



**QUEEN'S
UNIVERSITY
BELFAST**

Integrating field sports, hare population management and conservation

Reid, N., Magee, C., & Montgomery, I. (2010). Integrating field sports, hare population management and conservation. *ACTA THERIOLOGICA*, 55(1), 61-71. DOI: 10.4098/j.at.0001-7051.030.2009

Published in:
ACTA THERIOLOGICA

Queen's University Belfast - Research Portal:
[Link to publication record in Queen's University Belfast Research Portal](#)

General rights

Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact openaccess@qub.ac.uk.

Integrating field sports, hare population management and conservation

Neil REID, Ciarán MAGEE and W. Ian MONTGOMERY

Reid N., Magee C. and Montgomery W. I. 2010. Integrating field sports, hare population management and conservation. *Acta Theriologica* 55: 61–71.

Conflicts between field sports, animal welfare and species conservation are frequently contentious. In Ireland, the Irish Coursing Club (ICC) competitively tests the speed and agility of two greyhounds by using a live hare as a lure. Each coursing club is associated with a number of discrete localities, known as preserves, which are managed favourably for hares including predator control, prohibition of other forms of hunting such as shooting and poaching and the maintenance and enhancement of suitable hare habitat. We indirectly tested the efficacy of such management by comparing hare abundance within preserves to that in the wider countryside. In real terms, mean hare density was 18 times higher, and after controlling for variance in habitat remained 3 times higher, within ICC preserves than the wider countryside. Whilst we cannot rule out the role of habitat, our results suggest that hare numbers are maintained at high levels in ICC preserves either because clubs select areas of high hare density and subsequently have a negligible effect on numbers or that active population management positively increases hare abundance. The Irish hare *Lepus timidus hibernicus* Bell, 1837 is one of the highest priority species for conservation action in Ireland and without concessions for its role in conservation, any change in the legal status of hare coursing under animal welfare grounds, may necessitate an increase in Government subsidies for conservation on private land together with a strengthened capacity for legislation enforcement.

Quercus, School of Biological Sciences, Queen's University Belfast, Belfast, BT9 7BL, Northern Ireland, UK, e-mail: neil.reid@qub.ac.uk (NR, WIM); Somerton Lodge, Coleraine, Northern Ireland, UK (CM)

Key words: coursing, conservation, driven counts, hunting with dogs, *Lepus timidus*, mountain hare, population density

Introduction

Overexploitation of populations by hunting is widely accepted as one of the main causes of biodiversity loss and species population declines

(Bucher 1992, Milnergulland *et al.* 1993, Keane *et al.* 2005). Hunting for sport is particularly contentious as it frequently involves animal welfare issues and charismatic species of conservation concern. Nonetheless, field sports, such as hare coursing, fox hunting and game-bird

shooting, may have a conservation utility as participants may voluntarily conserve important habitats required by the quarry species (Tapper 1999, Macdonald and Johnson 2000, Oldfield *et al.* 2003). Farmers, landowners and gamekeepers that support field sports are significantly more likely to maintain established woodlands, restore hedgerows and create new plantations despite equal availability of subsidies to those that do not (Burns *et al.* 2000, Oldfield *et al.* 2003). Consequently, in some cases, field sports may benefit biodiversity in general while playing an important role in species-specific conservation.

Sustainable development goals promote the multifunctional use of farmland. Wildlife provides a resource for non-agricultural activities (including recreational field sports). Whilst widely perceived as negative, due to mortality of gamebirds, Stoate (2002) suggested that pheasant shooting has considerable potential for the conservation of nationally declining farmland birds due to its role in woodland management. The majority of natural habitats exist on privately owned land and few governments can afford to enforce or subsidize biodiversity conservation beyond designated sites (Oldfield *et al.* 2003). Conservation subsidy strategies, such as agri-environment schemes, frequently fail to benefit species of conservation concern (Reid *et al.* 2007a) or biodiversity in general (Kleijn *et al.* 2001, 2006, Kleijn and Sutherland 2003) as they are often poorly targeted (Kleijn *et al.* 2001), receive limited funding (Lovelace *et al.* 2000) and involve no coercion (Oldfield *et al.* 2003). In contrast, field sports may offer financial and recreational incentives to private landowners who are frequently willing to accept management costs over a wider area than Government can subsidize (Oldfield *et al.* 2003).

In many European countries, hares are considered a valuable game species and widely hunted (Marboutin *et al.* 2003). In common with other farmland species, the Irish hare *Lepus timidus hibernicus* Bell, 1837 has undergone a substantial population decline since the early 20th century. In Ireland, hares are rarely taken as game but regulated hare coursing is wide-

spread and common (Reid *et al.* 2007b). Hare coursing is a contest of speed and agility between two dogs (usually greyhounds) using a live hare as a lure. Hares are captured under Government licence from the wild using long-nets and held in captivity prior to a competitive event held within an enclosed field. The aim is not to kill the hare but release it back into the wild at or near the site of capture.

The Irish Coursing Club (the governing body of coursing in Ireland, hereafter, referred to as the 'ICC') is an association of approximately 76 local coursing clubs distributed throughout Ireland (Reid *et al.* 2007b). In accordance with ICC Directives, Instructions and Guidance "hares may only be netted on [a] club's recognised hunting grounds" with the permission and co-operation of local landowners (Anonymous 2008). Consequently, each club is associated with a number of discrete localities which are habitually used for the annual netting of hares. The ICC advocates active hare population management including predator control, prohibition of other forms of hunting such as shooting and poaching and the maintenance and enhancement of suitable hare habitat. Consequently, coursing clubs refer to their annual hunting grounds as "preserves" (Anonymous 2008).

