Wild Warwickshire

The distribution of molehills of the European Mole (Talpa europea) in a sub-urban environment

July 2013

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The Distribution of mole hills of the European Mole (*Talpa europea*) in a Sub-Urban environment.

By M. Smith

Summary

In the late winter of 2012-2013 every molehill within the sub-urban boundary of Warwick were identified and mapped with GPS. Four populations of moles were identified within this survey area with an estimated 107 individual moles. Each population is linked to an outside rural population indicating a species that is sustained from the outside.
Examination of the distribution of these molehills indicated a strong preference for open grassland interspersed with trees that have low impact management such as mowing only.

Introduction

The European Mole (*Talpa europea*) is one of nine species of Talpinae moles present in the Western Palaearctic (Gorman and Stone, 1990; Harris and Yalden, 2008). It is the only species endemic to Great Britain with records of their presence going back to the Cromerian period (780,000 -400,000 years ago) in the fossil record (Harris and Yalden, 2008).

Despite there being an estimated 31 million moles in the country (Harris *et al*, 1995; Harris and Yalden, 2008) they are rarely seen due to their subterranean lifestyle (Stone, 1986). Their presence, however, is easy to note due to their production of molehills.

The aims of this study are to identify all molehills in the town of Warwick, assess the spread of the species and analyse their relationship to the local urban and sub-urban habitats.

Molehills

Molehills are created from spoil excavated from deep tunnels. Moles produce two other types of tunnel, shallow and surface. In both cases the soil is pushed up or compressed meaning there is no excess soil to form a hill (Stone, 1986).

The tunnels are used as foraging territory. They are regularly patrolled for Earthworms the Moles primary prey and other invertebrates (Stone, 1986; Gorman *et al*, 1990; Stone, 1992 and Harris and Yalden, 2008). Tunnels are often branched and lead to chambers in which a nest for breeding is built (Stone, 1986 and Harris and Yalden, 2008). Most tunnel networks start with a 15m run in a straight line before the run branches out (Edwards *et al*, 1999).

In established territories Molehills tend to appear during extension and repair of existing tunnels (Gorman and Stone, 1990). The average molehill covers 0.14 square metres (Edwards *et al*, 1999). Some molehills can be considerable larger containing up to 50 kg of soil and are termed Fortresses (Gorman *et al*, 1990)

Habitat Selection

The European Mole was originally a species of deciduous woodland but quickly colonised pasture and arable land. Today it can also be found in coniferous woods, verges, moors, meadows gardens and stable dunes (Stone, 1986 and Funilayo, 1977).

Several studies have linked mole distribution to invertebrate density, with a greater density where earthworms were abundant (Funilayo, 1977 and Zurawska-seta *et al*, 2012). Studies by Zurawska-seta and Barczak (2012) on a Polish population indicated a variety of interactions between field and margin invertebrates. They showed that farmland tended to be less stable for populations than grassland and pasture, with field margins acting as a refuge from harvesting and ploughing activities Zurawska-seta *et al*, 2012. The Polish population also indicated the species preference for mixed forests and wide roads with verges (Zurawska-seta *et al*, 2012).

Methodology

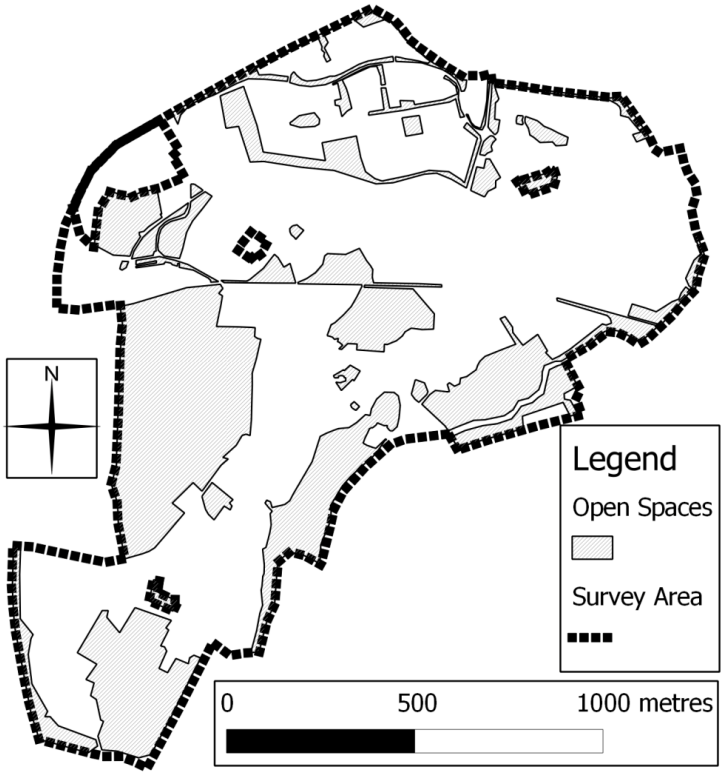
All molehills in the urban and sub-urban area of Warwick were recorded. The survey area is shown in Figure 1 and encompasses the perimeter of conurbation in Warwick. This area was 728 ha.

The survey was conducted in late winter (1st January – 28th February) when cold dry weather encourages the construction of deeper tunnels (Stone, 1992). All surveys were conducted on days with good visibility and with no ground snow cover.

