

Belfast Hills Partnership

Belfast Hills

Mammal Survey 2008

Quercus Project QU07-14



An Irish hare © Neil Reid



A Member of the Bryson Charitable Group

Prepared for

Belfast Hills Partnership (BHP)

by

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Executive Summary

1. The Mammal Survey of the Belfast Hills was undertaken during early 2008. The main aim of the survey was to establish the extent and range of the Irish hare population at three study sites including Cave Hill Country Park, Divis and the Black Mountain and Slievenacloy Nature Reserve.
2. Two survey methods were employed to assess the distribution and abundance of Irish hares and other mammals. Droppings were recorded on randomly selected day-walked transects. Animals were directly observed during night-driven spotlight surveys.
3. No signs or sightings of Irish hare were recorded at either Cave Hill Country Park or Slievenacloy Nature Reserve.
4. Irish hares were recorded at Divis and the Black Mountain but at low densities. In total it was estimated that there were 6 hares (95%CI 4-9) present on the site. The distribution of signs and sightings suggest that hares range across the entire site but are most likely to occur in the north-east and north-west of the site.
5. Foxes were present at all three study sites and were as numerous as Irish hares at Divis and the Black Mountain (5 foxes on the site, 95%CI 2-9). Rabbits were present only at Cave Hill Country Park. Badgers and the field signs of stoats were recorded at Divis and the Black Mountain.
6. Species-specific habitat associations could not be inferred due to low sample sizes. However, the occurrence of Irish hares at Divis and the Black Mountain was consistent with their known association with diverse and structurally heterogeneous landscapes.

7. We make 5 recommendations for future monitoring, conservation action and research:

- a. Future monitoring should employ night-driven surveys rather than day surveys as they provide a higher rate of animal detections. Estimates of density and abundance are likely to be biased by low sample sizes and inaccurate assumptions. Future between-year comparisons should use a measure of relative abundance, for example, the number of animals observed per kilometre driven, rather than an estimate of absolute density.
- b. Creating and maintaining habitat structural heterogeneity at a scale smaller than 50ha is likely to benefit the Irish hare. Consideration should be given to rotational grazing, burning or rush topping as management options to create a 'habitat patch-work quilt' that provides high quality grazing (short species-rich swards) interspersed with heather or rush dominated heath or scrub (tall swards providing refuge).
- c. Effective predator control is likely to increase hare abundance. Fox removal is most likely to have greatest effect during late winter through to early summer.
- d. Conservation resources should be primarily invested at Divis and the Black Mountain, in an attempt to increase existing hare numbers, prior to the implementation of conservation strategies at other sites where the species does not occur.
- e. Proposed management prescriptions should undergo field trials to test their efficacy and cost-effectiveness prior to widespread implementation.

Contents

Executive Summary	3
Introduction	6
Methods	8
Results	16
Discussion	25
Recommendations	29
Acknowledgements	30
References	31

Introduction

The Belfast Hills Partnership (BHP) is an independent charity which seeks to improve the environmental management of the Belfast hills. The BHP has developed close partnerships with local councils, government departments, community groups, nature conservation organisations and businesses committed to the conservation of biodiversity and increasing public awareness of wildlife and environmental issues throughout the Belfast hills.

The Irish hare (*Lepus timidus hibernicus* Bell, 1837) attracted major conservation concern following a population decline in Northern Ireland during the 1980s and 1990s (Dingerkus & Montgomery, 2002; Reid, Montgomery & McDonald, 2007). It is the only native lagomorph in Ireland (Fairley, 2001; Hamill, 2001) and is currently classified as an endemic sub-species of the mountain hare (*L. timidus* Linnaeus, 1758). Nevertheless, it differs phenotypically, behaviourally, ecologically and genetically from other mountain hares and recent research suggests it may warrant full species status (Hughes *et al.* 2006).

In Northern Ireland, the Irish hare is protected under the Wildlife Order (NI) 1985 and annual amendments to the Game Preservation (Special Protection for Irish Hares) Order (Northern Ireland) 2003. It is also listed on Appendix III of the Bern Convention (Anon, 1979) and Annex V(a) of the EC Habitats Directive (92/43/EEC), and is listed as an internationally important species in the Irish Red Data Book (Whilde, 1993). Furthermore, subject to a local Northern Ireland and an All-Ireland Species Action Plan (Anon, 2000; 2005) it is one of the highest priority species for conservation action in Northern Ireland.

The current projects focuses on three sites within the Belfast Hills including Cave Hill Country Park owned and managed by Belfast City Council, Divis and the Black Mountain owned and managed by the National Trust and Slievenacloy Nature Reserve and ASSI owned and managed by the Ulster Wildlife Trust (Fig. 1).

Specifically, the aims of the project were to:

1. Establish the extent and range of the Irish hare population at the three study sites.
2. Provide recommendations on best management practise regarding hare populations at the three study sites including the identification of key actions required to protect and enhance the existing hare population.
3. Development of a framework for future monitoring of the Irish hare at the three sites.
4. Provide an increased understanding of the ecology of the Irish hare in the Belfast hills.

In addition to aims specific to Irish hares, the current study also examined two common species that are not of conservation interest but may influence Irish hare distribution and abundance through interspecific competition or predation: the European rabbit (*Oryctolagus cuniculus* L.) and red fox (*Vulpes vulpes* L.).

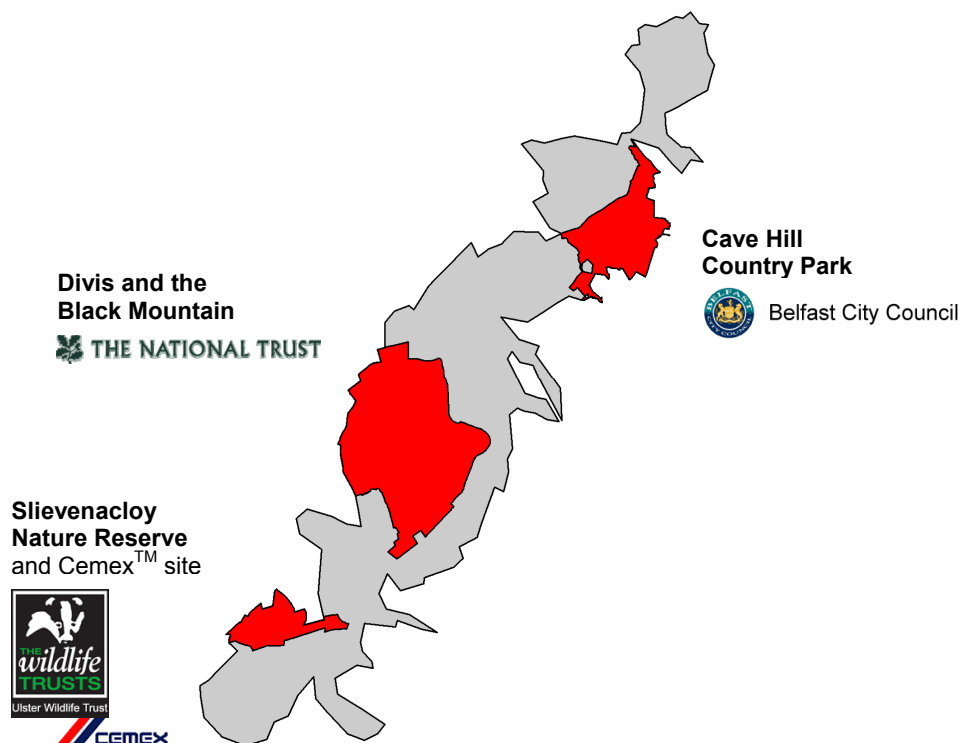


Fig. 1 The Belfast Hills Partnership management boundary (grey) and the three study sites (red) examined during the current project.