The Irish hare is listed on Appendix III of the Bern Convention (Anonymous 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). Subject to an All-Ireland Species Action Plan (Anonymous 2005) it is one of the highest priority species for conservation action in Ireland. Consequently, the continued legality of hare coursing in Ireland is highly controversial. Anti-field sports organisations, in addition to animal welfare objections, dispute the efficacy of ICC hare population management practices claiming that annual harvesting of hares causes local population declines and expiration (LACS 2006, ICABS 2009). To resolve this dispute, we indirectly tested the efficacy of such management by comparing hare abundance within ICC preserves to that in the wider countryside.

Methods

Study sites

The East Donegal Coursing Club is based at Lifford (54°50'44"N, 7°26'18"W), County Donegal, Republic of Ireland. Eight of the clubs fifteen preserves were randomly selected and compared to nine sites selected from the wider countryside. The later were not known to have been previously managed nor used for the capture of hares for coursing but anecdotal reports suggested that hares were present at all sites selected. Sites in the wider countryside were not chosen at random but on the basis of their perceived suitability for hares ie the presence of favourable habitat, specifically a heterogeneous mix of improved and unimproved grasslands interspersed by dense rush (*Juncus* spp.) or heather cover.

Hare abundance estimation

Driven counts were used to estimate hare numbers (Abildgård *et al.* 1972, Pépin 1985). The East Donegal Coursing Club provided the necessary labour to facilitate the enumeration of hares at all sites (under Governmental licence). Netting occurred during autumn (September to December) from 2003 to 2007. However, not all sites were netted each year. Each site was subdivided into discrete areas of manageable size for each survey replicate, referred to hereafter as a 'beat'. Each beat was taken as a repeated measure of the number of hares present. The number of beats varied per site from 2–10. Hares were flushed from their diurnal lie-up sites by a line of beaters (20–30 people). The total number of hares sighted from each beat was recorded. The area of each beat was measured using ArcGIS Map™ 9.3 (ESRI® 1999–2008) and the density of hares was expressed as hares/km².

Environmental variables

ArcGIS Map™ 9.3 was used to compute landscape and habitat variables using the Corine Land Cover 2000 map (EEA 2000). As beats were relatively small (\bar{x} = 5.5 ha) variables were extracted at two spatial scales; 'within beats' and 'within beats plus a 310 m buffer' approximating the radius of an average Irish hare home range of 30 ha (Wolfe and Hayden 1996). Patch Analyst 4.0 (Rempel 2008) was used to quantify the proportion of each area in three board habitat categories: improved farmland (which included pastoral, arable and complex cultivation patterns), unimproved farmland (which included land principally occupied by agriculture with significant areas of natural and semi-natural vegetation including scrub and woodland fragments) and bog, moor, heath and marsh. Habitat structure was described using three metrics: the number of habitat patches, Shannon's Diversity Index and Shannon's Evenness Index. The shortest linear distance to the nearest urban area from the centroid of each beat was taken as a proxy of rural development and human activity.

Statistical analyses

Descriptive statistics were used to illustrate the sampling regime within and between sites and to report mean values for hare density from the raw data with 95% confidence intervals derived from standard errors.

Landscape and habitat variables were standardised to have a \bar{x} = 0 and a σ = 1 prior to analysis (Schmidt *et al.* 2004). Variables not conforming to normality were transformed using a natural logarithm (Ln+1) whilst proportional data were Arcsine-square root transformed. To test whether sites differed in the area surveyed and in landscape and habitat metrics each was treated as the dependent variable in a linear mixed model using a REML procedure and assuming unstructured errors with site ID fitted as a random factor, beat fitted as a repeated measure and site status (ie preserve or wider countryside) fitted as a fixed factor.

Similarly, variance in hare density with respect to site status was examined using a linear mixed model using a REML procedure and assuming unstructured errors. Again, site ID was fitted as a random factor and beat was fitted as repeated measure. Year was treated as fixed factor while landscape and habitat variables were treated as covariates. The spatial extent at which each variable had most influence on hare density was determined using the Akaike weight (w_i) of each variable in a set of two univariate models; one at each spatial scale (McAlpine *et al.* 2006). For each variable, the spatial extent with the highest Akaike weight was selected for inclusion in analysis. All variables were tested for multicollinearity with one variable in each pair of significant correlates (Spearman's Rank correlation coefficient > 0.5) being removed so that all tolerance values were > 0.2 and VIF values < 5.0. The influence of each term was described by the *F* statistic generated when the term of interest was fitted last.

To remove any effect of the difference in landscape and habitat between preserve and wider countryside sites, all variables were fitted regardless of significance and estimated marginal means for hare density obtained when site status was fitted last. The difference between the estimated marginal means in preserve and wider countryside sites was taken as a measure of the effect of site management controlling for differences in landscape and habitat.

All statistical tests were performed using GenStat v6 (2002).

Results

A total of 135 Irish hares were flushed from 17 sites covering a total of 477.5 ha using 87 beats (Table 1). The number of beats and their size varied between sites. The mean density of hares within ICC preserves was 99.9 hares/km² compared to 5.6 hares/km² throughout the wider countryside; an 18-fold difference (Table 1).

Table 1. Descriptive statistics for each site surveyed in County Donegal from 2003–2007.

