10	12	30	3	0.25	0.46	0.54	0.92	0.34
11	2	1	0	0.00	0.46	0.00		
12	4	27	4	1.00	0.46	2.17	1.26	0.26
13	10	27	4	0.40	0.46	0.87	0.06	0.81
14	3	2	0	0.00	0.46	0.00		
15	12	20	5	0.42	0.46	0.91	0.04	0.85
16	17	33	5	0.29	0.46	0.64	0.79	0.37
17	75	165	48	0.64	0.46	1.39	3.20	0.07
18	33	36	10	0.30	0.46	0.66	1.36	0.24
19	34	17	7	0.21	0.46	0.45	3.97	0.05
20	15	32	7	0.47	0.46	1.01	0.00	0.98
21	12	3	2	0.17	0.46	0.36	1.93	0.17
22	9	3	2	0.22	0.46	0.48	0.91	0.34
23	3	0	0	0.00	0.46	0.00		
24	21	2	2	0.10	0.46	0.21	5.55	0.02
25	6	11	2	0.33	0.46	0.72	0.16	0.69
26	3	12	2	0.67	0.46	1.45	0.17	0.68
27	1	2	1	1.00	0.46	2.17	0.32	0.57
28	4	11	3	0.75	0.46	1.63	0.42	0.52
29	2	0	0	0.00	0.46	0.00		
30	9	3	2	0.22	0.46	0.48	0.91	0.34
31	11	8	3	0.27	0.46	0.59	0.66	0.42
32	35	47	4	0.11	0.46	0.25	8.17	0.004
totals	669	1276	308	0.46	0.46	1.00		

DISCUSSION

The principal aims of the research studies reported here were to provide information on badger numbers and distribution in Ireland, and to relate these results to habitat variables through the incorporation of a detailed habitat survey. This has been achieved by ground survey of *c.* 1% of Ireland's land surface area, with 729 1km squares surveyed in the Republic. In parallel, a similar survey has been conducted in Northern Ireland to complete a survey of the island. Only some preliminary findings from Northern Ireland have been included in this report. Additional to these surveys, studies were undertaken on licensed badger removal areas in conjunction with the Department of Agriculture, and these studies have provided some information on the size of badger social groups and on TB in badgers.

It should be pointed out that the survey represents a 'snapshot' in time, and was not intended to investigate the population dynamics of badger populations in Ireland. Nevertheless, information gained in this survey on badger group size and its variation and also on the habitat/landscape preferences exhibited by the species' group density and choice of sett location are useful, perhaps critical, in the evaluation of population studies that are carried out, perforce, on a very limited number of badger groups. Additionally, the valuable data and observations obtained from the snaring programmes evaluated in this report, have indicated that population parameters assessed in other studies have probably been markedly affected by the methods adopted to capture or observe badger groups and individuals. For example, even what should have been a simple issue - that of the sex ratio of badger populations - is now seen to have been affected by methodology of data collection in several studies.

The emphasis within this report has been to present the survey data in as much as detail as reasonably possible so that the data may be used by other researchers, with a limitation (therefore) to any bias that might result from the author's interpretation and summarising of results in a shorter document. The raw data constitute a large and complex database that could prove daunting to other researchers wishing to use it, so county, region and national statistics have been compiled and incorporated into this report, in a reasonably accessible form.

The report has been presented in several sections (badger survey, habitat survey, studies of licence areas, and evaluation of the distribution and abundance of badgers), within each of which the methodologies adopted have been described and their limitations discussed. There has been preliminary discussion of the results within each section. The *Discussion* that follows is intended to be an overview of the findings, relating the general nature of results to previous studies. Recommendations for future research and changes in operation of licence areas are marked R [boxed] in the right margin.

Badger survey

Survey methods

It was considered that there were two principal difficulties with the enumeration of badgers in Ireland. These were the difficulties of sett classification and the use of a 1km square as the sampling size. Of most concern, regarding the former, was the need to ensure that counts of active main setts were correct, as these ultimately determined most of the estimates of badger numbers.

Following studies on licence areas (licensed badger removal areas), in which survey results could be compared with 'real' presence and numbers of badgers at setts (as determined by snaring operations carried out by staff of the Department of Agriculture, Food & Forestry), stricter criteria for sett classification were adopted and applied. This resulted in a downward revision of the number of active main setts estimated in initial surveys by around 15%. It is not clear whether the adoption of similar criteria in the Britain would have suggested a similar revision there, and this is a matter that might be of interest to researchers in Britain. However, the fact that badgers are distributed far more equally in Ireland than elsewhere and that sett sizes are smaller, presumably as a result of a different habitat composition in Ireland (more hedgerows and grassland, less woodland), might suggest that a revision of British data would not lead to as substantial an alteration to estimates as was required here.

Nevertheless, it is apparent that sett survey is, undoubtedly, less reliable in assessing sett categories accurately than studies that involve the animals themselves. This obvious limitation has already been referred to by Griffiths (1992a). Whilst sett classification is affected by observer experience, in the main all surveys were conducted by highly experienced staff of the National Parks & Wildlife Service, and the detail with which each sett was required to be recorded allowed for checks afterwards and reference to the surveyors when the likelihood of misclassification in any particular square was considered to be present. There remains the fact that *whatever* criteria are adopted, there will remain error in sett classification unless direct observations are made of the badgers present and the use that they make of their setts.

The main factor, other than observer experience, that affected sett classification was noted to be sett relocation by badgers. In many cases, this was clearly the result of disturbance to setts through deliberate harassment or removal of badgers or destruction of setts. It was a regular feature to find that setts were anomalously active or inactive as a result of disturbance, creating difficulties for classification. The studies at licence areas suggested that relocation by badgers in the period between sett survey and snaring was common. Sleeman (pers. comm.) has also noted how disturbance to setts has produced unusual regrouping of social groups and an unusual pattern of territorial activity. Skinner (1987) observed high mobility of badger groups in Essex, where setts were occupied and then abandoned after several months, with the group moving to a new location. On the other hand, work carried out in the Cotswolds (an area of very high badger density) [Cheeseman *et al*, 1987] suggests a great deal of stability in main sett use and maintenance of territories over time. Cresswell *et al* (1990) considered that group mobility was a particular feature of low density areas, such as Essex.

The results from Ireland reveal that badger group relocation is surprisingly common at 'normal' density as well as at lower densities. With 15% of all setts suffering some form of disturbance (over 20% of main setts), it may be that disturbance is responsible for a great deal of this mobility. It should be noted, however, that it is very unlikely that *all* of the relocation events reported were caused by disturbance to setts or to badgers. Many relocations were, therefore, the result of 'normal' mobility and relocation by badgers, some of which, perhaps, had been brought about by natural mortality, amalgamation or break-up of social groups, or changes in territories possessed by neighbouring social groups. Partly, relocation of groups may be a consequence of the majority of setts being located in hedgerow and treeline. These 'narrow' linear habitats are prone to disturbance through normal agriculture activity (ploughing, fencing) and agriculture improvement (*e.g.* removal of hedgerows). Setts in hedgerow or treelines are also easy to find and to interfere with (if such is the intention), so that sett blocking, for example, was observed to be common.

The net effect of this 'mobility' of badger groups is that any survey of setts undertaken will have limited likelihood of obtaining the same result after a period of time, for any particular square. Although these difficulties were encountered, the (limited) studies at licence areas showed that relocation by badgers did *not* affect *overall* estimates of badgers in Ireland. Some badgers relocated to setts within the survey area (thus, no change in density estimates), others relocated elsewhere (or were destroyed) [leading to an overestimate], and others relocated to a square from elsewhere (leading to a survey underestimate). Overall, these movements balanced out so that the values obtained for counties, regions, or nationally, were considered to provide reliable estimates for these geographical zones.

The other difficulty was posed not by badger behaviour or disturbance to setts, but by the sampling size adopted for the surveys. The 1km square is relatively small compared to the mean range/territory size of badger groups. For many counties, and overall, badger densities were determined to be *c.* 0.5 groups km^{-2}. The placing, at random, of a 1km square has a tendency to sample setts randomly wherever overall habitat composition of a landscape is reasonably uniform. A Poisson distribution was therefore observed for some sett categories in this survey. As before, this is a result that would not have any overall equivalence with surveys in Britain, where badger distribution is far more uneven, but might apply to areas of higher density in Britain, such as the south-west (as observed by Thornton, 1987).

Thornton (1988) used tetrads (2x2km squares) for badger survey in south-west England, and this sample size has clear advantages, but also certain disadvantages. The main advantage is that 'randomness' in location of squares with regard to main setts is reduced. Most 1km squares sampled either 0 or 1 main sett in Ireland. Tetrads in Ireland would provide a mean of 2 groups per tetrad, range of *c.* 0 - 4. This means that far fewer tetrads would be required to effectively sample badger densities in Ireland, and correspondence between sett density and habitat variables would be closer. This report has shown that the total area required for survey (to determine mean badger densities) would have been lower if a tetrad had been adopted. This evaluation is based on an *a priori* knowledge of badger density and distribution, which, of course, was not available, as this study was the first of its kind in the country. Thornton (1987) also noted a Poisson distribution of main setts regarding survey squares and rejected the use of 1km squares for sett survey.

The main disadvantage of the tetrad approach is that fewer landscape types are sampled. About 150 tetrads would have been sampled using tetrads in Ireland, as compared to the 729 1km squares actually adopted. This considerably reduces the reliability of the habitat surveys: smaller squares are much more efficient in sampling landscapes and habitats (Harrison & Dunn, 1993). Also to be borne in mind is observer fatigue: each 1km survey square required *c.* 2.2 man-days to complete, so that a tetrad survey would have required 9 days, or 2 full working weeks for survey. Whilst the overall time for surveys would have been much the same, the survey of tetrads would, reasonably, be considered as an unacceptably tedious task for surveyors.

The other consideration of this survey was that it should follow the guidelines and general methodology adopted by the British survey (Cresswell *et al*, 1990) so that overall comparisons between the islands could be made without confusion arising from experimental design. Anticipated future research, involving environmental variables and landclasses in Ireland for 1km squares, was also a consideration, in view of means of extending these studies to unsurveyed areas.

In conclusion, 1km survey squares have provided valid estimates of badger numbers, but the predictive potential - from habitat information - for unsurveyed squares has been impaired by the size of 1km squares. Nevertheless, relationships between habitat variables and badger density have been clearly revealed, indicating that use of geographical zones or landscape types have considerable potential for predicting badger numbers, and might then be used for investigations of TB in cattle and badgers.

Badger sett survey results

In an overview of sett survey results, there are few studies with which the Irish survey can be compared. The principal ones, in Britain, are those of Cresswell *et al* (1990) for Britain, and Thornton (1987, 1988) for south-west England. Detailed survey results have not been published by Cresswell (and others) for the British survey. There are numerous papers describing sett distribution in various counties or areas of England and Wales, produced by surveys carried out mainly by local natural history societies, *etc.* (for references, refer to Cresswell *et al*) but these are of limited value in comparison to nation-wide surveys. In Ireland, the survey in the North has been completed (Feore, 1994). The population studies of O'Corry-Crowe (1992, and O'Corry-Crowe *et al*, 1993), Sleeman & Mulcahy (1993) provide data for comparison.

The majority of squares surveyed in Ireland had 0 main setts present, and this was also the case for Britain (Cresswell *et al*). The largest number of setts recorded in any square was 35, whilst that recorded in the British survey was 26. The 35 setts were located in a square that was largely composed of raised bog in the Midlands, but most of these setts were located in the dry and drained fringes (*c.* 1.2 km in length) of this bog, which adjoined improved and drained cattle pasture.

Although there were differences between the size of setts, habitat preferences, and other variables associated with badger setts in the British studies and in Ireland, the number of setts associated with each active main sett (= badger social group) was virtually identical (4.09 in Ireland and 4.1 in UK). The observed difference was in the proportion of minor (subsidiary and outlier setts), where the totals for these categories were very similar, but the proportions of each varied, with far more minor setts being designated as subsidiaries in Ireland than in

Britain, and, conversely, proportionately far more outliers in Britain than in Ireland. These differences (for minor setts) are not important, and may, partially at least, result from a different emphasis in interpreting sett classification. On the other hand, this difference may, again, have arisen from different ecological conditions in Ireland. One might summarise many British populations as being somewhat scattered, main setts usually located in woodlands, and the groups' ancillary and minor setts spread out over a substantial area. Irish densities tend to be higher (overall), main setts usually located in hedgerows, and minor setts perhaps closer to main setts than in Britain on average. This might account for the higher proportion of active setts observed in Ireland.

The close similarity in sett proportions observed in both national surveys does, at least, indicate that badger behaviour has an overall consistency. Similarly the number of setts associated with each main sett was very similar in O'Corry-Crowe *et al*'s (1993) study in Co. Offaly. They found that there were 5.0 setts associated with each social group, with the figure from the national survey for all of Co. Offaly identical at 5.0. Initial results from Northern Ireland do indicate that, overall, each social group in Northern Ireland is associated with *c.* 5.7 setts. Whilst higher than the average in the UK or in the Republic, this was similar to or below that found in several Irish counties, such as Clare, Longford, Meath and Wicklow. The latter county was found to possess 8.6 setts per social group. Thornton (1987) found far fewer ancillary setts in two study areas in south-west England than might be expected (11 main setts, 3 annexes, 6 subsidiaries and 9 outliers (only 2.7 per social group). The Irish counties with the lowest number of setts per group were also in this range: Cos. Waterford and Mayo (2.4 setts per social group).

In Ireland, in a study area in east Co. Offaly (a county with a *high* badger density, estimated here at 0.73 groups km^{-2}), O'Corry-Crowe *et al* (1993) presented data that suggested fewer annexe setts (per all main setts) than reported here for the whole county (0.36 *cf.* 0.50), the same proportion of subsidiaries (0.36 *cf.* 0.32) but more outliers (2.1 *cf.* 1.08). Correspondence between the studies was good once only active main setts were taken into consideration and the minor setts grouped. This survey revealed *c.* 3.2 minor setts per *active* main *cf. c.* 2.5 per (active and disused) main sett in O'Corry-Crowe *et al.* That report also noted some unclassified setts, which would have contributed to the number of minor setts per main sett.

The mean size of active main setts found in this study was smaller than in Britain. This might be expected from the occurrence of setts in hedgerow (in Ireland) rather than in woodland (as generally the case in Britain), but the differences are quite pronounced. The largest sett located in Ireland had 44 entrances and the smallest 1 entrance. The mean size was 6.9 entrances. This compares with 11.9 for Britain (Cresswell *et al*, 1990), which is a substantial difference, and the largest difference to have been observed between setts in Ireland and in Britain, and one that, again, might be attributed to setts being located in hedgerow rather than woodland. However, O'Corry-Crowe *et al* (1993) observed that main setts had an average size of 11.9 entrances in east Co. Offaly. In view of the overall similarity of main sett densities between this study and the east Co. Offaly study, and identical proportions of sett types observed, this observed difference is main sett size is anomalous, but there was found to be considerable variation in sett size from county with county, with the largest mean main sett size found to be 9.9 entrances in Co. Clare. Incidentally, details of the first main sett to be fully excavated in Ireland were reported recently by Clarke *et al* (1993): the sett was located in Abbotstown, Co. Dublin, and had 14 entrances.

Disturbance to setts was quite similar in Britain and in Ireland. Whilst 15% of all setts were disturbed in Ireland, 21% of main setts showed disturbance. The only comparable figures are from Cresswell *et al* (1990), where 26% of *active* main setts had been disturbed, so that the disturbance levels in Ireland are lower. There was, however, considerable regional variation in disturbance to setts in Ireland, from just 4% of all setts in the Mid-West (11% of main setts) to 26% in the East (30% of main setts).

The most common type of disturbance to setts in Ireland was by digging (38% of disturbed setts) but blocking was also common (23% of disturbed setts). Cresswell *et al* estimated that 10% of main setts and 5% of all setts had been affected by digging (from Table 15). In Ireland, 5.6% of setts were found to have suffered digging. Badger digging and baiting is a common practice in Ireland; newspaper reports have suggested that there is considerable cross-border movement of this 'sporting' fraternity into the Republic, with trips also being organised from Britain. Setts in all regions were affected by digging, with fewest in the Mid-West.

Whilst Cresswell *et al* estimated an annual death toll of 9,000 badgers due to sporting activity, the sett survey undertaken here does not realistically allow the period of time over which setts were disturbed to be estimated. Damage to setts is observable for several years, though most of the disturbance noted probably took place within the previous two years. If one were to assume that every badger was killed when main setts were disturbed and that signs lasted just two years, then an approximate upper bound to badgers killed per annum would be 4,255. The true value could be less than half of this, once relevant factors are taken into consideration: non-fatal disturbance types such as blocking and burning are excluded, not all badgers at a dug sett would be killed, and longevity of disturbance signs being more than two years.

Cresswell *et al* estimated that 9% of all setts had been blocked in Britain. The value was 3.4% in Ireland and little of this activity would have resulted from fox hunts, but appeared to have been mainly due to farmers resorting to this means of removing or persuading badgers to leave their farms. In Britain, 1% of setts were illegally snared, and a lower proportion in Ireland - 0.5%, but this excludes the licensed snaring operations which were estimated to affect 1.1% of setts, as judged from the sett survey results.

The persecution levels reported for Irish setts are unlikely to pose a threat to badger populations, except perhaps in isolated localities where persecution is particularly intense.

Griffiths has presented accounts of badger persecution and use as a commodity species throughout Europe and Asia (1991a, 1991b, 1992b, 1993a, 1993b, in press).

Conclusions

Sett parameters - types, proportion of each type, activity, *etc.* - were found to be generally similar to those reported in previous surveys and studies in Britain and Ireland, suggesting that overall badger behaviour is similar. The largest difference observed was that main setts in Ireland were substantially smaller in size than in Britain, possessing, on average, only 7 entrances. The sett survey methodology was confirmed by studies of licence areas, where main setts were validated by removal of badgers from them. Indeed, the implication might be that small main setts in Britain may have been considered as minor setts on occasion, as no validation exercises were carried out.

Certainly, whether a sett is a main sett or not cannot be judged by size alone, and many single entrance and two entrance main setts were identified and confirmed in this study. These were not necessarily in upland areas or western counties of lower badger density. Indeed, contrary to expectation, low badger density counties had setts that differed little in mean size from those in counties with higher badger density. The range for several western and upland counties was 5.3 - 8.8 entrances. The range for the 6 high badger density counties was 5.4 - 7.9 entrances. The smaller size of setts in Ireland relative to Britain is probably a result of limited woodland area (especially deciduous woodland), with setts in Ireland being largely confined to hedgerow and treelines.

One feature of the Irish survey, in comparison to Britain, is that badger densities are generally well distributed over Ireland, though densities were lower in certain western counties. This variation in badger density is considered in more detail in relation to habitat preferences.

The habitat survey of Ireland

The habitat survey of Ireland provided detailed data for a 1% sample of the Irish landscape, utilising over 40 principal habitat categories. There have been several agricultural censuses (see below) which allow for some comparisons to be made.

The systematic approach adopted here is efficient in sampling landscapes (Harrison & Dunn, 1993), but, in any landscape sampling methodology, the confidence limits for the means of uncommon or clustered habitats will be greater than those obtained for more common habitats. With a relatively small (1% sample), therefore, the means for woodland and plantation categories, for example, will have wider confidence intervals than major habitat components, such as grassland, hedgerow, bog and moorland. Data for any single county will be less reliable, especially so for the small counties, where as few as 8 squares were sampled. Statistical problems in dealing with the sampling of 2-dimensional variables have not yet been fully addressed (Harrison & Dunn, 1993).

The habitat categories were virtually identical to those used by Cresswell *et al* (1990), as described by Harris *et al* (1989), and would allow for some detailed comparisons of regions that are of especial interest such as the south-west of England. Only limited data for some landclasses presented by Cresswell *et al* (1990) have been published.

The habitat categories can be related to the Nature Conservancy Council's National Vegetation Classification, and, in Ireland, similar habitat groupings now form the basis of the National Park & Wildlife Service's current re-assessment and inventory of Areas of Scientific

Interest (to be re-designated Natural Heritage Areas) and also of previous work carried out under the European CORINE project.

Ireland's overall habitat composition has been assessed in various agricultural censuses, carried out every 10 years. These present results by census of the smallest political divisions, the District Electoral Divisions (DEDs), and the larger Rural Districts. These statistics are on file with the Central Statistics Office, but not available in detail in a readily assimilable form (Central Statistics Office, 1971, 1977, 1983). Horner *et al* (1984) produced an agricultural atlas of Ireland, based on the Rural Districts censused in 1980. The first agricultural atlas was that of Stamp (1931). The 1991 agricultural census results were published recently (Central Statistics Office, 1992). Other pertinent publications have been the assessment of land use potential (Gardiner *et al*, 1980) and land resources and agriculture (Gillmor, 1977a, 1977b) and also the more general Atlas of Ireland (Royal Irish Academy, 1979).

The agricultural censuses are relatively crude, carried out by census of all farms in the Republic (similar censuses have also carried out in Northern Ireland), and with unrefined habitat categories. The principal categories used to classify land use in the 1980 census enumerations were tillage, hay and pasture, rough grazing, woods and plantations, and 'other land' (the types of crops grown and livestock grazed were, of course, enumerated in substantial detail). Although the census data is limited, certain comparisons may be made for some of these broad categories, such as total area of pasture, arable land (= tillage) and total area of woodlands (though the latter is likely to include tall scrub in the agricultural census). There may also be some relationship between total area of grazing as assessed in this report with the sum of pasture and rough grazing, but the agricultural census would have included mountain areas that may not necessarily have been assessed as grazed in this survey unless stocks were present over all parts of the range and habitat divisions.

A comparison with the 1980 census data shows good correspondence (Table 62). Other habitat variables of interest are included; *e.g.* the length of hedgerow and treeline in the Republic is estimated at over 400,000 km (and this excludes vegetated field boundaries consisting of low or tall scrub). The difference in woodland area (between the 1980 census and this survey) reflects the substantial increase in afforestation in Ireland over the last decade, with some poor pastures being afforested also. The value for land currently afforested differs from 1993 estimates of 529,000 ha given by COFORD (1994). The discrepancy is largely resolved when felled areas, unplanted land designated for forestry, area planted since *c.* 1990, and area of tall scrub are taken into account. Adding area planted from 1980 - 1989 (98,000 ha; COFORD, 1994) to the 1980 census data gives a value of 416,220 ha - a value close to the estimates obtained in this survey. Underestimation may result from very young planting being placed in the principal habitat category.

The 1991 agricultural census is problematical in that it did not account for a substantial proportion of land in Ireland, and the results are not compatible with the 1980 census (as noted by Central Statistics Office, 1992). It appears that the agricultural census techniques employed in the 1991 survey are an incomplete assessment of farmed areas in the country.

A comparison may be made with this survey's data for Co. Offaly with the experimental area studied by O'Corry-Crowe (1992) in east Co. Offaly. The study area differed from the county as a whole, possessing more agricultural land. Comparing Badger & Habitat Survey data to the study site respectively: grassland pastures 49.5% *cf.* 62.2%; arable land 7.4% *cf.* 15.0%; coniferous plantation 8.0% *cf.* 6.4 %. These differences might have some implications for the larger study that has taken place in east Offaly, involving removal of badgers and assessment of resultant TB rates in cattle (Dolan *et al*, 1993) as the overall habitat composition of the Control area (no badger removal) may also differ from that of the Project area (badger removal area).

One limitation of the present habitat surveys was a relative lack of attention paid to boundary types. These were evaluated as being composed of hedgerow, treeline, or low scrub or tall scrub. Field boundaries comprised of stone walls or fences were not assessed. Given the very fragmented nature of Irish landscapes, particularly farming areas, this could be improved upon. Some of the categories of field boundaries described in the Atlas of Ireland (Royal Irish Academy, 1979) might form the basis of any re-evaluations.

The survey also assessed grazing by live-stock on each habitat element entered onto the 1km maps. Whilst these results have their limitations in precision, inclusion of the data has been very rewarding. For example, it now appears that a greater proportion of grazing land is used for sheep-grazing in Northern Ireland than in the Republic. This probably has considerable implications for TB investigations, and may be a partial explanation of lower TB levels in cattle there than in the south (this issue is discussed further at a later stage).

Table 62. Summaries of the total land areas of major habitat variables in the Republic.

	Census estimates 1980	***Census estimates 1991***	***Badger & Habitat Survey of Ireland***
habitat variables			
total 'grassland' ha	4,141,770	3,408,146	4,098,386
(total pasture, hay, silage, rough grazing) ha		4,050,065	
arable land ha	553,880	391,690	514,581
total woodland ha (likely overestimate in 1980, as included 'scrub')	318,220	(438,000)	397,400
total hedge and treeline ha			103,990
hedgerow length *km*			354,620 km
treeline length *km*			61,340 km
total areas of bog and worked peat ha			616,019
area of heather moorland			420,815
total area semi-natural broad-leaved woodland ha			31,003
total scrub ha			174,495
built land ha			111,373
roads ha			109,729

[The 1991 Census did not account for all farms and holdings in the country, probably accounting for several differences observed between 1991 census estimates for grassland and arable land and other estimates. The area of land used for agricultural activity in 1980 was 607,000 ha greater than in the 1991 census. Woodland was not assessed in 1991 either.]

There are several mechanisms by which the habitat data may be utilised for further research.

The first is simplistic: this is to examine various measures of TB breakdown in cattle directly with county means for habitat variables (including grazing by stock-type variables). R

The second is to make use of data from agricultural censuses, and to apply the relationships between badger density and habitat variables evaluated in this report directly to data for DEDs and Rural Districts. This seems a reasonably promising short-cut approach for quick evaluations with TB data, though somewhat crude. The lack of habitat detail in the census information limits its usefulness. R

The third is to establish a land-classification of Ireland, through the incorporation of mapped environmental variables (climate, soils, geology, topography, elevation, *etc.*). This allows for the prediction of habitat composition in unsurveyed areas, and the prediction of badger densities over zones (rather than individual squares). These habitat predictions can then be statistically evaluated against measures of TB in cattle (or in badgers, if TB incidence data were available). The data from visually assessed landclasses (in this report) have poor validity, but have served to illustrate the approach. R

The fourth approach is to use satellite imagery in a predictive way. If the detailed habitat maps of this survey can be matched against satellite images or databases for the 1km squares, then a fairly accurate predictive model for detailed habitat composition of unsurveyed areas may be possible. The satellite images and databases themselves have limitations of pixel size, with pixel size at *c.* 30 m, and, also, satellite images are unable to distinguish between certain habitat types. Nevertheless, there is considerable potential for this approach, as Ireland has been satellite-mapped under a European CORINE project, and the database available. Additionally, the introduction of set-aside under EC agricultural policy means that refined data based on satellite imagery is continuously coming on stream. R

These approaches create databases of habitat composition that may be used directly to measure correlations between TB in cattle and habitat variables and allow for complex statistical evaluations of any inter-relationships. The influence of badgers (by density) in these relationships may be considered by inclusion of the predictive models of badger density.

The 1km survey squares are also intended to be used as a permanent framework for monitoring of fauna and flora. The survey, if repeated in 10 years time, would evaluate changes in land use, removal of hedgerow, or changes in badger populations. With an established habitat database for these squares, they lend themselves readily to assessment of common elements of the flora and fauna: population density studies of birds, for example, or hares, can be carried out from the 1km squares stratified by habitat composition. This report has already mapped the distribution of some common mammals observed during badger sett survey. Once the squares are classified by landclass, then a more appropriate ecological stratification of the squares is possible, reducing sampling time and increasing efficiency in the assessment of the distribution and abundance of flora or fauna studied. One of the aims of future research is, therefore, to establish a firm foundation for the continued use of the 1km squares surveyed in this study. R R

Studies of badgers from licensed badger removal areas

Badger survey techniques were confirmed by follow-up snaring of badgers in areas for which licences for badger removal had been obtained. The difficulties created by relocation of badger groups to new setts have already been referred to. The overall conclusion was that the refined survey techniques and sett criteria could not be improved upon, and did give results that were confirmed by snaring - for totals, if not for all individual squares.

The main purpose, however, for establishing these studies (carried out jointly by staff of two government departments) was to obtain information on the size of badger social groups, as such data is extremely limited for Ireland. It would not have been possible to provide estimates for badger numbers in Ireland without this data. Prior to this study, it was considered that badger groups would be smaller in Ireland than in Britain, in relation to the observation that main setts are smaller (this report and Smal, 1993).

The snaring studies have yielded a substantial amount of interesting information. The principal results obtained were:

a) sex ratios of badgers are close to unity.
b) snaring success rate was very variable, with a mean success rate of 75%, but most normal snaring operations would probably not achieve 50% success rate.
c) values were obtained for the mean number of badgers captured at each sett type.
d) mean badger group size was determined at 5.9 adults.
e) differential trappability of sexes exists.
f) TB prevalence in badgers was lower than expected from national statistics.
g) there were indications that diseased animals may be more prone to capture, and that snaring methodologies may have led to national estimates for TB prevalence in badgers being overestimated.
h) relatively few badger groups had infected badgers present and few infected badgers are removed in total from use of normal snaring techniques.

Weaknesses in data collection and recommendations for changes

Full details of the choice of study areas and the survey and snaring methods were described in the appropriate section of this report. Briefly, a licence is granted (by the National Parks & Wildlife Service) for the removal of badgers from areas in which a herd breakdown was considered to have been caused by transmission from infected badgers. Badgers are snared within a 2 km zone surrounding the affected farm. In this study, an area of approximately only 1 km square was marked out, setts were surveyed (mainly by Wildlife Rangers) and then the setts that had been identified and categorised were snared by Department of Agriculture staff. A high snaring intensity was insisted upon. Whilst the procedure seems straightforward, only about half of all areas chosen for these studies yielded results, and, of these, not all provided results that were entirely satisfactory.

There were instances in which a licence was applied for without active setts being present within 1km of the breakdown farm: it is recommended that there be reasonable R likelihood that badgers have caused an outbreak and that setts be mapped and sett data and activity recorded before a licence is applied for.

The main problems observed stemmed from inconsistency in snaring intensity. Even in this study, only 19 social groups were considered to have been snared at a high snaring intensity (with a minimum of 400 snare nights per group).

Variation in snaring intensity had a profound influence on results obtained. The estimated capture rate was lower for badger groups snared at low intensity, sex ratio of captures also differed, and there were some differences in trappability of diseased animals. In total, 19 'high-snare' social groups and 17 'low-snare' groups were considered for analysis. This sample is not large, so there might be some manner in which data selection affected these conclusions, but this seems unlikely. Estimates of group size were based sôlely on the 19 high-snare groups. It is recommended, that in view of the very useful data that can be obtained from these studies, that further research be conducted on similar lines to increase the sample size, but with greater consistency in methodology. R

One of the most surprising differences was that the prevalence of TB in the groups studied was lower than in excluded data sets, and lower than national means (statistics from all badgers snared nationally, Department of Agriculture, Food & Forestry data).

There are several reasons for this outcome, and for other differences observed between national statistics and the excluded data sets as compared to the areas that were included for analyses on badger groups. One reason is that there is a bias in the selection of licence areas nationally as compared to those chosen in this study. Nationally, licences are granted and dealt with preferentially at 'black-spot' regions of the country. On request, this study attempted to sample 2 badger groups per county; counties without significant TB problems were included and licences made available for breakdown farms. Thus, some differences would be expected and the outcome is reasonable, given the resources available to the Department of Agriculture for snaring operations. The national statistics may, therefore, overestimate TB prevalence in badgers. The implication is that the TB incidence in badgers sampled totally at random (not necessarily on breakdown farms and adjoining areas) may be lower still (estimates from road casualty data are referred to below)

This conclusion suggests there are two contradictory hypotheses, neither of which may be proven presently:

a) that badgers on breakdown farms and in black-spot areas have higher rates of TB, and, therefore, that badgers play a rôle in the transmission of TB to cattle. The disease may be transmitted in both directions and requires eradication in both the wildlife sources and the live-stock.

b) that badgers in these 'high-risk' areas have higher TB rates as a result of transmission from cattle to badgers rather than *vice-versa*. Hancox (pers. comm.) has argued that TB in badgers tends to die out once the disease is largely removed from cattle, as in the British Midland counties.

These various arguments cannot be addressed in this report, which is not an epidemiological study. However, the true values for TB incidence in badgers are ones that should be available for consideration by researchers. Resources need to be made available to allow *all* badger removal operations to be conducted in a manner that would yield statistically reliable data.

This may mean reducing the radius of badger control operations around a breakdown herd to allow better use of limited resources. At present, licences are granted for a zone of 2 km radius (12.6 ha) around a breakdown farm, from which any badgers may be removed. In this study, survey of a 1km area required over 2 man-days, so 12.6 ha would require about 27 man-days. This has to be followed by snaring, which is a more time-intensive operation. Clearly, survey and snaring of all setts is totally impractical and would be very costly, so that such methodical work is not the norm. Added to this difficulty is the need (as observed in this report) to snare intensively, with *c.* 400-500 snare-nights per social group (or active main sett) in order to capture at least 80% of adult badgers. This study estimated that groups snared at low-intensity (in a 1km square *only)* was about 69%. It seems reasonable to conclude that many badger removal operations in a 12.6 ha zone most probably do not remove even 50% of badgers present.

If the *rationale* for badger-removal from breakdown farms is to remove the source of infection from the main wildlife source (the badger?), then the operations would usually appear to fail. On the other hand, the data would suggest that this very low-intensity approach to snaring seems to catch up to twice as many infected badgers than would be predicted. This conclusion is based on the comparison between TB rates in badgers from groups and those from licences 'excluded' from group analyses. In this [very limited] sense, then, the normal low-snaring methodology of dealing with licences has unexpectedly more impact than anticipated.

Several studies are either underway or anticipated (by the Department of Agriculture, Food & Forestry). One of these includes a comparison of 'before and after' rates of herd breakdown on farms, following normal badger removal from the 2 km zone. If under 50% of badgers are removed from these areas, then the conclusions will be weak, as badger populations and infected badgers will have probably remained within them.

To conclude, low-intensity snaring operations yield poor information on badger population parameters (such as age and sex ratios and group size) and, generally, probably fail to remove half of badgers present. Cost and man-power considerations are relevant, and, to maximise present resources, the following changes are recommended to badger removal operations: R

i) *that a consistent approach be adopted to the land area around a farm that should be snared. If it is normally impractical to snare a 2 km zone, then a uniform standard area should be adopted,* e.g. *a 1 km radius; this is an area of 3.1 ha around the affected farm, and would normally include most badger groups having territorial activity in the farm area.*

ii) *that a sett survey be carried out within this area.*

iii) *that a high-intensity snaring regime be adopted for all setts identified in the zone.*

iv) *that full details be kept of sett locations, of snares set and their locations, of snaring duration (for each snare) and of badgers snared (including various body and TB measurements).*

Sex ratios

Intensity of snaring affected the sex ratios of the badgers captured, and the difference was large. Badgers snared at a high intensity had a sex ratio of 1 : 1. However, data from badger groups snared at low intensity and also from areas that had been excluded from inclusion for group analyses, revealed a sex ratio with a pronounced preponderance of females: 1 male : 1.68 females and 1 : 64 females respectively.

The various capture-effort analyses suggested that data for low snare groups was unreliable, and could not be used for estimation of snaring success or group size. Whilst the data set from high-snare groups was also imperfect in some respects, it must be concluded that observations based on this data set approached reality more closely. The studies concluded that the true situation is that the sex ratio of badger populations is close to parity and that substantial deviations from this have resulted from the differential trappability of badgers. Females would appear to be more trappable than males, for reasons unknown.

There seems to be some diversity of opinion as to the sex ratio of badger populations. One review of the literature (Anderson & Trewhella, 1985) summarised findings from 15 studies, and concluded that with a total sample size of 6087 badgers, the sex ratio was exactly 1.0 : 1.0. Cheeseman *et al* (1985) studied five badger groups in Staffordshire and found 16 males to 16 females (adults), a study that clearly employed saturation trapping and snaring. Kruuk & Parish (1987) observed a sex ratio of 1.0 male : 1.1 females, in a sample of 56 badgers caught in Inverness-shire, Scotland.

However, Neal & Cheeseman (1991) have stated that the sex ratio is equal at birth but a higher mortality of boars gives a predominance of sows in the adult population, and this has also been the conclusion of Cheeseman, Wilesmith, Ryan & Mallinson (1987) and Harris & Cresswell (1987). In a quite complex study in Britain (Cheeseman, Cresswell, Harris & Mallinson, 1988), badgers were captured by trapping, snaring and stalking, over a period from 1976 to 1985 in two main areas (Gloucestershire and Bristol), with a substantial sample size in total: this revealed a sex ratio of 1.0 males : 1.5 females (n = 283, Gloucestershire) and 1.0 : 2.0 (n = 93, Bristol). O'Corry-Crowe (1992) also observed more females than males in the east Offaly study area.

There is considerable variation in the sex ratio of badger groups observed in this study and in most others. Thus, within any research programme concentrating on a small number of badger groups, there is some possibility that the overall sample reveals non-parity, by chance. This may be the case in some of the British studies or here. However, this study has shown that there is differential trappability between sexes, so that the methodology adopted for sampling badger populations affects the outcome (sex ratio observed), and this conclusion would probably apply to British studies also. The sex ratio in the Bristol study mentioned seems to have been *particularly* affected, perhaps because most of these badgers were stalked, though the methodological detail for each of the study areas is not clear (Cheeseman *et al*, 1988). The very large samples included in the review by Andersen & Trewhella (1985) would support the conclusion drawn here that the overall sex ratio of badger populations is 1 : 1.

The only possibility that may affect this conclusion is that, with males having greater ranges or movements than females, males may be caught in a greater proportion of snares, so that the net result is that the true sex ratio may indeed be one that has more females than males. This is a hypothesis which cannot explain how it is that, at *low* snaring intensities, females are caught far more often than males.

Groups in this study revealed large variation in composition by sex, captures sometimes indicating all male groups, and sometimes all female groups, as well as more usual configurations. Unbalanced sex ratios similar to those reported here were noted by O'Corry-Crowe (1992) and Sleeman (pers. comm.) in Irish studies. Five social groups studied by Cheeseman *et al* (1985) did show variation in group sex ratios, but not as marked as those observed here. Kruuk (1989) noted, with interest, an all male clan (group) consisting of 6 adults in Oxfordshire, and referred to another to a 'group' comprising one male only in Speyside in Scotland. These male clans would appear to be unusual. It should be noted that the sex ratios of groups observed here are based on badgers captured, with an overall snare success rate of *c*. 75%, so that data presented here is not obtained from groups in which all individuals were known or captured.

There was some evidence here that disturbed groups (this was a rather loose definition, as any group that possessed a single disturbed sett within its estimated territory was considered to have been disturbed) tended to have more males than females in comparison with undisturbed groups. If snaring was the cause, then the higher trappability of females would result in this outcome. One supposition might be that females in areas suffering disturbance do not tolerate it and move elsewhere (to another social group) whereas this option is less available to males because males are not likely to be as readily accepted into new groups.

Snaring success

There was found to be a surprisingly sparse literature on snare or trap-success rates, with most research papers describing snaring, trapping or stalking methodology but paying scant attention to its success, failure or difficulties. Even intensive snaring operations, carried out here, resulted in an estimated success rate of only 80%. The less intensive operations were reasonably successful in terms of captures per snare-night, but yielded an estimated catch of under 70% over a 10 day snaring period. It has been mentioned that under normal operation of licences, these values are probably rarely obtained.

Despite the use of a high density of snares, there remained anomalies in the data that require explanation and further trials. Normal expectation would be that a plot of catch and against accumulated effort should yield a straight line. This was more apparent for badger groups that were snared at high intensity, with a rather poor relationship observed for groups snared at low intensity, yet, in both samples, an increase was observed over days 8 - 10, the reasons for which are unclear; perhaps there was immigration from adjacent social groups as a result of reduced activity or territory marking in groups reduced in size. If this was the case, then population estimates derived here are overestimates.

Extended trapping over a period in east Offaly (O'Corry-Crowe *et al*, 1993) indicated a snare success rate of 69%. This would confirm that snaring operations generally do not capture all badgers and that the success rate is relatively poor unless an intensive snaring programme is adopted. As a result of these studies, Hayden & O'Corry-Crowe (pers. comm.) recommended 500 snare-nights (over a 10 day period) per social group as a guideline that was both practical and would achieve a likelihood of maximum snare success.

Badger social group size

From catch-effort analyses on 19 social groups, a mean group size of 5.9 adults was estimated. This outcome was identical to the value adopted by Cresswell *et al* (1990) for determination of badger numbers in Britain, which was based on 11 social groups from 5 British studies. The mean value for 5 groups studied by O'Corry-Crowe *et al* (1993) was 5.8.

That Irish and British populations should express such similarity in badger group size was surprising, in view of the relative lack of woodland habitats in Ireland and with main setts being smaller on average. There are several considerations here, which may perturb this rather tidy conclusion. It was shown that there was a good correspondence between a number of sett description variables at licence areas with 1km national sett survey squares (where at least one main sett was present), but there were differences overall. This probably resulted from these study areas and all licence areas being located in cattle grazing areas, by definition. Whilst it was considered that the degree of error was probably small overall (since most main setts are indeed found in cattle grazing areas in Ireland), it is likely that the licence area sample was not representative of Ireland as a whole. Nevertheless, the value of 5.9 adults per group was used for national estimates of badger numbers, as no other data is currently available for Ireland, but its use leads to some overestimation of badger numbers in Ireland. The possibility of estimates being affected by immigration has been mentioned. Feore (1994) has suggested revision for Northern Ireland which is based on mean group sizes for each landclass or landclass group. The limited data available for the Republic and the lack of landclass data (presently) precludes this option at this time.

Furthermore, whilst the values obtained from 19 groups here and the 5 from east Offaly are very similar, the preponderance of females in the east Offaly study suggests an underestimation of mean group size there through some males remaining uncaptured. This was a prime grassland area, and the mean size of setts was larger, so the expectation would be that mean group size would be larger than for the 19 social groups studied here, which, though located in grassland areas, were more scattered over Ireland's geographical regions.

It is recommended that additional attention be paid to research that would increase our knowledge of group sizes in Ireland, and, if possible, that groups be chosen for study from a variety of landscape types. It has already been suggested that greater use be made of licence applications for badger removal, though such studies have some limitations not only because licence areas are exclusively located in cattle-grazing areas but in areas where breakdowns have occurred in herds. The present studies have not allowed an evaluation of variation in badger social group size by region or landscape type, a matter that might be addressed.

R

R

TB in badgers

The number of badgers confirmed with TB was 21, with 240 TB-negative (in the studies reported here). The sample size was relatively small, therefore, and only tentative conclusions can be drawn. Nevertheless, there were some interesting observations.

Firstly, TB rates for the badger social groups were lower than for badgers in areas excluded from analyses of group size. The reason for exclusion of data from group analyses was mainly inadequate snaring effort. The conclusion to be drawn is that, where snaring effort is low, a higher proportion of the sampled badgers have TB. TB+ve badgers appear, therefore, to have been more likely to have been snared than clear badgers.

Normal badger removal practice with regard to the most licence areas operated would, if the observation is valid, result in overestimation of TB prevalence in badgers. Why TB+ve badgers should be more prone to capture (by snares) is unknown, but not an unlikely consequence of some impairment of visual or olfactory senses, or, perhaps, comparatively poor body condition. This cause was one suggested by R. Harrington (pers. comm.). The differences in TB rates were not insubstantial: the TB rate for badgers snared in groups was *c.* 6%, and that observed in areas not considered for group analyses was 14.5% (P = 0.15). Compared to the national statistics for 1991-1993 (11.0%, 12.7%, 8.8%), the values obtained here for badger groups did differ significantly, particularly for 1992, which is unexpected as most of the badgers involved in these studies were snared in 1992. There was little difference between TB rates of low and high snaring regimes for the groups; so, providing that a 'reasonable' density of snares is laid, sampling error would appear to be small or minimal.

Following earlier conclusions, high-snare groups should reveal the 'true' rates of TB in badgers, but with sample sizes being very small, the conclusion that TB rates are similar in each sex cannot be confirmed. In the overall data, it was found that males had a higher incidence of TB than females, but the suggestion was that this was a result of differential trappability of diseased animals between sexes. With low-snaring operations, differences between sexes and between healthy and diseased animals emerged, though, again, the conclusions are preliminary. Nevertheless, there were good indications that diseased badgers were more liable to capture than healthy ones (as above) and that diseased males were more likely to be captured than healthy ones. Comparisons of data from high snare groups and remaining data did not show any strong tendency for diseased females to be more prone to capture than clear females; as for males, though, occurrence of TB in females in badger groups studied was lower than in females in the 'excluded' areas.

The hypothesis was considered earlier that disease affects trappability, perhaps through impairment of senses. This may be the case, and certainly so for individuals that are not only TB positive but suffering from the symptoms. However, the observed increase in trappability was mainly for males rather than females suggesting that a social cause may come into play primarily. Sick males may be preferentially excluded from social groups resulting in movement to unfamiliar territory, increased aggression with other badgers, and disorientation - all factors contributing to an increased likelihood of being snared. All four badgers found debilitated by disease were males in one study in Gloucestershire (Cheeseman *et al*, 1988) and Cheeseman &

Mallinson (1981) recorded that diseased badgers may leave their social group to live a solitary existence.

A closer examination of road casualty data would be worthwhile; data to hand suggests that traffic mortalities show a TB prevalence similar to national statistics, but a breakdown by sex has not been examined by the author. Cheeseman *et al* (1988) did indeed find a higher TB prevalence in males than females (31.5% of males infected, 21.1% of females infected, n = 149, difference not significant). Of the animals tested, half were road mortalities but a detailed breakdown was not provided. They observed that 'although the difference in sex-specific prevalence was not statistically significant in our sample, [they] believe that the higher prevalence seen in male badgers has some biological significance'. They considered various possibilities - male badgers have more bite wounds than females, greater frequency of movement seen in males, that males may be more immunologically more susceptible to infection than females, a phenomenon recorded in other species and diseases. Gallagher & Nelson (1979) also noted a greater prevalence of *Mycobacterium bovis* in male badgers (22% *cf.* 17%). On the contrary, this study's principal finding is that diseased male badgers are prone to capture or death on roads relative to diseased females badgers, but there was no evidence that there were any sex-specific differences in TB prevalence. Anderson & Trewhella noted Gallagher & Nelson's result but stated that this may reflect the wider ranging movement and activity of males in the habitat, though it is not clear how this alone would affect the prevalence of TB, although they took aspects of differential trappability into consideration. Of the 16 badgers of each captured by Cheeseman *et al* (1985), 5 females and 3 males proved TB positive.

The problem of differential trappability is one that affects all studies of trapped mammals, yet one that has scarcely been addressed in British research despite its considerable implications for any study of the biology of badgers and the epidemiology of the disease. It is also one that requires further study, with examination of success of different trapping R
methodologies and trap/snare densities.

The major consideration, from the studies here, is that a high-snaring regime does sample badger populations and TB rates in badgers more effectively than low-snaring regimes. The national data is potentially unreliable and also complex, as a consequence of the way it has been collected. The lack of resources has meant that the snaring methodology in the 2 km radius zones has varied from place to place, a significant sampling difficulty. Re-snaring of areas also takes place (the following year or later), with re-snaring taking place at the same setts or at setts previously unsnared (akin, therefore, to 'new' areas rather than previously-snared areas). The areas snared are all from break-down farms and many from severe 'TB black-spots', and are, therefore, selective.

The national snaring data show a pronounced trend over the period 1991 - 1993, with falling numbers of badgers snared, an alteration in the overall sex ratio, and a change in TB prevalence in each sex, and in the sex ratios of clear and diseased animals. These trends are almost certainly an artefact of snaring and sampling methodology, and unreal, though there might have been change in TB prevalence over the period: this cannot be tested here. A modelling approach to these trends did not confirm a hypothesis that repeat snaring of some licence areas was bringing about some significant changes in sex ratios of badgers captured (in national data). Additionally, the national data did not confirm that males were more prone to capture than females overall but the weaknesses of the national data may play a rôle here. The national trends were highly significant statistically, and, with more detailed information on the individual licence areas, it should be possible to ascertain their root causes. R

The final observation was that badger removal operations are not particularly effective in removing TB positive badgers. Only 22.5% of licences removed TB+ve badgers (this may be an underestimate as most results were confined to the 1km square areas around the breakdown farm only) and that the mean number of diseased badgers removed per licence was only 0.5 individuals (*n.b.* repeat snaring of licence areas *not* included in calculations). As a result of these and earlier conclusions, it is recommended that the methodologies involved in badger-removal operations and licensing arrangements be reviewed. However, whether badger operations should continue has to be based on an examination, by epidemiological study, of the impact of badger removal (of *c.* 0.5 diseased badgers per licence) on the probability of transmission of disease from badgers to cattle. R

If diseased badgers are more prone to capture than healthy ones, greater attention should be paid to behavioural studies of diseased badgers. R

Badger numbers and density in Ireland

The estimated population of adult badgers in Ireland is *c.* 250,000, with *c.* 200,000 in the Republic (for details, refer *Results*). The number of social groups present in the Republic was estimated at 34,000, with a mean group size of 5.9 adults, and a mean group density of 0.5 groups per km^2. The mean badger density may thus be estimated at 2.95 individuals km^{-2}. The species is not, presently, under threat, nationally, from legal or illegal killing or disturbance. There has probably been some loss of populations locally. The mean group size of 5.9 adults is likely to be an overestimate but is based on currently available data.