Methods

Survey sites

Cave Hill Country Park is the most northerly site and was divided into two distinct areas. The lowland section (183ha) consists of gardens, parkland and woodland surrounding Belfast Castle. The upland section (115ha) consists of heather dominated heath, grassland and scrub extending to 368 metres above sea level. Only the latter is suitable for Irish hares and thus surveys concentrated solely on the upland section of the site.

Land owned by the National Trust at Divis (478 metres above sea level) and the Black Mountain (390 metres above sea level) was treated as single 808ha site. The mountains comprise a mosaic of grassland and heath, dominated by heather and rushes.

Slievenacloy Nature Reserve is the most southerly site and is dominated by unimproved grassland, meadows and heath. The site is listed as an Area of Special Scientific Interest (ASSI) with designated features including fungi, lowland meadow and pasture, purple moor-grass and rush pasture. For the purposes of this study Slievenacloy Nature Reserve was grouped with a similar adjacent site owned by CemexTM creating a single 137ha study site.

In total, the combined surveyable area of all three study sites was 1,060ha.

Historical records

Sightings of Irish hares were collated from incidental records held by the Belfast Hills Partnership and CEDaR (Northern Ireland's Centre for Environmental Data and Recording). Records were mapped spatially using ArcGIS v9.2 (ESRI, Redlands, California, USA).

Day-walked surveys

Each site was divided into hectare squares based on subdivisions of the Irish National Grid system. The large number of squares on each site and their relatively small size

(100m²) made them impractical as a sampling basis for surveying mammal signs. Thus, each hectare was paired with three adjacent neighbours to create a 4ha tetrad. Tetrads that fell completely within each site were randomly selected to ensure that 50% of the total area of each survey site was surveyed. A diagonal transect 283m in length bisected each selected tetrad (Fig. 2). Thus, each site had equal coverage of survey effort per unit area.

Transects were walked during daylight hours and signs or sightings of mammal occurrence were recorded. Most mammal droppings were easily identified in the field (Fig. 3). Ambiguous samples were collected for further inspection and identification in the laboratory. Surveys were conducted during February and March when ground vegetation was minimal, maximising the detectability of signs. The location of each sign or sighting was recorded using a handheld GPS to an accuracy of a 10 figure grid reference. Each record was attributed to the tetrad in which the observation occurred.

Night-driven spotlight surveys

Each site had a number of private tracks that provided access to some or all of the site by vehicle (Fig. 4). Tracks were driven at 10-15km/h and surveyed using a 2 x 10⁶ candle-power spotlight from a platform on a high clearance vehicle. The observer systematically swept the spotlight 180 degrees on both sides of the track twice, working from the area closest to the vehicle towards the horizon.

For each mammal detection, the species, the location of the observer (taken as a 10 figure Irish grid reference using a handheld GPS), the cluster size (i.e. number of animals), the radial distance of the cluster from the observer (measured using a laser range finder; Leica LRF 900 scan) and the bearing of the cluster from the direction of travel (measured using a field compass) were recorded. The precise location of each animal was calculated using simple trigonometry of the radial distance and bearing of the cluster from the observer.

(a) Cave Hill Country Park

(b) Divis & Black Mountains

(c) Slievenacloy Nature Reserve

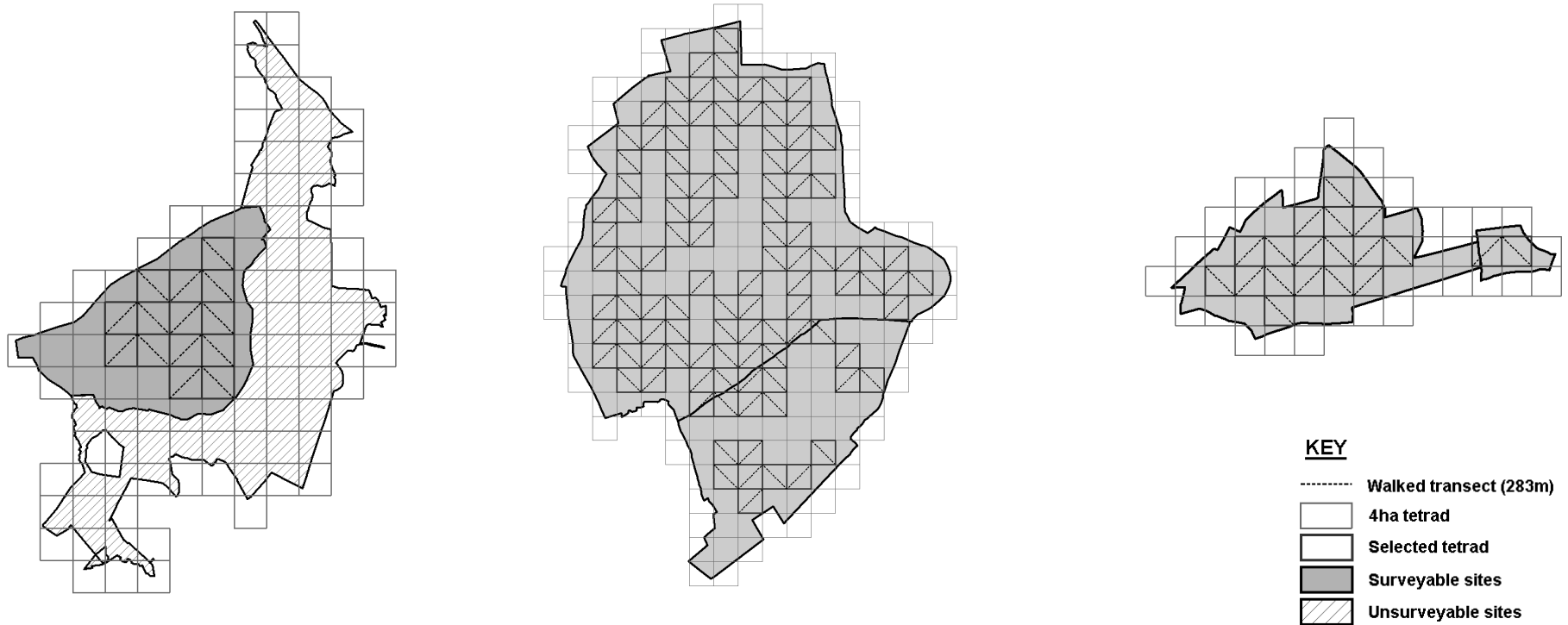


Fig. 2 Sampling protocol for day-walked surveys at **(a) Cave Hill Country Park**, **(b) Divis and the Black Mountain** and **(c) Slievenacloy Nature Reserve**. Each diagonal transect bisecting each 4ha square was 283m in length.