Only fresh molehills were recorded, such earthworks indicate current habitation. Size or mass of the hills were not recorded. The position of each molehill was recorded using a Garmin E-Trex Legend HC GPS device which logged the longitude and latitude. These records were uploaded and plotted using Quantum GIS software against habitat type and the distribution of open spaces.

From the plotted results distinct 'colonies' were identified. Colonies were determined to be collections of molehills in distinct habitat areas with some distance or obvious barrier between them.

Figure 1- The Survey Area



Assessing Colonies

Tunnel systems are the functional units of a moles habitat and represent elements of a territory that could be home to one or more moles. To assess the structure of burrows and hills each colonies structure was analysed to identify a range of structural elements. The descriptions of these elements can be seen in figure 2.

Figure 2 – Definitions of Structural Elements

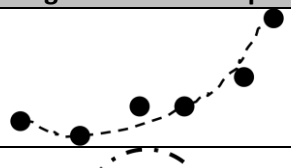
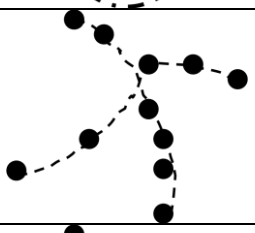
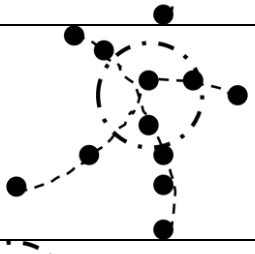
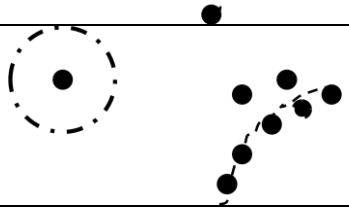
Element	Definition	Diagrammatic Example
Run	Straight row of hills illustrating a tunnel line (can be straight or curvilinear)	
Cluster	Group of hills in close proximity indicates possible nest areas or deeper tunnels	
Network	System of two or more connected runs	
Intersection	A point at which two runs cross	
Outlier	Single hill in isolation from others	

Figure 3 – Habitat Classification

Habitat Category	Description
Amenity Grassland	Short turf managed grassland i.e. Playing Fields and Golf courses.
Deciduous Plantation	Deciduous trees planted in regular rows. Managed.
Parkland	Short turf managed grassland interspersed with mixed trees randomly spaced.
Scrub/Shrub	Mixture of bramble, nettles and ephemeral shrub cover.
Semi-Improved Grassland	Mixture of grasses and flowering plants. Can be managed or unmanaged.
Semi-Natural Woodland	Mixed woodland.
Semi-Urban	Built up area with gardens and green spaces.
Urban	Built up area with little or no green spaces.
Verge	Similar to Parkland. Managed grassland with assorted trees alongside a linear element such as a road.

Assessing Habitats

A simple assessment of the habitat type within the survey area was made according to a set of categories as shown in Figure 3. These broad habitat types were taken to investigate the preference of moles for different habitats.

Electivity

Ivlev (1961) developed a formula for assessing a species preference for a particular food source. This electivity to food is just as applicable to other niche resources such as habitat. Ivlev's original formula has some inherent biases and so in analysing the electivity of moles for habitat Manly's Standardised Selection Ratio is shown (Manly et al, 2002). This revised index is $B_i = \frac{\hat{w}_i}{\sum_{i-1}^{I} \hat{w}_i}$ where, $\hat{w}_i$ equals the proportion of the sample of used resource units that are in category *i* divided by the proportion of available resource units that are in category *i*.

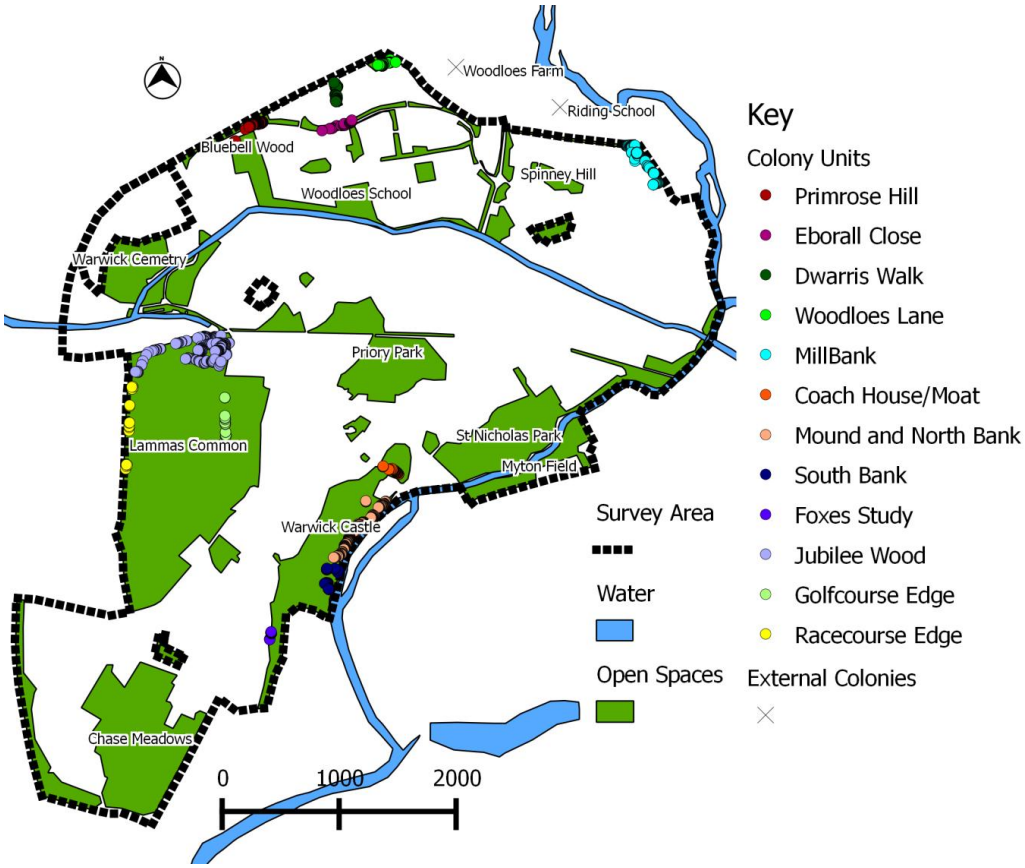
For this study the number of molehills per habitat type was recorded and their respective electivity scores calculated.

