Small Mammal Survey

Jersey 2014

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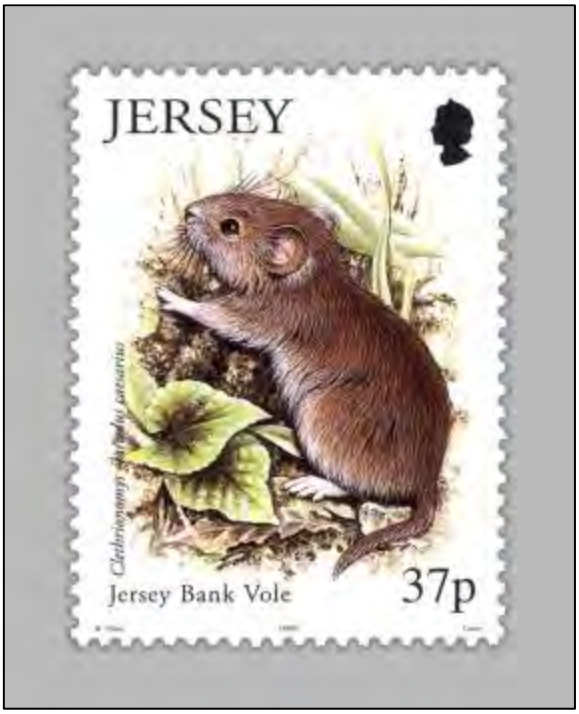

Executive summary

The aims of this survey were;

- to carry out a repeat island-wide survey of small mammals on Jersey similar to that carried out in 1998–2000
- to compare the results of both and
- to consider recommendations for the future conservation of these species.

Four species were surveyed: the wood mouse (*Apodemus sylvaticus*), Jersey bank vole (*Myodes glareolus caesarius)*, the lesser white-toothed shrew (*Crocidura suaveolens*) and Millet's shrew (*Sorex coronatus*).

The species were surveyed at 22 sites in nine different habitats across the Island using Longworth live traps set up in grids or where hedgerows were concerned, in lines . Each site was surveyed over a period of a week in both spring and autumn of 2014 in order to monitor pre- and post-breeding populations. Animals were weighed, sexed and breeding status determined. All caught animals were fur clipped to identify them if they were captured again. Traps were checked two or three times a day and surveying was conducted over ten consecutive weeks in both seasons.

There were over 2,300 captures in 9,065 trap nights consisting of nearly 900 individuals captured. Eight of the 22 sites were consistent with regard to particular species being present both spring and autumn or absent in both spring and autumn. For example, all four small mammal species were found at Le Braye Coastal Strip in both seasons, and wood mice were found in both spring and autumn at Green Street Cemetery with no record of other species in either season. The remaining 14 sites showed species presence in one season only, indicating that populations of particular species were not permanent at these sites across the year. This is an interesting result which could be investigated further in the future. Is it due to sampling efficiency or could it mean that species are transient in nature across many of Jersey's habitats?

Wood mice and bank voles were found in all habitats, however, shrew species were less widespread favouring semi-natural habitats (dunes, heathlands and undisturbed grassland) except woodlands. Five of the nine habitat types supported all four species, these were:

- dune
- heath
- undisturbed grassland
- large arable field
- hedge

At sites where shrews were present, numbers captured tended to be lower than the number of mice and voles; as a consequence, densities were generally low.

Dune and heathland sites were the most productive (using biomass indices) for all species with hedgerow and undisturbed grassland sites also faring well. A rapid survey of site vegetation and other attributes was made in the autumn. The results showed that shrew species were significantly negatively associated with increasing percentage of bare ground in the spring. Wood mice were significantly associated with tree shade and vegetation height. There were no significant habitat associations with bank voles. The findings indicate that further, more detailed

studies of site attributes would be beneficial to understand how the microhabitat of a site affects small mammal populations.

As with many surveys of this scale, care must be taken when examining the results in order to take into consideration the sampling efficiency. Seasonal trapping occurred over ten consecutive weeks and this seasonal difference and therefore changes in weather, food supply and time of the annual cycle of small mammal abundance can affect trapping results. Time of capture (day/night), grid edge effects and recapture rates were also examined and from this it is apparent that Millet's shrews were not sampled as efficiently as the other three species. Therefore a different methodology as set out in the discussion, would be required in order to better survey for this species. From the findings of this report the ecological requirements of this species are the least understood of the four small mammal species.

The 1998 to 2000 small mammal survey was carried out over four seasons and the current survey was conducted over the spring and summer of 2014. Comparing the two surveys we see that population numbers, densities and biomass of each species varied over seasons and according to habitat. Across both surveys wood mice were widespread and bank voles followed a similar pattern but appeared to favour heathlands, hedgerows, woodlands and undisturbed grasslands. The capture data for shrew species were more difficult to compare across the two surveys due to a low capture rate and a patchy distribution across sites, seasons and years.

It is recommended that a strategy and action plan be developed for the long-term survey and monitoring of small mammal populations on Jersey.
It is recommended that such a strategy would include island-wide surveys that:

- take place at regular intervals, e.g. every 4 or 8 years, or at shorter time intervals if resources permit
- use the same sampling methods to be consistent with those used in the first two surveys
- where possible, survey the same set of habitats with a core set of common sites
- take more detailed habitat inventories at sites. This would include habitat trap point data at each trap (e.g. vegetation height, percentage bare ground) at the time of trapping. This would aim to improve the scope and quality of indicators of habitat suitability for small mammal species.
- conduct a desk-top study, assess key small mammal habitat availability (e.g. woodland, heathland, dune, grassland) and the links between them (e.g. hedgerows) across the island
- coordinate site/habitat small mammal monitoring with other types of biodiversity surveillance so that collectively they provide better indicators of site and habitat conservation value. An efficient and practical way to do this would be to involve members of the general public. Surveys for a range of key species (e.g. reptiles, amphibians, birds, bats, wild orchids, and butterflies) could be centrally coordinated for particular habitats/sites at appropriate times of the year.

A series of additional studies have been outlined in the conclusions to fill knowledge gaps about small mammal metapopulation dynamics, annual and multi-annual cycles in numbers and shrew ecology. These could take the form of short-term (months) or long-term studies (years).

Acknowledgements

Denise McGowan would like to thank John Gurnell for his help, insight and patience for co-authoring this report. Also for his knowledge and experience in the field which was invaluable. Members of the Natural Environment Team at the Department of the Environment are thanked for their support especially Nina Cornish and John Pinel who also need to be thanked for trusting in my ability. Louise Magris was invaluable in her knowledge and experience from the previous study and her time was much appreciated.

Thank you to the various landowners across the Island who allowed for the trapping of small mammals on their land.

A big thank you to my husband John McLaughlin for his encouragement and help throughout the project.

A huge thank you needs to be offered up to the volunteers who helped out in the autumn trapping season; Rosie Barclay, Miranda Collett, Adam Dallas-Chapman, Bob Hodge, Philippa Kergozou, Krissy Le Feuvre, Rose Anne Mitchell, Anne Pilbeam, Alex Roberts, Piers Sangan, Amanda Shaw, Bob Tompkins, Jill Tompkins, Hester Whitehead. They stuck with me through hail, rain and shine!

We are grateful to Jersey Post for supplying the front page images of stamps issued in 1999
www.jerseystamps.com

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1.0 Introduction

Jersey is one of several inhabited islands (population of 99,000 in 2014) within the Channel Islands which lie in the Bay of St Malo. The Island is situated 30.5 km from the French Normandy coast and 137 km from the south of England. It is the largest of the Channel Islands measuring 8 km by 14.5 km or 118 square kilometres. The islands of the Channel Islands differ in their fauna. For example Guernsey (situated approximately 40 km north west of Jersey) does not have the same reptile and amphibian species as Jersey. In addition, bank voles (*Myodes glareolus*) do not occur on Guernsey, but common voles (*Microtus arvalis*) do. Jersey has 11 species of terrestrial mammal (Table 1). Some of these are native to the Island and others have been introduced at some time in the past such as the hedgehog (*Erinaceus europaeus*), introduced in the late 1800s from England (Le Sueur, 1976). The stoat is now thought to be extinct in Jersey with the last recorded sighting in 1973 when the stoat population was said to be sustainable and "not nearing extinction" (Le Sueur, 1976). During a mammal survey carried out across the island between 1998 and 2000 however, no stoats were recorded. Feral ferrets were known to be present in the 1970s (and still are), but it was not clear whether they were breeding then. It is possible that ferrets competed with stoats for food and habitat which may have contributed to their demise (States of Jersey BAP, 2008).
This means that the biodiversity of Jersey (the variety of living organisms in an area) has decreased in recent years. Biodiversity is an important aspect of any natural habitat and should be monitored, so that changes in biodiversity can be detected and where necessary conservation management put into place.

Common Name	***Species Name***
Red squirrel	*Sciurus vulgaris*
Jersey bank vole	*Myodes glareolus caesarius*
Lesser white-toothed shrew	*Crocidura suaveolens*
Millet's shrew	*Sorex coronatus*
Hedgehog	*Erinaceus europaeus*
Rabbit	*Oryctolagus cuniculus*
Wood mouse	*Apodemus sylvaticus*
Brown rat	*Rattus norvegicus*
Pole cat /feral ferret	*Mustela putorius*
Mole	*Talpa europaea*
House mouse	*Mus musculus*
Feral cat	*Felis catus*

Table 1 Terrestrial mammals of Jersey

The first Island-wide small mammal survey in Jersey was carried out between 1998 and 2000 by Dr Louise Magris working for the Department of the Environment. This survey looked at the Jersey bank vole, wood mouse, lesser white-toothed shrew, Millet's shrew, feral ferret, house mouse and stoat. The aims of the study were to collect baseline data and to make recommendations for the conservation and future monitoring of these species (Magris 2000).

This present survey set out to repeat some aspects of the survey carried out by Magris (2000). It involves field studies on four species: the Jersey bank vole, wood mouse, lesser white-toothed

shrew and Millet's shrew (Table 2), to examine their current population status and distribution. Ferrets and stoats were the subject of a recent survey (Russell, 2014) and not included here. The current survey was designed to compare the results with the previous study to assess changes in species density and composition according to habitat.

Many of the sites surveyed in 2000 were re-surveyed in 2014. However due to land ownership changes or change in land use, some sites were unavailable to re-survey (Table 3). These sites included arable fields (large and small) and two hedgerows. Therefore sites of the same habitat type and size were found as replacements. The previous two suburban sites were omitted from the current survey as these areas are regularly surveyed for mammals as part of a training programme run by Durrell (Hall *pers. comm.*) and these survey results are available from Durrell Wildlife in Jersey. In place of these, two urban sites were chosen for survey in 2014 as urban sites were not included in the 2000 study.

1.1 Why survey small mammals on Jersey?

The last survey commenced over 16 years ago and since then there has been no Island wide survey to investigate trends in small mammal population numbers or their distribution across habitats. Ecological consultancy survey work is now a legal requirement before many types of development can proceed and these surveys often include mammal species. Data from these surveys are useful in understanding the distribution of small mammals in Jersey. The Jersey Biodiversity Centre holds information on the distribution of small mammals on Jersey. Island-wide surveys can provide information on which habitats are the most productive for certain species, which have the highest density and which have the greatest diversity.

Jersey is a signatory to a number of Multi-lateral Environmental Agreements (MEAs). Of these the following are the relevant to this survey; the Convention of Biological Diversity and The Bern Convention. Survey work is essential in order to report on Jersey's work and progress, under these conventions.

These MEAs offer protection to certain species. The two shrews found in Jersey are listed under Appendix III (Protected Fauna Species) of the Bern Convention (Table 3). The CBD does not have a specific species list but signatory countries are obliged to protect biodiversity from further losses. In order to do this successfully it is essential to monitor species to understand any changes in population numbers or distribution.

Schedule One of The Conservation of Wildlife Law (Jersey) 2000 lists the Jersey bank vole, lesser white-toothed shrew and Millet's shrew (aka Crowned or French shrew) as protected wild animals. These three species also have specific Jersey Biodiversity Action Plans (Table 2) which detail recommendations concerning their conservation including future monitoring and research.

Common name	Scientific name	Other names	BAP species	Protected under CWL	MEA
Jersey bank vole	*Myodes glareolus caesarius*	Formerly in genus *Clethrionomys*	Yes	Yes	None (CBD)
Wood mouse	*Apodemus sylvaticus*	Long-tailed field mouse	No	No	None (CBD)
Lesser white-toothed shrew	*Crocidura suaveolens*		Yes	Yes	BERN (CBD)
Millet's shrew	*Sorex coronatus*	Crowned or French shrew	Yes	Yes	BERN (CBD)

Table 2 Small mammal species to target for the 2014 survey, including their local and international protection. BAP= Biodiversity Action Plan, CWL = Conservation of Wildlife Law, MEA = Multi-lateral Environmental Agreement.

The results of the current survey will provide information on the status of small mammal populations at various sites in Jersey. The data will also contribute to an understanding of the biodiversity of these habitats and sites. Some of the sites used in this survey are protected as they fall within a Site of Special Interest (SSI).These sites, surveyed in 1998-2000 and 2014 are:

- Ouaisne Common SSI
- Portelet Common SSI
- Les Landes de l'Est SSI (Grosnez/Les Landes)
- La Lande de l'Ouest SSI (Gorselands)
- Les Blanches Banques SSI

1.2 Small mammals of Jersey

The following pages give an overview of the ecological requirements and appearance of the four small mammal species covered in this report. Each page covers their preferred habitats and food, breeding and behaviour and includes a brief physical description.

1.2.1 Jersey bank vole (*Myodes glareolus caesarius*)

Bank voles (*Myodes glareolus*) are found in the British Isles, across most of Europe and into Russia. They are considered common throughout their range and are a species of 'least concern' according to the ICUN (International Union for Conservation of Nature and Natural Resources).

The Jersey bank vole (previously known as *Clethrionomys glareolus caesarius*) is a sub-species of bank vole found only in Jersey. Sub-species among the British Isles are also found on other islands including Skomer (*Myodes glareolus skomerensis*), Mull (*Myodes glareolus alstoni*) and Raasay (*Myodes glareolus erica*) (Hare 2009).

It should be pointed out that the Jersey bank vole is different to the Guernsey vole, (*Microtus arvalis sarnius)* which is a sub species of the common vole (*Microtus arvalis*), found across most of mainland Europe apart from British Isles. [Orkney also has a Subspecies *Microtus arvalis andayensis*.]

Figure 1 Jersey bank vole

M. g. caesarius is protected under the Conservation of Wildlife Law (Jersey) 2000 and is not protected under any other jurisdiction legislation or conventions.

Appearance The coat is a reddish / chestnut brown colour with the underneath varying between a light cream colour to a dark silvery grey. It has a short tail, approximately half the full body length (Flowerdew, 1993). It also has a blunt nose and small eyes and ears. Their short legs lead to a more scurrying type of movement.

Breeding Bank voles can breed throughout the year if there are good food resources e.g. many available seeds. Typically though they breed from March until October. Gestation lasts approximately 18 days. The litter size can be between three and five pups and females can have up to five litters a year. Female pups born early in the year can become sexually mature and breed in that same year. It is only the mothers that care for the young and mother and young use ultrasound to communicate. The lifespan of a bank vole is around 18 months.

Habitats Bank voles have been typically found in mature mixed deciduous woodlands with a thick shrub layer (Southern and Lowe 1968). They are also known to occur in hedgerows, banks, heathlands, grasslands, parks and gardens. They burrow underground (2 – 10 cm deep) and will build nests mainly underground around tree roots and fallen logs or in tree trunks (Corbet and Harris 1991).

Food The diet is quite varied, which allows for the proliferation of the species. It includes fleshy fruits and soft seeds, leaves and herbs, dead leaves, buds, moss, fungi, roots, grass, insects, worms, snails. Bank voles are known to make food stores.

Behaviour Females will have exclusive home ranges with the males' range being larger and overlapping several females'. Males will fight in the breeding season. As they reach sexual maturation, bank voles will begin to disperse to areas of suitable habitat. Bank voles can be active both day and night, although activity is reduced in the winter time.

1.2.2 Wood mouse (*Apodemus sylvaticus*)

They are found in the British Isles, across most of Europe including Iceland and in Northern Africa (north of the Atlas Mountains). It is thought to be abundant within its range and listed as a species of 'least concern' by the IUCN.

Wood mice are also known as long tailed field mice. Delany and Healy (1967) used skull measurements to confirm that mice in the Channel Islands are *A. sylvaticus* and not *A. flavicollis* as suggested by a theory based on their larger size.

A. sylvaticus in Jersey is not protected by the Conservation of Wildlife Law (Jersey) 2000 and is not protected under any other jurisdiction legislation or conventions.

Figure 2 Wood mouse

Appearance The coat is brown with the underneath being a paler cream colour, in some cases there is a yellowy tinge to the flanks. It has a long tail with hairs giving it a dark upper colour and lighter underneath. It has large bulging eyes and large ears. The long tail and large ears help to identify it against the Jersey bank vole. Its large hind legs aid its quick bouncing locomotion it to escape predators.

Breeding Wood mice breed between March and October and can breed throughout the year if conditions allow. Gestation lasts between 19 – 20 days but this will be longer if lactating due to delayed implantation. Litter size can be two to nine pups and on average there can be four litters per year. Young born early can reach sexually maturity and breed that year. In the non-breeding winter months, the reproductive tract can be regressed or undeveloped. (Corbet and Harris 1991). The lifespan of the wood mouse is typically between 18 and 20 months.

Habitats *A. sylvaticus* are typically found in woodlands, but are also found throughout arable land, scrub, sand dunes, heathland, hedgerows, dry stone walls, gardens and urban parks. Nests can be built underground and sometimes in trees and occasionally in nest boxes put up for birds. Refuge from predators and movement is often sought below ground.

Food The diet is varied and opportunistic, depending on the season and availability. Diet includes, seeds, seedlings, buds, fruit, nuts, snails, worms, fungi, moss, galls, larvae and arthropods. They are also known to eat arable weeds. They will also hide food in times of plenty.

Behaviour The home ranges of males can overlap but females have exclusive home ranges. It is thought that pair bonds can be formed at the start of the breeding season. Adults will disperse rather than juveniles. Wood mice are active both on ground and in trees. Over winter they will nest communally. They are mainly nocturnal but are less active on moonlit nights (Flowerdew 1993). They will enter torpor if food deprived or in times of cooler temperatures.

1.2.3 Lesser white-toothed shrew (*Crocidura suaveolens*)

Lesser white-toothed shrews are found across much of southern Europe (some exclusion zones in France and Spain), across Kazakhstan and on into China. It is not, however found in Britain or Ireland. In the western part of its range it is less abundant than in the east. It is listed as a species of 'least concern' by the IUCN. MacDonald and Barrett (1993) state that numbers in Europe are declining due to agriculture pesticides.

C. suaveolens are protected by the Conservation of Jersey (Wildlife) Law 2000. They are also listed on Appendix III of the Bern Convention and listed as Near Threatened on the French Red List of Threatened Species. All known shrews present in the UK are protected under Schedule Six of the Wildlife and Countryside Act 1981

Appearance The coat is typically grey in colour but have some reddish brown in it too and is paler underneath. The fur is dense and short. *C. suaveolens* is small and slender with a long pointed snout with long fine whiskers, small eyes and rounded ears. The tail is about the length of the body (excluding head). It has white teeth and it is quicker and more aggressive in character than the Millet's shrew.

Figure 3 Lesser white-toothed shrew

Breeding *C. suaveolens* breed between March and September. Gestation last 27 – 30 days with one to six young born. Females can have up to four litters per year. Young are generally weaned after 22 days. Sexual maturity occurs after approximately five months and therefore can breed in the year of birth.

Habitats This shrew species is found in dry bracken, heathlands, sand dunes, coastal scrub, hedgerows, banks and gardens. It is considered to be associated with coastal habitats but also favours grassy edge habitats. It will use burrows of other small mammals but will also make its own. Nests are built in thick grass or under woody debris.

Food Shrews are insectivorous and will eat a variety of insects. They have a high metabolic rate and need to eat quite regularly throughout the day, consuming 55% their body weight in a 24 hour period. (Corbet and Harris 1991).

Behaviour Lesser white tooth shrews are mainly solitary. Young are known to 'caravan' behind the mother; holding on to one another, mouth to tail. They aren't as territorial as other species and home ranges can overlap. Though their species name means 'sweet smelling', it is quite the opposite, where their pungent smell is often the best indicator of presence. They can also be heard squeaking if approaching very near the nest.

1.2.4 Millet's shrew (*Sorex coronatus*)

Millet's shrew, also known as the French shrew or crowned shrew, is found across France, Belgium and the Netherlands and into some of the neighbouring countries. Jersey is the only place in the British Isles where they are found. It was originally thought to be the common shrew (*Sorex araneus*) until further examination in the late 1970s revealed it to be the Millet's shrew. Worldwide, it is described as abundant and listed as a species of 'least concern' by the IUCN.

S. coronatus are protected by the Conservation of Jersey (Wildlife) Law 2000. They are also listed on Appendix III of the Bern Convention and listed as 'least concern' on the French Red List of Threatened Species. All known UK shrews are protected under Schedule Six of the Wildlife and Countryside Act 1981.

Figure 4 Millet's shrew

Appearance Small with rich brown coloured fur with paler cream coloured sides and underneath. The two fur colours meet on the flanks showing the definite colour difference. The fur is short and dense. They have a pointed snout with whiskers and small eyes. The tail is short, about the length of the body.

Breeding *S. coronatus* typically breed between May and September. Gestation is approximately 20 days with their litter size varying between three to seven pups. There can be up to six litters per year. Sexual maturity usually occurs the following year (MacDonald and Barrett, 1993). The lifespan will normally not exceed two years.

Habitats Heathland, scrubland, hedgerows, unmown meadows, marshes and deciduous woodlands. They tend to avoid areas populated by people (IUCN, 2014). Like *C. suaveolens* they will use other species burrows and make a nest of grass and leaves. They are generally not found in intensively farmed areas.

Food Being an insectivore, the diet includes earthworms, slugs, beetles, woodlice and spiders among others. Like many other shrew species they can detect prey up to 12cm deep in the soil. (Corbet and Harris 1991).

Behaviour Active throughout the day and night. They are solitary and territorial, with little overlap between home ranges especially for females. Males in the breeding season will overlap with females and other males (Corbet and Harris 1991).