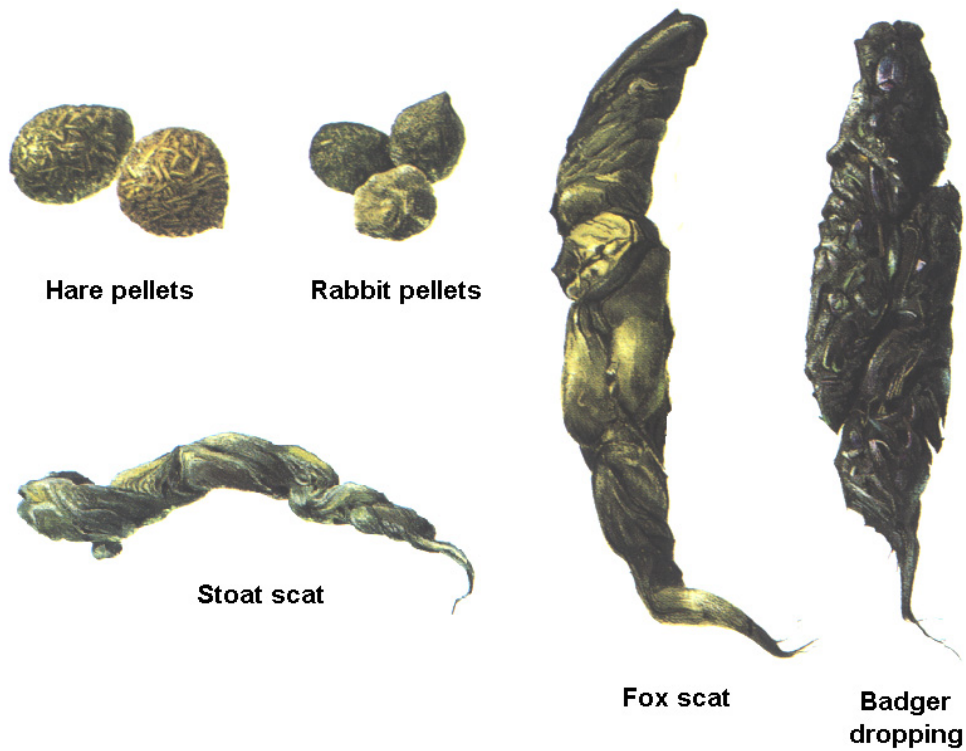


Fig. 3 Comparison of mammal droppings drawn to actual size.

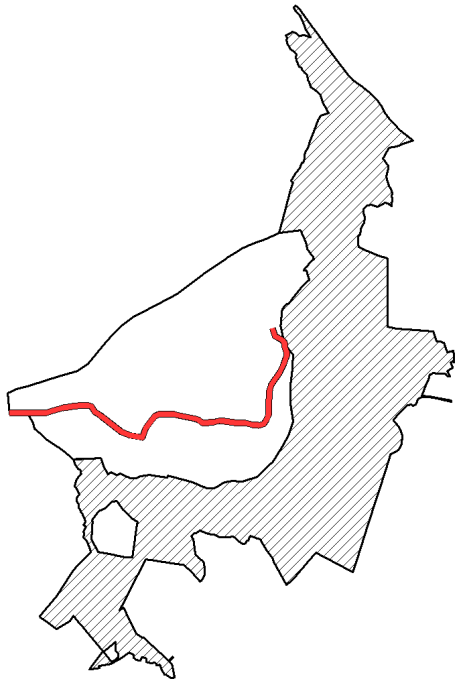
Five replicates of each navigable track were surveyed on five different nights. Surveys were conducted during early March when ground vegetation was minimal, maximising the detectability of animals. To ensure that nocturnal species would be active, surveys were not conducted until one hour after sunset.

Environmental data

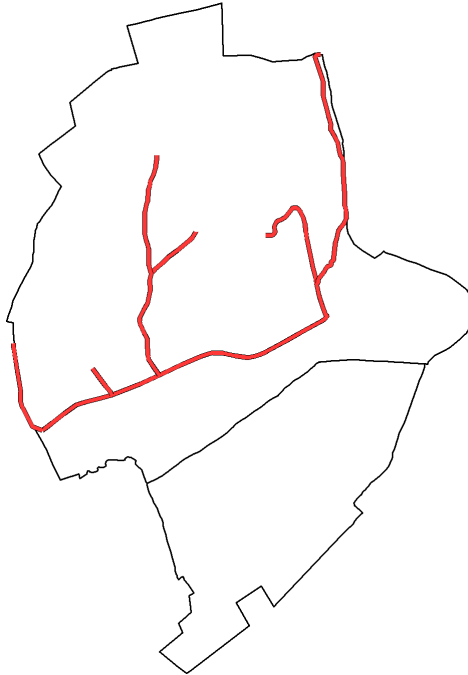
At the start, middle and end point of each day-walked transect the vegetation type (categorised as bracken, gorse, grass, heather, moss or rush) and its maximum height (cm) were recorded.

A geographic information system (GIS) was also used to gather environmental parameters using remotely-sensed data. Topographical data were derived from a Digital Elevation Model (DEM) of Northern Ireland and habitat variables were extracted from the Land Cover Map 2000.

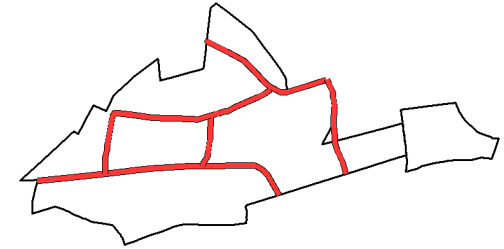
(a) Cave Hill Country Park



(b) Divis & Black Mountains



(c) Slievenacloy Nature Reserve



KEY

 Private track

Fig. 4 Tracks driven during night surveys at **(a)** Cave Hill Country Park, **(b)** Divis and the Black Mountain and **(c)** Slievenacloy Nature Reserve.

The choice of landscape variables chosen for inclusion in analyses were based on those shown to influence Irish hare distribution and abundance in previous studies (Jefferies, 1996; Dingerkus, 1997; Dingerkus & Montgomery, 2002; Strevens & Rochford, 2004; Reid, 2006; Reid & Montgomery, 2007; Reid, McDonald & Montgomery, 2007; Reid *et al.* 2007).

Statistical analyses

Descriptive statistics were used to summarise survey sightings for both the day-walked and night-driven surveys.

Locations of mammal signs or sightings were treated like radiotelemetry fixes using the Animal movement extension (USGS-BRD, Alaska Science Center, Anchorage, Alaska, USA) for Arcview GIS 3.3 software (ESRI, California, USA). Using signs and sightings separately a probabilistic kernel analysis (Worton, 1987) of locations using a smoothing parameter determined by least squares cross-validation (Silverman, 1986) was used to map the likelihood of detecting each species within each site.

Due to the low number of animal detections during night-driven surveys, population abundance could not be modelled using Distance[®] analysis. Instead, a relatively simple multiplicative model of animal abundance was employed. The mean number of animal observed per night was (\bar{x}_η) was calculated using the equation:

$$\bar{x}_\eta = \frac{\sum_{i=1}^5 n_i}{5} \quad \text{Equation 1}$$

where n equalled the number of animals observed on night i (ranging from 1 to 5). For comparability between sites, the mean number of animals observed per night was standardised for effort (\bar{x}_λ) i.e. the length of track surveyed per site:

$$\bar{x}_\lambda = \frac{\sum_{i=1}^5 n_i}{\sum_{i=1}^5 d_i} \quad \text{Equation 2}$$

where n equalled the number of animals observed on night i (ranging from 1 to 5) and d equalled the length of track surveyed in km on night i (ranging from 1 to 5).

For each species, the total length of track surveyed ($\sum_{i=1}^5 d_i$) was multiplied by the maximum radial distance (r_{\max}) at which that species was observed at each site. Thus, the mean density of each species per km² (\bar{x}_γ) was calculated using:

$$\bar{x}_\gamma = \frac{\sum_{i=1}^5 n_i}{r_{\max} \sum_{i=1}^5 d_i} \quad \text{Equation 3}$$

The 95% confidence limits for each mean was calculated in the standard fashion:

$$\text{Confidence limits} = \bar{x} \pm 1.96s.e. \quad \text{Equation 4}$$

where $s.e.$ is the standard error of the mean assuming a normal distribution.

An estimate of the total abundance of each species within each site was obtained by multiplying the mean estimated density of each species by the total area of the site.

Due to the low number of animal detections during night-driven surveys it was not possible to analyse species-specific habitat selectivity using standard compositional analysis. Moreover, species-specific analysis of habitat associations with rabbit and fox occurrence during day-walked surveys was not possible due to the low number of survey tetrads positive for either species.