Site status	Site ID	Year	No. of beats	Mean beat area ha (range)	Total area (ha)	Total no. of hares sighted	Mean hare density hares/km ² (95% CI)
ICC preserves (ie managed)	1	2007	10	6.2 (1.0–12.0)	61.9	37	65.8 (47.5–84.1)
	2	2007	6	3.6 (0.6–6.9)	21.4	14	106.7 (69.7–143.8)
	3	2007	5	4.3 (1.6–8.1)	21.5	13	50.0 (34.6–65.3)
	4	2007	4	6.0 (3.5–9.9)	24.1	17	63.5 (42.1–84.8)
	5	2007	5	4.9 (1.1–10.0)	24.4	8	60.4 (25.3–95.5)
	6	2007	5	1.6 (0.5–3.3)	7.9	14	269.2 (182.7–355.8)
	7	2007	5	5.1 (3.7–6.4)	25.6	12	46.5 (29.9–63.1)
	8	2007	2	1.5 (1.3–1.7)	3.1	8	256.7 (226.2–287.2)
Sub-total			42	4.5 (0.5–12.0)	189.9	123	99.9 (82.8–117.1)
Wider countryside (ie unmanaged)	9	2003	7	9.6 (3.3–19.2)	67.3	1	1.2 (0–2.3)
	10	2004	4	3.8 (1.2–8.1)	15.2	2	10.2 (3.4–16.9)
	11	2004	6	3.6 (1.9–5.7)	21.7	2	15.6 (5.6–25.7)
	12	2005	5	5.1 (4.1–5.6)	25.3	1	3.8 (0–7.5)
	13	2006	2	10.1 (6.2–14.0)	20.2	2	7.1 (0–14.3)
	14	2006	7	8.3 (2.9–18.6)	57.9	0	0 (0–0)
	15	2007	5	5.5 (3.1–10.1)	27.4	2	9.1 (0–18.2)
	16	2007	3	6.7 (4.9–9.1)	20.1	1	3.7 (0–7.3)
	17	2007	6	5.4 (3.6–7.5)	32.4	1	3.4 (0–6.7)
Sub-total			45	6.4 (1.2–19.2)	287.5	12	5.6 (3.7–7.5)
Total			87	5.5 (0.5–19.2)	477.5	135	51.1 (41.4–60.9)

Table 2. Comparison of habitat type and structure between ICC preserves and sites within the wider countryside at two spatial scales: (a) within beats and (b) within beats plus a 310 m buffer. Statistical differences ($p \leq 0.05$) are shown in bold.

Habitat and landscape metrics	Units	$\bar{x} \pm SD$		F_{df}	p
		ICC preserves	Wider countryside		
(a) Within beats					
Area	ha	4.52 ± 3.09	6.39 ± 4.25	5.43 _{1,84}	0.020
Improved farmland	%	87.55 ± 30.96	50.07 ± 49.01	18.01 _{1,84}	< 0.001
Unimproved farmland	%	5.55 ± 19.24	16.18 ± 32.98	3.95 _{1,84}	0.047
Bog, moor, heath and marsh	%	6.89 ± 22.56	33.75 ± 44.92	12.26 _{1,84}	< 0.001
Number of habitat patches	n	1.71 ± 0.86	1.56 ± 0.72	0.75 _{1,84}	0.385
Shannon's Diversity	Index	0.25 ± 0.28	0.18 ± 0.24	1.53 _{1,84}	0.216
Shannon's Evenness	Index	0.32 ± 0.36	0.23 ± 0.31	1.26 _{1,84}	0.261
Distance to urban	km	3.05 ± 1.33	2.72 ± 1.83	1.38 _{1,84}	0.240
(b) Within beats plus a 310 m buffer					
Area	ha	59.53 ± 16.29	67.93 ± 14.15	6.62 _{1,84}	0.010
Improved farmland	%	87.64 ± 22.07	49.62 ± 46.26	22.32 _{1,84}	< 0.001
Unimproved farmland	%	6.39 ± 12.48	22.01 ± 27.22	11.05 _{1,84}	< 0.001
Bog, moor, heath and marsh	%	5.97 ± 13.36	28.37 ± 37.16	11.99 _{1,84}	< 0.001
Number of habitat patches	n	3.55 ± 1.33	3.20 ± 1.65	1.98 _{1,84}	0.160
Shannon's Diversity	Index	0.67 ± 0.32	0.58 ± 0.40	1.40 _{1,84}	0.237
Shannon's Evenness	Index	0.71 ± 0.30	0.58 ± 0.33	3.54 _{1,84}	0.060

Mean beat size was significantly greater at sites in the wider countryside than at ICC preserve sites (Table 2). Habitat composition also varied with site status with ICC preserves being characterised by significantly greater coverage of improved farmland and significantly less coverage of unimproved farmland and bog, moor, heath and marsh than sites in wider countryside (Table 2). These differences were significant on both spatial scales tested. However, landscape structure did not differ significantly between ICC preserve and wider countryside sites regardless of the spatial scale examined. Rurality, measured as distance to urban also did not differ with site status.

All landscape and habitat variables had greatest influence on hare density at the larger of the two spatial scales examined (the beat plus a 310 m buffer) with the exception of the number of habitat patches and Shannon’s Diversity Index, both of which operated within beats (Fig. 1). The proportion of improved farmland was

removed from further analysis as it was highly negatively correlated with the proportion of unimproved farmland ($r = -0.806, p < 0.001$), proportion of bog, moor, heath and marsh ($r = -0.848, p < 0.001$), the number of habitat patches ($r = -0.220, p = 0.040$) and distance to urban ($r = -0.372, p < 0.001$).

After accounting for significant differences in habitat composition and landscape covariate noise only site status significantly affected hare density (Table 3). There was a moderately strong, but not statistically significant, positive trend between hare density and distance to urban. However, distance to urban did not significantly differ between ICC preserve sites and the wider countryside (Table 2). Accounting for variation in all other variables, the estimated marginal mean for hare density was 3 times higher within ICC preserves than the wider countryside (estimated marginal mean = 96.01 and 30.93 hares respectively).