The badger population in Ireland is amongst the highest in Europe. Griffiths (1993b) has given provisional figures for all of western and eastern Europe, with a total estimate for the continent (excluding Russia) of 1,200,000. Britain has the same number of badgers as Ireland, and only Sweden is considered as having more badgers than any other country (figure quoted is '>250,000'). No other countries have similarly high numbers of badgers.

Badger densities are not uniform, with lower densities prevailing over western and upland counties; this is an oversimplification, as badgers are also less common in counties such as Wexford, Waterford and Longford, for example. There are six counties of high badger density (over 0.7 groups per km^2; *c.* 4 - 7 badgers per km^2)

Based on estimates utilising landclasses, Cresswell *et al* produced maps of badger distribution in Britain which show that badger densities are highest in the south-west of England (including a broad band from the home counties to Gloucestershire) and in south and west Wales (see Figure 3, page 34, Cresswell *et al*, 1990). Badger densities were estimated to be in the range of 0.4 - 0.7 social groups km^{-2} over most parts of these regions. The mean group density reported by Thornton (1988) for south-west England was 0.58 groups km^{-2}.

Most Irish counties also fell into this general density range; a few were higher (*e.g.* Cos. Kilkenny and Louth) and most western and north-western counties were lower. As a general account of badger densities, it may be reasonably concluded that most Irish counties, and, in particular, Ireland's prime agricultural grassland areas, have badger densities that are similar to those prevailing over south-west Britain (a broad geographical zone of Britain, as described above). The overall range of densities in Ireland is similar to those in Britain: these cannot be compared directly as data has been compiled per county in Ireland and for landscapes in Britain, but there are areas of Ireland where badger density is zero, as in Britain, and there are also areas where badger densities are high in Ireland, as in Britain.

The maximum density of active main setts observed in Ireland was 3 km^{-2}, and even with error 4 km^{-2}, but no square had badger densities as high reported by studies in the Cotswolds in Britain. There, densities of up to *c.* 20 badgers per km^2 have been recorded (Cheeseman *et al*, 1981). Mean densities were lower in most Irish counties than the mean of 6.2 badgers km^{-2} (*c.* 1 social group km^{-2}) recorded by Cheeseman *et al* (1985). In comparison with many other population studies, Irish densities are relatively low. Anderson & Trewhella reviewed badger densities from various studies, including Cornwall (4.7 badgers km^{-2}), Avon (4.9), Durham (5.8) and Oxford (5.2 - 8.4). Kruuk & Parish (1987) reported a mean density of 2.2 badgers km^{-2} in Inverness-shire in Scotland (similar to some western counties here). Densities in Holland are lower still, at *c.* 1.0 badgers km^{-2} (Wijngaarden & Peppel, 1964).

There are two Irish population studies with which badger densities observed in this survey may be compared. O'Corry-Crowe *et al* (1993) estimated a main sett density of 0.65 km^{-2} (range 3.0 to 5.3 badgers km^{-2}) in their study area in east Co. Offaly. This study estimated 0.73 active main setts per km^2 for Co. Offaly as a whole - a comparable result.

Sleeman & Mulcahy (1993) reported that the badger density in their study area (12 km^{2}) was 3 - 4 badgers km^{-2}, a density that they considered as low with reference to Britain. Estimates of social group size have not been published, so assuming that this report's estimates of social group size hold true (5.9 adults per group), then group density for the study area in west Cork is *c.* 0.6 km^{-2}. This survey's estimate for Co. Cork, as a whole, is 0.64 groups km^{-2} (Table 38), again a comparable value. The observation that should be made, therefore, is that the study area in west Cork is one of moderately high badger density and not of low badger density as suggested by Sleeman & Mulcahy (1993). Areas of *low* badger density in Ireland do appear to be restricted to upland, moorland and mountainous areas mainly in the extreme west and north-west of the country.

In conclusion, with Ireland's agricultural landscapes being largely dominated by cattle grazing, badger densities are similar to those observed by Thornton (1987, 1988) and Cresswell *et al* (1990) for the south-west of Britain. Whilst it is true that Ireland has approximately the same population of badgers as Britain and has about $^1/_3$rd of the land area of Britain, *it would be an over-simplification to suggest that badger densities in Ireland are higher* (*e.g.* Dolan & Lynch, 1992) in a context that is meaningful, as badgers are absent or scarce over large parts of Britain.

Badger distribution in relation to habitat

Badger distribution in relation to habitat and habitat preferences for sett location have been evaluated at some length in this report. Problems were posed by a statistically random distribution of main setts, but the overall habitat composition of squares and of counties was shown to determine badger density. There was considerable success in the predictive capability of models both for individual squares and for larger zones - counties, which will be further enhanced by incorporation of environmental and landclass information into the database (research in progress). R

In summary, main setts were preferentially located in hedgerows and treelines (43% of all setts), semi-natural woodlands (7%), plantations (10%) and areas of scrub (19%). Bog and moorland were avoided, as were grasslands and built areas. 75% of setts were located within the vicinity of cattle grazing.

There appeared to be preferential selection by soil type. This was not considered statistically, as it required information on the overall availability of soil types but, generally, regional differences indicated that the soils observed at setts tended to reflect the overall soil characteristics of an area. Silt and clay soils seemed to be avoided generally (but over 10% were located in clay), with most setts found in soils characterised as sand or loam. Neal (1972) found (in the first British sett survey) that 44% of setts were situated in sandy soil in Britain, with 6% in clay. He added that 'clay is not despised and in many districts where no sand is available, it is utilised with success'. Quite a number of setts were found dug in peat in Ireland.

The preferences shown by badgers in sett location are similar to those observed by Cresswell *et al* (1990). In Britain, bracken was preferentially selected and quarries also. The statistical conclusions for sett location were stronger here than in the British study, but, for the broad habitat categories, there was a substantial correspondence between the findings. This is not unexpected; badgers locate their setts in available habitat, in cover, generally away from human activity, and avoid machinery in agricultural areas by not locating their setts directly in grasslands or arable areas (though 13% of all setts were located in grassland).

In Britain, hedgerows are not as prevalent as in Ireland so fewer setts were located in hedgerow in Britain and correspondingly were more located in woodland. Cresswell *et al* (1990) did not give any details but Neal (1972) found most setts located in deciduous woods (49%, up to 75% in Surrey). Only 13% were located in hedgerow and scrub. Thornton (1987) also found most setts in deciduous woodland in south-west England (61%), with the next favoured habitat being hedgerow (24%). In consideration of the hedgerow habitat in relation to badgers, Irish hedgerows and scrub/hedge boundaries are generally much wider than in Britain. O'Corry-Crowe *et al* (1993) estimated mean hedge width in east Offaly to be 2.5 m (the value adopted for this report), as compared to the value of 1.5 m used by Cresswell *et al* (1990).

Habitat preferences for sett location in east Offaly were similar to those reported for the overall Irish study, with 55% of setts located in hedgerow, and in total 78% located in cover (woodland, hedgerow and scrub) [O'Corry-Crowe *et al*]. They also found setts in grassland, open, locations - 15%, similar to the 13% value for the national sett survey. Neal

(1972) found 9% of setts in the open but made the useful point that cover in an open situation varies much during the year.

Urban areas were sampled in this study and no setts were found to be located in towns or cities, but 3 setts were located in 'built land' (includes roads and gardens), with 1 of these built under a road. However, urban badgers do exist in Ireland (Fannon & Fannon, 1983) as in Britain (Harris, 1982, 1984; Harris & Cresswell, 1987). Sleeman (pers. comm.) has found several setts located within walled gardens and garden enclosures on Fota Island, Co. Cork. The possibility exists that the present survey has underestimated setts present in urban and garden contexts but is would be unrealistic to suppose that there is a substantial margin of error in the present study, excepting large conurbations (Irish cities), where the surveys could not realistically evaluate badger densities. However, the number of survey squares located in these areas was very small and badger density in urban areas may be reasonably presumed to be low also.

In consideration of badger density, several habitat variables contributed substantially to variation observed. Rather than repeat detailed results, a broad overview is attempted. Badger densities, are, in the main, determined by the area of cattle grazing and improved grassland. The nature of Irish landscapes assists, by providing substantial hedgerow and treeline cover for sett location. Area of poorer grasslands, used mainly for sheep grazing, were negatively associated with badger density. Correspondingly, bog, upland and moorland were also negatively associated with badger density.

There were a number of interesting variables that assisted in explanation of the variation. For example, road length proved to be a feature that badger density was associated with, because road length was low in western counties and high in certain well-developed counties. However, the 'best' environments for badgers were ones of intermediate road length per square. Additionally, the length of canalised waterways was instrumental in improving analyses. This would seem to be related to the degree of grassland improvement and tends to include many Midland counties where drainage, land reclamation and improvement have assisted in a combination of habitat features that create a good environment for badgers. Woodland (mainly mixed or deciduous woodland) contributed positively to badger density, whereas badger densities were generally lower in prime arable counties.

Hedgerows and treelines are an important component of Irish landscapes. Badger densities increased with hedgerow length, but analyses showed that this was largely because of a correlation between hedgerow and pasture. Pasture was the more important of these variables and hedgerow could be excluded in most predictive models, though it was also noted that counties with a high badger density also had a greater density (km per ha) of hedgerow per unit grassland. Cattle pasture was preferred and sheep pasture avoided. Presumably this relationship has little to do with badger preference for stock type, but with the fact that high quality improved grasslands are usually utilised for cattle grazing, and poorer upland, western, or marginal pastures used for sheep. The analyses by landclass also suggested that higher badger densities were found in pasture areas, in landscapes that are undulating, gently rolling or of rounded intermediate slopes. Upland areas, with mountains, bogs, or heather moors, and afforested uplands, were poor landscapes for badgers.

The six counties of highest badger density were well separated from other counties in analyses. They can be identified as counties of low diversity, high farming productivity (but mainly cattle pasture rather than arable), more hedgerow, more canalised waterways and more semi-natural woodland (though the overall quantity of woodland remains low). These counties (all in a broad Midland zone) are characterised as being in less-developed areas with less road and more bog.

Neal (1972) found that hilly areas, interspersed with permanent pastureland and deciduous woodland provided the most favourable habitats. There is much similarity in that observation and that now found for Ireland, except that, with so little woodland in Ireland, one needs to substitute hedgerow for woodland - but, nevertheless, the area of certain woodland types remained positively correlated with main sett density in Ireland.

In view of this survey's results - and others, it is confusing, therefore, that Thornton (1987, 1988) found a negative correlation between badger density and pasture *and* with hedgerow (in south-west Britain). This was certainly not the case here. It is an aspect of both the Thornton study and that of Cresswell *et al* that the habitat surveys did not assess grazing areas or pastures by stock type. In this study, badger density was negatively correlated with sheep grazing (unimproved grasslands mainly) but showed a strong positive association with improved grassland and cattle grazing. If these relationships also hold for south-west Britain, then, if *more* of the grasslands are given over to sheep (or are unimproved grasslands), a correlation for *all* pastures would be negative, as observed. It is possible that, if most hedgerows are in sheep areas, then the relationship between badger numbers and hedgerow length would also be negative (unexpectedly, as Thornton stressed [1987]).

Significant positive correlations (in south-west England) found were hilliness (index), deciduous woodland, coniferous plantation, altitude and perimeter length of woods/copses, as well as some other indices not considered in this report. So, in addition to the unexpected negative correlations with pasture and hedgerow length, badger density was, surprisingly, positively correlated with altitude (!) and coniferous plantation (a negative correlation in this report). Thornton (1988) used predictive models derived from multiple regression; this technique is not the most appropriate for examination of how habitat composition determines badger density, with discriminant analysis being more fruitful. On the other hand, the use of tetrads for surveys produces values which are more appropriate to multiple regression analyses than 1km survey squares.

Generally, it has (to date) been considered that the south-west of England has a rather similar habitat composition to that of Ireland. Indeed, relative to other areas of Britain, this may be the case. However, Thornton (1987) did present data for the means of various variables. For example, 53% of the land area consisted of pasture, a value quite similar to that of Ireland, but the area of arable land is far greater (29%) and the area of deciduous woodland also (6%). Unfortunately, it is not clear what units of measurement were used for hedgerow. The conclusion to be drawn is that the south-west of England does, in fact, differ in certain habitat characteristics that influence badger density - in particular arable land and area of woodland. This difference creates some difficulties for general considerations of TB prevalence in cattle and its causes.

Cresswell *et al* (1990) presented no correlations of sett variables with habitat variables, and they presented limited discussion of which variables determine badger density. The variables used in the multiple regression analysis suggest that badger densities are positively associated with area of tall scrub, area of semi-natural broad-leaved woodland and hedgerow length, and negatively with area of parkland, area of natural running water and area of canals. Pasture was *not* a significant variable in any of the regressions. As noted above, multiple regression is not satisfactory for analyses of 1km survey squares.

In Ireland, given the overall availability of suitable soil conditions for sett building and also cover, such as hedgerow for security, food availability may be considered to determine badger densities. The overall habitat composition of the landscapes found to be associated with higher badger densities in Ireland is one that possesses adequate soil and cover conditions for sett construction and also a food supply in the form of earthworms (improved pasture). Food supply is probably the main factor determining the abundance of badgers, hence the positive association of badger density with improved cattle pasture. Kruuk & Parish (1982) considered that earthworms play an important rôle in determining territory size and population abundance. Kruuk & Parish (1981) and Kruuk (1989) considered badgers to be earthworm specialists, with foraging on other items compensating fluctuations in earthworm availability. Kruuk & Parish (1985) showed that the availability of earthworms affected body weight of badgers. Hofer (1988) found no correlation between earthworm biomass and group size, but did not evaluate the relationship with badger numbers. Harrington (pers. comm.) has indicated that additional studies of badger diet in Ireland would assist in comprehension of the species' relationship with cattle grazing areas.

Urban areas appear to be avoided in Ireland, though this survey was not able to conduct detailed studies in urban areas. One interesting result, in this context, was that disused main setts were correlated with road length, which would suggest that traffic hazards and consequent mortality may have contributed to their abandonment. Afforestation also appeared to be involved in main sett abandonment. Gallagher & Nelson (1979) considered that road fatalities probably constitute the major cause of adult death in Britain. Another possibility is that proximity to roads may tender badger setts easier to find and thus more prone to disturbance by human hand.

In the *Introduction*, it was considered that badger numbers in Ireland have increased in this century. In view of the improvements in pastures, through drainage, re-seeding and fertilisation, this hypothesis is probably correct. The effect of hedgerow clearance has probably had only a small effect (to date) on badger numbers, except in certain localities, where woodland and alternative sites for sett construction are also lacking.

Badgers, habitats, and TB in cattle

No attempt has been made in this report to statistically evaluate TB in cattle against the badger density or habitat variables detailed, with such studies to form further research carried out by the Department of Agriculture, Food & Forestry, the National Parks & Wildlife Service and others.

Notwithstanding, this report's findings do have certain implications for such studies, but before these are considered, brief attention is paid to which mechanisms might come into play that could be examined using data such as that presented in this report. If badgers do transmit the disease to cattle, then it may be argued that badger density will affect the likelihood of transmission occurrences. This may be qualified by two parameters; firstly, TB should be widespread in badger populations; secondly, some account should be taken of cattle presence/density as well, so that in any study, an area that might have high badger density, but no cattle present, should be excluded from study as no transmission events can possibly occur. There may be some threshold level of badger density below which transmission events are scarce.

There may be routes of infection that might, to some extent at least, be independent of badger density. For example, it has been suggested that urination and contamination of pasture by badgers is density-independent by White *et al* (1993) [this paper is evaluated critically later]. Other possible routes of infection are from faeces (at latrines), nosing by cattle of live badgers, nosing by cattle of badgers that have died in the open, contamination in barns or of drinking troughs, contamination of pasture by infected matter such as saliva, skin, puss from wounds, *etc*. Any other routes of infection from badgers are unlikely.

Conversely, it should be accepted that badgers are at risk themselves from contamination by cattle through dung or urine principally. As badgers forage in grasslands and in and around cow-pats, they are quite likely to become infected. If so, then lesions might be expected to be frequent in the mouth; Hancox (pers. comm.) has indicated that this is the case.

The principal problem identified in dealing with the issue of badger, habitats and TB in cattle, is that badger densities are higher in areas of prime agricultural grassland used for cattle grazing. Given this observation, it will be difficult for any study to isolate factors involved in the transmission of TB, except to observe that there are more badgers where there are more cattle. We may reasonably anticipate that correlations will be found with badger density, cattle density and herd density, but remain ignorant of whether these correlations suggest routes of transmission, as it may be merely the habitat composition of good grazing areas that results in higher badger densities. Of particular interest are the 6 counties identified not only as ones that have (in the Irish context) high badger density but have also been identified by a distinctive habitat composition.

Thornton (1987) found no relationship between TB in bovines and badger density but considered that there was one between herd density and TB. She found no correlation between badger density and pasture, but did not check for a relationship between badger density and *cattle* pasture (as noted earlier). It still remains unclear, therefore, whether such an evaluation of badger density, herd density, cattle density and TB breakdowns would be

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constructive in Ireland. It is recommended that this evaluation be carried out, and that an attempt be made to differentiate areas of dairy cattle and of beef cattle.

The badger density approach to evaluation of the TB problem was attempted by McAleer (1990) in Co. Galway (but without information on TB incidence in badgers): his study suggested that where badgers were more common, then TB in cattle was also more of a problem. On the basis of simple habitat data, his conclusions were not unreasonable, but the habitat variables employed to predict badger density now leave much to be desired. For example, badger density was presumed to be influenced by total woodland area, which this report has concluded is not correct, as badger density is negatively correlated with coniferous plantation. Some upland areas were identified as both of high badger density and high-risk TB areas, and it is not likely that these areas were, in fact, high badger density areas. Indeed, the poor correlation between upland areas with TB in cattle and badger density is suggestive of other causes or influences on cattle management rather than badger density, such as small farms, lateral spread from herd to herd, and stress in cattle under poorer conditions. The study included no statistical evaluations and may have suffered an absence of snaring of badgers in some areas [perhaps some of the DEDs had no badgers snared in them at all]. Despite these difficulties, the paper was a preliminary one, and the study has outlined a useful approach and one that has been recommended in this report. R

The final badger and habitat data from Northern Ireland (Feore, 1994) remain to be evaluated and placed in context with results from the Republic. Whilst results are preliminary, there are two principal observations:

(a) badger densities in Northern Ireland would not appear to be very different from those prevailing in the Republic, whilst TB levels in cattle are generally lower,

(b) no substantial habitat differences of any note have been observed, except for one, and that is that proportionately more grassland is devoted to sheep grazing in Northern Ireland than in the Republic.

This observation would suggest that herd density or cattle density may play some rôle in TB transmission, independent of badger density - and, whilst the results remain to be confirmed, the implications would be profound. *If* no other variables can be associated with the different overall levels of TB incidence in cattle herds in Northern Ireland (*e.g.* perhaps the prevalence of TB in badgers in Northern Ireland is much lower overall than in the Republic, or, differences in farm management and veterinary practice may be influential), then one is drawn to hypotheses that would explain any cross-border difference in TB incidence that are based on herd-herd separation distances or cattle densities. McIlroy (1988) has shown that most infections in Northern Ireland arose from cattle to cattle routes. It has been mentioned, within this report, that badgers might still play a rôle in these circumstances but that the consequences of badger/cattle transmission would be much reduced when cattle herds are more dispersed.

One future aim of research in Ireland, therefore, should investigate cattle/herd densities relative to TB incidence in cattle, and examine pasture use by stock type in various regions, including Northern Ireland and south-west England. R

The parallels with the south-west of England are intriguing: if the south-west has more sheep pasture also, akin to Northern Ireland, is there a possibility that pasture use and dispersion of herds are involved in the incidence of TB breakdowns in cattle? It is recommended that some of the matters be addressed by simple comparison of agricultural statistics immediately. Which parameters affect cattle breakdowns in these situations, and why does the Republic differ? With more land devoted to sheep, it may be presumed that distance between cattle herds is greater, perhaps herds are larger, with less farm fragmentation. It may be that pasture used by cattle contributes to badger densities more than the same pasture stocked with sheep - if, for example, food availability is increased. R

Hancox (pers. comm.) has suggested that TB in badgers dies out once it is removed from cattle as in the British Midlands. Even if there is a cycle of disease between badgers and cattle, a greater dispersion of herds may lead to a reduction of inter-species infections, and reduced badger-badger infection events also, cutting down movement of the disease through badger populations and through geographical areas generally. *Localised* outbreaks may be as severe as any experienced in the Republic; however, they will have a tendency to remain localised (as illustrated in MAFF's 15th report, 1991).

It is generally accepted that badgers can transmit TB to cattle, with the most obvious route being from sick or dead badgers which cattle might have the opportunity to nose. Nevertheless, the case has been made that badger to cattle transmission events are rare, and the contribution of badgers to the disease in cattle remains unknown, and the badger remains controversial.

Most farmers believe badgers to be the primary cause, with either lateral spread or cattle purchase being secondary and tertiary causes (O'Connor, Conway & Murphy, 1993). The study, based on a survey of farmers and veterinary practitioners, also showed that farms with a history of breakdown were far more likely to have badgers reported as present on or near the farm (86% *cf.* 53%). As the report points out, badger presence was indicated by farmers' perceptions and not by objective measure and, also, alertness to presence of badgers was likely to be enhanced if there was a history of TB on the farm or in the locality. The research reported here suggests that badgers are likely to be present in most cattle grazing areas, so there may, indeed, be bias in farmers' perception of badger presence.

Although most (60%) of farmers and practitioners attributed TB outbreaks to badgers and other wildlife, the authors reported: 'regression analysis shows that contrary to popular opinion the impact of badgers on TB breakdowns is rather small compared with that of other sources of infection'. 'The best fit equation which had five variables explained 37 per cent of the variation in disease category. ..... The reporting of badgers in the neighbourhood [contributed] 2 per cent'. Thus, the contribution of badgers may be low - though if badgers are present at most farms or reported as present at most farms, then multivariate regression analysis will be fruitless.

Nevertheless, the reported dissimilarity in TB levels between the Republic and Northern Ireland (and south-west Britain), with badger densities being somewhat similar in all three regions, would suggest that the contribution of badgers to TB outbreaks in cattle cannot be very high. Other estimates of the contribution of badgers to the disease in cattle were mentioned in the *Introduction.* To clarify this question, O'Connor *et al* recommended calculations using an objective measure of badger presence, based on technical studies. This report has provided the basis for the measures, which should now be applied. R

Finally, completing discussion of how badger densities may or may not be involved in TB breakdowns in cattle, one practical issue remains. If badgers do transmit TB to cattle, *and* in a density-dependent manner, *and* transmission events contribute substantially to TB outbreaks in cattle, then the difficulties of managing badgers are intense. The majority of Irish badgers co-exist with cattle, so their removal cannot be contemplated on practical, let alone on conservation grounds. If there was some threshold level at which badgers no longer pose a risk, then some reduction in badger numbers might be feasible over local areas, but the costs would be high.

The vaccination approach, whether for badgers or (preferably) for cattle, seems to be one of the best practical options, once suitable vaccines have been confirmed and tested. The prospects for vaccination of badgers have been discussed by Hughes & Rogers (1994) in a feasibility study and the programme recommended by O'Connor *et al* (1993) and Morris & Pfeiffer (1990). Optimal targeting of badgers is necessary to enhance gains from such a programme and reduce costs. Factors influencing optimal targeting include ease of sett location, evaluation of badger group densities in target areas, and prediction of effects dependent on adjoining landscape composition and badger population dynamics and behaviour. R
The information in this report has provided information on some of the best approaches to take, and landscape evaluation studies currently underway will assist this process further, particularly in a predictive capacity.

Two recent publications, reporting the same research findings (White, Brown & Harris, 1993; Brown, Harris & White, 1994), have suggested a hypothesis, based on behavioural studies of badger urination carried out in the Cotswolds, that contamination of pastures by badgers is responsible for the observed variation in TB outbreaks in cattle. The basis of the argument is that badgers urinate at linear features, *e.g.* fencing and hedgerow and woodland boundaries, *etc.*, moreso than elsewhere. It is a study that has aroused much interest and publicity (*e.g.* Anon., 1993; Cardwell, 1993). The hypothesis suggests that TB breakdowns are related to the length of various boundaries in an area but are *badger-density independent.* The study, for south-west England, is based on a sound piece of research on badger urinatory behaviour in the Cotswolds by one of the authors (Brown). There are many implications for management if the hypothesis were proved to be correct, such as fencing cattle away from hedgerows (but would these then become linear features to be marked by badgers?), or removal of linear features. Unfortunately, (or fortunately, if hedgerow protection is regarded as a conservation issue) the study's conclusions are unfounded on published evidence. The findings of the urinatory study are not disputed. However, the supposed identification of areas that have a history of TB outbreaks as ones that differ from ones that have not as being ones possessing higher length of linear features is. Since the papers have attracted attention, it is necessary to point out that the study's methodological approach appears fundamentally flawed.

1) it can be demonstrated, from data available, that badger density was, in fact, almost certainly correlated with major linear features in south-west Britain.

2) the fundamental flaw is sampling method. If one wishes to identify habitat features that differ between areas of high TB risk (*i.e.* herd breakdowns) and no risk (areas that have had no breakdowns), which is the root aim of the hypothesis, then one compares two samples statistically:

i) a random selection of 1km squares (or a larger area, *e.g.* 3x3km) in cattle breakdown areas, by identification of *breakdown herds.*

ii) a random selection of 1km squares chosen from location of *herds that have not had a breakdown.*

White *et al* did not sample this way. Instead they compared

iii) squares around breakdown herds, categorised by landclass.

iv) randomly chosen squares from each of the landclasses that were sampled in (iii).

If cattle and/or badgers and habitats were evenly distributed within all squares of a particular landclass, then this comparison might be valid. However, landclasses are not as uniform as White *et al* suggest. In fact, in order to establish their hypothesis, White *et al* proceed to show that squares within one landclass are *not at all* uniform - because, as they demonstrate, they vary in linear feature composition. The approach to analyses is inherently contradictory and the hypothesis *cannot* be confirmed.

Whilst landclasses do consist of similar types of landscapes that have been differentiated statistically, their individual squares still possess a range of environmental variables. For example, one of the landclasses that the authors use in their analysis (to demonstrate that their hypothesis is correct) is landclass 17 (Bunce *et al*, 1981). *This landclass includes squares that vary in mean altitude from 600 - 1500 feet above sea level.* A *random* selection of squares (*i.e.* selection [iv] above) from this landclass will provide mean values for habitats which *cannot* be compared with *herd* breakdown areas within the same landclass, all of which *must* be located in the lower altitude range (*unless* White *et al* can also confirm that cattle grazing is also equally distributed in those squares with mean altitudes over 1000 feet). It would also be an expectation that badger densities would be higher in the lower elevation squares, as they, also, would be relatively scarce above 1000 ft. Within this landclass, therefore, we would anticipate that the squares chosen with breakdown herds differ from randomly selected squares with regard to cattle density, herd density, badger density and also habitat variables such as hedgerow length, field boundary composition, *etc.*

The same kind of considerations can be shown to apply to all the other landclasses used to demonstrate the validity of their hypothesis. It seems inappropriate, therefore, for the study to have drawn conclusions from a comparison of samples which do not confirm that either badger density or habitat attributes (in particular, length of linear features) are independent of cattle presence or cattle density.

These, and other sampling errors, suggest that it is not improbable that the study has merely observed more TB breakdowns in those areas that have more cattle. The results of this report have revealed a positive correlation between the area of cattle grazing and hedgerow and treeline, so that a greater length of linear features in cattle areas is hardly surprising, and would suggest that the conclusions drawn from the UK studies might have a simpler explanation. Cattle density parameters should have been included in the analyses carried out by White *et al* (1993) and Brown *et al* (1994) - *e.g.* herd density, cattle density, area of cattle grazing, area of sheep grazing. Alternatively, the squares should have been sampled in an appropriate manner.

Two further matters merit mention: the most sizeable linear feature the authors observed was sheep-fencing. It is unclear why this should be so in cattle grazing areas, and, again, we return to the issue of the principal grazing stock there and the agricultural use of improved grazing land. The other matter is whether it is valid to apply data from the badger urinatory-behavioural studies, carried out in the very high density area of the Cotswolds, to the (relatively) lower density areas of south-west England and in particular to landclasses such as landclass 17, which is a low badger density landclass (mean density of active main setts 0.225; Cresswell *et al*, 1990).

The approach of using landclasses and habitat variables (in the investigation of TB in cattle) is one that has been recommended in this report and is the subject of current research. White *et al* have, at least, identified some of the problems of sampling methodology for such studies.

Conclusions

Various recommendations were made, earlier, as to how the habitat database may be exploited and added to, for the purposes of the study of TB in cattle, badger populations, and as a predictive tool. In this section, some of the landuse and habitat features that may play some part in explaining why TB rates differ from area to area have been considered, and various studies that have previously investigated habitat and environment have been discussed.

A current research programme is aimed at furthering this line of investigation. There are indications that badger density is relevant (to TB in cattle), and perhaps linear features also. R
Land use, especially national and regional differences in the use of pastures for sheep as opposed to cattle, is implicated in some, unexpected, manner.

Whether badger densities are directly related to *cattle* pasture is now a consideration. In clarification, if the same quality of improved grassland is used by *sheep* rather than cattle, is there a reduction in badger density (as a result of some change in earthworm density or the availability of cow-dung and its associated fauna to badgers)? Results from Northern Ireland suggest not, in which case some variables associated with cattle management and distribution of farms or herds seem to be pertinent. The database critically requires addition of data on R
herd densities and other parameters of farming practice.

In the this study, the main wildlife carrier considered has been the badger. Other wildlife sources require investigation; for example, deer were shown to be distributed over larger portions of Ireland than anticipated, and transmission from cats (feral and domestic), rats and others all merit attention, perhaps with regard to barns and over-wintering sheds. Hughes & Rogers (1994) list wildlife species known to have been naturally infected with *Mycobacterium bovis*.

The whole area of TB investigations is one that has not yielded satisfactory answers despite considerable expenditure on research and experimentation in Britain and Ireland. The routes of infection, between species, have still to be elucidated, and, because they are not clear, remain a source of contention between the farming sector and conservationists. Vaccination of cattle would provide a short-cut to dealing with the problem. In the meantime, it should be recognised that it is unlikely that the disease can be eliminated, whether this be because the primary sources of infection are from wildlife species or arise from farm hygiene and cattle-cattle spread.

The Republic would appear to have a TB problem in cattle greater than that of Northern Ireland and Britain. Some of the habitat, landuse and badger variables considered here have indicated that it should be possible to identify the principal problem areas and to suggest some differences relevant to the TB issues. In particular, discriminant analyses and machine rule-finding systems have proved quite successful in a predictive capacity, at least as far as badger densities are concerned. Current research is establishing a land classification for the country, which will allow environmental variables, and landscape attributes, to be assessed relative to badger densities and TB incidence in cattle, as well as formulating an approach to general ecological monitoring and assisting in utilisation of badger vaccination efforts. If these processes can, at least, suggest changes in management (in farming practice, or, of badgers and other wildlife sources) that would bring levels down to rates in the UK, then the necessary investigations should be continued and enlarged upon.

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Field surveys were conducted by the author and *c.* 50 Wildlife Rangers, co-ordinated by the author and the management side of the National Parks & Wildlife Service. A number of surveys (limited in number but very worthwhile) were carried out by volunteers of Badgerwatch Ireland, a body affiliated to the Irish Wildlife Federation.

The studies involving badger removal areas were carried out with field surveys undertaken by (in the main) Wildlife Rangers, and badger removal was carried out by staff of the District Veterinary Offices, co-ordinated by the Department of Agriculture, Food & Forestry, with laboratory analyses of badgers undertaken by the Department's Veterinary Laboratories.

The surveys in Northern Ireland, referred to in this report, have been conducted by Sarah Feore, under the supervision of Ian Montgomery, Department of Biology and Biochemistry, Queen's University of Belfast; the badger and habitat surveys there were co-ordinated with those in the Republic. The research there forms part of a larger post-graduate research programme on badgers, which has been funded by the Department of Agriculture for Northern Ireland. Surveys were assisted by staff and volunteers of the Department of Environment (Countryside and Wildlife Branch), Ulster Wildlife Trust Badger Group, the National Trust, Conservation Volunteers and others. Permission to incorporate certain elements of the Northern Ireland data here is gratefully acknowledged.

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APPENDICES

APPENDICES

APPENDIX A

APPENDIX B: APPENDED DOCUMENTS

APPENDIX 1

Proportions of sett types according to county and region, as given by the mean number per active main sett. Total number of setts per social group and per km square are also given.

County	disused main	annexe	subs-idiary	outlier	no. of setts per social group	mean no. of setts per square
Carlow	0.20	0.20	1.40	0.80	3.60	2.25
Cavan	0.00	0.33	0.83	1.17	3.33	1.25
Clare	0.10	1.00	2.29	0.86	5.24	3.06
Cork	0.18	0.51	1.20	1.49	4.38	2.53
Donegal	0.17	0.61	0.72	0.61	3.11	1.02
Dublin	0.00	0.80	1.00	1.60	4.40	2.20
Galway	0.29	0.43	0.50	1.00	3.21	0.70
Kerry	0.25	0.60	1.35	0.70	3.90	1.44
Kildare	0.57	0.71	0.86	1.43	4.57	1.88
Kilkenny	0.08	0.48	1.52	1.36	4.44	5.55
Laois	0.22	0.44	1.33	1.44	4.44	2.11
Leitrim	0.00	0.33	1.17	0.67	3.17	1.19
Limerick	0.05	0.33	1.33	1.00	3.71	2.89
Longford	0.50	0.50	3.50	1.00	6.50	1.18
Louth	0.00	0.13	1.00	0.63	2.75	2.75
Mayo	0.27	0.40	0.53	0.20	2.40	0.58
Meath	0.23	0.36	2.27	1.68	5.55	4.36
Monaghan	0.33	0.33	0.67	0.50	2.83	1.42
Offaly	0.23	0.54	1.62	1.62	5.00	3.61
Roscommon	0.00	0.89	0.67	0.44	3.00	1.13
Sligo	0.00	0.29	1.57	0.43	3.29	1.28
Tipperary	0.38	0.38	1.50	0.75	4.00	1.42
Waterford	0.13	0.00	1.00	0.25	2.38	0.86
Westmeath	0.14	0.43	1.14	1.71	4.43	3.65
Wexford	0.20	0.30	1.10	1.30	3.90	1.56
Wicklow	1.40	1.40	2.80	2.00	8.60	2.26
Region						
South-West	0.20	0.54	1.25	1.25	4.23	2.08
Mid-West	0.08	0.55	1.70	0.87	4.19	2.61
West	0.21	0.53	0.55	0.55	2.84	0.72
North-West	0.10	0.50	1.00	0.60	3.20	1.19
Midlands	0.19	0.38	1.53	1.38	4.48	2.65
South	0.21	0.45	1.47	1.08	4.21	2.46
East	0.44	0.63	1.34	1.41	4.81	1.95
Totals (Republic)	0.19	0.50	1.32	1.08	4.09	1.89

APPENDIX 2

Mean size of setts on a county by county basis, as given by the number of entrances.

	All setts				Setts in use			
	Main	Annexe	Subsd.	Outl.	Main	Annexe	Subsd.	Outl.
Carlow								
N	6	1	7	4	5	1	3	2
Mean sett size	**5.2**	**2.0**	**2.7**	**1.7**	**5.2**	**2.0**	**2.3**	**1.0**
s.e.	0.96	0.00	0.52	0.65	1.15	0.00	1.09	0.00
max. no. entrances	10	2	5	4	10	2	5	1
min. no. entrances	3	2	1	1	3	2	1	1
Cavan								
N	6	2	5	7	6	2	5	6
Mean sett size	**9.5**	**4.5**	**3.2**	**1.6**	**9.5**	**4.5**	**3.2**	**1.7**
s.e.	1.35	0.35	0.44	0.28	1.35	0.35	0.44	0.30
max. no. entrances	14	5	5	3	14	5	5	3
min. no. entrances	4	4	2	1	4	4	2	1
Clare								
N	23	21	48	18	21	18	40	9
Mean sett size	**9.9**	**4.4**	**2.8**	**1.4**	**10.3**	**4.4**	**2.9**	**1.4**
s.e.	1.73	0.57	0.29	0.16	1.87	0.61	0.35	0.23
max. no. entrances	44	12	11	3	44	12	11	3
min. no. entrances	4	2	1	1	4	2	1	1
Cork								
N	53	23	54	67	45	17	45	32
Mean sett size	**7.3**	**3.5**	**2.6**	**1.2**	**7.5**	**3.4**	**2.7**	**1.2**
s.e.	0.88	0.42	0.22	0.05	1.03	0.53	0.25	0.06
max. no. entrances	36	10	8	2	36	10	8	2
min. no. entrances	1	1	1	1	1	1	1	1
Donegal								
N	21	11	13	11	18	8	4	4
Mean sett size	**6.4**	**2.3**	**2.4**	**1.6**	**6.5**	**2.0**	**2.3**	**2.0**
s.e.	1.15	0.37	0.23	0.19	1.32	0.47	0.41	0.35
max. no. entrances	23	5	3	3	23	5	3	3
min. no. entrances	1	1	1	1	1	1	1	1
Dublin								
N	5	4	5	8	5	4	3	7
Mean sett size	**6.8**	**2.5**	**2.0**	**1.1**	**6.8**	**2.5**	**1.3**	**1.0**
s.e.	1.61	0.75	0.40	0.12	1.61	0.75	0.27	0.00
max. no. entrances	13	4	3	2	13	4	2	1
min. no. entrances	2	1	1	1	2	1	1	1
Galway								
N	18	6	7	14	14	6	6	9
Mean sett size	**5.9**	**4.5**	**3.3**	**1.5**	**6.7**	**4.5**	**3.5**	**1.4**
s.e.	0.82	0.51	0.48	0.13	0.94	0.51	0.51	0.17
max. no. entrances	18	6	6	2	18	6	6	2
min. no. entrances	1	3	2	1	4	3	2	1

APPENDIX 2 contd.

	All setts				Setts in use			
	Main	**Annexe**	**Subsd.**	**Outl.**	**Main**	**Annexe**	**Subsd.**	**Outl.**
Kerry								
N	25	12	27	14	20	10	11	5
Mean sett size	**8.8**	**7.0**	**4.2**	**1.5**	**9.1**	**7.8**	**5.6**	**1.4**
s.e.	0.82	1.23	0.44	0.17	0.95	1.33	0.83	0.22
max. no. entrances	18	14	12	3	18	14	12	2
min. no. entrances	3	1	1	1	3	1	3	1
Kildare								
N	11	5	6	10	7	2	3	2
Mean sett size	**7.2**	**3.2**	**2.7**	**1.3**	**8.1**	**5.0**	**2.3**	**1.5**
s.e.	1.12	1.11	0.45	0.14	1.60	2.12	0.72	0.35
max. no. entrances	15	8	4	2	15	8	4	2
min. no. entrances	2	1	1	1	2	2	1	1
Kilkenny								
N	27	12	38	34	25	11	34	29
Mean sett size	**7.2**	**4.5**	**3.4**	**1.4**	**7.2**	**4.5**	**3.3**	**1.4**
s.e.	0.65	0.46	0.25	0.11	0.69	0.50	0.27	0.12
max. no. entrances	17	9	7	3	17	9	7	3
min. no. entrances	4	2	1	1	4	2	1	1
Laois								
N	11	4	12	13	9	2	9	9
Mean sett size	**7.6**	**3.5**	**3.2**	**1.3**	**8.3**	**3.0**	**3.2**	**1.3**
s.e.	2.06	0.43	0.39	0.17	2.46	0.71	0.52	0.22
max. no. entrances	29	4	7	3	29	4	7	3
min. no. entrances	4	2	2	1	4	2	2	1
Leitrim								
N	6	2	7	4	6	2	6	2
Mean sett size	**7.5**	**5.0**	**2.3**	**1.3**	**7.5**	**5.0**	**2.2**	**1.0**
s.e.	1.82	2.12	0.33	0.22	1.82	2.12	0.37	0.00
max. no. entrances	16	8	3	2	16	8	3	1
min. no. entrances	2	2	1	1	2	2	1	1
Limerick								
N	22	7	28	21	21	6	25	11
Mean sett size	**4.9**	**3.9**	**2.5**	**1.4**	**4.9**	**3.8**	**2.4**	**1.2**
s.e.	0.38	0.24	0.22	0.13	0.39	0.28	0.24	0.12
max. no. entrances	11	5	5	3	11	5	5	2
min. no. entrances	3	3	1	1	3	3	1	1
Longford								
N	3	1	7	2	2	0	5	1
Mean sett size	**4.0**	**6.0**	**2.3**	**1.5**	**3.5**		**2.0**	**2.0**
s.e.	0.82	0.00	0.56	0.35	1.06		0.69	0.00
max. no. entrances	5	6	5	2	5		5	2
min. no. entrances	2	6	1	1	2		1	2

APPENDIX 2 contd.

	All setts				Setts in use			
	Main	Annexe	Subsd.	Outl.	Main	Annexe	Subsd.	Outl.
Louth								
N	8	1	8	5	8	1	7	4
Mean sett size	**5.4**	**5.0**	**2.5**	**2.2**	**5.4**	**5.0**	**2.4**	**2.3**
s.e.	0.64	0.00	0.18	0.18	0.64	0.00	0.19	0.22
max. no. entrances	9	5	3	3	9	5	3	3
min. no. entrances	3	5	2	2	3	5	2	2
Mayo								
N	19	6	8	3	15	5	4	1
Mean sett size	**6.3**	**3.7**	**3.3**	**1.3**	**6.8**	**3.8**	**3.5**	**2.0**
s.e.	0.65	0.30	0.42	0.27	0.77	0.33	0.43	0.00
max. no. entrances	13	5	5	2	13	5	4	2
min. no. entrances	1	3	1	1	1	3	2	2
Meath								
N	27	8	50	37	22	7	31	21
Mean sett size	**6.5**	**4.9**	**3.8**	**1.5**	**6.9**	**5.0**	**4.4**	**1.5**
s.e.	0.59	1.94	0.50	0.12	0.71	2.21	0.76	0.17
max. no. entrances	16	19	21	4	16	19	21	4
min. no. entrances	2	1	1	1	2	1	1	1
Monaghan								
N	8	2	4	3	6	1	2	3
Mean sett size	**5.9**	**6.0**	**2.5**	**2.0**	**5.7**	**6.0**	**1.5**	**2.0**
s.e.	0.82	0.00	0.56	0.47	1.07	0.00	0.35	0.47
max. no. entrances	11	6	4	3	11	6	2	3
min. no. entrances	3	6	1	1	3	6	1	1
Offaly								
N	16	7	21	21	13	6	12	17
Mean sett size	**6.2**	**3.1**	**3.0**	**1.1**	**6.0**	**3.0**	**2.9**	**1.1**
s.e.	0.48	0.37	0.22	0.08	0.54	0.41	0.28	0.08
max. no. entrances	11	5	5	2	11	5	5	2
min. no. entrances	4	2	1	1	4	2	2	1
Roscommon								
N	9	8	6	4	9	8	5	3
Mean sett size	**8.0**	**4.9**	**2.7**	**1.5**	**8.0**	**4.9**	**2.8**	**1.7**
s.e.	0.94	0.45	0.51	0.25	0.94	0.45	0.59	0.27
max. no. entrances	14	6	5	2	14	6	5	2
min. no. entrances	4	3	1	1	4	3	1	1
Sligo								
N	7	2	11	3	7	2	7	3
Mean sett size	**4.6**	**1.5**	**2.3**	**1.0**	**4.6**	**1.5**	**2.0**	**1.0**
s.e.	1.09	0.35	0.32	0.00	1.09	0.35	0.40	0.00
max. no. entrances	11	2	4	1	11	2	4	1
min. no. entrances	2	1	1	1	2	1	1	1

APPENDIX 2 contd.

		All setts				Setts in use		
	Main	**Annexe**	**Subsd.**	**Outl.**	**Main**	**Annexe**	**Subsd.**	**Outl.**
Tipperary								
N	22	6	24	12	16	4	15	11
Mean sett size	**6.4**	**4.0**	**3.1**	**1.2**	**6.6**	**4.3**	**3.2**	**1.1**
s.e.	0.63	0.33	0.32	0.11	0.79	0.41	0.46	0.09
max. no. entrances	13	5	9	2	13	5	9	2
min. no. entrances	3	3	1	1	3	3	1	1
Waterford								
N	9	0	8	2	8	0	6	2
Mean sett size	**6.3**		**3.1**	**1.0**	**6.5**		**3.2**	**1.0**
s.e.	0.61		0.21	0.00	0.66		0.28	0.00
max. no. entrances	10		4	1	10		4	1
min. no. entrances	4		2	1	4		2	1
Westmeath								
N	16	6	16	24	14	5	10	13
Mean sett size	**7.9**	**3.2**	**2.3**	**1.3**	**8.2**	**3.2**	**2.0**	**1.5**
s.e.	1.11	0.64	0.24	0.25	1.23	0.77	0.24	0.44
max. no. entrances	18	6	4	7	18	6	3	7
min. no. entrances	1	1	1	1	1	1	1	1
Wexford								
N	12	3	11	13	10	2	9	9
Mean sett size	**6.6**	**4.0**	**3.0**	**1.4**	**7.1**	**4.5**	**3.2**	**1.2**
s.e.	1.19	0.47	0.36	0.17	1.37	0.35	0.41	0.21
max. no. entrances	16	5	5	3	16	5	5	3
min. no. entrances	4	3	2	1	4	4	2	1
Wicklow								
N	12	7	14	10	5	6	7	0
Mean sett size	**5.3**	**3.0**	**2.9**	**1.0**	**5.6**	**2.8**	**2.6**	
s.e.	0.49	0.40	0.36	0.00	1.04	0.44	0.60	
max. no. entrances	9	5	6	1	9	5	6	
min. no. entrances	3	2	1	1	3	2	1	

APPENDIX 3

Sett distribution according to soil types observed at sett sites: Ireland.