1.3 Aims and objectives

The aim of the 2014 survey is survey small mammal populations in a variety of different types of habitat across the Island. The data collected will be compared with those from a similar survey conducted in 1998-2000. The findings will be used to make recommendations on the future protection of these mammals and contribute to the conservation of biodiversity on Jersey. This will include advice on managing the sites and habitats in which they reside.

The objectives are to understand:

1. which habitats and sites are most productive in terms of numbers and species presence
2. how the biomass of small mammals varies across habitats
3. the density of each species in each site?
4. whether populations have increased, decreased or remained stable since the previous survey in 1998-2000

The survey results will also be a useful indicator of the biodiversity of each habitat and site on Jersey.

1.4 Report outline

This report first looks at the data that were collected in spring and autumn in 2014. Consideration is given to the number, density and biomass of each species captured at each of the 22 sites distributed among nine types of habitat. The data have been further analysed with respect to population structure (sex, breeding), vegetation, weather, recapture rates, trap position on trap grids, and time of capture. The report then compares the 2014 results on the number, density and biomass of each species captured at sites in each habitat with those found from the 1998-2000 survey (Magris 2000). Of note is that the 1998-2000 survey was carried out over four seasons (autumn 1998, spring 1999, autumn 1999, spring 2000) whereas the 2014 survey took place in spring and autumn in one year. Furthermore, only 13 sites were surveyed in all seasons in both the 1998-2000 and 2014 surveys.

2.0 Study areas and methods

2.1 Study areas

Nine different types of habitats were surveyed across Jersey. Each habitat was replicated at least twice and some habitats were replicated four times e.g. there are four woodland sites and two dune grassland sites. In total 22 sites were surveyed (Table 3).

2.1.1 Habitats

The habitats were chosen to replicate the work carried out for the small mammal report in 2000. For the preparatory survey work which commenced in 1998, the Land Cover Map of Great Britain (LCMGB 1990) was used to select suitable habitats and sites. The Institute for Terrestrial Ecology used a Landsat satellite to record images to map the land cover of Jersey and work out the habitat types present thereby creating the LCMGB 1990. The confirmation of habitat type was between 85% and 90% true and habitats were ground-truthed by on site surveys. The satellite images classified much of Jersey as arable, therefore this broad category was divided up into hedgerows and fields of different sizes (Magris 2000).

Woodlands, hedgerows, agricultural land and urban areas were also surveyed (Figure 1, Table 3). Woodlands were the same ones as in the 2000 survey. The three hedgerows were each around agricultural fields. In 1998-2000, the agricultural land was divided up into hedgerows, large arable fields, small arable fields and disturbed arable fields. The latter habitat was considered one in which the field was being used to grow crops. In the current survey, both the urban sites were chosen to be in close proximity to each other for practical reasons. However both sites are known to contain other protected species, such as toads (*Bufo spinosus*) and slow worms (*Anguis fragilis*).

Figure 5 Location of survey sites in Jersey. Purple dots include sites used in both 2000 and 2014. Blue dots indicate new sites to 2014 survey.

Site no.	Survey site name	Habitat type	SSI (yes/no proposed)	Location within Jersey	Distance to sea (m)	Repeated from 2000 survey
1	Portelet	Heath	Yes	SW	175	Yes
2	Ouaisne	Heath	Yes	SW	170	Yes
3	The Elms Hedge	Hedgerow	No	N	2155 *	Yes
4	The Elms Undisturbed	Undisturbed grassland	No	N	2295 *	Yes
5	The Elms Field	Arable – disturbed field	No	N	2235 *	Yes
6	St Peter's Quetivel	Woodland	Proposed	S (C)	1660	Yes
7	St Peter's Gargate	Woodland	No	S (C)	2400	Yes
8	Jubilee Hill	Undisturbed grassland	No	W	170	Yes
9	Greenland / P80A	Arable - small field	No	W	1990	No
10	Les Landes	Heath	Yes	NW	445 *	Yes
11	Water Lane	Arable – large field	No	NW	1560	No
12	Le Braye	Dune	Proposed	W	65	Yes
13	Les Blanche Banques	Dune	Yes	W	590	Yes
14	Gorselands	Heath	Yes	SW	165 *	Yes
15	St Germain	Hedgerow	No	C	2300 *	No
16	Ville Machon Hedge	Hedgerow	No	NE	205 *	No
17	Ville Machon Field /	Arable – large field	No	NE	210 *	No
18	Ville Machon Potato	Arable – disturbed field	No	NE	155 *	No
19	Rozel	Woodland	No	NE	315	Yes
20	St Catherine	Woodland	Proposed	NE	890	Yes
21	Green Street Cemetery	Urban	No	S	425	No
22	Mount Bingham	Urban	No (by South Hill ecol, SSI)	S	150	No

Table 3 Survey sites for 2014, their habitat type, location and distance to the sea. 8 sites were not repeated from the 2000 survey. Site no. refers to the number featured on Figure 1 below. Location 'C' means central to the Island. Distance to sea is taken by measuring the distance from the most north westerly point of the trapping grid to the nearest coastal point – high water region using Cadcorp (Water Framework Directive Marine Sampling Points swd.) mapping and is approximate. * denotes that north coast cliffs is the nearest coastline.

2.1.2 Sites

There were 22 sites in total for the 2014 survey (Table 4). Each site was surveyed for small mammals for one week in both spring and autumn. The sites were chosen to replicate the 2000 survey, however due to land use changes, some of the year 2000 survey sites could not be repeated and new sites were required. These new sites were selected because they were considered to be the same habitat type and size as the original sites form the 2000 survey (Table 4; see Appendix 1 for site location). Also it was decided that the suburban sites of 2000 (situated at Durrell Wildlife Park) would be omitted as they are annually surveyed by Durrell for training purposes. Instead two urban sites were chosen in the town of St Helier. At all sites, a set of physical and vegetation attributes were recorded in the autumn; these are listed in Appendix 2, Table A2.

Habitat	Site Name	Trapping date spring	Trapping date autumn
Woodland	St Catherine's Woods	23-May-14	26-Sep-14
	Rozel Woods	23-May-14	26-Sep-14
	St Peter's Quetivel	11-Apr-14	12-Sep-14
	St Peter's Gargate	11-Apr-14	12-Sep-14
Dune	Le Braye	02-May-14	19-Sep-14
	Les Blanches Banques	02-May-14	19-Sep-14
Heath	Portelet	28-Mar-14	10-Oct-14
	Ouaisne	28-Mar-14	10-Oct-14
	Gorselands	09-May-14	17-Oct-14
	Les Landes	25-Apr-14	24-Oct-14
Undisturbed grassland	The Elms	04-Apr-14	07-Nov-14
	Jubilee Hill	18-Apr-14	17-Oct-14
Large arable field	Water Lane+	25-Apr-14	24-Oct-14
	Ville Machon+	16-May-14	03-Oct-14
Hedgerow	St Germain+	09-May-14	31-Oct-14
	The Elms	04-Apr-14	07-Nov-14
	Ville Machon+	16-May-14	03-Oct-14
Disturbed arable field	The Elms	04-Apr-14	07-Nov-14
	Ville Machon+	16-May-14	03-Oct-14
Small arable field	Greenland+	18-Apr-14	31-Oct-14
Urban	Green Street Cemetery+	02-Jun-14	08-Sep-14
	Mount Bingham+	02-Jun-14	08-Sep-14

Table 4 Habitats and the sites including date of trapping. Date is the Friday that the traps were put in place, traps were moved to a new site each Friday. + denotes that these sites differed from the 2000 survey sites.

The results of the current survey will provide information on the status of small mammal populations at various sites in Jersey. The data will also contribute to an understanding of the

biodiversity of these habitats and sites. Some of the sites used in this survey are protected as they fall within a Site of Special Interest (SSI).These sites, surveyed in 1998-2000 and 2014 are:

- Ouaisne Common SSI
- Portelet Common SSI
- Les Landes de l'Est SSI (Grosnez/Les Landes)
- La Lande de l'Ouest SSI (Gorselands)
- Les Blanches Banques SSI

Of the five SSIs listed above, the first four are predominately heathland sites and the survey areas within them were in heathland. (Ouaisne Common is made up of a variety of habitats including mature gorse and willow carr.) Les Blanches Banques SSI is a dune grassland site, also, Le Braye coastal dune is a proposed SSI. Dunes, heathlands and (coastal) undisturbed grassland had the highest density of small mammals of the habitat types surveyed in 2000 (Magris, 2000). All of these sites were replicated in the 2014 survey (Table 3, Figure 1).

2.2 Methods

The 22 sites were surveyed over ten (consecutive) weeks beginning 28th March until the 6th June in spring and from 8th September to 14th November in autumn (Table 4). The two seasons were chosen to examine pre- and post-breeding populations. Two sites were surveyed per week except for two weeks when it was possible to survey three sites together.

The methodology used in both the 1998-2000 and current survey followed standard procedures (Gurnell & Flowerdew 1990). Once the site was chosen, traps were put in place on the Friday afternoon. Traps were placed in a square grid of seven lines by seven rows, totalling 49 traps. Gurnell and Flowerdew (2006) state that if > 60% of traps have been activated in a session, the number of traps should be doubled on that site. In some cases two traps were placed at each point on the Friday and at some sites the situation was reactive, i.e. if numbers caught on the Tuesday morning were high then more traps would be put out.

Trap points were 5m apart therefore the area covered by the grid was approximately 30m squared. In hedgerow sites, traps were set in a line, again with each trap 5m apart. Traps were always placed in a position of some cover, or surrounding material (e.g. leaves, long grass) was placed on the traps to provide cover. This was to ensure that traps were not exposed to direct sunlight during the day and had some protection from the drop in night-time temperature.

Figure 6 Longworth trap in place at The Elms undisturbed grassland site.

Traps were filled with bedding; hay to provide warmth (which could also be eaten by bank voles), and bait. Bait differed from that used in the 2000 survey; rolled oats and mince beef were used in spring but this was changed to whole oats and blowfly larvae in autumn as used in the 2000 survey. The latter bait mix was more practical for surveying methods.

The traps were left locked open for three nights over the weekend in the pre-bait position. This helps mammals become familiar with the traps as they can come and go freely during this time. On Monday morning the traps were checked, re-baited, provided with more bedding if required, and then unlocked, i.e. set to trap. In the two urban sites, traps were not put in place on a Friday but on a Monday morning, set to trap straight away and left in place for four nights. Traps left at these particular sites over the weekend were thought to be at a greater threat of disturbance from people.

Traps were the checked at least twice a day; early morning and before dusk, and depending on circumstances, were checked three times a day. The additional afternoon check was carried out if shrews were present at the site or if the weather was especially hot during the day. Trap mortality can happen and shrews are more susceptible to this, typically if caught early on in the night. Shrews have a high metabolic rate and need to feed regularly throughout the day and night, as they can consume enough food to match their own body weight in one day (Gurnell & Flowerdew, 2006).

When a trap was shut, it was emptied and the animal identified, sexed and weighed. The animal was also checked for its reproductive status when possible. A piece of fur was then clipped near the base of the tail. Any fur clipped animals subsequently caught were released straight away. The trap was then replenished with more bait and bedding if required. Each animal was "processed" at its trapped location before moving onto checking the remainder of the traps.

2.3 Data analyses

Four measures of small mammal distribution and abundance at each site or in each habitat were used: presence/absence, an estimate of the number of individuals of a particular species that were present, density to allow comparisons with other small mammals studies, and biomass as an indication of how productive the sites were for those species.

The minimum number alive (MNA) (also called the minimum number of animals known to be alive, MNKA) at a particular site in a particular season has been used as an index of population size. This has been calculated using the data collected on the numbers of new or unmarked individuals captured, as determined by the absence of a fur clip, over the period of trapping (see Pocock *et al.* 2004). The MNA indices have been converted to a density based on the area of a trapping grid plus a 5 m border strip to account for any 'edge effect' (i.e. 1600 m^2) (Krebs, 1999, Gurnell & Gipps 1989). Estimating densities from the hedgerow trap line data was complicated by the fact that the effective area sampled cannot be known. However, here it has been assumed that each trap line represented a 10 m wide strip plus 5 m at either end (i.e. 2500 m^2). Indices of biomass (used as a measure of site productivity) for each species, site and season have been estimated using the total weight of unmarked individuals captured during the trapping week.

Daily weather records were kindly provided by the States of Jersey Meteorological Department. Data has been analysed using Excel, Xlstat and Minitab software. Where appropriate, because of

small sample sizes and that many variables did not conform to normality, non-parametric statistics have been used.

The physical (e.g. proximity of site to a road) and vegetation attribute data (Appendix Table A2) have been explored using multivariate analytical methods. No patterns emerged using the full set of physical and vegetation measurements (not included here). It was concluded that the physical measures contributed little to the results obtained. Therefore these results are not discussed further in the results section. The vegetation data was looked at more closely. Using mean site values of attributes for habitat types, a principal component ordination was carried out to see how similar or different the sites were on the basis of the variables measured: this is described in Appendix 2. The first two components from this analysis accounted for ~79% of variation in the data set (Appendix 2, Figure A1). The contributions of each vegetation attribute to the components are shown in Appendix 2, Table A3. To see if the findings from the ordination could explain the small mammal results, a correlation analysis was carried between the component scores and species biomass.

3.0 Results

There were over 2,300 captures in 9,065 traps nights (number of traps multiplied by number of nights traps were set i.e. 4) consisting of nearly 900 individuals captured.

3.1 Small mammal presence 2014

Over the course of the study, each species might have been sampled at each of the 22 sites in both spring and autumn seasons, that is a total of 44 possible sampling occasions (Table 5). Wood mice were sampled on 42 occasions giving a probability of being sampled at a site during the study of 42/44 or 0.955. Equivalent probabilities for bank voles, LWT shrews and Millet's shrews were 0.727, 0.386 and 0.341 respectively. For the four species combined, the overall probability of sampling any small mammal was 0.602.

Eight of the 22 sites were consistent in that each species was either present in spring and autumn or absent in both. In contrast the remaining 14 sites had at least one species which were only present in either spring or autumn (Table 5, boxed cells show 14 sites where a species was not captured in both seasons). This indicates that populations of the particular species were not permanent at these sites across the year. It should be noted that three sites were different in the autumn than in spring due to last minute changes in farm management plans; Greenland, Ville Machon large field and Ville Machon disturbed field.

	Wood mouse		Bank vole		LWT shrew		Millet's shrew	
Site	S	A	S	A	S	A	S	A
The Elms arable disturbed	Y	Y	x	x	x	x	x	x
Ville Machon arable disturbed	Y	Y	Y	x	x	x	Y	x
St Germain arable hedgerow	Y	Y	Y	Y	Y	x	x	x
The Elms arable hedgerow	Y	Y	Y	Y	x	x	Y	x
Ville Machon arable hedgerow	Y	Y	Y	Y	Y	Y	Y	Y
Le Braye coastal strip dune	Y	Y	Y	Y	Y	Y	Y	Y
Les Blanches Banques dune	Y	Y	x	Y	Y	Y	Y	Y
Gorselands heath	Y	Y	Y	Y	Y	x	x	x
Les Landes heath	Y	Y	Y	Y	x	x	Y	Y
Ouaisne heath	Y	Y	Y	Y	Y	Y	Y	x
Portelet heath	Y	Y	Y	Y	Y	Y	x	Y
Ville Machon large field	Y	x	Y	x	Y	x	Y	x
Water Lane large field	Y	x	Y	x	x	x	x	x
Greenland arable small field	Y	Y	x	Y	x	x	x	x
Green Street Cemetery urban	Y	Y	x	x	x	x	x	x
Mount Bingham urban	Y	Y	Y	Y	x	Y	x	x
Jubilee Hill undisturbed grassland	Y	Y	Y	Y	Y	Y	x	x
The Elms undisturbed grassland	Y	Y	Y	Y	x	x	Y	Y
Rozel woods	Y	Y	Y	x	x	x	x	x
St Catherine's woods	Y	Y	Y	Y	x	x	x	x
St Peter Gargate woods	Y	Y	Y	x	x	x	x	x
St Peter Quetivel woods	Y	Y	Y	x	x	Y	x	x

Table 5 Species presence (Y) and absence (X) in spring (s) and autumn (a) across each of the 22 sites surveyed in 2014. Some sites show a variation between seasons for species presence. The boxed cells highlight this difference.

When considering presence/absence according to habitat, it should be noted that on some occasions, the presence of a species in a habitat maybe due to the occurrence of just one individual (Table 6). These may be transient animals. This was the situation with shrews at Mount Bingham and St Peter Quetivel woods. Both rodents; wood mouse (WM) and bank vole (BV), were found in all habitats surveyed. The lesser white toothed shrew (LWTS) was not found in disturbed fields, or small arable fields. The Millet's shrew (MS) was not found in woodlands, small arable fields or urban habitats. However, these overall findings must be treated with caution because, as can be seen in Table 5, pooling seasonal and site data can be misleading. For example, some species were only captured in one season at some sites and sites within particular habitat categories were not always consistent in terms of presence/absence in both seasons.

Habitat	Wood mouse	Bank vole	LWT shrew	Millet's shrew
Woodland	Y	Y	Y*	x
Dune	Y	Y	Y	Y
Heath	Y	Y	Y	Y
Undisturbed grassland	Y	Y	Y	Y
Large arable field	Y	Y	Y	Y
Hedge	Y	Y	Y	Y
Disturbed field	Y	Y	x	Y
Small arable field	Y	Y	x	x
Urban	Y	Y	Y*	x

Table 6 Species presence (Y) and absence (x) according to the habitat surveyed in 2014, seasons and sites combined. Y* indicates that presence was due to one individual caught. (A comparison of this data with the 2000 survey is presented in section 3.3)

3.1.1 Shrew distribution

It was recommended in the 2000 survey that some attention should be given to the shrew species as these were the least abundant species on the Island. The two shrew species differed in their presence across many sites in 2014 (Table 7). This will be considered further below. The comparison of shrew presence and absence across the two surveys is presented in section 3.3 (Table 14).

Habitat	Site	LWTS	MS
Woodland	St Catherine	x	x
	Rozel	x	x
	St Peter Quetivel	Y	x
	St Peter Gargate	x	x
Dune	Le Braye Coastal strip	Y	Y
	Les Blanches Banques	Y	Y
Heath	Portelet	Y	Y
	Ouaisne	Y	Y
	Gorselands	Y	x
	Les Landes	x	Y
Undisturbed grassland	Jubilee Hill	Y	x
	The Elms	x	Y
Large arable field	Ville Machon	Y	Y
	Water Lane	x	x
Hedgerow	The Elms	x	Y
	St Germain	Y	x
	Ville Machon	Y	Y
Disturbed arable field	The Elms	x	x
	Ville Machon	x	Y
Small arable field	Greenland	x	x
Urban	Green Street Cemetery	x	x
	Mount Bingham	Y	x

Table 7 Shrew presence (Y) or absence (x) at each site in 2014, seasons combined.

3.1.2 Numbers of individuals

The minimum number of individuals alive (MNA) at a site refers to the number of individuals which were captured, excluding all those which were re-captured (identifiable from the fur clip) (Table 8).

Habitat	Site	Minimum Number Alive								
		Wood		Bank vole		LWT shrew		Millet's		
		S	A	S	A	S	A	S	A	Total
Woods	St Catherine	11	7	9	5	0	0	0	0	32
	Rozel	18	6	3	0	0	0	0	0	27
	St Peter Quetivel	14	12	9	0	0	1	0	0	36
	St Peter Gargate	24	5	2	0	0	0	0	0	31
Dune	Le Braye Coastal strip	12	36	7	22	8	10	2	2	99
	Les Blanches Banques	9	9	0	2	3	3	1	2	29
Heath	Portelet	20	7	20	20	5	9	0	1	82
	Ouaisne	15	8	1	8	2	1	1	0	36
	Gorselands	7	4	6	18	1	0	0	0	36
	Les Landes	2	9	13	32	0	0	14	1	71
Undisturbed grassland	Jubilee Hill	7	16	10	36	2	3	0	0	74
	The Elms	12	10	1	35	0	0	1	1	60
Large arable field	Ville Machon	14	0	3	0	13	0	2	0	32
	Water Lane	4	0	2	0	0	0	0	0	6
Hedgerow	The Elms	14	13	4	14	0	0	2	0	47
	St Germain	12	21	13	13	5	0	0	0	64
	Ville Machon	7	5	2	13	2	1	11	4	45
Disturbed arable field	The Elms	1	9	0	0	0	0	0	0	10
	Ville Machon	1	1	1	0	0	0	2	0	5
Small arable	Greenland	1	7	0	11	0	0	0	0	19
Urban	Green Street Cemetery	1	3	0	0	0	0	0	0	4
	Mount Bingham	17	7	4	20	0	1	0	0	49
Total		223	195	110	249	41	29	36	11	894

Table 8 Minimum number alive (MNA) across all sites for all four species in spring (S) and autumn (A).

Overall, the total MNA increased in autumn for only the bank vole and decreased for the other three species (Table 8) but there was a lot of variation across sites. It would be normal to expect post-breeding populations to be larger than pre-breeding populations due to the presence of young animals. However, there was no significant correlation between numbers of individuals captured in spring and autumn for wood mice (Figure 2), and although the correlations for the other three species were significant they were modest at best. Bar in a few instances, this makes it difficult to predict autumn numbers from spring numbers. These findings are probably

affected by the length of the sampling periods (ten weeks) in spring and autumn which means sites are being sampled at different stages of the annual cycle in numbers. However, it also reflects a variation in the suitability and productivity of sites and habitats at different times of the year for different species, in support of the presence/absence analysis above.

