The **Kent Harvest Mouse Survey 2015-2020**

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HERITAGE FUND

Wildwood

Kent & Medway Biological Records Centre

Kent Mammal Group

The endeavour of this survey and this report are dedicated to Ken West without whom it would not have been possible.

The Kent Harvest Mouse Survey 2015-2020

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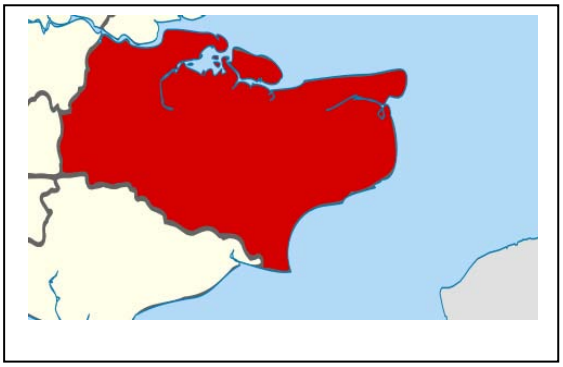
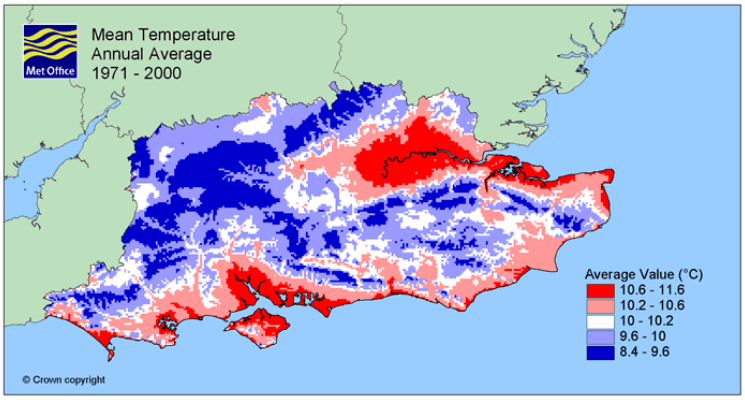
1 Introduction

1.1 Geography, Geology and Climate of Kent

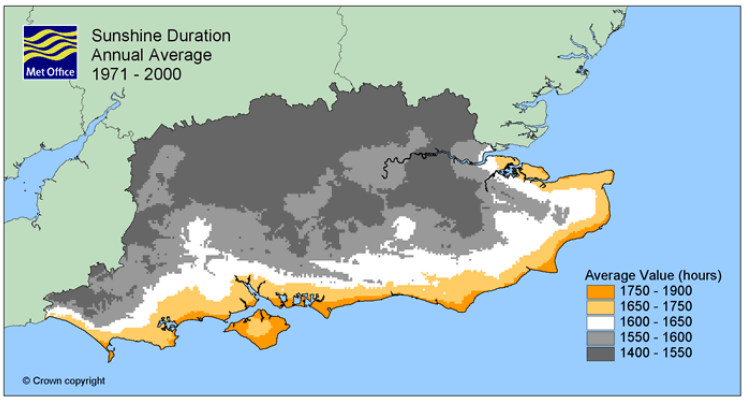


Kent is England's most south-eastern county. It is surrounded by sea on three sides. The Thames and Medway Estuaries converge to the north, flowing eastwards into the North Sea. East of the Isle of Sheppey the north and east Kent coasts face directly onto the North Sea, which extends southwards to the pinch-point of the Straits of Dover, its confluence with the English Channel. The county has over 563km of coastline, one of the longest in Britain [1]. The foreshore of the Halstow Marshes on the Thames Estuary, Latitude 51°29'13.7580", is Kent's most northerly point, while Dungeness, at Latitude 50°54'41.7024" is its most southerly. The county is bounded between Longitude 000°01'59.8111", the Kent Brook, near Edenbridge in the west, and 001°26'58.1539", with its easternmost extremity at North Foreland, Broadstairs. Landward it borders Greater London, Surrey and East Sussex. It is the nearest part of the British Isles to continental Europe, being 32 kilometres distant at its closest point [2].



Southeast England average temperature. Kent is on the right.

Kent is part of Southern England, one of eleven Met Office regional UK climate areas. The proximity to the European landmass is often responsible for a more 'continental', less 'maritime' influenced climate; that is to say with cold spells in winter and hot, humid summer weather. The county's position in the south-east corner of the country also means that it is furthest from the paths of most Atlantic depressions bringing clouds, wind and rain, so the climate is less mobile compared to other areas of Britain [3]. During January, the coldest month, mean daily minimum temperatures vary from over 3 °C in London and along the coast to about 0.5 °C over the higher ground. Extreme minima usually occur in December or January. Ground frost occurs on average less than 60 days per annum in areas bordering the Thames Estuary and near the South Coast, increasing to more than 110 a year over the higher ground.



Southeast England average sunshine. Kent is on the right.

In July, the warmest month, the mean daily maximum temperatures towards London of 23.5°C , are the highest in the UK; Gravesend and Faversham in north Kent have held record daytime temperatures of over 38°C, at various times in the last few decades.

Annual sunshine averages are typically 1550-1600 hours across most of the region but with a decrease towards the north that is more marked inland. The south coast can exceed those figures by an additional 200 hours, or more.

Climate maps © Crown copyright, Met Office

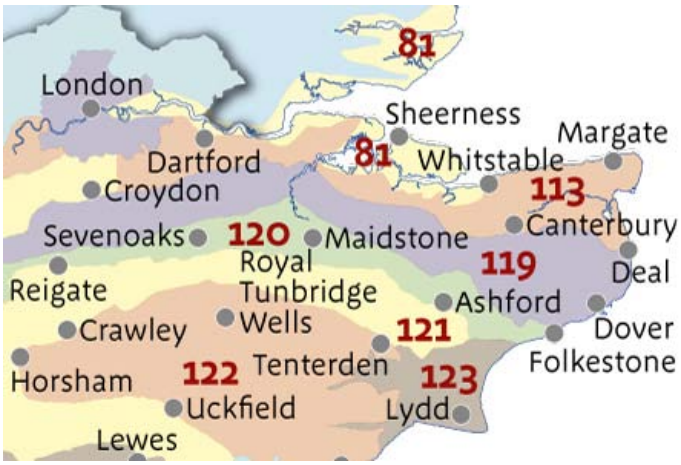
1.2 National Character Areas

National Character Areas (NCAs), as defined and revised by Natural England as part of their responsibilities under the Natural Environment White Paper, Biodiversity 2020 and the European Landscape Convention provide an excellent framework for conservation initiatives at a landscape scale. NCAs are natural subdivisions of England based on a combination of landscape, geology, settlement, development, agricultural and other land use activity that follow natural lines in the landscape. There are 159 National Character Areas that share similar landscape characteristics and Kent comprises seven. One advantage of using NCAs is that where they cross administrative boundaries (e.g. neighbouring counties) any outcomes they provide within one county may continue to hold true and inform decision-making in the adjacent one(s).

1.2 a Location and extent of NCAs in Kent

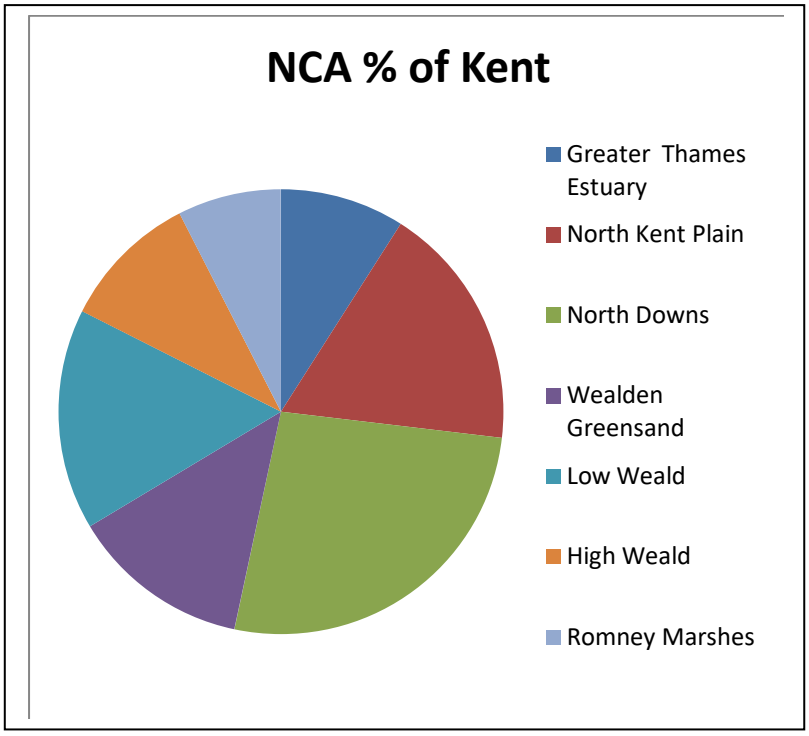
Kent's seven National Character Areas run in curving strips, broadly west to east across the county, each touching only its neighbouring NCA to the north and south until the Wealden sequence reaches the old Saxon shore line. At this point the Wealden Greensand, Low Weald and High Weald all abut the reclaimed land of the Romney Marshes.

From north to south, Kent's National Character Areas are:



Kent's National Character Areas

81 The **Greater Thames Estuary**, which comprises a narrow irregular strip west of Whitstable, containing the North Kent Marshes, Hoo Peninsula, Isle of Sheppey and the Gravesend and Dartford Marshes. Within Kent it covers an area of roughly 320km^2, but beyond the county borders it also extends into East London and Essex, as far as Suffolk. The larger urban areas of Faversham, Sittingbourne, Medway, Gravesend and Dartford straddle this NCA, all of which actually extend to a greater extent into the adjacent North Kent Plain, so that overall this, the smallest of Kent's NCAs is only about 7% developed.



113 The **North Kent Plain,** NCA is sandwiched between the Greater Thames Estuary to the north and the chalk hills of the North Downs NCA to the south. It gains its own coastline from Whitstable eastwards and this extends southwards around North Foreland, the county's most easterly extremity, as far as Deal. It is the second largest natural division of Kent, covering an area of approximately 632km^2, but it also contains some of the county's largest conurbations. The towns of Gillingham, Sittingbourne, Gravesend, Dartford, Whitstable and Herne Bay, the Thanet developments and the city of Canterbury occupy around 88km^2. Overall, about 14% of the area is urbanised or developed.

119 The **North Downs**, encompassing around 936km^2, is Kent's largest NCA. It extends in an ever narrowing band from the celebrated White Cliffs of Dover in the east and south, to Godalming, across the border in Surrey to the

west. It is a range of undulating chalk hills whose dip slope eases gently into the North Kent Plain, while the scarp steps abruptly down onto the Wealden Greensand to the south. Within Kent, the North Downs are cut through by the valleys of the Rivers Stour, Medway and Darent. Major urbanisation has occurred around the Medway valley and estuary area, as well as the important port of Dover, though overall only about 4 % of this NCA's total land area has been developed. The highest part of Kent is in the west at around 250 metres above sea level [4].

120 The **Wealden Greensand** NCA curves along the foot of the North Downs and continues westwards through the county of Surrey to Hampshire before turning southwards and doubling back on itself in West Sussex. This is because it forms the outer rim of an ancient (Lower Cretaceous) topographical basin – formerly a dome known as an anticline, that now through erosion reveals concentric bands of geological features, collectively known as the Weald. Of modest expanse in Kent, it covers approximately 464km^2, of which roughly 64km^2 or 13.7% are densely urban, being occupied by the likes of Folkestone, Maidstone and lower Medway and Sevenoaks. Communication corridors such as the M26, M25 and M20 motorways and railway lines including the Channel Tunnel Rail Link (High Speed 1) score the landscape, potentially isolating ecosystems from each other. Two small rivers rise on the Greensand ridge – the Upper Great Stour and the East Stour – and soon combine to form the Great Stour, east Kent's most important river.