A higher incidence of Irish hare occurrence, as defined by the presence of droppings in survey tetrads, did allow analysis of habitat associations using a generalized linear model assuming a Binomial error distribution and a logit link function (Table 1). Percentage data on the prevalence of habitat types within survey tetrads were arcsine square-root transformed (Hosmer & Lemeshow 2000). All possible model permutations

Table 1 *Environmental variables included in a generalised linear model of Irish hare occurrence.*

Explanatory variable	Description
Altitude	Mean elevation of each survey tetrad taken from a Digital Elevation Model (DEM) of Northern Ireland.
Dense dwarf scrub heath	Proportion of each survey tetrad classed as dense dwarf scrub heath. Calculated from Land Cover Map 2000 (LCM2000).
Habitat patch edge density	Cumulative length of habitat patch edges per ha.
Maximum vegetation height	Mean maximum height of vegetation in centimetres per survey tetrad. Calculated using the kriging function of the Spatial Analyst tool in ArcGIS v9.2 from survey points at the start, middle and end of each survey transect walked during day surveys.
Neutral grassland	Proportion of each survey tetrad classed as neutral grassland. Calculated from Land Cover Map 2000 (LCM2000).
Number of habitat patches	Number of patches of different kinds of habitat per survey tetrad.
Open dwarf scrub heath	Proportion of each survey tetrad classed as open scrub heath. Calculated from Land Cover Map 2000 (LCM2000).
Shannon's Diversity Index	Measure of the diversity of habitat types per survey tetrad.
Site	Categorical variable including Cave Hill Country Park, Divis and the Black Mountain and Slievenacloy Nature Reserve.
Slope	Mean gradient in degrees of each survey tetrad. Calculated from a Digital Elevation Model (DEM) of Northern Ireland using the ArcSlope function in ArcGIS v9.2.

were created and ranked using the Akaike Information Criterion (AIC; Akaike 1983).

The Akaike weight (w_i) of each model was calculated within the top set of N models, where the cumulated value of $\sum w_i \leq 0.95$ (Burnham & Anderson, 2002). To calculate the relative importance of each variable relative to all other variables, the $\sum w_i$ of all models within the top set of models that contained the variable of interest was calculated and the variables ranked by $\sum w_i$ (McAlpine *et al.*, 2006). The larger the value of $\sum w_i$ which varies between 0-1, the more important the variable. The effect size (β coefficient) of each variable in the global model was taken as a measure of the direction of influence of that variable. To allow the direct comparison of regression coefficients, variables were standardized to have a $\bar{x} = 0$ and a $\sigma = 1$ prior to analysis (Schmitz *et al.*, 2004).

All statistical analyses were conducted using GenStat v6 and, unless otherwise stated, all GIS analyses were conducted using ArcGIS v9.2 (ESRI, Redlands, California, USA).

Results

Five mammal species were detected at three study sites in the Belfast Hills; however, not all species were present at each site (Table 2).

Rabbit pellets were found in 4 survey tetrads (3%), but were confined to Cave Hill Country Park. Seven rabbits were recorded during night-driven surveys and were confined to Cave Hill Country Park. The distribution of spatial activity determined by pellet counts and animal sightings suggested that rabbits were restricted to the southern slopes of Cave Hill Country Park only (Fig. 5). Rabbits were not detected at Divis and the Black Mountain or Slievenacloy Nature Reserve (Figs. 6 & 7).

Irish hares sightings were recorded at Divis and the Black Mountain and Slievenacloy Nature Reserve from 1997 to 2005 (Fig. 8). During 2008, Irish hare pellets were found in 23 survey tetrads (18%) but were confined to Divis and the Black Mountain. Twelve Irish hares were recorded, but were confined again to Divis and the Black Mountain (3 during day-walked surveys and 9 during night-driven surveys). The distribution of spatial activity determined by pellet counts and animal sightings suggested that Irish hares ranged across the whole of the Divis and the Black Mountain site but are most likely to be found in the north-east and north-west of the site (Fig. 6). Irish hares were not recorded at Cave Hill Country Park or Slievenacloy Nature Reserve. If the species is present at these sites, densities are such that they remain undetectable.

Fox scat was found in 5 survey tetrads (4%) but was confined to Divis and the Black Mountain. Nineteen foxes were observed (1 during day-walked surveys and 18 during night-driven surveys) and were recorded at all three study sites (Fig. 5, 6 & 7). The distribution of spatial activity determined by scat counts and animal sightings and the known ubiquity of fox distribution and the size of fox home ranges (Fairley, 2001) suggests that they are likely to range widely across all three study sites.

A stoat scat was recovered from Divis and the Black Mountain near the BBC television aerial and 2 badgers were observed in the north-west of the site during night-driven surveys.

Table 2 Species list for each study site during 2008.

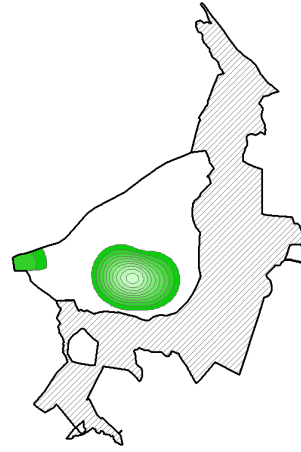
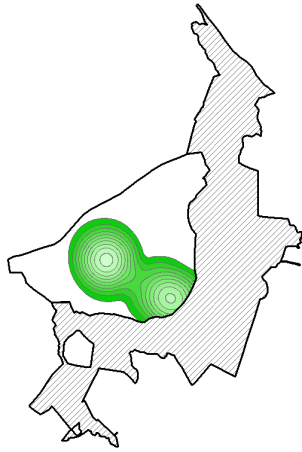
Site	# spp. detected	Species	Scientific name
Cave Hill Country Park	2	European rabbit	<i>Oryctolagus cuniculus</i>
		Red fox	<i>Vulpes vulpes</i>
Divis and the Black Mountain	4	Irish hare	<i>Lepus timidus hibernicus</i>
		Red fox	<i>Vulpes vulpes</i>
		Badger	<i>Meles meles</i>
		Stoat	<i>Mustela erminea</i>
Slievenacloy Nature Reserve	1	Red fox	<i>Vulpes vulpes</i>

The estimated density of Irish hares at Divis and the Black Mountain, notwithstanding likely sources of error, was calculated to be 0.79 hares.km⁻² (95% CI 0.47-1.11) giving a total estimated abundance of 6 hares (95% CI 4-9) on the site (Table 3). The estimated density of foxes at Divis and the Black Mountain, notwithstanding likely sources of error, was calculated to be 0.66 foxes.km⁻² (95% CI 0.26-1.06) giving a total estimated abundance of 5 foxes (95% CI 2-9) on the site (Table 3). We can have little confidence in estimates of density or total abundance for rabbits or foxes at Cave Hill Country Park or foxes at Slievenacloy Nature Reserve as the 95% confidence limits of each estimate encompassed the value zero (Table 3).

No landscape or habitat variables significantly influenced the probability of the incidence of Irish hare droppings within survey tetrads except the factor site (Fig. 9). Divis and the Black Mountain had a greater diversity of habitats types (using Land Cover Map 2000) than either Cave Hill Country Park or Slievenacloy Nature Reserve (Fig. 10). Divis and the Black Mountain also had a greater degree of habitat patchiness and habitat structural heterogeneity, in terms of small scale variation in maximum vegetation height (determined using field-derived data), than either Cave Hill Country Park or Slievenacloy Nature Reserve (Fig. 10).