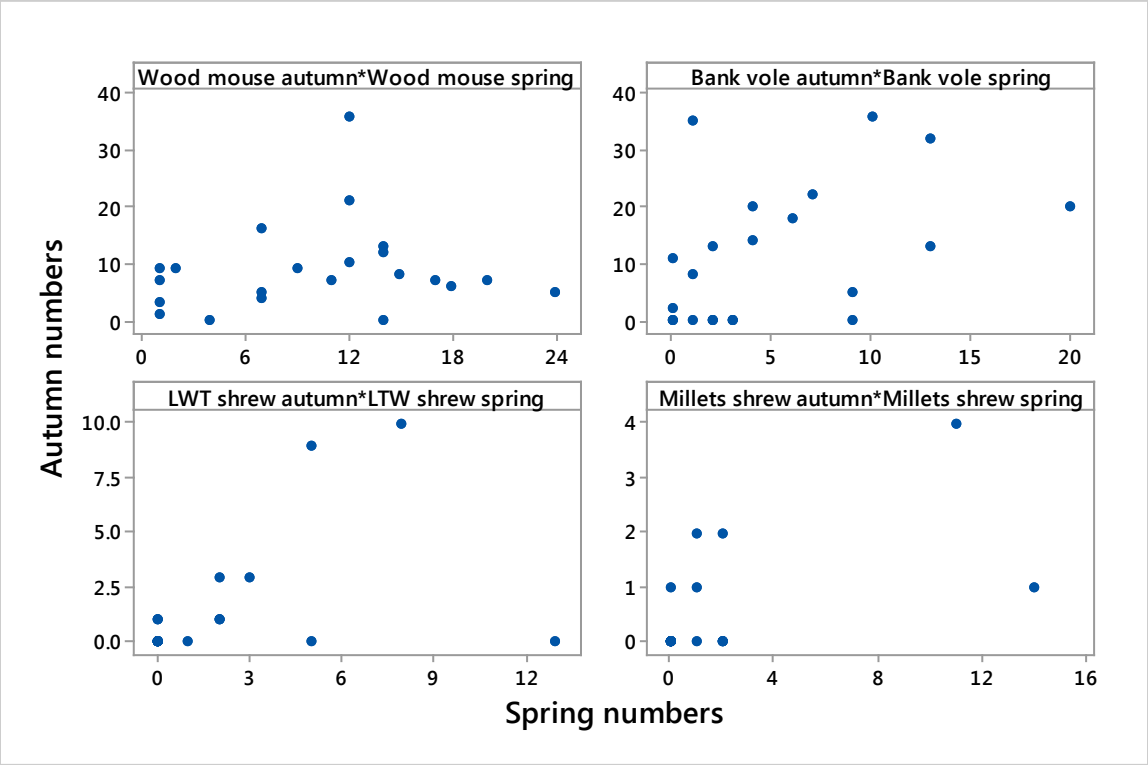


Figure 7 Scatterplots of autumn and spring numbers at each site for each species. Wood mouse r_s = 0.144, p=0.52; bank vole r_s = 0.49, p=0.02; LWT shrew; r_s = 0.56, p=0.007; Millet's shrew, r_s = 56, p=0.007.

Correlations between numbers of the two rodent species and the two shrew species were also modest or low (Figure 3) indicating the dynamics of each pair of species are independent (i.e. there was a lack of inter-specific competition). Because the number of individual shews captured were much smaller than the number of rodents, site comparisons between the two types of small mammal are difficult to make. In consequence, there are many sites over a range of rodent densities with few shrews (Figure 4). Nevertheless, there are a few sites, in particluar the dune site at Le Braye, which appear to be favoured by both types of small mammal (Figure 4).

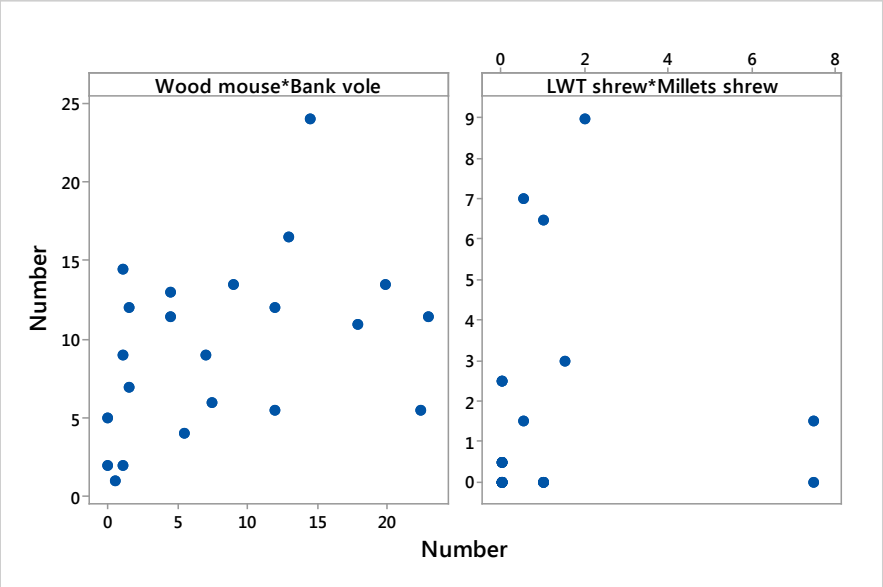


Figure 8 Scatterplots for average of spring and autumn wood mouse numbers against average bank vole numbers for each site (r_s = 0.45, p = 0.03), and for average LWT shrew numbers and average Millet's shrew numbers for each site (r_s = 0.30, p = 0.17).

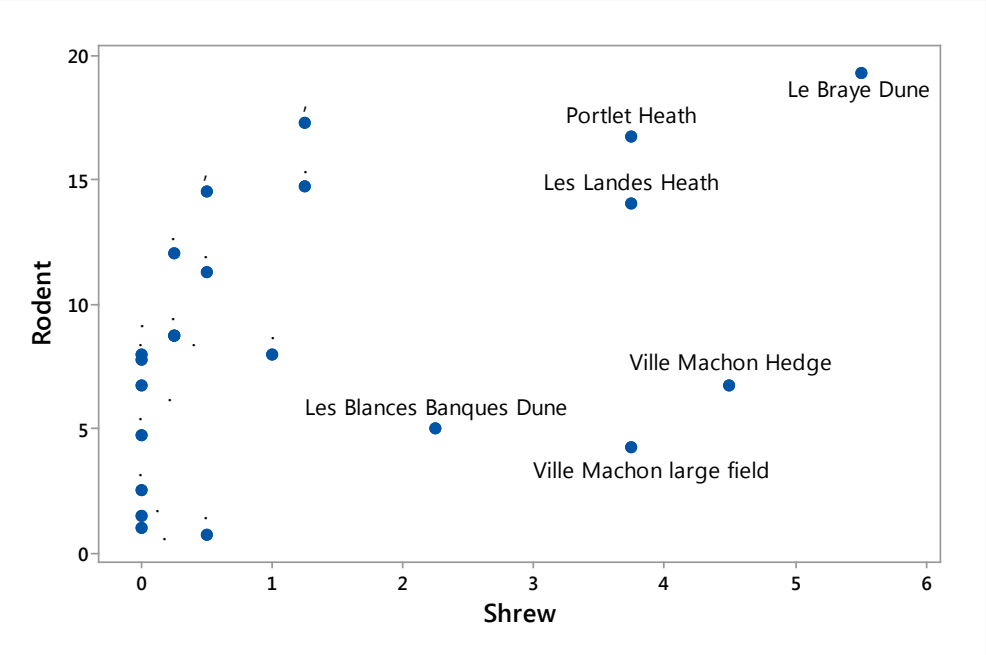


Figure 9 Scattergram of the average number of rodents against average number of shrews captured at each site for both seasons combined (r_s = 0.49, p = 0.02). Point labels refer to selected sites.

3.1.3 Density

Variations in density estimates among sites and seasons tend to follow the MNA estimates but the figures permit comparisons with findings from other studies in other places (Figure 5). Hedgerows had larger and somewhat arbitrary effective trapping areas than other sites with grids, and these results should be treated with caution. This is because hedgerows are line transects and density is calculated differently than on a grid.

Wood Mouse

Highest spring wood mouse densities were at St Peter Gargate woods (163 ha^{-1}) followed by Portelet heath (138 ha^{-1}) and the urban site, Mount Bingham (131 ha^{-1}). Mean spring density at sites where present was 65 ha^{-1} (Coefficient of variation, CV = 70%, N = 22). The dune site at Le Braye had a very high autumn density (225 ha^{-1}), much higher than the next three highest sites at Jubilee undisturbed grassland (100 ha^{-1}), St Germain hedgerow (84 ha^{-1}) and St Peter Quetival woods (75 ha^{-1}).Mean autumn density at sites where present was 57 ha^{-1} (CV = 79%, N = 20).

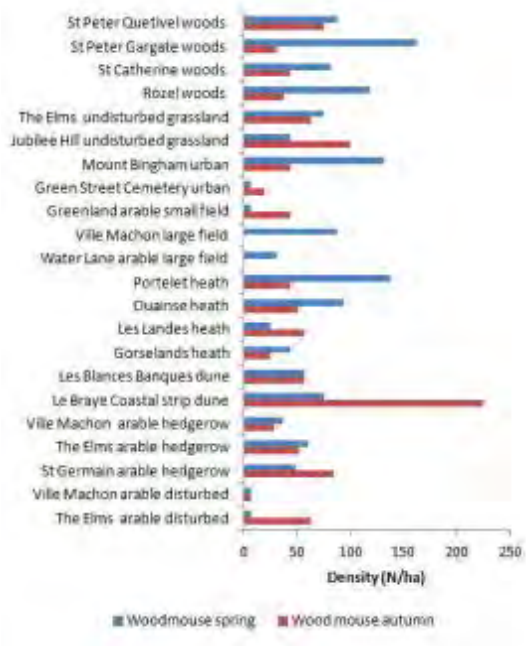
Bank Vole

Highest bank vole spring densities were Portelet heath (131 ha^{-1}), Les Landes heath (88 ha^{-1}) and both Jubilee Hill grassland and St Peter Quetival woods, each with 63 ha^{-1}. In contrast to Portelet and Les Landes, Ouaisne heath only had 6 ha^{-1}. Mean spring bank vole density was 37 ha^{-1} (CV = 91%, N = 18). Mean autumn densities were higher at 105 ha^{-1} but bank voles were found at fewer sites (CV = 67%, N = 14). The two undisturbed grassland sites, Jubilee Hill and the Elms, had high densities at ~ 220 ha^{-1} followed by Les Landes heath (200 $^{ha-}$1), Le Braye dune (138 ha^{-1}) and both Portelet heath and Mount Bingham (125 ha^{-1}).

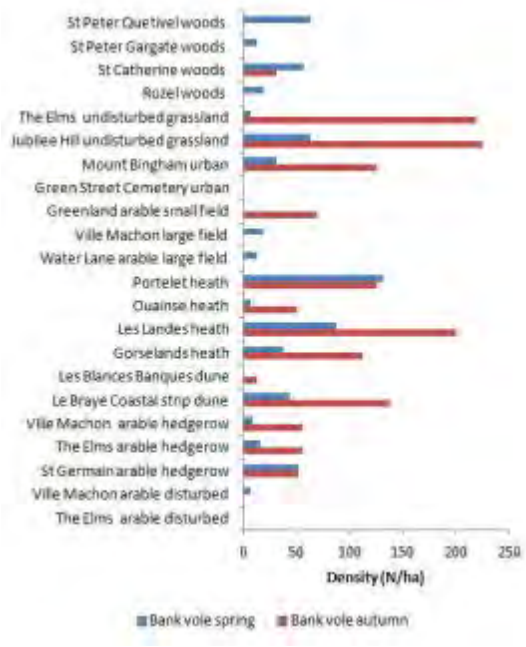
Shrews

Densities of the two shrew species were considerably lower than the two rodent species, and as commented on previously, they were captured in fewer sites.The higheset LWT shrew spring density was at Ville Machon large field (81 ha^{-1}) followed by Le Braye dune and Portelet heath each with 50 ha^{-1}. Mean spring density was 29 ha^{-1}(CV 86%, N = 9). Both Le Braye and Portelet heath had increased densities in the autumn (63 ha^{-1} and 56 ha^{-1} respectively) suggesting these were key sites for this species. Mean autumn density was 22 ha^{-1} (CV = 106%, N = 8). Millet's shrews were relatively abundant at two sites in the spring: Les Landes heath (88 ha^{-1}) and Ville Machon hedgerow (44 ha^{-1}), but few were captured elsewhere. The two high densities rather influenced the mean density of 22 ha^{-1} (CV = 126%, N = 9). Autumn densities were lower; the highest recorded was at Ville Machon hedgerow (24 ha^{-1}), which together with the spring density suggests this was a reasonable site for Millet's shrews. Millet's shrews were only recorded at six sites in the autumn; the mean autumn density was 11 ha^{-1} (CV = 61%, N = 6).

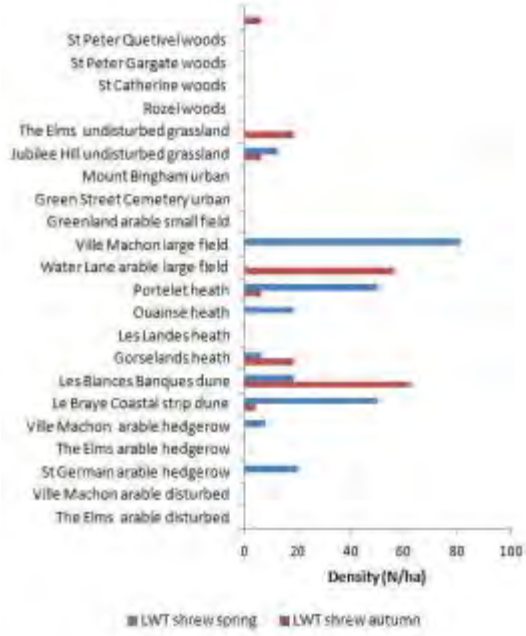
(a) Wood mouse



(b) Bank vole



(c) Lesser white-toothed shrew



(d) Millet's shrew

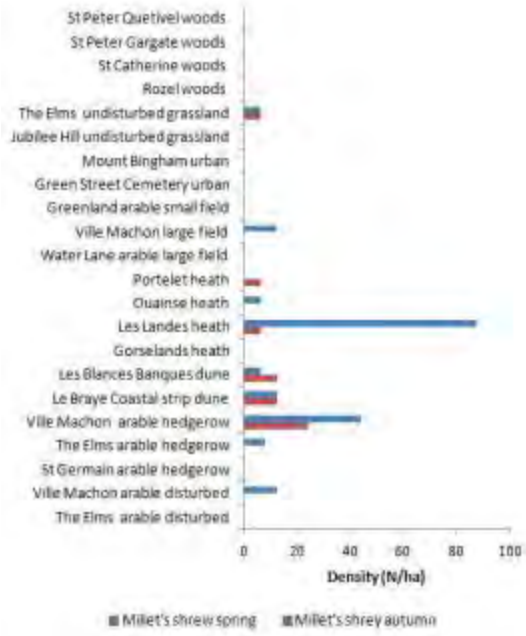


Figure 10 Densities of each species across all sites in both spring and autumn.

3.1.4 Biomass

Biomass, in relation to this survey is the mass of the living biological organisms in a given area. It was calculated as the total weight of all individual animals of a particular species at a particular site (Appendix 3). Sites and species have been classified according to upper and lower quartiles of biomass of a particular species across all sites into four classes: very good (biomass>upper quartile), moderate-good (>lower quartile<upper quartile), poor (<lower quartile>0) and very poor (0) for each species in spring and autumn (Table 9). Because many sites had no shrews either in spring, autumn or both, sites with just a few animals present and a low population biomass tended to be ranked as good-moderate. The best sites and changes in apparent suitability from spring to autumn or *vice versa* have already been considered above. These data will be used to compare this survey with the findings from the 1998-2000 survey below (sections 3.3.2).

	Wood mouse		Bank vole		LWT shrew		Millet's shrew	
Site/habitat	S	A	S	A	S	A	S	A
The Elms - arable disturbed	0	2	1	0	0	0	0	0
Ville Machon - arable disturbed	0	1	1	0	0	0	0	0
St Germain hedge	2	3	3	3	2	2	3	0
The Elms hedge	2	3	2	2	2	2	0	0
Ville Machon hedge	2	2	2	2	2	2	2	0
Le Braye Coastal strip - dune	2	3	3	2	3	3	3	3
Les Blanches Banques - dune	2	2	2	0	2	1	3	3
Gorselands heath	2	1	2	2	2	2	0	0
Les Landes heath	1	2	2	3	3	3	0	0
Ouaisne heath	3	2	2	2	2	2	2	3
Portelet heath	3	2	2	3	3	3	3	3
Ville Machon large field	2	0	1	2	0	2	0	0
Water Lane large field	2	0	2	2	0	2	3	0
Greenland small field	0	2	1	0	2	2	0	0
Green Street Cemetery - urban	1	1	1	0	0	0	0	0
Mount Bingham - urban	3	2	3	2	2	2	0	2
Jubilee Hill undisturbed grassland	2	3	2	3	3	3	2	3
The Elms undisturbed grassland	2	2	2	2	3	3	0	0
Rozel woods	3	2	3	2	0	2	0	0
St Catherine's woods	2	2	2	3	2	2	0	0
St Peter Gargate woods	3	2	3	0	0	0	0	0
St Peter Quetivel woods	2	3	2	2	0	2	0	2
Upper quartile	93.8	96.8	0.0	0.0	0.0	0.0	0.0	0.0
Median	233.0	146.5	105.0	281.5	0.0	0.0	0.0	0.0
Lower quartile	322.5	213.8	205.0	493.0	18.3	6.3	9.0	2.3

Table 9 Ranking of sites in order of population biomass for each species in spring (S) and autumn (A) based on upper and lower quartile descriptive statistics across sites. 3 > upper quartile = very good habitats, 2 (yellow) > lower quartile <upper quartile = moderate to good habitats, 1 <lower quartile>0 = poor habitats, 0 = no animals captured = very poor habitats.

An overall idea of habitat suitability based on the ranks of the mean biomass per habitat is shown in Table 10. The habitat ranks are not particularly consistent from spring to autumn for the two rodent species. They tend to be more consistent for shrews, but this is partly related to many habitats being poor, supporting few or no individuals. The suitability of agricultural habitats varied according to the stage of the crop cycle and husbandry carried out by the farmer, but they can be important transient habitats such as for wood mice in large field habitats during the spring or disturbed arable fields in the autumn. However, wood mice are generally ubiquitous across all habitat types, with biomass being greatest in woodland and heathland. Bank voles were also ubiquitous in the spring but had disappeared from several sites in the autumn. Overall, dune habitats were most favoured by both shrew species, but Millet's shrew in particular tended to be more dispersed and absent from many sites in one or both seasons. Dune, heathland and undisturbed grassland tended to be the best habitats for both species.

	Wood mouse		Bank vole		LWT shrew		Millet's shrew	
Habitat	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Arable disturbed	1	3	2	1	1	1	7	1
Arable hedgerow	6	7	8	7	7	6	8	8
Dune	5	9	5	5	8	9	6	9
Heath	7	5	9	8	6	8	9	6
Arable Large Field	4	1	4	1	9	1	4	1
Arable small field	2	4	1	6	1	1	1	1
Urban	8	2	3	4	1	4	1	1
Undisturbed Grassland	3	8	6	9	5	7	5	7
Woods	9	6	7	3	1	4	1	1

Table 10 Habitat types ranked 1 (worst) to 9 (best) based on average habitat population biomass (g) for each, species and season.

3.1.5 Breeding

It is not easy to sex or determine breeding status in shrews. This, combined with low 2014 shrew capture rate, means that breeding has only been examined in wood mice and bank voles. Week number has been built into the analysis, because time of the year affects breeding.

Spring sampling started on March 28th (Table 4)and by this time the majority of adult mice and voles were in breeding condition. However, proportionally fewer were breeding in the autumn with most breeding having stopped by week 42 (Figure 6). External signs of breeding condition, especially in males, do not necessarily mean the animals are fecund, but females that are clearly pregnant provide proof that reproduction is occurring. The first pregnant wood mouse captured in spring was in the first trapping week (starting 28th March) at Ouaisne and a pregnant bank vole during the same week at Portelet heath. Thus breeding appears to have already been underway at the beginning of the spring survey. In the autumn, there were two obviously pregnant animals captured, both wood mice; at St Catherine's wood and Ville Machon the latter being in the week beginning 3rd October which suggests that breeding ended sometime in mid - October.

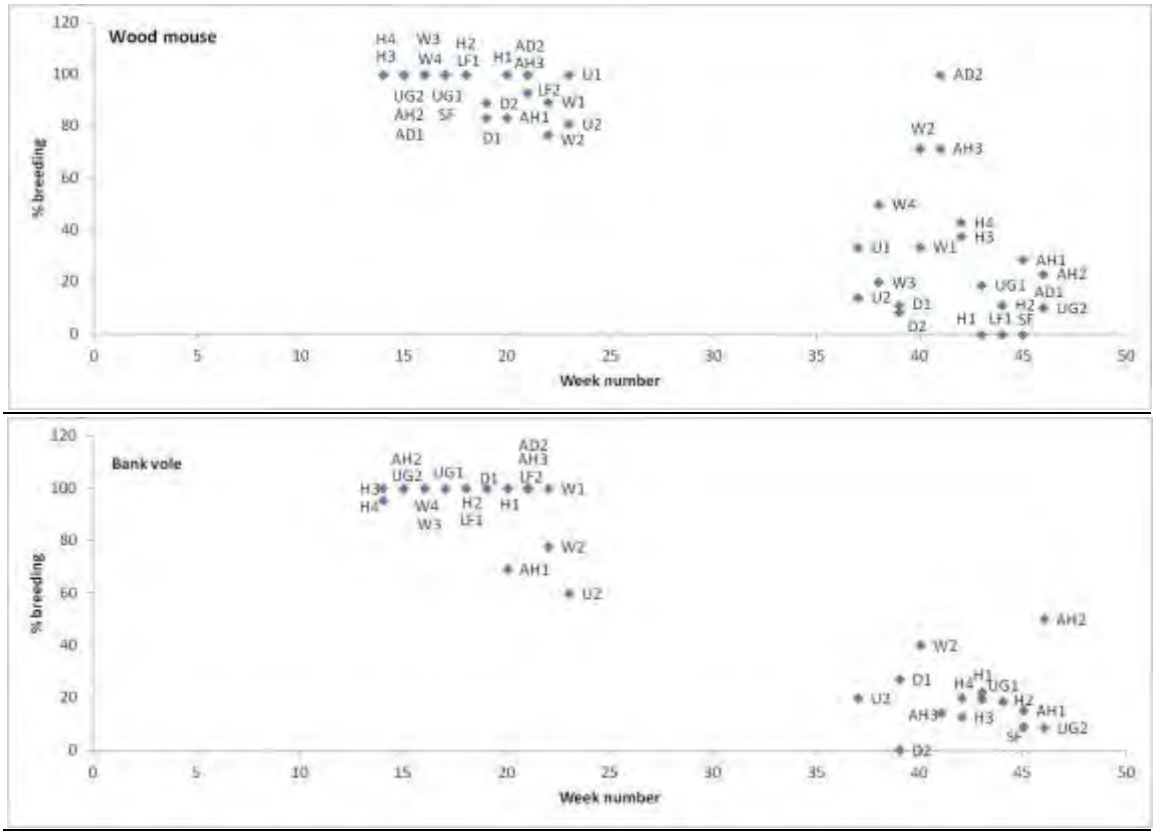


Figure 11 The proportion of adults in breeding condition according to week number. Point labels refer to habitats and individuals sites.