Results

Plotting the molehills and identifying colonies

Figure 4 shows the location of each molehill in the survey area overlaid with the distribution of open spaces

Figure 4 – Location of Molehills in the Survey Area



Fifteen colonies were identified within the survey area. Some of these colonies were more distinct than others and two have been dropped from the further analysis. Two molehills were found west of Millbank along a footpath on the edge of the survey area and the town's boundary. It was decided that these were in fact outliers of a major population outside of the survey area. Likewise a small number (10) of extremely isolated hills along the river Avon at Emscote is thought to be an outlier of populations over the river outside the survey area. Details of the separate colony units are shown in figure 5.

Figure 5 – Results of the elements of each Colony Unit

Colony	Number of Hills	Number of Runs	Number of Networks	Number of Clusters	Number of Outliers	Area covered by Molehills (ha)
Primrose Hill	119	5	1	0	2	0.19
Eborall Close	34	4	0	0	4	0.21
Dwarris Walk	57	4	0	0	2	0,20
Woodloes Lane	84	9	3	0	0	0.17
Riding School	2	0	0	0	2	-
Millbank	107	8	0	2	1	0.42
Avon-Emscote	10	1	0	0	0	-
Castle Mound	63	5	0	0	0	2.15
North Bank	334	18	6	4	3	
South Bank	51	4	2	0	2	
Coach-house	30	3	0	0	0	0.09
Foxes Study	15	2	0	0	0	0.11
Jubilee Wood	277	11	0	1	3	3.17
Golf course	25	3	0	0	1	0.37
Racecourse	16	3	0	1	0	1.11

Using Nearest Neighbour distances to identify discrete populations

The simplest measure of nearest neighbour connectivity is $I_i = d_{nn}$, where I is the isolation of patch i and d_{nn} is the distance to the next nearest patch (Moilanen and Nieminen, 2002). Figure 6 shows the nearest neighbour values for the 13 colonies included in the analysis. These values when plotted together and compared with known barriers and habitat restrictions create four populations as outlined in Figure 6. These four populations are a northern Woodoes Park population, an eastern Spinney Hill population, a southern Warwick Castle population and a western Warwick Racecourse population.

Habitat Assessment and Electivity

Figure 7 shows the habitats recorded in the survey area in relation to the distribution of moles hills and the areas of intensive management. Most amenity grassland is managed by regular mowing however some areas of short turf such as the golf course, racecourse, school grounds castle lawn will likely be actively managed to remove or reduce moles. Evidence of this can be found in the racecourse population that is confined entirely to the hedge line edge of the race track and no hills were evident on the actual track.

Figure 6 - Nearest Neighbour Analysis (not to scale)