121 South of the Wealden Greensand, at the foot of the modest scarp slope of the Greensand Ridge, the **Low Weald** NCA begins. This is an inner concentric band of the Wealden basin and so connects beyond Kent's borders into Surrey, and West and East Sussex. Within the county it has an expanse of around 568km^2 and extends from west to east in a strip that terminates at the Greensand cliffs overlooking Romney Marsh that represented the shoreline in Saxon times. It is predominantly rural with scattered larger small towns and just a part of Tonbridge contributing to the 0.7% overall development of this area.

122 A relatively small portion of the **High Weald** NCA, the inner ring, or core of the Wealden basin, encroaches into Kent. A band, covering roughly 356km^2, runs from the southwest corner of the county to the edge of the Romney Marshes in the south and the east. The majority of this NCA is in neighbouring East and West Sussex. Settlement is dispersed and the main conurbation is Tunbridge Wells and part of adjoining Tonbridge, accounting for about 5% development of this NCA within Kent.

123 The **Romney Marshes** NCA on the other hand is a predominantly Kentish-based landscape that, with an unwavering character, encroaches into East Sussex across the Kent Ditch boundary as far as Fairlight, near Hastings and along a few river plains that tongue into the surrounding High Weald. It is sparsely settled and little developed (>1% within Kent) but intensively farmed. The low-lying reclaimed land is largely below sea level and is criss-crossed with drainage channels, known locally as sewers. The long straight roads are often raised above the surrounding countryside and in some cases are built upon old sea walls.

The total area of Kent is 3544km^2 within the current administrative boundary [5].

1.3 The Harvest Mouse historically in Kent

Just 12 records (7 East Kent, 5 West Kent) were returned for the county as part of the baseline national survey conducted by Stephen Harris of the Mammal Society from 1973-1977, (published 1979) [6]. It is likely that these originated from E. G. Philp, County Recorder at the time, and correspond with records for Kent on the NBN Gateway by Philp that pre-date or were concurrent with the national survey period. There are also 2 records for Kent from the survey by Harris, himself.

In the Kent database [7] there are 263 harvest mouse records dating from 1961-2013, in tetrads that incorporate at least part of Kent. Those entirely in East Sussex were rejected from the total. Those records are scattered over 141 tetrads, out of 1004 within the current administrative boundaries or 1100 using the old vice-county boundary, much of which is now incorporated into Greater London.

Harvest mice have been recorded in fewer than 100 tetrads in the last 25 years. Nature reserves have provided evidence of continued presence over a span of years, e.g. RSPB Dungeness; RSPB Northward Hill; RSPB and KWT Oare Marshes; KWT Sevenoaks Wildfowl Reserve; the National Nature Reserve of Shellness, Isle of Sheppey and former NNR Elmley, now a private reserve.

In the 30 year period 1961-1999 a wide spread of records covered 66 tetrads. Harvest mice have been recorded in 83 tetrads since the turn of the millennium, largely as a result of the Kent Mammal Group and its activities. Harvest Mice are occasionally trapped as part of the KMG's Small Mammal Survey and their remains discovered during Barn Owl pellet analysis. The Kent Mammal Group provided early training in harvest mouse nest recognition and survey techniques from about 2006.

During this period some national harvest mouse researchers suggested that attention should shift to road verges, which had been largely overlooked prior to this [8]. This, and our experience within the county, has ultimately influenced the framework of our survey.

1.4 Biological and ecological requirements of the Harvest Mouse

This has been well summarised in many publications and is intended here to provide context for the survey rationale and perspective.

The harvest mouse has several physical adaptations for life in the stalk zone, an ephemeral environmental niche, composed of grasses and herbaceous vegetation that fluctuates annually in height, density, flexibility, structural integrity and availability. This suggests that the harvest mouse is a specialist, and thereby dependent on this niche. In reality it does seem to exhibit some flexibility, however, perhaps partly as a requirement of utilising this habitat, which comes and goes on a more or less regular cycle, and which yields in the long-term to succession. A light body weight – adults are typically just 6g – and small size are obviously helpful for scaling grass stems without them bending or breaking. However, it is the tendon-locking mechanism in the toes [Haffner, M. 1998], a degree of separation in the outer toes [Trout RC & Harris S. 2008] and a semi-prehensile tail that enable the mouse to move through this milieu with ease.

A wide range of both wet and dry grassy habitats are selected for locating breeding nests. These include crop margins, some crops, unmowed meadows, reedbeds, rushes, grassy hedgerows, ditches, grassy bramble patches, farm woodland plantations etc. [Bence, 1999; Dillon &Brown, 1975; Johnson, 1977; Harris, 1979] and to a far lesser extent than historically, cereal fields. Prior to some of the more recent surveys, such as those by Dobson and Meek, the harvest mouse was thought to occur only occasionally in rough road verges [Dickman, 1986; Harris, 1979; Trout, 1978 A Review]but a shift in the focus of searches suggests that it may be more common in this habitat than previously thought. Another reason that the mouse is wedded to these grassy habitats is because of the manner in which it constructs its nests, which are, by and large, over 30cm off the ground and which remain attached to the living grass by the very leaves from which they are woven. Grass leaves have parallel veins and this enables the harvest mouse to split the terminal ends into multiple fine threads that can be woven into the fabric of the nest while the base stays intact and securely attached to the stems. These nests can persist long after use [Dobson, 2008; Riordan, Lloyd & Macdonald, 2009], and thus formed the basis for our survey.

The breeding season starts in May ends December depending on weather [Trout, 1978 A Review], though in captivity and in sheltered habitats, such as hay ricks, it can begin in April. 74% litters found in August- September in one survey [Harris, 1979]. Cold, wet weather may cause high mortality to litters of young during the late autumn period [Sleptsov, MM. 1948]. Adult mice can succumb to persistent rain, sudden temperature drops and hard frosts [Sleptsov, MM. 1948.] One study indicates an annual 'boom and bust' cycle where the population builds rapidly over the summer-autumn period and then declines steeply through winter to spring, with February being the period of highest mortality in Britain [Trout, 1978 A Review]. In addition nest numbers fluctuate from year to year and may be hard to find in some years more than others; sometimes as often as two out of every three [Harris, 1979; Lloyd and Kirk, 2020, in prep.].

In winter the harvest mouse remains active and does not hibernate. Because of the fragile nature of herbaceous vegetation it appears to abandon the stalk zone as vegetation dies back and use the runway systems of other small mammals, though a great deal of habitat may survive the vicissitudes of the winter where this may not become necessary. During this die-back period from October to the end of March the disused nests from the summer breeding period may become exposed. Autumn/winter quarters, not used for breeding, are built on grass tussocks, in sedges and in secure places, lower down than in summer. These may also be found with relative ease at this time.

Wild food preferences are incompletely known but the remains of insects, seeds, fruit, leaves, fungi, moss and roots have been identified from wild faecal pellet analysis [Dickman, 1986]. It is likely to vary with the season as a seed-based diet is not available all year.

1.5 The Status of the Harvest Mouse

The harvest mouse is classified in the IUCN red list as near threatened (NT) in England, vulnerable (VU) in Wales and critical (CR) in Scotland. The species currently enjoys no legal protection in Britain or Europe.

Knowledge about the status, distribution and habitat preferences of the harvest mouse in the UK is founded on the Mammal Society's 1979 national survey that effectively established a baseline for the species' presence in Britain. It has since been used to extrapolate historical status and formed the basis for a re-survey in 1996. The latter appeared to find a significant decline and rang alarm bells that have resonated ever since, despite the 1996 survey results not being widely accepted [Tubney House, 2008]. However sufficient uncertainty remains about the harvest mouse's overall security of tenure meant that a Biodiversity Action Plan (BAP) was drawn up for it in 2007 and more recently, under Section 41 (England) and Section 42 (Wales) of the Natural Environment and Rural Communities (NERC) Act (2006) it was designated as a species of principal importance (SPI) for increasing biodiversity and therefore has to be taken into account by any public body to this end. In Kent, the species is rarely accounted for in environmental surveys prior to development taking place.

1.5 Project Aims:

Given the widely disjunct nature both in space and time of Kent's historical records, our aim was to determine the presence or absence of the harvest mouse across the county, and in doing so discover continuity of spread, as well as the mouse's landscape use and habitat preferences in the wider countryside. By discovering the mouse in novel areas we will garner a sense of whether the species' presence is robust, threatened or in need of reintroduction. This survey will establish an effective baseline with which to raise awareness of the mouse's presence so that it may be incorporated into landscape and reserve management plans, environmental reports and be accounted for across the county wherever development may occur or its habitat be threatened.

2 Methodology

2.1 Training of Volunteers

Volunteers were recruited from a wide demographic spectrum across Kent, with ages ranging from 8 to 80s. Minors were accompanied by adults to training sessions (and if they wished to survey later, were required to do so under parental supervision). Wildwood Trust, near Herne Bay, provided the venue for two to four training sessions each season, while a range of other venues were used over the five years to that ensure local populations were given every opportunity to participate. Eight to ten sessions per season were arranged in order to reach our desired target of 600 volunteers.

A typical training session would include a presentation incorporating the following:

- Introduction to the project
- Introduction to the harvest mouse and its ecology
- Examples of nests and habitats
- The equipment needed for the survey
- The survey methodology
- How to use the nest recording sheet
- How to use the habitat recording sheet
- An explanation of tetrads
- How to record a grid reference with a map or app

The interactive part would include the following:

- Nest samples to handle – some attached to grass, others loose
- Some less common examples e.g. thistledown nests, modified birds' nests
- Comparative samples – dormouse nests
- An opportunity to see harvest mice in the captive breeding area

The afternoon session was straightforward:

- A short drive to suitable habitat nearby
- A search for nests using the techniques described in the morning
- Actual experience of finding nests in the field

The final part comprised:

- Allocation of tetrads and transects to the surveyors (printed Magic Maps with transects marked)
- Completion of evaluation forms

2.1a Tetrads – rationale

Hectads (10km X 10km grid squares) are used for mapping and conveying distribution on a national scale. Just one specimen of the target species within that 100km^2 area constitutes a record. However, at a county level a hectad is a blunt instrument for recording something as small as an undersized mouse.

Tetrads are grid squares measuring 2km X 2km, a natural subdivision of a 1:25000 Ordnance Survey map, using the even numbers, and are equal to an area of 4km^2. Kent (including Medway despite administrative separation) comprises 1004 of these, both whole and partial, within the present county boundary. Tetrads are a standard biological recording quadrat for many of the more mobile species.

Within lowland England, in the majority of cases a tetrad is likely to incorporate at least some habitat that could support harvest mice even in largely built-up areas, (whereas many more 1km squares will not). By setting a target that all the larger divisions - hectads - should be broached, however, we ensured that we maximised the spread of the survey effort.

Although harvest mice may be site-faithful, they also may be inexplicably absent from suitable (and previously occupied) habitat in some years but be present elsewhere in the neighbourhood, within a particular tetrad. Although harvest mice do not appear to range far within their environment, given the ephemeral nature of many of their habitats, harvest mice must be relatively mobile to follow them as the grassy areas, including crops, disappear seasonally or for other reasons and may reappear in another location.

In terms of ease of surveying a tetrad is well within most people's capacity to walk, and a person's local 'patch' may be this sort of size, given that over time people like to vary their regular walking routes.