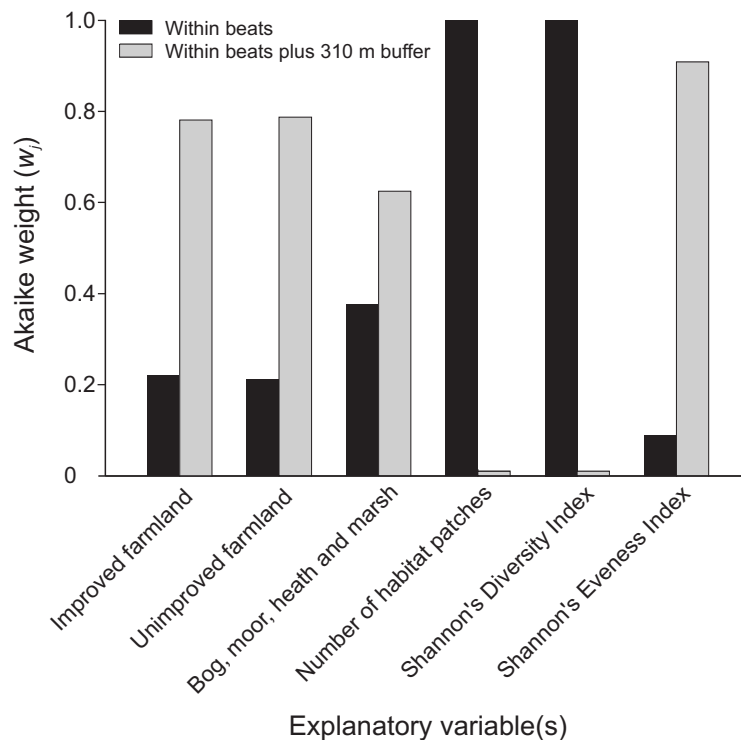


Fig. 1. Selection of the spatial extent at which each habitat and landscape metric had most influence on hare density was based on the Akaike weight of each univariate model within a set of two models; one at each spatial scale ie within beats and within beats plus a 310 m buffer.

Table 3. Linear mixed model of hare density. Site status denotes whether a site was an ICC preserve or located within the wider countryside. Statistical differences ($p \leq 0.05$) are shown in bold.

Random effect	Repeated measure	Fixed effects	F_{df}	$\beta \pm SE$	p
Site (Beat)	Beat	Shannon's Diversity Index (within beats)	0.01 _{1,84}	0.14 \pm 0.12	0.926
		Number of habitat patches	< 0.01 _{1,84}	-0.39 \pm 0.15	0.944
		Shannon's Evenness Index (within beat plus 310 m buffer)	0.11 _{1,84}	0.61 \pm 0.13	0.739
		Year	0.42 _{4,84}	Factor	0.792
		Unimproved farmland (within beat plus 310 m buffer)	1.20 _{1,84}	-0.12 \pm 0.12	0.273
		Bog, moor, heath and marsh (within beat plus 310 m buffer)	1.80 _{1,84}	-0.28 \pm 0.15	0.179
		Distance to urban	3.47 _{1,84}	0.21 \pm 0.11	0.062
		Site status	6.52 _{1,84}	Factor	0.011

Discussion

Whilst there is substantial anecdotal evidence to suggest that field sports, including hare coursing, impact local quarry abundance there is little consensus whether the effects are detrimental or beneficial (Stoate and Tapper 1993, Hutchings and Harris 1996, Vaughan *et al.* 2003). Here we provide evidence, that in some cases, field sports can be positively associated with high abundance of the quarry species.

In real terms, the mean density of hares within Irish Coursing Club preserves (99.9 hares/km²) was 18 times greater than mean density throughout the wider countryside (5.6 hares/km²). Irish hare densities have been reported to range from 0.1–138 hares/km² (Appendix). Thus, whilst densities within ICC preserves were notably high they were not unprecedented (Jeffery 1996, Dingerkus and Montgomery 2002). Mean hare density from sites in the wider countryside was not significantly different from mean estimates of density throughout the Republic of Ireland and Northern Ireland derived from recent national surveys (Appendix). Moreover, Scottish mountain hare populations have been shown to fluctuate up to 59 times their minimum density (Watson *et al.* 1973); thus large spatio-temporal disparities in density are not unknown in hare populations.

Variance in hare density is generally attributed to variation in habitat type and/or structure. Densities are generally significantly lower

in pastoral than arable landscapes and agricultural intensification is generally assumed to be the main factor involved in population declines (Tapper and Parsons 1984, Hutchings and Harris 1996, Tapper 1999, Smith *et al.* 2004, 2005, Kuijper *et al.* 2008). ICC preserves were significantly more agriculturally intense than sites selected from the wider countryside in terms of the gross coverage of improved farmland (predominately pastoral) compared to unimproved farmland and bog, moor, heath and marsh. Therefore, one might hypothesize that hare densities should have been lower in ICC preserves than in the wider countryside. However, this was not the case. Whilst none of the habitat and landscape metrics measured significantly influenced hare density directly, after accounting for significant differences in habitat coverage, the estimated marginal mean hare density remained 3 times greater in ICC preserves than in the wider countryside. This reduction from a 18-fold to a 3-fold difference supports the assumption that variance in habitat influences hare density and it maybe that more suitable measures of habitat or landscape could account for the remaining differences observed.

Whilst we cannot rule out the influence of naturally occurring habitat factors, neither can we rule out the possible role of active population management. The Game Conservancy Trust found that hares were maintained at high densities on land used for coursing, in part due to the maintenance and promotion of suitable habitat

(Burns *et al.* 2000). Irish hares have been shown to be associated a habitat matrix of improved farmland providing good quality grassland for forage interspersed with areas of tall vegetation providing cover and shelter for diurnal lie-up sites, for example, *Juncus* spp. (Reid *et al.* 2006, 2007a). Anecdotal evidence suggests that landowners associated with ICC preserves maintain areas of suitable cover for hares, in particular patches of *Juncus* within a wider matrix of improved farmland. Without ground-truthed data, such fine-scale structure would have been missed using the relatively crude habitat metrics derived from the low resolution Corine Land Cover map (EEA 2000) used in our analysis. It therefore, remains possible that the differences observed in habitat coverage between ICC preserves and the wider countryside may be associated with active habitat management.

Whilst coursing activity has been shown to be associated with high hare densities, without a before and after survey design, it is impossible to rule an *a priori* difference in hare density between ICC preserves and the wider countryside. It seems highly likely that coursing clubs should preferentially select localities of high hare abundance to ensure sufficient animals are found to support each coursing event (Stoate and Tapper 1993). Logically, coursing activity can have only three possible impacts on local hare abundance; negative, negligible or positive. Consequently, we consider each scenario in turn both assuming and rejecting an *a priori* bias in hare density (Fig. 2a–f).