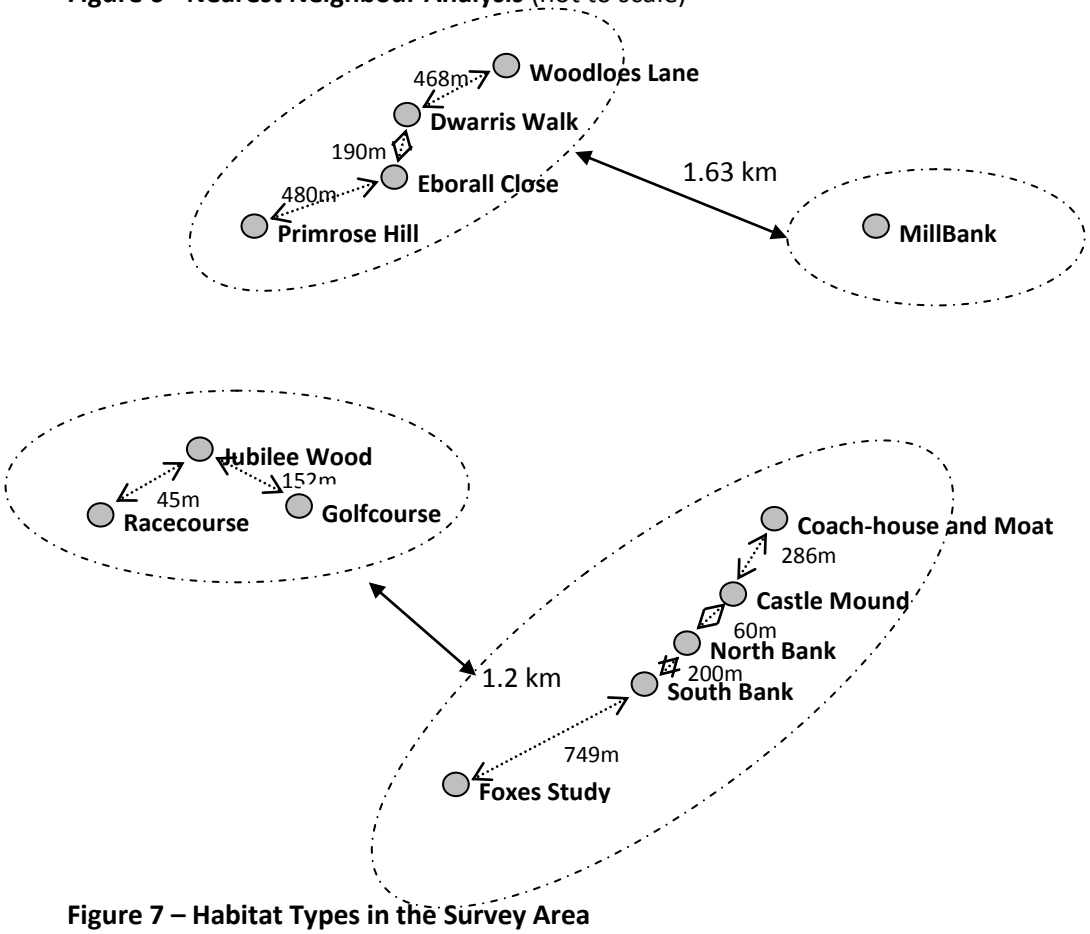
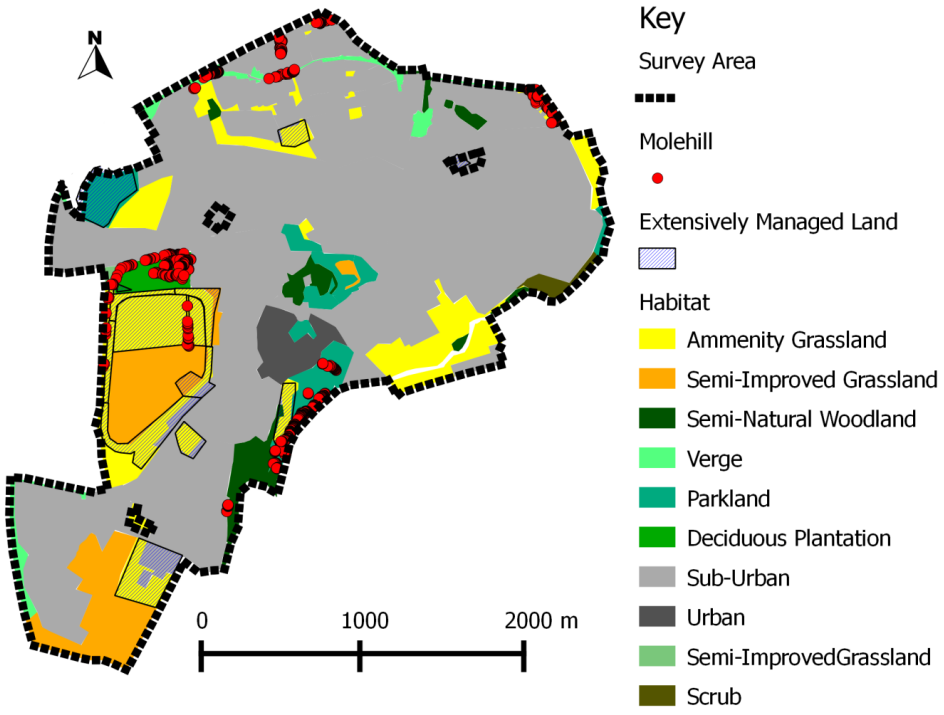