2.1b Tetrad and Transect Allocation:

The surveyor's postcode provided a randomised starting point. From there Google maps/Earth satellite imagery was used to find arable fields, or other appropriate habitats. For road verges it was possible to use Google street view to visually assess habitat quality. More recently, popular walking and cycling routes provide numerous points with 360 degree imagery where search viability can be determined. Roads and public footpaths act as convenient transects. Publicly accessible land was mostly used, in order to remove need for landowner's permission. Some difficulties arise if the online imagery has been in gathered in March, when everywhere is at its bleakest and most cut back, a world away from summer or even how much habitat remains in autumn. In this situation a determination is made by the project leader based on his experience.

A suggested route was then marked on a Magic Map, printed as a pdf and a copy sent to, or handed to a surveyor, or both. Transect lengths varied because every tetrad has a different degree of suitability and accessibility. A habitat was deemed unsuitable by lack of key features. Where requested, surveyors applied their own local knowledge to determine their search route.

Data collecting:

Paper and/or electronic data recording sheets were provided. Communication was via Facebook or email, and was available in real time.

Verification:

Users were able to upload photos to Facebook or send via email in order to check identification.

Self evaluation programme

Evaluation forms enabled us to fine tune the presentation and format of the day and evaluate the effectiveness our presentation and training methodology.

Coverage

Although it was unrealistic to expect to survey 1100 tetrads and we concentrated on the 1004 within Kent currently, to achieve our demographic target commitments we were obliged to create opportunities for people to participate right across Kent without exception, rather than simply reach as far as it was convenient for us. This ensured a wide and random spread.

Survey participation:

The vast majority of records came via surveyors that were newly trained amateurs, operating on their own, in pairs, or in small family groups. Contact with an experienced surveyor was available remotely through mobile phones and tablets.

As time progressed a number of additional methods were employed to increase the reach of the survey. So-called 'Nest Fests' were organised, in partnership with the Kent Mammal Group. A group of people would commit to meet up in the location and were led by an experienced surveyor or surveyors over suitable habitat that crossed into several tetrads. Then the best part of a day was spent gaining field experience and adding records.

'Family Harvest Mouse Hunts' were organised through Wildwood in a family-friendly location and children were welcome to join in. Harvest mouse nests were found.

With some groups it was necessary to provide in-the-field 'Walking Workshops', where the outdoor survey training was supplemented with information about harvest mouse ecology as no classroom-based presentation was possible.

Numerous surveys were carried out by the project leader in his leisure time and are included in the results. These were not recorded as work days, and were not remunerated.

Partnerships:

Kent universities and colleges Canterbury Christ Church University, Greenwich University and Hadlow College requested training and field experience for their students during the survey lifetime. On several occasions, the field trip element was used to survey an unrecorded tetrad with success, including finds of harvest mouse nests close to Canterbury city centre, an unusually urban situation. Some of these institutions also initiated field surveys with their students in their own time and provided additional records.

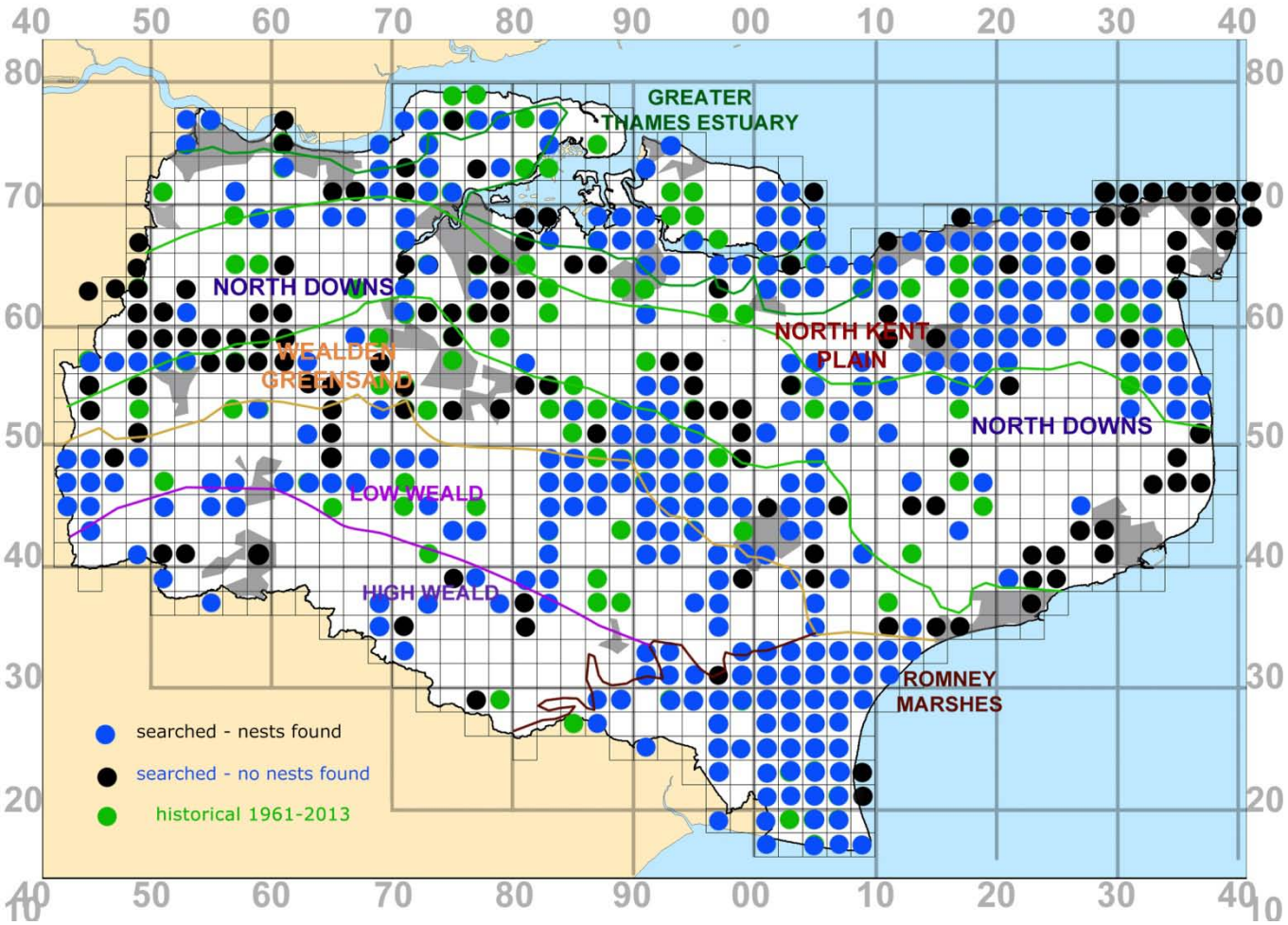
Pre-existing volunteer groups contributed to the pool of available potential surveyors, widening the spread and generating partnerships. Training these groups involved visiting new sites and afterwards, enthused individuals would often survey their own locality. Partnership organisations include; RSPB, Kent Wildlife Trust, Plantlife (Ranscombe Farm Study Group), Capstone Country Park (Tonbridge & Malling District Council), Sandwich Bay Bird Observatory, Dover White Cliffs Countryside Project, Medway Valley Countryside Partnership, Leybourne Lakes Country Parks, Kent High Weald Partnership, Riversearch Edenbridge, 'Our Stour' River Wardens, Oare Gunpowder Works, The Conservation Volunteers, Environment Agency and Kent Field Club.

3 Results

3.1 Broad results

The map below shows harvest mouse distribution at a tetrad level, not individual nest finds or records, and without landscape features. The minimum record per tetrad is one.

It appears that harvest mice have a number of potential strongholds in Kent, particularly in the low-lying, coastal and marshy areas such as along the north coast, including the Isle of Sheppey. In addition they are well-established in the Wantsum Channel (a broad diagonal strip of low-lying land separating the Isle of Thanet as the 'nose' of Kent) and Romney Marshes, where suitable habitat can be abundant with good connectivity and where, with additional management awareness, they would potentially thrive, as on the extensive RSPB reserves along with the other abundant wildlife such as birds, hares and water voles, and also in the adjacent countryside. These areas also link with and provide access to the wider countryside through a network of rivers and streams that flow though the rich agricultural land, where there is an apparent association with arable fields and narrow linear habitats, such as their margins and adjacent road verges. Harvest Mice appear to be absent from Thanet and are scattered and local along the North Downs; both are well-drained chalky areas. In the rolling High Weald, to the west and south of Kent harvest mice are present but much harder to find in the densely wooded, largely pastoral landscape, as suitable habitat patches are correspondingly smaller.



3.1a Number of nests and tetrads

A total of 1005 nests were discovered during the survey, in a variety of habitats.

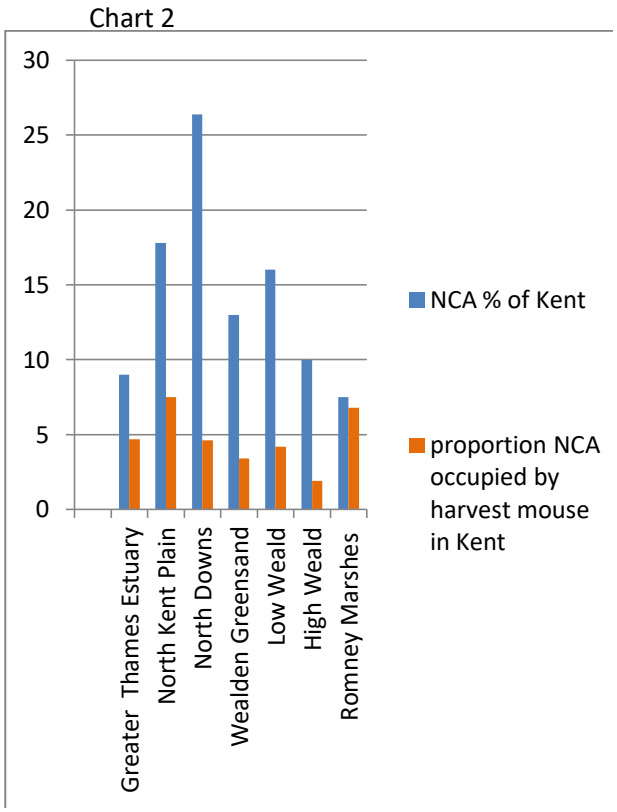
Harvest mice or their nests were found in 304 tetrads, covering 30% of the county. Some of these tetrads previously held records prior to 2013, dating back as far as 1962. Of the historical records that were randomly re-surveyed, 56 out of 72 (78%) still contained harvest mice, though not necessarily where they were originally recorded from, and 16 (22%) were searched but no evidence found. In our opinion, real losses are likely to account for only a small proportion of this, most notably around some of the larger urban areas (e.g. Maidstone). The remaining historical records – some relatively recent – when added to the map, increase harvest mouse presence to 36% of the county. However, if it is reasonable to assume that if re-surveyed, they would follow a similar ratio of 78%, it would reduce the overall count of positive tetrads to 35%.

3.1b Negative tetrads

Factors such as timing of search, access to suitable habitat from public land and recorder effort or ability, likely led to nests being missed. Some habitat was perfect but no nests were found. Some tetrads were/are composed of largely unsuitable habitat and produced nil returns. Searches during our first 'official' survey year were particularly problematic and appear to reflect an intermittent decrease in harvest mouse numbers that was clearly widespread across Kent. Overall there were 155 negative tetrads. 48% of the countryside within the current Kent and Medway administrative areas did not get surveyed.