Anti-field sports organisations (LACS 2006, ICABS 2009) support the hypothesis that localities with high hare density suffer population declines after exploitation by coursing clubs (Fig. 2d). Under this scenario, hare densities would have had to be even higher prior to exploitation. Given that the range of densities recorded on ICC preserves are some of the highest on record for this species (Appendix) it would appear somewhat unlikely that densities could have been substantially higher prior to site use. Such a hypothesis also assumes that the efficacies of any population management practices employed by coursing clubs are either negligible or do not counter any negative effect of coursing.

Alternatively, we might hypothesise that low mortality rates during coursing and high hare productivity may result in netting and coursing having a negligible impact on overall hare numbers (Fig. 2e). Hare populations have been shown to be relatively resilient to culling pressure (Macdonald *et al.* 2000) with previous studies suggesting that annual adult removal rates of up to 69% may be sustainable provided suitable habitat exists to allow high reproductive effort (Marboutin *et al.* 2003). In Ireland, it has been estimated that hare mortality during captivity and coursing kills $\leq 0.1\%$ of the total adult population annually (Reid *et al.* 2007b). Other studies have found similarly low rates of mortality suggesting that coursing has little or no impact on overall hare numbers (Stoate and Tapper 1993, Hutchings and Harris 1996, Burns *et al.* 2000). As with our first scenario, this hypothesis also assumes no net benefit of population management.

Tapper and Stoate (1994) suggest that predator control by landowners and gamekeepers is an important factor in helping to maintain local hare populations. Predation by foxes may limit hare numbers principally impacting juvenile recruitment (Lindström *et al.* 1994, Reynolds and Tapper 1995). Vaughan *et al.* (2003) suggested that hares were less abundant on farms where foxes were seen frequently whilst a fox sarcoptic mange epidemic demonstrated that fox removal can increase hare abundance (Lindström *et al.* 1994). It seems likely, therefore, that active fox control by coursing club members and associated landowners may positively affect local hare abundance.

In Ireland, where hares are held in captivity for up to 2 months prior to coursing, there may be less obvious benefits of coursing. Periods of captivity, veterinary attention, treatment with anthelmintics and artificial feeding during captivity (Anonymous 2008) may actually improve pre-breeding condition and subsequent reproductive fitness of hares released back into the wild (Murray *et al.* 1998, Dyrce *et al.* 2005, Molony *et al.* 2006). Overwinter survival of Scottish mountain hares *Lepus timidus scoticus* can be significantly improved by supplementary feeding, increasing male body mass and allow-