Figure 7 – Habitat Types in the Survey Area

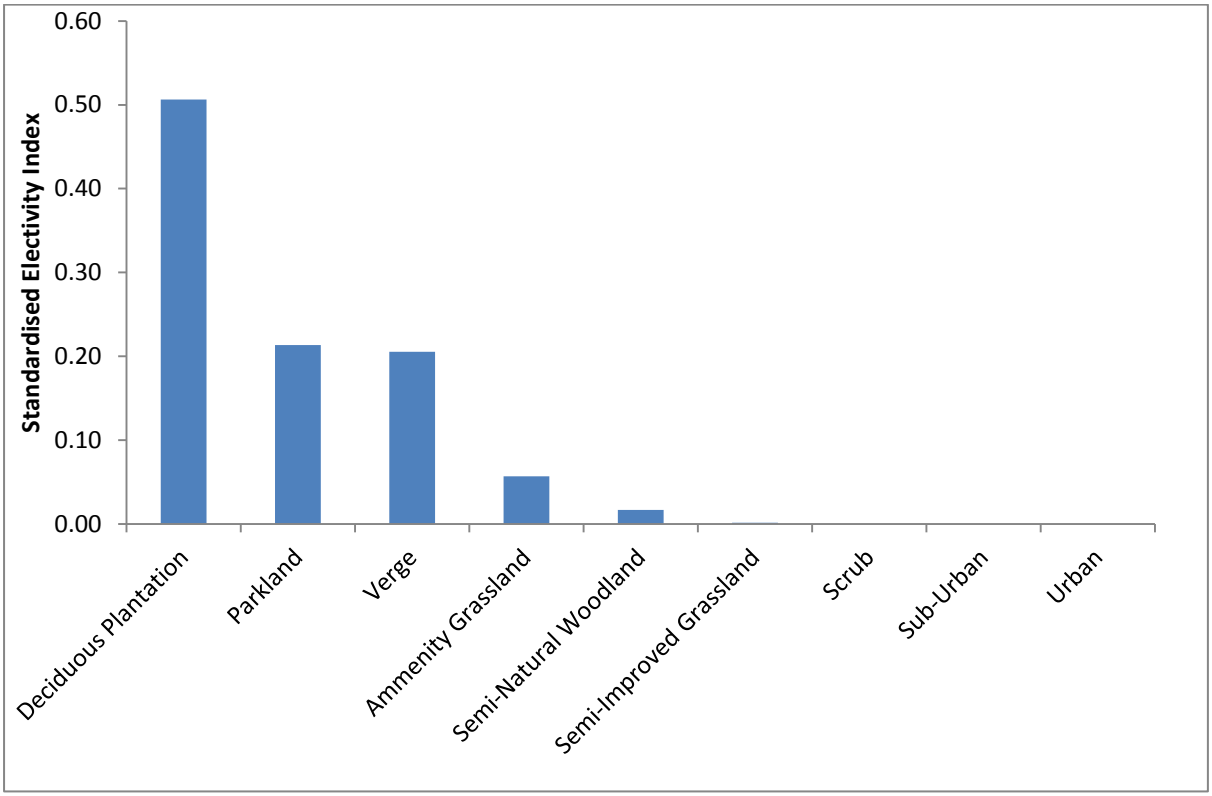


Analysis of the moles selection of habitat can be seen in Figure 8 and graphically in Figure 9. It shows that moles elect to build more molehills in deciduous plantations, parkland and verge and avoid all other habitat types. This electivity doesn't directly prove a link between a habitat and a moles preference for it. It merely illustrates that in some habitats more molehills are produced than in others. As molehills are not a reliable estimate of mole density it could therefore be other factors concerning the substrate or perhaps invertebrate concentrations that are being identified. That said, basic data indicates that there is some relationship between where moles are recorded on a presence/absence basis and the habitat that they are in.

Figure 8 – Table of Electivity Values

Habitat	Area in Hectares	Proportion of Total Area (p_i)	Proportion of Molehills (r_i)	Electivity E*	Standardised Index B
Deciduous Plantation	9.47	0.01	0.24	0.67	0.51
Parkland	32.65	0.04	0.34	0.36	0.21
Verge	12.96	0.02	0.13	0.35	0.21
Amenity Grassland	95.15	0.13	0.27	-0.28	0.06
Semi-Natural Woodland	20.70	0.03	0.01	-0.72	0.02
Semi-Improved Grassland	58.00	0.08	0.00	-0.98	0.00
Scrub	3.47	0.00	0.00	-1.00	0.00
Sub-Urban	481.05	0.66	0.00	-1.00	0.00
Urban	14.81	0.02	0.00	-1.00	0.00

Figure 9 – Graph of Standardised Electivity values for each broad habitat category



Analysis of Colony Elements

In the survey area there is an average of 0.09 elements per hectare with some variation within the habitat types. Verge colonies consistently have 0.03 elements per hectare whilst Amenity grassland has a mean value of 0.09 (range 0.02- 0.37). In the following analyses there are two few records for Semi-Natural Woodland and Semi-Improved grassland to be included. Figure 10 shows the range of elements in the remaining 4 habitat types. Parkland and Verges have a greater range of habitat elements whilst the plantation and amenity grassland only have runs. Significant clusters are only present in parkland and networks are only evident in verges and amenity grassland but in very low numbers.