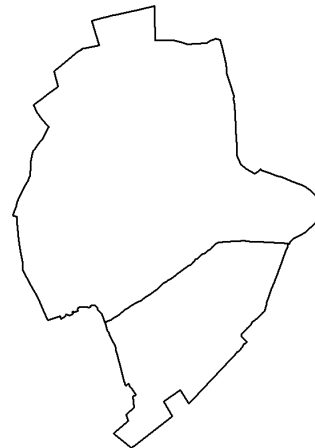
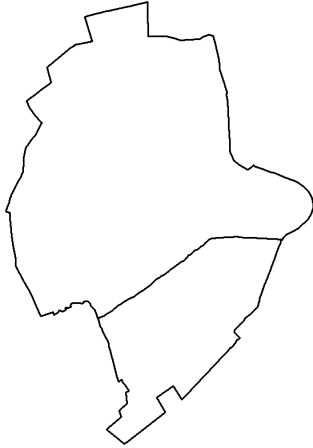
(a) Cave Hill Country Park
Rabbit pellet clusters (n=6)

Rabbit sightings (n=7)



(b) Divis and the Black Mountain
Rabbit pellet clusters (n=0)

Rabbit sightings (n=0)

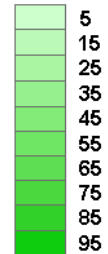


(c) Slievenacloy Nature Reserve
Rabbit pellet clusters (n=0)

Rabbit sightings (n=0)



KEY
% of records

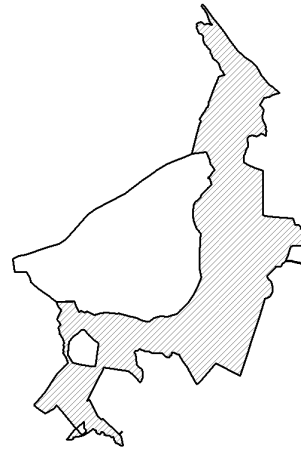
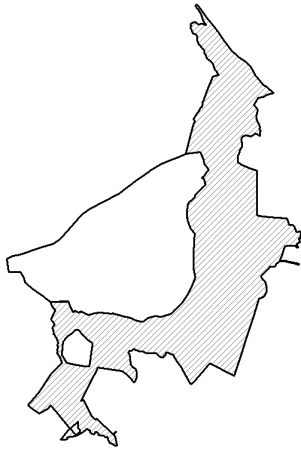


Surveyed area
Unsurveyed area

Fig. 5 A probabilistic measure of the spatial activity of rabbits determined by pellet counts during day-walked surveys and animal sightings during night-driven surveys calculated using kernel analysis for **(a)** Cave Hill Country Park, **(b)** Divis and the Black Mountain and **(c)** Slievenacloy Nature Reserve

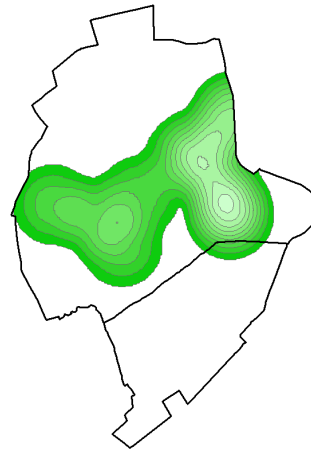
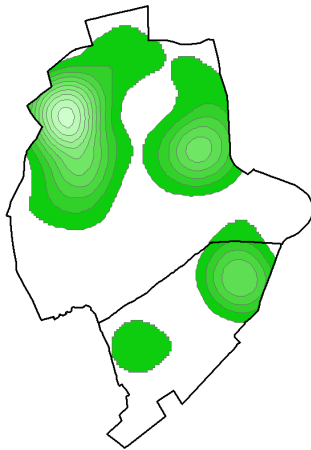
(a) Cave Hill Country Park
Irish hare pellet clusters (n=0)

Irish hare sightings (n=0)



(b) Divis and the Black Mountain
Irish hare pellet clusters (n=73)

Irish hare sightings (n=12)



(c) Slievenacloy Nature Reserve
Irish hare pellet clusters (n=0)

Irish hare sightings (n=0)

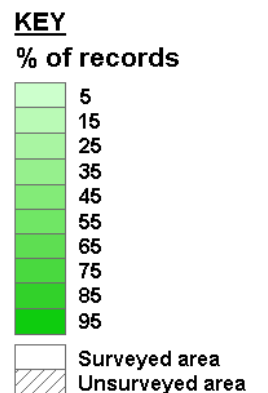
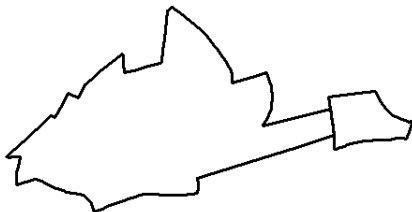
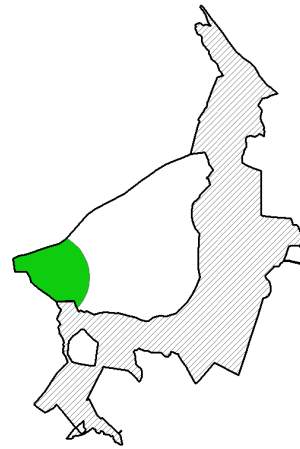
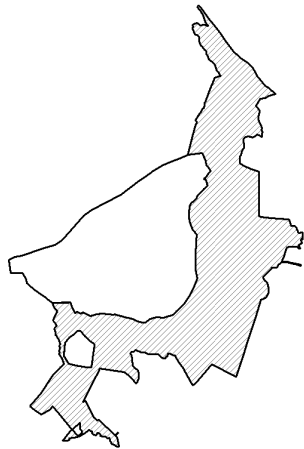


Fig. 6 A probabilistic measure of the spatial activity of Irish hares determined by pellet counts during day-walked surveys and animal sightings during night-driven surveys calculated using kernel analysis for **(a)** Cave Hill Country Park, **(b)** Divis and the Black Mountain and **(c)** Slievenacloy Nature Reserve.

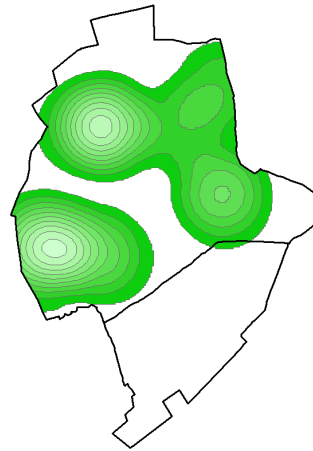
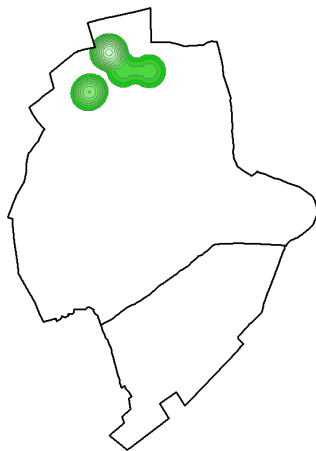
(a) Cave Hill Country Park
Fox scat (n=0)

Fox sightings (n=2)



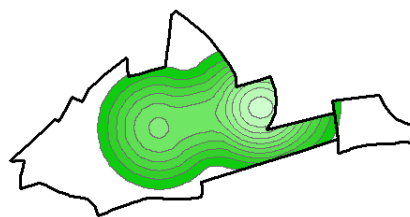
(b) Divis and the Black Mountain
Fox scat (n=7)

Fox sightings (n=15)

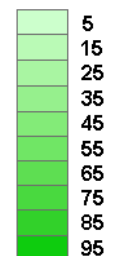


(c) Slievenacloy Nature Reserve
Fox scat (n=0)

Fox sightings (n=2)