3.1c Results by National Character Area

The two smallest NCAs in Kent, the Greater Thames Estuary and Romney Marshes yielded high results in terms of the number of tetrads with positive records, and the proportion of the overall number of tetrads that comprised these areas as shown in Chart 2.



The boundaries of National Character Areas are irregular and so may only be incorporated into part of a tetrad. As the area of each tetrad is 4km^2, rather than count and combine partial tetrads the overall area of the NCA was divided by 4 to give a tetrad coverage equivalent.

The table below gives an indication of how harvest mice are distributed by tetrad in each NCA. For example, the Greater Thames Estuary, an area in total of 836.75km^2, the bulk of which is in Greater London and Essex (and may include tidal mudflats in the area calculation) is estimated to be around 320km^2 in Kent, which is equivalent to 80 tetrads. Over half of these (42) had harvest mice in them (52.5%). This only a small proportion of Kent, but may have implications for harvest mouse use of the landscape on the other side of the river. Every NCA in Kent extends into at least one neighbouring county and if distribution patterns hold true they may prove helpful in future surveys and monitoring.

Note that the total number of tetrads divided between the NCAs (column 7) the total (308) comes to more than the actual number of tetrads recorded (303). Some tetrads are clearly in one NCA at one extremity and in a different one at another. Tetrad 14, straddling the A20 at Lenham, had 6 records that were on the North Downs and 5 on the Wealden Greensand, hence this tetrad is assigned two NCAs. This also applies to Tetrad 186 where 3 nests were found on the A 226 running through the North Kent Plain in the southern portion of this tetrad and a nest was found in Shorne Marshes, part of the Greater Thames Estuary, in the northern 1km square. The overlap means that the same tetrad is counted in 2 NCAs. Other transitional tetrads with records in both NCAs are 46

(High and Low Weald); 130 (North Kent Plain to North Downs); 189 (North Kent Plain to North Downs). (See Appendices).

NCA no.	NCA name	Kent area equivalent in tetrads (area divided by 4)	Kent area in km^2 (estimated)	NCA total area	No. of harvest mouse records	Number of positive tetrads	= % of Kent's NCA	NCA extends into
81	**Greater Thames Estuary**	**80**	**320**	**836.75**	**144**	**42**	**52.5**	**Greater London, Essex**
113	**North Kent Plain**	**158**	**632**	**848**	**237**	**67**	**42.4**	**Greater London**
119	**North Downs**	**234**	**936**	**1374.5**	**102**	**41**	**17.5**	**Greater London, Surrey**
120	**Wealden Greensand**	**116**	**464**	**1457.8**	**102**	**31**	**26.7**	**Surrey, Sussex, Hampshire**
121	**Low Weald**	**142**	**568**	**1824**	**217**	**49**	**34.5**	**Surrey, Sussex**
122	**High Weald**	**89**	**356**	**1748.8**	**44**	**17**	**19**	**Surrey, Sussex**
123	**Romney Marshes**	**67**	**268**	**366.8**	**177**	**61**	**91**	**East Sussex**
Total		**886**	**3544**		**1023**	**308**		

3.2 Nests

3.2a Nest sizes

Nests ranged in size from 4cm in diameter to 11cm. The majority of nests were spherical, but over 120 were elliptical. Surveyors were asked to distinguish between nests that had an oval shape because of the way it was built, such as when the nest is woven through stiff upright stems, rather than one that had become distorted, squashed or stretched by time and the weather. Out of a sample of 620 spherical nests the average diameter was 7.3 cm. Average diameters from the National Character Areas is as follows:

NCA Number	NCA Name	Average (Mean) Diameter	Size Relative to Overall Mean
81	Greater Thames Estuary	7.16	smaller
113	North Kent Plain	7.41	close
119	North Downs	7.5	slightly larger
120	Wealden Greensand	7.3	same
121	Low Weald	7.49	slightly larger
122	High Weald	7	smaller

123	Romney Marshes	7.13	smaller

Some of the elliptical nests can be quite substantial and include one with the dimensions of 12 X 16cm. This was constructed of entirely of reeds, wedged in between the vertical stems of common *Phragmites australis*, directly above water. The size in this case may relate to security in terms of anchorage to the reeds. Elliptical nests are difficult to rank on dimensions alone but a look at spherical nests using volume as a measurement clearly shows the potential increase in space that is available for a mouse family, although individual nests vary in terms of the thickness of their lining and we have no way of knowing without opening the nests. Even given a minimum requirement of insulation thickness, a larger sphere increases cubic capacity.

12X16cm nests in reeds, in water-filled dyke

Classic spherical *Micromys minutus* nest; about the size of a tennis ball (7cm).

3.32b Nest characteristics

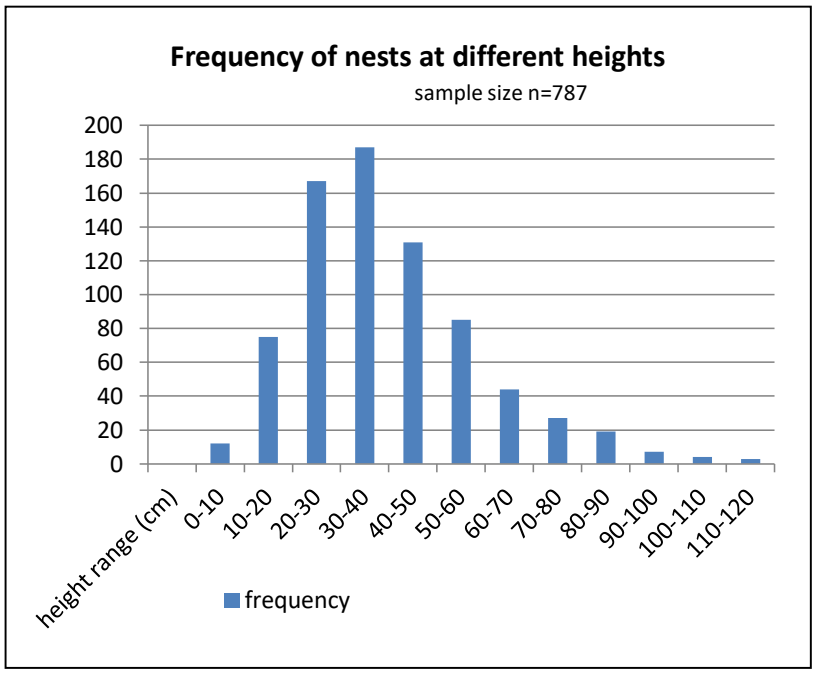
Although harvest mouse nest surveys are characterised by the distinctive aerial nature of summer breeding nests, many of our finds must have been used for other purposes, including autumn/winter quarters – a few were occupied and the mouse seen as it departed. Most finds were accompanied by a verification photo and we have accumulated a large database that requires further analysis. Several nests were green when found, a sign that they were recently made and suggestive that breeding was continuing into October and later.

A small number of harvest mouse nests are found annually that are either in birds' nests or are formed by the modification of one (examples shown). These are not considered to be aberrant or anomalous as they occur annually. Nests woven entirely from willowherb down or thistledown are found in most years, also.

Willowherb down and sedge

Attached to and woven of willowherb

Harvest mouse nest in Whitethroat nest



3.2c Height of nests above the ground

As can be seen in the chart to the left, there is an extensive range of heights at which nests were found. The lowest nest was a mere 5cm above the ground and the highest 120cm in reeds. Nests were plotted in ranges of 10, to allow for small variations, and a very clear trend is displayed. Most nests that were found during this survey were in the 30-40cm height range and the vast majority occur between 10 and 60cm above the ground.

3.2d Nest composition and support

The difficulties of identifying grasses in the winter notwithstanding, expertise in this field was variable among the surveyors. As a consequence the grasses and other plant species of which the nest was constructed and composed were identified with confidence 291 times. These are presented as a table below.

Grasses and other plants comprised within harvest mouse nests				
Monocotyledonous plants				
Latin Name	Common Name	Frequency	Percentage	Notes
Elymus repens	Common Couch	28	10.4	
Dactylis glomerata	Cocksfoot	90	33.45	
Phragmites australis	Common Reed	90	33.45	
Phalaris arundinacea	Canary reed-grass	15	5.5	
Carex pendula	Pendulous Sedge	9	3.3	
Carex riparia	Greater Pond Sedge	1	0.37	
Carex paniculata	Greater Tussock Sedge	1	0.37	
Carex elongata	Elongated Sedge	1	0.37	
Carex hirta	Hairy Sedge	1	0.37	
Carex distans	Distant Sedge	1	0.37	
Carex sp. ind.	Sedge	11	4	
Holcus lanatus	Yorkshire Fog	10	3.71	
Phleum pratense	Timothy	1	0.37	
Poa annua	Annual Meadow Grass	6	2.2	
Juncus inflexus	Hard Rush	1	0.37	support only
Juncus effusus	Soft Rush	1	0.37	
Arrhenatherum elatius	False Oat Grass	11	4	
Bolboschoenus maritimus	Sea Club-rush	1	0.37	
Miscanthus sp.	Silvergrass	2	0.74	
Molinia caerulea	Purple Moor Grass	2	0.74	
Lolium multiflorum	Italian Ryegrass	1	0.37	
Typha angustifolia	Lesser Reedmace	1	0.37	
Dicotyledonous plants				
Epilobium hirsutum	Great Hairy Willowherb	1	0.37	
Urtica dioica	Stinging Nettle	1	0.37	
Cirsium arvense	Creeping Thistle	1	0.37	
Picris echioides	Bristly Ox-tongue	1	0.37	
Galium mollugo	Hedge Bedstraw	1	0.37	
Sp. ind.		1	0.37	

3.3 Harvest mouse observations

There were a total of 19 encounters with live (or dead) harvest mice over six years, (including records from the trial year). The majority occurred in autumn/winter with one encounter in spring.

Incidental live trapping accounted for seven records, at two very different sites, both during the winter; one was an unmanaged grassy mound, used as a private cemetery, in otherwise low-lying farmland; the other, a chalk-stream with watercress beds. Six of the records came from the latter. Only one mouse was weighed, a female of 6g; a male was also captured and released. Time constraints and a specific objective meant that little attention was paid to the harvest mice. In one case only, juvenile mice were disturbed from a nest in October during a survey. Other live sightings at nests (three) represent mice occupying winter quarters being disturbed by discovery. These nests were all relatively low to the ground in grassy margins (bank of small river and road verges).

Dead harvest mouse in nest.
Photo by Lucy Price

Harvest mice were filmed at a feeding station by a camera trap on a wetland site in north Kent. A mouse foraging in reeds over water was filmed by a bird watcher from a hide overlooking a flooded extraction pit at Dungeness, and proves a brief but fascinating insight into this mouse's behaviour. An adult and two juveniles were photographed during Environment Agency operations, providing rare images of genuinely wild mice. These images were unusual in a number of ways; they were taken on a mobile phone; the mice were heard approaching allowing time to ready the camera setting; they appear to show a mother and juveniles active together. (*Cover photo by Benjamin Morris*).