Figure 10 – Number of different elements in each broad habitat category

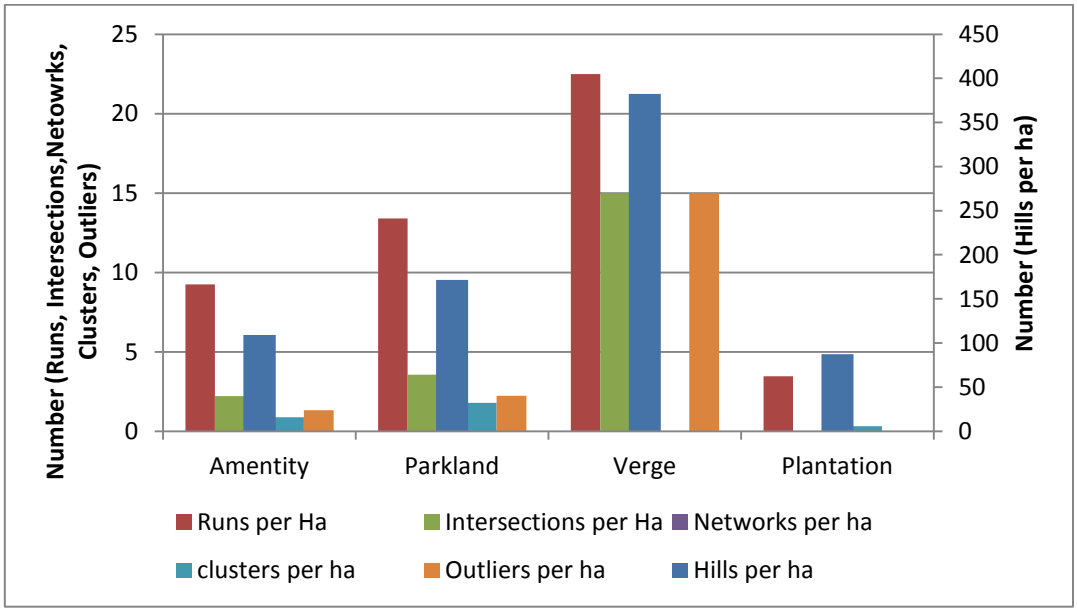
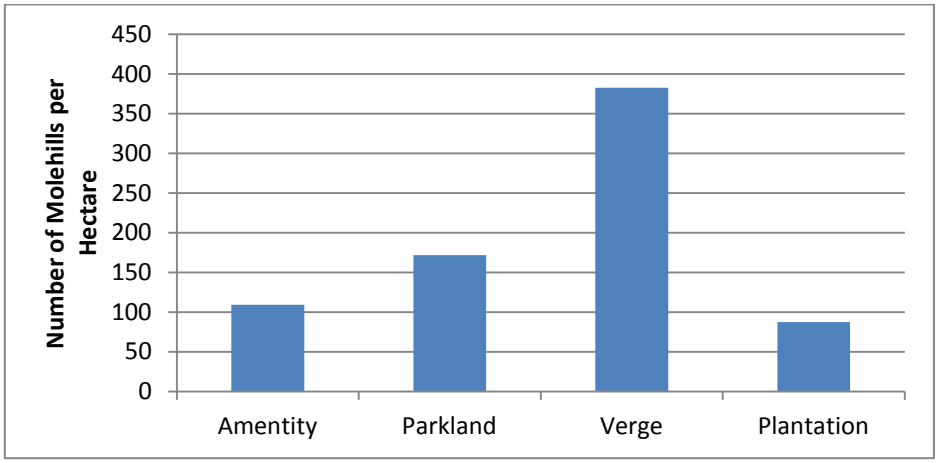


Figure 11 – Density of Molehills in each broad habitat category.



Hills

Figure 11 illustrates that Verge habitats have the greatest density of molehills with the other habitats having similar densities.

Runs

Figure 12 shows the variation in Run length between the broad habitat categories. It illustrates that plantations have greater run lengths whilst verges have the smallest.

The composition of these runs can be seen in Figure 13 that shows that as expected the total number of hills in a run and the number of hills per metre of run follow a similar pattern with Plantation having the greatest number although Parkland, Amenity Grassland and Verge habitats seem to have an equal balance.

In terms of the distance between hills the distance is not as short as one might assume given the number of hills. In parkland and verge these distances are proportionately larger.