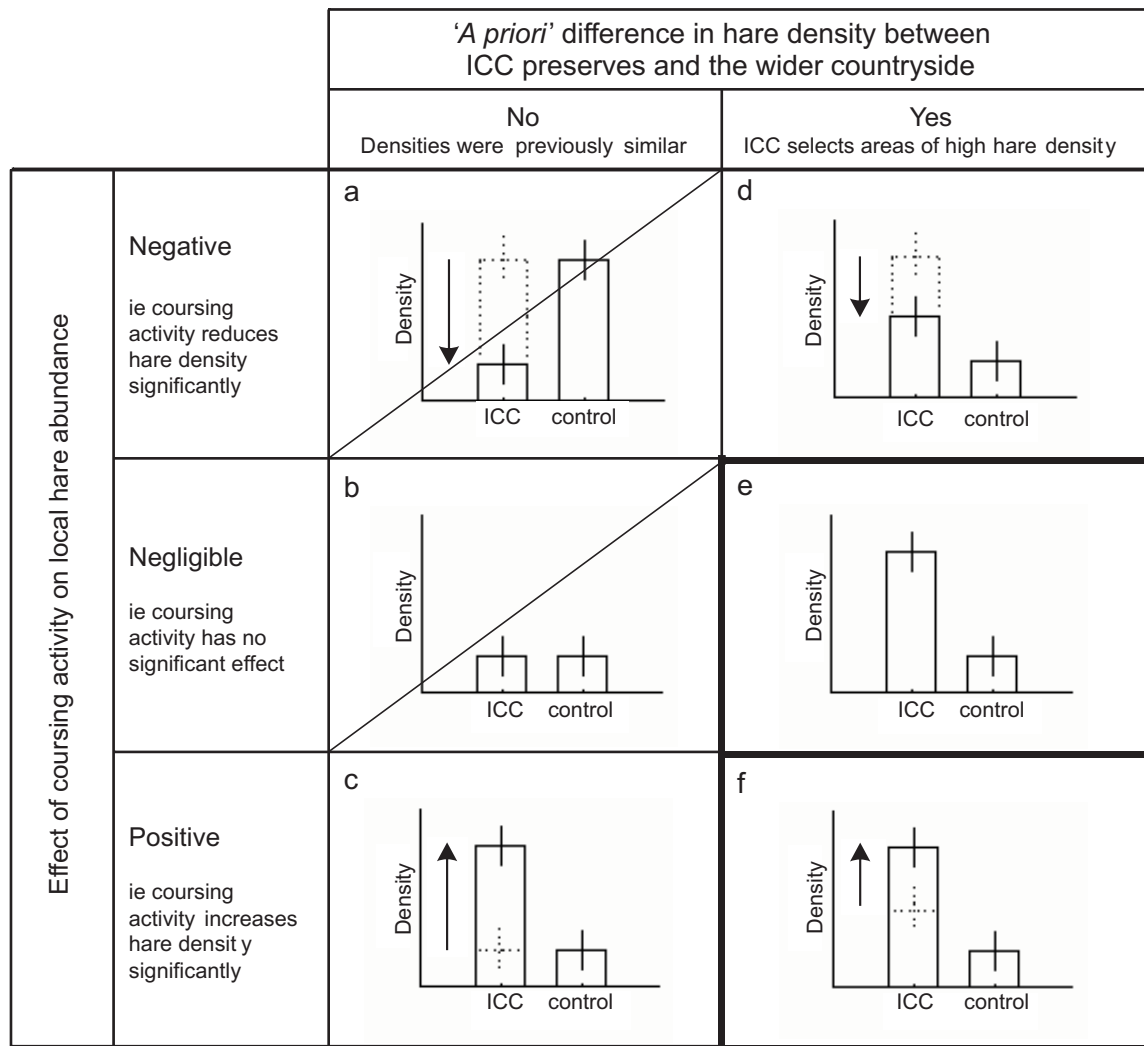


Fig. 2. Six scenarios for the possible impact of coursing activity on local hare abundance where dotted lines represent hare densities prior to management and solid lines represent current densities. Scenarios in boxes that have been crossed out (a–b) are inconsistent with observations of high hare density within ICC preserves. Open boxes contain scenarios that whilst possible are unlikely (c–d) and bold boxes contain scenarios that are both possible and plausible (e–f).

ing females to breed earlier while treatment with Ivermectin (a broad spectrum anti-parasite medication) can significantly improve female fecundity (Newey *et al.* 2007). Moreover, translocation of animals among subpopulations may increase genetic heterosis and combat the problems associated with habitat fragmentation.

Burns *et al.* (2000) suggested that in the absence of hare coursing there may be reduced tolerance by farmers of damage to agricultural

crops, less interest in encouraging and sustaining suitable habitats, greater propensity to allow shooting, an increase in illegal coursing and deliberate culling of hares to prevent illegal poaching. Coursing clubs are also responsible for actively publicising the hare and maintaining its importance to rural communities whilst collaboration with Government and academic institutions allow clubs to contribute information on the biology of the species.

Whilst we cannot rule out the role of habitat, our results suggest that hare numbers are maintained at high levels on Irish Coursing Club preserves either because clubs select areas of high hare density and subsequently have a negligible impact on hare numbers or actively manage hare populations and have a positive effect on numbers. Should the legal status of coursing be altered on animal welfare grounds without concessions for its potential affect on species and habitat conservation, additional public funds may be required to increase subsidies for conservation on private land together with a strengthened capacity to enforce legislation (Oldfield *et al.* 2003).

Acknowledgements: We are grateful to the Irish Coursing Club for their cooperation, specifically, the East Donegal Coursing Club for their collaboration and assistance in the field.

References

- Abildgård F., Andersen J. and Barnorff-Nielsen O. 1972. The hare population (*Lepus europaeus*, Pallas) of Illumø Island, Denmark. A report on the analysis of the data from 1959 to 1970. Danish Review of Game Biology 6: 1–31.
- Anonymous 1979. Convention on the conservation of European wildlife and natural habitats. Bern Convention. Council of Europe, Strasbourg.
- Anonymous 2005. All Ireland Species Action Plans: Irish Lady's-tresses (*Spiranthes romanzoffiana*), Pollan (*Coregonus autumnalis*), Irish hare (*Lepus timidus hibernicus*), and Corncrake (*Crex crex*). Environment & Heritage Service (DOE), Belfast and National Parks & Wildlife Service (DOEHLG), Dublin: 6–9.
- Anonymous 2008. A summary of directives, instructions and guidance notes issued by the executive committee of the Irish Coursing Club to the club secretaries, control stewards, judges and slippers. Irish Coursing Club, Ireland: 4–17.
- Bucher E. H. 1992. The causes of extinction of the Passenger Pigeon. Volume 9. [In: Current ornithology. D. M. Power, ed]. Plenum Press, New York: 1–36.
- Burns L., Edwards V., Marsh J., Soulsby L. and Winter M. 2000. Report of the committee of inquiry into hunting with dogs in England and Wales. HMSO, Norwich: 9–131.
- Dingerkus S. K. and Montgomery W. I. 2002. A review of the status and decline in abundance of the Irish hare (*Lepus timidus hibernicus*) in Northern Ireland. Mammal Review 32: 1–11. doi: 10.1046/j.1365-2907.2002.00098.x
- Dyrcz A., Wink M., Kruszewicz A. and Leisler B. 2005. Male reproductive success is correlated with blood parasite levels and body condition in the promiscuous aquatic warbler (*Acrocephalus paludicola*). Auk 122: 558–565. doi: 10.1642/0004-8038(2005)122[0558:MRSICW]2.0.CO;2
- EEA 2000. Corine Land Cover 2000 map. European Environment Agency. Copenhagen, Denmark.
- EEC 92/43 1992. Directive on the Conservation of Natural Habitats of Wild Fauna and Flora. Official Journal of the European Union L, 206: 7.
- ESRI® ArcMap™ 9.3 (1999–2008) software. San Francisco, California, USA.
- GenStat v6 2002. Lawes Agricultural Trust, VSN International Ltd. Oxford. United Kingdom.
- Hall-Asplund S., Sweeney O., Tosh D., Preston S. P., Montgomery W. I. and McDonald R. A. 2006. Northern Ireland Irish hare survey 2006. Report prepared by Quercus for the Environment and Heritage Service (DOE, N.I.). UK.
- Hutchings M. R. and Harris S. 1996. The current status of the brown hare *Lepus europaeus* in Britain. Joint Nature Conservation Committee, Peterborough: 53–61.
- ICABS 2009. Irish council against blood sports. <http://www.banbloodsports.com> last accessed 03/09/2009.
- Jeffery R. J. 1996. Aspects of the ecology and behaviour of the Irish hare, *Lepus timidus hibernicus* (Bell, 1837) on lowland farmland. PhD thesis, Trinity College, University of Dublin: 35–73.
- Keane A., Brooke M. D. and McGowan P. J. K. 2005. Correlates of extinction risk and hunting pressure in gamebirds (Galliformes). Biological Conservation 126: 216–233. doi: 10.1016/j.biocon.2005.05.011
- Kleijn D., Baquero R. A., Clough Y., Diaz M., De Esteban J., Fernández F., Gabriel D., Herzog F., Holzschuch A., Jöhl R., Knop E., Kruess A., Marshall E. J. P., Steffan-Dewenter I., Tschardtke T., Verhulst J., West T. M. and Yela J. L. 2006. Mixed biodiversity benefits of agri-environment schemes in five European countries. Ecology Letters 9: 243–254. doi: 10.1111/j.1461-0248.2005.00869.x
- Kleijn D., Berendse F., Smit R. and Gilissen N. 2001. Agri-environment schemes do not effectively protect biodiversity in Dutch agricultural landscapes. Nature 413: 723–725. doi: 10.1038/35099540
- Kleijn D. and Sutherland W. J. 2003. How effective are European agri-environment schemes in conserving and promoting biodiversity? Journal of Applied Ecology 40: 947–967. doi: 10.1111/j.1365-2664.2003.00868.x
- Kuijper D. P. J., Beek P., Van Wieren S. E. and Bakker J. P. 2008. Time-scale effects in the interaction between a large and a small herbivore. Basic and Applied Ecology 9: 126–134. doi: 10.1016/j.baae.2006.08.008
- LACS 2006. League Against Cruel Sports. <http://www.league.uk.com/campaigns/ni> last accessed 03/09/2009.
- Lindström E. R., Andren H., Angelstam P., Cederlund G., Hornfeldt B., Jaderberg L., Lemnell P. A., Martinsson B., Skold K. and Svenson J. E. 1994. Disease reveals the predator: sarcoptic mange, red fox predation, and prey populations. Ecology 75: 1042–1049. doi: 10.2307/1939428