Soil type	all n	all %	main n	main %	annx. n	annx. %	sbsd. n	sbsd. %	outl. n	outl. %
loam	137	10.01	35	2.56	12	0.88	39	2.85	51	3.73
sand	111	8.11	33	2.41	11	0.80	35	2.56	32	2.34
loamy sand	175	12.79	59	4.31	19	1.39	47	3.44	50	3.65
sandy clay	139	10.16	38	2.78	25	1.83	52	3.80	24	1.75
sandy loam	137	10.01	41	3.00	18	1.32	42	3.07	36	2.63
clay	159	11.62	58	4.24	18	1.32	47	3.44	36	2.63
clay loam	170	12.43	50	3.65	30	2.19	50	3.65	40	2.92
silt	3	0.22	2	0.15	0	0.00	1	0.07	0	0.00
silt clay loam	56	4.09	6	0.44	9	0.66	24	1.75	17	1.24
silt loam	18	1.32	3	0.22	2	0.15	9	0.66	4	0.29
sandy clay loam	72	5.26	21	1.54	8	0.58	23	1.68	20	1.46
sandy silt loam	36	2.63	11	0.80	4	0.29	10	0.73	11	0.80
fibrous peat	93	6.80	28	2.05	7	0.51	28	2.05	30	2.19
partly decomposed peat	43	3.14	5	0.37	2	0.15	30	2.19	6	0.44
amorphous peat	19	1.39	8	0.58	2	0.15	6	0.44	3	0.22
Totals	1368	100.00	398	29.09	167	12.21	443	32.38	360	26.32

APPENDIX 4

Sett distribution according to soil types observed at sett sites: regional results.

soil type

	all		main		annx.		sbsd.		outl.	
	n	%	n	%	n	%	n	%	n	%
south-west										
loam	37	13.55	6	2.20	3	1.10	8	2.93	20	7.33
sand	20	7.33	6	2.20	1	0.37	4	1.47	9	3.30
loamy sand	30	10.99	8	2.93	2	0.73	7	2.56	13	4.76
sandy clay	37	13.55	9	3.30	9	3.30	14	5.13	5	1.83
sandy loam	24	8.79	8	2.93	4	1.47	9	3.30	3	1.10
clay	43	15.75	15	5.49	6	2.20	12	4.40	10	3.66
clay loam	38	13.92	14	5.13	5	1.83	9	3.30	10	3.66
silt	2	0.73	1	0.37	0	0.00	1	0.37	0	0.00
silt clay loam	7	2.56	0	0.00	1	0.37	5	1.83	1	0.37
silt loam	1	0.37	1	0.37	0	0.00	0	0.00	0	0.00
sandy clay loam	9	3.30	2	0.73	2	0.73	5	1.83	0	0.00
sandy silt loam	4	1.47	0	0.00	0	0.00	2	0.73	2	0.73
fibrous peat	16	5.86	5	1.83	2	0.73	3	1.10	6	2.20
partly decom-posed peat	4	1.47	2	0.73	0	0.00	1	0.37	1	0.37
amorphous peat	1	0.37	1	0.37	0	0.00	0	0.00	0	0.00
totals	273	100.00	78	28.57	35	12.82	80	29.30	80	29.30

	all		main		annx.		sbsd.		outl.	
west	n	%	n	%	n	%	n	%	n	%
loam	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
sand	3	2.86	1	0.95	1	0.95	1	0.95	0	0.00
loamy sand	10	9.52	5	4.76	1	0.95	4	3.81	0	0.00
sandy clay	16	15.24	10	9.52	5	4.76	1	0.95	0	0.00
sandy loam	3	2.86	1	0.95	0	0.00	0	0.00	2	1.90
clay	32	30.48	11	10.48	7	6.67	8	7.62	6	5.71
clay loam	19	18.10	10	9.52	4	3.81	3	2.86	2	1.90
silt	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
silt clay loam	6	5.71	1	0.95	1	0.95	2	1.90	2	1.90
silt loam	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
sandy clay loam	1	0.95	1	0.95	0	0.00	0	0.00	0	0.00
sandy silt loam	2	1.90	0	0.00	0	0.00	0	0.00	2	1.90
fibrous peat	6	5.71	3	2.86	0	0.00	0	0.00	3	2.86
partly decom-posed peat	1	0.95	0	0.00	0	0.00	0	0.00	1	0.95
amorphous peat	6	5.71	2	1.90	1	0.95	2	1.90	1	0.95
totals	105	38.46	45	16.48	20	7.33	21	7.69	19	6.96

APPENDIX 4 contd.

	all		main		annx.		sbsd.		outl.	
midlands	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
loam	39	10.74	10	2.75	2	0.55	11	3.03	16	4.41
sand	56	15.43	17	4.68	6	1.65	18	4.96	15	4.13
loamy sand	57	15.70	17	4.68	6	1.65	13	3.58	21	5.79
sandy clay	14	3.86	5	1.38	0	0.00	2	0.55	7	1.93
sandy loam	23	6.34	8	2.20	3	0.83	7	1.93	5	1.38
clay	30	8.26	12	3.31	2	0.55	7	1.93	9	2.48
clay loam	24	6.61	5	1.38	6	1.65	6	1.65	7	1.93
silt	1	0.28	1	0.28	0	0.00	0	0.00	0	0.00
silt clay loam	4	1.10	0	0.00	0	0.00	1	0.28	3	0.83
silt loam	7	1.93	1	0.28	0	0.00	3	0.83	3	0.83
sandy clay loam	12	3.31	3	0.83	1	0.28	2	0.55	6	1.65
sandy silt loam	9	2.48	1	0.28	0	0.00	5	1.38	3	0.83
fibrous peat	51	14.05	13	3.58	3	0.83	21	5.79	14	3.86
partly decomposed peat	35	9.64	2	0.55	2	0.55	28	7.71	3	0.83
amorphous peat	1	0.28	1	0.28	0	0.00	0	0.00	0	0.00
totals	363	132.97	96	35.16	31	11.36	124	45.42	112	41.03

	all		main		annx.		sbsd.		outl.	
east	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
loam	12	7.79	4	2.60	0	0.00	4	2.60	4	2.60
sand	14	9.09	7	4.55	1	0.65	3	1.95	3	1.95
loamy sand	41	26.62	15	9.74	7	4.55	8	5.19	11	7.14
sandy clay	10	6.49	1	0.65	1	0.65	6	3.90	2	1.30
sandy loam	3	1.95	1	0.65	0	0.00	0	0.00	2	1.30
clay	23	14.94	6	3.90	2	1.30	9	5.84	6	3.90
clay loam	23	14.94	6	3.90	4	2.60	8	5.19	5	3.25
silt	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
silt clay loam	5	3.25	1	0.65	1	0.65	1	0.65	2	1.30
silt loam	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
sandy clay loam	14	9.09	4	2.60	2	1.30	3	1.95	5	3.25
sandy silt loam	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
fibrous peat	9	5.84	1	0.65	2	1.30	1	0.65	5	3.25
partly decomposed peat	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
amorphous peat	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
totals	154	56.41	46	16.85	20	7.33	43	15.75	45	16.48

APPENDIX 4 contd.

	all		main		annx.		sbsd.		outl.	
mid-west	n	%	n	%	n	%	n	%	n	%
loam	17	7.69	4	1.81	0	0.00	11	4.98	2	0.90
sand	9	4.07	1	0.45	1	0.45	3	1.36	4	1.81
loamy sand	12	5.43	4	1.81	1	0.45	5	2.26	2	0.90
sandy clay	19	8.60	5	2.26	5	2.26	8	3.62	1	0.45
sandy loam	53	23.98	12	5.43	7	3.17	19	8.60	15	6.79
clay	22	9.95	9	4.07	1	0.45	7	3.17	5	2.26
clay loam	26	11.76	7	3.17	3	1.36	11	4.98	5	2.26
silt	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
silt clay loam	31	14.03	4	1.81	6	2.71	14	6.33	7	3.17
silt loam	8	3.62	1	0.45	2	0.90	4	1.81	1	0.45
sandy clay loam	3	1.36	0	0.00	0	0.00	3	1.36	0	0.00
sandy silt loam	9	4.07	2	0.90	3	1.36	2	0.90	2	0.90
fibrous peat	8	3.62	5	2.26	0	0.00	2	0.90	1	0.45
partly decomposed peat	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
amorphous peat	4	1.81	2	0.90	0	0.00	1	0.45	1	0.45
totals	221	80.95	56	20.51	29	10.62	90	32.97	46	16.85

	all		main		annx.		sbsd.		outl.	
north-west	n	%	n	%	n	%	n	%	n	%
loam	31	32.98	11	11.70	7	7.45	4	4.26	9	9.57
sand	3	3.19	0	0.00	1	1.06	2	2.13	0	0.00
loamy sand	10	10.64	3	3.19	2	2.13	5	5.32	0	0.00
sandy clay	11	11.70	2	2.13	2	2.13	5	5.32	2	2.13
sandy loam	5	5.32	1	1.06	1	1.06	3	3.19	0	0.00
clay	4	4.26	4	4.26	0	0.00	0	0.00	0	0.00
clay loam	9	9.57	1	1.06	0	0.00	5	5.32	3	3.19
silt	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
silt clay loam	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
silt loam	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
sandy clay loam	1	1.06	1	1.06	0	0.00	0	0.00	0	0.00
sandy silt loam	8	8.51	5	5.32	1	1.06	1	1.06	1	1.06
fibrous peat	3	3.19	1	1.06	0	0.00	1	1.06	1	1.06
partly decomposed peat	2	2.13	1	1.06	0	0.00	1	1.06	0	0.00
amorphous peat	7	7.45	2	2.13	1	1.06	3	3.19	1	1.06
totals	94	34.43	32	11.72	15	5.49	30	10.99	17	6.23

APPENDIX 4 contd.

	all		main		annx.		sbsd.		outl.	
south	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
loam	1	0.63	0	0.00	0	0.00	1	0.63	0	0.00
sand	6	3.80	1	0.63	0	0.00	4	2.53	1	0.63
loamy sand	15	9.49	7	4.43	0	0.00	5	3.16	3	1.90
sandy clay	32	20.25	6	3.80	3	1.90	16	10.13	7	4.43
sandy loam	26	16.46	10	6.33	3	1.90	4	2.53	9	5.70
clay	5	3.16	1	0.63	0	0.00	4	2.53	0	0.00
clay loam	31	19.62	7	4.43	8	5.06	8	5.06	8	5.06
silt	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
silt clay loam	3	1.90	0	0.00	0	0.00	1	0.63	2	1.27
silt loam	2	1.27	0	0.00	0	0.00	2	1.27	0	0.00
sandy clay loam	32	20.25	10	6.33	3	1.90	10	6.33	9	5.70
sandy silt loam	4	2.53	3	1.90	0	0.00	0	0.00	1	0.63
fibrous peat	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
partly decomposed peat	1	0.63	0	0.00	0	0.00	0	0.00	1	0.63
amorphous peat	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
totals	158	57.88	45	16.48	17	6.23	55	20.15	41	15.02

APPENDIX 5

Habitat summaries: ***maximum*** *values observed in each of the habitat categories within each region. Means are given in Table 15 in text, and standard errors in the following Appendix.*

		South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
1	Hedgerow length (km)	16.31	19.19	14.98	11.06	22.34	15.74	14.93	**22.34**
2	Treeline length (km)	3.90	2.46	3.46	7.64	7.80	2.93	6.45	**7.80**
2B	Bare treeline length (km)	9.00	0.97	0.53	1.15	1.29	0.00	0.49	**9.00**
3	Semi-natural broad-leaved woodland	31.70	7.30	1.50	25.00	13.60	11.20	6.80	**31.70**
4	Broad-leaved plantation	1.20	4.30	5.80	16.40	22.00	10.30	3.60	**22.00**
5	Semi-natural coniferous woodland	1.20	3.30	5.10	0.20	4.20	0.00	5.30	**5.30**
6	Coniferous plantation	75.70	91.50	46.60	88.50	47.60	64.10	60.20	**91.50**
6Y	Young coniferous plantation	56.10	50.00	98.70	25.20	46.50	36.80	41.10	**98.70**
7	Semi-natural mixed woodland	0.00	2.50	6.90	2.90	2.60	0.00	1.40	**6.90**
8	Mixed plantation	3.40	13.50	0.00	1.20	11.60	6.10	2.60	**13.50**
9	Young mixed or broad-leaved plantation	0.30	5.70	0.00	0.00	0.00	1.10	5.20	**5.70**
10	Recently felled woodland	0.00	2.10	17.90	13.70	7.60	0.00	3.30	**17.90**
11	Parkland	16.70	2.50	0.00	13.60	5.60	0.00	3.60	**16.70**
12A	Tall scrub (area)	6.00	38.50	29.20	9.60	28.60	12.10	3.90	**38.50**
12L	Tall scrub (length km)	5.22	0.47	2.00	2.97	2.96	0.91	0.54	**5.22**
13A	Low scrub (area)	13.90	18.00	17.10	17.40	13.30	24.80	15.30	**24.80**
13L	Low scrub (length km)	6.74	1.45	1.73	9.64	3.52	4.21	10.28	**10.28**
14	Bracken	13.20	41.00	4.90	12.40	3.70	17.50	20.10	**41.00**
15	Coastal sand dunes	0.40	0.00	43.60	62.40	0.00	0.00	17.90	**62.40**
16	Coastal sand or mudflats	92.10	98.20	38.30	19.50	0.00	21.90	74.80	**98.20**
17	Coastal shingle or boulder beaches	5.20	6.70	16.60	14.50	0.00	5.60	7.10	**16.60**
18	Lowland heath	27.60	26.00	14.70	56.40	20.10	0.00	0.00	**56.40**
19	Heather moorland	98.50	97.40	82.60	93.60	27.50	99.90	52.30	**99.90**
20	Blanket bog	98.50	55.10	98.90	87.30	99.70	0.00	96.50	**99.70**
21	Raised bog	68.80	15.30	97.30	29.60	46.60	0.00	42.30	**97.30**
20/21W	Worked peat	0.00	0.00	99.90	24.00	97.40	14.70	93.50	**99.90**
22	Marginal inundations	3.30	9.30	8.00	0.50	17.50	5.50	3.90	**17.50**
23	Coastal marsh	3.30	0.00	5.20	1.30	28.80	45.20	4.30	**45.20**
24	Wet ground	40.40	33.70	40.30	21.60	17.00	40.60	24.40	**40.60**
25	Standing natural water	98.50	52.00	100.00	89.90	51.70	0.80	0.50	**100.00**
26	Standing man-made water	0.10	0.70	0.10	6.70	0.90	1.60	75.20	**75.20**
27A	Running natural water (area)	7.60	20.30	7.50	4.40	22.60	12.80	4.90	**22.60**
27L	Running natural water (length km)	7.70	3.39	3.14	5.15	3.83	3.67	2.93	**7.70**
28A	Running canalised water (area)	1.90	3.20	5.50	1.80	4.50	1.00	1.80	**5.50**
28L	Running canalised water (length km)	10.40	4.91	8.91	6.58	10.03	3.14	5.02	**10.40**
29	Upland unimproved grassland	85.50	91.10	82.00	71.30	97.20	40.50	73.90	**97.20**
30	Lowland unimproved grassland	62.90	64.70	57.60	49.00	87.10	23.30	47.70	**87.10**
31	Semi-improved grassland	86.00	93.80	93.40	74.60	87.90	79.40	45.70	**93.80**
32	Improved grassland	96.00	98.40	97.20	94.00	96.70	98.40	85.30	**98.40**
33 TOT	Arable (total)	92.20	58.40	18.80	55.80	80.20	96.80	72.50	**96.80**

APPENDIX 5 contd.

		South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
33B	Arable (seedcrops)	54.50	45.10	18.80	13.50	80.20	69.40	51.70	**80.20**
33R	Arable (rootcrops)	37.40	11.30	9.50	7.20	20.70	38.30	24.90	**38.30**
33G	Arable (grassland leys)	85.00	10.90	7.70	51.20	32.10	61.60	29.60	**85.00**
33H	Arable (horticultural)	6.20	0.50	0.00	0.00	3.30	9.30	19.20	**19.20**
34	Amenity grasslands	31.00	15.00	22.20	35.80	28.10	12.60	13.40	**35.80**
35	Unquarried inland cliffs	2.40	0.20	98.30	25.60	0.00	0.00	0.00	**98.30**
36	Vertical coastal cliffs	6.20	0.00	7.40	0.70	0.00	0.00	5.80	**7.40**
37	Sloping coastal cliffs	2.10	0.00	0.00	1.60	0.00	4.20	0.00	**4.20**
38	Quarries and open-cast mines	2.60	1.90	20.90	3.60	10.00	12.80	7.50	**20.90**
39	Bare ground	25.50	48.30	46.00	63.40	4.50	3.70	22.70	**63.40**
40	Built land area (excl. roads)	43.60	6.60	11.50	13.60	7.10	7.50	59.90	**59.90**
41A	Roads (area)	4.30	4.20	4.50	3.50	5.20	6.10	4.50	**6.10**
41L	Roads (length km)	5.10	6.15	7.55	5.12	4.74	4.80	8.06	**8.06**
40/41-TOT	Total built land (roads and built land)	46.60	10.00	15.40	16.70	10.60	83.50	74.10	**83.50**
42	Sea	97.80	86.10	96.90	95.50	0.00	57.30	71.10	**97.80**
OTHER	Unspecified	1.30	2.70	3.70	9.50	5.80	1.50	1.70	**9.50**
TOTAL	Total area calculated	100.30	100.40	100.30	100.30	100.30	100.20	100.30	**100.40**
	Principal habitat groups (*n.b.* maxima were only computed for primary groupings)								
	total hedge and treeline (km)	18.98	19.26	15.08	15.71	22.34	16.62	15.37	**22.34**
	total scrub length (km)								
	total hedge, treeline and boundary scrub (km)	18.98	19.26	15.08	15.71	22.34	17.53	15.90	**22.34**
	total hedgerow/treeline area (est. 2.5 m wide)								
	total hedgerow/treeline/scrub area								
	total grasslands (29-32)	99.10	98.60	99.20	95.10	97.20	98.40	91.10	**99.20**
	total grazing and arable (29-33)								
	total woodland (3-9)	84.40	98.20	98.70	88.50	71.60	68.90	60.20	**98.70**
	total peat areas (20,21,20/21W)	99.80	55.10	99.90	87.30	99.70	14.70	96.50	**99.90**
	total peat, moorland and lowland heath								
	hedge density: hedgerow area/area grazing and arable								
	hedge/scrub density: hedge/scrub area/area grazing and arable								

APPENDIX 6

Habitat summaries: ***standard errors*** *for the means of each habitat type, for each region, presented in Table 15 in the text.*

		South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
1	Hedgerow length (km)	0.39	0.56	0.23	0.34	0.37	0.57	0.41	**0.17**
2	Treeline length (km)	0.07	0.04	0.05	0.15	0.14	0.11	0.17	**0.05**
2B	Bare treeline length (km)	0.07	0.01	0.01	0.02	0.02	0.00	0.01	**0.01**
3	Semi-natural broad-leaved woodland	0.26	0.13	0.01	0.32	0.17	0.18	0.16	**0.07**
4	Broad-leaved plantation	0.01	0.07	0.04	0.21	0.18	0.18	0.08	**0.05**
5	Semi-natural coniferous woodland	0.01	0.05	0.03	0.00	0.04	0.00	0.07	**0.01**
6	Coniferous plantation	0.83	2.05	0.51	1.47	0.64	1.17	0.93	**0.39**
6Y	Young coniferous plantation	0.60	0.74	0.76	0.38	0.56	0.77	0.84	**0.26**
7	Semi-natural mixed woodland	0.00	0.03	0.05	0.06	0.03	0.00	0.02	**0.01**
8	Mixed plantation	0.03	0.24	0.00	0.02	0.09	0.11	0.04	**0.04**
9	Young mixed or broad-leaved plantation	0.00	0.07	0.00	0.00	0.00	0.02	0.07	**0.01**
10	Recently felled woodland	0.00	0.03	0.12	0.17	0.06	0.00	0.04	**0.03**
11	Parkland	0.13	0.03	0.00	0.17	0.04	0.00	0.05	**0.03**
12A	Tall scrub (area)	0.10	0.52	0.26	0.21	0.26	0.19	0.09	**0.10**
12L	Tall scrub (length km)	0.04	0.01	0.02	0.06	0.03	0.02	0.01	**0.01**
13A	Low scrub (area)	0.23	0.34	0.18	0.43	0.22	0.55	0.31	**0.11**
13L	Low scrub (length km)	0.11	0.03	0.03	0.19	0.05	0.08	0.14	**0.04**
14	Bracken	0.14	0.50	0.04	0.23	0.05	0.27	0.30	**0.08**
15	Coastal sand dunes	0.00	0.00	0.29	0.77	0.00	0.00	0.23	**0.11**
16	Coastal sand or mudflats	0.72	1.18	0.31	0.24	0.00	0.42	0.94	**0.23**
17	Coastal shingle or boulder beaches	0.08	0.08	0.19	0.26	0.00	0.08	0.11	**0.05**
18	Lowland heath	0.35	0.45	0.10	1.00	0.18	0.00	0.00	**0.15**
19	Heather moorland	1.83	1.29	1.36	2.99	0.24	3.02	0.78	**0.66**
20	Blanket bog	1.54	1.16	2.27	2.52	0.76	0.00	1.44	**0.68**
21	Raised bog	0.65	0.24	1.31	0.41	0.73	0.00	0.54	**0.34**
20/21W	Worked peat	0.00	0.00	0.67	0.29	1.22	0.22	1.18	**0.30**
22	Marginal inundations	0.03	0.12	0.05	0.01	0.15	0.09	0.07	**0.04**
23	Coastal marsh	0.03	0.00	0.04	0.02	0.21	0.68	0.05	**0.07**
24	Wet ground	0.42	0.45	0.46	0.37	0.25	0.66	0.36	**0.16**
25	Standing natural water	0.81	0.71	1.37	1.60	0.54	0.02	0.01	**0.39**
26	Standing man-made water	0.00	0.01	0.00	0.08	0.01	0.02	0.95	**0.10**
27A	Running natural water (area)	0.08	0.33	0.07	0.08	0.18	0.20	0.09	**0.06**
27L	Running natural water (length km)	0.10	0.09	0.07	0.13	0.07	0.09	0.09	**0.04**
28A	Running canalised water (area)	0.02	0.06	0.06	0.03	0.05	0.02	0.04	**0.02**
28L	Running canalised water (length km)	0.13	0.15	0.16	0.14	0.18	0.09	0.12	**0.06**
29	Upland unimproved grassland	1.14	1.72	1.03	1.57	0.78	0.68	1.10	**0.45**
30	Lowland unimproved grassland	1.01	1.57	1.18	1.47	1.37	0.36	0.75	**0.49**
31	Semi-improved grassland	1.37	2.43	1.56	1.78	1.67	1.74	1.23	**0.68**
32	Improved grassland	2.83	3.55	2.25	2.77	2.30	4.19	2.83	**1.14**

APPENDIX 6 contd.

		South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
33 TOT	Arable (total)	1.52	0.92	0.20	0.81	1.35	2.46	2.02	**0.54**
33B	Arable (seedcrops)	0.73	0.69	0.15	0.20	1.05	1.32	1.45	**0.34**
33R	Arable (rootcrops)	0.38	0.22	0.07	0.13	0.21	0.58	0.47	**0.11**
33G	Arable (grassland leys)	1.01	0.16	0.07	0.65	0.41	1.46	0.73	**0.27**
33H	Arable (horticultural)	0.05	0.01	0.00	0.00	0.04	0.24	0.27	**0.04**
34	Amenity grasslands	0.26	0.19	0.15	0.44	0.21	0.22	0.28	**0.10**
35	Unquarried inland cliffs	0.02	0.00	0.66	0.32	0.00	0.00	0.00	**0.14**
36	Vertical coastal cliffs	0.06	0.00	0.05	0.01	0.00	0.00	0.07	**0.02**
37	Sloping coastal cliffs	0.03	0.00	0.00	0.02	0.00	0.06	0.00	**0.01**
38	Quarries and open-cast mines	0.02	0.04	0.14	0.05	0.09	0.20	0.09	**0.04**
39	Bare ground	0.21	0.65	0.68	0.80	0.05	0.08	0.31	**0.19**
40	Built land area (excl. roads)	0.38	0.13	0.12	0.22	0.12	0.15	0.82	**0.12**
41A	Roads (area)	0.09	0.10	0.09	0.12	0.08	0.13	0.13	**0.04**
41L	Roads (length km)	0.12	0.13	0.12	0.15	0.08	0.14	0.15	**0.05**
40/41-TOT	Total built land (roads and built land)	0.56	0.19	0.18	0.30	0.16	1.24	1.31	**0.22**
42	Sea	2.17	1.05	1.54	1.97	0.00	1.22	1.00	**0.59**
OTHER	Unspecified	0.01	0.04	0.02	0.12	0.07	0.04	0.03	**0.02**
TOTAL	Total area calculated (s.e.)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	**0.00**

Principal habitat groups

(*n.b.* standard errors were computed only for primary groupings)

	South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
total hedge and treeline (km)	0.43	0.56	0.26	0.45	0.38	0.60	0.45	**0.18**
total scrub length (km)								
total hedge, treeline and boundary scrub (km)	0.44	0.56	0.27	0.47	0.37	0.61	0.45	**0.18**
total hedgerow/treeline area (est. 2.5 m wide)								
total hedgerow/treeline/scrub area								
total grasslands (29-32)	2.90	3.20	2.87	3.49	2.13	3.89	2.67	**1.18**
total grazing and arable (29-33)								
total woodland (3-9)	1.14	2.25	0.93	1.52	1.05	1.47	1.41	**0.51**
total peat areas (20,21,20/21W)	1.73	1.17	2.52	2.57	1.58	0.22	1.95	**0.80**
total peat, moorland and lowland heath								
hedge density: hedgerow area/area grazing and arable								
hedge/scrub density: hedge/scrub area/area grazing and arable								

APPENDIX 7

Habitat summaries: ***means per km square for each habitat type and principal habitat groupings, for each county. Uncorrected data.***

		Car-low	Cavan	Clare	Cork	Don-egal	Dub-lin	Gal-way
1	Hedgerow length (km)	5.39	7.96	5.38	5.98	1.80	4.41	1.95
2	Treeline length (km)	0.74	1.59	0.20	0.60	0.54	1.37	0.30
2B	Bare treeline length (km)	0.00	0.01	0.00	0.13	0.03	0.00	0.01
3	Semi-natural broad-leaved woodland	0.38	0.36	0.39	0.49	0.77	1.01	0.04
4	Broad-leaved plantation	0.04	0.00	0.14	0.04	0.20	0.00	0.02
5	Semi-natural coniferous woodland	0.00	0.00	0.05	0.00	0.00	0.53	0.02
6	Coniferous plantation	2.42	0.93	6.56	2.99	3.66	0.46	1.70
6Y	Young coniferous plantation	0.15	2.95	2.53	0.66	0.37	0.30	0.28
7	Semi-natural mixed woodland	0.13	0.00	0.11	0.00	0.07	0.00	0.00
8	Mixed plantation	0.00	0.00	0.49	0.04	0.01	0.00	0.00
9	Young mixed or broad-leaved plantation	0.18	0.00	0.16	0.00	0.00	0.00	0.00
10	Recently felled woodland	0.00	0.00	0.00	0.00	0.00	0.00	0.28
11	Parkland	0.00	0.00	0.01	0.21	0.00	0.53	0.00
12A	Tall scrub (area)	0.06	0.83	2.58	0.39	0.92	0.02	1.31
12L	Tall scrub (length km)	0.00	0.00	0.04	0.06	0.08	0.03	0.02
13A	Low scrub (area)	2.29	2.37	1.63	2.09	2.55	1.79	1.58
13L	Low scrub (length km)	0.80	0.09	0.06	0.34	1.01	0.25	0.25
14	Bracken	1.64	0.18	0.78	0.28	0.78	0.63	0.04
15	Coastal sand dunes	0.00	0.00	0.00	0.00	1.13	0.00	0.00
16	Coastal sand or mudflats	0.00	0.00	2.73	1.54	0.00	7.59	0.00
17	Coastal shingle or boulder beaches	0.00	0.00	0.23	0.30	1.07	0.71	0.32
18	Lowland heath	0.00	0.16	1.42	0.62	0.79	0.00	0.34
19	Heather moorland	0.78	0.73	2.32	1.01	18.74	0.00	7.57
20	Blanket bog	0.00	6.57	6.43	4.49	14.62	0.00	5.75
21	Raised bog	0.00	0.84	0.20	0.00	0.58	0.00	4.83
20/21W	Worked peat	0.00	0.00	0.00	0.00	0.44	0.00	1.64
22	Marginal inundations	0.00	0.38	0.40	0.05	0.01	0.00	0.02
23	Coastal marsh	0.00	0.00	0.00	0.09	0.02	0.43	0.00
24	Wet ground	1.91	2.68	1.86	2.03	1.41	0.46	1.39
25	Standing natural water	0.03	5.35	1.46	0.03	1.73	0.02	5.76
26	Standing man-made water	0.00	0.00	0.00	0.00	0.00	0.12	0.00
27A	Running natural water (area)	0.90	0.71	0.95	0.35	0.44	0.26	0.24
27L	Running natural water (length km)	0.75	1.06	0.70	0.85	1.45	0.51	0.40
28A	Running canalised water (area)	0.25	0.21	0.44	0.04	0.10	0.51	0.53
28L	Running canalised water (length km)	1.26	1.63	1.44	0.50	0.85	1.31	1.32
29	Upland unimproved grassland	1.35	1.88	4.99	1.16	5.60	7.39	6.80
30	Lowland unimproved grassland	2.49	17.24	14.94	2.93	5.64	4.17	6.62
31	Semi-improved grassland	11.77	23.92	17.39	8.22	10.21	4.95	15.12
32	Improved grassland	36.42	27.09	21.81	42.77	11.53	18.54	25.47
33 TOT	Arable (total)	31.29	1.36	0.09	13.36	3.05	18.96	0.80
33B	Arable (seedcrops)	12.89	0.00	0.00	5.39	0.80	12.41	0.30
33R	Arable (rootcrops)	6.44	0.00	0.09	2.23	0.51	0.00	0.13
33G	Arable (grassland leys)	5.36	0.17	0.00	4.58	1.54	2.40	0.12
33H	Arable (horticultural)	0.95	0.00	0.00	0.17	0.00	2.20	0.00

APPENDIX 7 contd.

		Car-low	Cavan	Clare	Cork	Don-egal	Dub-lin	Gal-way
34	Amenity grasslands	0.64	0.18	0.00	0.63	0.68	4.20	0.06
35	Unquarried inland cliffs	0.00	0.00	0.01	0.00	0.48	0.00	0.00
36	Vertical coastal cliffs	0.00	0.00	0.00	0.03	0.01	0.04	0.00
37	Sloping coastal cliffs	0.00	0.00	0.00	0.10	0.05	0.00	0.00
38	Quarries and open-cast mines	0.94	0.00	0.11	0.04	0.01	0.04	0.37
39	Bare ground	0.06	0.00	2.36	0.57	1.48	0.18	3.75
40	Built land area (excl. roads)	1.94	1.23	0.58	2.23	1.14	10.70	0.96
41A	Roads (area)	1.97	1.66	1.54	1.63	1.42	2.37	1.04
41L	Roads (length km)	2.28	2.43	2.25	2.28	1.93	2.85	1.43
40/41-TOT	Total built land (roads and built land)	3.91	2.89	2.12	4.38	2.56	19.04	2.00
42	Sea	0.00	0.00	2.39	8.04	8.25	7.11	5.31
OTHER	Unspecified	0.00	0.24	0.01	0.04	0.03	0.04	0.07
TOTAL	Total area calculated (mean)	100.01	100.03	100.06	100.01	100.02	100.03	100.04
	Principal habitat groups							
	Means per km square							
	total hedge and treeline (km)	6.13	9.56	5.57	6.71	2.37	5.78	2.26
	total scrub length (km)	0.80	0.09	0.10	0.40	1.08	0.27	0.27
	total hedge, treeline and boundary scrub (km)	6.93	9.64	5.67	7.11	3.45	6.05	2.52
	total hedgerow/treeline area (est. 2.5 m wide)	1.53	2.39	1.39	1.68	0.59	1.45	0.56
	total hedgerow/treeline/scrub area	3.88	5.60	5.60	4.15	4.06	3.26	3.46
	total grasslands (29-32)	52.04	70.12	59.13	55.08	32.98	35.05	54.01
	total grazing and arable (29-33)	83.33	71.47	59.21	68.44	36.03	54.01	54.81
	total woodland (3-9)	3.29	4.24	10.43	4.23	5.09	2.30	2.07
	total peat areas (20,21,20/21W)	0.00	7.41	6.62	4.49	15.64	0.00	12.22
	total peat, moorland and lowland heath	0.78	8.30	10.36	6.11	35.17	0.00	20.13
	hedge density: hedgerow area/area grazing and arable	0.0184	0.0334	0.0235	0.0245	0.0164	0.0268	0.0103
	hedge/scrub density: hedge/scrub area/area grazing and arable	0.0466	0.0783	0.0946	0.0607	0.1126	0.0603	0.0631

APPENDIX 7 contd.

		Kerry	Kild-are	Kilk-enny	Laois	Leit-rim	Lime-rick	Long-ford
1	Hedgerow length (km)	2.34	3.26	9.97	6.97	5.63	7.44	5.84
2	Treeline length (km)	0.35	2.53	0.99	0.72	1.43	0.20	1.02
2B	Bare treeline length (km)	0.17	0.03	0.00	0.00	0.03	0.00	0.06
3	Semi-natural broad-leaved woodland	0.70	0.73	0.56	0.20	0.99	0.30	1.13
4	Broad-leaved plantation	0.04	0.37	0.97	0.00	0.13	0.00	0.05
5	Semi-natural coniferous woodland	0.02	0.00	0.00	0.00	0.00	0.08	0.00
6	Coniferous plantation	1.84	0.99	1.09	3.34	7.60	7.91	1.64
6Y	Young coniferous plantation	3.27	4.05	1.27	2.27	0.59	1.43	0.49
7	Semi-natural mixed woodland	0.00	0.00	0.00	0.04	0.04	0.00	0.00
8	Mixed plantation	0.00	0.12	0.40	0.21	0.00	0.76	0.00
9	Young mixed or broad-leaved plantation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Recently felled woodland	0.00	0.21	0.00	0.00	0.86	0.00	0.00
11	Parkland	0.00	0.00	0.00	0.00	0.06	0.00	0.51
12A	Tall scrub (area)	0.46	0.12	0.31	1.78	0.66	0.34	3.04
12L	Tall scrub (length km)	0.16	0.00	0.12	0.13	0.27	0.00	0.27
13A	Low scrub (area)	1.44	1.11	2.92	1.98	1.63	1.39	1.01
13L	Low scrub (length km)	0.86	0.03	0.40	0.16	0.16	0.03	0.14
14	Bracken	0.65	0.00	0.18	0.02	0.00	1.54	0.00
15	Coastal sand dunes	0.01	0.00	0.00	0.00	0.00	0.00	0.00
16	Coastal sand or mudflats	0.41	0.00	0.00	0.00	0.00	0.17	0.00
17	Coastal shingle or boulder beaches	0.16	0.00	0.00	0.00	0.00	0.00	0.00
18	Lowland heath	1.09	0.00	0.00	0.21	0.00	0.60	0.00
19	Heather moorland	17.86	0.00	4.20	2.43	6.62	0.00	0.00
20	Blanket bog	8.27	0.00	0.00	2.36	0.76	0.27	0.00
21	Raised bog	2.31	3.28	0.00	2.19	0.61	0.23	13.06
20/21W	Worked peat	0.00	6.60	0.00	0.66	0.00	0.00	0.00
22	Marginal inundations	0.01	0.22	0.08	0.00	0.00	0.00	0.00
23	Coastal marsh	0.01	0.00	0.00	0.00	0.00	0.00	0.00
24	Wet ground	0.36	0.30	0.47	1.37	0.05	0.10	1.15
25	Standing natural water	2.62	0.02	0.03	0.02	1.80	0.02	3.61
26	Standing man-made water	0.00	0.03	0.01	0.03	0.00	0.00	0.00
27A	Running natural water (area)	0.40	0.05	0.89	0.23	0.98	0.26	0.40
27L	Running natural water (length km)	1.12	0.21	0.53	0.41	1.50	0.61	0.13
28A	Running canalised water (area)	0.13	0.42	0.08	0.24	0.27	0.23	0.85
28L	Running canalised water (length km)	0.88	1.34	0.45	2.73	0.87	0.92	3.19
29	Upland unimproved grassland	6.66	0.02	0.00	1.22	14.18	7.30	0.00
30	Lowland unimproved grassland	9.33	5.97	1.17	6.98	31.91	4.91	18.38
31	Semi-improved grassland	11.73	8.92	1.18	20.73	15.05	19.96	36.10
32	Improved grassland	15.68	45.09	73.81	32.12	12.16	48.51	13.07
33 TOT	Arable (total)	3.49	13.97	6.58	15.78	0.02	0.61	1.55
33B	Arable (seedcrops)	0.16	7.33	3.93	9.74	0.00	0.34	0.95
33R	Arable (rootcrops)	0.03	1.21	0.08	1.59	0.02	0.00	0.00
33G	Arable (grassland leys)	2.86	4.03	0.19	0.86	0.00	0.01	0.00
33H	Arable (horticultural)	0.00	0.22	0.00	0.00	0.00	0.02	0.00

APPENDIX 7 contd.

		Kerry	Kild-are	Kilk-enny	Laois	Leit-rim	Lime-rick	Long-ford
34	Amenity grasslands	0.02	0.33	0.00	0.26	0.00	0.00	0.47
35	Unquarried inland cliffs	0.04	0.00	0.00	0.00	0.29	0.00	0.00
36	Vertical coastal cliffs	0.26	0.00	0.00	0.00	0.00	0.00	0.00
37	Sloping coastal cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	Quarries and open-cast mines	0.02	0.00	0.34	0.09	0.23	0.04	0.00
39	Bare ground	0.17	0.00	0.04	0.09	0.09	0.00	0.00
40	Built land area (excl. roads)	0.81	2.75	1.64	1.28	0.96	0.84	1.32
41A	Roads (area)	1.01	1.68	1.82	1.56	1.51	1.57	1.62
41L	Roads (length km)	1.68	1.85	2.23	1.88	1.94	1.97	2.02
40/41-TOT	Total built land (roads and built land)	2.58	6.99	3.47	2.88	2.46	2.41	2.94
42	Sea	7.98	0.00	0.00	0.00	0.00	0.64	0.00
OTHER	Unspecified	0.04	0.14	0.02	0.26	0.00	0.01	0.50
TOTAL	Total area calculated (mean)	100.05	100.02	100.01	100.01	100.01	100.04	99.96
	Principal habitat groups							
	Means per km square							
	total hedge and treeline (km)	2.86	5.82	10.96	7.70	7.09	7.63	6.92
	total scrub length (km)	1.02	0.03	0.52	0.29	0.44	0.03	0.42
	total hedge, treeline and boundary scrub (km)	3.87	5.85	11.47	7.98	7.53	7.66	7.34
	total hedgerow/treeline area (est. 2.5 m wide)	0.71	1.46	2.74	1.92	1.77	1.91	1.73
	total hedgerow/treeline/scrub area	2.62	2.69	5.97	5.69	4.05	3.64	5.78
	total grasslands (29-32)	43.41	60.00	76.15	61.06	73.29	80.68	67.55
	total grazing and arable (29-33)	46.90	73.97	82.74	76.83	73.31	81.29	69.11
	total woodland (3-9)	5.86	6.25	4.27	6.07	9.36	10.49	3.31
	total peat areas (20,21,20/21W)	10.59	9.88	0.00	5.21	1.37	0.51	13.06
	total peat, moorland and lowland heath	29.53	9.88	4.20	7.86	7.99	1.11	13.06
	hedge density: hedgerow area/area grazing and arable	0.0152	0.0197	0.0331	0.0250	0.0242	0.0235	0.0250
	hedge/scrub density: hedge/scrub area/area grazing and arable	0.0559	0.0363	0.0722	0.0740	0.0553	0.0448	0.0836

APPENDIX 7 contd.

		Louth	Mayo	Meath	Mon-aghan	Offaly	Rosco mmon	Sligo
1	Hedgerow length (km)	8.03	1.18	6.67	8.87	4.42	3.60	3.85
2	Treeline length (km)	0.66	0.23	2.65	1.26	1.59	0.86	0.79
2B	Bare treeline length (km)	0.00	0.01	0.11	0.00	0.00	0.03	0.06
3	Semi-natural broad-leaved woodland	0.33	0.00	0.25	0.02	0.56	0.03	0.27
4	Broad-leaved plantation	0.25	0.01	0.34	2.44	0.47	0.37	0.91
5	Semi-natural coniferous woodland	0.00	0.00	0.02	0.58	0.00	0.23	0.00
6	Coniferous plantation	5.95	0.95	0.33	2.98	3.23	1.92	2.74
6Y	Young coniferous plantation	0.09	2.77	0.35	0.31	4.81	1.18	2.86
7	Semi-natural mixed woodland	0.00	0.00	0.18	0.13	0.09	0.29	0.29
8	Mixed plantation	0.00	0.00	0.03	0.97	0.27	0.00	0.09
9	Young mixed or broad-leaved plantation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Recently felled woodland	0.00	0.00	0.00	0.34	0.08	0.00	0.00
11	Parkland	0.00	0.00	0.02	0.00	0.00	0.00	0.76
12A	Tall scrub (area)	1.15	0.10	0.37	0.18	0.56	0.74	0.82
12L	Tall scrub (length km)	0.15	0.01	0.06	0.00	0.14	0.17	0.43
13A	Low scrub (area)	0.45	1.03	0.33	0.00	2.73	1.10	1.47
13L	Low scrub (length km)	0.09	0.12	0.20	0.00	0.64	0.22	0.58
14	Bracken	0.00	0.09	0.13	0.48	0.07	0.06	0.05
15	Coastal sand dunes	0.00	0.84	0.00	0.00	0.00	0.00	0.00
16	Coastal sand or mudflats	0.00	1.29	0.00	0.00	0.00	0.00	1.08
17	Coastal shingle or boulder beaches	0.00	0.72	0.00	0.00	0.00	0.00	0.00
18	Lowland heath	0.00	0.00	0.00	2.06	0.90	0.01	7.88
19	Heather moorland	0.00	7.69	0.00	0.40	0.04	0.00	8.96
20	Blanket bog	0.00	22.91	0.00	0.00	0.43	4.22	1.14
21	Raised bog	0.00	4.39	1.63	0.00	3.14	5.17	1.03
20/21W	Worked peat	0.00	0.10	0.02	0.00	14.24	0.00	0.00
22	Marginal inundations	0.00	0.13	0.37	0.00	1.31	0.07	0.03
23	Coastal marsh	3.60	0.13	0.00	0.00	0.00	0.00	0.00
24	Wet ground	2.26	1.10	0.34	4.07	0.65	2.18	0.59
25	Standing natural water	0.03	2.91	0.01	2.19	1.20	5.63	9.78
26	Standing man-made water	0.00	0.00	0.04	0.00	0.08	0.00	0.37
27A	Running natural water (area)	0.19	0.47	0.36	0.32	1.51	0.59	0.39
27L	Running natural water (length km)	0.64	0.99	0.35	0.84	0.52	0.52	0.73
28A	Running canalised water (area)	0.20	0.20	0.71	0.13	0.57	0.67	0.34
28L	Running canalised water (length km)	2.42	0.81	2.36	1.80	2.93	2.45	1.13
29	Upland unimproved grassland	0.00	1.31	0.00	2.73	0.83	0.00	4.37
30	Lowland unimproved grassland	7.01	10.40	4.08	11.73	9.28	16.60	6.31
31	Semi-improved grassland	16.67	11.43	14.45	35.76	15.07	24.21	14.03
32	Improved grassland	29.87	15.97	55.91	24.02	24.28	28.41	29.83
33 TOT	Arable (total)	27.71	0.42	15.67	3.08	7.40	1.72	0.00
33B	Arable (seedcrops)	22.88	0.06	11.07	0.08	3.34	1.04	0.00
33R	Arable (rootcrops)	4.14	0.03	0.55	0.00	1.02	0.52	0.00
33G	Arable (grassland leys)	0.00	0.15	2.32	1.08	1.50	0.11	0.00
33H	Arable (horticultural)	0.00	0.00	0.15	0.00	0.18	0.00	0.00

APPENDIX 7 contd.

		Louth	Mayo	Meath	Mon-aghan	Offaly	Rosco mmon	Sligo
34	Amenity grasslands	0.34	0.07	0.06	0.48	1.80	1.06	0.13
35	Unquarried inland cliffs	0.00	1.81	0.00	0.00	0.00	0.18	0.00
36	Vertical coastal cliffs	0.00	0.13	0.00	0.00	0.00	0.14	0.00
37	Sloping coastal cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	Quarries and open-cast mines	0.00	0.00	0.04	0.62	0.56	0.00	0.03
39	Bare ground	0.00	1.50	0.12	0.38	0.05	0.03	0.00
40	Built land area (excl. roads)	2.14	0.75	2.10	1.09	1.67	1.46	1.23
41A	Roads (area)	1.56	1.15	1.60	1.98	1.83	1.78	1.44
41L	Roads (length km)	1.89	1.75	1.75	2.70	2.08	2.42	1.84
40/41-TOT	Total built land (roads and built land)	3.70	1.90	3.70	3.08	3.51	3.24	2.67
42	Sea	0.00	7.27	0.00	0.00	0.00	0.00	0.00
OTHER	Unspecified	0.30	0.00	0.15	0.53	0.32	0.00	0.77
TOTAL	Total area calculated (mean)	100.10	100.02	100.00	100.05	100.04	100.02	100.01
	Principal habitat groups							
	Means per km square							
	total hedge and treeline (km)	8.69	1.42	9.42	10.12	6.01	4.49	4.71
	total scrub length (km)	0.24	0.13	0.26	0.00	0.78	0.39	1.01
	total hedge, treeline and boundary scrub (km)	8.93	1.55	9.68	10.12	6.79	4.88	5.72
	total hedgerow/treeline area (est. 2.5 m wide)	2.17	0.35	2.36	2.53	1.50	1.12	1.18
	total hedgerow/treeline/scrub area	3.77	1.49	3.05	2.71	4.79	2.96	3.47
	total grasslands (29-32)	53.56	39.10	74.43	74.23	49.47	69.22	54.53
	total grazing and arable (29-33)	81.28	39.53	90.10	77.31	56.87	70.94	54.53
	total woodland (3-9)	6.61	3.73	1.49	7.42	9.43	4.01	7.17
	total peat areas (20,21,20/21W)	0.00	27.40	1.65	0.00	17.82	9.38	2.18
	total peat, moorland and lowland heath	0.00	35.09	1.65	2.46	18.76	9.39	19.02
	hedge density: hedgerow area/area grazing and arable	0.0267	0.0090	0.0261	0.0327	0.0264	0.0158	0.0216
	hedge/scrub density: hedge/scrub area/area grazing and arable	0.0464	0.0376	0.0339	0.0351	0.0843	0.0417	0.0637

APPENDIX 7 contd.

		Tipperary	Waterford	Westmeath	Wexford	Wicklow
1	Hedgerow length (km)	8.16	7.86	4.40	7.88	3.96
2	Treeline length (km)	0.59	0.55	1.61	1.54	0.72
2B	Bare treeline length (km)	0.02	0.00	0.32	0.01	0.02
3	Semi-natural broad-leaved woodland	0.22	0.15	1.78	0.47	0.45
4	Broad-leaved plantation	0.20	0.28	0.33	0.31	0.17
5	Semi-natural coniferous woodland	0.07	0.00	0.23	0.00	0.00
6	Coniferous plantation	3.34	2.04	4.06	3.62	5.45
6Y	Young coniferous plantation	1.73	0.19	1.97	0.34	4.95
7	Semi-natural mixed woodland	0.00	0.00	0.06	0.10	0.00
8	Mixed plantation	0.07	0.00	0.00	0.13	0.09
9	Young mixed or broad-leaved plantation	0.00	0.05	0.00	0.00	0.26
10	Recently felled woodland	0.05	0.00	0.48	0.00	0.00
11	Parkland	0.06	0.00	0.00	0.00	0.00
12A	Tall scrub (area)	0.66	0.16	0.72	0.46	0.47
12L	Tall scrub (length km)	0.03	0.02	0.14	0.06	0.01
13A	Low scrub (area)	0.97	3.70	1.60	1.78	1.25
13L	Low scrub (length km)	0.12	0.24	0.54	0.49	0.92
14	Bracken	0.09	0.84	0.08	1.13	0.13
15	Coastal sand dunes	0.00	0.00	0.00	0.00	0.90
16	Coastal sand or mudflats	0.00	2.12	0.00	0.00	0.00
17	Coastal shingle or boulder beaches	0.00	0.25	0.00	0.00	0.25
18	Lowland heath	0.27	0.00	0.00	0.00	0.00
19	Heather moorland	9.00	6.30	0.00	0.00	4.68
20	Blanket bog	0.35	0.00	0.00	0.00	10.46
21	Raised bog	0.57	0.00	2.80	0.00	0.00
20/21W	Worked peat	0.33	0.00	6.24	0.00	0.00
22	Marginal inundations	0.07	0.33	0.00	0.00	0.20
23	Coastal marsh	0.00	2.07	0.00	0.00	0.00
24	Wet ground	1.91	0.79	1.05	0.51	2.47
25	Standing natural water	1.19	0.00	0.22	0.02	0.04
26	Standing man-made water	0.06	0.00	0.00	0.18	3.78
27A	Running natural water (area)	0.68	0.15	0.02	0.26	0.72
27L	Running natural water (length km)	0.54	0.51	0.04	0.61	1.03
28A	Running canalised water (area)	0.25	0.10	0.93	0.18	0.13
28L	Running canalised water (length km)	0.89	0.22	3.59	0.49	0.74
29	Upland unimproved grassland	1.19	2.37	0.00	0.90	4.10
30	Lowland unimproved grassland	2.59	0.54	11.32	0.69	1.75
31	Semi-improved grassland	10.45	12.47	22.43	4.38	9.37
32	Improved grassland	45.76	43.32	32.57	55.48	32.93
33 TOT	Arable (total)	14.21	7.21	6.73	22.14	7.29
33B	Arable (seedcrops)	7.58	1.86	2.70	11.25	4.27
33R	Arable (rootcrops)	1.81	0.45	0.69	2.70	0.93
33G	Arable (grassland leys)	4.20	2.67	2.71	2.60	0.09
33H	Arable (horticultural)	0.05	1.79	0.13	0.17	0.00

APPENDIX 7 contd.