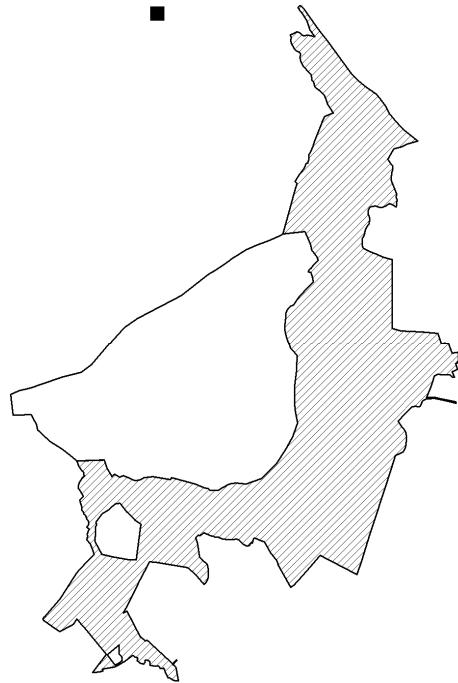
KEY
% of records



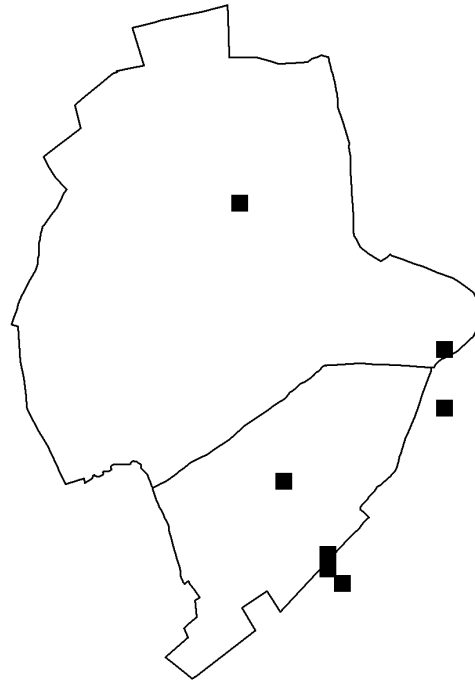
Surveyed area
Unsurveyed area

Fig. 7 A probabilistic measure of the spatial activity of foxes determined by scat counts during day-walked surveys and animal sightings during night-driven surveys calculated using kernel analysis for (a) Cave Hill Country Park, (b) Divis and the Black Mountain and (c) Slievenacloy Nature Reserve.

(a) Cave Hill Country Park



(b) Divis & Black Mountains



(c) Slievenacloy Nature Reserve

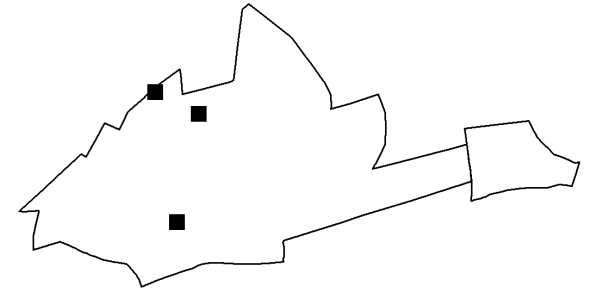


Fig. 8 Historical records of Irish hare sightings (black squares) between 1997 and 2005 at **(a) Cave Hill Country Park**, **(b) Divis and the Black Mountain** and **(c) Slievenacloy Nature Reserve**.

Table 3 Measures of relative abundance, estimated density and total abundance for three common mammal species during early 2008 at three sites within the Belfast Hills (mean figures are accompanied with 95% confidence intervals in parenthesis). Estimates of total abundance have been rounded to the nearest whole value.

Site	Species	Mean number observed per night (animals)	Max. number observed per night (animals)	Transect length (km)	Mean number per unit effort (animals.km ⁻¹)	Max. detection distance (m)	Area surveyed (ha)	Mean density (animals.km ⁻²)	Mean total estimated abundance (animals.site)
Cave Hill Country Park* (Belfast City Council)	Rabbits	1.40 (0.62 - 2.18)	2	1.99	0.70 (0.31 - 1.10)	139	55.48	2.52 (1.11 - 3.94)	3 (0 - 5) [†]
	Foxes	0.40 (0.00 - 1.18)	2	1.99	0.20 (0.00 - 0.59)	62	24.54	1.63 (0.00 - 4.83)	1 (0 - 3) [†]
	Irish hares	0.00 (0.00 - 0.00)	0	1.99	0.00 (0.00 - 0.00)	0	0.00	0.00 (0.00 - 0.00)	0 (0 - 0)
Divis & Black Mountain (The National Trust)	Rabbits	0.00 (0.00 - 0.00)	0	7.87	0.00 (0.00 - 0.00)	0	0.00	0.00 (0.00 - 0.00)	0 (0 - 0)
	Foxes	2.80 (1.11 - 4.49)	6	7.87	0.36 (0.14 - 0.57)	373	422.08	0.66 (0.26 - 1.06)	5 (2 - 9)
	Irish hares	1.80 (1.07 - 2.53)	3	7.87	0.23 (0.14 - 0.32)	167	228.46	0.79 (0.47 - 1.11)	6 (4 - 9)
Slievenacloy Nature Reserve (Ulster Wildlife Trust)	Rabbits	0.00 (0.00 - 0.00)	0	4.17	0.00 (0.00 - 0.00)	0	0.00	0.00 (0.00 - 0.00)	0 (0 - 0)
	Foxes	0.40 (0.00 - 0.88)	1	4.17	0.10 (0.00 - 0.21)	133	85.56	0.47 (0.13 - 0.81)	1 (0 - 1) [†]
	Irish hares	0.00 (0.00 - 0.00)	0	4.17	0.00 (0.00 - 0.00)	0	0.00	0.00 (0.00 - 0.00)	0 (0 - 0)

[†] 95% confidence intervals that include zero indicate poor reliability of population estimation.

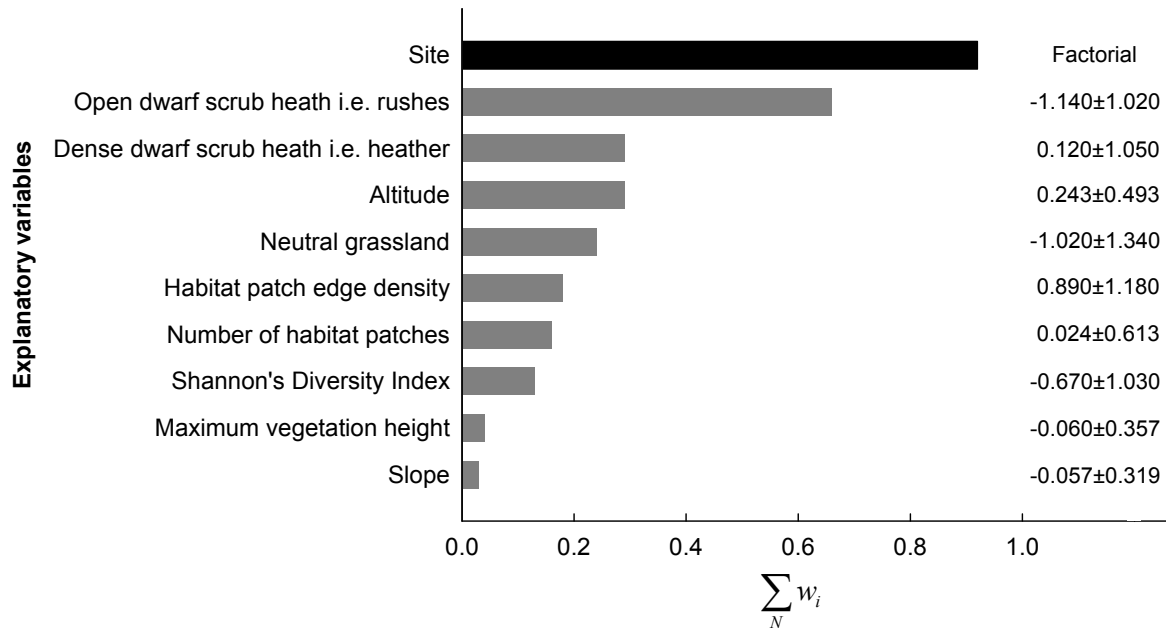


Fig. 9 Relative importance of factors in explaining variation in the occurrence of Irish hare droppings within survey tetrads. Variables are ranked in order of the sum of their Akaike weights ($\sum w_i$) within the top 95% set of models. Black bars indicate those variables that had consistent effects and were significant at a $p < 0.05$ level in the best single approximating model (i.e. that with the lowest AIC value). Grey bars indicate variables included in all other models within the top set that were not significant at $p < 0.05$. Notation to the right indicates the direction and strength of the slopes for each standardized covariate.

