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# Integrating field sports, hare population management and conservation

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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.

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## 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 widespread 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/km$^2$.

### 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 $\sigma$ = 1 prior to analysis (Schmidt *et al*. 2004). Variables not confirming 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 multicolinearity 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/km$^2$ compared to 5.6 hares/km$^2$ 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 | $\bar{x}$ ± 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).

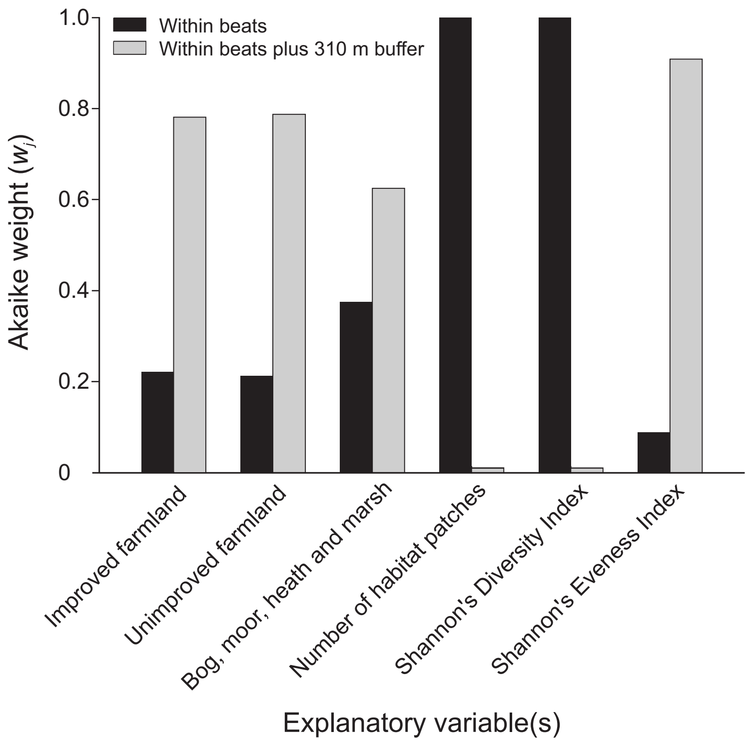


Fig. 1. Selection of the spatial extent at which each habitat and landscape metric had most influence on hare density was based on the Akaike weight of each univariate model within a set of two models; one at each spatial scale ie within beats and within beats plus a 310 m buffer.

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 ± 0.12 | 0.926 |
| | | Number of habitat patches | $< 0.01_{1,84}$ | −0.39 ± 0.15 | 0.944 |
| | | Shannon's Evenness Index (within beat plus 310 m buffer) | $0.11_{1,84}$ | 0.61 ± 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 ± 0.12 | 0.273 |
| | | Bog, moor, heath and marsh (within beat plus 310 m buffer) | $1.80_{1,84}$ | −0.28 ± 0.15 | 0.179 |
| | | Distance to urban | $3.47_{1,84}$ | 0.21 ± 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/km$^2$) was 18 times greater than mean density throughout the wider countryside (5.6 hares/km$^2$). Irish hare densities have been reported to range from 0.1–138 hares/km$^2$ (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 ≤ 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, were 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, Dyrcz *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-