		Tipp-erary	Wate-rford	West-meath	Wex-ford	Wick-low
34	Amenity grasslands	0.44	0.97	0.08	0.59	0.23
35	Unquarried inland cliffs	0.00	0.00	0.00	0.00	0.00
36	Vertical coastal cliffs	0.00	0.00	0.00	0.00	0.29
37	Sloping coastal cliffs	0.00	0.19	0.00	0.00	0.00
38	Quarries and open-cast mines	0.43	0.00	0.00	0.00	0.00
39	Bare ground	0.03	0.33	0.22	0.00	1.79
40	Built land area (excl. roads)	1.11	0.69	2.43	3.94	1.68
41A	Roads (area)	1.46	1.78	1.69	2.21	1.10
41L	Roads (length km)	1.79	2.33	1.93	2.46	1.31
40/41 TOT	Total built land (roads and built land)	2.57	6.54	4.12	6.15	2.78
42	Sea	0.00	6.47	0.00	0.00	2.65
OTHER	Unspecified	0.22	0.07	0.00	0.18	0.06
TOTAL	Total area calculated (mean)	100.03	100.00	100.06	100.00	100.01
	Principal habitat groups					
	Means per km square					
	total hedge and treeline (km)	8.77	8.40	6.32	9.43	4.71
	total scrub length (km)	0.15	0.26	0.68	0.55	0.93
	total hedge, treeline and boundary scrub (km)	8.91	8.66	7.01	9.98	5.64
	total hedgerow/treeline area (est. 2.5 m wide)	2.19	2.10	1.58	2.36	1.18
	total hedgerow/treeline/scrub area	3.82	5.96	3.90	4.60	2.90
	total grasslands (29-32)	59.99	58.70	66.31	61.46	48.14
	total grazing and arable (29-33)	74.20	65.91	73.04	83.60	55.42
	total woodland (3-9)	5.64	2.71	8.44	4.96	11.36
	total peat areas (20,21,20/21W)	1.24	0.00	9.04	0.00	10.46
	total peat, moorland and lowland heath	10.51	6.30	9.04	0.00	15.14
	hedge density: hedgerow area/area grazing and arable	0.0295	0.0319	0.0216	0.0282	0.0212
	hedge/scrub density: hedge/scrub area/area grazing and arable	0.0515	0.0904	0.0534	0.0550	0.0523

APPENDIX 8

Habitat summaries: ***means*** *per km square for each habitat type and principal habitat groupings, for each county.* ***Data corrected for sea, lake and beach areas..***

		Car-low	Cavan	Clare	Cork	Don-egal	Dub-lin	Gal-way
1	Hedgerow length (km)	5.39	8.41	5.77	6.63	2.02	5.22	2.20
2	Treeline length (km)	0.74	1.68	0.21	0.67	0.60	1.62	0.34
2B	Bare treeline length (km)	0.00	0.01	0.00	0.14	0.03	0.00	0.01
3	Semi-natural broad-leaved woodland	0.38	0.38	0.42	0.54	0.86	1.20	0.05
4	Broad-leaved plantation	0.04	0.00	0.15	0.05	0.23	0.00	0.02
5	Semi-natural coniferous woodland	0.00	0.00	0.05	0.00	0.00	0.63	0.02
6	Coniferous plantation	2.43	0.98	7.04	3.32	4.12	0.54	1.92
6Y	Young coniferous plantation	0.15	3.12	2.72	0.73	0.42	0.36	0.32
7	Semi-natural mixed woodland	0.13	0.00	0.12	0.00	0.08	0.00	0.00
8	Mixed plantation	0.00	0.00	0.52	0.05	0.01	0.00	0.00
9	Young mixed or broad-leaved plantation	0.18	0.00	0.17	0.00	0.00	0.00	0.00
10	Recently felled woodland	0.00	0.00	0.00	0.00	0.00	0.00	0.32
11	Parkland	0.00	0.00	0.01	0.24	0.00	0.63	0.00
12A	Tall scrub (area)	0.06	0.88	2.77	0.43	1.03	0.02	1.48
12L	Tall scrub (length km)	0.00	0.00	0.04	0.06	0.08	0.03	0.02
13A	Low scrub (area)	2.29	2.51	1.75	2.32	2.86	2.12	1.78
13L	Low scrub (length km)	0.80	0.09	0.07	0.38	1.13	0.29	0.28
14	Bracken	1.64	0.19	0.83	0.31	0.88	0.75	0.05
15	Coastal sand dunes	0.00	0.00	0.00	0.00	1.28	0.00	0.00
16	Coastal sand or mudflats							
17	Coastal shingle or boulder beaches							
18	Lowland heath	0.00	0.17	1.53	0.68	0.89	0.00	0.38
19	Heather moorland	0.78	0.77	2.49	1.12	21.06	0.00	8.54
20	Blanket bog	0.00	6.94	6.89	4.98	16.44	0.00	6.49
21	Raised bog	0.00	0.89	0.21	0.00	0.66	0.00	5.45
20/21W	Worked peat	0.00	0.00	0.00	0.00	0.49	0.00	1.85
22	Marginal inundations	0.00	0.40	0.43	0.06	0.01	0.00	0.02
23	Coastal marsh	0.00	0.00	0.00	0.10	0.03	0.51	0.00
24	Wet ground	1.91	2.83	2.00	2.25	1.59	0.54	1.57
25	Standing natural water							
26	Standing man-made water							
27A	Running natural water (area)	0.90	0.75	1.02	0.39	0.50	0.31	0.27
27L	Running natural water (length km)	0.75	1.12	0.75	0.94	1.63	0.61	0.45
28A	Running canalised water (area)	0.25	0.22	0.47	0.05	0.11	0.60	0.59
28L	Running canalised water (length km)	1.26	1.72	1.55	0.55	0.96	1.55	1.49
29	Upland unimproved grassland	1.35	1.98	5.35	1.29	6.30	8.75	7.67
30	Lowland unimproved grassland	2.49	18.21	16.03	3.25	6.34	4.94	7.47
31	Semi-improved grassland	11.78	25.27	18.66	9.13	11.48	5.86	17.07
32	Improved grassland	36.43	28.62	23.40	47.48	12.96	21.95	28.75
33 TOT	Arable (total)	31.30	1.43	0.10	14.83	3.43	22.45	0.90
33B	Arable (seedcrops)	12.89	0.00	0.00	5.98	0.90	14.69	0.33
33R	Arable (rootcrops)	6.44	0.00	0.10	2.47	0.58	0.00	0.14
33G	Arable (grassland leys)	5.36	0.18	0.00	5.09	1.73	2.84	0.14
33H	Arable (horticultural)	0.95	0.00	0.00	0.19	0.00	2.60	0.00

APPENDIX 8 contd.

		Car-low	Cavan	Clare	Cork	Don-egal	Dub-lin	Gal-way
34	Amenity grasslands	0.64	0.18	0.00	0.70	0.76	4.97	0.06
35	Unquarried inland cliffs	0.00	0.00	0.01	0.00	0.54	0.00	0.00
36	Vertical coastal cliffs	0.00	0.00	0.00	0.03	0.01	0.05	0.00
37	Sloping coastal cliffs	0.00	0.00	0.00	0.12	0.06	0.00	0.00
38	Quarries and open-cast mines	0.94	0.00	0.12	0.04	0.01	0.05	0.42
39	Bare ground	0.06	0.00	2.53	0.64	1.67	0.21	4.23
40	Built land area (excl. roads)	1.94	1.30	0.62	2.48	1.28	12.67	1.09
41A	Roads (area)	1.98	1.76	1.65	1.81	1.60	2.81	1.17
41L	Roads (length km)	2.28	2.56	2.41	2.53	2.17	3.37	1.61
40/41 TOT	Total built land (roads and built land)	3.91	3.06	2.27	4.86	2.88	22.54	2.26
42	Sea							
OTHER	Unspecified	0.00	0.25	0.01	0.04	0.04	0.05	0.08
TOTAL	Total area calculated (mean)	100.01	100.03	100.06	100.01	100.02	100.03	100.04

Principal habitat groups

	Car-low	Cavan	Clare	Cork	Don-egal	Dub-lin	Gal-way
total hedge and treeline (km)	6.13	10.10	5.98	7.45	2.66	6.85	2.55
total scrub length (km)	0.80	0.09	0.11	0.44	1.22	0.32	0.30
total hedge, treeline and boundary scrub (km)	6.93	10.19	6.09	7.89	3.87	7.17	2.85
total hedgerow/treeline area (est. 2.5 m wide)	1.53	2.52	1.50	1.86	0.66	1.71	0.64
total hedgerow/treeline/scrub area	3.88	5.91	6.01	4.61	4.56	3.85	3.90
total grasslands (29-32)	52.05	74.08	63.44	61.14	37.08	41.50	60.96
total grazing and arable (29-33)	83.35	75.51	63.54	75.97	40.51	63.95	61.85
total woodland (3-9)	3.29	4.48	11.19	4.69	5.73	2.72	2.33
total peat areas (20,21,20/21W)	0.00	7.83	7.11	4.98	17.58	0.00	13.79
total peat, moorland and lowland heath	0.78	8.77	11.12	6.78	39.54	0.00	22.71
hedge density: hedgerow area/area grazing and arable	0.0184	0.0334	0.0235	0.0245	0.0164	0.0268	0.0103
hedge/scrub density: hedge/scrub area/area grazing and arable	0.0466	0.0783	0.0946	0.0607	0.1126	0.0603	0.0631

APPENDIX 8 contd.

		Kerry	Kild-are	Kilk-enny	Laois	Leit-rim	Lim-erick	Long-ford
1	Hedgerow length (km)	2.63	3.26	9.97	6.98	5.73	7.50	6.06
2	Treeline length (km)	0.39	2.53	0.99	0.72	1.46	0.20	1.05
2B	Bare treeline length (km)	0.19	0.03	0.00	0.00	0.03	0.00	0.06
3	Semi-natural broad-leaved woodland	0.78	0.73	0.56	0.20	1.01	0.30	1.17
4	Broad-leaved plantation	0.04	0.37	0.97	0.00	0.13	0.00	0.06
5	Semi-natural coniferous woodland	0.03	0.00	0.00	0.00	0.00	0.08	0.00
6	Coniferous plantation	2.07	0.99	1.09	3.35	7.74	7.98	1.70
6Y	Young coniferous plantation	3.68	4.05	1.27	2.27	0.60	1.44	0.51
7	Semi-natural mixed woodland	0.00	0.00	0.00	0.04	0.04	0.00	0.00
8	Mixed plantation	0.00	0.12	0.40	0.21	0.00	0.77	0.00
9	Young mixed or broad-leaved plantation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Recently felled woodland	0.00	0.21	0.00	0.00	0.87	0.00	0.00
11	Parkland	0.00	0.00	0.00	0.00	0.06	0.00	0.53
12A	Tall scrub (area)	0.52	0.12	0.31	1.78	0.67	0.34	3.15
12L	Tall scrub (length km)	0.17	0.00	0.12	0.13	0.28	0.00	0.28
13A	Low scrub (area)	1.62	1.11	2.92	1.98	1.65	1.40	1.05
13L	Low scrub (length km)	0.97	0.03	0.40	0.16	0.17	0.03	0.15
14	Bracken	0.73	0.00	0.18	0.02	0.00	1.55	0.00
15	Coastal sand dunes	0.01	0.00	0.00	0.00	0.00	0.00	0.00
16	Coastal sand or mudflats							
17	Coastal shingle or boulder beaches							
18	Lowland heath	1.22	0.00	0.00	0.21	0.00	0.61	0.00
19	Heather moorland	20.11	0.00	4.20	2.43	6.74	0.00	0.00
20	Blanket bog	9.31	0.00	0.00	2.36	0.77	0.28	0.00
21	Raised bog	2.60	3.28	0.00	2.19	0.62	0.24	13.55
20/21W	Worked peat	0.00	6.60	0.00	0.66	0.00	0.00	0.00
22	Marginal inundations	0.01	0.22	0.08	0.00	0.00	0.00	0.00
23	Coastal marsh	0.01	0.00	0.00	0.00	0.00	0.00	0.00
24	Wet ground	0.40	0.30	0.47	1.37	0.05	0.10	1.20
25	Standing natural water							
26	Standing man-made water							
27A	Running natural water (area)	0.45	0.05	0.89	0.23	0.99	0.26	0.41
27L	Running natural water (length km)	1.26	0.21	0.53	0.41	1.53	0.62	0.14
28A	Running canalised water (area)	0.14	0.42	0.08	0.24	0.27	0.24	0.89
28L	Running canalised water (length km)	0.99	1.34	0.45	2.73	0.89	0.93	3.31
29	Upland unimproved grassland	7.50	0.02	0.00	1.22	14.43	7.36	0.00
30	Lowland unimproved grassland	10.50	5.97	1.17	6.98	32.49	4.95	19.07
31	Semi-improved grassland	13.21	8.92	1.18	20.74	15.33	20.13	37.45
32	Improved grassland	17.65	45.11	73.84	32.14	12.39	48.92	13.56
33 TOT	Arable (total)	3.93	13.97	6.58	15.79	0.02	0.62	1.61
33B	Arable (seedcrops)	0.18	7.33	3.93	9.74	0.00	0.34	0.99
33R	Arable (rootcrops)	0.04	1.21	0.08	1.60	0.02	0.00	0.00
33G	Arable (grassland leys)	3.22	4.03	0.19	0.86	0.00	0.01	0.00
33H	Arable (horticultural)	0.00	0.22	0.00	0.00	0.00	0.02	0.00

APPPENDIX 8 contd.

		Kerry	Kild-are	Kilk-enny	Laois	Leit-rim	Lim-erick	Long-ford
34	Amenity grasslands	0.03	0.33	0.00	0.26	0.00	0.00	0.49
35	Unquarried inland cliffs	0.05	0.00	0.00	0.00	0.29	0.00	0.00
36	Vertical coastal cliffs	0.29	0.00	0.00	0.00	0.00	0.00	0.00
37	Sloping coastal cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	Quarries and open-cast mines	0.02	0.00	0.34	0.09	0.23	0.04	0.00
39	Bare ground	0.19	0.00	0.04	0.09	0.09	0.00	0.00
40	Built land area (excl. roads)	0.91	2.75	1.64	1.28	0.97	0.84	1.37
41A	Roads (area)	1.14	1.68	1.83	1.56	1.53	1.59	1.68
41L	Roads (length km)	1.89	1.85	2.23	1.88	1.97	1.99	2.10
40/41 TOT	Total built land (roads and built land)	2.91	7.00	3.47	2.88	2.51	2.43	3.05
42	Sea							
OTHER	Unspecified	0.05	0.14	0.02	0.26	0.00	0.01	0.52
TOTAL	Total area calculated (mean)	100.05	100.02	100.01	100.01	100.01	100.04	99.96
Principal habitat groups								
	total hedge and treeline (km)	3.22	5.82	10.96	7.70	7.22	7.70	7.18
	total scrub length (km)	1.14	0.03	0.52	0.29	0.44	0.03	0.43
	total hedge, treeline and boundary scrub (km)	4.36	5.85	11.48	7.99	7.67	7.73	7.61
	total hedgerow/treeline area (est. 2.5 m wide)	0.80	1.46	2.74	1.92	1.81	1.92	1.79
	total hedgerow/treeline/scrub area	2.95	2.69	5.97	5.69	4.13	3.67	5.99
	total grasslands (29-32)	48.86	60.03	76.19	61.09	74.64	81.36	70.08
	total grazing and arable (29-33)	52.79	74.00	82.77	76.87	74.66	81.98	71.70
	total woodland (3-9)	6.60	6.25	4.27	6.08	9.53	10.57	3.43
	total peat areas (20,21,20/21W)	11.91	9.88	0.00	5.21	1.39	0.51	13.55
	total peat, moorland and lowland heath	33.24	9.88	4.20	7.86	8.13	1.12	13.55
	hedgerow density: hedgerow area/area grazing and arable	0.0152	0.0197	0.0331	0.0250	0.0242	0.0235	0.0250
	hedge/scrub density: hedge/scrub area/area grazing and arable	0.0559	0.0363	0.0722	0.0740	0.0553	0.0448	0.0836

APPENDIX 8 contd.

		Louth	Mayo	Meath	Mona-ghan	Offaly	Rosco mmon	Sligo
1	Hedgerow length (km)	8.03	1.34	6.67	9.07	4.48	3.81	4.34
2	Treeline length (km)	0.66	0.26	2.66	1.28	1.61	0.92	0.89
2B	Bare treeline length (km)	0.00	0.01	0.11	0.00	0.00	0.03	0.07
3	Semi-natural broad-leaved woodland	0.33	0.00	0.25	0.02	0.56	0.03	0.31
4	Broad-leaved plantation	0.25	0.01	0.34	2.50	0.47	0.39	1.03
5	Semi-natural coniferous woodland	0.00	0.01	0.02	0.59	0.00	0.25	0.00
6	Coniferous plantation	5.95	1.08	0.33	3.05	3.28	2.03	3.09
6Y	Young coniferous plantation	0.09	3.15	0.35	0.32	4.87	1.25	3.22
7	Semi-natural mixed woodland	0.00	0.00	0.18	0.13	0.10	0.30	0.33
8	Mixed plantation	0.00	0.00	0.03	0.99	0.27	0.00	0.11
9	Young mixed or broad-leaved plantation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Recently felled woodland	0.00	0.00	0.00	0.35	0.08	0.00	0.00
11	Parkland	0.00	0.00	0.02	0.00	0.00	0.00	0.85
12A	Tall scrub (area)	1.15	0.11	0.37	0.19	0.57	0.78	0.93
12L	Tall scrub (length km)	0.15	0.01	0.06	0.00	0.15	0.18	0.49
13A	Low scrub (area)	0.45	1.18	0.33	0.00	2.76	1.16	1.66
13L	Low scrub (length km)	0.09	0.14	0.20	0.00	0.65	0.24	0.65
14	Bracken	0.00	0.10	0.13	0.49	0.07	0.07	0.06
15	Coastal sand dunes	0.00	0.95	0.00	0.00	0.00	0.00	0.00
16	Coastal sand or mudflats							
17	Coastal shingle or boulder beaches							
18	Lowland heath	0.00	0.00	0.00	2.10	0.91	0.01	8.88
19	Heather moorland	0.00	8.76	0.00	0.41	0.04	0.00	10.09
20	Blanket bog	0.00	26.09	0.00	0.00	0.44	4.47	1.29
21	Raised bog	0.00	5.00	1.63	0.00	3.19	5.48	1.16
20/21W	Worked peat	0.00	0.11	0.02	0.00	14.43	0.00	0.00
22	Marginal inundations	0.00	0.15	0.37	0.00	1.32	0.07	0.03
23	Coastal marsh	3.60	0.15	0.00	0.00	0.00	0.00	0.00
24	Wet ground	2.26	1.25	0.34	4.16	0.66	2.31	0.67
25	Standing natural water							
26	Standing man-made water							
27A	Running natural water (area)	0.19	0.54	0.36	0.32	1.53	0.63	0.44
27L	Running natural water (length km)	0.64	1.12	0.35	0.85	0.53	0.55	0.83
28A	Running canalised water (area)	0.20	0.22	0.71	0.14	0.57	0.71	0.39
28L	Running canalised water (length km)	2.42	0.93	2.36	1.84	2.97	2.59	1.27
29	Upland unimproved grassland	0.00	1.49	0.00	2.79	0.84	0.00	4.92
30	Lowland unimproved grassland	7.01	11.84	4.08	12.00	9.40	17.59	7.10
31	Semi-improved grassland	16.68	13.01	14.45	36.56	15.27	25.66	15.80
32	Improved grassland	29.88	18.19	55.93	24.55	24.60	30.10	33.60
33 TOT	Arable (total)	27.72	0.48	15.68	3.14	7.50	1.82	0.00
33B	Arable (seedcrops)	22.88	0.07	11.07	0.08	3.38	1.10	0.00
33R	Arable (rootcrops)	4.14	0.03	0.55	0.00	1.03	0.55	0.00
33G	Arable (grassland leys)	0.00	0.18	2.32	1.10	1.52	0.11	0.00
33H	Arable (horticultural)	0.00	0.00	0.15	0.00	0.19	0.00	0.00

APPENDIX 8 contd.

		Louth	Mayo	Meath	Mona-ghan	Offaly	Rosco mmon	Sligo
34	Amenity grasslands	0.34	0.08	0.06	0.49	1.82	1.13	0.14
35	Unquarried inland cliffs	0.00	2.06	0.00	0.00	0.00	0.19	0.00
36	Vertical coastal cliffs	0.00	0.15	0.00	0.00	0.00	0.15	0.00
37	Sloping coastal cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	Quarries and open-cast mines	0.00	0.00	0.04	0.63	0.56	0.00	0.04
39	Bare ground	0.00	1.71	0.12	0.38	0.05	0.03	0.00
40	Built land area (excl. roads)	2.14	0.85	2.10	1.12	1.69	1.55	1.38
41A	Roads (area)	1.56	1.31	1.60	2.03	1.86	1.88	1.63
41L	Roads (length km)	1.89	2.00	1.75	2.76	2.11	2.57	2.07
40/41 TOT	Total built land (roads and built land)	3.70	2.16	3.70	3.14	3.55	3.43	3.01
42	Sea							
OTHER	Unspecified	0.30	0.00	0.15	0.55	0.33	0.00	0.86
TOTAL	Total area calculated (mean)	100.10	100.02	100.00	100.05	100.04	100.02	100.01
Principal habitat groups								
	total hedge and treeline (km)	8.69	1.61	9.43	10.35	6.09	4.76	5.30
	total scrub length (km)	0.24	0.15	0.26	0.00	0.79	0.41	1.14
	total hedge, treeline and boundary scrub (km)	8.93	1.76	9.69	10.35	6.88	5.17	6.44
	total hedgerow/treeline area (est. 2.5 m wide)	2.17	0.40	2.36	2.59	1.52	1.19	1.33
	total hedgerow/treeline/scrub area	3.77	1.69	3.05	2.78	4.85	3.13	3.91
	total grasslands (29-32)	53.58	44.53	74.46	75.90	50.11	73.35	61.43
	total grazing and arable (29-33)	81.30	45.01	90.14	79.04	57.60	75.17	61.43
	total woodland (3-9)	6.61	4.25	1.49	7.58	9.55	4.25	8.07
	total peat areas (20,21,20/21W)	0.00	31.20	1.65	0.00	18.05	9.94	2.45
	total peat, moorland and lowland heath	0.00	39.96	1.65	2.51	19.00	9.95	21.42
	hedgerow density: hedgerow area/area grazing and arable	0.0267	0.0090	0.0261	0.0327	0.0264	0.0158	0.0216
	Hedge/scrub density: hedge/scrub area/area grazing and arable	0.0464	0.0376	0.0339	0.0351	0.0843	0.0417	0.0637

APPENDIX 8 contd.

		Tipp-erary	Wate-rford	West-meath	Wexf-ord	Wick-low
1	Hedgerow length (km)	9.15	8.73	4.47	8.13	4.12
2	Treeline length (km)	0.66	0.61	1.64	1.59	0.75
2B	Bare treeline length (km)	0.02	0.00	0.32	0.01	0.03
3	Semi-natural broad-leaved woodland	0.25	0.17	1.81	0.48	0.46
4	Broad-leaved plantation	0.22	0.31	0.34	0.32	0.18
5	Semi-natural coniferous woodland	0.08	0.00	0.23	0.00	0.00
6	Coniferous plantation	3.74	2.27	4.12	3.74	5.66
6Y	Young coniferous plantation	1.94	0.21	2.00	0.35	5.14
7	Semi-natural mixed woodland	0.00	0.00	0.06	0.10	0.00
8	Mixed plantation	0.08	0.00	0.00	0.13	0.09
9	Young mixed or broad-leaved plantation	0.00	0.06	0.00	0.00	0.27
10	Recently felled woodland	0.05	0.00	0.49	0.00	0.00
11	Parkland	0.06	0.00	0.00	0.00	0.00
12A	Tall scrub (area)	0.73	0.18	0.73	0.47	0.49
12L	Tall scrub (length km)	0.03	0.02	0.14	0.06	0.01
13A	Low scrub (area)	1.09	4.11	1.62	1.84	1.30
13L	Low scrub (length km)	0.13	0.27	0.55	0.51	0.95
14	Bracken	0.10	0.93	0.08	1.17	0.13
15	Coastal sand dunes	0.00	0.00	0.00	0.00	0.93
16	Coastal sand or mudflats					
17	Coastal shingle or boulder beaches					
18	Lowland heath	0.30	0.00	0.00	0.00	0.00
19	Heather moorland	10.09	7.00	0.00	0.00	4.86
20	Blanket bog	0.39	0.00	0.00	0.00	10.87
21	Raised bog	0.64	0.00	2.84	0.00	0.00
20/21W	Worked peat	0.37	0.00	6.34	0.00	0.00
22	Marginal inundations	0.08	0.37	0.00	0.00	0.20
23	Coastal marsh	0.00	2.30	0.00	0.00	0.00
24	Wet ground	2.14	0.87	1.07	0.53	2.57
25	Standing natural water					
26	Standing man-made water					
27A	Running natural water (area)	0.76	0.16	0.02	0.26	0.75
27L	Running natural water (length km)	0.60	0.57	0.04	0.62	1.07
28A	Running canalised water (area)	0.28	0.11	0.95	0.18	0.14
28L	Running canalised water (length km)	1.00	0.24	3.64	0.50	0.77
29	Upland unimproved grassland	1.34	2.64	0.00	0.93	4.25
30	Lowland unimproved grassland	2.90	0.60	11.49	0.71	1.81
31	Semi-improved grassland	11.71	13.85	22.78	4.52	9.73
32	Improved grassland	51.30	48.13	33.07	57.21	34.21
33 TOT	Arable (total)	15.93	8.02	6.84	22.83	7.57
33B	Arable (seedcrops)	8.49	2.07	2.74	11.60	4.43
33R	Arable (rootcrops)	2.03	0.49	0.71	2.78	0.96
33G	Arable (grassland leys)	4.70	2.96	2.75	2.68	0.09
33H	Arable (horticultural)	0.06	1.98	0.13	0.17	0.00

APPENDIX 8 contd.

		Tipp-erary	Wate-rford	West-meath	Wexf-ord	Wick-low
34	Amenity grasslands	0.50	1.08	0.08	0.61	0.23
35	Unquarried inland cliffs	0.00	0.00	0.00	0.00	0.00
36	Vertical coastal cliffs	0.00	0.00	0.00	0.00	0.30
37	Sloping coastal cliffs	0.00	0.21	0.00	0.00	0.00
38	Quarries and open-cast mines	0.49	0.00	0.00	0.00	0.00
39	Bare ground	0.03	0.36	0.23	0.00	1.85
40	Built land area (excl. roads)	1.24	0.77	2.47	4.06	1.75
41A	Roads (area)	1.64	1.98	1.72	2.28	1.14
41L	Roads (length km)	2.01	2.59	1.95	2.53	1.36
40/41 TOT	Total built land (roads and built land)	2.88	7.27	4.19	6.34	2.89
42	Sea					
OTHER	Unspecified	0.25	0.08	0.00	0.19	0.06
TOTAL	Total area calculated (mean)	100.03	100.00	100.06	100.00	100.01
Principal habitat groups						
	total hedge and treeline (km)	9.83	9.34	6.42	9.73	4.89
	total scrub length (km)	0.17	0.29	0.69	0.57	0.97
	total hedge, treeline and boundary scrub (km)	9.99	9.63	7.12	10.29	5.86
	total hedgerow/treeline area (est. 2.5 m wide)	2.46	2.33	1.61	2.43	1.22
	total hedgerow/treeline/scrub area	4.28	6.62	3.96	4.74	3.01
	total grasslands (29-32)	67.25	65.22	67.34	63.37	50.01
	total grazing and arable (29-33)	83.18	73.23	74.18	86.20	57.57
	total woodland (3-9)	6.32	3.02	8.57	5.12	11.80
	total peat areas (20,21,20/21W)	1.40	0.00	9.18	0.00	10.87
	total peat, moorland and lowland heath	11.79	7.00	9.18	0.00	15.73
	hedgerow density: hedgerow area/area grazing and arable	0.0295	0.0319	0.0216	0.0282	0.0212
	hedge/scrub density: hedge/scrub area/area grazing and arable	0.0515	0.0904	0.0534	0.0550	0.0523

APPENDIX 9

Estimates of land use by stock type: ***Maximal values*** *and* ***standard errors of means*** *observed by region (for* ***means****, refer to Table 17 in text). Based on uncorrected data.*

Maximal values

	South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
Mean land area utilised for grazing - ha km^{-2}; all habitat categories								
Cattle	97.60	98.60	77.40	94.20	87.60	94.10	91.00	98.60
Sheep	100.00	51.80	100.00	98.70	83.20	99.90	98.90	100.00
Cattle and sheep	77.00	65.30	100.00	95.10	47.40	86.00	45.10	100.00
Other	22.00	23.10	37.60	26.40	50.00	13.20	21.80	50.00

Standard errors

	South-West	Mid-West	West	North-West	Mid-lands	South	East	Rep-ublic
Mean land area utilised for grazing - ha km^{-2}; all habitat categories								
Cattle	2.87	3.63	2.22	2.52	2.28	3.57	2.16	1.14
Sheep	2.73	0.89	2.52	3.84	1.29	2.29	2.33	0.98
Cattle and sheep	0.86	1.20	2.10	3.21	0.93	1.81	1.11	0.67
Other	0.26	0.37	0.31	0.38	0.59	0.30	0.38	0.15

APPENDIX 10

Estimates of land use by stock type, by county. Given by ***mean area (ha km^{-2})*** *of land used by stock type. Percentages are given of land utilised for cattle grazing over the total grazing land assessed.* ***Data is uncorrected for sea, lake and coastal habitats.***

	Car-low	Cavan	Clare	Cork	Don-egal	Dublin	Gal-way
Mean land area utilised for grazing - ha km2; all habitat categories							
Cattle	19.51	43.04	30.23	43.07	16.29	18.78	24.37
Sheep	21.09	4.88	2.43	7.36	30.06	8.58	20.78
Cattle and sheep	5.05	1.00	2.12	1.59	10.93	2.54	7.73
Other	1.06	0.24	1.76	0.95	0.55	2.52	1.18
Total land with cattle grazing on it	24.56	44.04	32.36	44.66	27.23	21.32	32.10
Overall total grazing land	46.71	49.16	36.55	52.96	57.84	32.42	54.06
percentage of total with cattle grazing	52.6	89.6	88.5	84.3	47.1	65.8	59.4
Mean land area utilised for grazing in specified 'grazing' habitats (see text)							
Cattle	19.51	43.04	29.90	42.93	15.86	18.78	23.21
Sheep	20.63	4.88	2.36	7.36	28.49	8.58	19.84
Cattle and sheep	5.05	1.00	2.12	1.59	10.17	2.54	7.73
Other	1.06	0.24	1.24	0.95	0.55	2.52	0.42
Total land with cattle grazing on it	24.56	44.04	32.02	44.52	26.04	21.32	30.94
Overall total grazing land	46.25	49.16	35.63	52.82	55.08	32.42	51.19
percentage of total with cattle grazing	53.1	89.6	89.9	84.3	47.3	65.8	60.4
Total area undesignated in specific 'grazing' habitats							
Total undesignated	39.76	31.24	36.60	24.86	17.77	26.24	22.17
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	18.93	42.40	28.21	40.63	10.48	18.78	22.71
Sheep	17.25	4.88	2.36	2.62	8.08	8.58	16.35
Cattle and sheep	4.46	1.00	2.12	1.53	5.17	2.54	6.04
Other	1.06	0.24	1.06	0.72	0.06	2.52	0.42
Total land with cattle grazing on it	23.39	43.40	30.33	42.16	15.65	21.32	28.75
Overall total grazing land	41.70	48.52	33.75	45.50	23.79	32.42	45.51
percentage of total with cattle grazing	56.1	89.4	89.9	92.7	65.8	65.8	63.2
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	10.34	28.76	24.85	10.16	9.21	4.08	8.90
Total area of land grazed in arable land (including grass leys)							
Cattle	0.44	0.00	0.00	1.86	0.98	0.00	0.00
Sheep	3.13	0.00	0.00	0.56	0.53	0.00	0.01
Cattle and sheep	0.34	0.00	0.00	0.06	0.05	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	3.90	0.00	0.00	2.49	1.56	0.00	0.01

APPENDIX 10 contd.

	Kerry	Kild-are	Kilk-enny	Laoise	Leit-rim	Lime-rick	Long-ford
Mean land area utilised for grazing - ha km2; all habitat categories							
Cattle	34.01	27.07	44.54	32.26	13.36	70.11	30.17
Sheep	29.54	16.09	11.65	11.71	25.52	2.73	13.13
Cattle and sheep	5.93	8.21	5.19	5.92	13.03	3.75	3.73
Other	0.28	2.82	0.91	0.48	1.48	0.97	0.00
Total land with cattle grazing on it	39.94	35.28	49.73	38.18	26.39	73.86	33.90
Overall total grazing land	69.76	54.19	62.30	50.36	53.39	77.56	47.03
percentage of total with cattle grazing	57.3	65.1	79.8	75.8	49.4	95.2	72.1
Mean land area utilised for grazing in specified 'grazing' habitats (see text)							
Cattle	33.82	27.07	44.49	32.26	12.32	67.79	30.17
Sheep	28.46	16.09	11.65	11.71	25.52	2.73	13.13
Cattle and sheep	5.85	7.96	5.19	5.92	13.03	3.75	3.73
Other	0.28	2.82	0.91	0.48	0.44	0.97	0.00
Total land with cattle grazing on it	39.67	35.04	49.68	38.18	25.36	71.54	33.90
Overall total grazing land	68.40	53.94	62.24	50.36	51.32	75.24	47.03
percentage of total with cattle grazing	58.0	65.0	79.8	75.8	49.4	95.1	72.1
Total area undesignated in specific 'grazing' habitats							
Total undesignated	9.36	23.60	25.16	34.60	26.02	7.26	43.78
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	29.45	24.16	42.10	31.71	12.32	67.57	29.37
Sheep	8.87	15.92	11.65	10.79	20.38	2.71	13.13
Cattle and sheep	4.07	7.96	5.19	5.75	13.03	3.75	3.73
Other	0.28	2.82	0.91	0.48	0.44	0.97	0.00
Total land with cattle grazing on it	33.52	32.12	47.29	37.46	25.36	71.32	33.10
Overall total grazing land	42.68	50.87	59.85	48.72	46.18	75.01	46.23
percentage of total with cattle grazing	78.6	63.2	79.0	76.9	54.9	95.1	71.6
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	2.33	9.13	16.31	14.15	19.92	5.67	28.75
Total area of land grazed in arable land (including grass leys)							
Cattle	2.40	2.91	2.39	0.00	0.00	0.22	0.00
Sheep	0.08	0.16	0.00	0.74	0.00	0.01	0.00
Cattle and sheep	0.80	0.00	0.00	0.17	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	3.28	3.08	2.39	0.91	0.00	0.24	0.00

APPENDIX 10 contd.

	Louth	Mayo	Meath	Mon-aghan	Offaly	Rosco-mmon	Sligo
Mean land area utilised for grazing - ha km2; all habitat categories							
Cattle	24.29	18.46	40.77	46.88	39.96	39.33	12.08
Sheep	6.87	21.95	8.13	5.66	5.63	11.78	16.29
Cattle and sheep	2.66	18.62	9.51	0.00	3.51	13.00	40.16
Other	2.71	0.00	2.28	1.10	0.77	0.97	0.00
Total land with cattle grazing on it	26.94	37.08	50.28	46.88	43.47	52.33	52.25
Overall total grazing land	36.53	59.03	60.69	53.64	49.87	65.08	68.54
percentage of total with cattle grazing	73.8	62.8	82.8	87.4	87.2	80.4	76.2
Mean land area utilised for grazing in specified 'grazing' habitats (see text)							
Cattle	24.29	18.46	40.67	46.88	39.96	39.18	12.08
Sheep	6.64	21.81	7.50	4.38	5.63	11.78	16.29
Cattle and sheep	2.66	17.96	9.51	0.00	3.51	13.00	40.16
Other	2.71	0.00	2.28	1.10	0.77	0.97	0.00
Total land with cattle grazing on it	26.94	36.42	50.17	46.88	43.47	52.19	52.25
Overall total grazing land	36.30	58.24	59.95	52.36	49.87	64.94	68.54
percentage of total with cattle grazing	74.2	62.5	83.7	89.5	87.2	80.4	76.2
Total area undesignated in specific 'grazing' habitats							
Total undesignated	52.69	18.18	31.73	29.66	12.16	18.16	7.67
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	24.29	17.44	40.61	46.44	39.05	37.86	10.05
Sheep	6.64	6.50	7.50	4.38	4.63	11.78	4.52
Cattle and sheep	2.66	9.27	9.14	0.00	3.44	11.52	38.48
Other	2.71	0.00	2.28	1.10	0.77	0.49	0.00
Total land with cattle grazing on it	26.94	26.72	49.75	46.44	42.49	49.38	48.53
Overall total grazing land	36.30	33.22	59.52	51.92	47.90	61.65	53.05
percentage of total with cattle grazing	74.2	80.4	83.6	89.4	88.7	80.1	91.5
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	18.43	6.07	13.74	24.34	1.57	7.07	2.34
Total area of land grazed in arable land (including grass leys)							
Cattle	0.00	0.00	0.00	0.14	0.49	0.00	0.00
Sheep	0.00	0.00	0.00	0.00	0.94	0.00	0.00
Cattle and sheep	0.00	0.00	0.37	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	0.00	0.00	0.37	0.14	1.44	0.00	0.00

APPENDIX 10 contd.

	Tipp-erary	Wate-rford	West-meath	Wex-ford	Wick-low
Mean land area utilised for grazing - ha km2; all habitat categories					
Cattle	47.37	49.15	33.71	19.05	12.42
Sheep	10.14	2.45	6.59	14.64	20.54
Cattle and sheep	7.02	10.44	7.61	3.38	6.46
Other	0.76	0.94	5.26	0.54	0.69
Total land with cattle grazing on it	54.39	59.59	41.32	22.43	18.88
Overall total grazing land	65.29	62.99	53.17	37.61	40.11
percentage of total with cattle grazing	83.3	94.6	77.7	59.6	47.1
Mean land area utilised for grazing in specified 'grazing' habitats (see text)					
Cattle	47.37	48.37	33.48	19.05	12.42
Sheep	10.14	2.45	6.59	14.64	20.12
Cattle and sheep	7.02	10.22	7.61	3.38	6.46
Other	0.76	0.93	5.26	0.54	0.69
Total land with cattle grazing on it	54.39	58.60	41.09	22.43	18.88
Overall total grazing land	65.29	61.98	52.94	37.61	39.69
percentage of total with cattle grazing	83.3	94.5	77.6	59.6	47.6
Total area undesignated in specific 'grazing' habitats					
Total undesignated	20.58	11.02	23.70	47.07	36.29
Total area of grazing recorded on pastures only (habitats 29-32)					
Cattle	43.86	45.85	33.02	17.09	11.73
Sheep	3.94	2.33	6.59	13.63	14.23
Cattle and sheep	5.45	8.01	7.61	3.38	6.43
Other	0.76	0.93	5.22	0.54	0.69
Total land with cattle grazing on it	49.31	53.86	40.62	20.46	18.16
Overall total grazing land	54.01	57.12	52.44	34.63	33.07
percentage of total with cattle grazing	91.3	94.3	77.5	59.1	54.9
Total area undesignated in pasture lands only (habitats 29-32)					
Total undesignated	4.27	1.57	16.09	27.89	16.23
Total area of land grazed in arable land (including grass leys)					
Cattle	2.33	2.52	0.25	1.97	0.07
Sheep	0.75	0.12	0.00	1.01	0.19
Cattle and sheep	1.06	0.44	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	4.14	3.08	0.25	2.98	0.26

APPENDIX 11

Estimates of land use by stock type, by county. Given by ***mean area (ha km^{-2})*** *of land used by stock type. Percentages are given of land utilised for cattle grazing over the total grazing land assessed.* ***Data is corrected for sea, lake and coastal habitats.***

	Carlow	Cavan	Clare	Cork	Donegal	Dublin	Galway
Mean land area utilised for grazing - ha km^{-2}; all habitat categories							
Cattle	19.52	45.47	32.44	47.80	18.32	22.23	27.50
Sheep	21.09	5.16	2.61	8.17	33.79	10.16	23.45
Cattle and sheep	5.05	1.06	2.28	1.76	12.29	3.01	8.72
Other	1.06	0.25	1.89	1.05	0.62	2.99	1.34
Total land with cattle grazing on it	24.57	46.53	34.72	49.57	30.61	25.25	36.22
Overall total grazing land	46.72	51.94	39.22	58.79	65.02	38.39	61.01
percentage of total with cattle grazing	52.6	89.6	88.5	84.3	47.1	65.8	59.4
Mean land area utilised for grazing in specified 'grazing' habitats (see text)							
Cattle	19.52	45.47	32.09	47.65	17.84	22.23	26.19
Sheep	20.63	5.16	2.54	8.17	32.03	10.16	22.39
Cattle and sheep	5.05	1.06	2.28	1.76	11.43	3.01	8.72
Other	1.06	0.25	1.33	1.05	0.62	2.99	0.47
Total land with cattle grazing on it	24.57	46.53	34.36	49.41	29.27	25.25	34.91
Overall total grazing land	46.26	51.94	38.23	58.63	61.92	38.39	57.77
percentage of total with cattle grazing	53.1	89.6	89.9	84.3	47.3	65.8	60.4
Total area undesignated in specific 'grazing' habitats							
Total undesignated	39.77	33.01	39.28	27.59	19.98	31.08	25.02
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	18.93	44.80	30.27	45.10	11.78	22.23	25.63
Sheep	17.25	5.16	2.54	2.91	9.08	10.16	18.45
Cattle and sheep	4.46	1.06	2.28	1.70	5.81	3.01	6.81
Other	1.06	0.25	1.14	0.80	0.07	2.99	0.47
Total land with cattle grazing on it	23.39	45.85	32.54	46.80	17.59	25.25	32.44
Overall total grazing land	41.71	51.26	36.22	50.51	26.74	38.39	51.36
percentage of total with cattle grazing	56.1	89.4	89.9	92.7	65.8	65.8	63.2
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	10.34	30.39	26.67	11.28	10.35	4.83	10.04
Total area of land grazed in arable land (including grass leys)							
Cattle	0.44	0.00	0.00	2.07	1.10	0.00	0.00
Sheep	3.13	0.00	0.00	0.62	0.60	0.00	0.01
Cattle and sheep	0.34	0.00	0.00	0.07	0.05	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	3.90	0.00	0.00	2.76	1.75	0.00	0.01

APPENDIX 11 contd.

	Kerry	Kil-dare	Kilk-enny	Laoise	Leit-rim	Lim-erick	Long-ord
Mean land area utilised for grazing - ha km^{-2}; all habitat categories							
Cattle	38.28	27.09	44.56	32.28	13.60	70.70	31.30
Sheep	33.25	16.09	11.66	11.71	25.99	2.75	13.63
Cattle and sheep	6.67	8.21	5.19	5.92	13.27	3.78	3.87
Other	0.32	2.82	0.91	0.48	1.50	0.98	0.00
Total land with cattle grazing on it	44.96	35.30	49.75	38.20	26.87	74.48	35.17
Overall total grazing land	78.52	54.21	62.32	50.39	54.37	78.21	48.80
percentage of total with cattle grazing	57.3	65.1	79.8	75.8	49.4	95.2	72.1
Mean land area utilised for grazing in specified 'grazing' habitats (see text)							
Cattle	38.06	27.09	44.50	32.28	12.55	68.36	31.30
Sheep	32.03	16.09	11.66	11.71	25.99	2.75	13.63
Cattle and sheep	6.59	7.97	5.19	5.92	13.27	3.78	3.87
Other	0.32	2.82	0.91	0.48	0.45	0.98	0.00
Total land with cattle grazing on it	44.65	35.05	49.69	38.20	25.82	72.15	35.17
Overall total grazing land	77.00	53.97	62.26	50.39	52.26	75.88	48.80
percentage of total with cattle grazing	58.0	65.0	79.8	75.8	49.4	95.1	72.1
Total area undesignated in specific 'grazing' habitats							
Total undesignated	10.53	23.61	25.17	34.62	26.50	7.32	45.42
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	33.15	24.17	42.11	31.73	12.55	68.14	30.47
Sheep	9.99	15.93	11.66	10.79	20.75	2.74	13.63
Cattle and sheep	4.58	7.97	5.19	5.75	13.27	3.78	3.87
Other	0.32	2.82	0.91	0.48	0.45	0.98	0.00
Total land with cattle grazing on it	37.73	32.14	47.30	37.48	25.82	71.92	34.34
Overall total grazing land	48.04	50.89	59.87	48.75	47.02	75.64	47.97
percentage of total with cattle grazing	78.6	63.2	79.0	76.9	54.9	95.1	71.6
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	2.63	9.14	16.31	14.16	20.29	5.72	29.83
Total area of land grazed in arable land (including grass leys)							
Cattle	2.70	2.91	2.39	0.00	0.00	0.22	0.00
Sheep	0.08	0.16	0.00	0.74	0.00	0.01	0.00
Cattle and sheep	0.90	0.00	0.00	0.17	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	3.69	3.08	2.39	0.91	0.00	0.24	0.00

APPENDIX 11 contd.

	Louth	Mayo	Meath	Mona- ghan	Offaly	Rosco mmon	Sligo
Mean land area utilised for grazing - ha km2; all habitat categories							
Cattle	24.29	21.02	40.79	47.93	40.47	41.67	13.61
Sheep	6.87	24.99	8.14	5.79	5.71	12.48	18.35
Cattle and sheep	2.66	21.20	9.51	0.00	3.56	13.78	45.25
Other	2.71	0.00	2.28	1.12	0.78	1.03	0.00
Total land with cattle grazing on it	26.95	42.22	50.30	47.93	44.03	55.46	58.86
Overall total grazing land	36.54	67.22	60.71	54.84	50.52	68.97	77.21
percentage of total with cattle grazing	73.8	62.8	82.8	87.4	87.2	80.4	76.2
Mean land area utilised for grazing in specified 'grazing' habitats (see text)							
Cattle	24.29	21.02	40.68	47.93	40.47	41.52	13.61
Sheep	6.64	24.84	7.50	4.48	5.71	12.48	18.35
Cattle and sheep	2.66	20.45	9.51	0.00	3.56	13.78	45.25
Other	2.71	0.00	2.28	1.12	0.78	1.03	0.00
Total land with cattle grazing on it	26.95	41.48	50.19	47.93	44.03	55.30	58.86
Overall total grazing land	36.31	66.31	59.98	53.53	50.52	68.81	77.21
percentage of total with cattle grazing	74.2	62.5	83.7	89.5	87.2	80.4	76.2
Total area undesignated in specific 'grazing' habitats							
Total undesignated	52.70	20.70	31.74	30.32	12.32	19.25	8.64
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	24.29	19.86	40.63	47.48	39.56	40.12	11.32
Sheep	6.64	7.40	7.50	4.48	4.69	12.48	5.09
Cattle and sheep	2.66	10.56	9.14	0.00	3.49	12.21	43.35
Other	2.71	0.00	2.28	1.12	0.78	0.52	0.00
Total land with cattle grazing on it	26.95	30.42	49.77	47.48	43.04	52.33	54.67
Overall total grazing land	36.31	37.82	59.55	53.08	48.52	65.33	59.76
percentage of total with cattle grazing	74.2	80.4	83.6	89.4	88.7	80.1	91.5
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	18.43	6.91	13.75	24.89	1.59	7.49	2.63
Total area of land grazed in arable land (including grass leys)							
Cattle	0.00	0.00	0.00	0.14	0.50	0.00	0.00
Sheep	0.00	0.00	0.00	0.00	0.96	0.00	0.00
Cattle and sheep	0.00	0.00	0.37	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	0.00	0.00	0.37	0.14	1.46	0.00	0.00

APPENDIX 11 contd.