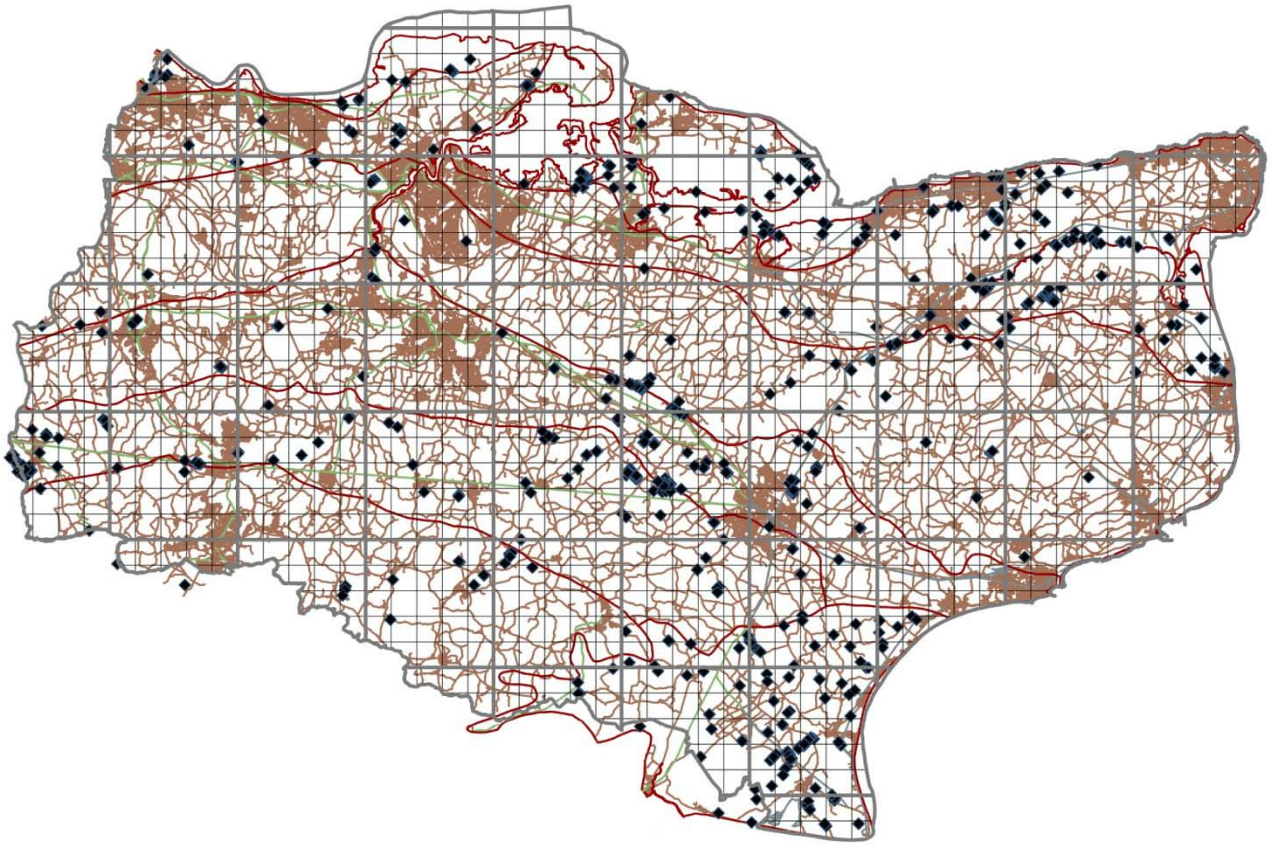
Several mice were seen and one of them photographed by a trained surveyor when they were disturbed at ground level during tractor work in an arable field that had been cropped and harvested last year. There was very little cover remaining apart from weeds. This occurred in April of 2020.

One live mouse survived an encounter with a cat and was released. Two dead mice were reported in interesting circumstances; one was found dead in a nest in a field margin and the other had apparently drowned in a saltmarsh.

Harvest mouse in field layer, April 2020.
Photo by Greg Ovenden

3.4 Harvest mice and road verges

Road verges accounted for 34% of all records for the county.



84% of road verges supporting harvest mouse nests were dominated by ruderal plants, e.g. docks, stinging nettles, cow parsley, hogweed, thistles, brambles, greater plantain and other plants indicative of rubbish, disturbance, nutrient enrichment and high nitrogen content. Just 9% composed largely of species that suggested a more natural wayside or grassland environment, e.g. ox-eye daisies, knapweeds, scabious, etc. (insofar as they were identifiable out of season) 30% of road verges held a mixture of the two.

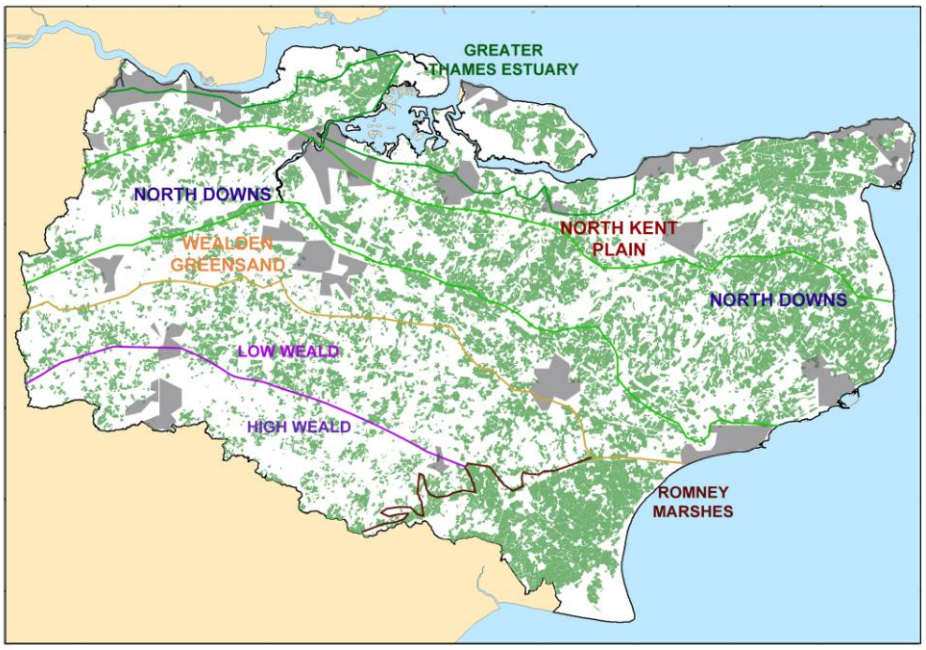
The majority of road verges with harvest mouse nests bordered an arable field, separated by a hedge, ditch or dyke or within a gap in the hedge. A small number of road verges were not associated with an arable field, 32/351 = 9%. Harvest mice showed a preference for wide verges (>1m) in 76% of road verge records.

Ruderal plants dominated the grassy vegetation in 76% of all records, clearly indicating that harvest mice often use low grade habitat and should not be considered as indicative of habitat quality or biodiversity. Overall, occupied habitat contained 34% of 'finer' flora, with the 10% discrepancy being accounted for by the presence of both types of vegetation.

Major roads with wide verges, especially when adjacent to arable farmland, supported numerous nests. The A226, Gravesend Road, Shorne; A228, on the Hoo Peninsula; A259, Romney Marsh; A21, Lamberhurst bypass; A20, between Ashford and Lenham; A299, Thanet Way and long sections of the A2070 between Ashford and Brenzett all yielded multiple harvest mouse nests.

3.5 Arable fields and their margins

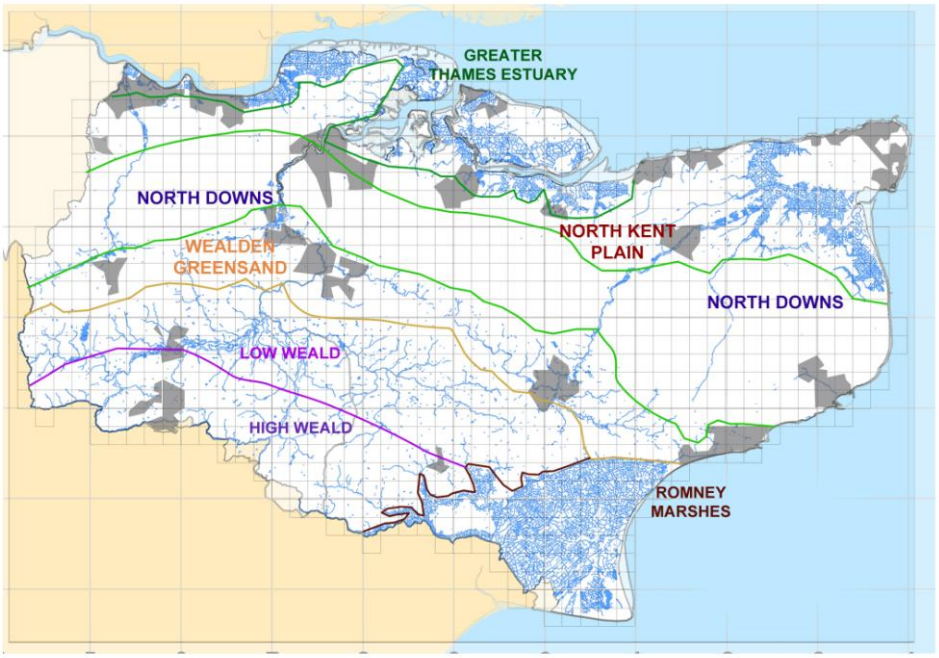
An association with arable fields was found in the 68% of all records. These include direct association, i.e. found within the field boundary (50% of 698 records), or indirectly associated, found just outside along an adjacent road verge also (50%). Any directly adjoining water features e.g., rivers, dykes, ponds and lakes are also included as being associated even if the nests were found within their margins as the mice would be able to move freely into any adjacent crop.



Distribution of areas of arable land within Kent's NCAs

This is partly explained because agricultural land use is the dominant habitat in the county. The percentage varies from NCA to NCA. However, if the constantly fluctuating state of the habitat that is created by agricultural land use was inimical to harvest mice, one might expect them to avoid it.

Kent, in common with other English eastern coastal counties, comprises large areas of land that historically have been reclaimed from the sea. As a consequence there are vast drainage networks along the north coastal marshes; the Wantsum Channel in the west that in Saxon times separated the Isle of Thanet from the rest of Kent and associated low-lying areas in the North Kent Plain NCA and also Romney marshes in the south where the former cinque ports of New Romney and Tenterden are now well inland and inaccessible by boat.



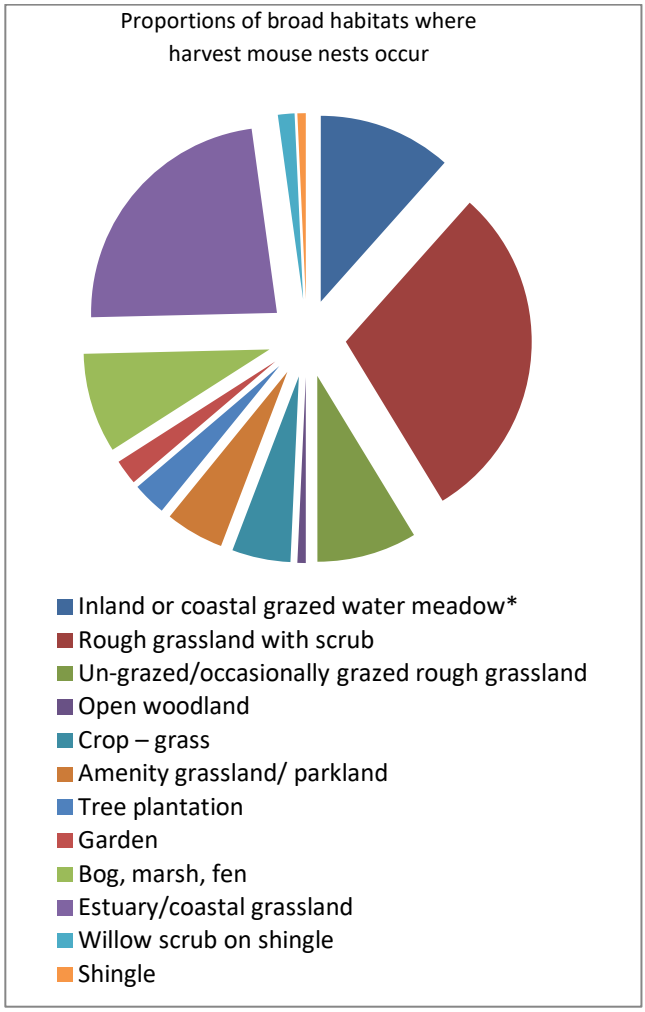
Distribution of areas of water within Kent's NCAs

64% of all the harvest mouse records were associated with a water source. The margins of water features of all kinds provide a refuge for harvest mice and frequently contain strips of monocotyledonous vegetation that are suitable for the creation and support of harvest mouse nests, most especially reeds (*Phragmites*), sedges (*Carex*), rushes (*Juncus*), and reedmace (*Typha*).