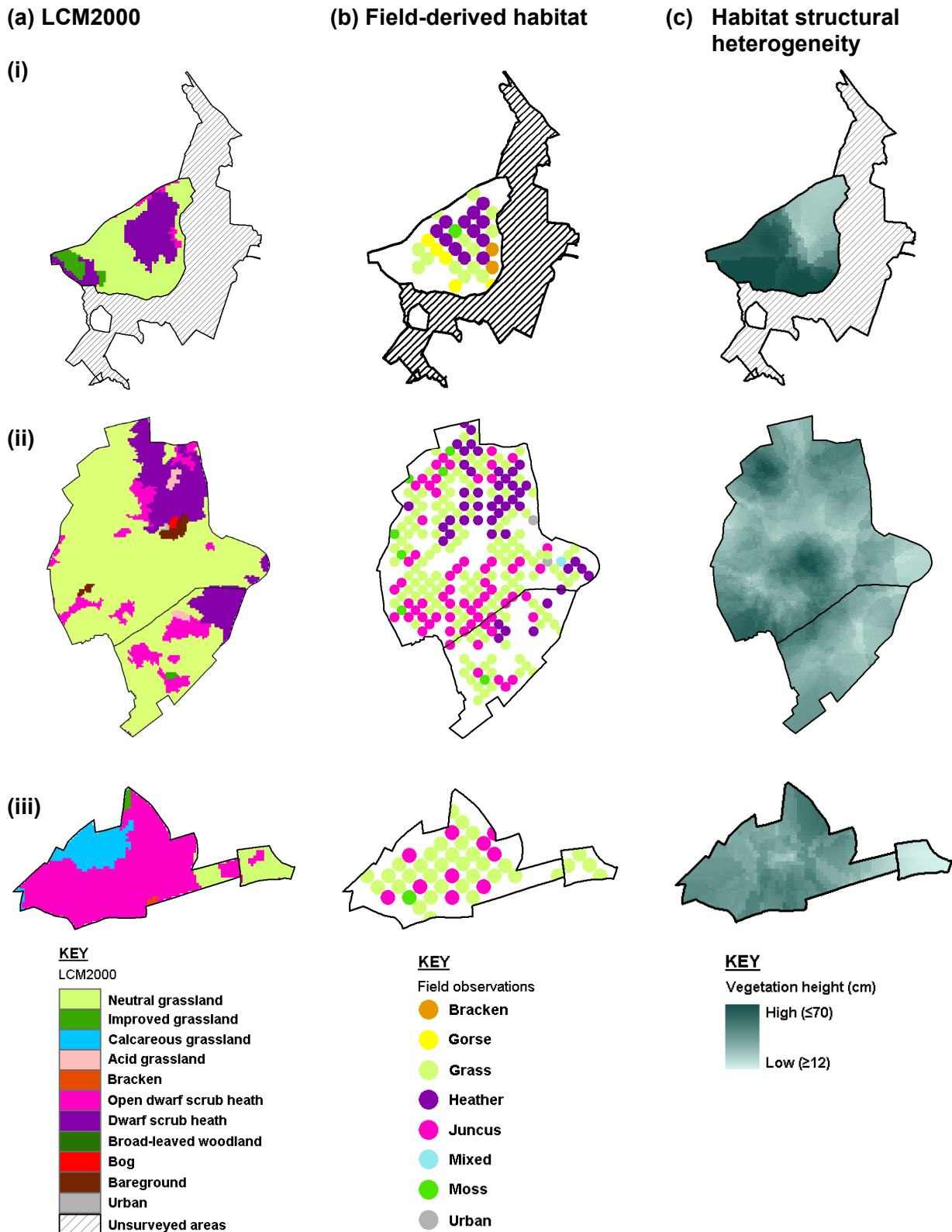


Fig. 10 The distribution of habitat types determined by (a) Land Cover Map 2000 and (b) field-derived observations plus (c) habitat structural heterogeneity, in terms of variation in the maximum vegetation height calculated by ArcGIS kriging for (i) Cave Hill Country Park, (ii) Divis and the Black Mountain and (iii) Slievenacloy Nature Reserve. NB. Land Cover Map 2000 habitat classification for Slievenacloy Nature Reserve did not match field-derived habitat classification demonstrating the need to ground truth remotely-sensed satellite data.

Discussion

Dung counts and nocturnal spotlight surveys are well established approaches to estimating mammal populations (Krebs *et al.* 1987; Langbein *et al.* 1999; Krebs *et al.* 2001). The current study has successfully established the incidence and abundance of the Irish hare across three sites in the Belfast hills.

Whilst there is always the possibility of occasional sightings of vagrant animals, current results suggest that neither Cave Hill Country Park nor Slievenacloy Nature Reserve support extant populations of Irish hare. If the species is present at these sites, densities are such that they remain undetectable. The reasons for the species low density or absence at these sites remain unclear but it seems likely that they do not provide suitable hare habitat.

Irish hares are present at Divis and the Black Mountain but at low densities. Current estimates suggest that no more than a total of 9 hares occur on the site. Estimates of animal density or abundance that incorporate assumptions about the detectability of animals with distance from the vehicle are likely to be unreliable. Animals may be present but remain undetected due to the obscurity of the vegetation or undulations in the terrain. Furthermore, small sample sizes make reliance on the maximum distance to observations unreliable. Therefore, estimates of density or total abundance presented here should be treated with caution and should only be used as a rule of thumb.

With respect to future monitoring, night-driven surveys provided a greater number of animal observations over a shorter survey period than day-walked surveys. Temporal comparisons in future should rely on a measure of relative abundance that does not make assumptions about detectability of animals with distance from the vehicle e.g. the number of animals observed per unit effort (mean number of animals per kilometre driven).

Whilst the estimated abundance of Irish hares at Divis and the Black Mountain is small relative to the overall hare population of Northern Ireland, the occurrence of such high priority species raises important conservation issues with regard to site management.

Divis and the Black Mountain had a greater diversity of habitats types and a greater degree of habitat patchiness and structural heterogeneity than either Cave Hill Country Park or Slievenacloy Nature Reserve. Due to small sample sizes, it was not possible to attribute the incidence of Irish hare to any of these feature statistically. However, it seems likely that such features may contribute to Irish hare occurrence and abundance.