	Tipp-erary	Wate-rford	West-meath	Wex-ford	Wick-low
Mean land area utilised for grazing - ha km^{-2}; all habitat categories					
Cattle	47.97	53.93	33.78	19.09	13.31
Sheep	10.27	2.69	6.60	14.67	22.02
Cattle and sheep	7.11	11.45	7.62	3.38	6.92
Other	0.77	1.03	5.28	0.54	0.74
Total land with cattle grazing on it	55.08	65.38	41.41	22.48	20.23
Overall total grazing land	66.12	69.10	53.29	37.68	42.99
percentage of total with cattle grazing	83.3	94.6	77.7	59.6	47.1
Mean land area utilised for grazing in specified 'grazing' habitats (see text)					
Cattle	47.97	53.07	33.56	19.09	13.31
Sheep	10.27	2.69	6.60	14.67	21.57
Cattle and sheep	7.11	11.22	7.62	3.38	6.92
Other	0.77	1.02	5.28	0.54	0.74
Total land with cattle grazing on it	55.08	64.28	41.18	22.48	20.23
Overall total grazing land	66.12	67.99	53.06	37.68	42.54
percentage of total with cattle grazing	83.3	94.5	77.6	59.6	47.6
Total area undesignated in specific 'grazing' habitats					
Total undesignated	20.84	12.09	23.75	47.17	38.90
Total area of grazing recorded on pastures only (habitats 29-32)					
Cattle	44.41	50.31	33.09	17.12	12.57
Sheep	3.99	2.56	6.60	13.66	15.25
Cattle and sheep	5.52	8.79	7.62	3.38	6.89
Other	0.77	1.02	5.23	0.54	0.74
Total land with cattle grazing on it	49.94	59.09	40.71	20.50	19.46
Overall total grazing land	54.70	62.67	52.55	34.70	35.45
percentage of total with cattle grazing	91.3	94.3	77.5	59.1	54.9
Total area undesignated in pasture lands only (habitats 29-32)					
Total undesignated	4.33	1.73	16.13	27.94	17.39
Total area of land grazed in arable land (including grass leys)					
Cattle	2.36	2.76	0.25	1.97	0.07
Sheep	0.76	0.13	0.00	1.01	0.20
Cattle and sheep	1.08	0.48	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	4.20	3.38	0.25	2.98	0.27

APPENDIX 12

Summaries of habitat data for each landclass, given by means for each habitat type and habitat group summaries. Data is ***uncorrected*** *for areas of sea, lake and beaches* etc. *Data is given by mean ha per km² or km per km².*

	Landclass	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	Hedgerow length (km)	7.56	5.50	7.31	5.52	4.64	7.15	1.94
2	Treeline length (km)	1.17	1.25	1.02	1.15	1.53	1.16	0.19
2B	Bare treeline length (km)	0.05	0.02	0.00	0.00	0.12	0.08	0.03
3	Semi-natural broad-leaved woodland	0.30	0.31	0.35	0.00	1.00	0.71	0.07
4	Broad-leaved plantation	0.26	0.50	0.52	0.00	1.17	0.13	0.00
5	Semi-natural coniferous woodland	0.05	0.22	0.00	0.00	0.02	0.03	0.00
6	Coniferous plantation	0.99	2.10	0.00	0.00	1.35	1.69	0.48
6Y	Young coniferous plantation	0.68	0.10	0.00	0.00	1.84	0.62	0.00
7	Semi-natural mixed woodland	0.05	0.00	0.00	0.00	0.13	0.08	0.00
8	Mixed plantation	0.16	0.15	0.00	0.00	0.41	0.19	0.00
9	Young mixed or broad-leaved plantation	0.01	0.00	0.00	0.00	0.00	0.06	0.00
10	Recently felled woodland	0.05	0.00	0.00	0.00	0.09	0.08	0.00
11	Parkland	0.00	0.00	0.00	0.02	0.00	0.26	0.00
12A	Tall scrub (area)	0.38	0.78	0.27	1.54	1.30	0.64	0.00
12L	Tall scrub (length km)	0.05	0.03	0.07	0.00	0.13	0.10	0.00
13A	Low scrub (area)	1.48	0.89	1.75	0.02	1.53	1.79	2.61
13L	Low scrub (length km)	0.25	0.25	0.19	0.12	0.46	0.21	0.57
14	Bracken	0.24	0.03	0.03	0.00	0.00	0.16	0.04
15	Coastal sand dunes	0.00	0.00	0.00	0.00	0.00	0.00	1.12
16	Coastal sand or mudflats	0.04	0.00	0.00	0.00	0.00	0.00	9.05
17	Coastal shingle or boulder beaches	0.00	0.52	0.00	0.00	0.00	0.00	1.88
18	Lowland heath	0.37	0.22	0.00	0.00	0.53	0.00	0.24
19	Heather moorland	0.15	0.94	0.00	0.00	0.78	0.35	0.00
20	Blanket bog	0.31	0.22	0.00	0.00	1.74	0.47	0.00
21	Raised bog	0.45	0.10	0.00	0.00	0.31	2.21	0.00
20/21W	Worked peat	0.04	4.00	0.00	0.00	0.23	0.10	0.00
22	Marginal inundations	0.16	0.08	0.00	0.00	0.11	0.31	0.00
23	Coastal marsh	0.00	0.00	0.00	0.00	0.00	0.00	2.93
24	Wet ground	1.10	1.35	0.00	0.16	1.26	1.44	0.41
25	Standing natural water	0.90	3.44	0.00	0.00	0.04	3.79	0.02
26	Standing man-made water	0.52	0.00	0.00	0.00	0.01	0.02	0.02
27A	Running natural water (area)	0.29	0.62	0.10	0.00	1.16	0.71	0.04
27L	Running natural water (length km)	0.55	0.42	0.37	0.00	0.73	0.65	0.16
28A	Running canalised water (area)	0.31	0.27	0.22	0.14	0.93	0.42	0.03
28L	Running canalised water (length km)	1.33	1.29	1.43	0.24	2.49	1.63	0.16
29	Upland unimproved grassland	0.48	1.34	0.00	0.00	1.36	0.04	0.00
30	Lowland unimproved grassland	7.02	3.55	4.12	1.64	13.20	11.88	6.54
31	Semi-improved grassland	15.03	12.00	3.98	9.70	18.02	15.32	2.36
32	Improved grassland	53.73	42.01	19.92	45.44	31.95	47.12	13.93
33 TOT	Arable (total)	10.19	16.82	65.80	14.96	13.92	5.70	5.60
33B	Arable (seedcrops)	5.44	9.40	31.68	6.32	8.22	1.70	3.00
33R	Arable (rootcrops)	0.75	2.50	18.22	1.68	1.19	0.36	1.93
33G	Arable (grassland leys)	2.45	3.12	14.43	0.28	2.33	2.44	0.39
33H	Arable (horticultural)	0.17	0.11	0.20	0.84	0.34	0.02	0.00

APPENDIX 12 contd.

	Landclass	1	2	3	4	5	6	7
34	Amenity grasslands	0.21	0.07	0.00	0.76	1.35	0.12	0.23
35	Unquarried inland cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	Vertical coastal cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.58
37	Sloping coastal cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.58
38	Quarries and open-cast mines	0.17	0.51	0.00	0.04	0.31	0.10	0.03
39	Bare ground	0.10	0.00	0.08	0.00	0.03	0.10	4.44
40	Built land area (excl. roads)	1.74	2.17	1.50	18.80	2.11	1.51	1.42
41A	Roads (area)	1.82	1.78	1.40	2.53	1.77	1.83	0.67
41L	Roads (length km)	2.27	2.41	2.20	2.68	2.22	2.32	1.17
40/41-TOT	Total built land (roads and built land)	3.56	3.96	2.90	25.60	3.88	3.33	2.67
42	Sea	0.12	2.92	0.00	0.00	0.00	0.00	44.15
OTHER	Unspecified	0.13	0.02	0.00	0.00	0.06	0.05	0.00
TOTAL	Total area calculated (mean)	100.03	100.04	100.03	100.02	100.01	100.01	100.04
	sum area sea, lake and shores	1.59	6.36	0.00	0.02	0.13	4.15	44.19
	Sample size	148	25	6	5	28	92	16
	Principal habitat groups							
	total hedge and treeline (km)	8.78	6.77	8.32	6.68	6.28	8.39	2.16
	total scrub length (km)	0.30	0.27	0.26	0.12	0.59	0.31	0.57
	total hedge, treeline and boundary scrub (km)	9.07	7.05	8.59	6.79	6.88	8.70	2.72
	total hedgerow/treeline area (est. 2.5 m wide)	2.18	1.69	2.08	1.67	1.54	2.08	0.53
	total hedgerow/treeline/scrub area	4.04	3.36	4.10	3.23	4.37	4.51	3.14
	total grasslands (29-32)	76.25	58.90	28.02	56.78	64.53	74.37	22.83
	total grazing and arable (29-33)	86.44	75.72	93.82	71.74	78.45	80.07	28.43
	total woodland (3-9)	2.51	3.38	0.87	0.00	5.93	3.49	0.55
	total peat areas (20,21,20/21W)	0.80	4.31	0.00	0.00	2.28	2.78	0.00
	total peat, moorland and lowland heath	1.32	5.47	0.00	0.00	3.58	3.12	0.24
	hedgerow area/area grazing and arable	0.0252	0.0223	0.0222	0.0233	0.0197	0.0260	0.0187
	hedge/scrub area/area grazing and arable	0.0467	0.0444	0.0437	0.0450	0.0558	0.0563	0.1106
	hedge/treeline (km) density per unit grass/arable	0.1016	0.0895	0.0887	0.0931	0.0801	0.1048	0.0759
	hedge/treeline/scrub (km) density per unit grass/arable	0.1050	0.0931	0.0915	0.0947	0.0877	0.1087	0.0958

APPENDIX 12 contd.

	Landclass	8	9	10	11	12	13	14
1	Hedgerow length (km)	2.19	7.35	4.35	3.42	4.59	2.47	3.00
2	Treeline length (km)	0.53	1.40	2.05	2.25	0.00	0.21	0.34
2B	Bare treeline length (km)	0.00	2.25	0.00	0.00	0.00	0.00	0.25
3	Semi-natural broad-leaved woodland	0.75	0.15	0.43	0.00	0.30	0.00	0.53
4	Broad-leaved plantation	1.43	0.20	0.37	0.25	0.00	0.01	0.00
5	Semi-natural coniferous woodland	0.00	0.00	0.24	0.00	0.00	0.00	0.40
6	Coniferous plantation	0.00	0.00	1.98	0.20	0.00	3.68	0.03
6Y	Young coniferous plantation	0.00	0.00	0.00	0.00	0.00	3.98	0.00
7	Semi-natural mixed woodland	0.04	0.00	0.13	0.00	0.00	0.00	0.00
8	Mixed plantation	0.10	0.00	0.97	1.85	0.00	0.00	0.00
9	Young mixed or broad-leaved plantation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Recently felled woodland	0.00	0.00	0.06	0.00	0.00	0.00	0.00
11	Parkland	1.43	0.00	0.00	0.00	0.00	0.00	0.00
12A	Tall scrub (area)	0.40	0.15	0.05	0.00	0.15	3.01	1.23
12L	Tall scrub (length km)	0.11	0.07	0.01	0.00	0.00	0.28	0.23
13A	Low scrub (area)	2.33	0.05	0.41	5.70	0.20	3.34	0.80
13L	Low scrub (length km)	0.72	0.04	0.21	0.00	0.00	0.41	0.26
14	Bracken	0.24	0.00	0.00	0.00	0.00	0.04	1.80
15	Coastal sand dunes	3.63	0.00	0.00	0.00	0.00	0.00	0.13
16	Coastal sand or mudflats	18.76	0.00	0.63	0.00	0.00	0.00	19.00
17	Coastal shingle or boulder beaches	0.31	0.00	0.17	0.00	0.40	0.00	1.63
18	Lowland heath	0.02	0.00	0.38	0.00	0.00	0.66	0.00
19	Heather moorland	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	Blanket bog	0.00	0.00	0.00	0.00	0.00	1.48	0.00
21	Raised bog	0.00	0.00	0.00	0.00	0.00	1.19	0.00
20/21W	Worked peat	0.00	0.00	0.04	0.00	0.00	1.19	0.00
22	Marginal inundations	0.00	0.00	0.00	0.00	0.63	0.16	0.00
23	Coastal marsh	3.08	0.00	0.00	0.00	0.00	0.00	1.73
24	Wet ground	0.02	0.00	0.94	13.10	0.80	5.09	0.00
25	Standing natural water	0.11	0.00	0.08	0.00	4.80	11.01	0.00
26	Standing man-made water	0.60	0.00	0.01	0.00	0.00	0.00	0.00
27A	Running natural water (area)	0.28	0.05	0.48	3.80	0.15	0.17	1.40
27L	Running natural water (length km)	0.39	0.11	0.72	3.85	0.56	0.64	0.65
28A	Running canalised water (area)	0.14	0.30	0.38	0.10	0.25	0.50	0.07
28L	Running canalised water (length km)	0.67	1.92	1.55	0.36	1.08	2.34	0.16
29	Upland unimproved grassland	0.00	0.00	0.00	0.00	0.00	5.97	0.00
30	Lowland unimproved grassland	6.26	11.23	3.41	29.55	3.50	13.87	4.23
31	Semi-improved grassland	12.80	13.90	13.03	11.65	16.80	15.67	24.60
32	Improved grassland	13.80	32.55	51.23	26.95	53.22	10.96	11.20
33 TOT	Arable (total)	1.49	13.80	19.32	2.60	15.60	7.08	1.20
33B	Arable (seedcrops)	1.38	11.45	12.07	2.60	3.53	1.88	0.00
33R	Arable (rootcrops)	0.11	0.13	1.19	0.00	0.30	1.16	0.00
33G	Arable (grassland leys)	0.00	1.10	3.17	0.00	11.05	3.05	0.00
33H	Arable (horticultural)	0.00	0.58	1.60	0.00	0.00	0.00	0.00

APPENDIX 12 contd.

	Landclass	8	9	10	11	12	13	14
34	Amenity grasslands	5.39	3.63	1.35	0.00	0.00	0.44	0.00
35	Unquarried inland cliffs	0.17	0.00	0.00	0.00	0.00	0.00	0.00
36	Vertical coastal cliffs	0.03	0.00	0.00	0.00	0.00	0.00	0.00
37	Sloping coastal cliffs	0.18	0.00	0.07	0.00	0.00	0.00	0.00
38	Quarries and open-cast mines	0.22	0.00	0.00	0.00	0.00	0.00	0.03
39	Bare ground	0.00	0.00	0.00	0.00	0.00	1.18	0.00
40	Built land area (excl. roads)	5.88	20.40	2.15	2.00	1.40	0.74	2.15
41A	Roads (area)	1.75	3.13	1.67	2.30	1.85	1.41	1.45
41L	Roads (length km)	1.86	2.80	2.20	3.64	2.63	2.48	2.91
40/41-TOT	Total built land (roads and built land)	10.99	23.52	3.82	4.30	3.25	9.35	11.13
42	Sea	14.76	0.00	0.00	0.00	0.00	0.00	18.40
OTHER	Unspecified	0.28	0.55	0.03	0.00	0.00	0.01	0.53
TOTAL	Total area calculated (mean)	100.02	100.07	99.97	100.05	100.05	100.04	100.10
	sum area sea, lake and shores	16.90	0.00	0.14	0.00	4.80	11.01	18.40
	Sample size	12	4	12	2	4	10	3
	Principal habitat groups							
	total hedge and treeline (km)	2.72	11.00	6.40	5.67	4.59	2.68	3.59
	total scrub length (km)	0.82	0.10	0.21	0.00	0.00	0.69	0.50
	total hedge, treeline and boundary scrub (km)	3.54	11.10	6.61	5.67	4.59	3.37	4.09
	total hedgerow/treeline area (est. 2.5 m wide)	0.68	2.19	1.60	1.42	1.15	0.67	0.83
	total hedgerow/treeline/scrub area	3.40	2.39	2.06	7.12	1.50	7.02	2.87
	total grasslands (29-32)	32.86	57.67	67.67	68.15	73.53	46.47	40.03
	total grazing and arable (29-33)	34.35	71.47	86.98	70.75	89.13	53.55	41.23
	total woodland (3-9)	2.32	0.35	4.10	2.30	0.30	7.67	0.97
	total peat areas (20,21,20/21W)	0.00	0.00	0.04	0.00	0.00	3.86	0.00
	total peat, moorland and lowland heath	0.02	0.00	0.42	0.00	0.00	4.52	0.00
	hedgerow area/area grazing and arable	0.0198	0.0306	0.0184	0.0200	0.0129	0.0125	0.0203
	hedge/scrub area/area grazing and arable	0.0991	0.0334	0.0237	0.1006	0.0168	0.1311	0.0696
	hedge/treeline (km) density per unit grass/arable	0.0791	0.1539	0.0736	0.0801	0.0514	0.0500	0.0871
	hedge/treeline/scrub (km) density per unit grass/arable	0.1031	0.1553	0.0760	0.0801	0.0514	0.0629	0.0991

APPENDIX 12 contd.

	Landclass	15	16	17	18	19	20	21
1	Hedgerow length (km)	4.20	5.30	5.49	1.93	1.27	3.24	0.93
2	Treeline length (km)	0.53	0.86	0.64	0.24	0.11	1.22	0.09
2B	Bare treeline length (km)	0.00	0.01	0.03	0.03	0.02	0.08	0.05
3	Semi-natural broad-leaved woodland	0.12	1.00	0.38	0.20	0.00	0.29	2.64
4	Broad-leaved plantation	0.00	0.55	0.15	0.04	0.02	0.01	0.08
5	Semi-natural coniferous woodland	0.00	0.04	0.09	0.02	0.00	0.00	0.00
6	Coniferous plantation	7.19	3.11	2.45	5.41	18.63	1.40	2.38
6Y	Young coniferous plantation	6.85	0.51	1.13	2.74	9.49	1.13	0.29
7	Semi-natural mixed woodland	0.00	0.56	0.00	0.01	0.00	0.00	0.00
8	Mixed plantation	0.15	0.00	0.01	0.00	0.00	0.00	0.00
9	Young mixed or broad-leaved plantation	0.43	0.00	0.02	0.00	0.00	0.00	0.00
10	Recently felled woodland	0.00	0.00	0.00	0.00	0.53	0.00	0.00
11	Parkland	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12A	Tall scrub (area)	0.83	0.58	1.05	0.61	0.31	1.35	0.79
12L	Tall scrub (length km)	0.04	0.14	0.04	0.05	0.21	0.45	0.06
13A	Low scrub (area)	2.30	2.93	2.40	1.58	1.66	2.46	1.53
13L	Low scrub (length km)	0.26	0.40	0.69	0.47	0.60	1.11	0.51
14	Bracken	0.09	0.04	0.64	0.40	0.07	1.17	1.23
15	Coastal sand dunes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Coastal sand or mudflats	0.00	0.00	0.00	0.00	0.00	0.11	0.00
17	Coastal shingle or boulder beaches	0.00	0.00	0.13	0.32	0.00	0.00	0.00
18	Lowland heath	1.42	1.68	0.37	1.21	0.79	0.13	0.00
19	Heather moorland	1.92	2.52	0.79	32.14	21.05	11.25	23.62
20	Blanket bog	1.72	1.18	1.94	8.62	11.98	10.79	41.63
21	Raised bog	0.00	3.81	2.52	3.48	7.21	2.47	0.00
20/21W	Worked peat	0.00	0.71	0.16	0.24	0.00	1.60	0.00
22	Marginal inundations	0.04	0.64	0.11	0.22	0.00	0.00	0.00
23	Coastal marsh	0.00	0.00	0.00	0.00	0.00	0.02	0.00
24	Wet ground	1.21	0.98	2.45	0.83	1.13	0.13	0.38
25	Standing natural water	0.03	6.02	0.85	0.36	1.97	1.50	0.68
26	Standing man-made water	0.14	0.00	0.01	0.00	0.00	0.27	0.00
27A	Running natural water (area)	0.79	0.92	0.35	0.92	0.34	0.67	0.31
27L	Running natural water (length km)	1.16	0.63	0.74	1.10	1.18	1.83	1.86
28A	Running canalised water (area)	0.72	0.31	0.28	0.16	0.14	0.14	0.03
28L	Running canalised water (length km)	2.49	1.23	1.17	0.68	0.88	0.44	0.36
29	Upland unimproved grassland	12.58	0.00	3.65	9.39	8.46	7.27	8.91
30	Lowland unimproved grassland	6.18	10.94	8.72	3.53	6.42	18.06	0.13
31	Semi-improved grassland	23.06	13.25	26.83	11.13	4.39	15.71	7.04
32	Improved grassland	24.38	35.19	31.69	9.16	2.69	14.19	4.68
33 TOT	Arable (total)	2.28	7.58	4.57	0.11	0.12	2.57	0.04
33B	Arable (seedcrops)	0.69	1.68	1.15	0.08	0.00	2.45	0.00
33R	Arable (rootcrops)	0.35	0.58	0.61	0.03	0.04	0.12	0.04
33G	Arable (grassland leys)	0.24	1.20	1.45	0.00	0.00	0.00	0.00
33H	Arable (horticultural)	0.00	0.11	0.43	0.00	0.00	0.00	0.00

APPENDIX 12 contd.

	Landclass	15	16	17	18	19	20	21
34	Amenity grasslands	0.18	0.36	0.29	0.02	0.00	0.00	0.00
35	Unquarried inland cliffs	0.72	0.00	0.00	0.27	0.00	0.00	0.27
36	Vertical coastal cliffs	0.00	0.00	0.00	0.35	0.00	0.00	0.00
37	Sloping coastal cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	Quarries and open-cast mines	0.07	0.12	0.01	0.63	0.00	0.06	0.00
39	Bare ground	1.91	0.00	0.24	0.44	1.80	2.01	2.37
40	Built land area (excl. roads)	1.07	1.94	1.35	0.35	0.16	1.53	0.13
41A	Roads (area)	1.35	1.60	1.79	0.78	0.64	1.73	0.87
41L	Roads (length km)	1.95	2.25	2.46	1.20	0.91	2.23	1.33
40/41-TOT	Total built land (roads and built land)	2.48	3.54	3.13	1.13	0.80	3.25	0.99
42	Sea	0.00	0.00	2.54	4.23	0.00	0.00	0.00
OTHER	Unspecified	0.26	0.95	0.09	0.13	0.00	0.06	0.00
TOTAL	Total area calculated (mean)	100.05	100.01	100.04	100.04	100.01	100.06	100.03
	sum area sea, lake and shores	0.17	6.02	3.40	4.59	2.50	1.77	0.68
	Sample size	12	17	75	33	34	15	12
	Principal habitat groups							
	total hedge and treeline (km)	4.73	6.17	6.16	2.20	1.40	4.54	1.07
	total scrub length (km)	0.30	0.54	0.72	0.52	0.81	1.56	0.57
	total hedge, treeline and boundary scrub (km)	5.02	6.71	6.88	2.72	2.21	6.10	1.64
	total hedgerow/treeline area (est. 2.5 m wide)	1.18	1.54	1.53	0.54	0.34	1.12	0.25
	total hedgerow/treeline/scrub area	4.32	5.05	4.97	2.73	2.32	4.92	2.58
	total grasslands (29-32)	66.21	59.38	70.88	33.22	21.96	55.23	20.76
	total grazing and arable (29-33)	68.49	66.95	75.46	33.32	22.09	57.79	20.80
	total woodland (3-9)	14.74	5.78	4.22	8.43	28.14	2.84	5.40
	total peat areas (20,21,20/21W)	1.72	5.71	4.62	12.34	19.19	14.86	41.63
	total peat, moorland and lowland heath	5.06	9.91	5.78	45.68	41.03	26.23	65.24
	hedgerow area/area grazing and arable	0.0173	0.0230	0.0203	0.0163	0.0156	0.0193	0.0122
	hedge/scrub area/area grazing and arable	0.0630	0.0754	0.0659	0.0820	0.1052	0.0852	0.1240
	hedge/treeline (km) density per unit grass/arable	0.0690	0.0921	0.0816	0.0661	0.0635	0.0786	0.0514
	hedge/treeline/scrub (km) density per unit grass/arable	0.0733	0.1002	0.0912	0.0816	0.1003	0.1056	0.0786

APPENDIX 12 contd.

	Landclass	22	23	24	25	26	27	28
1	Hedgerow length (km)	1.43	0.00	0.02	5.98	6.06	8.76	1.57
2	Treeline length (km)	0.08	0.00	0.00	1.46	0.70	0.00	0.28
2B	Bare treeline length (km)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Semi-natural broad-leaved woodland	0.00	0.00	0.00	0.05	0.67	0.00	0.00
4	Broad-leaved plantation	0.00	0.00	0.00	0.00	0.00	0.00	0.13
5	Semi-natural coniferous woodland	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Coniferous plantation	12.37	0.00	0.83	1.00	0.23	0.00	9.98
6Y	Young coniferous plantation	6.59	0.00	1.51	0.00	0.40	0.00	0.88
7	Semi-natural mixed woodland	0.26	0.00	0.00	0.00	0.03	0.00	0.00
8	Mixed plantation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Young mixed or broad-leaved plantation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Recently felled woodland	1.52	0.00	0.00	0.00	0.00	0.00	0.00
11	Parkland	0.00	0.00	0.00	0.00	0.00	2.50	0.00
12A	Tall scrub (area)	0.09	0.00	0.00	0.00	0.17	1.20	2.35
12L	Tall scrub (length km)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13A	Low scrub (area)	2.09	0.00	0.00	2.02	1.57	0.00	6.60
13L	Low scrub (length km)	0.40	0.00	0.00	0.76	0.18	0.00	0.40
14	Bracken	0.10	0.00	2.34	0.00	0.00	0.00	1.13
15	Coastal sand dunes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Coastal sand or mudflats	0.00	0.00	0.00	0.00	0.00	0.00	1.03
17	Coastal shingle or boulder beaches	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	Lowland heath	6.27	0.00	1.31	0.00	0.00	0.00	7.00
19	Heather moorland	38.09	67.63	32.42	0.00	0.00	0.00	0.00
20	Blanket bog	4.99	0.00	28.64	0.00	0.00	0.00	4.48
21	Raised bog	0.69	0.00	0.00	1.32	0.00	0.00	0.00
20/21W	Worked peat	0.00	0.00	0.00	0.83	0.00	0.00	3.68
22	Marginal inundations	0.04	0.00	0.00	0.00	0.00	0.00	0.18
23	Coastal marsh	0.00	0.00	0.00	0.00	0.00	0.00	0.58
24	Wet ground	0.49	0.00	0.03	1.02	2.40	0.00	7.43
25	Standing natural water	4.86	0.57	0.22	0.13	0.07	0.00	0.10
26	Standing man-made water	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27A	Running natural water (area)	0.40	0.07	0.07	0.85	1.07	0.20	0.00
27L	Running natural water (length km)	1.01	0.82	1.03	0.86	0.92	0.18	0.12
28A	Running canalised water (area)	0.02	0.03	0.01	0.87	0.20	0.00	0.28
28L	Running canalised water (length km)	0.05	0.17	0.12	3.23	0.41	0.00	1.13
29	Upland unimproved grassland	5.07	0.00	16.57	0.00	0.00	0.00	0.00
30	Lowland unimproved grassland	6.48	0.00	0.95	9.82	0.23	0.00	4.98
31	Semi-improved grassland	4.44	24.67	1.74	10.80	1.07	0.00	16.50
32	Improved grassland	4.16	1.73	0.25	36.97	56.60	78.50	24.58
33 TOT	Arable (total)	0.00	0.00	0.00	31.48	30.80	11.90	5.03
33B	Arable (seedcrops)	0.00	0.00	0.00	17.70	20.47	5.80	1.03
33R	Arable (rootcrops)	0.00	0.00	0.00	1.87	9.67	6.10	0.13
33G	Arable (grassland leys)	0.00	0.00	0.00	11.82	0.57	0.00	0.00
33H	Arable (horticultural)	0.00	0.00	0.00	0.00	0.10	0.00	0.48

APPENDIX 12 contd.

	Landclass	22	23	24	25	26	27	28
34	Amenity grasslands	0.00	0.00	0.00	0.00	1.23	0.00	0.28
35	Unquarried inland cliffs	0.00	0.00	5.90	0.00	0.00	0.00	0.00
36	Vertical coastal cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	Sloping coastal cliffs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	Quarries and open-cast mines	0.40	0.00	0.05	0.07	0.00	1.60	0.00
39	Bare ground	0.00	4.90	6.85	0.00	0.17	0.00	0.20
40	Built land area (excl. roads)	0.14	0.03	0.03	0.87	1.47	0.50	1.23
41A	Roads (area)	0.50	0.33	0.27	1.98	1.63	3.20	1.53
41L	Roads (length km)	0.96	0.67	0.37	2.33	1.84	3.35	2.35
40/41-TOT	Total built land (roads and built land)	0.64	0.37	0.30	2.85	3.10	3.70	2.75
42	Sea	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER	Unspecified	0.00	0.00	0.00	0.03	0.00	0.40	0.00
TOTAL	Total area calculated (mean)	100.04	99.97	100.01	100.10	100.00	100.00	100.07
	sum area sea, lake and shores	6.38	0.57	0.22	0.13	0.07	2.50	0.10
	Sample size	9	3	21	6	3	1	4
	Principal habitat groups							
	total hedge and treeline (km)	1.50	0.00	0.02	7.44	6.76	8.76	1.85
	total scrub length (km)	0.40	0.00	0.00	0.76	0.18	0.00	0.40
	total hedge, treeline and boundary scrub (km)	1.91	0.00	0.02	8.19	6.94	8.76	2.24
	total hedgerow/treeline area (est. 2.5 m wide)	0.38	0.00	0.01	1.86	1.69	2.19	0.46
	total hedgerow/treeline/scrub area	2.55	0.00	0.01	3.88	3.42	3.39	9.41
	total grasslands (29-32)	20.14	26.40	19.51	57.58	57.90	78.50	46.05
	total grazing and arable (29-33)	20.14	26.40	19.51	89.07	88.70	90.40	51.08
	total woodland (3-9)	19.21	0.00	2.34	1.05	1.33	0.00	10.98
	total peat areas (20,21,20/21W)	5.68	0.00	28.64	2.15	0.00	0.00	8.15
	total peat, moorland and lowland heath	50.03	67.63	62.38	2.15	0.00	0.00	15.15
	hedgerow area/area grazing and arable	0.0186	0.0000	0.0003	0.0209	0.0191	0.0242	0.0090
	hedge/scrub area/area grazing and arable	0.1268	0.0000	0.0003	0.0435	0.0386	0.0375	0.1843
	hedge/treeline (km) density per unit grass/arable	0.0746	0.0000	0.0012	0.0835	0.0762	0.0969	0.0361
	hedge/treeline/scrub (km) density per unit grass/arable	0.0946	0.0000	0.0012	0.0920	0.0783	0.0969	0.0439

APPENDIX 12 contd.

	Landclass	29	30	31	32
1	Hedgerow length (km)	0.00	0.27	0.06	0.32
2	Treeline length (km)	0.00	0.08	0.04	0.13
2B	Bare treeline length (km)	0.00	0.06	0.01	0.00
3	Semi-natural broad-leaved woodland	0.00	0.23	0.00	0.00
4	Broad-leaved plantation	0.00	0.03	0.00	0.00
5	Semi-natural coniferous woodland	0.00	0.00	0.00	0.01
6	Coniferous plantation	0.00	0.97	0.00	0.93
6Y	Young coniferous plantation	0.00	0.00	0.00	4.53
7	Semi-natural mixed woodland	0.00	0.00	0.00	0.00
8	Mixed plantation	0.00	0.00	0.00	0.00
9	Young mixed or broad-leaved plantation	0.00	0.03	0.00	0.00
10	Recently felled woodland	0.00	0.00	0.00	0.00
11	Parkland	0.00	0.00	0.00	0.00
12A	Tall scrub (area)	0.00	1.29	0.10	0.31
12L	Tall scrub (length km)	0.00	0.04	0.00	0.09
13A	Low scrub (area)	0.00	2.79	1.15	1.27
13L	Low scrub (length km)	0.00	0.95	0.59	0.25
14	Bracken	0.00	1.94	0.16	0.19
15	Coastal sand dunes	0.00	0.92	0.00	0.00
16	Coastal sand or mudflats	0.90	0.69	0.00	0.28
17	Coastal shingle or boulder beaches	8.95	2.90	4.55	0.00
18	Lowland heath	0.00	0.07	1.59	1.79
19	Heather moorland	0.00	7.94	6.62	8.17
20	Blanket bog	0.00	26.47	1.24	38.72
21	Raised bog	0.00	0.00	0.00	6.43
20/21W	Worked peat	0.00	0.00	0.00	12.19
22	Marginal inundations	0.00	0.00	0.00	0.00
23	Coastal marsh	0.00	0.08	0.00	0.08
24	Wet ground	0.00	2.92	0.67	0.33
25	Standing natural water	0.00	0.42	0.95	2.49
26	Standing man-made water	0.00	0.00	0.00	0.00
27A	Running natural water (area)	0.00	0.31	0.02	0.60
27L	Running natural water (length km)	0.00	0.87	0.20	1.08
28A	Running canalised water (area)	0.00	0.00	0.01	0.21
28L	Running canalised water (length km)	0.00	0.14	0.35	1.36
29	Upland unimproved grassland	0.00	0.60	15.75	4.09
30	Lowland unimproved grassland	4.70	8.29	4.29	4.69
31	Semi-improved grassland	1.45	0.92	9.62	3.83
32	Improved grassland	0.00	0.00	0.60	3.06
33 TOT	Arable (total)	0.35	0.01	0.68	1.03
33B	Arable (seedcrops)	0.00	0.00	0.23	0.15
33R	Arable (rootcrops)	0.35	0.01	0.11	0.01
33G	Arable (grassland leys)	0.00	0.00	0.34	0.59
33H	Arable (horticultural)	0.00	0.00	0.00	0.00

APPENDIX 12 contd.

	Landclass	29	30	31	32
34	Amenity grasslands	0.00	0.12	0.00	0.10
35	Unquarried inland cliffs	0.00	0.00	0.22	0.00
36	Vertical coastal cliffs	0.25	0.56	0.65	0.00
37	Sloping coastal cliffs	0.00	0.13	0.15	0.00
38	Quarries and open-cast mines	0.00	0.00	0.00	0.01
39	Bare ground	0.00	3.50	0.49	2.15
40	Built land area (excl. roads)	0.10	0.69	0.43	0.45
41A	Roads (area)	0.15	0.79	0.62	1.01
41L	Roads (length km)	0.28	1.26	0.93	1.23
40/41-TOT	Total built land (roads and built land)	0.25	1.48	1.05	1.47
42	Sea	83.20	34.39	49.43	1.01
OTHER	Unspecified	0.00	0.00	0.04	0.01
TOTAL	Total area calculated (mean)	100.05	100.01	100.01	99.99
	sum area sea, lake and shores	83.20	34.81	50.37	3.50
	Sample size	2	9	11	35
	Principal habitat groups				
	total hedge and treeline (km)	0.00	0.41	0.11	0.45
	total scrub length (km)	0.00	0.99	0.59	0.33
	total hedge, treeline and boundary scrub (km)	0.00	1.40	0.69	0.79
	total hedgerow/treeline area (est. 2.5 m wide)	0.00	0.09	0.02	0.11
	total hedgerow/treeline/scrub area	0.00	4.17	1.27	1.69
	total grasslands (29-32)	6.15	9.81	30.25	15.67
	total grazing and arable (29-33)	6.50	9.82	30.94	16.70
	total woodland (3-9)	0.00	1.27	0.00	5.48
	total peat areas (20,21,20/21W)	0.00	26.47	1.24	57.35
	total peat, moorland and lowland heath	0.00	34.48	9.45	67.31
	hedgerow area/area grazing and arable	0.0000	0.0089	0.0008	0.0068
	hedge/scrub area/area grazing and arable	0.0000	0.4241	0.0410	0.1012
	hedge/treeline (km) density per unit grass/arable	0.0000	0.0416	0.0034	0.0272
	hedge/treeline/scrub (km) density per unit grass/arable	0.0000	0.1426	0.0224	0.0472

APPENDIX 13

Estimates of land use by stock type, by landclass. Given by ***mean area (ha km^{-2})*** *of land used by stock type. Percentages are given of land utilised for cattle grazing over the total grazing land assessed.* ***Data is not corrected for sea, lake and shores.***

Landclass	1	2	3	4	5	6	7
Mean land area utilised for grazing - ha km^{-2}; all habitat categories							
Cattle	46.22	28.68	34.13	34.28	38.22	41.74	11.37
Sheep	10.73	8.85	1.53	9.35	8.14	10.20	4.74
Cattle and sheep	6.41	4.33	3.73	3.55	4.04	10.26	0.15
Other	1.74	1.49	0.53	1.78	1.58	1.48	1.13
Total land with cattle grazing on it	52.63	33.00	37.87	37.83	42.26	52.00	11.52
Overall total grazing land	65.09	43.34	39.93	48.95	51.98	63.68	17.39
percentage of total with cattle grazing	80.8	76.2	94.8	77.3	81.3	81.7	66.2
Mean land area utilised for grazing in specified 'grazing ' habitats (see text)							
Cattle	45.89	28.68	32.75	34.28	38.22	41.58	11.21
Sheep	10.63	8.85	1.53	9.35	8.14	10.20	4.63
Cattle and sheep	6.38	4.33	3.73	3.55	4.04	10.26	0.15
Other	1.74	1.49	0.53	1.78	1.58	1.13	1.13
Total land with cattle grazing on it	52.27	33.00	36.48	37.83	42.26	51.84	11.36
Overall total grazing land	64.64	43.34	38.55	48.95	51.98	63.17	17.13
percentage of total with cattle grazing	80.9	76.2	94.6	77.3	81.3	82.1	66.3
Total area undesignated in specific 'grazing' habitats							
Total undesignated	23.94	34.63	55.27	17.98	31.49	23.94	13.17
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	44.10	27.22	21.85	31.45	36.24	39.34	10.69
Sheep	9.90	6.81	1.43	9.35	7.34	9.53	4.41
Cattle and sheep	6.25	4.33	0.53	2.35	3.83	9.88	0.15
Other	1.73	1.49	0.53	1.78	1.58	0.90	1.13
Total land with cattle grazing on it	50.35	31.55	22.38	33.80	40.07	49.22	10.84
Overall total grazing land	61.99	39.85	24.35	44.93	48.99	59.65	16.38
percentage of total with cattle grazing	81.2	79.2	91.9	75.2	81.8	82.5	66.2
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	13.77	18.15	3.67	8.23	16.27	16.25	6.10
Total area of land grazed in arable land (including grass leys)							
Cattle	1.29	1.15	10.90	2.83	1.52	1.98	0.52
Sheep	0.67	2.03	0.10	0.00	0.27	0.60	0.23
Cattle and sheep	0.09	0.00	3.20	1.20	0.21	0.35	0.00
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	2.05	3.18	14.20	4.03	2.00	2.92	0.74

APPENDIX 13 contd.

Landclass	8	9	10	11	12	13	14
Mean land area utilised for grazing - ha km^{-2}; all habitat categories							
Cattle	10.87	68.80	32.03	33.35	21.77	28.31	28.47
Sheep	5.06	8.95	14.12	29.00	0.00	4.94	2.17
Cattle and sheep	7.43	0.00	3.89	0.00	0.00	6.93	6.40
Other	0.14	0.00	2.55	1.90	1.30	0.18	0.00
Total land with cattle grazing on it	18.29	68.80	35.92	33.35	21.77	35.24	34.87
Overall total grazing land	23.49	77.75	52.59	64.25	23.07	40.36	37.03
percentage of total with cattle grazing	77.9	88.5	68.3	51.9	94.4	87.3	94.1
Mean land area utilised for grazing in specified 'grazing ' habitats (see text)							
Cattle	10.87	68.80	32.03	33.35	21.77	27.38	28.47
Sheep	5.06	8.95	13.54	29.00	0.00	4.71	2.17
Cattle and sheep	4.14	0.00	3.89	0.00	0.00	6.93	6.40
Other	0.14	0.00	2.55	1.90	1.30	0.18	0.00
Total land with cattle grazing on it	15.01	68.80	35.92	33.35	21.77	34.31	34.87
Overall total grazing land	20.21	77.75	52.01	64.25	23.07	39.20	37.03
percentage of total with cattle grazing	74.3	88.5	69.1	51.9	94.4	87.5	94.1
Total area undesignated in specific 'grazing' habitats							
Total undesignated	15.61	10.15	35.41	19.60	72.33	22.77	4.20
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	10.87	68.80	30.11	33.35	20.83	27.38	28.47
Sheep	5.06	8.95	13.54	29.00	0.00	4.32	2.17
Cattle and sheep	3.01	0.00	3.89	0.00	0.00	6.93	6.40
Other	0.14	0.00	2.55	1.90	1.30	0.18	0.00
Total land with cattle grazing on it	13.87	68.80	34.00	33.35	20.83	34.31	34.87
Overall total grazing land	19.07	77.75	50.09	64.25	22.13	38.81	37.03
percentage of total with cattle grazing	72.7	88.5	67.9	51.9	94.1	88.4	94.1
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	13.78	-0.10	14.81	3.90	51.53	7.66	3.00
Total area of land grazed in arable land (including grass leys)							
Cattle	0.00	0.00	0.89	0.00	0.93	0.00	0.00
Sheep	0.00	0.00	0.00	0.00	0.00	0.26	0.00
Cattle and sheep	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	0.00	0.00	0.89	0.00	0.93	0.26	0.00

APPENDIX 13 contd.

Landclass	15	16	17	18	19	20	21
Mean land area utilised for grazing - ha km^{-2}; all habitat categories							
Cattle	28.38	39.29	45.51	15.98	12.69	23.80	9.98
Sheep	18.63	8.96	6.74	31.85	24.29	27.12	41.65
Cattle and sheep	5.68	3.34	13.16	13.12	1.55	10.08	17.59
Other	0.35	1.06	0.29	1.47	0.20	0.00	0.00
Total land with cattle grazing on it	34.06	42.63	58.67	29.10	14.24	33.88	27.57
Overall total grazing land	53.04	52.66	65.70	62.42	38.73	60.99	69.23
percentage of total with cattle grazing	64.2	81.0	89.3	46.6	36.8	55.5	39.8
Mean land area utilised for grazing in specified 'grazing ' habitats (see text)							
Cattle	28.38	39.29	45.20	15.58	12.69	23.80	9.65
Sheep	18.63	8.96	6.66	31.63	22.85	27.04	37.61
Cattle and sheep	5.68	3.34	13.15	12.91	1.55	10.02	17.23
Other	0.35	1.06	0.27	1.47	0.20	0.00	0.00
Total land with cattle grazing on it	34.06	42.63	58.35	28.50	14.24	33.82	26.87
Overall total grazing land	53.04	52.66	65.29	61.60	37.29	60.86	64.48
percentage of total with cattle grazing	64.2	81.0	89.4	46.3	38.2	55.6	41.7
Total area undesignated in specific 'grazing' habitats							
Total undesignated	19.30	25.46	18.09	17.00	24.41	22.77	20.74
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	27.44	38.34	43.05	14.83	11.12	23.80	4.62
Sheep	18.63	5.91	6.30	7.87	6.01	15.42	8.24
Cattle and sheep	5.39	3.00	11.74	6.46	1.55	6.53	5.92
Other	0.35	0.31	0.27	0.62	0.02	0.00	0.00
Total land with cattle grazing on it	32.83	41.34	54.78	21.29	12.67	30.33	10.54
Overall total grazing land	51.81	47.55	61.35	29.77	18.70	45.74	18.77
percentage of total with cattle grazing	63.4	86.9	89.3	71.5	67.8	66.3	56.1
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	14.55	11.22	8.69	4.18	5.39	8.58	3.87
Total area of land grazed in arable land (including grass leys)							
Cattle	0.00	0.96	0.93	0.00	0.00	0.00	0.00
Sheep	0.00	0.00	0.01	0.05	0.00	0.00	0.00
Cattle and sheep	0.29	0.34	0.14	0.00	0.00	0.00	0.00
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	0.29	1.29	1.08	0.05	0.00	0.00	0.00

APPENDIX 13 contd.

Landclass	**22**	**23**	**24**	**25**	**26**	**27**	**28**
Mean land area utilised for grazing - ha km^{-2}; all habitat categories							
Cattle	8.61	0.00	5.32	59.98	39.50	78.50	35.92
Sheep	47.21	61.93	48.63	0.64	2.57	0.00	3.75
Cattle and sheep	0.96	2.77	7.32	5.00	10.03	0.00	2.15
Other	0.00	0.00	0.00	0.96	5.73	0.00	0.00
Total land with cattle grazing on it	9.57	2.77	12.64	64.98	49.53	78.50	38.08
Overall total grazing land	56.78	64.70	61.27	66.58	57.83	78.50	41.83
percentage of total with cattle grazing	16.8	4.3	20.6	97.6	85.6	100.0	91.0
Mean land area utilised for grazing in specified 'grazing ' habitats (see text)							
Cattle	8.61	0.00	3.35	59.98	39.50	78.50	35.92
Sheep	47.21	61.93	48.63	0.64	1.33	0.00	3.75
Cattle and sheep	0.96	2.77	7.32	5.00	10.03	0.00	2.15
Other	0.00	0.00	0.00	0.96	5.73	0.00	0.00
Total land with cattle grazing on it	9.57	2.77	10.67	64.98	49.53	78.50	38.08
Overall total grazing land	56.78	64.70	59.30	66.58	56.60	78.50	41.83
percentage of total with cattle grazing	16.8	4.3	18.0	97.6	87.5	100.0	91.0
Total area undesignated in specific 'grazing' habitats							
Total undesignated	13.89	29.33	22.62	25.32	34.50	14.40	28.15
Total area of grazing recorded on pastures only (habitats 29-32)							
Cattle	6.61	0.00	2.70	48.70	39.50	78.50	35.65
Sheep	11.28	22.17	9.58	0.56	1.33	0.00	3.75
Cattle and sheep	0.96	2.77	1.96	0.92	10.03	0.00	2.15
Other	0.00	0.00	0.00	0.96	5.73	0.00	0.00
Total land with cattle grazing on it	7.57	2.77	4.67	49.62	49.53	78.50	37.80
Overall total grazing land	18.84	24.93	14.25	51.14	56.60	78.50	41.55
percentage of total with cattle grazing	40.2	11.1	32.8	97.0	87.5	100.0	91.0
Total area undesignated in pasture lands only (habitats 29-32)							
Total undesignated	1.30	1.47	5.27	1.82	1.30	0.00	4.50
Total area of land grazed in arable land (including grass leys)							
Cattle	0.00	0.00	0.00	11.28	0.00	0.00	0.00
Sheep	0.00	0.00	0.00	0.08	0.00	0.00	0.00
Cattle and sheep	0.00	0.00	0.00	4.08	0.00	0.00	0.00
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall total grazing land	0.00	0.00	0.00	15.44	0.00	0.00	0.00

APPENDIX 13 contd.

Landclass	29	30	31	32
Mean land area utilised for grazing - ha km^{-2}; all habitat categories				
Cattle	1.55	21.67	15.51	6.31
Sheep	3.85	20.42	19.49	22.71
Cattle and sheep	0.00	3.31	7.44	16.99
Other	0.00	0.07	0.00	0.01
Total land with cattle grazing on it	1.55	24.98	22.95	23.30
Overall total grazing land	5.40	45.47	42.44	46.02
percentage of total with cattle grazing	28.7	54.9	54.1	50.6
Mean land area utilised for grazing in specified 'grazing ' habitats (see text)				
Cattle	1.55	20.66	15.18	6.27
Sheep	3.85	18.84	19.36	22.67
Cattle and sheep	0.00	1.93	7.44	16.99
Other	0.00	0.07	0.00	0.01
Total land with cattle grazing on it	1.55	22.59	22.61	23.26
Overall total grazing land	5.40	41.50	41.97	45.93
percentage of total with cattle grazing	28.7	54.4	53.9	50.6
Total area undesignated in specific 'grazing' habitats				
Total undesignated	1.10	5.72	2.23	26.73
Total area of grazing recorded on pastures only (habitats 29-32)				
Cattle	1.55	5.76	13.01	3.88
Sheep	3.85	0.67	13.51	3.89
Cattle and sheep	0.00	0.00	3.75	4.13
Other	0.00	0.00	0.00	0.01
Total land with cattle grazing on it	1.55	5.76	16.76	8.01
Overall total grazing land	5.40	6.42	30.28	11.91
percentage of total with cattle grazing	28.7	89.6	55.4	67.3
Total area undesignated in pasture lands only (habitats 29-32)				
Total undesignated	0.75	3.39	1.55	3.82
Total area of land grazed in arable land (including grass leys)				
Cattle	0.00	0.00	0.46	0.30
Sheep	0.00	0.00	0.00	0.00
Cattle and sheep	0.00	0.00	0.00	0.35
Others	0.00	0.00	0.00	0.00
Overall total grazing land	0.00	0.00	0.46	0.65

APPENDIX 14

Details of badger removal licence areas considered for study.