3.2 Factors affecting trap success

3.2.1 Weather

Two measures of daily weather were used to see whether they affected daily trapping success, grass minimum temperature (^{o}C), mainly affecting activity and captures during the night, and rainfall (mm). There was a modest significant negative correlation between temperature and captures of wood mice (r_s = -0.24, p = 0.041; Figure 7) but no correlation was found for any of the other species (all r_s values p>0.05).

To look at the effects of rainfall, numbers of individuals were logarithmically transformed (Log_{10} N+1) because of the large number of zero captures. Significant negative relationships were found between log number of individuals and rainfall for wood mouse (r_s = -0.47, p=0.006) and bank voles (r_s = -0.56, p = 0.001) indicating that fewer animals were captured when there was more rain, but no such relationship was found in either of the shrew species (r_s values p>0.05; Figure 8).

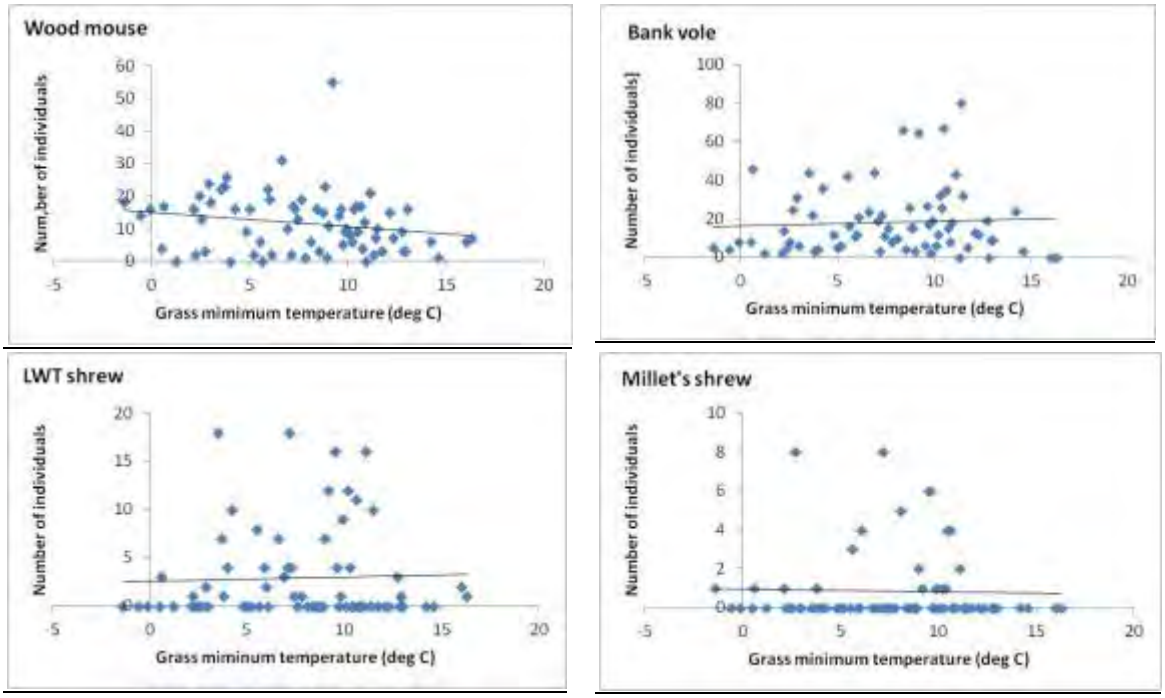


Figure 12 Numbers of individuals captured according the grass minimum temperature with trend lines.

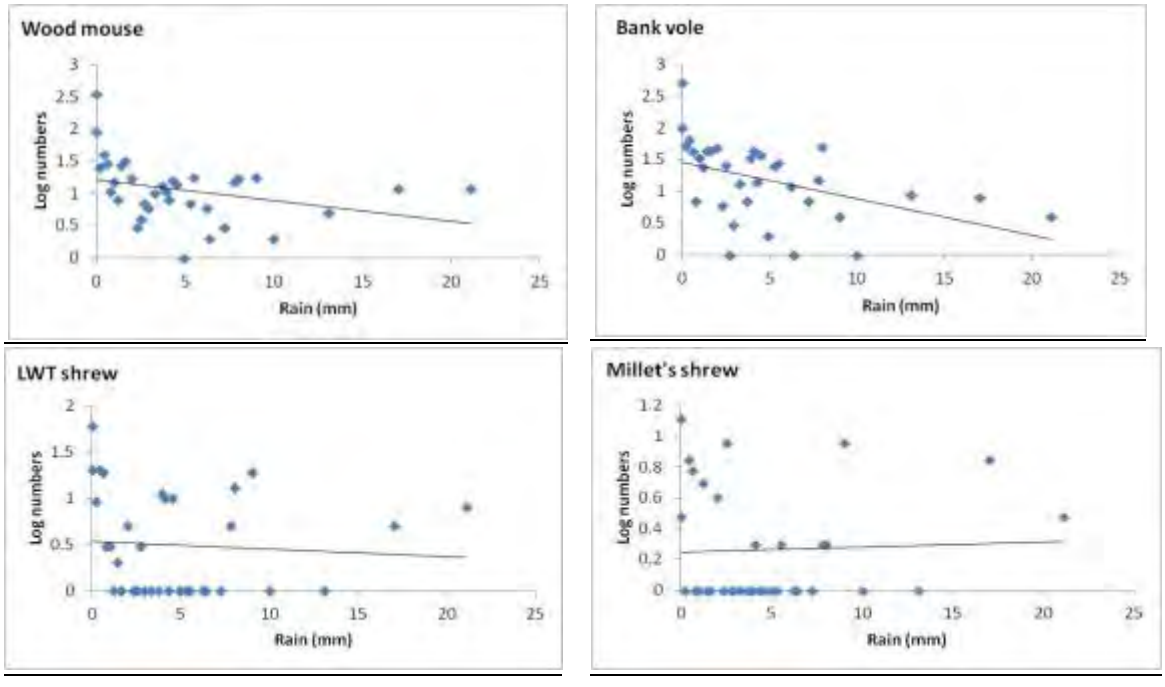


Figure 13 Numbers of individuals (log N+1) captured according to rainfall, with trend lines.

3.2.2 Week of trapping

The programme of field work to sample all sites took ten weeks during the spring and the autumn. Thus sampling at the beginning and end of these periods reflected different stages in the annual cycle of numbers of individuals in small mammal populations. However, there was no discernible pattern in the numbers captured across all sites in different weeks of the year (Figure 9). Wood mice tended to increase in weight during the spring and overall mean body weights were higher in the spring for overwintered animals than autumn reflecting the mix of age classes in the latter (Figure 10).

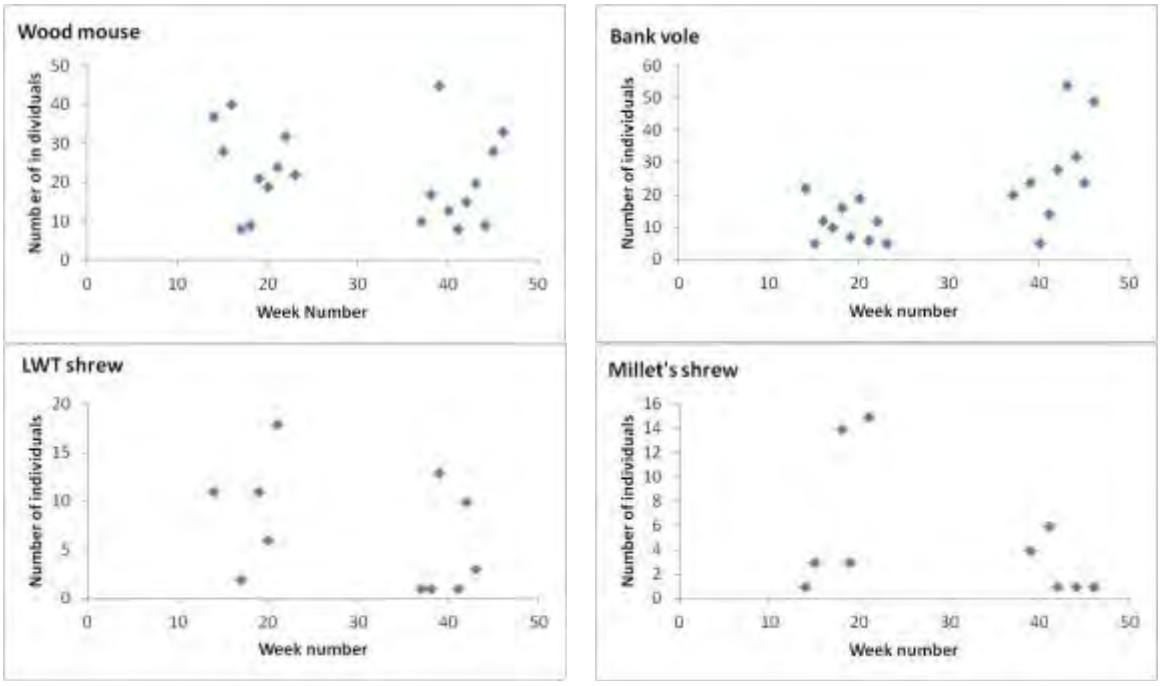


Figure 14 Numbers captured across sites according to the week of trapping.

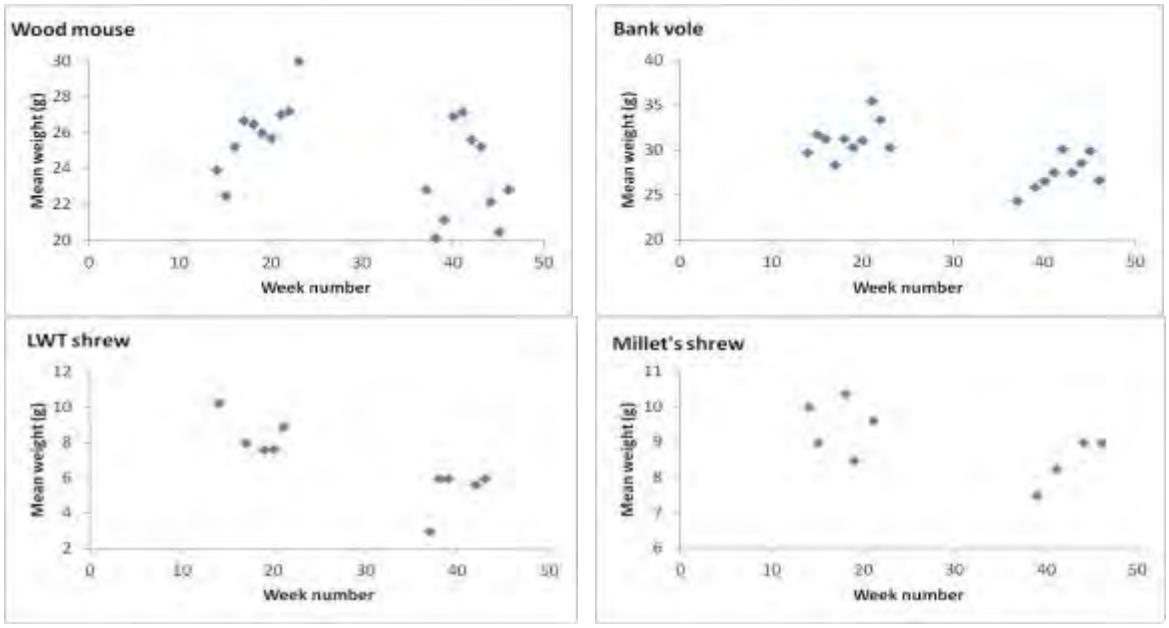


Figure 15 Mean weight of individuals across sites according to week of trapping.

3.2.3 Trapping grid edge effects

Excluding the line trapping along hedgerows, significantly more individuals were captured on outer or edge of grid traps (n = 24 traps) than inner traps (n = 25 traps) for all species in both seasons except for Millet's shrews in spring, when the opposite was found, although this was not significant (Table 11).

	Trap	Spring	X^2	P	Autumn	X^2	P
As	Inner	161	10.7	0.001	253	132.5	<0.001
	Outer	217			566		
Mg	Inner	186	7.83	0.005	437	128.1	<0.001
	Outer	235			812		
Cs	Inner	37	3.5	0.06	72	17.49	<0.001
	Outer	53			127		
Sc	Inner	23	0.99	0.32	24	13.44	<0.001
	Outer	16			55		

Table 11 Number of captures on inner and outer (edge) grid traps (thus excluding hedgerows) in spring and autumn. Chi-square tests assume equal numbers captured in inner and outer traps.

3.2.4 New and recaptured animals

An efficient trapping programme should be reflected in a higher proportion of the catch being marked or recaptured animals as the trapping week progresses; by the end of the week, ideally most of the captured animals should be marked. This was found to be the case for bank voles and LWT shrews with ~90% of individuals being marked on day 5 (Figure 11). However, ~35% of wood mice were unmarked on day 5 suggesting a considerable number of individuals had not be trapped which probably reflects wide ranging movement in these mice. The pattern of an increased proportion of animals being recaptured as the trapping week progressed was not seen in Millet's shrews indicating these animals were more ephemeral than LWT shrews or were less re-trappable.

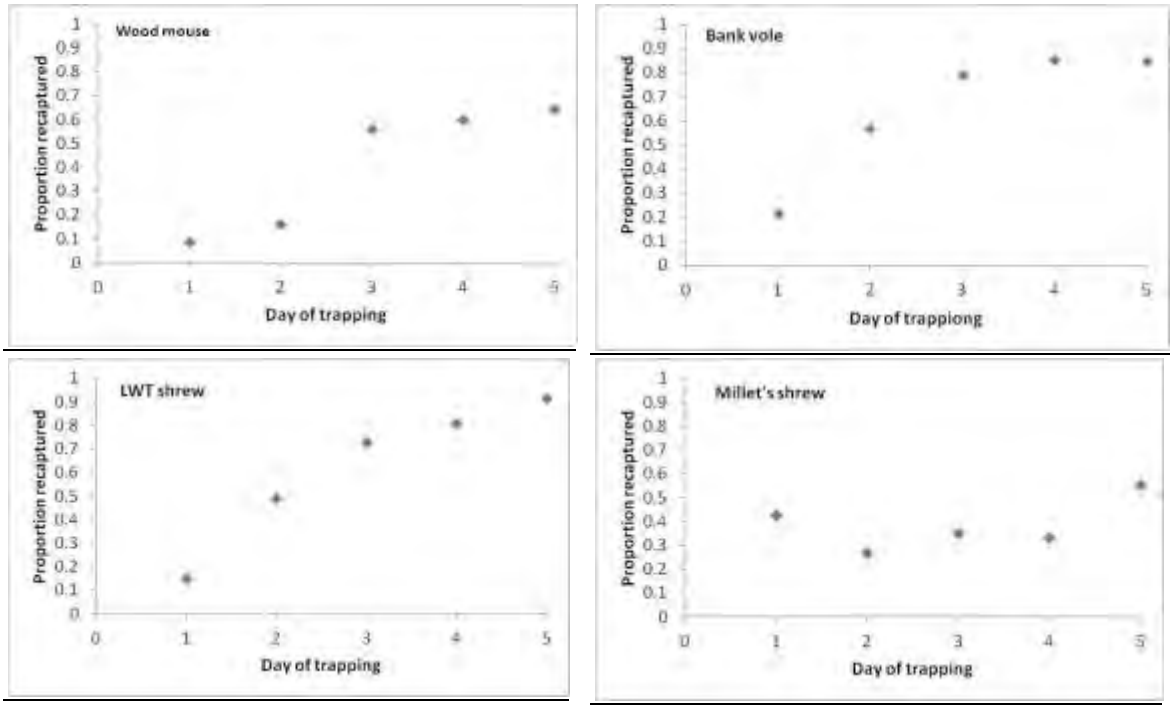


Figure 16 Proportion of individuals recaptured on each day of trapping. On day 1, individuals captured in the morning could be recaptured during the midday and evening trap rounds; on days 2 to 5 recaptures could occur during morning, midday and evening trap rounds. On day 5 there was only one trap round in the morning.

3.2.5 Time of capture

Significantly more wood mice were captured over night as represented by the number of animals captured in the morning trap round (Figure 12); this reflects their nocturnal habits. In contrast, significantly more bank voles were captured during the daytime (i.e. midday and/or evening trap rounds); captures of both shrew species were much lower than those for mice or voles, and there were no significant differences in numbers captured during the day and night.

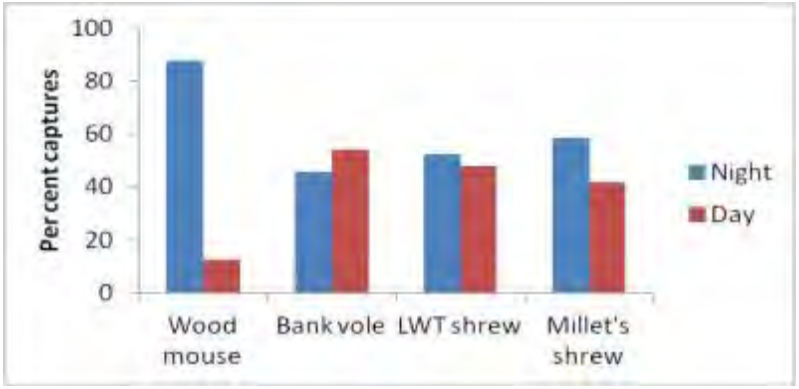


Figure 17 Number of captures during the night and day for each species across the study. Wood mouse X^2= 436.38, P<0.001 - 836 captures, Bank vole X^2= 8.56, P=0.003 - 1287 captures, LWT shrew X^2= 0.39, P=0.532 - 207 captures, Millet's shrew X^2= 1.67, P=0.20 - 60 captures.

3.2.6 Habitat

The relationships between the average population biomass across both seasons for each species and the component scores from the PCA (Principal Component Analysis) ordination presented in Appendix 2 revealed two positive correlations. Wood mouse biomass was highly correlated with the Component 1 scores (Figure 13); this indicates that wood mouse productivity increases along Component 1 from agricultural habitats with less diverse vegetation attributes to habitats with more diverse vegetation such as woodland, heathland, urban and hedgerow habitats. LWT shrew biomass was highly negatively correlated with Component 2 scores (Figure 14) suggesting productivity decreased from sites with grass present to those with bare ground.

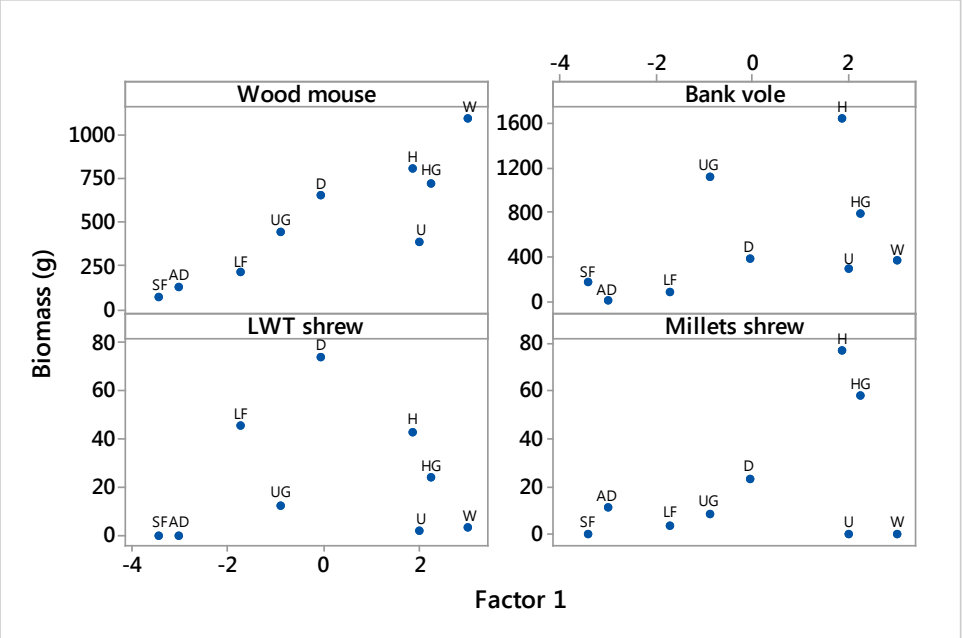


Figure 18 Scatterplots between species population biomass (averaged across the two seasons) against PCA Factor 1 scores for habitat attributes. Point labels refer to habitats. Wood mouse r_s = 0.87, p = 0.002; Bank vole r_s = 0.52, p = 0.15; LWT shrew r_s = 0.23, p = 0.50; Millet's shrew r_s = 0.10, p = 0.80.