- Lovelace D., May R. and Perkins R. 2000. Money Makes the Countryside Go Round WWF. Godalming, UK.
- Macdonald D. W. and Johnson P. J. 2000. Farmers and the custody of the countryside: trends in loss and conservation of non-productive habitats 1981–1998. *Biological Conservation* 94: 221–234. doi: 10.1016/S0006-3207(99)00173-1
- Macdonald D. W., Tattersall F. H., Johnston P. J., Carbone C., Reynolds J. C., Langbein J., Rushton S. P. and Shirley M. D. F. 2000. Management and control of populations of foxes, deer, hares and mink in England and Wales, and the impact of hunting with dogs. [In: Report of the committee of inquiry into hunting with dogs in England and Wales. L. Burns, V. Edwards, J. Marsh, L. Soulsby and M. Winter, eds]. HMSO, Norwich: 9–131.
- Marboutin E., Bray Y., Péroux R., Mauvy B. and Lartiges A. 2003. Population dynamics in European hare: breeding parameters and sustainable harvest rates. *Journal of Applied Ecology* 40: 580–591. doi: 10.1046/j.1365-2664.2003.00813.x
- McAlpine C. A., Rhodes J. R., Callaghan J. G., Bowen M. E., Lunney D., Mitchell D. L., Pullar D. V. and Possingham H. P. 2006. The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: a case study of koalas in Queensland, Australia. *Biological Conservation* 132: 153–165.
- Milnergulland E. J. and Beddington J. R. 1993. The exploitation of Elephants for the ivory trade – An historical-perspective. *Proceedings of the Royal Society of London Series B-Biological Sciences* 252(1333): 29–37. doi: 10.1098/rspb.1993.0042
- Molony S. E., Dowding C. V., Baker P. J., Cuthill I. C. and Harris S. 2006. The effect of translocation and temporary captivity on wildlife rehabilitation success: An experimental study using European hedgehogs (*Erinaceus europaeus*). *Biological Conservation* 130: 530–537. doi: 10.1016/j.biocon.2006.01.015
- Murray D. L., Keith L. B. and Cary J. R. 1998. Do parasitism and nutritional status interact to affect production in Snowshoe hares? *Ecology* 79: 1209–1222. doi: 10.1890/0012-9658(1998)079[1209:DPANSI]2.0.CO;2
- Newey S., Allison P., Smith A., Graham I. and Thirgood S. 2007. The role of parasites and nutrition in driving unstable population dynamics in the mountain hare (*Lepus timidus*). [In: Proceedings of the International Union of Game Biologists XXVII Congress, Uppsala, Sweden. K. Sjöberg and T. Rooke, eds]. Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences, Umea: 117.
- Oldfield T. E. E., Smith R. J., Harrop S. R. and Leader-Williams N. 2003. Field sports and conservation in the United Kingdom. *Nature* 423: 531–533.
- O'Mahony D. and Montgomery W. I. 2006. The Distribution, abundance and habitat use of the Irish hare (*Lepus timidus hibernicus*) in upland and lowland areas of Co. Antrim and Co. Down. Environment and Heritage Service Research and Development Series No. 06/20.
- Pépin D. 1985. Spring density and day time distribution of the European hare in relation to the habitat in an open field agrosystem. *Zeitschrift für Säugetierkunde* 51: 79–86.
- Preston J., Prodöhl P., Portig A. and Montgomery I. 2003. The Northern Ireland hare *Lepus timidus hibernicus* Survey 2002. Queen's University Belfast: 13–16.
- Reynolds J. C. and Tapper S. C. 1995. Predation by foxes *Vulpes vulpes* on brown hares *Lepus europaeus* in central southern England, and its potential impact on annual population growth. *Wildlife Biology* 1: 145–158.
- Reid N. 2006. Conservation ecology of the Irish hare (*Lepus timidus hibernicus*). PhD thesis, Queen's University Belfast, UK: 137–155.
- Reid N., McDonald R. A. and Montgomery W. I. 2007a. Mammals and agri-environment schemes: hare haven or pest paradise? *Journal of Applied Ecology* 44: 1200–1208. doi: 10.1111/j.1365-2664.2007.01336.x
- Reid N., McDonald R. A. and Montgomery W. I. 2007b. Factors associated with hare mortality during coursing. *Animal Welfare* 16: 427–434.
- Reid N., Dingerkus K., Montgomery W. I., Marnell F., Jeffrey R., Lynn D., Kingston N. and McDonald R. A. 2007c. Status of hares in Ireland: hare survey of Ireland 2006/07. [In: Irish Wildlife Manuals. No. 30. F. Marnell and N. Kingston, eds]. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland: 25–46.
- Rempel R. 2008. Patch Analyst 4.0 software. Centre for Northern Forest Ecosystem Research. Ontario. Canada.
- Schmidt N. M., Asferg T. and Forchhammer M. C. 2004. Long-term patterns in European brown hare population dynamics in Denmark: effects of agriculture, predation and climatic. *BMC Ecology* 4: 15. doi: 10.1186/1472-6785-4-15
- Smith R. K., Jennings N., Robinson A. and Harris S. 2004. Conservation of European hares *Lepus europaeus* in Britain: is increasing habitat heterogeneity in farmland the answer? *Journal of Applied Ecology* 41: 1092–1102. doi: 10.1111/j.0021-8901.2004.00976.x
- Smith R. K., Vaughan-Jennings N. and Harris S. 2005. A quantitative analysis of the abundance and demography of European hares *Lepus europaeus* in relation to habitat type, intensity of agriculture and climate. *Mammal Review* 35: 1–24. doi: org/10.1111/j.1365-2907.2005.00057.x
- Stoate C. 2002. Multifunctional use of a natural resource on farmland: wild pheasant (*Phasianus colchicus*) management and the conservation of farmland passerines. *Biodiversity and Conservation* 11: 561–573.
- Stoate C. and Tapper S. C. 1993. The impact of three hunting methods on brown hare populations in Britain. *Game and Wildlife Science* 10: 229–240.
- Tapper S. 1999. A question of balance: game animals and their role in the British Countryside. Game Conservancy Trust, Fordingbridge: 1–288.
- Tapper S. C. and Parsons N. 1984. The changing status of the brown hare (*Lepus capensis* L.) in Britain. *Mammal Review* 14: 57–70. doi: 10.1111/j.1365-2907.1984.tb00339.x