Licence No.	County	Surveys	Data inclusion?	Comments
101/92	Carlow	No WS survey No DVO results	Excluded	No surveys.
102/92	Carlow	WS survey DVO snaring		1 sett located. DVO reported no badger activity. Snaring in area confirmed survey.
130/93	Carlow	DVO survey and snaring	Excluded	Survey of 1km area appears incomplete. Cannot class setts and badger groups.
440/91	Cavan	WS survey No DVO results	Excluded	No snaring results.
441/91	Cavan	WS survey No DVO results	Excluded	No snaring results.
24/92	Clare	WS survey 2 DVO snarings		Some discrepancies re. sett size. Results based on two snarings.
23/92	Clare	WS survey 2 DVO snarings		Some discrepancies re. sett size. Results based on two snarings. One annexe sett blocked with stones.
568/91	Cork	No WS survey (report of badgers removed) No DVO snaring results	Excluded	Excluded because of prior disturbance.
569/91	Cork	No WS survey (report of badgers removed) No DVO snaring results	Excluded	Excluded because of prior disturbance.

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Licence No.	County	Surveys	Data inclusion?	Comments
574/91	Cork	WS survey DVO snaring		Lack of snaring intensity data. Badger data indicates snaring in February, March and April.
598/91	Cork	WS survey DVO snaring		Incomplete snaring data for 4 setts.
4/93	Cork	DVO survey only	Excluded	Inadequate sett data; prior snaring under previous licence (UCC project).
32/92	Donegal	WS survey DVO snaring		Some discrepancies in sett sizes. One disused main sett blocked.
130/91	Donegal	No WS survey (report that badgers disturbed) No DVO snaring results	Excluded	Excluded because of prior disturbance.
618/91	Donegal	WS survey DVO snaring		1 km^2 area contained no badgers. 3 outlier setts. Main sett nearby (no snaring data). One outlier sett blocked.
142/93	Donegal	DVO survey and snaring		Both groups disturbed and dug.
532/91	Galway	WS survey DVO snaring		Some discrepancies re. sett sizes. One outlier blocked; Ranger reports 2 badger removed from this sett some months ago (digging).
571/91	Galway	WS survey DVO snaring		Some discrepancies re. sett size. No snaring details for 2 of 4 setts (minor setts). Main sett disturbed by burning.

APPENDIX 14 contd.

Licence No.	County	Surveys	Data inclusion?	Comments
80/92	Kerry	WS survey DVO snaring		Few details of the badgers captured.
86/92	Kerry	DVO survey and snaring	Excluded	Inadequate snaring data and badger data. 1 sett bulldozed.
33/92	Kerry	DVO survey only		Some sett information lacking: data for one territory adequate. No data on sett disturbance.
85/92	Kildare	No WS survey No DVO snaring	Excluded	No WS staff available to conduct survey.
151/93	Kildare	No WS survey No DVO results	Excluded	No results received.
463/91	Kilkenny		Excluded	Badgers already removed under previous licence.
522/91	Kilkenny	WS survey 2 DVO snarings		Snaring information inadequate for validation and group size. Data on badgers captured adequate.
44/92	Kilkenny	WS survey 2 DVO snarings		Discrepancies in sett information. Results based on 2 snarings.
107/92	Laois	WS survey DVO snaring		No snaring of main sett (DVO reported as inactive). Results adequate for 1 social group. Disused main sett was disturbed.
108/92	Laois	WS survey DVO snaring		2 snarings; sett disturbance and snares removed.
427/91	Leitrim		Excluded	Badgers removed under previous licence.

APPENDIX 14 contd.

Licence No.	County	Surveys	Data inclusion?	Comments
45/92	Leitrim	WS survey DVO snaring		Some confusion over sett locations and sizes.
46/92	Leitrim		Excluded	Badgers removed under previous licence.
57/92	Leitrim	WS survey	Excluded	Survey carried out too late in season: unreliable data.
177/92	Limerick	WS survey DVO snaring	Excluded	Inadequate snaring and badger data.
82/92	Limerick	WS survey No DVO snaring results	Excluded	Snared by DVO prior to WS survey. No DVO results submitted.
83/92	Limerick	WS survey DVO snaring	Excluded	Inadequate snaring and badger data. Badgers snared but no data submitted by DVO.
15/92	Longford	WS survey DVO snaring		Disturbance to setts confused results. No full group captured. High levels of disturbance and digging in area.
16/92	Longford	WS survey DVO snaring		-
166/92	Longford	No WS survey DVO survey and snaring		No WS survey organised. No data on disturbance.
575/91	Mayo	WS survey DVO snaring		Discrepancies in sett data. No data sheets for 2 (minor setts) of 4 setts.
610/91	Mayo	WS survey DVO snaring		Snaring effort below recommendation. Main disused sett had been dug years ago.

APPENDIX 14 contd.

Licence No.	County	Surveys	Data inclusion?	Comments
133/92	Mayo		Excluded	Badgers snared prior to WS survey.
31/93	Mayo	WS survey DVO snaring		2 setts destroyed. Snaring details inadequate for validation and group size. Data on badgers adequate.
140/93	Mayo	DVO survey and snaring		No weight data for badgers captured.
25/92	Meath	WS survey	Excluded	NO DVO snaring results for designated 1 km^2 area.
55/92	Meath		Excluded	Badgers already removed (unclear by whom).
A77/92	Monaghan	WS survey No DVO results	Excluded	No snaring results.
78/92	Monaghan		Excluded	Badgers already removed under previous licence.
120/92	Monaghan	WS survey	Excluded	No setts located in 1 km^2 area. No snaring data from DVO.
8/92	Offaly	WS survey 2 DVO snarings		Some sett discrepancies; some data confused. Based on 2 snarings. Snaring data inadequate for 1 group.
149/92	Offaly	No WS survey	Excluded	No WS staff available to conduct survey.
566/91	Roscommon	WS survey No full DVO snaring	Excluded	Setts bulldozed. No badgers in farm area.
569/91	Roscommon	WS survey DVO snaring		Some sett discrepancies. Some setts identified by DVO did not appear to exist.

APPENDIX 14 contd.

Licence No.	County	Surveys	Data inclusion?	Comments
89/92	Sligo	WS survey No DVO snaring	Excluded	Interference by farmers: no badger activity.
51/92	Sligo	WS survey DVO snaring		Too much disturbance by farmers/others. Setts disturbed by slurry and snares.
6/93	Sligo	DVO survey and snaring.	Excluded	DVO survey and snaring, but badgers not identified by sett location.
514/91	Tipperary	WS survey DVO snaring		Inadequate snaring information: 4 (minor setts) of 6 setts not snared. Setts marked by DVO apparently did not exist.
581/91	Tipperary	WS survey DVO snaring		Some sett discrepancies. One subsidiary snared.
112/93	Tipperary	DVO survey and snaring		Results for 1 social group of 2 adequate. No data for sett disturbance.
136/93	Tipperary	DVO survey and snaring	Excluded	Only 1 minor sett in square. Inadequate sett information and snaring results.
544/91	Waterford	WS survey DVO snaring		Disturbed main sett.
47/92	Waterford	WS survey DVO snaring		Disturbed main sett. No snaring intensity information.
202/92	Waterford	WS survey DVO snaring		No captures. No active setts according to DVO.
17/91	Westmeath	WS survey	Excluded	No active setts in square: no snaring.

APPENDIX 14 contd.

Licence No.	County	Surveys	Data inclusion?	Comments
18/91	Westmeath	WS survey DVO snaring		Snaring period 16 days.
596/91	Westmeath	WS survey DVO snaring		One main sett dug.
48/92	Wexford	WS survey DVO snaring		All setts were not snared. Results adequate for 1 of 2 social groups.
49/92	Wexford	WS survey	Excluded	No active setts located in 1 km^2 area. Sett marked by DVO apparently non-existent.
181/92	Wexford		Excluded	Adequate maps not available.
174/93	Wexford	DVO survey and snaring		Sett information inadequate. Data on badgers adequate.
515/91	Wicklow	WS survey No DVO snaring results	Excluded	No snaring results.
103/92	Wicklow	WS survey DVO snaring	Excluded	No active setts found in $1km^2$ area, possibly as a result of disturbance in previous years. Snaring inadequate due to difficulties of access.
197/92	Wicklow	No WS survey	Excluded	No WS staff available.

APPENDIX 15

Dates of survey and snaring periods for licence areas included in Table 22, with approximate intervals between survey and commencement of snaring. Summary data are given at the bottom of this appendix.

Licence	County	Survey	First snaring	Second snaring	Length of interval weeks approx-imately	Comments
102/92	Carlow	end April 1992	20th Jan. 1993		35	
24/92	Clare	Jan. 1992	March 1992		9	
				July 1992	26	The second interval is irrelevant as no badger groups found to have moved over the period
23/92	Clare	Jan. 1992	March 1992		9	
				June 1992	22	The second interval is irrelevant as no badger groups found to have moved over the period
574/91	Cork	Jan. 1992	Feb,March, April 1992		5	Snared over 3 months.
598/91	Cork	week 1 Jan. 1992	week 1 April 1992		13	
32/92	Donegal	week 2 Feb. 1992	March 1992		6	
618/91	Donegal	week 4 Feb. 1992	end March 1992		5	
142/93	Donegal	May 1993	May 1993			DVO survey and snaring.
532/91	Galway	week 4 Nov. 1991	week 1 Mar. 1992		15	
571/91	Galway	week 5 Nov. 1991	week 1 Mar. 1992		14	
80/92	Kerry	week 4 Mar. 1992	week 1 May 1992		7	
33/93	Kerry	April 1993	April 1993			DVO survey and snaring.

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Licence	County	Survey	First snaring	Second snaring	Length of interval weeks approx-imately	Comments
522/91	Kilkenny	week 2 Feb. 1992	week 1 April 1992		7	This licence not used for group assessment.
				week 4 Nov. 1992	41	
44/92	Kilkenny	week 5 Mar 1992	week 2 Oct. 1992		27	
				week 2 Jan 1993	48	
107/92	Laois	week 5 April 1992	week 4 April 1993		52	
108/92	Laois	week 5 April 1992	week 3 April 1993		50	First snaring attempt in October 1992 abandoned; snares disturbed.
45/92	Leitrim	week 1 Mar. 1993	week 1 April 1992		4	
15/92	Longford	week 2 Mar. 1992	week 1 May 1993		60	
16/92	Longford	week 1 Feb. 1992	week 2 Mar. 1992		5	
166/92	Longford					DVO survey and snaring.
575/91	Mayo	week 3 Feb. 1992	week 4 Mar. 1992		5	
610/91	Mayo	week 4 April 1992	week 1 Aug. 1992		14	
31/93	Mayo	April 1993	April 1993			DVO survey and snaring.
140/93	Mayo	June 1993	June 1993			DVO survey and snaring.
8/92	Offaly	week 1 Feb. 1992	week 3 Mar. 1992		6	

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Licence	County	Survey	First snaring	Second snaring	Length of interval weeks approx- imately		Comments
569/91	Roscommon	week 2 Jan. 1992	week 1 Mar. 1992		7		
A51/92	Sligo	week 3 Mar. 1992	week 2 May 1992		7		
514/91	Tipperary	week Jan. 1992	week 2 April 1992		13		
581/91	Tipperary	week 2 Jan 1992	week 2 Mar. 1992		9		
112/93	Tipperary	May 1993	May 1993				DVO survey and snaring.
544/91	Waterford	week 1 Feb. 1992	week 1 April 1992		9		
47/92	Waterford	week 5 May 1992	week 1 July 1992		5		
202/92	Waterford	week 5 Jan. 1992	Nov. 1992		43		
18/91	Westmeath	week 3 Dec. 1991	week 2 Mar. 1993		12		
596/91	Westmeath	week 1 Jan. 1993	week 2 May 1993		17		
48/92	Wexford	week 2 April 1992	week 4 June 1992		11		
174/93	Wexford	June 1993	June 1993				DVO survey and snaring.
Totals	**37**			**n**	**29**	**34**	
				overall mean (weeks)		**18.2**	
				mean excl. col. 2	**12.7**		

n.b. The mean excluding column 2 gives the usual interval of time between survey and snaring. For various reasons, some intervals were exceptionally long. The overall mean includes the data for these.

APPENDIX 16

Numbers of badgers captured, at each sett within the licence (badger removal) areas, with setts classed according to type. Sett sizes are also given, by the number of entrances.

The data given here is uncorrected for errors in classification (see text). In analyses, certain of the data required correction, as a result of the snaring results: these setts are indicated by ***. Other discrepancies are marked *, but these data were not considered to be appropriate for correction.

Licence	County	sett size	sett disturbed?	Active setts Main	Active setts Ann.	Active setts Sub.	Active setts Out.	Disused setts Main	Disused setts Ann.	Disused setts Sub.	Disused setts Out.	Comments
102/92	Carlow	7	N					0				
24/92	Clare	1	N				0					
		2	N				0					
		10	N	4								
		6	N		0							
		7	N			2						
		2	N				0					
		13	N	5								
		5	N		0							
		2	N			0						
		4	N			1						
		8	N	3								underestimate?
23/92	Clare	5	N	2								
		2	N			0						
		12	Y		0							
		1	Y				0					
		2	Y			0						
		3	N		0							
		12	N	2								
		3	N		1							
		7	N	1								
574/91	Cork	8	N	3								
		5	N	5								
		14	N	1								* only 1 capture at 14 entrance active main sett.
598/91	Cork	6	N	2								
		1	N		2							
		3	N			0						
		1	N			0						

APPENDIX 16 contd.

Licence	County	sett size	sett disturbed?	Active setts Main	Active setts Ann.	Active setts Sub.	Active setts Out.	Disused setts Main	Disused setts Ann.	Disused setts Sub.	Disused setts Out.	Comments
32/92	Donegal	1	N								5	*** M active.
		1	N				0					
		2	N				0					
		2	N			1						
		7	Y					0				
		4	N			1						
		4	N			0						
		4	N			0						
		5	N	0								*** M disused.
		4	N		0							*** A disused.
		2	N							0		
		1	N								0	
		3	N			0						
		2	N							0		
		4	N							0		
618/91	Donegal	2	Y								0	
		2	N								0	
		1	N				0					
142/93	Donegal	12	Y	4								
		3	Y			2						
		12	Y	2								
		3	N								0	
		5	Y			1						
532/91	Galway	4	N	3								
		2	N		3							
		2	Y								0	
571/91	Galway	6	N	5								
		5	N	4								
		2	N							0		
		3	N			0						
80/92	Kerry	5	N					3				*** M active.
		4	N						0			
33/93	Kerry	4	N	2								
		5	N			1						
		5	N			1						
			N				0					no data sett size.
			N				0					no data sett size.

APPENDIX 16 contd.

Licence	County	sett size	sett dist-urb-ed?	Active setts Main	Ann.	Sub.	Out.	Disused setts Main	Ann.	Sub.	Out.	Comments
44/92	Kilkenny	10	N	6								
		1	N		1							
		1	N			0						
		1	N				0					
		1	N				0					
		1	N				0					
107/92	Laois	2	N						4			*** A active.
		7	Y					2				*** M active.
		2	N			0						
		2	N			0						
		2	N				0					
		9	N	0								*** M disused.
108/92	Laois	6	Y	2								
		2	Y			2						plus 1 cub.
		2	N								0	
		2	N				0					
45/92	Leitrim	13	N	5								
		2	N		0							
		3	N			1						
		1	N				3					*
		4	N		2							
15/92	Longford	3	Y			1						plus 1 cub.
		4	N			0						
		3	N			1						
		1	N								0	
		5	N					0				
16/92	Longford	4	N			1						
		3	N	6								
166/92	Longford	1	N								0	
		3	N						0			
		7	N	3								
		5	N		0							
		2	N			0						
		7	N	3								
		1	N								0	
		1	N				0					
575/91	Mayo	3	N							0		
		3	N				0					
		4	N					3				*** M active. plus 1 cub.
		17	N	3								plus 1 cub.
			N			1						no data sett size.

APPENDIX 16 contd.

Licence	County	sett size	sett disturbed?	Active setts Main	Ann.	Sub.	Out.	Disused setts Main	Ann.	Sub.	Out.	Comments
610/91	Mayo	6	Y					4				*** M active.
		4	N						0			
		3										
140/93	Mayo	4	N			1						
		5	N			1						
		4	N	3								
8/92	Offaly	3	N			2						data from 4 setts insufficient.
		5	N			0						
		3	N				0					
		5	N	1								
		1	N		0							
		2	N			0						
		3	N			2						
		1	N			0						
569/91	Roscommon	6	N	2								
		1	N			0						
A51/92	Sligo	3	Y	0								*** M disused.
		1	Y		0							
		3	Y		0							
		3	Y		0							
		1	N				0					
		3	Y	1								*
		2	Y		0							
514/91	Tipperary	8	N	4								
		3	N	4								
		2	N			0						
581/91	Tipperary	8	N			2						
		11	N	2								
		4	Y			0						
		3	N			0						
112/93	Tipperary	5	N	4								
		4	N			1						
544/91	Waterford	5	Y	1								* sett much disturbed by digging.

APPENDIX 16 contd.

Licence	County	sett size	sett dist-urb-ed?	Active setts Main	Ann.	Sub.	Out.	Disused setts Main	Ann.	Sub.	Out.	Comments
47/92	Waterford	6	Y	1								* sett much disturbed by digging.
		4	N			0						
202/92	Waterford	5	N	0								*** M disused.
		1	N			0						*** S disused.
			N								0	
18/91	Westmeath	10	N	4								
		2	N			1						
		4	N			7						*** M active.
		5	N			1						
596/91	Westmeath	5	Y	4								plus 1 cub.
		2	N			3						
48/92	Wexford	8	N	0								*** M disused.
		1	N			0						
		8	N	3								plus 1 cub.

APPENDIX 17

Summary of total snare nights for first snaring period for the groups referred to in Table 23 (in main text) and utilised in catch-effort analyses.

Licence	County	Group	Group number	Comments	Total snare nights (first snaring period only)
102/92	Carlow				
24/92	Clare	A	1		260
		B	2		261
23/92	Clare	A	3		60
		B	4		70
		C	5		30
574/91	Cork	A	6	no data	
		B	7	no data	
598/91	Cork	A	8	no data	
32/92	Donegal	A	9		2096
618/91	Donegal				
142/93	Donegal	B	10		580
		A	11		1100
532/91	Galway	A	12		1010
571/91	Galway	A	13		520
		B	14		480
80/92	Kerry	A	15		100
33/93	Kerry	A	16	(included)	390
44/92	Kilkenny	A	17		510
107/92	Laois	A	18		696
108/92	Laois	A	19		906
45/92	Leitrim	A	20		320

APPENDIX 17 contd.

Licence	County	Group	Group number	Comments	Total snare nights
15/92	Longford				
16/92	Longford	A	21		400
166/92	Longford	A	22		460
		B	23		180
575/91	Mayo	A	24		106
		B	25		120
610/91	Mayo	A	26		117
140/93	Mayo	A	27		300
8/92	Offaly	A	28		470
569/91	Roscommon	A	29		490
A51/92	Sligo	B	30		730
514/91	Tipperary	A	31		90
		B	32		270
581/91	Tipperary	A	33		826
112/93	Tipperary	A	34		200
544/91	Waterford	A	35		200
47/92	Waterford	A	36	no data	
202/92	Waterford				
18/91	Westmeath	A	37		1152
		B	38		340
596/91	Westmeath	A	39		650
48/92	Wexford	A	40		426
			mean		**469.9**
			n		**36**

APPENDIX 18

Details of each badger listed as being snared in submissions from DVOs for all the badger removal areas studies.

Note that some of these records include badgers snared within the licence area but outside the 1km square chosen for survey; in other cases, badgers captured outside the 1km area have not had details submitted and are not included.

Note: the details for each badger captured are presented in this and the following Appendix. Group numbers are those utilised in the previous Appendix and indicate which group each badger was deemed to belong to. Some badgers were not included in analyses of groups but were included in *Numbers by sett type analyses*: all of those included are marked *Y* in the Included? column. Badgers not included in either of these former analyses are marked *N*.

Licence	County	Group no.	Incl-uded?	Sett	Date	Tag number	Sex	Age	Adult?	Cub?
102/92	Carlow									
24/92	Clare	2	Y	S10	March 1992	660944CMA	F	1 yr old	A	
24/92	Clare	2	Y	S7	07-Mar-92	660988CMA	F		A	
24/92	Clare	2	Y	S7	09-Mar-92	660955CMA	M		A	
24/92	Clare	2	Y	S7	13-Mar-92	660113CMA	F		A	
24/92	Clare	2	Y	S7	15-Mar-92	660157CMA	M		A	
24/92	Clare	2	Y	S7	06-Mar-92	661001CMA	M		A	
24/92	Clare	1	Y	S5	07-Mar-92	660977CMA	F		A	
24/92	Clare	1	Y	S3	07-Mar-92	660999CMA	F		A	
24/92	Clare	1	Y	S3	12-Mar-92	660922CMA	M		A	
24/92	Clare	1	Y	S3	12-Mar-92	660911CMA	F		A	
24/92	Clare		Y	S11	08-Mar-92	660966CMA	F		A	
24/92	Clare		Y	S11	10-Mar-92	660933CMA	F		A	
24/92	Clare		Y	S11	15-Mar-92	660146CMA	F		A	
24/92	Clare	1	Y	S5	03-Jul-92	660339CMA	M		A	
24/92	Clare	1	Y	S3	07-Jul-93	660099CMA	F		A	
23/92	Clare	3	Y	S1	31-Mar-92	660192CMA	F		A	
23/92	Clare	3	Y	S1	28-Mar-92	660181CMA	F		A	
23/92	Clare	4	Y	S7	02-Apr-92	660727CMA	M		A	
23/92	Clare	4	Y	S7	26-Mar-92	660168CMA	F		A	
23/92	Clare	5	Y	S8	28-Mar-92	660179CMA	M		A	
23/92	Clare	5	Y	S9	13-Jun-92	660317CMA	F		A	
574/91	Cork	6	Y	M1	16-Apr-92	DRK701931	F		A	
574/91	Cork	6	Y	M2	April 1992	DRK701075	M		A	
574/91	Cork	6	Y	M2	20-Mar-92	DRK701031	M		A	
574/91	Cork	7	Y	M3	07-Apr-92	DRK701601	F		A	
574/91	Cork	7	Y	M3	04-Feb-92	Ref. 754	M		A	
574/91	Cork	7	Y	M3	20-Mar-92	DRK701032	F		A	
574/91	Cork	7	Y	M3	19-Mar-92	DRK701029	M		A	
574/91	Cork	7	Y	M3	24-Mar-92	DRK701042	M		A	
598/91	Cork	8	Y	S1	02-Apr-92	DRK331454	M		A	
598/91	Cork	8	Y	S1	03-Apr-92	DRK331465	F		A	
598/91	Cork	8	Y	S2	01-Apr-92	DRK331591	M		A	
598/91	Cork	8	Y	S2	09-Apr-92	DRK331487	F		A	
32/92	Donegal	9	Y	S1	25-Mar-92	19659AK	F	1 year	A	
32/92	Donegal	9	Y	S1	26-Mar-92	19660AK	F	1 year	A	
32/92	Donegal	9	Y	S1	27-Mar-92	19661AK	F		A	
32/92	Donegal	9	Y	S1	28-Mar-92	19662AK	F	1 year	A	
32/92	Donegal	9	Y	S1	29-Mar-92	19663AK	F		A	
32/92	Donegal	9	Y	S4	03-Apr-92	19665AK	F	1 year	A	
32/92	Donegal	9	Y	S6	29-Mar-92	19664AK	M		A	

APPENDIX 18 contd.

Licence	County	Group no.	Incl-uded?	Sett	Date	Tag number	Sex	Age	Adult?	Cub?
618/91	Donegal		N	area 2		15711AK	F		A	
618/91	Donegal		N	area 2		15714AK	M		A	
618/91	Donegal		N	area 2		15721AK	M		A	
618/91	Donegal		N	area 2		15729AK	M	1 year	A	
142/93	Donegal		N	S3	14-May-93	19419AK				
142/93	Donegal		N	S3	14-May-93	19420AK				
142/93	Donegal		N	S3	15-May-93	14338AK				
142/93	Donegal		N	S3	16-May-93	14342AK				
142/93	Donegal		N	S3	16-May-93	14343AK				
142/93	Donegal		N	S3	17-May-93	14344AK				
142/93	Donegal		N	S9	11-May-93	14333AK				
142/93	Donegal		N	S9	18-May-93	14345AK				
142/93	Donegal		N	S9	20-May-93	14347AK				
142/93	Donegal		N	S10	18-May-93	19421AK				
142/93	Donegal		N	S10	06-May-93	14331AK				
142/93	Donegal		N	S12	12-May-93	19417AK				
142/93	Donegal		N	S13	07-May-93	19416AK				
142/93	Donegal		N	S15	07-May-93	19415AK				
142/93	Donegal		N	S15	13-May-93	19418AK				
142/93	Donegal		N	S15	21-May-93	19422AK				
142/93	Donegal	10	Y	S4	11-May-93	14335AK	F		A	
142/93	Donegal	10	Y	S4	14-May-93	14337AK	F		A	
142/93	Donegal	10	Y	S4	15-May-93	14339AK	M		A	
142/93	Donegal	10	Y	S4	20-May-93	14348AK	M		A	
142/93	Donegal	10	Y	S6	11-May-93	14334AK	M		A	
142/93	Donegal	10	Y	S6	15-May-93	14341AK	M		A	
142/93	Donegal	11	Y	S7	20-May-93	14346AK	M		A	
142/93	Donegal	11	Y	S8	11-May-93	14332AK	F		A	
142/93	Donegal	11	Y	S8	14-May-93	14336AK	M		A	
532/91	Galway	12	Y	S2	06-Mar-92	51677G	M	1 year	A	
532/91	Galway	12	Y	S2	06-Mar-92	414955CLA	F	1 year	A	
532/91	Galway	12	Y	S2	09-Mar-92	62693G	M	1 year	A	
532/91	Galway	12	Y	S1	10-Mar-92	414533CLA	M	1 year	A	
532/91	Galway	12	Y	S1	04-Mar-92	84786GJ	F	2 years	A	
532/91	Galway	12	Y	S1	11-Mar-92	58181G	M	1 year	A	
571/91	Galway	13	Y	S1	05-Mar-92	11192-4GTA	F	2 years	A	
571/91	Galway	13	Y	S1	05-Mar-92	11191-3GTA	F	2 years	A	
571/91	Galway	13	Y	S1	04-Mar-92	11173-1GTA	M	2 years	A	
571/91	Galway	13	Y	S1	07-Mar-92	11165-1GTA	M	3 years	A	
571/91	Galway	13	Y	S1	04-Mar-92	11172-9GTA	M	3 years	A	
571/91	Galway	14	Y	S2	05-Mar-92	111178-6GTA	F	3 years	A	
571/91	Galway	14	Y	S2	13-Mar-92	36004-9GTA	M	2 years	A	
571/91	Galway	14	Y	S2	05-Mar-92	11139-8GTA	M	4 years	A	
571/91	Galway	14	Y	S2	07-Mar-92	11104-6GTA	M	1 year	A	
80/92	Kerry	15	Y	S2	07-May-92	634299HSA	F		A	
80/92	Kerry	15	Y	S2	15-May-92	680412HSA			A	
80/92	Kerry	15	Y	S2	15-May-92	680707HSA			A	
33/93	Kerry	16	Y	S1	22-Apr-92	HVA037039	M		A	
33/93	Kerry	16	Y	S1	29-Apr-92	HVA037052	F		A	
33/93	Kerry	16	Y	S2	24-Apr-92	HVA037041	M		A	
33/93	Kerry	16	Y	S3	20-Apr-92	HVA499973	F		A	
522/91	Kilkenny		N	S3	04-Apr-92	50360	F		A	
522/91	Kilkenny		N	S22	06-Apr-92	46500	M		A	
522/91	Kilkenny		N	S14	10-Apr-92	461798	F		A	
522/91	Kilkenny		N	S1	10-Apr-92	461765	F		A	
522/91	Kilkenny		N	S1	25-Nov-92	578879JMA	F		A	
522/91	Kilkenny		N	S9	25-Nov-92	578301JMA	F		A	

APPENDIX 18 contd.

Licence	County	Group no.	Incl-uded?	Sett	Date	Tag number	Sex	Age	Adult?	Cub?
44/92	Kilkenny	17	Y	S1	14-Oct-92	JO33924	F		A	
44/92	Kilkenny	17	Y	S1	10-Oct-92	JO33150	F		A	
44/92	Kilkenny	17	Y	S2	08-Oct-92	JO33149	F		A	
44/92	Kilkenny	17	Y	S1	05-Jan-93	JO33148	M		A	
44/92	Kilkenny	17	Y	S1	08-Jan-93	JO33132	F		A	
44/92	Kilkenny	17	Y	S1	11-Jan-93	JO30358	M		A	
44/92	Kilkenny	17	Y	S1	15-Jan-93	JO33139	M		A	
107/92	Laois	18	Y	S5	23-Apr-93	37126-2KIA	F		A	
107/92	Laois	18	Y	S5	27-Apr-93	37127-3KIA	M		A	
107/92	Laois	18	Y	S5	21-Apr-93	371238KIA	M		A	
107/92	Laois	18	Y	S5	21-Apr-93	37124-9KIA	F		A	
107/92	Laois	18	Y	S6	21-Apr-93	371227KIA	F		A	
107/92	Laois	18	Y	S6	23-Apr-93	37125-1KIA	M		A	
108/92	Laois	19	Y	S1	20-Apr-93	079121KIA	F		A	
108/92	Laois	19	Y	S1	21-Apr-93	079132KIA	F		A	
108/92	Laois	19	Y	S2	27-Apr-93	079143KIA	F		A	
108/92	Laois	19	Y	S2	30-Apr-93	079223KIA	M		A	
108/92	Laois	19	Y	S2	30-Apr-93	079212KIA	F	5 weeks		Y
45/92	Leitrim	20	Y	S1	01-Apr-92	59080	F		A	
45/92	Leitrim	20	Y	S1	02-Apr-92	59082	F		A	
45/92	Leitrim	20	Y	S1	06-Apr-92	59087	F		A	
45/92	Leitrim	20	Y	S1	08-Apr-92	59098	F		A	
45/92	Leitrim	20	Y	S1	10-Apr-92	59097	F		A	
45/92	Leitrim		Y	S4	01-Apr-92	59081	F		A	
45/92	Leitrim		Y	S4	04-Apr-92	59088	M		A	
45/92	Leitrim		Y	S4	04-Apr-92	59091	M		A	
45/92	Leitrim	20	Y	S3	05-Apr-92	59099	F		A	
45/92	Leitrim	20	Y	S7	09-Apr-92	59092	F		A	
45/92	Leitrim	20	Y	S7	09-Apr-92	59095	M		A	
15/92	Longford		Y	S1	08-May-93	87220	F			Y
15/92	Longford		Y	S1	05-May-93	87218	F	4 years	A	
15/92	Longford		Y	S3	13-May-93	87221	F	1 year	A	
16/92	Longford	21	Y	S1	11-Mar-93	59889	F	2 years	A	
16/92	Longford	21	Y	S2	11-Mar-93	59878	M	2 years	A	
16/92	Longford	21	Y	S2	13-Mar-93	59892	M	3-4 years	A	
16/92	Longford	21	Y	S2	14-Mar-93	59808	M	1 year	A	
16/92	Longford	21	Y	S2	18-Mar-93	59836	F	1 year	A	
16/92	Longford	21	Y	S2	18-Mar-93	59837	F	3-4 years	A	
16/92	Longford	21	Y	S2	20-Mar-93	59898	F	1 year	A	
166/92	Longford	22	Y	S3	21-Apr-93	87212	F	4 years	A	
166/92	Longford	22	Y	S3	22-Apr-93	87213	M	3 years	A	
166/92	Longford	22	Y	S3	27-Apr-93	87224	F	1 year	A	
166/92	Longford	23	Y	S4	22-Apr-93	87214	F	4 years	A	
166/92	Longford	23	Y	S4	22-Apr-93	87215	F	1 year	A	
166/92	Longford	23	Y	S4	25-Apr-93	87225	M	2 years	A	
610/91	Mayo	26	Y	M1	03-Aug-92	95309-7	M		A	
610/91	Mayo	26	Y	M1	12-Aug-92	95304-6	F		A	
610/91	Mayo	26	Y	M1	06-Aug-92	95308-1	M		A	
610/91	Mayo	26	Y	M1	03-Aug-92	95303-5			A	
610/91	Mayo	26	Y	S	10-Aug-92	95309-2	F		A	
575/91	Mayo	25	Y	S4	01-Apr-92	521794	F			Y
575/91	Mayo	24	Y	S3	01-Apr-92	521783	F			Y
575/91	Mayo	24	Y	S3	28-Mar-92	521761	M	1 year	A	
575/91	Mayo	25	Y	S4	26-Mar-92	521759	F		A	
575/91	Mayo	25	Y	S4	25-Mar-92	521748	F		A	
575/91	Mayo	24	Y	S3	24-Mar-92	521715	F	1 year	A	
575/91	Mayo	24	Y	S3	24-Mar-92	521726	M		A	
575/91	Mayo	25	Y	S4	24-Mar-92	521737	F		A	

APPENDIX 18 contd.

Licence	County	Group no.	Incl-uded?	Sett	Date	Tag number	Sex	Age	Adult?	Cub?
140/93	Mayo	27	Y	R1	28-Jun-93	571022	M		A	
140/93	Mayo	27	Y	R2	29-Jun-93	571055	M		A	
140/93	Mayo	27	Y	R3	01-Jul-93	41599	F		A	
140/93	Mayo	27	Y	R3	30-Jun-93	571066	M		A	
140/93	Mayo	27	Y	R3	23-Jun-93	571204	F		A	
31/93	Mayo		N	P3	29-Apr-93	265375	F		A	
31/93	Mayo		N	P3	01-May-93	42512	M		A	
31/93	Mayo		N	P4	01-May-93	42513	F		A	
8/92	Offaly	28	Y	S4	22-Mar-92	27706	M		A	
8/92	Offaly		N	S10	22-Mar-92	27705	M		A	
8/92	Offaly	28	Y	S7	25-Mar-92	27712	M		A	
8/92	Offaly	28	Y	S1	25-Mar-92	27711	M		A	
8/92	Offaly	28	Y	S1	18-Mar-92	27701	F		A	
8/92	Offaly	28	Y	S7	18-Mar-92	27702	F		A	
569/91	Roscommon	29	Y	S1	04-Mar-92	033705TIA	M		A	
569/91	Roscommon	29	Y	S1	05-Mar-92	033476TIA	M	1 year	A	
A51/92	Sligo	30	Y	M5	10-May-92	88373	F	1 year	A	
514/91	Tipperary	31	Y	S1	09-Apr-92	15298	F		A	
514/91	Tipperary	31	Y	S1	10-Apr-92	77663	M		A	
514/91	Tipperary	31	Y	S1	11-Apr-92	20750	M		A	
514/91	Tipperary	31	Y	S1	15-Apr-92	15289	F		A	
514/91	Tipperary	32	Y	S2	09-Apr-92	15277	F		A	
514/91	Tipperary	32	Y	S2	09-Apr-92	15275	F	1 year	A	
514/91	Tipperary	32	Y	S2	10-Apr-92	77658	M		A	
514/91	Tipperary	32	Y	S2	11-Apr-92	15279	F		A	
581/91	Tipperary	33	Y	S1	09-Mar-92	10765	F		A	
581/91	Tipperary	33	Y	S1	13-Mar-92	10796	M		A	
581/91	Tipperary	33	Y	S2	10-Mar-92	10749	M		A	
581/91	Tipperary	33	Y	S2	09-Mar-92	10788	M		A	
112/93	Tipperary	34	Y	S2	20-May-93	31743	F	1 year	A	
112/93	Tipperary	34	Y	S2	25-May-93	31746	M		A	
112/93	Tipperary	34	Y	S2	26-May-93	31747	M		A	
112/93	Tipperary	34	Y	S2	23-May-93	31744	F		A	
112/93	Tipperary		Y	S1	18-May-93	31742	F		A	
544/91	Waterford	35	Y	M1	06-Apr-92	31380	F	1 year	A	
47/92	Waterford	36	Y	M1	06-Jul-92	19262			A	
202/92	Waterford									
18/91	Westmeath	38	Y	S3	18-Mar-92	27587	M		A	
18/91	Westmeath	38	Y	S3	13-Mar-92	27584	F		A	
18/91	Westmeath	38	Y	S3	12-Mar-92	27583	F		A	
18/91	Westmeath	38	Y	S3	18-Mar-92	27586	M		A	
18/91	Westmeath	38	Y	S3	21-Mar-92	27590	F		A	
18/91	Westmeath	37	Y	S4	25-Mar-92	27573	F	1 year	A	
18/91	Westmeath	37	Y	S1	11-Mar-92	27581	M		A	
18/91	Westmeath	37	Y	S1	17-Mar-92	27585	M		A	
18/91	Westmeath	37	Y	S1	19-Mar-92	27588	M		A	
18/91	Westmeath	37	Y	S1	22-Mar-92	27589	M		A	
18/91	Westmeath	37	Y	S2	26-Mar-92	27574	F		A	
18/91	Westmeath	38	Y	S3	26-Mar-92	27575	M		A	
18/91	Westmeath	38	Y	S3	25-Mar-92	27572	M		A	

APPENDIX 18 contd.

Licence	County	Group no.	Incl-uded?	Sett	Date	Tag number	Sex	Age	Adult?	Cub?
596/91	Westmeath	39	Y	S1	17-May-93	34466	F	1 year	A	
596/91	Westmeath	39	Y	S1	08-May-93	34460	M		A	
596/91	Westmeath	39	Y	S1	10-May-93	34463	M			Y
596/91	Westmeath	39	Y	S1	10-May-93	34464	F		A	
596/91	Westmeath	39	Y	S1	13-May-93	34465	M		A	
596/91	Westmeath	39	Y	S2	16-May-93	34467	M		A	
596/91	Westmeath	39	Y	S2	09-May-93	34462	F	1 year	A	
596/91	Westmeath	39	Y	S2	09-May-93	34461	M		A	
48/92	Wexford	40	Y	M2	25-Jun-92	23542YO	F		A	
48/92	Wexford	40	Y	M2	27-Jun-92	23543YO	F	*c.* 6 months		Y
48/92	Wexford	40	Y	M2	28-Jun-92	23544YO	F		A	
48/92	Wexford	40	Y	M2	02-Jul-92	23545YO	M		A	
174/93	Wexford		N	S1	19-Jun-93	23555YO	F		A	
174/93	Wexford		N	S3	16-Jun-93	23552YO	F	*c.* 6 months		Y
174/93	Wexford		N	S4	16-Jun-93	23553YO	F	1 year	A	
174/93	Wexford		N	S4	16-Jun-93	23554YO	F	1 year	A	

Additional results from other areas

Licence	County	Group no.	Incl-uded?	Sett	Date	Tag number	Sex	Age	Adult?	Cub?
130/93	Carlow		N	S1	02-May-93	45640	F	1 year	A	
130/93	Carlow		N	S2	28-Apr-93	45631	M		A	
130/93	Carlow		N	S2	02-May-93	45670	M	1 year	A	
130/93	Carlow		N	S4	30-Apr-93	45691	F		A	
130/93	Carlow		N	S4	29-Apr-93	45693	F	1 year	A	
130/93	Carlow		N	S5	29-Apr-93	45666	F		A	
130/93	Carlow		N	S5	28-Apr-93	45673	F		A	
4/93	Cork		N	S2	18-May-93	Blue 1	F		A	
86/92	Kerry		N	S1	10-Jun-92	HSA634701	F		A	
86/92	Kerry		N		28-Jun-92	HSA680467	M		A	
86/92	Kerry		N		29-Jun-92	HSA680478	F		A	
86/92	Kerry		N		01-Jul-92	HSA680489	M		A	
86/92	Kerry		N		24-Jun-92	HSA680456	M		A	
86/92	Kerry		N		03-Jul-92	HSA680491	F		A	
86/92	Kerry		N		15-Jul-92	HSA680503	F		A	
86/92	Kerry		N		28-Jul-92	HSA680514				
86/92	Kerry		N		28-Jul-92	HSA634164				
177/92	Limerick									
83/92	Limerick									
25/92	Meath		N	S1	27-Oct-92	33953	M		A	
25/92	Meath		N	S3	27-Oct-92	33952	F		A	
25/92	Meath		N	S2	26-Oct-92	33950	F	1 year	A	
25/92	Meath		N	S1	25-Oct-92	33951	F		A	
25/92	Meath		N	S4	24-Oct-92	33949	M		A	
25/92	Meath		N	S3	24-Oct-92	33948	F		A	
25/92	Meath		N	S2	23-Oct-92	33947	F		A	
25/92	Meath		N		23-Oct-92	33946	F		A	
25/92	Meath		N	S4	22-Oct-92	33945	F		A	
25/92	Meath		N	S2	22-Oct-92	33944	M	1 year	A	
25/92	Meath		N	S2	22-Oct-92	33943	M		A	
566/91	Roscommon									

APPENDIX 18 contd.

Licence	County	Group no.	Incl-uded?	Sett	Date	Tag number	Sex	Age	Adult?	Cub?
6/93	Sligo		N		20-Apr-93	16482	M		A	
6/93	Sligo		N		20-Apr-93	16483	F	1 year	A	
6/93	Sligo		N		23-Apr-93	16484	F		A	
6/93	Sligo		N		24-Apr-93	16485	M	1 year	A	
6/93	Sligo		N		26-Apr-93	16486	M		A	
6/93	Sligo		N		26-Apr-93	16487	M		A	
6/93	Sligo		N		28-Apr-93	16490	F	1 year	A	
136/93	Tipperary		N	S1	28-Apr-93	30091	F		A	
136/93	Tipperary		N	S3	02-May-93	34114	M	1 year	A	
136/93	Tipperary		N	S3	01-May-93	30092	F			Y
136/93	Tipperary		N	S3	28-Apr-93	15295	F		A	
136/93	Tipperary		N	S3	28-Apr-93	41435	F		A	
136/93	Tipperary		N	S3	28-Apr-93	90275	M			Y
103/92	Wicklow		N	S1	29-Apr-93	11708/2	M	4 years	A	

APPENDIX 19

Further information on each badger captured in badger removal areas. The data is ordered exactly as in the previous Appendix.

Notes: TB status of badgers was usually determined by gross visible lesions (VL), but additional histological examination was performed and/or cultures were taken for some individuals. Whether each badger was included in a high or low snaring group is indicated in the last column.

Licence	County	Tag number	Weight kg	VL?	Body length cm	Tail length cm	Colour	Condition	Comments	Group >400 snare nights ?
102/92	Carlow									
24/92	Clare	660944CMA	6.3	N	80.0	5.0	Grey	Healthy		N
24/92	Clare	660988CMA	7.7	N	83.0	15.0	Grey	Healthy		N
24/92	Clare	660955CMA	9.1	N	85.0	14.0	Grey	Healthy		N
24/92	Clare	660113CMA	7.7	N	77.0	15.0	Grey	Healthy		N
24/92	Clare	660157CMA	9.0	N	78.0	15.0	Grey	Healthy		N
24/92	Clare	661001CMA	5.0	Y	80.0	9.0	Dark grey	Healthy but light in weight		N
24/92	Clare	660977CMA	11.1	N	84.0	16.0	Grey	Healthy		N
24/92	Clare	660999CMA	11.4	N	89.0	16.0	Grey	Healthy		N
24/92	Clare	660922CMA	12.0	N	89.0	16.0	Grey	Healthy		N
24/92	Clare	660911CMA	8.2	N	77.0	15.0	Grey	Healthy		N
24/92	Clare	660966CMA	6.8	N	81.0	12.0	Grey	Healthy		
24/92	Clare	660933CMA	7.4	N	80.0	14.0	Grey	Healthy		
24/92	Clare	660146CMA	7.2	N	84.0	15.0	Grey	Healthy		
24/92	Clare	660339CMA	9.9	N	87.0	15.0	Grey and white	Healthy		N
24/92	Clare	660099CMA	9.0	N	77.0	14.0	Grey and white	Healthy		N
23/92	Clare	660192CMA	7.7	N	81.0	14.0	Grey	Healthy		N
23/92	Clare	660181CMA	8.6	N	82.0	14.0	Grey	Healthy		N
23/92	Clare	660727CMA	9.9	Y	87.0	15.0	Grey	Healthy		N
23/92	Clare	660168CMA	8.6	N	83.0	15.0	Grey	Healthy		N
23/92	Clare	660179CMA	9.5	N	84.0	14.0	Grey	Healthy		N
23/92	Clare	660317CMA	9.5	N	82.0	14.0	Grey	Healthy		N
574/91	Cork	DRK701931	7.4	N				Normal		
574/91	Cork	DRK701075	9.4	N				Normal		
574/91	Cork	DRK701031	9.5	N				Normal		
574/91	Cork	DRK701601	8.4	N				Normal, healthy		
574/91	Cork	Ref. 754	10.2	N				Normal		
574/91	Cork	DRK701032	7.1	N				Normal		
574/91	Cork	DRK701029	8.8	N				Normal		
574/91	Cork	DRK701042	9.1	N				Normal		
598/91	Cork	DRK331454	9.1	N				Normal		
598/91	Cork	DRK331465	8.1	N				Normal		
598/91	Cork	DRK331591	9.5	N				Normal		
598/91	Cork	DRK331487	8.5	N				Normal		
32/92	Donegal	19659AK	7.5	N	62.0	16.0	Grey	Fair to good		Y
32/92	Donegal	19660AK	7.0	N	65.0	14.0	Grey	Poor		Y
32/92	Donegal	19661AK	8.0	N	69.0	18.0	Grey	Good		Y
32/92	Donegal	19662AK	7.0	Y	63.0	16.0	Grey	Fair to good		Y
32/92	Donegal	19663AK	7.8	N	71.0	16.0	Grey	Poor		Y
32/92	Donegal	19665AK	7.3	N	69.0	16.0	Grey	Good		Y

APPENDIX 19 contd.

Licence	County	Tag number	Weight kg	VL?	Body length cm	Tail length cm	Colour	Condition	Comments	Group >400 snare nights ?
32/92	Donegal	19664AK	6.5	Y	64.0	16.0	Grey	Very poor		Y
618/91	Donegal	15711AK		N					Capture outside survey areas.	
618/91	Donegal	15714AK		N					Capture outside survey areas.	
618/91	Donegal	15721AK		Y					Capture outside survey areas.	
618/91	Donegal	15729AK		N					Capture outside survey areas.	
142/93	Donegal	19419AK		N					no data submitted: captured outside 1 km square area	
142/93	Donegal	19420AK		N					ditto	
142/93	Donegal	14338AK		N					ditto	
142/93	Donegal	14342AK		N					ditto	
142/93	Donegal	14343AK		N					ditto	
142/93	Donegal	14344AK		N					ditto	
142/93	Donegal	14333AK		N					ditto	
142/93	Donegal	14345AK		N					ditto	
142/93	Donegal	14347AK		N					ditto	
142/93	Donegal	19421AK		N					ditto	
142/93	Donegal	14331AK		N					no data submitted: captured outside 1 km square area	
142/93	Donegal	19417AK		N					ditto	
142/93	Donegal	19416AK		N					ditto	
142/93	Donegal	19415AK		N					ditto	
142/93	Donegal	19418AK		Y					ditto. +ve lesions and culture.	
142/93	Donegal	19422AK		Y					ditto. +ve lesions and culture.	
142/93	Donegal	14335AK		N						Y
142/93	Donegal	14337AK		N						Y
142/93	Donegal	14339AK		N						Y
142/93	Donegal	14348AK		N						Y
142/93	Donegal	14334AK		N					Found dead.	Y
142/93	Donegal	14341AK		N						Y
142/93	Donegal	14346AK		N						Y
142/93	Donegal	14332AK		N						Y
142/93	Donegal	14336AK		N						Y
532/91	Galway	51677G	8.0	N	69.0	14.0	Black, white, grey	Good		Y
532/91	Galway	414955CLA	8.0	N	69.0	15.0	Black, white, grey	Good		Y
532/91	Galway	62693G	9.5	N	72.0	14.0	Black, white, grey	Good		Y
532/91	Galway	414533CLA	8.5	N	69.0	15.0	Black, white, grey	Good		Y
532/91	Galway	84786GJ	8.5	N	69.0	16.0	Black, white, grey	Good		Y
532/91	Galway	58181G	9.0	N	70.0	16.0	Black, white, grey	Good		Y

APPENDIX 19 contd.