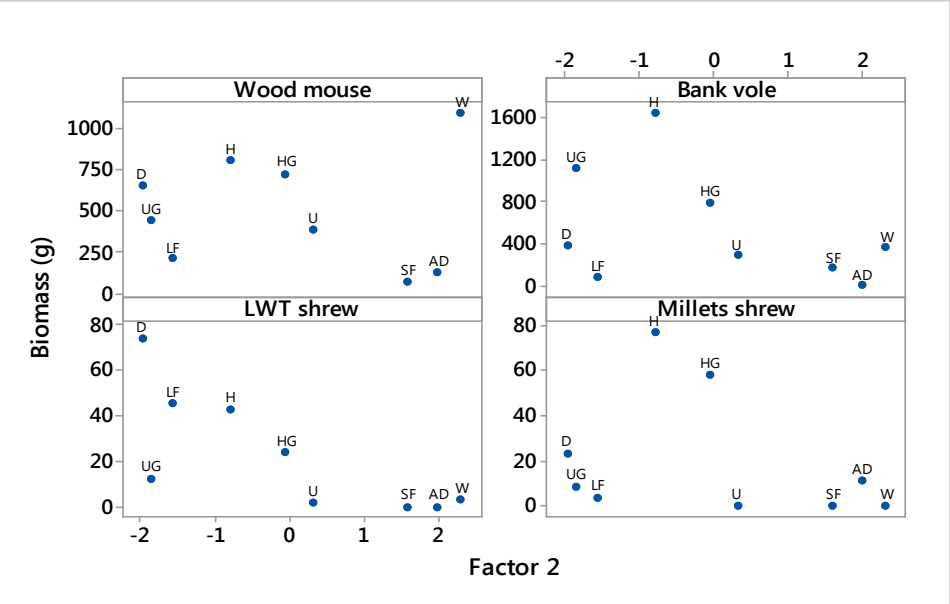


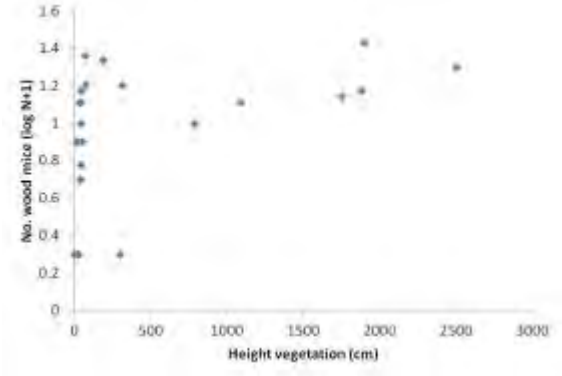
Figure 19 Scatterplots between species population biomass (averaged across the two seasons) against PCA Factor 2 scores for habitat attributes. Point labels refer to habitats. Wood mouse r_s -0.08, p = 0.83; Bank vole r_s = -0.47, p = 0.21 ; LWT shrew r_s = -0.80, p = 0.01 ; Millet's shrew r_s = -0.48, p = 0.20.

To explore habitat associations further, the numbers of individuals of each species have been correlated with the three continuous habitat measures: % bare ground, % tree shade and vegetation height (Table 12, Figure 15). Most species were negatively associated with % bare ground, but significantly so in the case of both shrew species in the spring. Shrew species were negatively associated with tree shade in both seasons, but no correlations were significant. Wood mice were significantly associated with tree shade in the spring. They were also significantly associated with vegetation height in the spring. No other associations between numbers and vegetation height were significant, although most were negative.

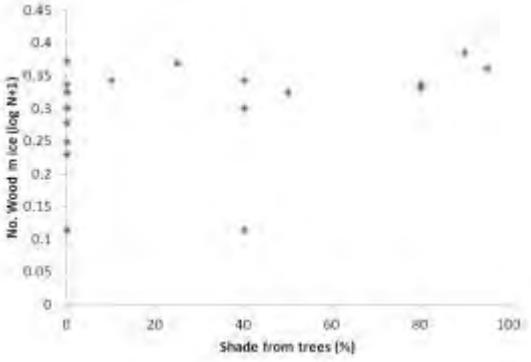
	Bare ground (%)		Tree shade (%)		Height Veg (cm)	
Spp/ season	r_s	p	r_s	p	r_s	p
Wood mouse spring	0.11	0.63	**0.51**	**0.02**	**0.65**	**0.00**
Wood mouse autumn	-0.01	0.98	0.01	0.96	-0.09	0.70
Bank vole spring	0.10	0.65	0.14	0.53	0.28	0.21
Bank vole autumn	-0.14	0.53	-0.34	0.12	-0.27	0.22
LWT shrew spring	**-0.50**	**0.02**	-0.29	0.19	-0.07	0.76
LWT shrew autumn	-0.33	0.14	-0.16	0.47	-0.03	0.89
Millet's shrew spring	-0.25	0.26	-0.28	0.21	-0.23	0.31
Milllet's shrew autumn	**-0.42**	**0.05**	-0.32	0.15	-0.15	0.49
Total Spring	-0.04	0.86	0.24	0.29	0.42	0.05
Total Autumn	-0.14	0.54	-0.22	0.33	-0.17	0.45

Table 12 Spearman's correlation analysis between number of individuals of each species in spring and autumn. r_s = Spearman's rank correlation coefficient; numbers in bold are significant (P<0.05), As = wood mouse, Mg = bank vole, Cs = LWT shrew, Sc = Millet's shrew, S = spring, A = autumn.

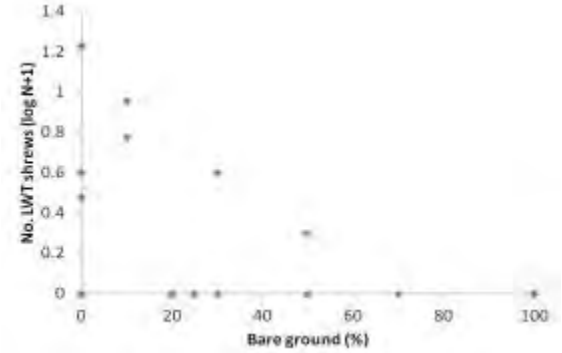
(a) Wood mice and mean height of vegetation



(b) Wood mice and tree shade



(c) LWT shrews and per cent bare ground



(d) Millet's shrews and per cent bare ground

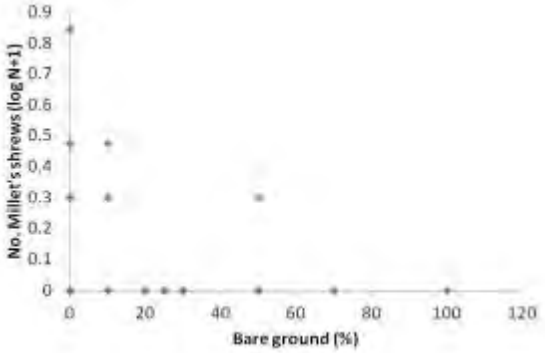


Figure 20 Relationships between numbers of individuals and habitat variables, (a) number of wood mice (log N+1) in spring and mean height of vegetation at each site (r_s = 0.65, P<0.001), (b) number of wood mice (logN+1) in spring and per cent tree shade (r_s = 0.51, P=0.02), (c) number of LWT shrews (log N+1) and per cent bare ground in spring (r_s = -0.50, P=0.02), (d) number of Millet's shrews(log N+1) and per cent bare ground in autumn (r_s = -0.42, p = 0.05).

3.3 Comparing the 1998-2000 survey and 2014 survey

In the 1998-2000 survey, trapping was carried out at 16 sites in autumn 1998, and 19 sites in spring and autumn 1999 across eight habitat types. In spring 2000 there were 20 sites with two additional urban sites trapped. This gives 75 possible sampling occasions. Wood mice were captured on 68 of these 73 possible occasions, giving a probability of catching this species of 0.932. Equivalent probabilities for bank voles, LWT shrews and Millet's shrews were 0.863, 0.205 and 0.233 respectively. For the four species combined, the overall probability of sampling any small mammal was 0.543. This is a higher probability of capture for bank voles than 2014 but lower for the two shrew species (see Section 3.1). It should be noted that only 13 sites were trapped in both surveys which may partially account for differences in these sampling probabilities. However, the pattern still holds if just these 13 sites are considered (Table 13).

Species	1998-2000	2014
Wood mouse	0.865	1.000
Bank vole	0.904	0.769
LWT shrew	0.288	0.462
Millet's shrew	0.212	0.346

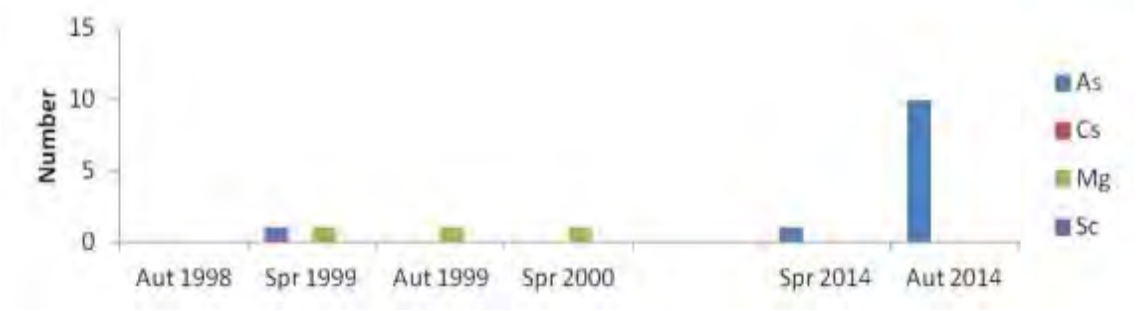
Table 13 Probabilities of sampling each small mammal species at each of the 13 sites that were common to both the 1998-2000 and 2014 surveys.

With respect to presence/absence, these findings suggest that bank voles were less widespread but shrews more widespread in 2014 compared to 1998-2000.

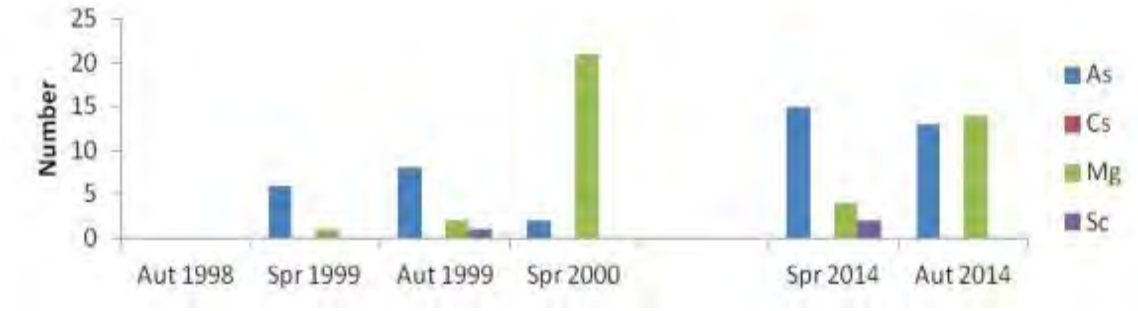
3.3.1 Small mammal numbers across sites

In order to compare the numbers of small mammals caught across the same surveyed sites, it is important to divide each survey into seasons due to the variation of species and numbers captures across time of year, as highlighted previously.

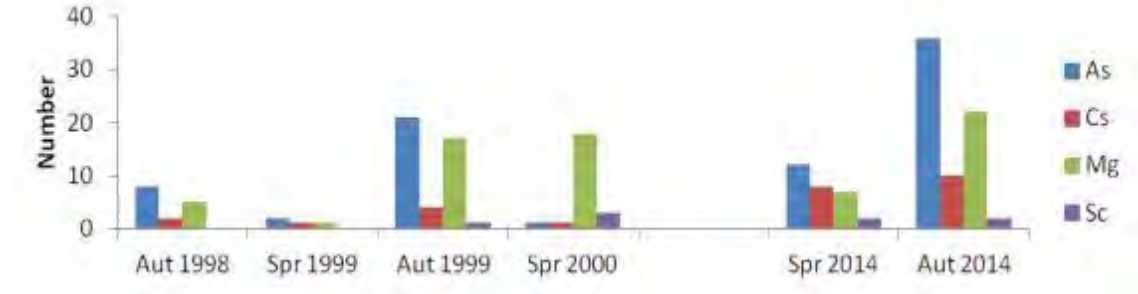
(a) The Elms disturbed field



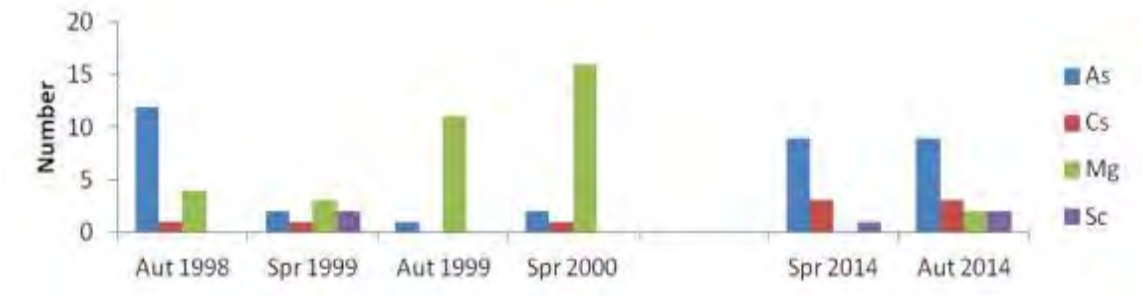
(b) The Elm hedge



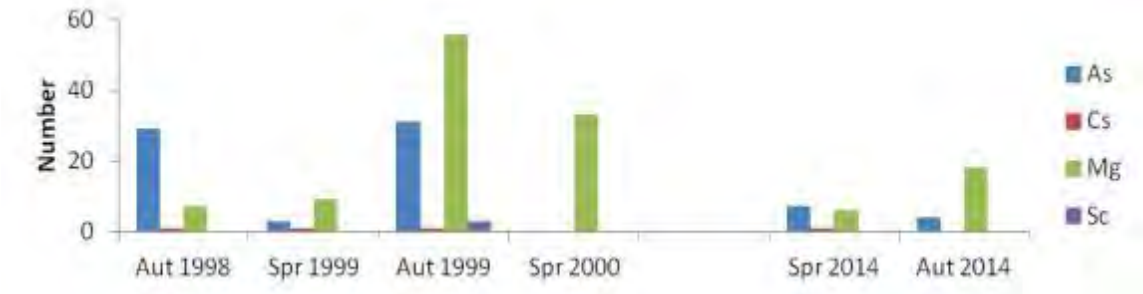
(c) Le Braye coastal strip dune



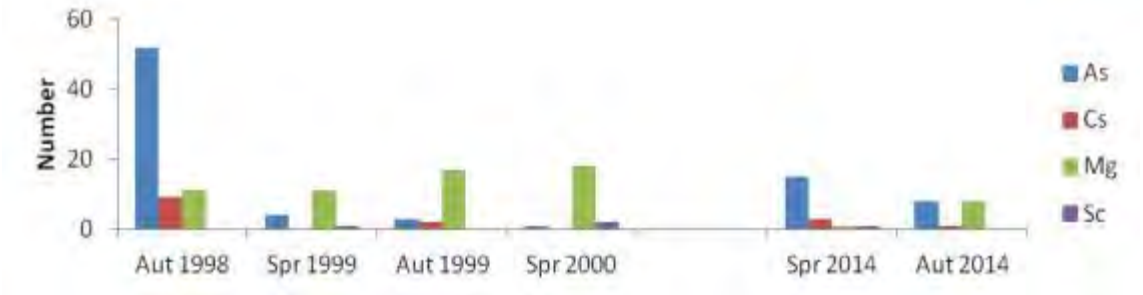
(d) Les Blanches Banques dune



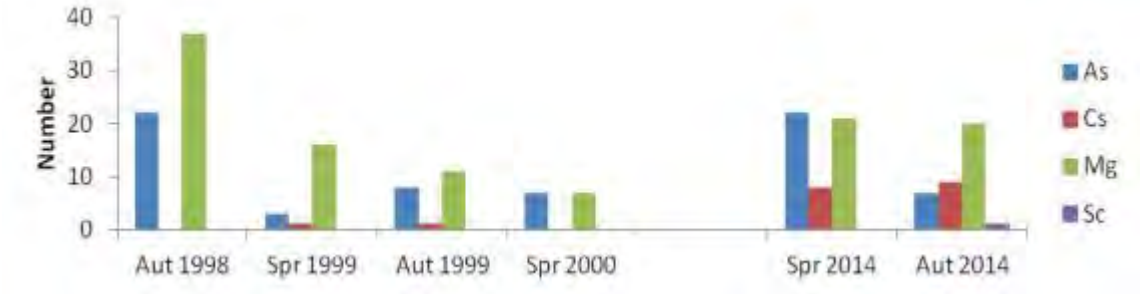
(e) Gorselands heath



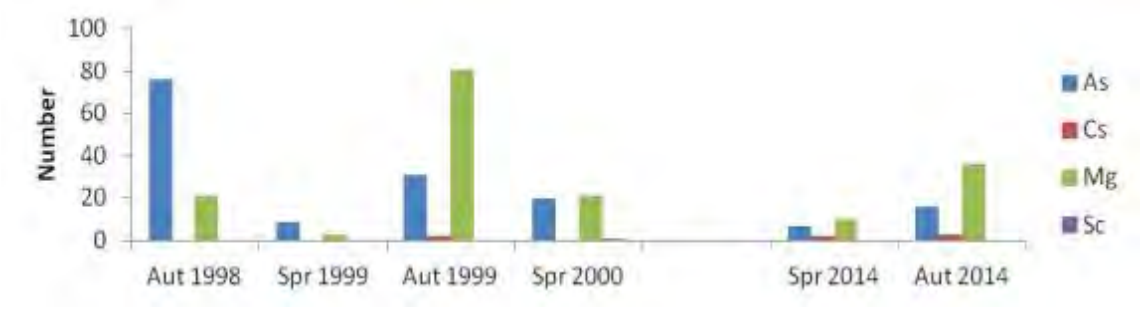
(f) Ouaisne heath



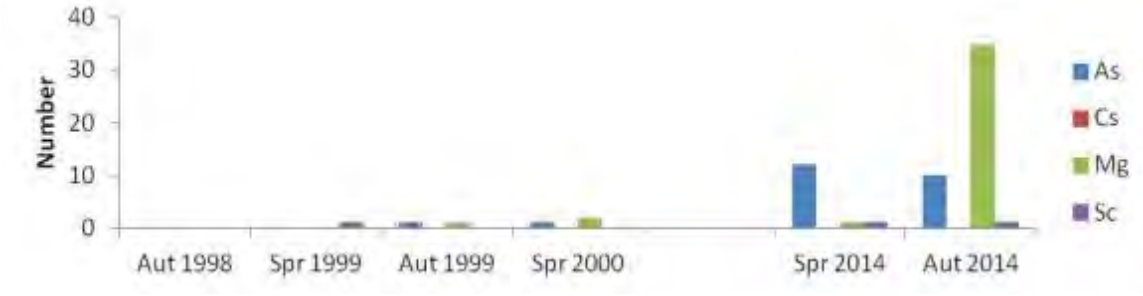
(g) Portelet heath



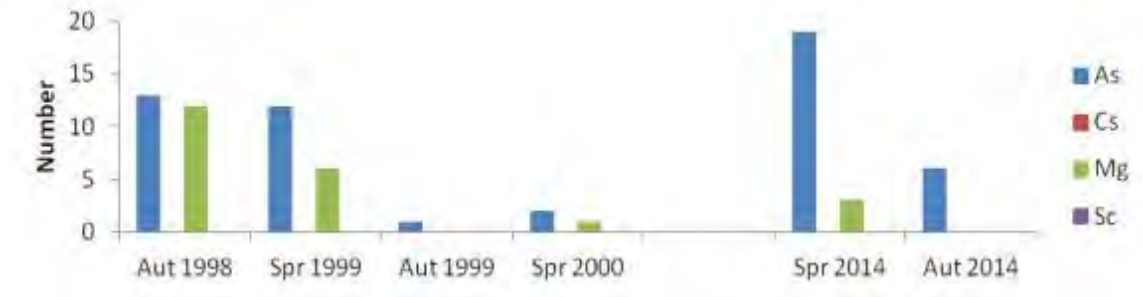
(h) Jubilee Hill undisturbed grassland



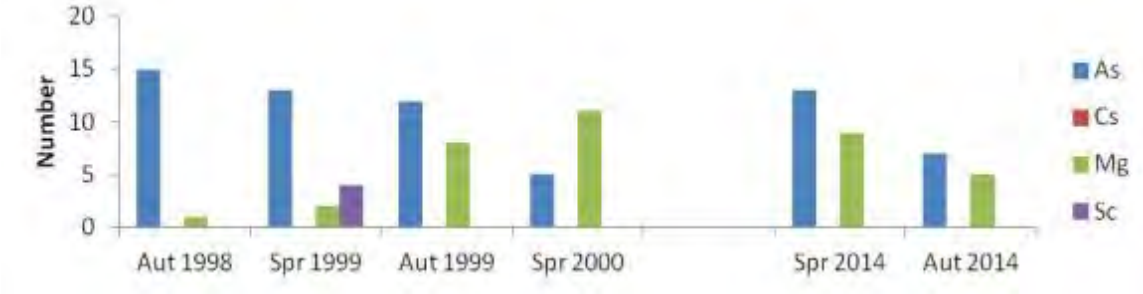
(i) The Elms undisturbed grassland



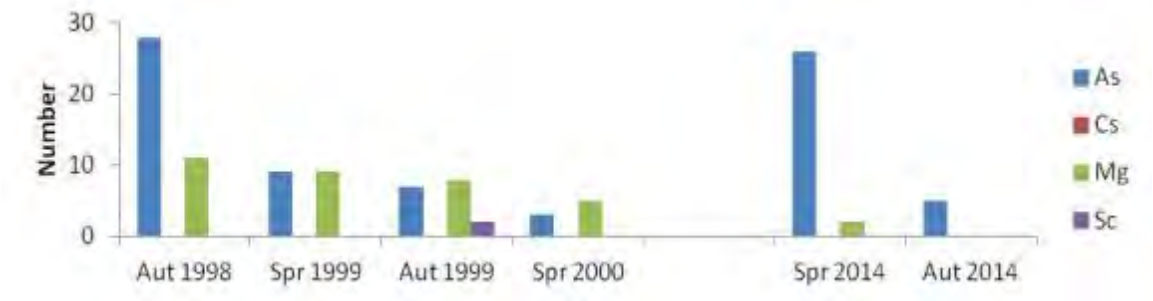
(j) Rozel woods



(k) St Catherine woods



(l) St Peter Gargate woods



(m) St Peter Quetivel woods

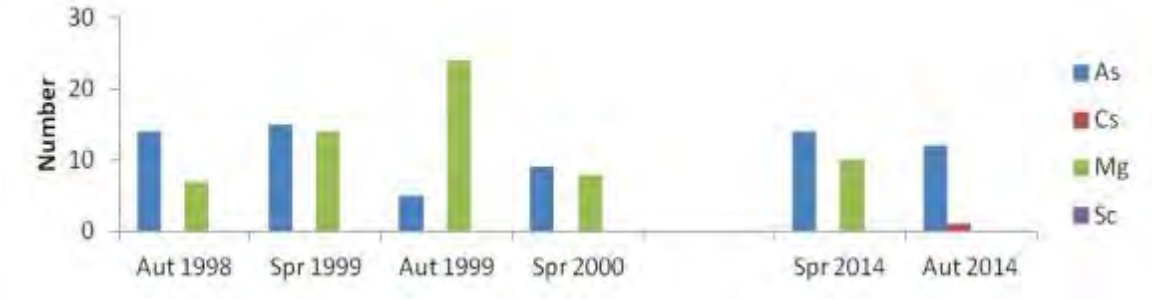


Figure 21 Small mammal numbers across sites, seasons and years surveyed, for the 13 repeated sites for comparison of the two surveys. As = wood mouse, Cs = lesser white-toothed shrew, Mg = bank vole, Sc = Millet's shrew. (The three Elms sites were not surveyed in autumn 1998).