Figure 12 – Mean length of Run in broad habitat categories

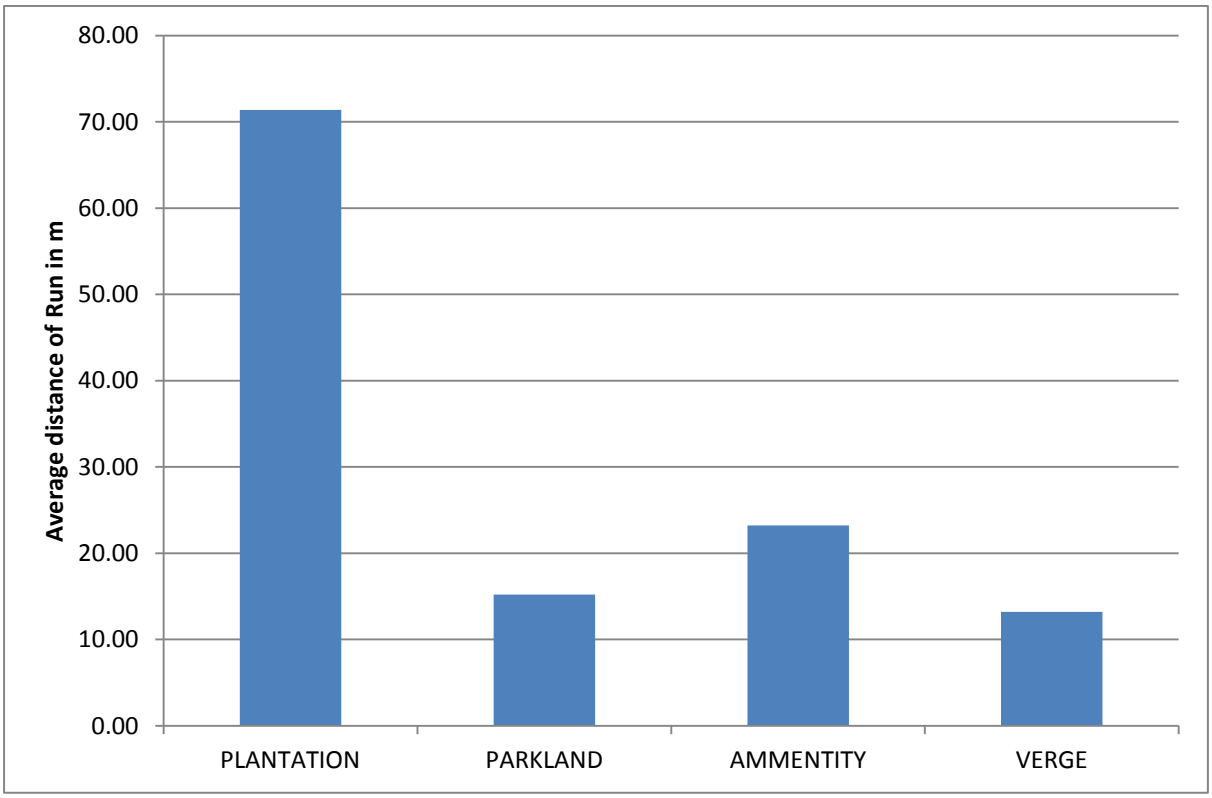
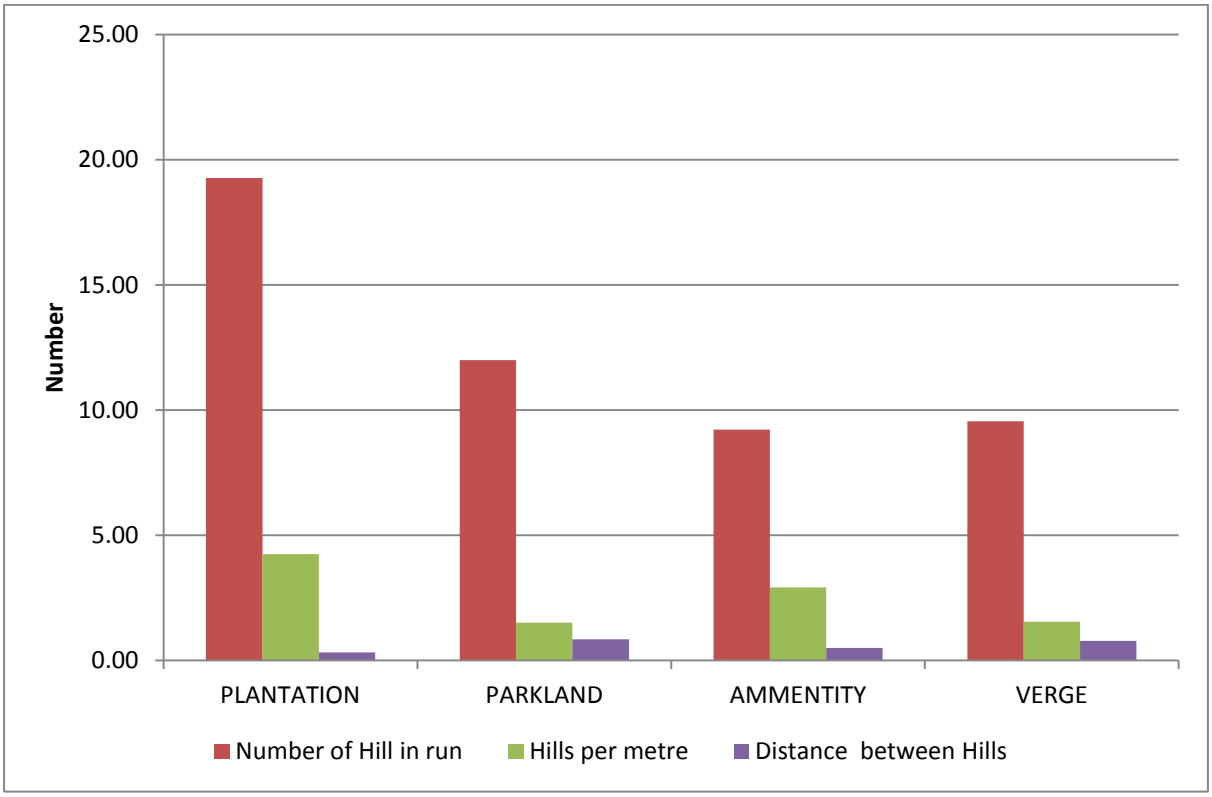