Divis and the Black Mountain are dominated by neutral grassland, ideal grazing habitat for hares (Reid, McDonald & Montgomery, 2007). Areas of open dwarf scrub heath, dominated by rushes, and dense dwarf scrub heath, dominated by heather, are likely to provide hares with shelter from the elements and cover from predators. Habitat heterogeneity is important to hares as they often move between areas that provide high quality forage at night and those that provide refuge during the day (Reid, 2006). Heterogeneity of habitat types is required on a scale smaller than the average Irish hare's home range (5-50ha; Reid, 2006). Loss of cohesive small scale habitat patches is likely to have a negative impact on hare populations (Smith *et al.* 2004; Reid *et al.* 2007). The relative homogeneity of habitat structure at Cave Hill Country Park and Slievenacloy Nature Reserve may make the sites less favourable for the Irish hare. Smith *et al.* (2004) suggested the promotion of habitat structural heterogeneity at the within-site level is likely to benefit not only hares but biodiversity as a whole, providing a variety of species, including plants and invertebrates, with resources at different times (Vickery *et al.*, 1999; Robinson & Sutherland, 2002; Benton, Vickery & Wilson, 2003).

Land management prescriptions can be successfully tailored to meet the needs of particular species (Evans, 1997; Peach *et al.* 2001) provided their specific requirements are taken into account (Bayliss, Simonite & Thompson, 2005). If increases in Irish hare abundance, consistent with the aims of the Irish hare Species Action Plan, are to be achieved, site-specific management prescriptions will need to be developed and implemented. Conservation strategies should aim to increase the availability of patches

of high-quality neutral grassland adjacent to patches of rush or heather dominated heath or scrub. Prescriptive management of rushes, particularly in areas that have become rank, might include rotational grazing, burning or rush topping. In order to be cost-effective, such measures should undergo field trials to test their efficacy, prior to widespread implementation on any site. Consideration should be given to the relative merits of investing conservation resources in sites that do not currently support Irish hares, in an attempt to encourage the species' return, compared to sites where the species is currently extant, in an attempt to increase hare abundance.

The impact of livestock disturbance on hare density remains unclear. Whilst there is a large body of literature that suggests hares avoid livestock (Pielowski & Pucek, 1976; Barnes, Tapper & Williams, 1983; Whelan, 1985; Pépin, 1985; Hewson, 1990; Hutchings & Harris, 1995; Dingerkus, 1997), recent research suggests that they are largely unaffected (McLaren, Hutchings & Harris, 1997; Vaughan *et al.*, 2003; Smith *et al.* 2004). Indeed, some authors suggest that grassland management using livestock grazing may actually increase hare density (Karmiris & Nastis, 2007). The three sites examined here are grazed at low livestock stocking densities. Irish hare densities are highest in areas of pastoral farmland (Reid *et al.* 2007). It, therefore, seems unlikely that the low livestock stocking densities at each of the three sites examined will have any negative affect on hare density.

Disturbance by dogs can take two forms; unintentional disturbance by dog walkers and intention disturbance by illegal poaching using lurchers. The level of disturbance to hares by dogs in the Belfast hills is currently unknown. Anecdotally, of the three sites, Cave Hill Country Park has the highest level of visitor use. Whilst, Slievenacloy Nature Reserve has a relatively low number of visitors it has a high proportion of dog walkers. However, there is no evidence that disturbance is a contributing factor to the apparent absence of hares at these sites.

There is strong evidence that predation by foxes at high density negatively affects hare abundance. Lagomorphs constitute between 10-52% of the diet of foxes throughout the British Isles (Looney, 2001; O'Mahony, 2003; Webbon *et al.* 2006). Rabbits make up the

vast majority of this but some hares, mainly leverets, are taken (Reynolds & Tapper 1995). Vaughan *et al.* (2003) suggested that hares were less abundant in areas where foxes were seen frequently. The association of hare abundance and low numbers of foxes is consistent with the hypothesis that predation by foxes may limit hare numbers directly influencing juvenile recruitment (Lindström *et al.* 1994; Reynolds & Tapper 1995). A natural experiment caused by a sarcoptic mange epidemic in foxes demonstrated that partial predator removal can result in an increase in hare abundance (Lindström *et al.* 1994). It, therefore, seems likely that effective predator control, particularly during late winter through to early summer when leverets are at their most vulnerable, may benefit hare abundance. Successful fox management is likely to benefit biodiversity in general as foxes are likely to impact other animal species of conservation priority, particularly ground nesting birds (O'Mahony, 2003).

Whilst the current study focused on three specific sites, it is probable that populations of Irish hare exist in areas suitable habitat throughout the Belfast Hills system. Therefore, thought should be given to the wider implementation of recommended land management prescriptions beyond the boundaries of the sites examined and across the Belfast Hills system as a whole.

Recommendations

With respect to the Irish hare we make 5 broad recommendations for future monitoring, conservation action and research:

1. Future monitoring should employ night-driven surveys rather than day surveys as they provide a higher rate of animal detections. Estimates of density and abundance are likely to be biased by low sample sizes and inaccurate assumptions. Future between-year comparisons should use a measure of relative abundance, for example, the number of animals observed per kilometre driven, rather than an estimate of absolute density.
2. Creating and maintaining habitat structural heterogeneity at a scale smaller than 50ha is likely to benefit the Irish hare. Consideration should be given to rotational grazing, burning or rush topping as management options to create a 'habitat patch-work quilt' that provides high quality grazing (short species-rich swards) interspersed with heather or rush dominated heath or scrub (tall swards providing refuge).
3. Effective predator control is likely to increase hare abundance. Fox removal is most likely to have greatest effect during late winter through to early summer.
4. Conservation resources should be invested primarily at Divis and the Black Mountain, in an attempt to increase existing hare numbers, prior to the implementation of conservation strategies at other sites where the species does not occur.
5. Proposed management prescriptions should undergo field trials to test their efficacy and cost-effectiveness prior to widespread implementation.

See **Appendix 1** for a short report outlining management objectives in keeping with the Irish hare Biodiversity Action Plan targets and objectives with specific actions.

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Appendix 1 - Site management and monitoring recommendations for the Irish hare in the Belfast Hills

The Irish hare is one of the highest priority species for conservation action in Northern Ireland. The Belfast Hills Mammal Survey¹ established that a small population of hares were present at Divis and the Black Mountain during early 2008. It is likely that there were no more than 9 hares on the site (estimated range 4-9 hares). No hares were detected at Cave Hill Country Park or Slievenacloy Nature Reserve.



An Irish hare © Neil Reid

Future site management prescriptions should aim to contribute to the targets set out in the Irish hare Species Action Plan² to maintain the existing range of Irish hares, demonstrate a population increase by 2010 and maintain and increase the area and quality of suitable hare habitat.

Management aims: Create and maintain habitat structural heterogeneity at a scale beneficial to individual hares. Specially, provide areas of good quality grazing (short species-rich swards) adjacent to areas that provide refuge such as heather or rush dominated heath or scrub (tall vegetation). Increase population recruitment by effective predator control.

Recommendations:

- Selected Irish hare management units should be ≤50ha.
- Consideration should be given to rotational grazing, burning or rush topping within selected management units to create a 'habitat patchwork quilt' effect.
- Maintain species-rich grassland and heath.
- Rush control should be undertaken within management units where cover ≥50%. Herbicide should not be used.
- No field operations using machinery from 1st January to 30th June.
- Effective predator control, particularly from 1st January to 30th June.
- Management prescriptions should undergo field trials to test efficacy prior to widespread implementation.

Population monitoring: Night-driven surveys provide a higher rate of animal detection than day-walked surveys. It is recommended that between-year comparisons should use a measure of relative abundance, for example, the number of animals observed per kilometre driven, rather than an estimate of absolute density, as these are likely to be negatively biased.

¹ Reid, N., Kessopersadh, A. & Montgomery, W.I. (2008) *Belfast Hills Mammal Survey 2008*. Report prepared by Quercus for the Belfast Hills Partnership, Northern Ireland, UK.

² Anonymous (2000) *Biodiversity in Northern Ireland: Species Action Plans - Irish Hare, Chough & Curlew*. Environment and Heritage Service NI. pp6-9, Department of Environment. Belfast. UK.