Figure 16 shows that small mammal numbers will fluctuate over time at a site, however some sites such as St Catherine's woods show consistency across the two surveys. Le Braye coastal dune site shows the same species assemblage but with slightly greater numbers in 2014 compared with the first year of surveying. Also notable from the above figure is shrew unpredictability; shrews appear to be present on site randomly over a season and then disappear again, e.g. St Catherine's woods or The Elms hedge. Bank voles numbers appear to be consistent across woodlands, but of note is their disappearance in the autumn of 2014 at three woodland sites. The Elms undisturbed grassland shows that 2014 was a better year for species caught on site compared with the previous survey. The graphs also show what could be seen as a peak in number of captures, but this may be due to conditions on site at that particular time, or it may be a peak due to population cycles.

3.3.2 Small mammal presence according to habitat

Dune habitats

The second year of the first survey showed the presence of all four species across the dune habitats. This is also evident in the present survey but with slightly higher numbers of shrews caught and a big increase in wood mice caught in the final trapping period.

Heath habitats

Heathlands show overall the same species diversity with the occasional absence of a shrew species.

Undisturbed grassland habitats
The second year of the first survey and the present survey show similar trends during the seasons across undisturbed grassland habitats. The 2014 survey also confirmed that these habitats can support all four species.

Woodland
Woodlands showed the same species present with wood mice and bank voles being the dominant species. 2014 showed that numbers peaked in spring time rather than autumn as in the previous study.

Hedgerow habitats
2014 showed greater diversity in species present with both species of shrew being captured in both spring and autumn. Two of the three hedgerows surveyed were different in 2014 than in 2000 and only one of these in 2014 revealed both species, the other two hedgerows only supported one species of shrew.

Large arable field habitats
Generally large arable fields were poor in abundance and species diversity with spring 2014 being the exception. This site was different to all the other seasons, including autumn 2014.

Disturbed field habitats
2014 saw a greater number of wood mice and an increase in species diversity. Again these sites were different to those in 2000.

Small arable field habitats
Small arable fields show a drop off in numbers in the spring across both surveys (Figure 17).

3.3.3 Small mammal numbers according to habitat
In order to compare the numbers of small mammals in the various habitats from the previous survey and this survey, the mean number of animals caught has been plotted according to species across each of the 6 seasons (2 spring and autumn seasons in the initial survey and one year in the second survey). This has been done for eight of the nine habitats; the urban (2014) and suburban habitats (2000) were not compared because of their difference (Figure 16). Care should be taken when comparing some of the arable sites (large arable field, hedgerow, small arable field and disturbed field) as these sites changed from 2000 to 2014 (Table 3). The heath, dune, undisturbed grassland and woodland site locations all remained the same for both surveys.

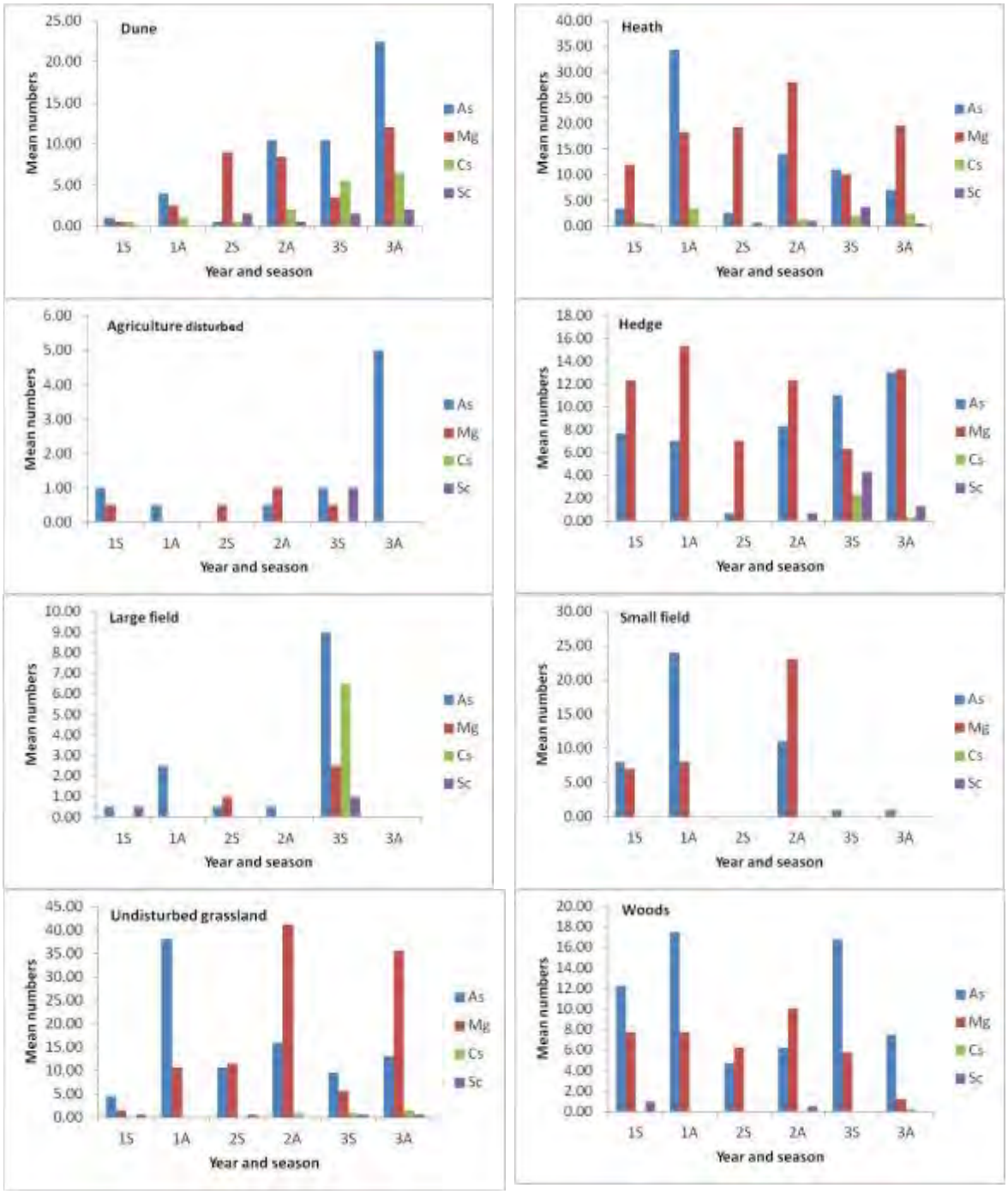


Figure 22 Mean number of animals caught per site in different habitats over six seasons. (1S = spring 1999, 1A = autumn 1998, 2S = spring 2000, 2A = autumn 1999, 3S = spring 2014, 3A = autumn 2014).

3.3.4 Small mammal biomass according to site and habitat

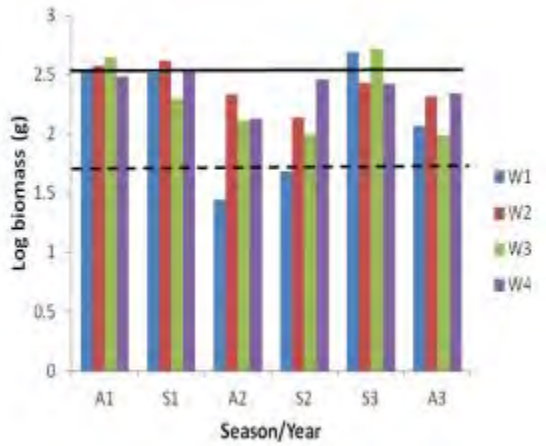
The biomass of each species was calculated separately according to species, season and year. In most instances, and particularly in relation to the two shrew species, the distribution of biomass values was positively skewed. Thus, to help visualise the results, the biomass data have been log transformed. The first survey year is autumn 1998 to spring 1999, second survey year is autumn 1999 to spring 2000 and the third survey is the current survey with spring 2014 and autumn 2014. Data was only used from the 13 sites which were surveyed over each of the three years (2 years of the 2000 survey and one for the 2014 survey), new sites in 2014 were omitted from this result (Table 13). Les Landes heath has also excluded as it was a site of a fire in the first survey.

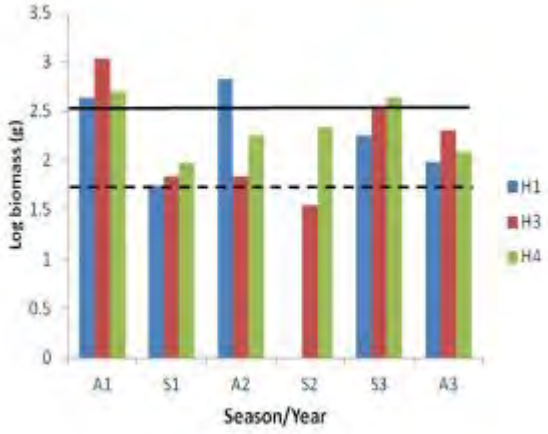
AD1	The Elms disturbed field	UG1	Jubilee Hill undisturbed grassland
AH2	The Elm hedge 2	UG2	The Elms undisturbed grassland
D1	Coastal strip dune	W1	Rozel woods
D2	Les Blances Banques dune	W2	St Catherine woods
H1	Gorselands heath	W3	St Peter Gargate woods
H3	Ouainse heath	W4	St Peter Quetivel woods
H4	Portlet heath		

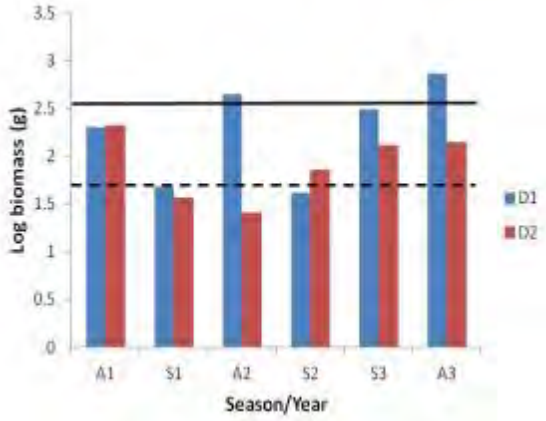
Table 14 Key for Figure 17, listing the 13 sites which were repeated exactly from the 2000 survey.

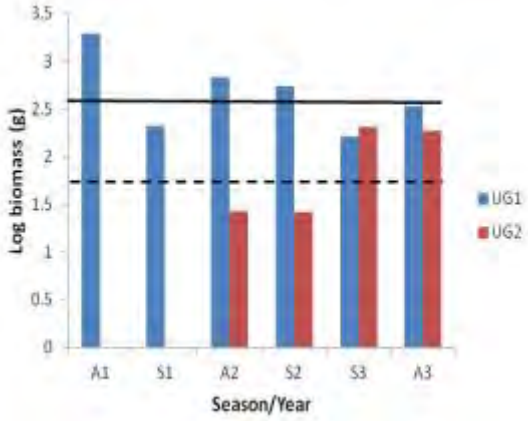
Biomass figures for all years, seasons and species are shown in Figure 17 with sites grouped according to habitat type. As a visual aid to help compare the data across the years and seasons, upper quartiles and lower quartiles (where appropriate) have been included in the plots.

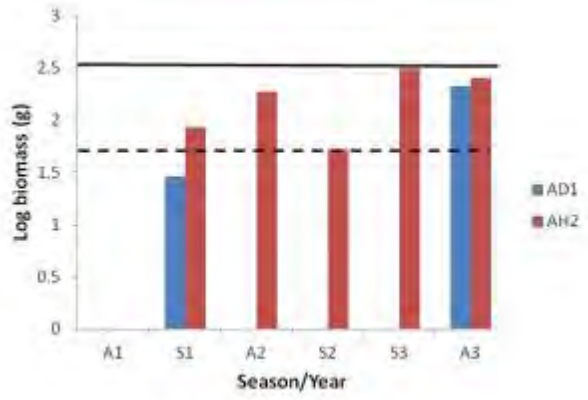
(a) Wood mouse


Log biomass (g)
Season/Year
A1
S1
A2
S2
S3
A3
W1
W2
W3
W4

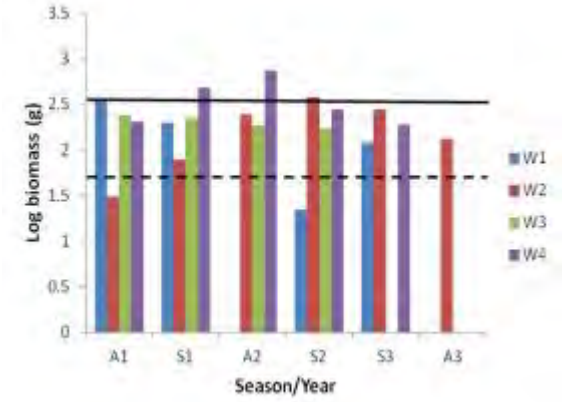

Log biomass (g)
Season/Year
A1
S1
A2
S2
S3
A3
H1
H3
H4

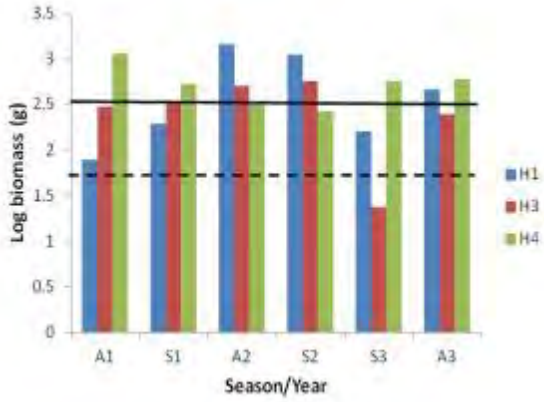

Log biomass (g)
Season/Year
A1
S1
A2
S2
S3
A3
D1
D2

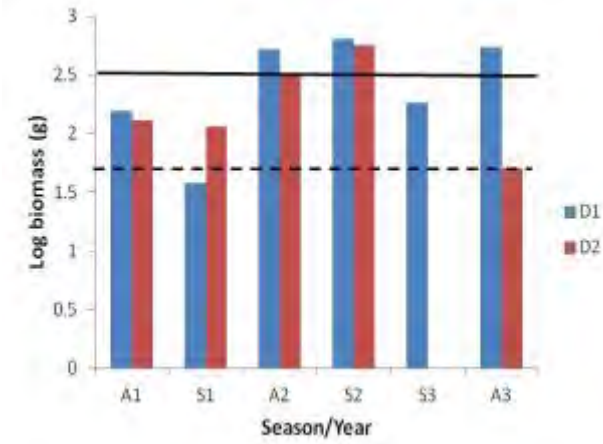

Log biomass (g)
Season/Year
A1
S1
A2
S2
S3
A3
UG1
UG2

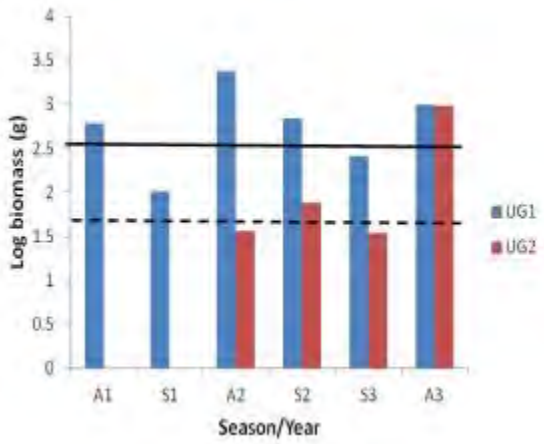

Log biomass (g)
Season/Year
A1
S1
A2
S2
S3
A3
AD1
AH2

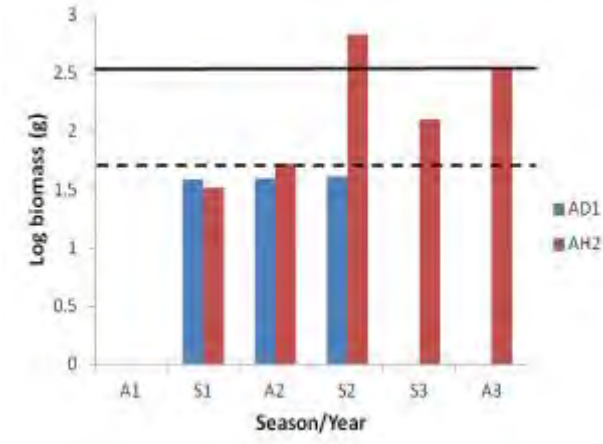
(b) Bank vole


Log biomass (g)
3.5
3
2.5
2
1.5
1
0.5
0
A1
S1
A2
S2
S3
A3
Season/Year
W1
W2
W3
W4