3.6 Broad habitats

Under ideal circumstances, within a broad habitat harvest mice should be able to achieve a dispersed pattern of nest locations with a consistent vegetation structure, provided there are no bounding features. A tussocky neglected meadow might achieve this, for example, as was found at Haysden Country Park. Grassy scrubland where the scrub is of even age and structure for supporting nests or stable reed or sedge beds, such as the greater tussock sedge beds at Hothfield Common, that are strong and self-supporting can provide these habitats, but they are uncommon in a landscape that is heavily influenced by human beings. Although defined as broad habitats they are often small and patchy by nature. The table below shows a breakdown of the records from a variety of Kent's broad habitats and the chart shows their relative importance in our results.

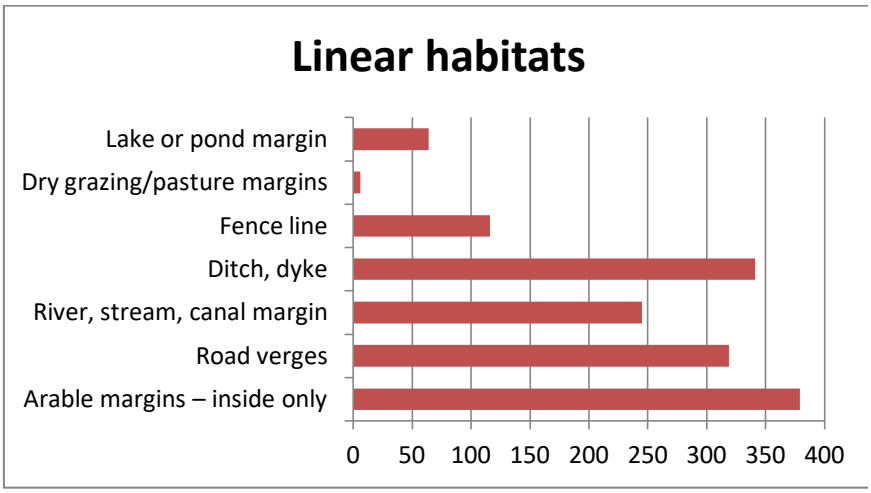
Carex paniculata – Greater Tussock Sedge



Broad habitats	Number of records
Inland or coastal grazed water meadow*	16
Rough grassland with scrub	41
Fallow/occasionally grazed rough grassland	12
Open woodland	1
Crop – grass	7
Amenity grassland/ parkland	7
Tree plantation	4
Garden	3
Bog, marsh, fen	12
Estuary/coastal grassland	32
Willow scrub on shingle	2
Shingle	1

*(can be linear, pushing mice to margins)

3.7 Linear habitats



Naturally-created grassy linear features are uncommon except where water flows. Artificial linear features, on the other hand, abound. A great many more harvest mouse nests were found in man-made linear features, such as road verges, field margins and ditches as well as more natural ones such as water courses. These features have breadth, of course, so it would be more accurate to describe them as 'belts' of varying width. In practice, unless very wide, harvest mice rarely make use of the breadth unless a female constructing for a second or third brood builds 'in front of' the previous nest. It would be difficult for two mice to meet a minimum safe distance to avoid territorial clashes unless the belt was wider than the average road verge or field headland. This is sometimes the case along strips of grassland bordering marshland or coastal field systems where they may morph into broad habitats.

Linear habitats	
	Number of records
Arable margins – inside only	379
Road verges	319
River, stream, canal margin	245
Ditch, dyke	341
Fence line	116
Dry grazing/pasture margins	6
Lake or pond margin	64

It should be noted that totals from above will exceed the stated number of records from the survey because linear habitats frequently occur together e.g. ditches are mainly proximal to road verges. Dykes can occur with road verges or agricultural margins; those that don't are a feature of marsh drainage. Rivers flow through all habitats and so on.

4 Discussion

4.1 Permanent and long-term habitats

As well as its disposition to produce and sustain expanses of tall grasses, the habitat to which harvest mice are uniquely adapted, permanent or long-term occupation of a habitat by harvest mice is a reflection of the resistance of the particular habitat to succession and the slow pace or inability of an area to become climax woodland.

4.1a Marshland, Coastal and Inland:

In Kent, a county that has coastline on three sides, grassy long-term habitats prevail in the low-lying coastal marshland of the Greater Thames Estuary and the reclaimed marshland of the Romney Marshes, as well as the Great Stour estuary that comprises a large part of the North Kent Plain in the Sandwich Bay area. These areas have, to some extent resulted from natural conditions, over hundreds of years, driven by a variety of mechanisms. Conditions hostile to trees – periodic inundation, waterlogging, soil salinity, lack of oxygen in the soil, saltburn and constant winds that damage and stunt tree formation are to be found within a certain distance of the sea in these exposed areas. Particularly on the north Kent coast they may represent continuity over thousands of years from the early colonisation of eastern and southern England by the harvest mouse as postulated by Perrow & Jowitt 1995. Traditional farming and modern agricultural management practices serve to largely maintain a state of treeless equilibrium.

Traditional grazing of floodplain and coastal marshes is highly regarded in conservation circles for the way in which it produces an open, grassy habitat that suits many species. This periodically inundated pasture, or meadow, is criss-crossed with a network of ditches, often of high bio-diversity, containing standing brackish or fresh water, and which maintain the water levels. It is in these linear features and any adjoining reed and fen that harvest mice effectively take refuge, pushed to the marginal areas at the limits of the ability of livestock to graze – beyond stock proof barriers, either natural – such as deep ditches, thorn bushes or open water, or man-made – such as barbed wire or electric fences. A less intensive grazing regime, with fields left fallow in rotation, would most likely lead to a different spatial usage by harvest mice.

While the loss of this BAP habitat is not inherently desirable, a conversion to arable, rather than reducing a harvest mouse's accessible habitat, may actually increase represent little change, provided non-productive margins are not eliminated or harshly managed. In the case of ditches and dykes in these habitats, they are regarded as desirable for drainage and flood prevention.

Nest in road verge located at the very limit of tidal saltmarsh

Large stretches of the north Kent coastline and the southern part of the Isle of Sheppey are fringed by saltmarsh – in the tidal reaches of the Thames, Medway and Swale Estuaries and the tidal creeks in the Faversham and Sittingbourne areas. Also Pegwell Bay and the mouth of the River Stour, in east Kent, have extensive saltmarsh, of a particular character owing to the fine sedimentary mudflats. The saline, brackish and freshwater floodplains landward of these areas are all well-favoured by harvest mice. Those parts with regular winter inundation such as the RSPB reserves of Shorne Marshes and Cliffe Pools in north Kent are also utilised by this species. A few nests were found close to the edge of the upper tidal saltmarsh and a dead harvest mouse found at Oare Marshes had apparently drowned in the salt water.

In some places, tidal salt marsh mudflats vegetated with species such as *Salicornia* (Glasswort), *Halimione portulacoides* (Sea Purslane),

Limonium (Sea Lavender) and dense *Spartina* grasses are separated from the land by a sea wall, in others they grade directly in. It is possible or even likely that harvest mice would use the tidal areas for foraging. They have the ability to traverse watercress beds without difficulty (see p. 23), however a dunking in salt water has potentially more serious consequences. Given the composition of Kent's tidal saltmarshes, it is less likely that they would be suitable for nesting.

Fortunately, coastal wetlands are host to many species more highly visible than harvest mice and the habitats contained therein are valued for their conservation dividend, thus large expanses are designated as SSSIs, International Ramsars (The Swale, Thames and Medway Estuaries and Marshes) European Special Protection Areas (SPA), Special Area of Conservation (SAC) and National Nature Reserves (NNR). The management of many of these coastal reserves is principally for birds, numerous species of which require large expanses of shorter sward unsuitable for harvest mice. In a study of Estonian coastal wetlands by Scott, et al. (2008) it was found that small mammal relative abundance, richness, and biomass were positively correlated with tall grass and mosaic habitats and negatively correlated with lower shore habitats, short grass and bare ground. The study indicated potential nature conservation conflicts between small mammals and other biodiversity priorities in wetlands. On a positive note, however, provided there are tall grasses at the margins, supported by brambles, scrub and such like, we found that then there is both cover, forage and structure that will suit small passerines and the tiny harvest mouse. We also found, in one sample pellet of a Barn Owl - *Tyto alba* (Linn.) that harvest mice feature in their diet on the north Kent marshes and nature reserves, as it does in Suffolk [9] and elsewhere. It is in the interests of bird-focused conservation organisations like the RSPB to maintain habitats in such a way that also suit the mammal prey base of their resident raptor species. This can be a complex challenge, especially without full data. Co-operation and partnership is to be encouraged between specialist groups to co-ordinate the best possible outcomes for all species concerned.

4.2 Romney Marshes – not all simply marshland

4.2a Coastal vegetated shingle

Romney Marsh contains the largest shingle cuspate foreland (a triangular-shaped spit) in Britain at Dungeness and, with over 2000 ha of shingle, one of the largest in the world. Over many centuries flint shingle from the chalk cliffs of Sussex has been transported eastward by longshore drift and the prevailing winds to Dungeness 50km away where it has built up in a series of ridged storm beaches. Where the shingle has stabilised a complex pattern of micro-habitats has developed, such as prostrate blackthorn scrub and lichen-rich acidic grassland. Harvest mice are found in this area, most often in vegetation associated with gravel extraction pits extraction pits that hold both fresh and brackish water but also in the coastal reed beds and salt marsh with nests being found very close to the sea (28m)and mice being live-trapped on expanses of shingle that are devoid of long grasses.

4.2b Sand dunes

Prevailing winds have formed sand dunes at Camber in East Sussex and Romney Warren in Kent. The dunes are still mobile and require management to impede further progress inland, despite extensive marram growth. There is a great deal of human disturbance and physical erosion of the dunes, that also needs managing. There was no sign of harvest mouse presence in the beach dunes but on the stabilised dunes inland harvest mouse exhibit a continual presence, especially close to cultivated arable fields and along dykes in the Greatstone and New Romney areas.

4.2c Grazing marshes

Historically the marshes inland of the shingle and dunes were almost entirely sheep pasture. Nowadays, much of this has been converted to agricultural use. Considerable expanses of pasture still remain, however, and provide the landscape with a particular character, especially towards the west of the marshes where it extends over the border into border East Sussex on the Pett and and East Guldeford Levels and on Walland Marsh. Extensive grazing pressure means that harvest mice are pushed to the margins, of necessity beyond the reach of livestock, which would devour

their breeding and foraging habitats, their nests and in all likelihood their young with them. Riordan, Lloyd & Macdonald, 2009 concluded that nest counts were negatively influenced to presence of livestock and to hedgerows. On the marshes hedgerows are in relatively short supply. Harvest mice exhibit a continued presence along the road verges, along the edges of waterbodies and in the network of ditches, dykes and 'sewers' – as the drainage channels are known locally, though they are somewhat hemmed in. The linear features are for the most part well connected and link to extensive reed beds.