- Tapper S. and Stoate C. 1994. Hares – the game management connection. *Game Conservancy Review* 25: 102–103.
- Tosh D., Brown S., Preston J., Montgomery W. I., Reid N., Marques T. A., Borchers D. L., Buckland S. T. and McDonald R. A. 2005. Northern Ireland Irish hare survey 2005. Report prepared by *Quercus* for the Environment and Heritage Service (DOE, N.I.), UK: 1–12.
- Vaughan N., Lucas E. A., Harris S. and White P. C. L. 2003. Habitat associations of the European hare *Lepus europaeus* in England and Wales: implications for farmland management. *Journal of Applied Ecology* 40: 163–175. doi: 10.1046/j.1365-2664.2003.00784.x
- Watson A., Hewson R., Jenkins D. and Parr P. 1973. Population densities of mountain hares compared with red grouse on Scottish moors. *Oikos* 24: 225–230.
- Whelan J. 1985. The population and distribution of the mountain hare (*Lepus timidus* L.) on farmland. *Irish Naturalists' Journal* 21: 532–534.
- Wilde A. 1993. Threatened mammals, birds, amphibians and fish in Ireland. *Irish Red Data Book II: Vertebrates*. HMSO, Belfast, UK: 1–25.
- Wolfe A. 1995. A study of the ecology of the Irish mountain hare (*Lepus timidus hibernicus*) with some considerations for its management and that of the rabbit (*Oryctolagus cuniculus*) on North Bull Island, Dublin Bay. PhD thesis, National University of Ireland, Dublin: 1–234.
- Wolfe A. and Hayden T. J. 1996. Home ranges of Irish mountain hares on coastal grassland. *Biology and Environment: Proceedings of the Royal Irish Academy* 96B: 141–146.

Received 11 May 2009, accepted 12 October 2009.

Associate editor was Magdalena Niedziałkowska.

Appendix. Review of Irish hare population densities recorded in various habitats from 1973–2008.

Country	Habitat(s)	Year	Hares/km ² (range or 95% CI)	Reference
Republic of Ireland	Mixed farmland	1985	6.2 (5.5–6.8)	Whelan (1985)
	Coastal grassland	1990–1994	12.0 (5.0–19.0)	Wolfe (1995)
	Pastoral farmland	1992–1993	12.4 (4.7–17.6)	Jeffery (1996)
	Coastal grassland	1994–1996	50.5 (24.5–129.4)	Jeffery (1996)
	All	2006	3.3 (2.0–6.2)	Reid <i>et al.</i> (2007c)
	All	2007	7.7 (4.8–14.3)	Reid <i>et al.</i> (2007c)
Northern Ireland	Shooting estates	1856–1940	63.0 (2.0–138.0)	Dingerkus and Montgomery (2002)
	All	1994–1996	0.7 (0.2–1.5)	Dingerkus and Montgomery (2002)
	Uplands	2000	2.1 (1.7–2.7)	O'Mahony and Montgomery (2006)
	Lowlands	2000	0.3 (0.1–0.6)	O'Mahony and Montgomery (2006)
	All	2002	1.0 (0.5–1.8)	Preston <i>et al.</i> (2003)
	All	2004	5.1 (4.2–6.2)	Tosh <i>et al.</i> (2005)
	All	2005	3.1 (2.5–3.9)	Tosh <i>et al.</i> (2005)
	All	2005	3.0 (2.0–4.5)	Reid (2006)
	All	2006	2.6 (1.9–3.5)	Hall-Aspland <i>et al.</i> (2006)
	All	2007	4.0 (2.8–5.8)	Reid <i>et al.</i> (2007c)