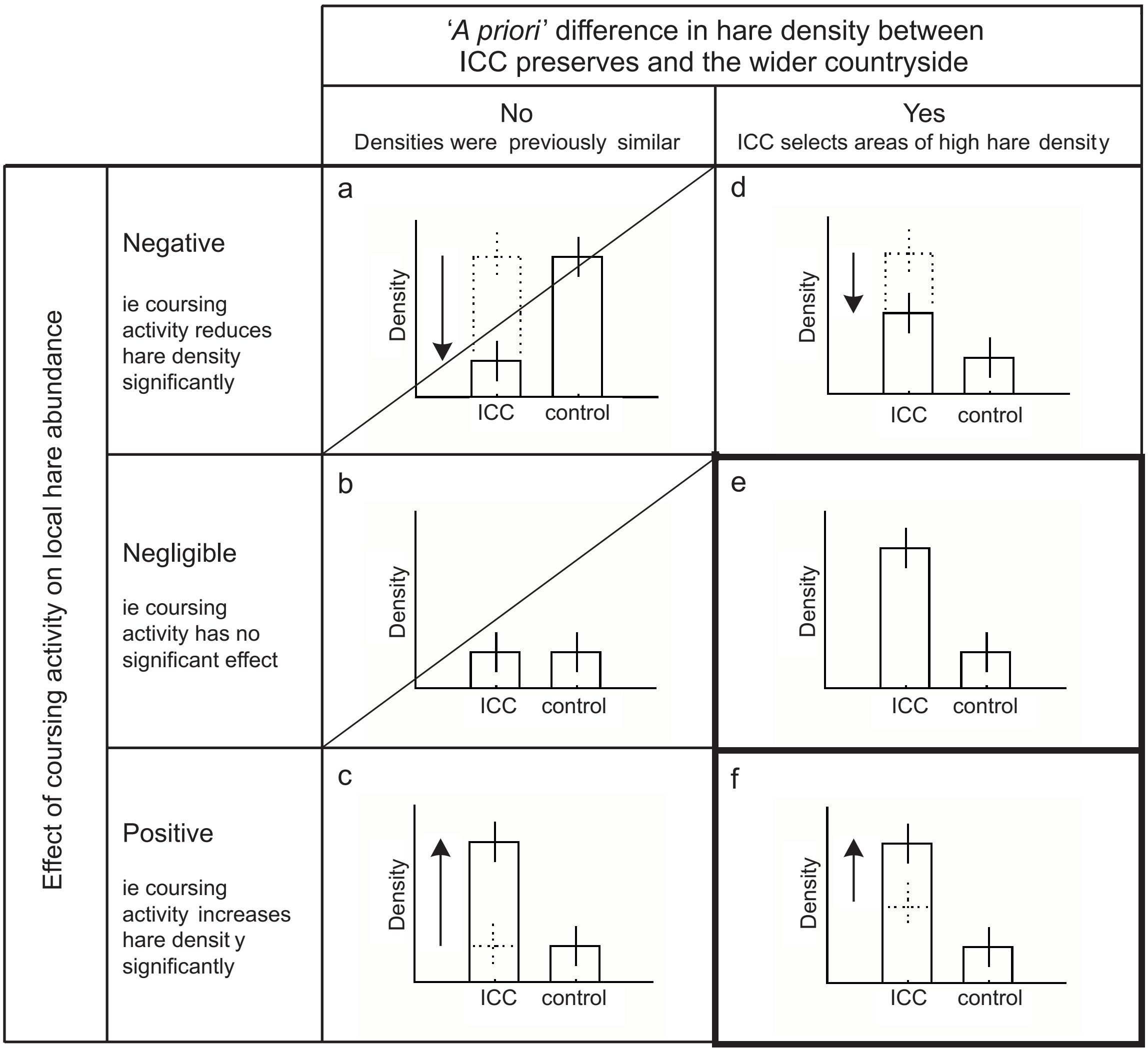


Fig. 2. Six scenarios for the possible impact of coursing activity on local hare abundance where dotted lines represent hare densities prior to management and solid lines represent current densities. Scenarios in boxes that have been crossed out (a–b) are inconsistent with observations of high hare density 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).

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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 *et al.* (2007c) |
| | All | 2007 | 7.7 (4.8–14.3) | Reid *et al.* (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 *et al.* (2003) |
| | All | 2004 | 5.1 (4.2–6.2) | Tosh *et al.* (2005) |
| | All | 2005 | 3.1 (2.5–3.9) | Tosh *et al.* (2005) |
| | All | 2005 | 3.0 (2.0–4.5) | Reid (2006) |
| | All | 2006 | 2.6 (1.9–3.5) | Hall-Aspland *et al.* (2006) |
| | All | 2007 | 4.0 (2.8–5.8) | Reid *et al.* (2007c) |