4.2d Agriculture

Inland, agriculture provides a niche for harvest mice also, creating open three-dimensional mosaics of domesticated grasses, e.g, wheat and barley, usually on a rotational basis, often within a more wooded landscape framework where harvest mice would be less commonly encountered. In many cases cereal and other crop fields provide linear habitats along the margins that may contain sufficiently long and dense grasses that harvest mice can breed in for a time, though this is inconsistent across the NCAs. Arable margins in large parts of the chalk of the North Downs and the Thanet area of the North Kent Plain, are non-existent, very thin or, towards the Thanet coast, dominated by the invasive umbellifer Alexanders – *Smyrnium olusatrum*. Where grass exists in these areas it tends to be sparser than on the low-lying clay soils and often lacks the additional support structure that harvest mouse nests require.

The actual crops themselves appear to be no longer used to the same degree by harvest mice, if at all, for nesting, as they once were. Anecdotally, according to farmers [personal communication] and naturalists of long experience [T. Hatton, personal communication], nests used to be seen in cereal fields and no longer are and while this may not be the full picture, it is a strong perception.

Harris, 1979 states and demonstrates with photographic evidence that nests at this time would pass through the combine harvester and come out relatively intact. Nowadays, the straw is baled up differently, into giant rolls or oblong bales depending on the part of the country, but is also often shredded as it passes through the machine and left as a needle-thin scatter on the surface of the stubble field. No evidence, should it exist, survives. It is not known how much cereal fields are currently used by harvest mice (Perrow & Jowitt 1995) and it is difficult to survey for them. Perrow & Jordan (1992) found only low numbers. Crops are harvested in August and the field soon ploughed, harrowed and drilled, replacing the stalk zone with bare soil. In addition, the inner grassy margins and inside of the hedgerows are then cut while machinery is still active in the fields; all this just as peak breeding gets underway. This practice is widespread and was noted by Bence 2003. The lack of available foraging at such sites when laid bare in winter strongly suggests that the harvest mice must move elsewhere, not simply continue leading a terrestrial existence at the same site. Yet nests will appear time and again along the same margins in the following season. This is highly suggestive that harvest mice are more highly mobile than we currently recognise and may be seasonally migratory, if not nomadic, when they need to be.

Why then the association with arable fields? It seems likely to me that a field of wheat or barley, and probably a field of oilseed rape, for that matter, provides a large three-dimensional foraging ground where the harvest mouse can still maintain an aerial existence in the stalk zone, which presumably affords a similar security and ease of movement as long grass.

While it may be unsuitable in terms of supporting nests because of the morphology of modern cereal plants, which tend to be stouter-stemmed, shorter and less leafy than older varieties, nests can be found in weedy, grassy margins amongst the corn and in contiguous ditches, river margins, hedgerows and headlands or in those separated from the crop by a hedge. The timing and method of harvesting by combine is certainly more savage and ruthless than in Gilbert White's day and has long been cited as responsible for a perceived decline. It makes sense for the harvest mouse not to be in the way; and perhaps they have adapted, or the crop has coincidentally become unsuitable.

During the growing period of the crop any breeding harvest mice have another reason to make use of the vast 3D highway; for the dispersal of the young and for their own free movement. Harvest mice are notoriously aggressive to their own kind, often biting off each other's tail, in captivity, or worse, inflicting mortal wounds. For the young mice

to run the gauntlet to disperse along a linear habitat that may be only two metres wide or less, passing through the core territories close to other breeding females and an unknown number of males must be highly stressful to the species, and might be expected to affect survival chances. There must be an opportunity for early dispersing mice to pass through the hedge from an adjacent ditch or road verge or from the field's edge straight into a cereal crop and then to be able to move freely in any direction. Harvest mice may be occasionally seen clinging to an ear of wheat by choice [9] rather than a photographer's artifice. After harvest, however, dispersing mice would be forced to take a more roundabout route, following the margins. If a field is planted with oilseed rape in rotation, harvest mouse nests may still be found in adjacent grassy margins or roadside verges in the following winter. While the crop itself would not support nests it may nonetheless enable passage and dispersal, or provide foraging, by connecting one side of the field to three others with a stalk zone.

4.3 Case study

Analagous to this is the way harvest mice were shown to use a watercress bed during our survey. Harvest mice were caught incidentally, whilst live-trapping under licence for water shrews. The watercress beds contained expanses of open flowing chalk stream with a monoculture of Watercress – *Nasturtium officinale*, which although evergreen, was in a short vegetative state, because it was wintertime. Traps had been set along artificial linear features that had been part of the original farming process in the middle of the beds, apparently supports for large poly-tunnels – at the roughly the furthest possible point from any 'shore' and yet harvest mice were caught alive on several occasion over the trapping period. When released they scrambled away over the watercress plants or, on a couple of occasions, jumped into the water and swam, despite it being cold and flowing and in the middle of winter. A quick search of the site revealed several harvest mouse nests, some disused and some current, in a narrow strip of sedges and willowherb fringing the beds, with willow scrub woods beyond. Although the water provided a means of escape it is unlikely that the harvest mice swam to the traps, as it is a highly risky, energy costly way to explore for a small rodent not explicitly adapted to an aquatic or semi-aquatic lifestyle, thus the harvest mice must have been using the watercress canopy as a thoroughfare and discovered the traps in the course of their normal foraging and exploration. The mice were generally paid little attention, being weighed only once and sexed only 3 times out of 6 captures, as they were not part of the project in hand. They were trapped at three locations and in one trap twice. On two occasions the mouse was male and on one, a female, thus involving a minimum of two mice. Three out of four nests found were potentially still in use, the fourth was very damp and deteriorated. The closest contemporaneous nest to a trap was 15m. One current nest was a minimum of 50m from all traps that caught mice but it cannot be determined from the data if the occupant was trapped.

Watercress beds showing marginal vegetation where nests were located (L) and the position of one of the live traps that captured mice (white arrow).

4.4 Dry pasture, silage and hay

Only a small percentage of records came from within a field that was being utilised as a grass crop, or as dry pasture (0.2%). The disruptive pressures of the management of this type of land must cause enormous problems for harvest mice. Intensive farming methods mean that fields are infrequently left fallow compared to traditional methods. Silage is harvested from May and often again later, while hay is somewhat weather dependant between June and

September, meaning that the habitat could disappear unpredictably at any time in the summer, often before it is suitable condition for bearing nests. Livestock push harvest mice out beyond the inner margins of the field and despite often lush vegetation on the road side of its hedge, the mice rarely nest alongside pasture in my experience, (but do occasionally especially if there is arable nearby).

4.5 Hedgerows, ditches and road verges:

By mid or late winter roadside ditches and verges and many internal field margins and ditches are given a final mowing and flailing that can make nest searches frustratingly difficult, with many surveyors reporting that they arrived at what had once appeared to be suitable habitat – but too late. The loss of evidence is the price for re-setting the clock. The very same ditches and margins would yield to succession – some quicker than others – were they not erased every year, enabling, the following spring, the same herbaceous vegetation and grasses to regenerate. Such management is more intended for weed control and drainage maintenance but has the fortunate consequence of enabling a repeat performance for the harvest mouse each year. However it can be sufficiently drastic that it would be almost impossible for harvest mice to live in the same area throughout the winter, even using underground burrows of other mammals, particularly if the ditches were prone to seasonal flooding, for example.

Low-grade roadside/ fieldside bramble hedge with abundant harvest mouse nests

Two types of hedge are most frequent alongside arable land from the 6 that we recognised as typical of Kent. The low, square-cut heavily flailed hedge that may be continuous, or gappy but usually sparse and the bramble hedge that acts like a roll of barbed-wire on no-man's land separating intensive agriculture from their adjacent spaces. These are not attractive habitats, nutrient-enriched by agricultural run-off, full of ruderal plants such as nettles, dock, cleavers and thistles and usually lacking in any finer flora. However bramble hedges in particular support lax grasses like Couch – *Elymus repens*, and Cocksfoot – *Dactylis glomerata* in its rank and choking form rather than as tussocks, and this, combined with their annual management that tends to maintain a proportional balance between bramble and grass that suits harvest mouse breeding requirements. The frequently damaged and gappy nature of the first kind creates spaces that may be replaced by square-gauge wire fence or where sufficient hedge remains to support grasses without shading them too heavily. Our survey demonstrates that harvest mice often use the robust but open framework of this type of wire fence as a means of extra insurance that the grasses supporting their nests do not fail.

4.6 Amenity grassland and the role of Country Parks

The harvest mouse is a flexible species, within its requirements, a trait that enables it to take up residence in the wider countryside outside of nature reserves. Even country parks, maintained by district and borough councils or, occasionally, trusts with both a recreational amenity and biodiversity and conservation brief, such as Milton Creek, Sittingbourne can provide good harvest mouse habitat albeit on a limited scale. Other examples of country parks that supported good habitats that were occupied by harvest mouse are Leybourne Lakes Country Park, near Maidstone; Conningbrook Lakes, Ashford; Haysden Country Park, Tonbridge, Fowlmead Country Park, Sholden near Deal; Barton's Point Recreation Centre, Sheerness, Sheppey. In the cases of Tonbridge, Maidstone and Ashford rivers run through the parks, though the nests were by no means confined to their margins and the others had various water sources nearby. In all cases nests were found in less disturbed areas though some would have had to tolerate quite a degree of human and dog proximity.

4.7 Notable small scale habitats:

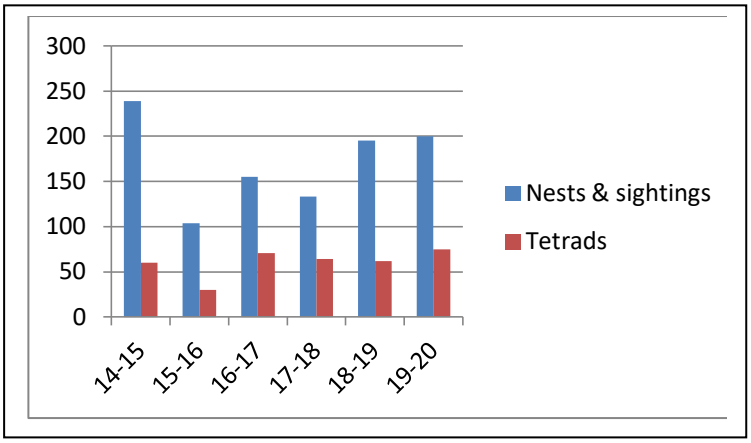
Great Comp Garden is a 2.8 (7-acre) luxuriantly planted garden surrounding an early 17th century manor that is run as a commercial enterprise, near St Mary's Platt and Borough Green in the Wealden Greensand National Character Area. For two successive years, volunteers who work in the gardens have discovered harvest mouse nests in *Miscanthus* grass in different locations, (allowing for the lack of precision of 6 figure grid references). Miscanthus, also known as Silvergrass in English, is a favourite nesting location of harvest mice in Japan [Kuroe, et.al, 2007], where this mouse has been relatively well-studied. The grass forms large tussocks and the nests sit on them and in them. Great Comp is surrounded by arable fields on three sides and woodland on the other.