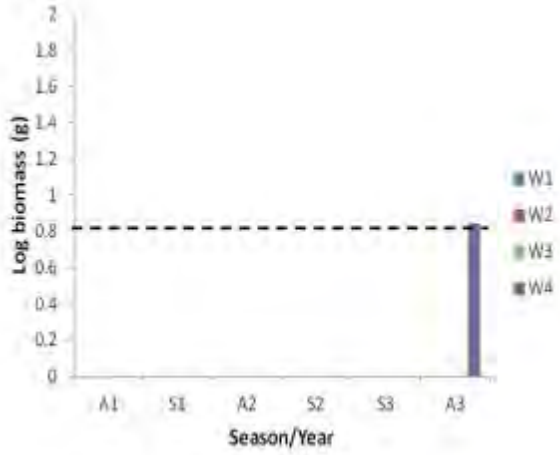

Log biomass (g)
3.5
3
2.5
2
1.5
1
0.5
0
A1
S1
A2
S2
S3
A3
Season/Year
H1
H3
H4

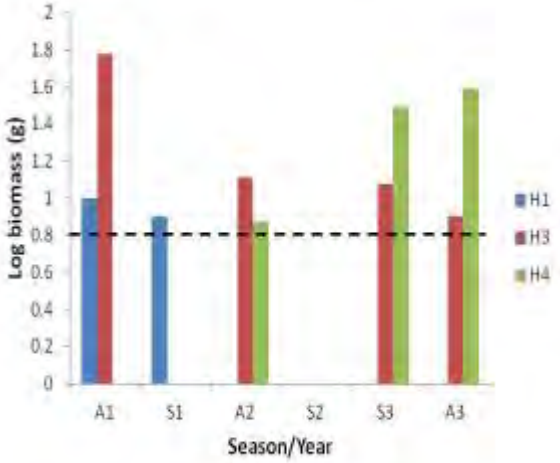

Log biomass (g)
3
2.5
2
1.5
1
0.5
0
A1
S1
A2
S2
S3
A3
Season/Year
D1
D2

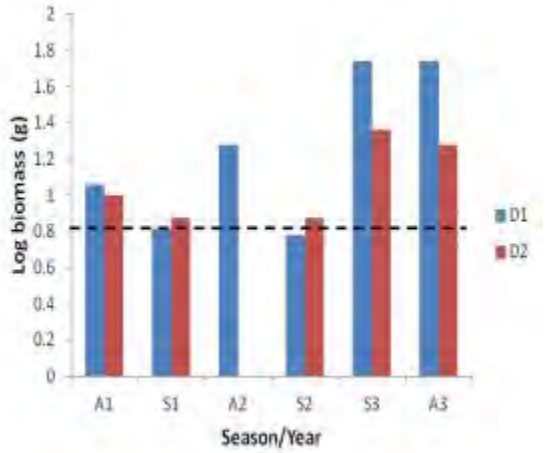

Log biomass (g)
4
3.5
3
2.5
2
1.5
1
0.5
0
A1
S1
A2
S2
S3
A3
Season/Year
UG1
UG2

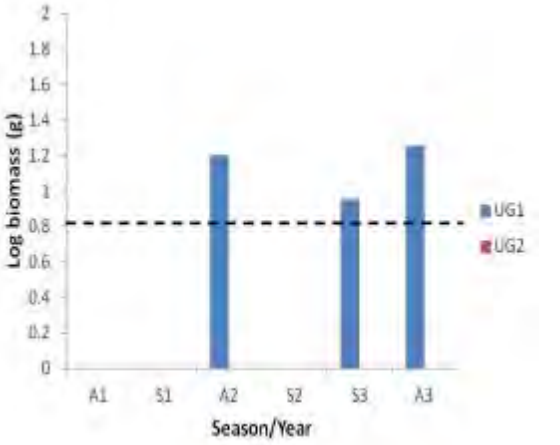

Log biomass (g)
3
2.5
2
1.5
1
0.5
0
A1
S1
A2
S2
S3
A3
Season/Year
AD1
AH2

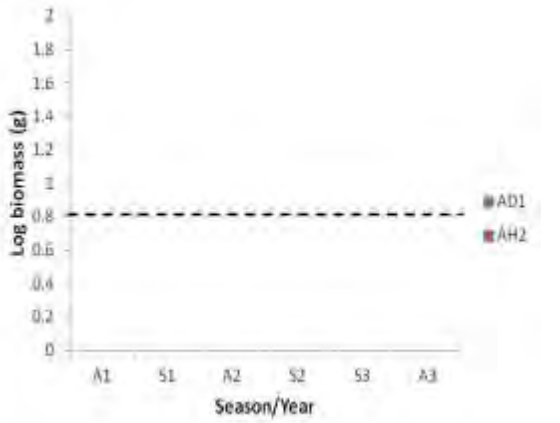
(c) Lesser white-toothed shrew











(d) Millet's shrew

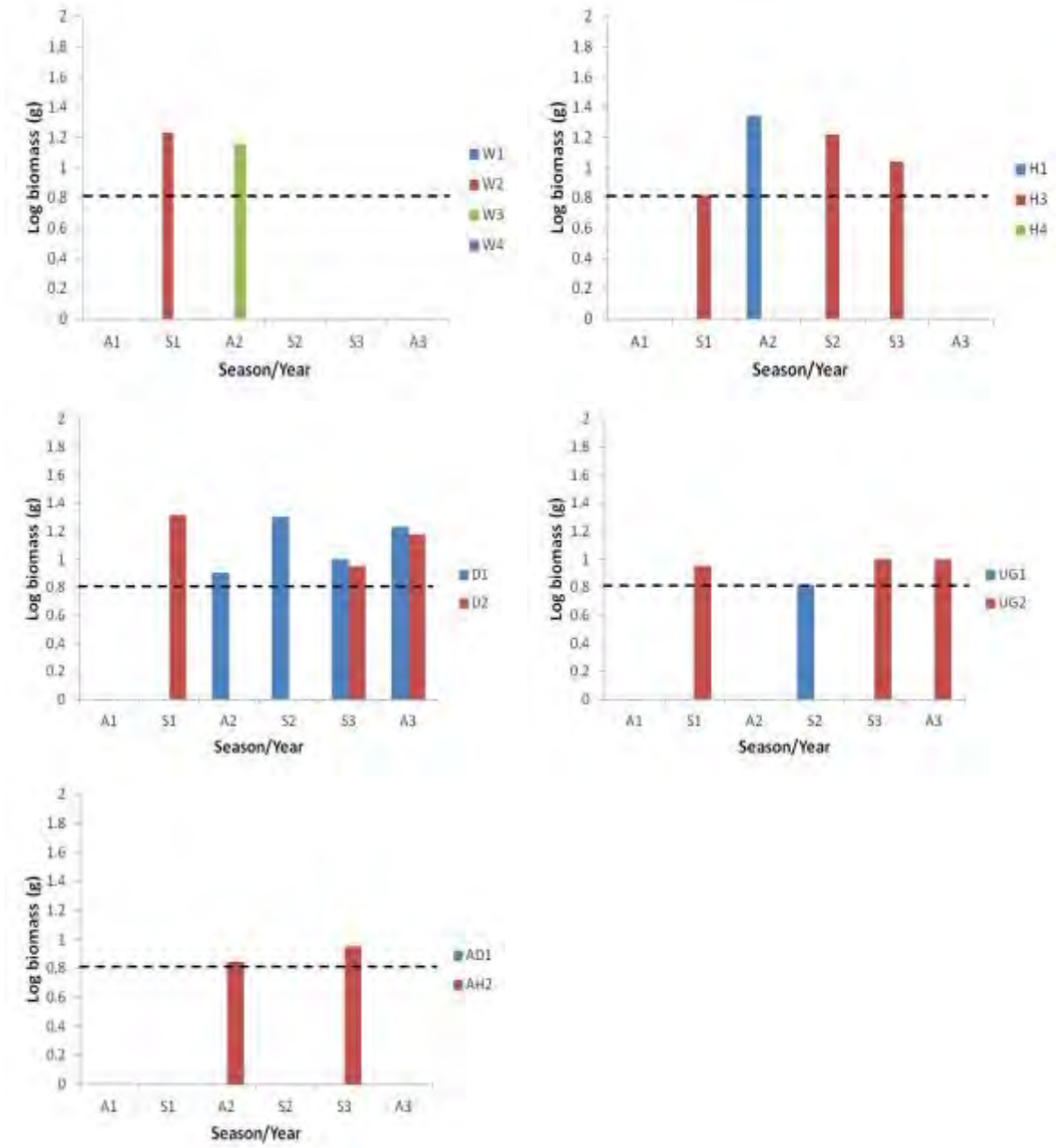


Figure 23 Population biomass (g) according to species, year and season. For wood mouse and bank vole plots, the solid horizontal line is the upper quartile of biomass for the two rodent species taken over all years and seasons, the hashed line is the lower quartile. For Lesser white-toothed shrew and Millet's shrew plots the hashed horizontal line is the upper quartile of biomass for the two insectivore species taken over all years and seasons. (A1 = autumn 1998, S1 = spring 1999, A2 = autumn 1999, S2 = spring 2000, S3 = spring 2014, A3 = autumn 2014).

Wood mouse biomass generally remained between the upper and lower quartile range across most of the sites and seasons and years. At some sites it appeared that biomass decreased after the first trapping season (autumn 1998) but it increased again in spring 2014. Wood mice were not present on occasions during a season but reappeared later in the initial survey. For example

wood mice were not found in Gorselands Heath (H1) in the spring of 2000 but were found there in all other seasons. Note: the lack of woodmice in UG1 and AD1 in autumn 1998 was because no survey took place at these sites during that season. Wood mice were not found in disturbed arable fields over three seasons but reappeared in the autumn of 2014; this again shows the transient nature of agricultural habitats**.**

Similar to wood mice, bank vole biomass tended to range between the upper and lower quartile values across most site, seasons and years. The results reveal an interesting picture for woodlands in 2014. In the spring of 2014 no bank voles were found in (W3) St Peter's Gargate woodland and, continuing into that year's autumn, voles were only found in St Catherine's woodland. It is not clear whether the woodlands were unsuitable habitat for bank voles at that time or the nearby agricultural habitat attracted voles and were more productive. Again the two agricultural sites AD1 and AH2 show the most variation across years and seasons. AD1 was quite short in vegetation during both 2014 seasons which may be the reason for the lack of bank voles.

Lesser white-toothed shrews were only found consistently across the two dune sites, across all seasons and years (Table 14). Shrews were not found in woodlands in 2014 apart from St Peter's Quetivel woodland in the autumn and this was down to one (breeding) female captured. Heathlands showed some consistency with shrew presence, but this varied from site to site and between seasons. LWT shrews were not found in any disturbed arable field sites across the two surveys. However, it should be noted that they were found in 2014 in the two other hedgerow sites (St Germain and Ville Machon) in good numbers. These were new sites to the survey. It also shows that LWT shrews were not only found in sandy soils or coastal areas, especially as St Germain is relatively central to the Island.

There was little pattern to the changes in Millet's shrew biomass across most sites and years which can generally be described as intermittent, apart from Le Braye Coastal strip (D1). Thus, there is agreement here between the two surveys. Millet's shrews were found in two woodland sites in the first survey but not at all in the second survey. In 2014 the two dune and UG2 (The Elms undisturbed grassland) sites showed Millet's shrew presence in both seasons. It is not possible to say whether their population was more established at these sites.

		2000		2014	
Habitat	Site	LWTS	MS	LWTS	MS
Woodland	St Catherine's Woods	x	Y	x	x
	Rozel Woods	x	x	x	x
	St Peter's Gargate	x	Y	x	x
	St Peter's Quetivel	x	x	Y	x
Dune	Le Braye	Y	Y	Y	Y
	Les Blanche Banque	Y	Y	Y	Y
Heathland	Portelet	Y	x	Y	Y
	Ouaisne	Y	Y	Y	Y
	Gorselands	Y	Y	Y	x
	Les Landes	x	x	x	Y
Undisturbed grassland	Jubilee Hill	Y	Y	Y	x
	The Elms undist	x	Y	x	Y
Hedge	The Elms hedge	x	Y	x	Y
Arable disturbed field	The Elms dist	x	x	x	x

Table 15 Comparison of shrew density across same surveyed sites in 2000 and 2014.

To try and obtain an overall picture of similarities and differences in habitat suitability for each species between the two surveys, the population biomass for each of six habitats for each species in each season have been ranked from smallest (1) to largest (6) in Table 14 using the sites as detailed in Table 13. Interestingly the total biomass of small mammals (all species), averaged across years and seasons, was similar between the two surveys: 6091g in 1998-2000 and 6004g in 2014. To help compare the rankings between the two surveys, Spearman's rank correlation coefficients (r_s) have been calculated between the ranks of the two surveys for each species and each season (Table 15). The correlation coefficient varies between -1 and +1 and measures the strength and direction of the relationship between the ranks from the two surveys; id the findings from the two surveys are completely unrelated then $r_s = 0$. The correlation was good (r_s>0.8) for bank voles in both seasons and LWT shrews in the autumn. The correlation was moderate for LWT shrews and wood mice in spring (r_s~0.6), poor for wood mice in the autumn (r_s=0.3) and non-existent for Millet's shrews in both seasons (r_s~0.0). This reiterates our findings that the data does not show any patterns for Millet's shrews across the habitat types or between seasons.

	Wood mouse				Bank vole			
Season	Spring	Spring	Autumn	Autumn	Spring	Spring	Autumn	Autumn
Survey	1	2	1	2	1	2	1	2
Arable disturbed	1	1	1	1	1	1	1	1
Arable hedgerow	3	4	2	4	5	5	2	4
Dune	2	3	3	6	4	2	4	3
Heath	4	5	5	2	6	6	5	5
Undisturbed Grassland	5	2	6	5	2	3	6	6
Woods	6	6	4	3	3	4	3	2
	LWT shrew				Millet's shrew			
Arable disturbed	1	1	1	1	1	4	1	1
Arable hedgerow	1	5	1	3	1	5	3	5
Dune	6	6	5	6	5	3	4	6
Heath	5	4	6	5	6	6	6	3
Undisturbed Grassland	1	3	4	4	3	2	1	4
Woods	1	1	1	2	4	1	5	1

Table 16 Rank order of habitats (1 = worst to 6 = best in terms of average population biomass per site for each habitat type, species and season for the surveys carried out in 1998-2000 (Survey 1) and in 2014 (Survey 2). Urban and large and small arable fields have not been included as they were not consistent across the two surveys.

	r_s	
Species	Spring	Autumn
Wood mouse	0.66	0.31
Bank vole	0.83	0.83
LWT shrew	0.69	**0.88**
Millet's shrew	0.06	-0.04

Table 17 Spearman's rank correlation coefficients (r_s) between the rank positions of each habitat in Survey 1 and Survey 2 for each species and season. The figure in bold is significant (P,0.05).

4.0 Discussion

The aims of this survey were;

- to carry out a repeat island-wide survey of small mammals on Jersey similar to that carried out in 1998–2000
- to compare the results of both and
- to consider recommendations for the future conservation of these species.

Before considering the findings from the survey with respect to these aims, some consideration will be given to the sampling methods adopted.

4.1 Sampling methods

4.1.1 Date of sampling and effects of weather

The survey period was carried out over ten consecutive weeks in both spring and autumn and populations at different sites will not be at the same stage of the annual population cycle or subject to the same weather conditions. Weather may also be a factor affecting the activity of small mammals and their catchability (Tanton 1965, Gurnell 1976). For example, the weather was still relatively warm at the start of the autumn trapping period (18.7 degrees centigrade) compared with the end; second week of November (12.7 degrees centigrade). There was some evidence that capture rates of wood mice declined slightly with increasing temperature and rainfall, and that bank vole capture rates also declined with increasing rainfall. However, more extreme effects of temperature are unlikely to be evident due to the temperate climate on Jersey with relatively mild winters and cool summers.

4.1.2 Grid edge effects

Trapping grids are subject to an edge effect whereby some animals may move on and off the grid or have ranges that only partly overlap the study area and brings into question the effective trapping area of a grid (Gurnell & Gipps 1985, Krebs, 1999). Thus, it is expected that traps at the edge of a grid, and especially small grids, will catch relatively more animals than traps on the inside. This was found to be the case with three of the four species. The exception was Millet's shrew in the spring suggesting they either have small home ranges or they do not move far.

4.1.3 Recaptured animals

Very few new bank voles were captured at the end of the survey week. LWT shrews followed a similar pattern. This indicates that the MNA estimates of population size in these species are reasonable. However new individual wood mice were often still being captured on the last day of trapping suggesting the MNA estimates are slightly on the low side. Millet's shrews do not show any recapture rate pattern which suggests that this species may be less trappable than the other species and that the sampling programme used was less effective at catching Millet's shrews than the other species.

4.1.4 Time of capture

More wood mice were captured in the morning trap round than in the day time showing that Jersey's wood mice were also nocturnal as the literature states (Flowerdew & Tattersall, 2008). Bank voles were captured slightly more often in the day time and were generally active throughout the day and night (Shore & Hare 2008). The shrew species showed no preference

between day and night and tend to be active in 1-2 hour bouts across the 24 hours because of their high metabolic rate and need to feed frequently (Churchfield & Searle, 2008). The variation in day-night activity and time of capture supports the good practice carried out here of inspecting traps two or three times a day to minimise the time animals are confined in the traps (Gurnell & Flowerdew, 2006).

4.1.5 Multiple captures and site disturbance

Occasionally a trap had more than one animal inside, usually of the same species but with the exception of one occasion where a bank vole and lesser white-toothed shrew were in one trap. At one site (Les Landes) three bank voles were found in one trap. Green lizards were also caught at the Gorselands and Le Braye sites. Green lizards may be attracted to the traps once they have been warmed by the sun; however at the latter site the lizard was found during the early morning trap round.

Traps were disturbed by corvids at a few sites. At one site in spring approximately 90% of the traps were disturbed by corvids on the fourth day and it was decided to remove traps from the site due to the risk of exposure of animals caught in traps. This was remedied in the future by the removal of old bait from the site and by hiding the traps further into vegetation.

The urban site at Green Street Cemetery had a low trap capture rate which was likely due to the high disturbance level. Refugia were used in the cemetery to see if this revealed more animals. Ten refugia (corrugated black roofing material) were placed on site and checked once a week over the summer period. Only wood mice were observed, both juvenile and adult individuals with up to three seen in one day. Slow worms were also observed on site.

4.2 Small mammal populations

4.2.1 Population cycles

Small mammal species undergo annual cycles in which their numbers increase and decrease depending on the season, especially in more temperate climates. Wood mice tend to have autumn-winter peaks and spring-summer lows (e.g. Flowerdew 1985, Flowerdew & Tattersall, 2008). Bank vole numbers tend to increase over summer, peak in autumn-early winter and decline in late winter-spring (Alibhai & Gipps 1985, Shore & Hare 2008). Hare (2005) noted a heathland site within Les Landes on Jersey initially had low numbers of captures of bank voles, but the 2014 survey revealed a high density at Les Landes. There are few data of LWT shrews and Millet's shrews, but common shrews (*Sorex araneus*) tend to increase in summer, peaking in late summer-early autumn, then declining through to spring (Churchfield, Hollier & Brown 1995, Churchfield & Searle 2008). Shrew numbers may 'disappear' from the trappable population during very cold weather as they move deeper underground in search of their invertebrate prey (see Churchfield *et al.* 2012). This may have occurred in 2014 as less shrews were trapped in the latter part of the autumn survey when temperatures dropped.

As well as annual cycles, small mammal numbers can vary from year to year, depending, for example, on the amount of food available (e.g. Mallorie & Flowerdew 1994). Indeed year to year differences in numbers were noted in the first Jersey small mammal (1998-2000) survey and by Hall's (2001 – 2014) small mammal survey collected annually at Durrell. In some places in Europe, bank voles can exhibit multiannual cycles of 3-5 years duration (e.g. Huitu *et al.* 2004).

There are too few data to know whether multiannual cycles occur on Jersey, although Hare (2005) trapped the heathland site at Les Landes and initially trapped few animals. However, the 2014 survey revealed a high density of bank voles at Les Landes.

Trapping twice a year did not make it possible to assess the nature of annual cycles in numbers of the small mammals on Jersey, but the fact that they do must be born in mind when comparing the results from different sites within a season over the 10 week sampling periods.

4.2.2 Metapopulations

A metapopulation consists of a group of spatially separated local populations which are connected such that individuals can move between the local populations. Landscape structure can influence the dynamics of a metapopulation (Moilanen & Hanski, 1998) and small mammals are likely to function as a metapopulation across the heterogeneous habitats on the small island of Jersey. Local populations for a particular species will occupy habitat patches that vary in quality (e.g. in terms of food availability, cover, nest sites) and in both time and space (Dias, 1996). As such, good quality habitat patches at a particular time (source habitats) act as a source of small mammals to move into habitat patches poorer in quality (sink habitats). The ability of individuals to disperse between patches depends on life history traits, population dynamics, patch size, patch isolation, edge characteristics and movement corridors. Some local populations may experience extinction and recolonisation whereas the metapopulation remains relatively stable. It is these dynamics which needs to be considered when understanding the findings from the small mammal surveys on Jersey. In particular, although agriculture dominates the landscape, woodlands, dunes, heathland, urban and other habitats provide the mix of habitats within which the metapopulation can function, providing there are links to movement among them.

The results collected in 2014 reflect this and some sites are suitable for a species in both spring and autumn. Other sites are more transient in nature with a lower capture rate and there are times when some species are not present. This is typical of agricultural habitats and will depend on the season and the crop management in that field. For example a field that grows potatoes in Jersey can be harvested in spring and then sown with a grass lay which is cut in the autumn. Potato fields are often covered in plastic in the winter to aid the early spring harvest.

4.2.3 Habitats

Some sites supported a local population in both seasons and at reasonable densities e.g. Portelet heath and Le Braye coastal strip. However, some sites were “patchy” in their ability to support a species in both seasons e.g. bank voles were not captured at most woodland sites in the autumn. There was also variation between sites of the same type of habitat. For example, two of the three hedgerow sites did not have shrews present in either spring or autumn with the exception of Ville Machon. The hedgerow at St Germain only revealed LWT shrew whereas The Elms hedgerow only had Millet’s shrews. Neither of these two hedgerow had shrews in the autumn. The reasons for these disparities are not known.

There was some evidence that sites with bare ground were less preferred by shrews, especially in the spring. Wood mice numbers were also significantly correlated with tree shade and vegetation height in the spring. No other habitat associations were found and the habitat analysis was only moderately illuminating. However, the assessment of habitat attributes was somewhat cursory and the results suggest that more detailed measures of habitat attributes,

including plant species composition, at the actual time of trapping at each site would be rewarding in trying to understand environmental influences on small mammal abundance and diversity.

4.3 Small mammal populations in 2014

4.3.1 Small mammal presence across habitats

All four species were found in five of the habitat types and these are ranked in the following order:

1. dune
2. heath
3. undisturbed grassland
4. large arable field
5. hedge

Dune, heath and undisturbed grassland are considered to be semi natural sites on Jersey and generally known to have a greater variety of plant species present especially compared with arable land. Hedgerows act as movement corridors and provide food and shelter, especially mixed tree species hedgerows. Landowners are encouraged to plant species rich hedgerows rather than a one species monoculture. The 2014 hedgerows had higher small mammal species diversity than the 1998-2000 survey which maybe because the hedge contained a higher plant species richness than in 1998-2000. It is also interesting to note that one of the large arable fields (Ville Machon) had all four species present and in relatively high numbers, especially compared with the 2000 survey.

4.3.2 Small mammal presence across sites

Le Braye coastal strip was the most productive site; all four species were present in both seasons and had the highest MNA and density estimates across seasons and species and revealed all four species in both seasons. Even though five habitat types supported each of the four small mammal species, only six of the 22 sites did so:

- Le Braye Coastal Strip (dune)*[1]
- Les Blanches Banques (dune)*
- Portelet (heath)*
- Ouaisne (heath)*
- Ville Machon (large arable field)
- Ville Machon (hedge)

For example, the undisturbed grassland habitat supported all four species but neither of the two sites are listed above because individually the sites did not.

It is important to highlight that of the six sites above, three of them are SSIs (*) and another is a proposed SSI (*[1]). This means that the habitats and species present within the larger SSI are protected by Law (The Planning and Building (Jersey) Law 2002) from certain activities which may cause damage to that site. The protection of these SSIs should encourage habitat management which can help safeguard these areas of public importance and should have a positive impact on the small mammal populations.

The two sites at Ville Machon farm also showed this high species diversity. It should be noted that the hedgerow did not border the large arable field but was in close proximity to it, as it is separated by a rough heavily used driveway. This farm was a replacement for one of the 2000 survey sites. In the past some of the land has been farmed in a less intensive fashion and it appears from the diversity of shrubs that hedgerow planting has been considered with biodiversity in mind. Also during 2005 – 2009, conservation cover crops were planted on this land. The large field has been left fallow for a number of years, apart from being mown and occasionally sprayed. Further habitat analysis could infer the reason behind the relative high densities here.

Seven sites had only one or two species present, of these three were woodland sites, three were arable sites and one was urban. Woodlands generally supported higher mean numbers of wood mice but shrew numbers were low if not absent from these sites. The fourth woodland site only revealed one individual lesser white-toothed shrew. These results show that shrews do not favour woodlands as a habitat on Jersey and this may be due to food availability. Lesser white-toothed shrews have been associated with coastal habitats in the past in Jersey (Godfrey 1978), but this survey showed that several sites further inland contained this species including St Germain hedgerow.

Wood mice are generalists and appear to be ubiquitous in their choice of habitat and therefore could potentially be found across any site in Jersey (Table 10). If agricultural and urban habitats are excluded, the same could be said for bank voles when comparing both surveys but with less confidence. LWT shrews tended to be present in dune and heathland habitats, possibly favoured hedgerows and undisturbed grasslands too. The presence of Millet's shrews across all the sites was very patchy (Table 9) making it difficult to summarise habitat preferences. Nevertheless, they appear to have preferred heathland, dune and one of the undisturbed grassland sites, and were also present in two of the three hedgerow sites and one arable large field site in spring (Tables 9 and 10). They were also present in one woodland site in the autumn.

As an indicator of preferred sites, the site for each of the four species with the highest density in 2014 was:

- Wood mice - Le Braye coastal strip (dune)
- Bank vole - Jubilee hill (undisturbed grassland)
- Lesser white-toothed shrew - Ville Machon (large arable field)
- Millet’s shrew - Les Landes (heath)

4.4 Comparing the 1998-2000 and 2014 survey results

Common to both surveys is that numbers, densities and biomass of each species varied considerably through time (year, season) and according to habitat. Generally there was a lack of close synchrony in these measures of population performance. Despite understanding that pooling the results for different sites within the same habitat category can mask site differences, a comparison between population numbers has been made according to habitat-type. Excluding the rather transient and patchy nature of agricultural habitats, wood mice tended to be widespread and found in most habitats at most times. Bank voles also showed a similar pattern but seemed to prefer heathland, hedgerows and woods on a consistent basis, with autumn

peaks in undisturbed grassland in two out of the three years. Shrew population levels and habitat preferences are more difficult to summarise across both surveys as captured animals were patchily distributed and, where present, usually caught in small numbers. Dune and heathland habitats and undisturbed grassland albeit with low numbers, appeared to be most consistent in terms of the presence of both species in both surveys. Occasionally one or other species of shrew turned up in woodland and hedgerows in both surveys, but with no pattern.