Figure 13 – Run Data in broad habitat categories

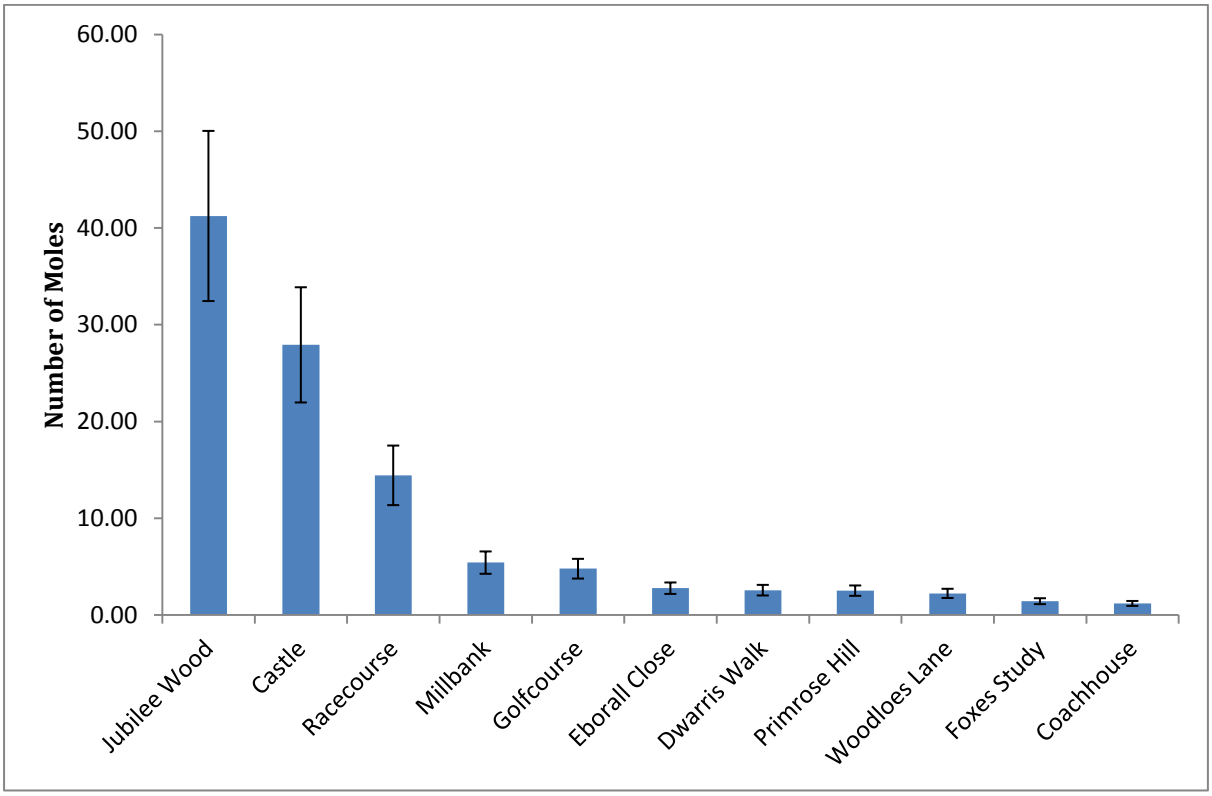


Basic Population Estimates

Population density is not a variable that can be assessed via the density of molehills (within an environment however there are much data on the possible density of moles per hectare for a range of habitat types and locations in the UK and abroad (Fumilayo, 1977; Stone, 1986; Gorman and Stone, 1990; Harris et al, 1995 MacDonald, 1995). Taking into account the variety of figures one can assign a range of between 5 and 25 individuals per ha. Figure 14 shows this in terms of separate colony sites. This calculation is based on only the area in which the moles are obviously using in this instance the extent of molehills as evidence of tunnel networks. The value derived ranges from 41 to 204 individuals with an average number for the survey area of 107 (StDev = 60.29) individual moles.

If moles were to occupy all of the available habitat within the study area at the same densities then the average total population would be 3952 individuals (1520-7600).

Figure 14 – Estimates of Population based on generic density data



Discussion

The identification of all molehills within the urban and sub-urban has identified four populations of moles. Each of these populations exist on the periphery of the town where their colonies either overlap or are adjacent to rural populations of moles. There are no moles identified within what can be understood to be the fully urbanised sections of the region.

The obvious limitation of the methodology in excluding the surveying of gardens naturally excludes the identification of moles in much of the area however given the dislike of moles by gardeners and the prevalence of gardens without lawns or open space suggests that any population is likely to be very small. Likewise the lack of any moles in Priory Park in the town centre suggests that the metalled roads and pavements provide a significant barrier to migration and colonisation.

Without analysis of the size and structure of the abutting rural populations it is unclear if the colonies identified are a distinct population unit or metapopulation units of a wider population.

Analysis of the locations of the molehills indicates a strong preference for deciduous plantation, verges and parkland. These habitat types are characterised in Warwick by either poor ground cover woodland with regularly planted young trees or open spaces of managed grassland interspersed with a range of trees of different ages. Many of the sites such as the Racecourse and Castle have been untouched by human impact for generations other areas such as the Woodloes population have been untouched for at least 30 years since the estate was constructed in the mid-1970's.

The impact of disturbance can be seen most clearly in the Castle population. Here the molehills are restricted to the steep bank sides along the river and upon the mound. No mounds are found on the main lawn where it is likely that gardening and active management occurs. Likewise moles on the Racecourse are confined to the hedge line rather than the actual track or the greens of the golf course. This is not to say that the verges and parkland are not managed at all but in these cases management is restricted to periodic mowing that only affects the structure of the colony at the level that some hills are flattened and it is possible that some tunnels collapse or are filled up.

Using aggregated density values we can broadly estimate a current population of 107 moles within the survey area with a capacity availability of 4000 individuals. The fact that more of the suitable habitat is not used, and it is unrealistic to expect the total capacity to be reached, suggests either that the suitable habitat is deficient in food, that expansion occurs outwardly from the survey area into the rural matrix or that some other population constraint is in action. As molehills are not a long term structure and reflect seasonal movements and expansions to tunnel networks future repeats of this study would enable us to begin to explore whether the populations in Warwick are static or whether they are more fluid with individuals or colonies moving around within a suitable habitat over time.

The structure of the colonies shows some variation depending on habitat type. The plantation population has the greatest number of molehills per meter of run which are closer together indicating greater excavation below ground. This is perhaps due to the quantity of roots that moles must navigate round or perhaps the scarcity of food available therefore requiring more foraging territory. The longest runs also occur in the plantation and tend to follow the rows of the trees where the roots will be the lightest. Elsewhere in the region trees encountered are usually solitary or in small groups. Here runs tend to be more curvilinear bending around trees or forming clusters around the base. The largest numbers of hills are found on verges where the structure of the open linear grassland promotes long uninterrupted runs.

Having now identified some interesting features of the mole populations in Warwick more can only be learned from future study. Repeated analysis of some of the populations might be able to assess how the arrangement of hills alters from year to year and give evidence of temperature effects over seasons. Analysis of each habitats invertebrate soil fauna would also help look at the relative value of each area to a population of moles.

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