Miscanthus is also planted also at Bedgebury Pinetum, in the gardens, along with Pampas Grass - *Cortaderia selloana*, which harvest mice also utilise on occasion. Unfortunately, on a training day that was held there, only the briefest of searches of these two species was possible and nothing found. However, amongst the trees in a boggy valley that had large patches of Purple Moor Grass – *Molinia caerulea*, two harvest mouse nests were found in this tussock-forming species also. In Devon, Culm grassland, of which *Molinia caerulea* is a prime constituent, "has proven to be pretty ideal habitat" [P. Cooper, personal communication, 2017].

4.8 Harvest mouse population fluctuations:

Harris [1979] stated that in 3 out of 5 years nests may be harder to find. The author's own experiences and data from 2004 – 2015 from one farm in Kent indicates that harvest mouse nest numbers fluctuate and are at times frustratingly scarce.

Accordingly the Kent Harvest Mouse Survey expected to have at least one difficult year. Unfortunately this coincided with our first official Heritage Lottery funded season. This can be de-motivating for surveyors when nests may be absent in perfectly good habitat for no apparent reason. The trends over the survey years are less clear, because in a presence or absence survey one good nest is sufficient evidence of presence, so overall nest counts were not required. It is possible that there was a second trough in the 17-18 survey season.



The Kent Harvest Mouse Survey

5 The future of the harvest mouse in Kent

5.1 Threats

5.1a Development

The geographic position that contributes so greatly to Kent's rich landscape and fair climate also puts it under huge development pressure. To the northwest the county adjoins London and to the southeast, its proximity to the continent means that three major transport arteries converge on the port of Dover and the Channel Tunnel; HS1, M20 and M2/A2, dividing Kent into 'islands'. These infrastructures are already in place but there are plans for further developments; some with potentially far-reaching environmental consequences such as the new Lower Thames Crossing that will be constructed through a European Special Protection Area and a Ramsar Site of International designation – the Thames Estuary and Marshes. Additional growth and development of the Thames Estuary is planned for businesses and housing including a theme-park on the Swanscombe Marshes and Botany Marshes. In Kent, the Greater Thames Estuary N C A represents an area that has been identified by the Kent Harvest Mouse Survey as important for the harvest mouse's long-term security.

The perception that marshes are a low-grade habitat has led to them being undervalued. Typifying this, is one of the highest impact developments that has been given the go-ahead in the Kent Greater Thames Estuary NCA ; the Cleve Hill Solar Park that will occupy four square kilometres, (400 hectares = 1000 acres – the equivalent of 1 entire tetrad), of marsh and agricultural land that harvest mice are known to inhabit.

5.1b Housing

Ease of access to London and the Continent has created rapid expansion of dormitory towns like Ashford, and led to the controversial building on floodplains. The proposed and actual locations of these housing developments and the proposal of expansive and sprawling scattered settlements – new towns and villages with the epithet 'garden' will impact directly upon known harvest mouse sites. The wild margins and watercourses, unkempt grasslands, bramble hedges and scrub all run the risk of all being 'tidied-up' as soon as they fall within the boundaries of a 'garden', rendering them unsuitable for the diverse species they support, including very directly *Micromys minutus*.

There are numerous places where harvest mice live in close proximity to humans. Waterways, such as rivers and streams, running through relatively built up areas can sustain populations of harvest mice (as well as a host of other species of course) when bordered by green buffer strips. This is often achieved by chance but would be easy to include as a matter of policy. A respectful 'step-back' from the water's edge for any development bordering a river or estuary would have a beneficial effect provided the buffer strip also included protection from disturbance and was not mown like a lawn but treated as wilderness. As has been demonstrated, harvest mice can accommodate themselves in linear strips of suitable grassy habitat with access to foraging, if those features are of adequate width and connectivity. At the very least, linear features provide corridors to allow dispersal of species from area to another.

Human beings need homes, too. The challenge is to ensure that we don't destroy and displace the wild denizens of these places in meeting the needs of people. Harvest mice are a Species of Principal Importance. They are small, hard to detect and thereby easily overlooked but this does not mean that they should not be taken into account, as has previously been the case. We now have a clear idea of their distribution and landscape use throughout the county and confidence in our ability to detect or predict their presence or otherwise in as yet unsurveyed areas.

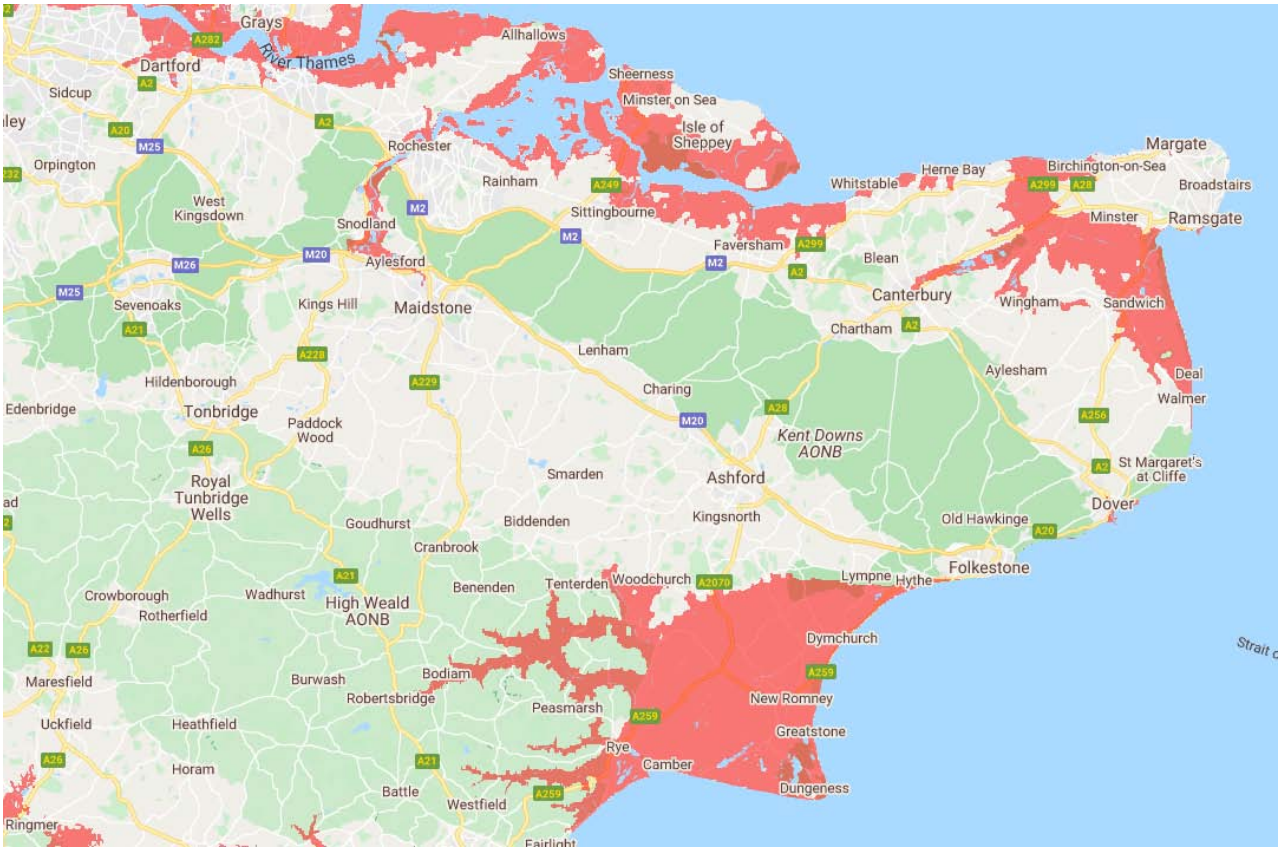


Image via Climate Central

5.1c Flooding

It is an unsettling 'coincidence' (see Discussion: Permanent and long-term habitats – Marshland), that the tidal inundation risk map of Kent above appears to highlight some of the most important areas of harvest mouse occupation within the county. Rising sea-levels and sinking land on the east coast are slow and natural changes, albeit exacerbated by anthropogenic forces. A predicted 3m sea-level rise at the current rate might not impact seriously for 300 years, but will inevitably re-shape the southeast corner without intervention. The greater and sooner risk comes from flooding during a storm surge where a combination of a very high tide, a large swell created by a low pressure system and wind-blown waves over-top the sea defences around the Thames Estuary, allowing the sea to invade the surrounding low-lying land. This last occurred in 1953, resulting in loss of life and great economical and ecological damage. Romney Marsh could be similarly afflicted by a low pressure system surging up the English Channel and indeed in 2013 almost suffered a similar fate. Plans have, of course, been drawn up to mitigate the situation. Perhaps now would be an appropriate time to consider the future of the humble harvest mouse in our desired outcomes?

5.1d Agriculture

There is still a strong link between arable farming and harvest mice even if it is no longer the original one. Harvest mice seem to have adapted to modern agriculture in the way already described. However, farming methods can evolve rapidly and further rapid changes could easily prove catastrophic for them. At a local level, inappropriately timed mowing, cutting and dredging has serious impacts on harvest mouse populations (Perrow & Jowitt, 1995). Environmental Stewardship schemes contribute to habitat creation but more needs to be done. Working with farmers to effect positive change without economic loss to them will be important for the future survival of this species as well as many others [10]. Other things that could be done specifically for harvest mice would be to operate with a lighter touch on the margins and boundaries, perhaps by mowing only every 2 years to prevent excess scrub and bramble growth and encourage grasses.

5.1e Roadside verge maintenance

Harvest mice demonstrably utilise road verges; however populations will have established themselves under a different management regime to the current prevailing one. This has slowly extended from needing to be completed by May, to taking place further and further into the summer in recent years – sometimes more than once – until it now gives the impression of being completely *ad hoc*. Also verges, previously not heavily maintained are now being regularly cut including wide sections beside A-roads that do not interfere with sight lines or obscure approaching traffic. Councils need engaging regarding the timing and practices of roadside verge maintenance. Targeted, well-timed annual verge cutting would be more cost-effective for road safety purposes, while uncut margins might have a precautionary traffic-calming effect. To prevent scrubbing up of low-maintenance verges a two or three year programme of wider cutting could be implemented, not only benefiting harvest mice and other wildlife but potentially gaining local authorities considerable financial savings.

5.2 Monitoring

Whether or not there is an actual decline as widely perceived, the status of the harvest mouse seems precariously balanced. With all its adaptations, walking a tightrope might be something that this little mouse does well, however, it would be appropriate to ensure that there is a safety net. Monitoring is the key. It has been the long-term monitoring of bird species that has revealed the dramatic declines of several species. Amongst mammals, the monitoring of dormice has highlighted trends in their status and has led to a great deal more knowledge about the species, as well as enabling additional research and conservation programmes.

While the harvest mouse is a more challenging prospect being, in some ways, more elusive, it is nonetheless detectable. Having established a baseline presence, using a county-wide network of volunteers annual surveys could be carried out to monitor both the continued presence of the mouse and the status of its habitat. With continued training new sites could be added to the distribution map, while to ensure freshness of data, sites with older records could be revisited. To that end Kent has begun recruiting and placing monitors ready for the new season to report on their previously allocated sites.

5.2a Raising the harvest mouse's profile

The greater the awareness of the harvest mouse with the public the more potential there is for public financial and volunteer support for conservation efforts. Wildwood Trust is a possible conduit for raising this mouse's profile, as is the Kent Wildlife Trust and the Royal Society for the Protection of Birds, spreading the word and motivating volunteers.

5.2b Further study needed

A good deal more academic study is also needed to address the gaps in our knowledge about the ecology of this species. To that end, continuing to link with universities and colleges is essential to demonstrate to science students the presence, accessibility and opportunity for research that harvest mice present.

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