Licence	County	Tag number	Weight kg	VL?	Body length cm	Tail length cm	Colour	Condition	Comments	Group >400 snare nights ?
571/91	Galway	11192-4GTA	6.4	Y	64.0	15.0	Black, white, grey	Poor		Y
571/91	Galway	11191-3GTA	9.5	N	67.0	17.0	Black, white, grey			Y
571/91	Galway	11173-1GTA	8.6	N	61.0	17.0	Black, white			Y
571/91	Galway	11165-1GTA	10.8	N	70.0	19.0	Black, white, grey			Y
571/91	Galway	11172-9GTA	9.1	N	68.0	16.5	Black, white, grey			Y
571/91	Galway	111178-6GTA	7.7	N	64.0	15.0	Black, white, grey			Y
571/91	Galway	36004-9GTA	9.5	N	66.0	15.0	Black, white, grey			Y
571/91	Galway	11139-8GTA	9.5	N	68.0	16.0	Black, white, grey			Y
571/91	Galway	11104-6GTA	7.3	N	68.0	17.0	Black, white, grey			Y
80/92	Kerry	634299HSA	8.2	N			Brown			N
80/92	Kerry	680412HSA	7.8	N			Brown		No sex data.	N
80/92	Kerry	680707HSA	8.8	N			Brown		No sex data.	N
33/93	Kerry	HVA037039	9.0	N	85.0	15.0	Grey	Poor		Y
33/93	Kerry	HVA037052	7.1	N	84.0	14.0	Grey	Poor		Y
33/93	Kerry	HVA037041	7.8	N	85.0	14.0	Grey	Good		Y
33/93	Kerry	HVA499973	9.8	N	86.0	13.0	Grey	Poor		Y
522/91	Kilkenny	50360	7.0	Y	70.0	20.0			Note tail length.	
522/91	Kilkenny	46500	10.0	Y	85.0	24.0			Note tail length.	
522/91	Kilkenny	461798	7.8	N	75.0	23.0			Note tail length.	
522/91	Kilkenny	461765	8.5	N	73.0	21.0			Note tail length.	
522/91	Kilkenny	578879JMA	11.0	Y	68.0	12.0	Normal	Appeared healthy		
522/91	Kilkenny	578301JMA	12.0	N	73.0	15.0	Normal			
44/92	Kilkenny	JO33924	7.3	N	73.0	12.5	Grey and white	Good		Y
44/92	Kilkenny	JO33150	5.9	N	65.0	12.5	Grey, white, black	Very good		Y
44/92	Kilkenny	JO33149	6.8	N	70.0	12.5	Grey and white	Very good		Y
44/92	Kilkenny	JO33148	6.4	N	70.0	12.5	Grey and white	Very good		Y
44/92	Kilkenny	JO33132	5.7	N	66.0	12.0	Grey and white	Good		Y
44/92	Kilkenny	JO30358	5.2	N	64.0	11.0	Grey and white	Good		Y
44/92	Kilkenny	JO33139	5.9	N	68.0	12.0	Grey and white	Good		Y
107/92	Laois	37126-2KIA	8.6	N	75.0	18.0	Brown and white	Good		Y
107/92	Laois	37127-3KIA	8.9	N	75.0	18.5	Brown and white	Good		Y
107/92	Laois	371238KIA	8.4	Y	77.0	18.0	Brown and white	Good		Y
107/92	Laois	37124-9KIA	8.3	N	79.0	18.0	Brown and white	Good		Y

APPENDIX 19 contd.

Licence	County	Tag number	Weight kg	VL?	Body length cm	Tail length cm	Colour	Condition	Comments	Group >400 snare nights ?
107/92	Laois	371227KIA	8.2	N	68.0	18.0	Brown and white	Fair		Y
107/92	Laois	37125-1KIA	9.1	N	85.0	17.0	Brown and white	Good		Y
108/92	Laois	079121KIA	8.2	N	62.5	12.5	Grey and black	Good		Y
108/92	Laois	079132KIA	7.7	N	61.0	12.0	Grey and black	Good		Y
108/92	Laois	079143KIA	9.1	N	63.0	13.0	Grey and black	Good		Y
108/92	Laois	079223KIA	8.6	N	65.0	13.0	Grey and black			Y
108/92	Laois	079212KIA		N	31.0	7.5	Grey and black	Good		Y
45/92	Leitrim	59080	7.0	N	73.7	10.2	Dark brown	Good strong adult		N
45/92	Leitrim	59082	7.0	N	76.2	12.7	Dark brown	Good strong badger		N
45/92	Leitrim	59087	5.0	N	67.3	11.4	Brown	Light, poor		N
45/92	Leitrim	59098	6.5	N	72.4	11.4	Brown	Good		N
45/92	Leitrim	59097	7.0	N	76.2	12.7	Dark brown	Good		N
45/92	Leitrim	59081	8.0	N	76.2	12.7	Silver brown	Good		
45/92	Leitrim	59088	8.0	N	73.7	17.8	Silver and brown	Good		
45/92	Leitrim	59091	11.0	N	83.8	17.8	Silver and brown	Good strong badger		
45/92	Leitrim	59099	6.5	N	73.7	15.2	Brown	Good		N
45/92	Leitrim	59092	6.5	N	81.3	11.4	Silver and brown	Good		N
45/92	Leitrim	59095	6.0	N	73.7	12.7	Brown	Light poor badger		N
15/92	Longford	87220	3.0	N	51.0	12.0	Bright	Good		
15/92	Longford	87218	9.0	N	70.0	14.0	Medium to dark	Good		
15/92	Longford	87221	7.8	N	69.0	15.0	Bright	Good		
16/92	Longford	59889	8.6	N	68.0	14.5	Medium	Good		Y
16/92	Longford	59878	9.0	N	69.0	14.0	Medium	Fair (bite marks)		Y
16/92	Longford	59892	9.2	N	71.0	14.0	Medium	Fair		Y
16/92	Longford	59808	8.4	N	69.0	14.0	Medium	Good		Y
16/92	Longford	59836	6.8	N	67.0	14.0	Medium	Fair	Many ticks around head and ears.	Y
16/92	Longford	59837	9.3	N	70.0	16.0	Dark	Good	All molars worn to half.	Y
16/92	Longford	59898	6.8	N	65.0	15.0	Medium	Good		Y
166/92	Longford	87212	9.0	N	68.0	14.0	Dark	Good	2 molar teeth missing.	Y
166/92	Longford	87213	9.8	N	73.0	14.0	Dark	Good	Molar teeth worn.	Y
166/92	Longford	87224	7.0	N	66.0	15.0	Bright	Good		Y
166/92	Longford	87214	9.0	N	69.0	14.0	Dark	Good		N
166/92	Longford	87215	8.8	N	68.0	14.0	Very bright	Good		N
166/92	Longford	87225	7.8	Y	70.0	14.0	Medium/dark	Medium/poor	Long front nails.	N

APPENDIX 19 contd.

Licence	County	Tag number	Weight kg	VL?	Body length cm	Tail length cm	Colour	Condition	Comments	Group >400 snare nights ?
610/91	Mayo	95309-7		N						N
610/91	Mayo	95304-6		N						N
610/91	Mayo	95308-1		N						N
610/91	Mayo	95303-5		N					No sex data. NVL, sent for culture [no further info.]	N
610/91	Mayo	95309-2		N						N
575/91	Mayo	521794		N			Normal	Good	Badger marked at S3 and S4 on different data sheets.	N
575/91	Mayo	521783		N			Normal	Good	Badger marked at S3 and S4 on different data sheets.	N
575/91	Mayo	521761		N			Normal	Good		N
575/91	Mayo	521759		N			Normal	Good		N
575/91	Mayo	521748		N			Normal	Good		N
575/91	Mayo	521715		N			Normal	Good		N
575/91	Mayo	521726		N			Normal	Good		N
575/91	Mayo	521737		N			Normal	Good		N
140/93	Mayo	571022		N	66.0	15.2	Normal	Good		N
140/93	Mayo	571055		N	68.6	17.8	Normal	Good		N
140/93	Mayo	41599		N	66.0	14.0	Normal	Good		N
140/93	Mayo	571066		N	68.6	16.5	Normal	Good		N
140/93	Mayo	571204		N	66.0	14.0	Normal	Good		N
31/93	Mayo	265375	8.2	N	63.5	11.4	Normal	Good		
31/93	Mayo	42512	10.9	Y	76.2	15.2	Normal	Good		
31/93	Mayo	42513	9.1	Y	71.1	14.0	Normal	Good		
8/92	Offaly	27706	8.0	N	79.0	7.0	Black and white	OK	Note tail length. [*n.b.* DVO reported total of 28 badgers snared in all of licence area, of which 2 TB +ve. [No further info.]	Y
8/92	Offaly	27705	10.0	N	71.0	7.0	Black and white	Long nails	Note tail length.	
8/92	Offaly	27712	10.0	N	68.0	16.0	Black and white	Long front nails		Y
8/92	Offaly	27711	10.2	N	71.0	17.0	Black and white	OK		Y
8/92	Offaly	27701	8.1	N	66.0	17.0		OK		Y
8/92	Offaly	27702	8.0	N	66.0	16.0	Black and white	OK, long nails		Y
569/91	Roscommon	033705TIA	8.5	Y	62.0	26.0	Usual colour		Note tail length.	Y
569/91	Roscommon	033476TIA	7.1	N	53.0	23.0	Usual colour		Note tail length.	Y
A51/92	Sligo	88373	5.5		60.0	15.0			No TB status data.	Y
514/91	Tipperary	15298	7.0	N	60.0	15.0	Grey			N
514/91	Tipperary	77663	10.0	Y	74.0	15.0	Grey			N
514/91	Tipperary	20750	9.5	N	64.0	14.0	Grey			N
514/91	Tipperary	15289		N	66.0	13.5	Grey			N
514/91	Tipperary	15277	9.0	N	66.0	16.0	Grey			N
514/91	Tipperary	15275	8.7	N	71.0	15.0	Grey			N
514/91	Tipperary	77658	9.0	N	75.0	15.0	Grey			N
514/91	Tipperary	15279	9.0	N	67.0	14.0	Grey			N

APPENDIX 19 contd.

Licence	County	Tag number	Weight kg	VL?	Body length cm	Tail length cm	Colour	Condition	Comments	Group >400 snare nights ?
581/91	Tipperary	10765	7.5	N	67.0	13.0	Grey			Y
581/91	Tipperary	10796	9.0	N	67.0	14.0	Grey			Y
581/91	Tipperary	10749	10.0	N	72.0	13.0	Grey			Y
581/91	Tipperary	10788	9.0	N	73.0	10.0	Grey			Y
112/93	Tipperary	31743	5.5	N	56.3	9.3	Brown/grey	Good		N
112/93	Tipperary	31746	7.7	N	62.5	10.0	Brown/grey	Good		N
112/93	Tipperary	31747	8.2	N	59.4	9.5	Brown/grey	Good		N
112/93	Tipperary	31744	6.0	N	61.3	9.5	Brown/grey	Fair		N
112/93	Tipperary	31742	5.9	N	57.5	10.3	Brown/grey	Good		
544/91	Waterford	31380	6.8	N	72.0	20.0				N
47/92	Waterford	19262		N						
202/92	Waterford									
18/91	Westmeath	27587		N				Light		N
18/91	Westmeath	27584		N						N
18/91	Westmeath	27583		N						N
18/91	Westmeath	27586	7.7	N			Grey/black	Light, hair loss		N
18/91	Westmeath	27590	8.0	N	74.0	12.0	Grey/black	Thin, suckling		N
18/91	Westmeath	27573	8.0	N	75.0	13.5	Grey/black	Very good		Y
18/91	Westmeath	27581		N						Y
18/91	Westmeath	27585		N						Y
18/91	Westmeath	27588		N						Y
18/91	Westmeath	27589	10.5	N	77.0	14.0	Grey/black	Good		Y
18/91	Westmeath	27574	6.5	N	64.0	13.0	Black/white		Escaped and resnared.	Y
18/91	Westmeath	27575	8.5	N	75.0	15.0	Black/brown		Coat of hair light. Sores on forelegs.	N
18/91	Westmeath	27572	9.0	N	76.0	14.0	Black/brown	Good		N
596/91	Westmeath	34466	8.0	N	50.0	13.0	Brown			Y
596/91	Westmeath	34460	8.5	N	70.0	14.0	Brown			Y
596/91	Westmeath	34463	3.0	N	40.0	10.0	Black			Y
596/91	Westmeath	34464	9.0	N	70.0	19.0	Brown			Y
596/91	Westmeath	34465		N	70.0	16.0	Brown			Y
596/91	Westmeath	34467	10.0	N	70.0	12.0	Brown			Y
596/91	Westmeath	34462	8.0	N	68.0	12.0	Brown	Normal		Y
596/91	Westmeath	34461	10.0	N	71.0	16.0	Brown	Normal		Y
48/92	Wexford	23542YO	7.3	Y	62.0	18.0	Greyy, black, brown		Looked healthy and active; poor condition after rearing cubs.	Y
48/92	Wexford	23543YO	4.1	N	49.0	14.0	Brown, grey	Medium to poor		Y
48/92	Wexford	23544YO	8.3	N	67.0	18.0	Grey and black	Good		Y
48/92	Wexford	23545YO	8.4	N	69.0	16.0	Grey, brown, black	Medium	Good size, looked healthy.	Y

APPENDIX 19 contd.

Licence	County	Tag number	Weight kg	VL?	Body length cm	Tail length cm	Colour	Condition	Comments	Group >400 snare nights ?
174/93	Wexford	23555YO	11.8	N	63.0	16.0	Grey and brown	Appeared healthy		
174/93	Wexford	23552YO	3.4	N	50.0	13.0	Grey and brown	Appeared healthy		
174/93	Wexford	23553YO	6.4	N	56.0	15.0	Grey and brown	Appeared healthy		
174/93	Wexford	23554YO	6.1	N	51.0	14.0	Grey and brown	Appeared healthy		

Additional results from other areas

Licence	County	Tag number	Weight kg	VL?	Body length cm	Tail length cm	Colour	Condition	Comments	Group >400 snare nights ?
130/93	Carlow	45640	6.0	N	65.0	12.0				
130/93	Carlow	45631	8.2	N	76.0	14.0				
130/93	Carlow	45670	6.0	N	70.0	12.0				
130/93	Carlow	45691	7.8	N	75.0	15.7				
130/93	Carlow	45693	6.3	N	74.0	13.0				
130/93	Carlow	45666	5.5	N	68.0	13.0				
130/93	Carlow	45673	8.5	Y	82.0	16.5				
4/93	Cork	Blue 1	7.4	N			Standard	Light bodied, poor condition		
86/92	Kerry	HSA634701	7.5	N	78.7	15.2	Grey	Good	Recorded as 10.6 kgs on other data sheet.	
86/92	Kerry	HSA680467	7.0	N						
86/92	Kerry	HSA680478	5.0	N					Age uncertain.	
86/92	Kerry	HSA680489	9.3	N						
86/92	Kerry	HSA680456	7.3	Y						
86/92	Kerry	HSA680491	8.5	N						
86/92	Kerry	HSA680503	7.8	N						
86/92	Kerry	HSA680514		N					Almost no data on this badger.	
86/92	Kerry	HSA634164		N					Almost no data on this badger.	
177/92	Limerick								Informed that 2 badgers snared, but no details submitted.	
83/92	Limerick								Informed that 5 badgers snared (all NVL), but no details submitted.	
25/92	Meath	33953	11.4	N	63.5	15.2				
25/92	Meath	33952	9.1	N	61.0	12.7			Kidney lesions. -ve histological. Culture -ve.	
25/92	Meath	33950	7.3	N	59.7	14.0				
25/92	Meath	33951	10.9	N	69.9	16.5				
25/92	Meath	33949	10.9	N	66.0	15.2				
25/92	Meath	33948	9.1	N	63.5	15.2				
25/92	Meath	33947	10.0	N	63.5	15.2			Lesions mesenteric l.n. -ve histological. Culture -ve.	
25/92	Meath	33946	9.1	Y	67.3	14.0			TB-like granuloma in kidney culture. Culture +ve.	
25/92	Meath	33945	10.0	N	63.5	15.2				
25/92	Meath	33944	6.4	N	55.9	15.2				

APPENDIX 19 contd.

Licence	County	Tag number	Weight kg	VL?	Body length cm	Tail length cm	Colour	Condition	Comments	Group >400 snare nights ?
25/92	Meath	33943	10.9	N	72.4	14.0				
566/91	Roscommon								Informed that 1 badger was snared about 1 km distant from our survey area. No details.	
6/93	Sligo	16482	10.0	N	58.0	14.0			(weight data weak?)	
6/93	Sligo	16483	8.0	N	50.0	15.0			(weight data weak?)	
6/93	Sligo	16484	8.0	N	60.0	15.0			(weight data weak?)	
6/93	Sligo	16485	8.0	N	63.0	14.0			(weight data weak?)	
6/93	Sligo	16486	10.0	N	70.0	19.0			(weight data weak?)	
6/93	Sligo	16487	8.0	N	65.0	16.0			(weight data weak?)	
6/93	Sligo	16490	6.0	N	59.0	15.0			(weight data weak?)	
136/93	Tipperary	30091	6.5	N	64.0	5.0				
136/93	Tipperary	34114	9.0	N	71.0	15.0				
136/93	Tipperary	30092	3.0	N	46.0	9.0				
136/93	Tipperary	15295	8.0	N	68.0	7.0				
136/93	Tipperary	41435	8.0	N	65.0	6.5				
136/93	Tipperary	90275	3.0	N		4.5				
103/92	Wicklow	11708/2	10.0	N	76.0	14.0	Grey/white	Very healthy		

APPENDIX 20

Fitting statistical distributions to the sett distribution data

The frequency of occurrence of active main setts was found to approximate to a Poisson distribution - Table 37 in the text, and Figure 87. The other active sett types followed a negative binomial distribution. The Poisson distribution is an extreme form of the negative binomial (Snedecor & Cochran, 1989), whose particular properties were described by Poisson (1837, quoted in Snedecor & Cochran). The variance : mean ratio of the Poisson distribution is equal to 1, whereas that of the negative binomial is always greater than 1.

Since the variance : mean ratios for the active main setts in the various regions and in totals for the country were close to unity, it was considered more appropriate to use the Poisson distribution for obtaining confidence intervals. In any case, for larger samples, confidence limits obtained by the two distributions are very similar (see below). Additionally, the fit of the data to a Poisson distribution was shown to be acceptable by use of a 2 sample χ^2 test (goodness of fit test) [Table 37 in main text].

However, predicted values obtained from fitting a negative binomial distribution were sometimes closer to the observed values than those obtained from the Poisson distribution, though the Poisson distribution also gave predicted values close to the observed. The χ^2 test (goodness of fit test) could not be performed on the expected values obtained from the negative binomial because of the limitations of the data - which concern degrees of freedom in the goodness of fit tests. These are addressed briefly here, because it appears that some statistical packages ignore this matter, giving erroneous results.

In the data here, for main setts, a square could contain either 0 or 1 or 2 or 3 setts (4 were not observed). Therefore, there were 4 class sizes into which a square could be counted. The maximum number of degrees of freedom for a *standard* goodness of fit test is given by

$n-1$

where n = number of size classes

and this is where the expected frequencies are *known*. In estimating expected frequencies for the Poisson distribution, the fit is obtained by estimating a parameter μ from the data itself. In so doing, a degree of freedom is lost (Snedecor & Cochran, 1989; Krebs, 1989) so that

degrees of freedom = $n - 2$.

To fit a negative binomial distribution to a data set, 2 parameters are estimated (k and the mean), so that

degrees of freedom = $n - 3$.

For most of the data here where the largest size category was 2 setts in a square, d.f. = 0, and no test can be performed.

Krebs (1989) described the use of U goodness of fit test (Evans, 1953) and T goodness of fit test to test whether a data set could be considered to fit to a negative binomial distribution.

Thus, although the data here (active main setts) had variance : mean ratios of *c.* 1, they did in fact not differ statistically from the negative binomial distribution in some cases, including the overall data. The results of the tests, and 95% confidence limits for the means are given below. These may be compared with the results given in Table 38 (in the main text), based on the Poisson distribution. The means, of course, do not differ.

Table. U and T tests performed on the regional data for active main setts, with estimates of parameters, and means and confidence limits based on the negative binomial distribution.

The χ^2 test for clumping shows significant presence of clumping if P<0.05. The standardised Morisita coefficient is given (positive values indicate clumping, negative values lack of clumping; significant if coeff. >0.50 or <-0.50 respectively). The goodness of fit tests found that some of the data did *not* have a negative binomial distribution (at the 0.05 level). Values differing from Table 38 are marked *. Deviations from Table 38 are minor in all instances.

Region	**S-W**	**M-W**	**W**	**N-W**	**Midl.**	**S**	**E**	**Ireland**
mean	0.49	0.62	0.25	0.37	0.59	0.58	0.41	0.46
lower limit	0.38	0.47	0.17*	0.25	0.47*	0.38*	0.27	0.41
upper limit	0.61*	0.77*	0.34	0.49*	0.71*	0.79	0.54*	0.51
variance	0.44	0.48	0.26	0.31	0.48	0.65	0.35	0.42
χ^2 test for clumping P values given	0.83	0.95	0.43	0.85	0.95	0.24	0.81	0.96
Morisita	-0.26	-0.43	0.03	-0.28	-0.43	0.16	-0.25	-0.44
k	-4.64	-2.80	33.33	-1.88	-2.20	4.84	-2.17	-5.15
U	0.005	0.009	0.002	0.014	0.046	0.002	0.017	0.001
s.e.U	0.018	0.022	0.009	0.004	0.012	0.066	0.008	0.007
Negbinom. fit?	Y	Y	Y	N	N	Y	N	Y
T	0.038	0.028	0.017	0.011	0.054	0.163	0.020	0.001
s.e.T	0.043	0.047	0.027	0.10	0.025	0.213	0.018	0.018
Negbinom. fit?	Y	Y	Y	(Y)	N	(Y)	(Y)	Y

Conclusions from the above table:

A negative binomial distribution gives a reasonable fit for the observed distribution data of active main sets - for 4 of the 7 regions, and for the overall Republic data, as judged by the U and T tests. However, the Poisson distribution was an acceptable fit for all regions and for Republic totals (Table 37 in text). Furthermore, the variance : mean ratios indicate the lack of clumping - which is always present in negative binomial distributions. The high P values for the χ^2 clumping tests also show this, as do the Morisita standardised coefficients, which are negative for all regions except the South and the West. The negative values for the Morisita coefficient are particularly high for the Mid-West, Midlands, and the overall data, indicating randomness close to significance at the 5% level. It was concluded that the Poisson distribution provided a better overall description of the distribution of active main setts in Ireland.

Addendum 1:

The U statistic goodness of fit test: if the observed value of U exceeds 2 standard errors of U, then the null hypothesis that the negative binomial is an adequate fit to the data is rejected [at $\alpha = 0.05$] (Krebs, 1989)

The T statistic goodness of fit test: if the observed value of T exceeds 2 standard errors of T, then the null hypothesis that the negative binomial is an adequate fit to the data is rejected [at $\alpha = 0.05$] (Krebs, 1989).

Degrees of freedom for χ^2 tests:

d.f. = n - 1 - number of fitted parameters (Snedecor & Cochran, 1989).

If expected number of observations in a size class was less than 3, the size classes were grouped.

Addendum 2:

Terminology: for the χ^2 test, results are reported in the form χ^2_3 , where the subscript denotes the degrees of freedom.

Generally, throughout the report and for all statistical techniques, a statistical evaluation was considered as significant where $P<0.05$ (5% level).

APPENDIX 21

Calculating confidence intervals for estimates obtained from two or more independent studies

National estimates of numbers of adult badgers were obtained by multiplying the estimate of the number of social groups present by the mean number of social groups. Originally, these estimates were presented with 95% confidence limits. If one uses these confidence limits to calculate extreme limits, these limits do not represent a 95% confidence interval for the number of badgers present in Ireland.

Probability theory (Snedecor & Cochran, 1989) gives the probability as that obtained by multiplying the probability of each observation, thus

0.95*0.95, which equals 0.90, so the confidence interval is given by 90% confidence limits. For the calculations of badger numbers given by captures at each sett type, 3 estimates were used to obtain a value, each with P = 0.95. Thus the new P = 0.857

More generally, the new probability ($P_{overall}$) is given by

$$P_{overall} = 1 - \text{number of independent studies}*(1-P_{\text{individual studies}})$$

$$\begin{aligned} \text{Thus P for the above} &= 1 - 2*(1 - 0.95) \\ &= 0.9, \text{ or } 90\% \\ \text{and} \quad & 1 - 3*(1 - 0.95) \\ &= 0.85, \text{ or } 85\%. \end{aligned}$$

Actual confidence limits for a mean given using this method require multiplication of the standard error by the *z* score using $1 - \alpha/2$, with *z* scores obtained from the standard normal. There has been some confusion over this. Generally,

confidence limits are obtained by the mean
$\pm$ appropriate *z* score using $(1-[\alpha/2])$

There is a general rule for the above calculations, known as one of Bonferroni's inequalities, which was utilised in its general form for the computation of habitat preferences for sett location by badgers.

Use of Bonferroni's adjustment for calculating confidence limits for observed use of habitats

Confidence limits are given in the usual way by the appropriate value of *z* (approximation to normal distribution) multiplied by the estimated standard error of the mean (= observed value). Normally the appropriate *z* value is given from tables at the chosen significance level, as above, thus with

$z_{(1-\alpha/2)}$

where, if one expects to calculate 80% confidence intervals, $\alpha = 0.2$ (*i.e.*, $\alpha = 1-0.8$).

Where several observations (*e.g.*, in this case, a number of habitat types) are considered, the confidence limits for the actual observed proportions in each habitat type are corrected by the Bonferroni adjustment, so that the confidence limits are obtained by use of:

$z_{(1-\alpha/(2k))}$

where k = number of habitat types.

Confidence intervals for the actual observation in any habitat type are given by:

$$Z_{\left(1-\frac{\alpha}{2k}\right)} \cdot \sqrt{\frac{p\cdot(1-p)}{n}}$$

where p is the observed proportion of individuals in the habitat and where n = total number of setts observed.

These confidence intervals are known as family confidence intervals.

The error in equations which purport to relate to Neu *et al* (1974) and the Bonferroni adjustment for number of habitats concerned given by Cresswell *et al* (1990) firstly relates to brackets. Their computations calculate the appropriate z statistic as

$z_{((1-\alpha)/2k)}$ and *not* $z_{(1-\alpha/2k)}$

These bracketing errors lead to errors in estimation of confidence intervals for observed proportions. In any case, the first equation given on page 49 (Cresswell *et al*, 1990), does not compute correctly: the statistic of $z_{(0.1)}$ quoted cannot be arrived at from the equation presented *even* if the equation is altered (the statistic is either $z_{(0.4)}$ or $z_{(0.9)}$). Following that, the value of z cannot be calculated as 1.99 (with $\alpha = 0.2$) as given in following equations on the same page. The value of 1.99 for the z statistic was adopted by Cresswell *et al* (1990) for all analyses for each landclass. The correct value is 2.475. Their observation that α should not be too small as z becomes too large is incorrect as the maximum value that z may have is 4.9 (≈ 5). Also, Cresswell *et al* utilised 15 habitat categories, but some of these comprised totals of others *e.g.* the total woodland grouping consisted of 4 woodland categories. Preferably, there should be exclusion of groupings of habitat data already included in the analysis.

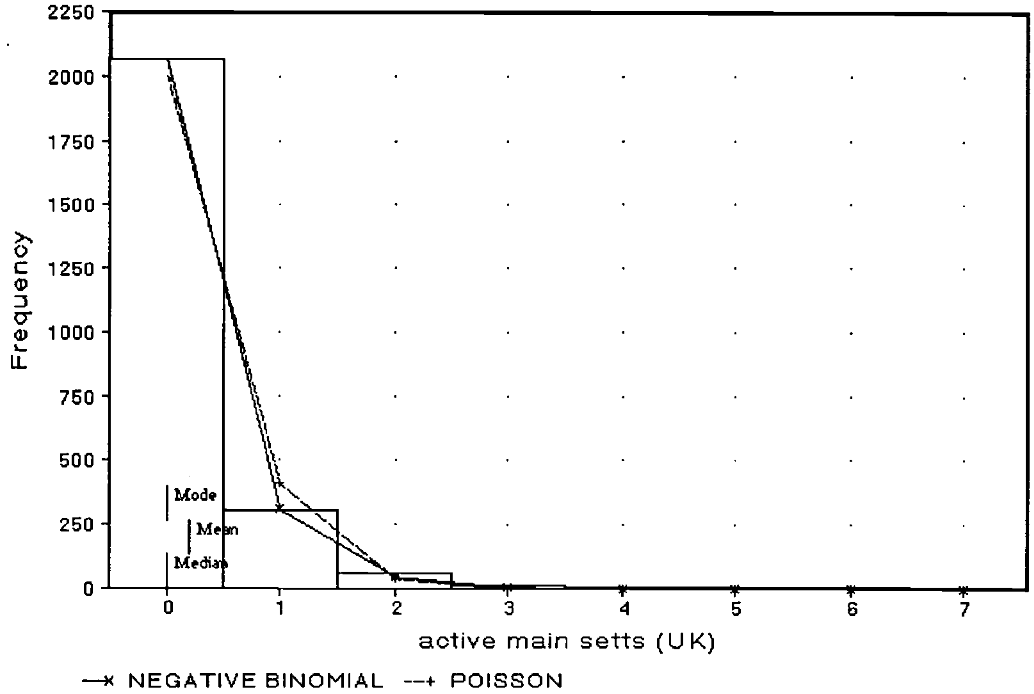
The next difficulty arises from misuse of commonly used statistical tables. Evaluation of the data given by O'Corry-Crowe (1992), suggests that the z statistic is often misunderstood - but poor explanatory information with tables presented in many statistical texts is not helpful. Checks on computations presented by Neu *et al* (1974) and also by Alldredge & Ratti (1992) confirmed the correct equations given above and the use of standard normal cumulative distributions of z. As there has been, therefore, some difficulty in the comprehension of the use of z statistic as given by tables in common texts, the Appendices here present copies of tables of the Normal distribution - which in, the first case, present tables which proffer a full z statistic (from z values of -3.99 to +3.99) and, also, those in which the area covered by a normal curve is computed from $z = 0$, which are *not* appropriate for evaluation of the z statistic for the requirements of the Neu *et al* method, unless care is taken to determine the area under the normal curve correctly at the chosen significance level. z values required for the correct computations above, necessitate the use of z values wherein the area (cumulative distribution) of the normal curve is 0.5 at $z = 0.0$. Thus, normally, for a 95% confidence interval, $\alpha = 0.975$ and $z = 1.96$, a well known statistic. Thus, the usual tables supplied with various texts for the z distribution require that a value of 0.5 be added to the area values.

O'Corry-Crowe used a correct Bonferroni adjustment, *i.e.* z value at $(1 - (\alpha/2k))$ and not $((1-\alpha)/2k)$, but evaluated $z_{(0.986)}$ by looking up $z_{(0.986/2)}$ in the one-sided tables rather than looking up $z_{(0.986-0.5)}$.

To further confuse matters somewhat, Byers, Steinhorst & Krausman (1984) clarified the technique developed by one of them (Byers re. Neu *et al*, 1974) in a paper entitled *'Clarification of ....'*. In this case the z score was obtained at $\alpha/2k$ not $1 - \alpha/2k$. Using the full tables, the value of z obtained is identical except that it is -ve rather than +ve. Since the calculation of confidence limits utilise + and - values of z, the end result is the same.

APPENDIX 22

UK data for active main sett distribution, given in Table 4 of Cresswell et al, *1990.*



Statistics:

Number of survey squares: 2455
Mean: 0.206
Variance: 0.299
Variance : mean ratio: 1.45
Significance of presence of clumped distribution: $P < 0.0001$
Fitted to negative binomial. U and T tests showed that the fit was acceptable ($P>0.05$).
$\chi^2_2 = 3.28, P = 0.19.$

Negative binomial $k = 0.4924$

Tested for possibility of Poisson distribution: rejected. χ^2 goodness of fit test:

$\chi^2_2 = 153.56, P < 0.00001;$
G test (Williams, 1976): $G = 86.69$, 2 d.f., $P < 0.00001$.

APPENDIX B

APPENDED DOCUMENTS

APPENDIX B1

Sample record from the habitat database

Note: this is the habitat composition summary for the 1km square illustrated in colour in Figure 5 of the main text. The square is located in Co. Tipperary and was assessed as having 1 main sett, 1 annexe sett, 1 subsidiary sett and 1 outlier sett. All were active.

Details of the square's location have been removed from the record shown and from the map, in order to maintain confidential the locations of badger setts.

RECORD NO. 146
SQUARE REFERENCE: [ ]
LOCATION: [ ]
COUNTY: TIPPERARY
DISTRICT: RYAN
DATE: 16/12/91
OBSERVER: PADRAIG COMERFORD
ADDRESS: WR

DETAILS OF HABITAT AREAS AND LENGTHS

HABITAT NO.	HABITAT DESCRIPTION	AREA (HA.) TOTAL	LENGTH (KMS)	C (breakdowns)	S	CS	O
1	hedgerow		12.45				
2	treeline	0.00					
2B	bare treeline		0.00				
3	semi-natural broadleaved woodland		0.0				
4	broad-leaved plantation	0.0					
5	semi-natural coniferous woodland	0.0					
6	coniferous plantation	0.0					
6Y	young coniferous plantation	0.0					
7	semi-natural mixed woodland	0.0					
8	mixed plantation	0.0					
9	young mixed broad-leaved woodland	0.0					
10	recently felled woodland	0.0					
11	parkland	0.0		0.0	0.0	0.0	0.0
12	tall scrub	0.0	0.00				
13	low scrub	1.8	0.00				
14	bracken	0.0					
15	coastal sand dunes	0.0					
16	coastal sand/mud	0.0					
17	coastal shingle/boulder	0.0					
18	lowland heaths	0.0		0.0	0.0	0.0	0.0
19	heather moorlands	0.0		0.0	0.0	0.0	0.0
20	blanket bogs	0.0		0.0	0.0	0.0	0.0
21	raised bogs	0.0		0.0	0.0	0.0	0.0
20/21W	worked bog	0.0					
22	marginal inundations	0.0					
23	coastal marsh	0.0					
24	wet ground	1.4		0.0	0.0	0.0	0.0
25	standing natural water	0.0					
26	standing man-made water	0.0					
27	running natural water	0.0	0.00				
28	running canalised water	0.2	2.02				
29	upland unimproved grassland	0.0		0.0	0.0	0.0	0.0
30	lowland unimproved grassland	0.0		0.0	0.0	0.0	0.0
31	semi-improved grassland	0.0		0.0	0.0	0.0	0.0
32	improved grassland	87.7		56.3	15.6	10.9	0.0

SQUARE REFERENCE: [ ]

HABITAT NO.	HABITAT DESCRIPTION	AREA (HA.) TOTAL	LENGTH (KMS)	C (breakdowns)	S	CS	O
33	arable (TOTAL)	6.9		0.0	0.0	0.0	0.0
33B	arable (seedcrops)	6.9					
33R	arable (rootcrops)	0.0					
33G	arable (grassleys)	0.0					
33H	arable (hortic/other)	0.0					
34	amenity grassland	0.0					
35	unquarried inland cliffs	0.0					
36	vertical coastal cliffs+	0.0					
37	sloping coastal cliffs	0.0					
38	quarries/open cast mines	0.0					
39	bare ground	0.0					
40	built land	0.7					
41	road	1.4	1.20				
40/41	built land & roads (TOTAL)	2.1					
42	sea	0.0					
OTHER	unspecified; CSO in all other	0.0		0.0	0.0	0.0	0.0

SUMMARIES AND DATA SUITABILITY

TOTAL CALCULATED AREA: 100.1 ha.
Scales (1km square): X: 15.55 cms Y: 15.45 cms
Is data thorough enough for inclusion in analysis for cattle/sheep/other grazing areas? Y
Is data thorough enough for inclusion in analysis of lengths AND area of categories 12/13? Y
Have areas of 40 & 41 been considered separately? Y
Have areas of rivers and drains been assessed? Y
Suitability Notes: OK

APPENDIX B2

Statistical tables - Cumulative Normal: Standard Normal

1) pages 410 and 411 from Afifi & Azen (1979): these tables present z from -3.9 to +3.9, and were used for computations of confidence limits in determining habitat selection by badgers for sett location.

2) pages 78 and 79 from Rohlf & Sokal (1981), with z values from 0 to 5 only. Care should be taken in applying values from these tables for calculation of z statistics (see Appendix A21).

TABLE 2. *Cumulative N(0, 1) (Section 1.2.5)*[a]

z	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
− ·0	·5000	·4960	·4920	·4880	·4840	·4801	·4761	·4721	·4681	·4641
− ·1	·4602	·4562	·4522	·4483	·4443	·4404	·4364	·4325	·4286	·4247
− ·2	·4207	·4168	·4129	·4090	·4052	·4013	·3974	·3936	·3897	·3859
− ·3	·3821	·3783	·3745	·3707	·3669	·3632	·3594	·3557	·3520	·3483
− ·4	·3446	·3409	·3372	·3336	·3300	·3264	·3228	·3192	·3156	·3121
− ·5	·3085	·3050	·3015	·2981	·2946	·2912	·2877	·2843	·2810	·2776
− ·6	·2743	·2709	·2676	·2643	·2611	·2578	·2546	·2514	·2483	·2451
− ·7	·2420	·2389	·2358	·2327	·2297	·2266	·2236	·2206	·2177	·2148
− ·8	·2119	·2090	·2061	·2033	·2005	·1977	·1949	·1922	·1894	·1867
− ·9	·1841	·1814	·1788	·1762	·1736	·1711	·1685	·1660	·1635	·1611
−1·0	·1587	·1562	·1539	·1515	·1492	·1469	·1446	·1423	·1401	·1379
−1·1	·1357	·1335	·1314	·1292	·1271	·1251	·1230	·1210	·1190	·1170
−1·2	·1151	·1131	·1112	·1093	·1075	·1056	·1038	·1020	·1003	·09853
−1·3	·09680	·09510	·09342	·09176	·09012	·08851	·08691	·08534	·08379	·08226
−1·4	·08076	·07927	·07780	·07636	·07493	·07353	·07215	·07078	·06944	·06811
−1·5	·06681	·06552	·06426	·06301	·06178	·06057	·05938	·05821	·05705	·05592
−1·6	·05480	·05370	·05262	·05155	·05050	·04947	·04846	·04746	·04648	·04551
−1·7	·04457	·04363	·04272	·04182	·04093	·04006	·03920	·03836	·03754	·03673
−1·8	·03593	·03515	·03438	·03362	·03288	·03216	·03144	·03074	·03005	·02938
−1·9	·02872	·02807	·02743	·02680	·02619	·02559	·02500	·02442	·02385	·02330
−2·0	·02275	·02222	·02169	·02118	·02068	·02018	·01970	·01923	·01876	·01831
−2·1	·01786	·01743	·01700	·01659	·01618	·01578	·01539	·01500	·01463	·01426
−2·2	·01390	·01355	·01321	·01287	·01255	·01222	·01191	·01160	·01130	·01101
−2·3	·01072	·01044	·01017	·0^{2}9903	·0^{2}9642	·0^{2}9387	·0^{2}9137	·0^{2}8894	·0^{2}8656	·0^{2}8424
−2·4	·0^{2}8198	·0^{2}7976	·0^{2}7760	·0^{2}7549	·0^{2}7344	·0^{2}7143	·0^{2}6947	·0^{2}6756	·0^{2}6569	·0^{2}6387
−2·5	·0^{2}6210	·0^{2}6037	·0^{2}5868	·0^{2}5703	·0^{2}5543	·0^{2}5386	·0^{2}5234	·0^{2}5085	·0^{2}4940	·0^{2}4799
−2·6	·0^{2}4661	·0^{2}4527	·0^{2}4396	·0^{2}4269	·0^{2}4145	·0^{2}4025	·0^{2}3907	·0^{2}3793	·0^{2}3681	·0^{2}3573
−2·7	·0^{2}3467	·0^{2}3364	·0^{2}3264	·0^{2}3167	·0^{2}3072	·0^{2}2980	·0^{2}2890	·0^{2}2803	·0^{2}2718	·0^{2}2635
−2·8	·0^{2}2555	·0^{2}2477	·0^{2}2401	·0^{2}2327	·0^{2}2256	·0^{2}2186	·0^{2}2118	·0^{2}2052	·0^{2}1988	·0^{2}1926
−2·9	·0^{2}1866	·0^{2}1807	·0^{2}1750	·0^{2}1695	·0^{2}1641	·0^{2}1589	·0^{2}1538	·0^{2}1489	·0^{2}1441	·0^{2}1395
−3·0	·0^{2}1350	·0^{2}1306	·0^{2}1264	·0^{2}1223	·0^{2}1183	·0^{2}1144	·0^{2}1107	·0^{2}1070	·0^{2}1035	·0^{2}1001
−3·1	·0^{3}9676	·0^{3}9354	·0^{3}9043	·0^{3}8740	·0^{3}8447	·0^{3}8164	·0^{3}7888	·0^{3}7622	·0^{3}7364	·0^{3}7114
−3·2	·0^{3}6871	·0^{3}6637	·0^{3}6410	·0^{3}6190	·0^{3}5976	·0^{3}5770	·0^{3}5571	·0^{3}5377	·0^{3}5190	·0^{3}5009
−3·3	·0^{3}4834	·0^{3}4665	·0^{3}4501	·0^{3}4342	·0^{3}4189	·0^{3}4041	·0^{3}3897	·0^{3}3758	·0^{3}3624	·0^{3}3495
−3·4	·0^{3}3369	·0^{3}3248	·0^{3}3131	·0^{3}3018	·0^{3}2909	·0^{3}2803	·0^{3}2701	·0^{3}2602	·0^{3}2507	·0^{3}2415
−3·5	·0^{3}2326	·0^{3}2241	·0^{3}2158	·0^{3}2078	·0^{3}2001	·0^{3}1926	·0^{3}1854	·0^{3}1785	·0^{3}1718	·0^{3}1653
−3·6	·0^{3}1591	·0^{3}1531	·0^{3}1473	·0^{3}1417	·0^{3}1363	·0^{3}1311	·0^{3}1261	·0^{3}1213	·0^{3}1166	·0^{3}1121
−3·7	·0^{3}1078	·0^{3}1036	·0^{4}9961	·0^{4}9574	·0^{4}9201	·0^{4}8842	·0^{4}8496	·0^{4}8162	·0^{4}7841	·0^{4}7532
−3·8	·0^{4}7235	·0^{4}6948	·0^{4}6673	·0^{4}6407	·0^{4}6152	·0^{4}5906	·0^{4}5669	·0^{4}5442	·0^{4}5223	·0^{4}5012
−3·9	·0^{4}4810	·0^{4}4615	·0^{4}4427	·0^{4}4247	·0^{4}4074	·0^{4}3908	·0^{4}3747	·0^{4}3594	·0^{4}3446	·0^{4}3304

TABLE 2 *(continued)*[a]

z	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
·0	·5000	·5040	·5080	·5120	·5160	·5199	·5239	·5279	·5319	·5359
·1	·5398	·5438	·5478	·5517	·5557	·5596	·5636	·5675	·5714	·5753
·2	·5793	·5832	·5871	·5910	·5948	·5987	·6026	·6064	·6103	·6141
·3	·6179	·6217	·6255	·6293	·6331	·6368	·6406	·6443	·6480	·6517
·4	·6554	·6591	·6628	·6664	·6700	·6736	·6772	·6808	·6844	·6879
·5	·6915	·6950	·6985	·7019	·7054	·7088	·7123	·7157	·7190	·7224
·6	·7257	·7291	·7324	·7357	·7389	·7422	·7454	·7486	·7517	·7549
·7	·7580	·7611	·7642	·7673	·7703	·7734	·7764	·7794	·7823	·7852
·8	·7881	·7910	·7939	·7967	·7995	·8023	·8051	·8078	·8106	·8133
·9	·8159	·8186	·8212	·8238	·8264	·8289	·8315	·8340	·8365	·8389
1·0	·8413	·8438	·8461	·8485	·8508	·8531	·8554	·8577	·8599	·8621
1·1	·8643	·8665	·8686	·8708	·8729	·8749	·8770	·8790	·8810	·8830
1·2	·8849	·8869	·8888	·8907	·8925	·8944	·8962	·8980	·8997	·90147
1·3	·90320	·90490	·90658	·90824	·90988	·91149	·91309	·91466	·91621	·91774
1·4	·91924	·92073	·92220	·92364	·92507	·92647	·92785	·92922	·93056	·93189
1·5	·93319	·93448	·93574	·93699	·93822	·93943	·94062	·94179	·94295	·94408
1·6	·94520	·94630	·94738	·94845	·94950	·95053	·95154	·95254	·95352	·95449
1·7	·95543	·95637	·95728	·95818	·95907	·95994	·96080	·96164	·96246	·96327
1·8	·96407	·96485	·96562	·96638	·96712	·96784	·96856	·96926	·96995	·97062
1·9	·97128	·97193	·97257	·97320	·97381	·97441	·97500	·97558	·97615	·97670
2·0	·97725	·97778	·97831	·97882	·97932	·97982	·98030	·98077	·98124	·98169
2·1	·98214	·98257	·98300	·98341	·98382	·98422	·98461	·98500	·98537	·98574
2·2	·98610	·98645	·98679	·98713	·98745	·98778	·98809	·98840	·98870	·98899
2·3	·98928	·98956	·98983	·9^{2}0097	·9^{2}0358	·9^{2}0613	·9^{2}0863	·9^{2}1106	·9^{2}1344	·9^{2}1576
2·4	·9^{2}1802	·9^{2}2024	·9^{2}2240	·9^{2}2451	·9^{2}2656	·9^{2}2857	·9^{2}3053	·9^{2}3244	·9^{2}3431	·9^{2}3613
2·5	·9^{2}3790	·9^{2}3963	·9^{2}4132	·9^{2}4297	·9^{2}4457	·9^{2}4614	·9^{2}4766	·9^{2}4915	·9^{2}5060	·9^{2}5201
2·6	·9^{2}5339	·9^{2}5473	·9^{2}5604	·9^{2}5731	·9^{2}5855	·9^{2}5975	·9^{2}6093	·9^{2}6207	·9^{2}6319	·9^{2}6427
2·7	·9^{2}6533	·9^{2}6636	·9^{2}6736	·9^{2}6833	·9^{2}6928	·9^{2}7020	·9^{2}7110	·9^{2}7197	·9^{2}7282	·9^{2}7365
2·8	·9^{2}7445	·9^{2}7523	·9^{2}7599	·9^{2}7673	·9^{2}7744	·9^{2}7814	·9^{2}7882	·9^{2}7948	·9^{2}8012	·9^{2}8074
2·9	·9^{2}8134	·9^{2}8193	·9^{2}8250	·9^{2}8305	·9^{2}8359	·9^{2}8411	·9^{2}8462	·9^{2}8511	·9^{2}8559	·9^{2}8605
3·0	·9^{2}8650	·9^{2}8694	·9^{2}8736	·9^{2}8777	·9^{2}8817	·9^{2}8856	·9^{2}8893	·9^{2}8930	·9^{2}8965	·9^{2}8999
3·1	·9^{3}0324	·9^{3}0646	·9^{3}0957	·9^{3}1260	·9^{3}1553	·9^{3}1836	·9^{3}2112	·9^{3}2378	·9^{3}2636	·9^{3}2886
3·2	·9^{3}3129	·9^{3}3363	·9^{3}3590	·9^{3}3810	·9^{3}4024	·9^{3}4230	·9^{3}4429	·9^{3}4623	·9^{3}4810	·9^{3}4991
3·3	·9^{3}5166	·9^{3}5335	·9^{3}5499	·9^{3}5658	·9^{3}5811	·9^{3}5959	·9^{3}6103	·9^{3}6242	·9^{3}6376	·9^{3}6505
3·4	·9^{3}6631	·9^{3}6752	·9^{3}6869	·9^{3}6982	·9^{3}7091	·9^{3}7197	·9^{3}7299	·9^{3}7398	·9^{3}7493	·9^{3}7585
3·5	·9^{3}7674	·9^{3}7759	·9^{3}7842	·9^{3}7922	·9^{3}7999	·9^{3}8074	·9^{3}8146	·9^{3}8215	·9^{3}8282	·9^{3}8347
3·6	·9^{3}8409	·9^{3}8469	·9^{3}8527	·9^{3}8583	·9^{3}8637	·9^{3}8689	·9^{3}8739	·9^{3}8787	·9^{3}8834	·9^{3}8879
3·7	·9^{3}8922	·9^{3}8964	·9^{4}0039	·9^{4}0426	·9^{4}0799	·9^{4}1158	·9^{4}1504	·9^{4}1838	·9^{4}2159	·9^{4}2468
3·8	·9^{4}2765	·9^{4}3052	·9^{4}3327	·9^{4}3593	·9^{4}3848	·9^{4}4094	·9^{4}4331	·9^{4}4558	·9^{4}4777	·9^{4}4988
3·9	·9^{4}5190	·9^{4}5385	·9^{4}5573	·9^{4}5753	·9^{4}5926	·9^{4}6092	·9^{4}6253	·9^{4}6406	·9^{4}6554	·9^{4}6696

[a] Abridged from Table II of A. Hald, "Statistical Tables and Formulas," 1952, Wiley, New York.