To further analyse the data, comparisons of biomass were made only for sites, and their associated habitats, trapped in both 2000 and 2014 surveys and these number 13 out of 22 sites. Findings for wood mice and bank voles are consistent with those made above for woodlands, heathland, dunes, hedgerow and undisturbed grassland sites, with findings for the one common agriculturally disturbed site being patchy for both species. The dune sites were best for the two shrew species, although there were some species absences depending on site and season. LWT shrews and Millet's shrews were never caught at the agriculturally disturbed site. The two shrew species only turned up sporadically at the other sites making generalisations difficult.

There was a reasonable correlation in the rankings of the habitats for these sites used in both surveys for bank voles in spring and autumn and bank voles in the autumn. There was moderate correlation for LWT shrews and wood mice in spring, poor correlation for wood mice in the autumn and no correlation for Millet's shrews in either season. The preferences for the two rodent species are much as described before, but perhaps the most important findings are for the two shrew species. However, it should be remembered that these analyses are in the main based on small numbers of captures and therefore an increase or decrease in just one or two animals can have a marked bearing on the rankings. There is a degree of correlation with LWT shrews with dunes, heathland, undisturbed grassland and occasionally hedgerows' being moderate to good habitats. In contrast, Millet's shrews show a complete lack of any correlation in habitat preference between the surveys. The conclusion from this and the analysis on trap response is that little is understood about the dynamics of Millet's shrew populations on Jersey and indeed, whether using Longworth traps is the best way to study them. Consideration should be given to using additional survey methods such as pitfall traps and camera traps (Shore *et al.* 1995, Dizney *et al.* 2008, Caceres *et al.* 2010, Glen *et al.* 2013). It may also be worth trailing Sherman or BioEcoSS traps for effectiveness in catching shrews, indeed this latter trap type may be worth comparing alongside Longworth traps in the field for shrews.

5. Conclusions and recommendations for future studies

Fourteen years after the first island-wide survey of small mammals on Jersey in 1998-2000, wood mice, bank voles, LWT shrews and Millet's shrews were successfully re-surveyed in 2014. The surveys were carried out during spring and autumn, and involved 22 sites in nine habitat-types. Using the trapping protocols adopted here, the chance or probability of sampling a wood mouse at any of the sites in spring or autumn was 0.955. Equivalent probabilities for bank voles, LWT shrews and Millet's shrews were 0.727, 0.386 and 0.341 respectively. Overall sampling probabilities for the 1998-200 survey were: wood mice 0.932, bank voles 0.863, LWT shrews 0.205 and Millet's shrews 0.233. When considering the presence/absence of species in different sites in different seasons, these findings clearly indicate that bank voles were less widespread but shrews more widespread in 2014 compared to 1998-2000.

Agricultural habitats varied in suitability according to seasonal disturbance and cover as a result of farming operations. With respect to the other habitats, the two rodent species: wood mice and bank voles, were common and found in most habitats across the Island with bank voles showing a slight preference for two semi-natural habitat-types: dunes and heathlands. To some extent shrews appear to favour dunes, heathlands and undisturbed grasslands, but at many sites, shrews were not detected or numbers captured were low and intermittent. It is particularly difficult to understand the population dynamics of Millet's shrews on Jersey on the basis of the findings. A complicating factor may be that they were under-represented in the trapped population.

It is recommended that a strategy and action plan be developed for the long-term survey and monitoring of small mammal populations on Jersey. Surveys should be island- wide and:

- take place at regular intervals, e.g. every 4 or 8 years, or at shorter time intervals if resources permit
- use the same sampling methods to be consistent with those used in the first two surveys
- where possible, survey the same set of habitats with a core set of common sites
- take more detailed habitat inventories at sites including habitat trap point data at each trap (e.g. vegetation height, percentage bare ground) at the time of trapping. This would aim to improve the scope and quality of indicators of habitat suitability for small mammal species.
- conduct a desk-top study, assess key small mammal habitat availability (e.g. woodland, heathland, dune, grassland) and the links between them (e.g. hedgerows) across the island
- coordinate site/habitat small mammal monitoring with other types of biodiversity surveillance so that collectively they provide better indicators of site and habitat conservation value. An efficient and practical way to do this would be to involve members of the general public. Surveys for a range of key species (e.g. reptiles, amphibians, birds, bats, wild orchids, and butterflies) could be centrally coordinated for particular habitats/sites at appropriate times of the year.

In order to fill gaps in our knowledge about the dynamics of the small mammal species on Jersey, some specific studies could be carried out as separate projects:

- trap a limited number of sites at the same time at more regular intervals of say six weeks to get a better understanding of changes in numbers and synchronicity between sites
- as above but examine the metapopulation dynamics of small mammals at the landscape scale by trapping a suite of adjacent sites that might include permanent sites (e.g. heathland, woodland, dunes), corridors and edge habitats (e.g. hedgerows, field headlands) and transient habitats (e.g. agricultural land)
- trap some sites once or twice a year for several years to see whether small mammals, especially bank voles, exhibit multiannual cycles on Jersey
- investigate the ecology of shrews, especially Millet's shrews, in more detail at selected sites, including the use of pitfall and camera traps. Food sources could also be studied (e.g. Churchfield *et al.* 2012).

These studies may be short-term of the order of months, or long-term over a period of 2-3 years.

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Appendix 1 Sites

Site Name	Latitude and Longitude SE & NW corners	6 Figure Grid Ref. Centre point
Portelet	SE 49.17449, -2.184311	596 474
	NW 49.175002, -2.184756	
Ouaisne	SE 49.178278, -2.182701	597 478
	NW 49.178458, -2.183149	
The Elms – Hedgerow	Start pt 49.229784, -2.16678 End pt 49.230242, -2.166498	Start pt 608 505 End pt 608 536 St Mary no. 887
The Elms - Undisturbed field	SE 49.228937, -2.166772	608 535
	NW 49.22938, -2.16675	St Mary Field no. 819
The Elms - Disturbed field	SE 49.209573, -2.163084	608 536
	NW 49.230091,-2.166291	St Mary Field no. 824
St Peter's Quetivel	SE 49.209594, -2.162933	611 513
	NW 49.209618, -2.163422	
St Peter's Gargate	SE 49.214233, -2.172031	604 518
	NW 49.214118, -2.172595	
Jubilee Hill	SE 49.20591, -2.220531	569 508
	NW 49.206205, -2.221218	St Peter Field no. 246
Greenland*[1]	SE 49.214055, -2.197571	5855 5175
	NW 49.214335, -2.198049	St Peter Field no. 168
Les Landes	SE 49.247264, -2.246624	549 554
	NW 49.247747, -2.246752	
Water Lane	SE 49.23166, -2.21235	575 537
	NW 49.231965, -2.212699	St Ouen Field no. 692
Le Braye	SE 49.199247, -2.223696	5665 5015
	NW 49.199494, -2.224082	
Les Blanches Banques	SE 49.202153, -2.215038	573 504
	NW 49.202197, -2.215722	
Gorselands	SE 49.180972, -2.237684	5565 4810
	NW 49.181176, -2.23837	

St Germain (Hedge)	Start pt 49.227679, -2.120611	Start pt 6410 5335
	End pt 49.229662, -2.120225	End pt 6415 5360
Ville Machon - Hedgerow	Start pt 49.234174, -2.067428	Start pt 6805 5415
	End pt 49.234559, -2.068104	End pt 6795 5420
Ville Machon - Arable Field Large*[2]	SE 49.234867, -2.066183	681 542
	NW 49.23535, -2.066237	
Ville Machon - Disturbed field*[3]	SE 49.236499, -2.064982	6815 5435
	NW 49.23645, -2.065819	
Rozel Woods	SE 49.235498, -2.048717	693 543
	NW 49.235764, -2.049285	
St Catherine's Woods	SE 49.222725, -2.03905	701 529
	NW 49.223181,-2.039565	
Green Street Cemetery	SE 49.180787, -2.101347	656 482
	NW 49.181214, -2.101932	
Mount Bingham	SE 49.176673, -2.107189	651 476
	NW/Start 49.176708, -2.108273	

Table A1 The sites surveyed for small mammals. The * denotes that in Autumn these sites became; *1 Field no P80A 49.213364,-2.203038 (581 517), *2 Field no T675, 49.236039,-2.064722, (681 544), *3 Field no T683, 49.234428,-2.067833, (679 542), due to agricultural work in the original fields.

Appendix 2 Site characteristics

Habitat	Site name	Ecological SSI	Site surrounded by semi-natural habitat?	Site surrounded by improved grassland(agricultural land)?	Site surrounded by human habitation (eg housing)	% bare ground (bare grd inc leaf litter over soil and short grass <5cm)	% Shade from trees	Under 5 plant species present?	Gorse present? *Ulex europeaus*	Heather present? *Erica cinerea/ Calluna vulgaris*	Bracken present? *Pteridium aquilinum*	Bramble present? *Rubus spp*	Grasses present? *Poaceae spp.*	Agricultural single crop?	Fruit bearing trees present? (excluding bramble)	Mean height of vegetation based on four points (cm)	Dwelling within 100m of site?	Main road (30- 40mph) within 100m or site?
Heathland	Portelet	1	1	0	0	10	0	0	1	1	1	1	1	0	1	68.8	0	0
	Ouaisne	1	1	0	0	30	10	0	1	1	1	1	1	0	0	72.5	0	0
	Gorselands	1	1	0	0	50	0	0	1	1	1	1	1	0	0	52.5	1	1
	Les Landes	1	1	0	0	50	0	0	1	1	1	1	1	0	0	37.5	0	0
Dune	Le Braye	0	1	0	0	10	0	0	0	0	1	0	1	0	0	42.5	1	1
	Les Blanche Banque	1	1	0	0	0	0	0	1	0	1	0	1	0	0	42.5	0	1
Woodland	St Catherine's Woods	0	1	0	0	70	80	0	0	0	1	1	0	0	1	1755	0	0
	Rozel Woods	0	1	0	0	50	95	0	0	0	1	1	1	0	1	2500	0	1
	St Peter's Gargate	0	1	0	0	25	90	0	0	0	1	1	1	0	1	1900	0	0
	St Peter's Quetivel	0	1	0	0	25	80	0	0	0	1	1	0	0	1	1880	1	1
Undisturbed grassland	Jubilee Hill	0	1	0	0	0	0	0	0	0	1	0	1	0	0	17.5	0	1
	The Elms undist	0	0	1	0	0	0	0	0	0	0	0	1	0	0	33.8	1	1
Hedgerow	Villen Machon hedge	0	0	1	0	0	40	0	0	0	1	1	1	0	1	788	1	1
	St Germain	0	0	1	0	10	50	0	1	0	1	1	1	0	1	1088	1	1
	The Elms hedge	0	0	1	0	30	40	0	0	0	1	1	1	0	1	313	1	1
Arable large field	Water Lane	0	0	1	0	0	0	1	0	0	0	0	1	0	0	42.5	1	0
	Ville Machon arable/changed	0	0	0	0	0	0	0	0	0	0	0	1	0	0	42.5	1	1
Arable small field	Greenland/P80A	0	0	1	0	20	0	1	0	0	0	0	0	1	0	25	1	0
Arable disturbed field	The Elms dist	0	0	1	0	100	0	1	0	0	0	0	0	1	0	0	1	1
	Ville Machon dist	0	0	1	0	20	0	1	0	0	0	0	1	1	0	25	0	1
Urban	Green Street Cemetery	0	0	0	1	20	40	0	0	0	1	1	1	0	1	300	1	1
	Mount Bingham	0	0	1	1	50	25	0	1	0	1	1	1	0	1	188	1	1

Table A2 Site characteristics (1 = present, 0 = absent)

Using mean site values of attributes for habitat types, a Principal Component Analysis based on a Spearman correlation matrix of the vegetation attributes has been used to visualise the correlations between the variables and habitats in two dimensional space (Figure 5). The first two Components account for ~79% of variation in the data. The attributes that contribute to each Component are shown in Table 5. Component 1 is defined by shade, >5 plant species, presence of bracken, bramble, fruit bearing trees and height of vegetation. Component 2 is defined by presence of bare ground to grasses. Together these account for the position of the habitats within the two-dimensional space (Figure 5). These findings seem reasonably consistent with the exception of the >5 plant species measure, which is difficult to interpret.

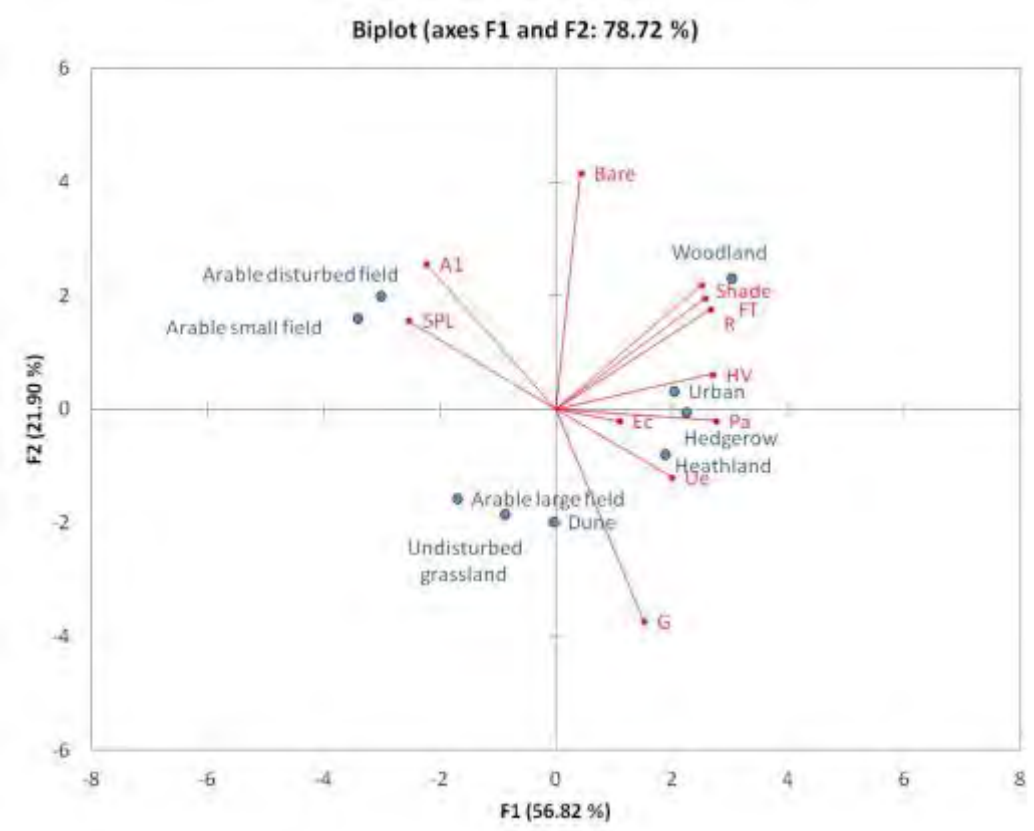

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Figure A1 A biplot of habitats and their attributes

Code	Attribute	% contribution F1	F2
Bare	% bare ground	0.3	32.1
Shade	% Shade from trees	11.5	8.9
5PL	Over 5 plant species present? (Y/N)	12.1	4.6
Ue	Gorse present? (Y/N)	7.3	2.6
Ec	Heather present? (Y/N)	2.2	0.1
Pa	Bracken present? (Y/N)	14.0	0.1
R	Bramble present? (Y/N)	13.1	5.8
G	Grasses present? (Y/N)	4.2	25.8
A1	Agricultural single crop? (Y/N)	9.4	12.3
FT	Fruit bearing trees present? (Y/N)	12.2	7.1
HV	Height of vegetation	13.5	0.7

TableA3 Per cent contribution of habitat attributes to the first two principal components

Appendix 3 Biomass

	Wood mouse		Bank vole		LWT shrew		Millet's shrew	
Site	S	A	S	A	S	A	S	A
The Elms arable disturbed	25	212	0	0	0	0	0	0
Ville Machon arable disturbed	25	38	31	0	0	0	23	0
St Germain arable hedgerow	271	324	339	318	31	0	0	0
The Elms arable hedgerow	314	255	126	357	0	6	8	0
Ville Machon arable hedgerow	159	125	70	358	17	0	75	33
Le Braye Coastal strip dune	311	729	182	547	54	54	9	16
Les Blances Banques dune	131	140	0	50	22	18	8	14
Gorselands heath	179	96	159	457	8.5	0	0	0
Les Landes heath	51	177	379	858	0	0	135	9
Ouainse heath	348	201	23	245	11	7	10	0
Portelet heath	431	122	572	599	30	38	0	8.1
Water Lane arable large field	108	0	60	0	0	0	0	0
Ville Machon large field	303	0	108	0	91	0	8	0
Greenland arable small field	25.3	134	0	341	0	0	0	0
Green Street Cemetery urban	29	75	0	0	0	0	0	0
Mount Bingham urban	511	153	102	475	0	3	0	0
Jubilee Hill undisturbed grassland	160	342	256	1004	8	17	0	0
The Elms undisturbed grassland	203	185	33	952	0	0	9	9
Rozel woods	493	116	121	0	0	0	0	0
St Catherine woods	269	207	280	133	0	0	0	0
St Peter Gargate woods	526	97	61.8	0	0	0	0	0
St Peter Quetivel woods	263	219	188	0	0	6	0	0

Table A4 Population biomass (g) for each species at each site in spring (S) and autumn (A).Red numbers - mean individual weight for each species/ season inserted for animals captured but not weighed (using an average weight value for the species).

Appendix 4 Aerial view and photographs of trapping sites 2014

Heath

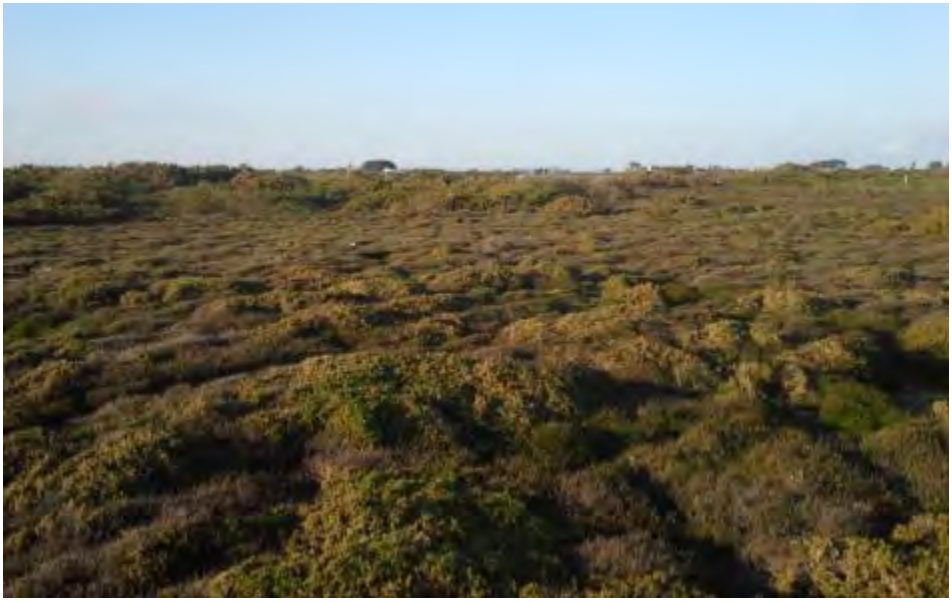
Picture 1a Portelet – aerial view

Picture 1b Portelet

Picture 2a Ouaisne – aerial view

Picture 2b Ouaisne

Picture 3a Les Landes – aerial view



Picture 3b Les Landes

Picture 4a Gorselands – aerial view

Picture 4b Gorselands

Woodland

Picture 5a St Catherine's Woods – aerial view

Picture 5b St Catherine's woods

Picture 6a Rozel Woods – aerial view

Picture 6b Rozel Woods

Picture 7a St Peter Quetivel – aerial view

Picture 7b St Peter Quetivel

Picture 8a St Peter Gargate – aerial view

Picture 8b St Peter Gargate

Dune

Picture 9a Les Blanches Banques – aerial view

Picture 9b Les Blanches Banques

Picture 10a Le Braye Coastal strip – aerial view

Picture 10b Le Braye Coastal strip

Undisturbed grassland

Picture 11a Jubilee Hill – aerial view

Picture 11b Jubilee Hill

Picture 12a The Elms – aerial view showing the three sites (southernmost site is the undisturbed grassland)

Picture 12b The Elms

Hedgerow

Aerial view of The Elms see picture 12a

Picture 13a The Elms (other half of hedge was younger hawthorn)

Picture 14a St Germain – aerial view

Picture 14b St Germain (alongside left and in distance)

Picture 15a Ville Machon showing all three sites – aerial view

Picture 15b Ville Machon (other half of hedge was younger hawthorn with grasses at ground level)

Large arable field

See Picture 15a for Ville Machon aerial view

Picture 16a Ville Machon large field (spring)

Picture 16b Ville Machon (autumn replicated site due to farm work)

Picture 17a Water Lane – aerial view

Picture 17b Water Lane

Disturbed field

See Picture 12a for The Elms aerial view

Picture 18a The Elms (traps were covered with straw and bark chip for protection)

See picture 15a for Ville Machon aerial view

Picture 19a Ville Machon (with hawthorn hedge on left) Had been potatoes in spring.

Small arable field

Picture 20a Greenland (spring location)

Picture 20b Greenland (autumn location)

Picture 20c Greenland (P80A in autumn – field was potatoes in spring)

Urban

Picture 21a Green Street Cemetery – aerial view

Picture 21b Green Street Cemetery

Picture 22a Mount Bingham – aerial view

Picture 22b Mount Bingham 1

Picture 22c Mount Bingham 2