TABLE 11 Areas of the normal curve

Standard deviation units	0.	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	Standard deviation units
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359	0.0
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753	0.1
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141	0.2
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517	0.3
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879	0.4
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224	0.5
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549	0.6
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852	0.7
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133	0.8
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389	0.9
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621	1.0
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830	1.1
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015	1.2
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177	1.3
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319	1.4
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441	1.5
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545	1.6
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633	1.7
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706	1.8
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767	1.9
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817	2.0
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857	2.1
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890	2.2
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916	2.3
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936	2.4
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952	2.5
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964	2.6
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974	2.7
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981	2.8
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986	2.9
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990	3.0
3.1	.4990	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993	3.1
3.2	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995	.4995	.4995	3.2
3.3	.4995	.4995	.4995	.4996	.4996	.4996	.4996	.4996	.4996	.4997	3.3
3.4	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4998	3.4
3.5	.499767										
3.6	.499841										
3.7	.499892										
3.8	.499928										
3.9	.499952										
4.0	.499968										
4.1	.499979										
4.2	.499987										
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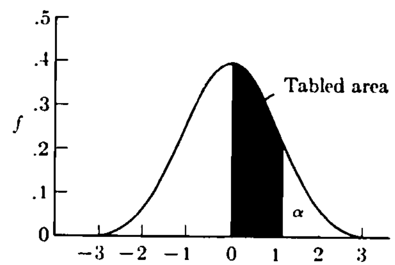

Argument $= \frac{Y - \mu_Y}{\sigma}$

APPENDIX B3 Instructions for Badger & Habitat Survey

prepared 1989, and used throughout the survey

NATIONAL BADGER SURVEY 1990 - 1992

WILDLIFE SERVICE

CONTENTS

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NATIONAL BADGER SURVEY 1990 - 1992

OBJECTIVES

(from 'Outline Research Proposals', Smal.C.M., October 1989)

1 to assess overall distribution of badgers in Ireland based on presence/absence in 10km squares of the National Grid.

2 to sample a minimum of 1% of Ireland's land area, and assess the density of badgers within approximately 900 1km squares, providing an approximate overall assessment of the density of badgers in Ireland.

3 if possible, to allow inclusion of data for badgers from volunteer effort in the North of Ireland, on the basis of above.

4 to relate density to environmental and habitat variables (e.g. topography, geology and soils, climate, land use, vegetation type and pattern) and develop a predictive model allowing estimation of badger density within each of Ireland's land classes and according to habitat variability. This will allow a refined assessment of the status, distribution and density of the badger in Ireland, and also allow prediction of the number of badgers to be affected by any large-scale removal operations.

5 to validate or refine British models within the Irish context to allow full comparison of Irish data with that available for Britain.

6 to investigate the relationship of badger density to incidence of TB in cattle in Ireland and develop a predictive model for 'high-risk' areas ('high-risk' areas, for example, could be identified by land class and habitat predicting very high badger densities).

7 to investigate the incidence of TB in cattle in relation to farming practice, as well as to badger densities, and to attempt to isolate confounding effects between the two.

8 to assess the level of human disturbance to badgers.

9 to provide a reliable baseline for future badger surveys, to allow monitoring of future changes in status. These may be necessary due to the impact of culling operations and changes in agricultural practice and land use.

10 to provide techniques for the evaluation of the success, in terms of badger numbers, of badger removal operations, and the rate of recolonisation of 'cleared' areas by badgers.

11 to prepare a land classification of the country and thereby to provide a framework for future flora and fauna and land use surveys and investigations such as this one in Ireland.

NATIONAL BADGER SURVEY

OUTLINE OF INSTRUCTIONS FOR CARRYING OUT BADGER SURVEY

The national badger survey is based on a complete and thorough survey of setts within selected 1km squares of the Irish National Grid. In almost all cases, the 1km square in the south-west corner of every 10km square in Ireland will be surveyed. As well as recording every single sett and describing its activity and site, all habitat features present within the 1km square must also be recorded. Since the survey is to be thorough, observations on the presence of other mammals are to be noted.

You are provided with:

1) enlarged 6" map of survey square.
2) record sheets for each sett observed.
3) a field record sheet for each 1km square.
4) a summary record sheet for each 1km square.
5) a mammal record sheet for each 10km square.
6) notes on classifying badger sett activity.
7) notes on classifying badger setts.
8) a list of habitat categories.
9) a list of land classification categories.
10) notes on classifying soil types.

You will also require:

1) half-inch or one-inch map of the relevant area.
2) compass.
3) pen, and spare.
4) lead pencil, and spare.
5) coloured pencils (minimum 5 colours).
6) plastic pad/folder for covering the map and data sheets in use in the field.

You may find useful:

1) 'Collins Guide to Animal Tracks & Signs'
2) Mammal Society Booklet: 'Surveying Badgers'

GENERAL POINTS

1) DO NOT SURVEY IN SUMMER (mid-May to mid-October) when vegetation does not allow a thorough survey. Exceptions might be made for 'easy' habitats.
2) Allow up to 2 days for each 1km square survey - on average. Easy squares could be done in a half-day, difficult squares (e.g. woodland, moors) could take 3 days. Many squares include expanses of lake or sea and will be quicker to survey.
3) Do not handle badger faeces without disposable gloves (you are not required to handle animals or faeces for the purpose of the survey).
4) Avoid conflicts: some squares may be 'unsurveyable' e.g. on the border with the North, or with 'difficult' landowners. Choose to ignore such squares, using your judgment, and contact me for allocation of an alternative square.
5) Avoid controversy on the badger/TB issue: this is an unbiased survey of badgers in the country, and we would not wish to create the impression that we have predetermined opinions.
6) Do NOT publicise or inform landowners about locations of badger setts: this could be used to harm badgers - use your judgment.

BADGER SURVEY INSTRUCTIONS contd.

METHODS

SURVEY SQUARE LOCATION

1) On your half-inch OS map, find approximate location of the 1km survey square, and check the co-ordinates. Note that the grid reference for a 1km square is given by its south-west corner e.g. the 1km square at W 20 90 has four corners, with W 20 90 being the south-west corner: W is the Irish map reference, 20 is the Easting and 90 is the Northing. (The other 3 corners are given by the co-ordinates, clockwise: W2091, W2191, W2190).

2) Before you start, fill in the 1km square grid reference, location, your name, address and the date on the 1KM FIELD RECORD SHEET.

3) On the spot, use a compass and the enlarged 6" map to orientate yourself and plan the day's survey: every part of the survey square must be covered.

SETT SEARCH AND BADGER SIGNS

4) Proceed to search for every badger sett in the square, however small (some setts are only one hole). Look also for signs of badgers - feeding areas (soil scrapes), footprints, etc. and especially latrines. Latrines and setts must be marked on the map (see below), and it may be useful to you to mark other signs also. Asking locals you meet can be helpful in ensuring a full survey.

NOTING OTHER MAMMALS

5) In your survey, note observations within the 1km square of ANY other wild mammals present, including rabbits, hares, deer, foxes, and others, and record presence on the 1KM SQUARE FIELD RECORD SHEET. Signs and evidence of these mammals are OK but give details. Note sheep/cattle with habitat (see below).

RECORDING ALL HABITATS

6) You are required to fill in the ENLARGED 6" MAP with every detail of habitat. Every field, hedge, woodland, etc. MUST be coloured in on the map using coloured pencils, and the appropriate Habitat Category marked in on the map (mark in the number of the habitat category). Be familiar with the List of Habitat Categories. Refer to the List in the field.

Be as complete and accurate as possible. All the 6" maps of the survey squares will be digitised and computer processed, in order to relate badger densities to environmental and habitat variables such as number of woodland units, woodland areas, areas and type of grazing land, hedgerow length etc. Information on land use is of considerable value. On farmland or grazing land, note whether

the land is used for sheep or cattle or others by adding (S) or (C) or (O) after the habitat number on the map.
The 6" maps are out-of-date in many areas: please out features, such as hedgerows, that might have been removed since the maps were prepared. Use a normal pencil for marking in and crossing out.

BADGER LATRINES

7) Mark locations of badger latrines on the 6" map, and give each one a name e.g. L1, L2 etc. Add a note on such badger signs on the 1KM SQUARE FIELD RECORD SHEET. {There is no need to mark latrines found at or immediately next to an active badger sett, as this is recorded with information on the sett (see below)}. Latrines are collections of dung pits and boundary latrines are larger and more conspicuous than those within the territory. Boundary latrines are often along natural boundaries, such as hedgerow, fences etc. Knowing the locations of boundary latrines can be very helpful in finding a main sett - as you know it must be there! It also helps you to estimate how many main setts you might have missed, however hard you tried to survey the area thoroughly.

Signs of much feeding activity can also be helpful in this way.

BADGER SETTS - RECORDING INFORMATION ON EACH SETT

8) When you find a badger sett, fill in a BADGER SETT RECORD SHEET for that sett.

ACTIVITY: Assess the activity of the sett - refer to Instructions on Sett Identification and Activity. A sett is in Use if it has ANY well-used OR partially used entrance holes.

SETT TYPE: Assess the category of the sett - most importantly, whether it is a Main Sett or not, and whether it is active. Refer to the Instructions on Classifying Setts.

LOCATION: Mark the sett on the 6" map and give it a name on the map and on the record sheet. Suitable names would be M1 and M2 for two Main Setts, S1 and S2 for Subsidiary Setts and so on. Be sure to put a letter in front of the number so that the marks on the map are not confused with habitat categories. Use a standard pencil for marking in badger setts. Give the exact grid reference of the sett on the record sheet.

SITE: Assess the site of the sett, and note on the BADGER SETT RECORD SHEET - site description is given by Habitat Category or by ticking one of the additional categories listed on the data sheet.

SOILS: Assess the soil type at the sett - the spoil from diggings. Refer to Instructions on Soil Classification.

OTHER MAMMALS:	Note if any other mammals (foxes, rabbits) are using the sett.
DISTURBANCE:	If the sett shows signs of human disturbance: snares, traps, digging, or you know it to have been affected by legal or illegal control operations, please give details. You might need to search the area near the sett in order to be confident of classification of the sett. You can go outside the 1km square to check for setts nearby, but do not include setts outside the square as present within the square. Mark them on the map, and refer to them in Notes on the 1km Square Field Record Sheet.
LAND CLASS	9) When you finish the survey of the 1km square, try to place the landscape into a LAND CLASS category - refer to the List of Land Classes. Record the number on the 1KM SQUARE FIELD RECORD SHEET.
FARMING PRACTICE	10) If you have any observations on farming practice in the area relevant to transmission of TB, please note them on the 1KM SQUARE FIELD RECORD SHEET. Such observations relate mainly to herd-herd contact (poor fencing?), access by badgers to water troughs or cattle sheds or cattle feed, spreading of slurry.
FIELD DATA SHEETS	11) Before you leave the area, make sure that all data on every BADGER SETT RECORD SHEET has been entered correctly, including grid references etc. Fill in all data on the 1KM SQUARE FIELD RECORD SHEET. Try and fill in all parts of the record sheets as best as possible.
SETT SUMMARY SHEET	12) Later, fill in the BADGER SETT SUMMARY SHEET, which requests totals of setts found in the 1km square etc.
10KM SQUARE MAMMAL RECORD SHEET	13) Finally, any observations of mammals within the 1km square will be used for a nationwide survey of mammals based on presence within each 10km square. Any mammals present within the 1km square are automatically present in the 10km square with the same grid reference (given by south-west co-ordinate). Please fill in the 10KM SQUARE MAMMAL RECORD SHEETS, and do not forget to include the badgers also. If you have definite observations of mammals within the 10km square that were not found in the 1km square, please include them on the 10KM SQUARE MAMMAL RECORD SHEETS, giving details. Use extra sheets if necessary, remembering to fill in the

grid reference on each sheet.

Please include even common mammals such as rabbits, hares etc. The badger survey is covering EVERY habitat type and land class in the country, and is recording all the habitats within the squares. The information gained on distributions of mammals with regard to habitat will be of value.

AT COMPLETION

1) After survey of a 1km square has been completed, check that all data sheets (the 6"map, each badger sett record sheet, the 1km square field record sheet, the 1km square sett summary sheet and the 10km square mammal record sheet) are correct. You can redraw the map you used in the field, using a spare copy, if you think it necessary.
2) Preferably make a photocopy of the record sheets and maps for your future use, and for future surveys in your area. This also safeguards against losses in the post.
3) Return completed records to me as soon as possible (address below).

DEADLINES

1) The National Badger Survey is to be completed within 2 years (January 31st 1992). There are a total of 900 1km squares to be surveyed, with each Ranger being assigned 20 - 30 squares to complete within the 2 years. Volunteers will be allocated additional squares.
2) Please aim at completing half of your squares within one year (January 1991).
3) Please return a minimum of 5 1km square records by May 31st 1990.

ADDRESS

Dr. Christopher M. Smal
Wildlife Service,
Sidmonton Place,
Bray,
Co. Wicklow
Phone: 01-867751

Please do not hesitate to contact me with any queries.

THANKS

MINK SURVEY: your work in the survey of feral mink (1985 - 1986) was appreciated. This has been published: please request a copy if you need one.

The badger survey is considerably more complex taking all habitat variables into consideration.

IDENTIFYING BADGER SETTS AND RECORDING THEIR ACTIVITY

Identifying

Badger holes are usually at least 10" in diameter and are rounded or flattened oval in shape. Fox and rabbit holes tend to be smaller and are often taller than broad. If the sett is in use by badgers, there will be other evidence: hairs, bedding, latrines, footprints. Rabbit holes usually have rabbit droppings on the spoil and signs of grazing around the holes. Fox holes usually have a characteristic odour, footprints in the spoil, and often scats or prey remains outside (badgers never bring prey remains back to the sett). Note that foxes or rabbits may co-habit with badgers in different parts of the sett; or foxes and rabbits may use temporarily uninhabited setts (which should be recorded as Disused Badger Setts).

A sett is defined as either a single hole or a series of a few or many holes that are connected underground. An exception may be made for two setts dug on either side of a ditch, but close together, and clearly forming one sett complex. As a rough guide, two discrete series of holes separated by at least 15m, or closer if separated by a major obstacle (such as a steep ditch or road) would be classified as two separate setts (Harris, Cresswell & Jeffries, 1989).

Activity

Activity is useful in determining the classification of setts.
Record the following:

1) THE NUMBER OF WELL USED HOLES
These are usually clear of any debris or vegetation (though not always!), are obviously in regular use, and may or may not have been excavated recently.

2) THE NUMBER OF PARTIALLY USED HOLES
These are not in regular use and have debris such as leaves or twigs in the entrance, or have moss and/or other plants growing in and around the entrance. Partially used holes could be in regular use after a minimal amount of clearance.

3) THE NUMBER OF DISUSED HOLES
These have not been in use for some time, are partially or completely blocked, and cannot be used without a considerable amount of clearance. If the hole has been disused for some time, all that may be visible is a depression in the ground where the hole used to be, and the remains of the spoil heap, which may be covered by moss or plants. (Note that a sett not in use by badgers but in active use by foxes or rabbits is classified as a Disused Sett).

Disturbance

Note if holes are blocked by children, fox-hunts or landowners. Note severe disturbance such as filling with slurry or signs of gassing (or you may be aware of legal or illegal snaring or gassing of badgers at the sett). Sett digging is evidenced by a single hole dug straight down into a tunnel, though diggers may follow a tunnel backwards, leaving a long trench, or, if it has been refilled, a long depression and spade marks.

CLASSIFYING BADGER SETTS

Classification of badger setts is essential to the aims of the national badger survey. A count of the number of Main setts gives an estimate of the number of social groups, and hence the numbers of badgers in an area.

Setts may be classed as Main setts, Annexe setts, Subsidiary setts and Outlier setts. These may be In Use or Disused.

The categories below are a guide only. Do not expect always expect all categories to be present - annexe setts, for example, might be absent. In upland areas, main setts mauy have only one or two entrances in rocky cairns. Classification within the 1km square is simpler after you complete the survey, and, if you are in doubt, it may be helpful to go a little outside of the survey square to search for setts (mark these on the map).

MAIN SETTS	These usually have a large number of entrances (used and disused) with conspicuous soil heaps. The setts look well used, with the paths between entrances and to and from the sett being obvious and well worn. Main setts are breeding setts and are normally in continuous use. However, main setts may become disused due to disturbance or some other reason, and should be recorded as Disused Main Setts: these are particularly common in areas of low badger density. Well used setts are not necessarily entirely clear of leaf debris, especially in autumn.
ANNEXE SETTS	These are close to a Main sett, between 50m and 150m away, and are usually connected to the Main sett by well-worn paths. They usually have several holes, but may not be in use all the time, even if the Main sett is very active.
SUBSIDIARY SETTS	Subsidiary setts have an intermediate number of entrances (three to five in most areas) and are not connected to another sett by obvious paths. They are usually at least 50m from a Main sett and are not continuously active.
OUTLIERS	These usually have only one or two holes, often with little spoil outside the hole, and have no obvious path connecting with another sett. They are used only sporadically, and, when not in use by badgers, they may be taken over by foxes and even by rabbits.
NOTES:	1) The number of entrances at Main setts and Annexe setts is, on average, about the same. Subsidiary and Outlier setts have significantly fewer entrances. 2) As Main setts and Annexe setts are connected to one another, and close together, they can be used together as a unit in the determination of social group density. 3) Record every sett found even if it is totally disused and only the old spoil heaps are evident. 4) Record a badger sett occupied by foxes or rabbits as a Disused Badger Sett, and note also the presence of the Other Occupants on the Badger Sett Record Sheet.

BADGER SURVEY
Soil Classification

A: Rub between fingers

1. Gritty - B
2. Sticky - C(i)
3. Silky - C(ii)
4. Sticky and gritty - C(iii)
5. Silky and gritty - C(iv)
6. None of these, but black - (D)
7. None of these, nor black = LOAM $\boxed{1}$

B: Try to mould into a roll

(i) cannot - does not stick or mark the skin = SAND $\boxed{2}$

(ii) roll formed and marks skin

(a) roll breaks when bent double = LOAMY SAND $\boxed{3}$

(b) roll does not break

(i) surface can be polished with thumb = SANDY CLAY $\boxed{4}$

(ii) surface cannot be polished = SANDY LOAM $\boxed{5}$

C: Roll soil into ball and polish with thumb

(i) sticky

(a) ball resists deformation CLAY $\boxed{6}$

(b) ball fairly resistant to deformation CLAY LOAM $\boxed{7}$

(ii) silky

(a) ball fairly resistant to deformation SILT $\boxed{8}$

(b) ball has little or no cohesion SILT CLAY LOAM $\boxed{9}$

(c) ball smooth; fairly resistant to deformation SILT LOAM $\boxed{10}$

(iii) sticky and gritty; can be balled and polished SANDY CLAY LOAM $\boxed{11}$

(iv) silky and gritty; can be balled but not polished SANDY SILT LOAM $\boxed{12}$

D: Peat

(i) firm, coherent, tough, not plastic, plant structures visible, often spongy

= FIBROUS PEAT $\boxed{13}$

(ii) may appear fibrous, soft, becoming paste-like under pressure

= PARTLY DECOMPOSED PEAT $\boxed{14}$

(iii) plastic when wet, powdery when dry, no plant remains visible $\boxed{15}$

= AMORPHOUS PEAT

from 'Surveying Badgers', Mammal Society Occ. Publ. No. 9 Harris, S., Cresswell, P. & Jeffries, D. 1989

NATIONAL BADGER SURVEY
WILDLIFE SERVICE
SIDMONTON PLACE
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BADGER SURVEY: HABITAT CATEGORIES
(adapted from Cresswell, Harris & Jeffries, 1989)

For the British national badger survey, 40 habitat categories were used. These are given below with some minor changes. Any piece of habitat greater than 50m in length or 500m square is to be recorded. In most areas, there are only 5 or so categories present.

Mark in the habitats on the enlarged 6" maps of the 1km survey square using coloured pencils, along with the category number, and (if relevant) whether cattle or sheep use the land (see end). If your map is crowded, colour in the habitats on the map, and use a key next to the map: this must give colour and its code for habitat (the habitat number in the list below).

It is not possible to use 40 different colours for the 40 different habitats, so choose your own colours - hence, YOU MUST GIVE A KEY OR MARK IN THE HABITAT NUMBER ON THE MAP. IF YOU HAVE TO USE THE SAME COLOUR FOR DIFFERENT HABITAT TYPES ON THE SAME MAP, THEN MARK IN HABITAT NUMBER ON OR NEXT TO THE AREA MARKED.

Use these colours for main habitats: e.g. light green for grasslands; blue - hedges; black - treelines; dark green - woodlands; yellow - scrub,brambles, bracken; light brown - arable land; dark brown - moors and bogs; light blue for waterways/sea; red for roads, buildings, towns; others: grey, orange, etc.

LIST OF HABITAT CATEGORIES

NUMBER	HABITAT	DESCRIPTION
1	HEDGEROWS	These are less than 4m (12ft) high and less than 5m wide. Draw them as continous lines if any gaps are less than 10m wide. SEE ALSO 2.
2	TREELINES	A line of single trees (minimum of 3) greater than 4m high and less than 2 canopy widths apart. A HEDGEROW IS ASSOCIATED WITH THE TREE LINE.
2B	BARE TREELINES	As for treelines, but with no hedgerow.
3	SEMI-NATURAL BROAD-LEAVED WOODLAND	Predominantly broadleaved trees more than 5m high with a semi-natural or natural growth.
4	BROAD-LEAVED PLANTATION	Predominantly broad-leaved trees of any height which may or may not be native to the site and are of even age. Orchards are included in this category.
5	SEMI-NATURAL CONIFEROUS WOODLAND	Predominantly coniferous trees more than 5m high with semi-natural or natural growth.

6	CONIFEROUS PLANTATION	Predominantly coniferous trees more than 3m high which have been planted.
6Y	YOUNG CONIFEROUS PLANTATION	Predominantly coniferous trees under 3m high, which have been planted.
7	SEMI-NATURAL MIXED WOODLAND	At least 25% broad-leaved and at least 25% coniferous trees over 5m high with semi-natural or natural growth.
8	MIXED PLANTATION	At least 25% broad-leaved and at least 25% coniferous trees which have been planted.
9	YOUNG MIXED OR BROAD-LEAVED PLANTATION	Young trees, up to 3m high, which have been planted. (More than 75% conifer is 6Y - young conifer plantation).
10	RECENTLY FELLED WOODLAND	Areas for which there is evidence that woodland has been recently felled.
11	PARKLAND	Areas where treecover is less than 30%, the majority of the trees are between 30 and 70m apart, and a minimum number of 10 trees.
12	TALL SCRUB	Between 3 and 5m high e.g. thickets of blackthorn, old hazel coppice, etc. Stands of trees less than 5m high should be classified as woodland, not scrub.
13	LOW SCRUB	Woody vegetation less than 3m high, e.g. young coppice, bramble thickets.
14	BRACKEN	Land dominated by bracken with at least 75% cover.
15	COASTAL SAND DUNES	Includes all stages of succession where the vegetation is grass-dominated or wet dune slacks.
16	COASTAL SAND OR MUD FLATS	Bare areas of sand or mud.
17	COASTAL SHINGLE OR BOULDER BEACHES	Includes shingle and boulder beaches and outcrops of bare rock on foreshores.
18	LOWLAND HEATHS	Lowland heathland with at least 25% dwarf shrubs such as heather.
19	HEATHER MOORLANDS	Upland heathland with at least 25% dwarf shrubs such as heather and bilberry (Vaccinium).
20	BLANKET BOG	Areas of peat, dominated by heather, cotton or Sphagnum.

21 RAISED BOGS

At least half the peat area rised into a shallow dome, and drier than blanket bogs.

22 MARGINAL INUNDATIONS

Swamps or fens but not coastal marshes.

23 COASTAL MARSH

Consists predlominantly of salt marsh vegetation, such as Spartina, sea asters etc.

24 WET GROUND

Areas of wet land found in association with other habitats e.g. wet area in a grassland field or flushes in upland areas.

25 STANDING NATURAL WATER

No evidence of damming.

26 STANDING MAN-MADE WATER

Artificially created reservoirs and impoundments.

27 RUNNING NATURAL WATER

No evidence of canalisation.

28 RUNNING CANALISED WATER

A water course that has been artificially confined to flow in a certain channel.

29 UPLAND UNIMPROVED GRASSLAND

In upland areas, and will include some areas used for rough grazing and poor quality grassland such as purple moor grass. They have not been improved by the application of fertilisers, herbicides or by drainage.

30 LOWLAND UNIMPROVED GRASSLAND

May be regularly grazed or mown, or totally neglected. Should not have been improved by the application of fertilisers or herbicides to significantly alter the composition of the sward. Includes herb-rich grassland such as downland, cliff-tops etc. Neglected grassland that had reverted from categories 31 and 32 was included in this category.

31 SEMI-IMPROVED GRASSLAND

Grassland which has been slightly modified by fertiliser or herbicide application, or by heavy hrazing pressure and/or drainage.

32 IMPROVED GRASSLAND

Grassland that has had regular treatments of artifial fertilisers and herbicides: this category should NOT include monoculture grassland i.e. grassland leys (see 33).

33 ARABLE

All classes of arable land, including grassland leys and horticulture. A grassland is defined as short-term grassland, and will usually have been reseeded less than five years previously. It is characterised by evidence of ploughing, bare soil between the grass plants, a scarcity of broad-leaved plants, and is usually dominated by a single grass species, often rye grass. There are usually fewer than 5 - 10 species of plant per sqaure metre. Category 32 consists of longer term grassland with a higher density of grass and broadleaf species, usually in enclosed land.

DIFFERENTIATE THIS CATEGORY AS FOLLOWS:

33B ARABLE(SEEDCROPS) Arable land that is being used or has recently been used for seedcrops such as Barley or wheat.

33R ARABLE(ROOTCROPS) Arable land that is being used or has recently been used for rootcrops such as potatoes, beet.

33G ARABLE(GRASSLAND LEYS)

33H ARABLE(HORTICULTURE AND OTHER CROPS)

34 AMENITY GRASSLAND

This includes well-maintained non-agricultural grass, such as playing fields, recreation grounds and golf courses.

35 UNQUARRIED INLAND CLIFFS

Unvegetated rock over 5m in height and at an angle of at least 60 degrees. It includes scree.

36 VERTICAL COASTAL CLIFFS

As above but in coastal areas and mostly unvegetated.

37 SLOPING COASTAL CLIFFS

At an angle of less than 60 degrees and mostly vegetated.

38 QUARRIES AND OPEN-CAST MINES

Any excavation (gravel pits, chalk pits, etc.) including unvegetated spoil heaps.

39 BARE GROUND

Bare soil or bare ground not covered by vegetation and which does not fall into categories 35 - 38 or 40.

40 BUILT LAND

Any urban areas including gardens and transport corridors, and will include roads, buildings etc.

FARMLAND AND GRAZING LANDS: PRINCIPAL USE FOR WHICH LIVESTOCK?:

SHEEP	Add (S) after habitat number
CATTLE	Add (C) after habitat number
OTHERS	Add (O) after habitat number
UNKNOWN	Do not add anything after habitat number.
BOTH SHEEP AND CATTLE	Add (S)(C) after habitat number.

SURVY4.DOC

BADGER SURVEY

LAND CLASSIFICATION GUIDE

Land classes : the main categories (after Bunce, Barr & Whittaker, 1981), obtained from an analysis of principal environmental variables

1) undulating country, varied agriculture, mainly grassland
2) open, gentle slopes, often lowland, varied agriculture
3) flat arable land, mainly cereals, little native vegetation
4) flat, intensive agriculture, otherwise mainly built-up
5) lowland, somewhat enclosed land, varied agriculture and vegetation
6) gently rolling enclosed country, mainly fertile pasture
7) coastal with variable morphology and vegetation
8) coastal, often estuarine, mainly pasture, otherwise built-up
9) fairly flat, open intensive agriculture, often built-up
10) flat plains with intensive farming, often arable/grass mixture
11) rich alluvial plains, mainly open with pasture or arable
12) very fertile coastal plains with very productive crops
13) somewhat variable land forms, mainly flat, heterogeneous land use
14) level coastal plains with arable, otherwise often urbanised
15) valley bottoms with mixed agriculture, predominantly pasture
16) undulating lowlands, variable agriculture, and native vegetation
17) rounded intermediate slopes, mainly improvable permanent pasture
18) rounded hills, some steep slopes, varied moorlands
19) smooth hills, mainly heather moors, often afforested
20) midvalley slopes, wide range of vegetation types
21) upper valley slopes, mainly covered with bogs
22) margins of high mountains, moorlands, often afforested
23) high mountain summits, with well drained moorlands
24) upper, steep, mountain slopes, usually bog covered
25) lowlands with variable land use, mainly arable
26) fertile lowlands with intensive agriculture
27) fertile lowland margins with mixed agriculture
28) varied lowland margins with heterogeneous land use
29) sheltered coasts with varied land use, often crofting
30) open coast with low hills dominated by bogs
31) cold exposed coasts with variable land use and crofting
32) bleak undulating surfaces mainly covered with bogs

APPENDIX B4 Sample data sheets, Badger & Habitat Survey

Sett Summary Record Sheet
Badger Sett Record Sheet
1km Square Field Record Sheet
1km Square Field Record Sheet: Additional Notes
10km Square Mammal Record Sheet

NATIONAL BADGER SURVEY
WILDLIFE SERVICE
SIDMONTON PLACE
BRAY, CO.WICKLOW

1 KM SQUARE SETT SUMMARY SHEET

DATE: DAY/MONTH/YEAR

RECORDER: NAME

ADDRESS

PHONE NO.

LOCATION:

1 KM SQUARE REF.:
give reference south-west corner with Irish map ref. e.g. W 20 70 = W / easting/ northing

__ | __ __ | __ __

NAME OF LOCATION
townland/locality/nearest village/county

NUMBER OF DAYS TO COMPLETE SURVEY OF THIS SQUARE: DAYS
TOTAL NUMBER OF HOURS TO COMPLETE SURVEY OF SQUARE: HRS.

NUMBER OF SETTS OBSERVED

YOU SHOULD HAVE ONE SETT RECORD SHEET FOR EVERY SETT OBSERVED WITHIN THE 1KM SQUARE. PLEASE GIVE TOTAL NUMBER OF SETT RECORD SHEETS IN THIS SQUARE. IF THIS IS NOT EQUAL TO THE TOTAL NUMBER OF SETTS OBSERVED, GIVE REASONS BELOW

BADGER SETTS - SUMMARY OF DATA

TOTAL NUMBERS		TOTALS FOR SETTS IN USE BY BADGERS		
MAIN SETTS		MAIN SETTS		*(minm M)*
ANNEXE SETTS		ANNEXE SETTS		
SUBSIDIARY SETTS		SUBSIDIARY SETTS		
OUTLIER SETTS		OUTLIER SETTS		

NOTE: DATA ON SETTS IN USE IS FOR THOSE IN USE BY BADGERS
TOTALS (ABOVE LEFT) MAY INCLUDE SETTS NOT PRESENTLY IN USE BY BADGERS

HAVE YOU BEEN UNCERTAIN ABOUT THE CATEGORIES OF SOME OF THE SETTS? IF SO, GIVE ESTIMATES:

TOTAL NUMBER OF MAIN SETTS:		MAIN SETTS IN USE BY BADGERS		
MINIMUM		*MINIMUM*		*(minm L)*
MAXIMUM		*MAXIMUM*		*(minm U)*

IN YOUR OPINION, WHAT IS THE MAXIMUM NO. OF MAIN SETTS IN USE BY BADGERS THAT MIGHT BE PRESENT WITHIN THE 1KM SQUARE?

(maxm)

OTHER OCCUPANTS

numbers of:	FOXES ALONE	RABBITS ALONE	SHARED SETTS FOXES AND BADGERS	SHARED SETTS RABBITS AND BADGERS	OTHER SPECIES (SPECIFY)
MAIN SETTS					
ANNEXE SETTS					
SUBSIDIARY SETTS					
OUTLIER SETTS					

NOTE: any setts in this section MUST have been included in ABOVE section ALSO

SURVEY: NOTES OR OBSERVATIONS ON BADGER SETTS/ OTHER NOTES:

NATIONAL BADGER SURVEY
WILDLIFE SERVICE
SIDMONTON PLACE
BRAY, CO.WICKLOW

BADGER SETT RECORD SHEET

DATE: ☐ DAY/MONTH/YEAR

RECORDER: ☐ NAME

ADDRESS

PHONE NO.

LOCATION:

1 KM SQUARE REF.: ☐ __ / ___ / ___
give reference south-west corner with Irish map ref. e.g. W 20 70 = W / easting/ northing

EXACT SETT LOCATION GRID REF. **e.g. W 204 708** ☐ _ ___ ___

Your sett name on 6" map ☐

NAME OF LOCATION
townland/locality/nearest village/county

TICK BOXES AS APPROPRIATE (if neccsary add notes on additional sheets)

CATEGORY OF SETT: (If uncertain, please still tick most likely of choices below) UNCERTAIN? Y/N ☐

MAIN ☐ ANNEXE ☐ SUBSIDIARY ☐ OUTLIER ☐

ENTRANCES/USAGE BY BADGERS

TOTAL NO. OF ENTRANCES: ☐

BADGERS
SETT IN USE?: tick if YES ☐
SETT DISUSED? tick if YES ☐

OTHERS
FOXES? tick if YES ☐
RABBITS? tick if YES ☐

NO. WELL USED: (BADGERS) ☐ NO. PARTIALLY USED: (BADGERS) ☐ NO. DISUSED: (BADGERS) ☐

SIGNS OF OCCUPATION:

TRACKS: ☐ BEDDING: ☐ DUNG PITS/LATRINES: ☐ HAIRS: ☐ SCRATCHING POSTS: ☐ OTHER: (specify) ☐

SETT & SETT SITE DESCRIPTION:

GIVE HABITAT CATEGORY AT SETT SITE: ☐
Refer to HABITAT check list

OTHER HABITAT CATEGORIES:

Woodland edge ☐ Roadside verges ☐
River banks ☐ Dry ditches ☐
Railway Embankments ☐ Other man-made embankments ☐

OTHER: ☐ AND NOTES: please give brief description if above does not suffice

ARE CATTLE PRESENT AT TIMES IN VICINITY OF SETT?

YES	NO	UNKNOWN

SOIL TEXTURE IN SPOIL HEAPS: refer to soil identification key

				LOAM	☐ 1
SAND	☐ 2	CLAY LOAM	☐ 7	SANDY SILT LOAM	☐ 12
LOAMY SAND	☐ 3	SILT	☐ 8	FIBROUS PEAT	☐ 13
SANDY CLAY	☐ 4	SILT CLAY LOAM	☐ 9	AMORPHOUS PEAT	☐ 14
SANDY LOAM	☐ 5	SILT LOAM	☐ 10	PARTLY - DECOMPOSED PEAT	☐ 15
CLAY	☐ 6	SANDY CLAY LOAM	☐ 11		

OTHER (specify/describe): ☐ IF YOU KNOW THE GEOLOGY AT SETT SITE, SPECIFY HERE:

DISTURBANCE/HISTORY/NOTES:

EVIDENCE OF OFFICIAL DISTURBANCE/UNOFFICIAL DISTURBANCE
YES ☐ NO ☐ DETAILS:

LOCAL DEVELOPMENTS NEARBY (housing etc.) ?
PREVIOUS HISTORY if any:
NOTES:

NATIONAL BADGER SURVEY
WILDLIFE SERVICE
SIDMONTON PLACE
BRAY, CO.WICKLOW

1KM SQUARE FIELD RECORD SHEET

FIELD WORK CHECK LIST:
COMPASS HALF-INCH MAP PEN PENCIL COLOURED PENS
RUBBER WARRANT CARD ENLARGED 6" MAP OF SURVEY SQUARE (2 COPIES)
1KM SQUARE FIELD RECORD SHEET (2 COPIES) BADGER SETT RECORD SHEETS (30 COPIES)

INSTRUCTION FOLDER: SETT TYPE, ACTIVITY
INSTRUCTION SHEETS: SOILS, HABITAT, LAND CLASS

DATE: DAY/MONTH/YEAR

RECORDER: NAME

ADDRESS

PHONE NO.

LOCATION:

1 KM SQUARE REF.:
give reference south-west corner with Irish map ref. e.g. W 20 70 = W / easting/ northing

NAME OF LOCATION
townland/locality/nearest village/county

ENVIRONMENTAL DETAILS

LAND CLASSIFICATION:
Give suggested land class value (one number only)
refer to LAND CLASSIFICATION check list

ARE DEER PRESENT IN AREA?:

YES	NO	UNKNOWN

are deer known to be present within 5km ?

FARMING PRACTICE: observations on poor fencing, likely access of badgers to cattle sheds/ salt licks/ water etc and any other observation with a bearing on TB transmission:
NOTES ON HABITATS (problems, comments):

SIGHTINGS OR SIGNS OF BADGERS AND OTHER MAMMAL SPECIES

PLEASE NOTE ANY SIGNS OR OBSERVATIONS OF ANY OTHER WILD MAMMAL SPECIES

	TICK IF PRESENT	TYPE OF OBSERVATION (signs, carcase, sighting etc.) (give date if different from above)
BADGER	☐	
for badgers: use this space to tick presemce/absence. Give details of latrines on next sheet. Give details of setts on badger sett record sheets		
MINK	☐	
FOX	☐	
DEER (specify species)	☐	
RABBIT	☐	
HARE	☐	
OTHER MAMMAL: SPECIFY:	☐	

NOTES ON THIS 1KM SQUARE:
NOTES/COMMENTS/OBSERVATIONS
(continue on additional sheet if necessary)

any points of special interest in this square? with regard to badgers or any other flora/fauna. Have any landowners been especially co-operative (give names and addresses if relevant)? Have any landowners been especially difficult?

NATIONAL BADGER SURVEY
WILDLIFE SERVICE
SIDMONTON PLACE
BRAY, CO.WICKLOW

1KM SQUARE FIELD RECORD SHEET
ADDITIONAL NOTES

DATE: DAY/MONTH/YEAR

RECORDER: NAME

ADDRESS

PHONE NO.

LOCATION:

1 KM SQUARE REF.:
give reference south-west corner with Irish map ref. e.g. W 20 70 = W / easting/ northing

NAME OF LOCATION

townland/locality/nearest village/county

BADGERS: NOTES ON LATRINES, OR OTHER OBSERVATIONS

INFORMATION ON BADGER SETTS SHOULD BE NOTED ON THE INDIVIDUAL BADGER SETT RECORD SHEETS
USE THIS SPACE FOR NOTES ON LATRINES, SIGHTINGS, CARCASES, ROAD KILLS, COMMENTS BY LOCAL PEOPLE ETC.
IIF YOU REFER TO LOCATIONS MARKED ON YOUR MAP, PLEASE GIVE NAME MARKED ON MAP

ADDITIONAL COMMENTS\NOTES

USE THIS SPACE IF YOU HAD INSUFFICIENT ROOM ON FIRST SHEET FOR VARIOUS COMMENTS

NATIONAL BADGER SURVEY
WILDLIFE SERVICE
SIDMONTON PLACE
BRAY, CO.WICKLOW

MAMMAL RECORDS
10KM SQUARE RECORD SHEET

DATE: DAY/MONTH/YEAR

RECORDER: NAME

ADDRESS

PHONE NO.

10KM SQUARE REF.

give reference south-west corner
Give Irish map ref. e.g. W27
= W / easting/ northing

BADGER SURVEY: MAMMAL RECORDS

This is primarily a badger survey, but observations of other mammals are of interest - in particular mink, foxes, pine martens. Information gained during surveys of 1km squares should be included here. If badgers were recorded absent in the 1km square, please ascertain presence or absence within the 10km square. These may be casual observations, such as road casualties. Similarly for other species.

PLEASE NOTE ANY MAMMAL SPECIES OBSERVED DURING THE BADGER SURVEY

IF YOU HAVE RECORDED ANY MAMMALS AS BEING PRESENT IN THE 1KM SQUARE SURVEY, THEN THEY ARE PRESENT IN THE GREATER 10KM SQUARE ALSO.

	TICK IF PRESENT	TYPE OF OBSERVATION (signs, carcase, sighting etc.)	DATE (If different from above)
BADGER	☐		
MINK	☐		
FOX	☐		
DEER (specify species)	☐		
RABBIT	☐		
HARE	☐		
BANK VOLES	☐		
OTHER MAMMAL: SPECIFY			

NOTES:

APPENDIX B5 Sample data sheets for studies at 'licence' areas

Snaring data sheet
Badger Record Sheet

DETAILS OF SNARES PLACED AND CAPTURES

SEND RESULTS TO:

DR. CHRIS SMAL
WILDLIFE SERVICE
OFFICE OF PUBLIC WORKS
51 ST. STEPHEN'S GREEN
DUBLIN 2

BADGER SURVEY: GROUP SIZE

LICENCE NO.:

OPERATIVE'S NAME:

NAME OF APPLICANT:

ADDRESS:

USE ONE SHEET FOR EVERY BADGER SETT SNARED

SETT INFORMATION

SETT NUMBER:

USE SETT NUMBERS GIVEN ON MY MAP NOT ON INITIAL ERAD SURVEY

NUMBER OF ENTRANCES:

DESCRIBE SETT HABITAT:

NOTES:

DAY	DATE DD/MM/YY	NO. OF SNARES	BADGERS CAPTURED: TAG NUMBERS OF EACH ONE
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Preliminary data sheet

DO YOU THINK ANY BADGERS WERE MISSED?: Y/N

IF YES, HOW MANY DO YOU THINK WERE MISSED?:

NOTE: SNARES SHOULD BE SET FOR A MINIMUM OF 10 DAYS, AND CHECKED AT WEEKENDS AS WELL DURING THE WEEK. 10 SNARES SHOULD BE SET PER ENTRANCE, WITH A MINIMUM OF 50 SNARES AT MAIN SETTS DAY WHEN SNARES PUT DOWN = DAY 0

DETAILS OF BADGERS CAPTURED

SEND RESULTS TO:

DR. CHRIS SMAL
WILDLIFE SERVICE
OFFICE OF PUBLIC WORKS
51 ST. STEPHEN'S GREEN
DUBLIN 2

BADGER SURVEY: GROUP SIZE

LICENCE NO.:

OPERATIVE'S NAME:

NAME OF APPLICANT:

ADDRESS:

USE ONE SHEET FOR EVERY BADGER CAPTURED

TAG NUMBER::

DATE OF CAPTURE:
DAY/MONTH/YEAR

SETT AT WHICH CAPTURED
GIVE SETT NUMBER ON MY MAP
NOT ON ANY EARLIER SURVEY

CARCASE DESTINATION:
GIVE NAME AND ADDRESS OF LABORATORY
TO WHICH THE CARCASE WAS SENT

SEX:
MALE/FEMALE

BODY LENGTH
NOSEN TO ANUS CMS.

AGE
CUB/JUVENILE/ADULT YRS?

WEIGHT:
0.1 KG (e.g. 7.4 KG)

TAIL LENGTH
ANUS TO TIP OF TAIL CMS

TB STATUS

TO BE FILLED AFTER LAB. TESTS

COLOUR:

GENERAL CONDITION
AND NOTES:

SAMPLES TAKEN? Y/N

BLOOD

TISSUE

SKULL

APPENDIX B6 Additional instructions for studies at 'licence' areas which were not pre-surveyed by Wildlife Rangers (issued to DVO personnel)

STUDY OF SETTS AND BADGER GROUP SIZES AT SPECIFIC LICENCE AREAS

Brief Outline

In 1992, a number of licence areas throughout Ireland were chosen for studies which were carried out jointly by the Department of Agriculture and the Wildlife Service. These studies proved valuable but the sample size was small.

It is intended to continue with similar studies entailing Dept. of Agriculture staff alone. The licences will be operated in the usual manner, except that staff will be required to provide maps locating all setts within the core of the licence area, providing brief descriptions of all these setts, and also full details of the snaring effort and captures, with all badgers being sent for TB tests.

Methods

1) Obtain a 6": 1 mile OS map of the licence area

2) Carry out a detailed pre-snaring survey of an area of at least $1km^2$ around the breakdown herd (A 1km square measures approximately 9.5cms by 9.5 cms on a 6" OS map (3.8 x 3.8 inches).

3) Mark the location of each sett on the map and give it a number. Please include all setts whether active or not. If setts outside this 1km area are also to be snared, then please mark these in on the map also and give them a number also.

4) Fill in sett details for each sett on the appropriate data sheet, giving details for inactive as well as active setts. Describe the habitat at the sett site briefly, as well as number of entrances, signs of occupation (e.g. latrines, recent digging etc.), and if possible classify the sett according to type (details enclosed).

One sheet should be filled in for each sett.

5) Snare all active setts, but please note that the snaring programme should be as that adopted in the previous joint studies: a single snaring period consisting of 10 continuous days with a high number of snares (minimum of 50 for a social group: a group usually has a main sett and some smaller setts within 500m or so). As a guideline, use about 10 snares per active entrance at all setts).

Fill in snaring details and captures on each of the sett data sheets.

6) For each capture, fill in the Badger data sheet, and complete details on the sheet once returns are obtained from the veterinary laboratory.

Results

Send in the following to Margaret Good at the Dept. of Agriculture:

1) Map of full licence area on 6" scale OS map, with all setts marked and given a number and mark the position of the breakdown farm and also the area which was surveyed in detail.

2) A Sett record sheet for each sett located, with snaring details

3) A Badger record sheet for each badger captured

4) Any notes you wish to make about how thorough the survey was and any observations about the breakdown or thoroughness of the badger snaring operation.

N.B. Include full details of setts and badgers captured anywhere within the licence area not just the 'core' area.

DETAILS OF SETTS, SNARING AND CAPTURES

SEND RESULTS TO:

BADGER SURVEY: GROUP SIZE

LICENCE NO.:

OPERATIVE'S NAME:

NAME OF APPLICANT:

ADDRESS:

USE ONE SHEET FOR EVERY BADGER SETT

SETT INFORMATION

YOUR SETT NUMBER:

HABITAT AT SETT: (e.g. hedgerow, field, woodland type, rail bank, river bank, woodland edge, roadside verge etc.)

SIGNS OF OCCUPATION

SETT TYPE (tick) Main ☐ Annexe ☐ Subsidiary ☐ Outlier ☐

NUMBER OF ENTRANCES:	TOTAL	ACTIVE

NOTES:

DAY	DATE DD/MM/YY	NO. OF SNARES	BADGERS CAPTURED: TAG NUMBERS OF EACH ONE
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

IF SETT WAS NOT SNARED, PLEASE ENTER ZERO FOR NO. OF SNARES ON DAY 1

DO YOU THINK ANY BADGERS WERE MISSED?: Y/N ☐

IF YES, HOW MANY DO YOU THINK WERE MISSED?: ☐

NOTE: SNARES SHOULD BE SET FOR A MINIMUM OF 10 DAYS, AND CHECKED AT WEEKENDS AS WELL DURING THE WEEK. PLEASE USE A MINIMUM OF 50 SNARES PER BADGER GROUP DAY WHEN SNARES PUT DOWN = DAY 0

DETAILS OF BADGERS CAPTURED

SEND RESULTS TO:

BADGER SURVEY: GROUP SIZE

LICENCE NO.:

OPERATIVE'S NAME:

NAME OF APPLICANT:

ADDRESS:

USE ONE SHEET FOR EVERY BADGER CAPTURED

TAG NUMBER::

DATE OF CAPTURE:
DAY/MONTH/YEAR

SETT AT WHICH CAPTURED
GIVE SETT NUMBER ON MY MAP
NOT ON ANY EARLIER SURVEY

CARCASE DESTINATION:
GIVE NAME AND ADDRESS OF LABORATORY
TO WHICH THE CARCASE WAS SENT

SEX:
MALE/FEMALE

BODY LENGTH
NOSEN TO ANUS CMS.

AGE
CUB/JUVENILE/ADULT YRS?

WEIGHT:
0.1 KG (e.g. 7.4 KG)

TAIL LENGTH
ANUS TO TIP OF TAIL CMS

TB STATUS
TO BE FILLED AFTER LAB. TESTS

COLOUR:

GENERAL CONDITION
AND NOTES:

SAMPLES TAKEN? Y/N

BLOOD	TISSUE	SKULL