BRAES OF DOUNE WINDFARM

REPORT ON RED KITE STUDIES 2004 - 2012

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On behalf of the
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Summary

An intensive monitoring programme for red kites was initiated in 2004 as a requirement for consent of planning permission for a 36 turbine wind farm to be constructed on the Braes of Doune. The Braes of Doune wind farm was finally completed and commissioned in 2007 and post-construction monitoring work continued until March 2012. This work consisted of vantage point observations, radio tagging and tracking of individual kites, turbine searches and carcass persistence trials. A total of 1486 hours of vantage point observations were completed from six vantage points. Eighty-four kites were radio tagged and 79 of these were studied.

Mapping of vantage point and radio tracking results indicated a reduction in activity at the wind farm site after construction although kites continued to use the area and frequently pass through the wind farm. Changing dynamics of the population may have been the cause of reduced activity rather than turbine avoidance. Survival of the tagged sample of kites was comparable to populations in areas where there were no wind farm developments.

Trials on searcher efficiency were carried out resulting in 83% of test carcasses located. Carcass persistence work with pheasants and buzzard carcasses indicated carcasses of the latter species lasted longer and were more detectable. The remaining feather patches of most buzzard carcasses persisted to the end of the 90 day search interval used in the actual turbine searches. These results suggested the turbine search method was appropriate for detecting kite fatalities at the wind farm.

Three red kites were recovered dead as a result of turbine strike during the period including one of the radio tagged sample. The study individual was the only kite found through systematic turbine searches. Analysis of searcher and carcass persistence work allowed revised estimates of kite fatality rates at the wind farm. A newly derived rate of 1.02 kites killed by the wind farm per anum was in line with pre-construction Collision Risk Modelling work which gave a broadly similar rate of annual fatalities. The Central Scotland kite population continued to increase through the entire study period.

Introduction

Red kites in Central Scotland

Red kites *Milvus milvus* (hereafter 'kites' for brevity) were formerly a common and widespread raptor throughout Great Britain but by the late 19th century were restricted to mid-Wales by human persecution (Lovegrove 1990, Carter 2007). Due to the slow recovery of the Welsh population it was decided by statutory conservation bodies and RSPB to begin a series of reintroductions in England and Scotland to re-establish the species to its former range. These projects began in 1989 and the release project in central Scotland was the fourth to be undertaken in Britain and the second in Scotland (Carter 2007). Between 1996 and 2001, 103 kites were imported from Germany and released in the area.

Breeding first occurred in 1998 when two pairs reared 5 young. Breeding has occurred in every subsequent year. By 2007 there had been 165 breeding attempts with 121 of these successful and at least 259 young reared locally (RSPB Scotland). In addition a number of individuals from the other populations of kites have settled to breed with the established population and birds from other areas regularly winter with the local birds. Kites from all the other re-established populations have now been recorded within the central Scotland kites' range.

The wind farm site is in the centre of the kites' core range in central Scotland. Doune Estate itself was one of two estates that played host to kite releases and the nearest (now demolished) set of release cages were only 4 km from the most southerly turbine. A number of nest sites have since been recorded even closer to the turbines. The breeding range of the whole central Scotland population now extends as far north-east as the Dunkeld area of Perthshire, and consisted of 79 territorial pairs in 2012 (RSPB Scotland). Around 50% of these territories are within 10 km of the Braes of Doune wind farm.

The Braes of Doune Wind Farm

The wind farm site is 10 km north west of Dunblane and 18 km north west of Stirling, and centred around NN 7210 on the eastern slopes of Beinn Odhar. Proposals to build a wind farm at the Braes of Doune were first made in 2001. A formal application to build 49 turbines was made by Airtricity Developments (Scotland) Ltd on 31 October 2002 with planning permission and consent granted in October 2004 (Scottish Executive 2004). The Airtricity company was eventually absorbed into

Scottish and Southern Energy (SSE) in 2008 and site was subsequently managed by the latter company.

The consented wind farm consists of 36 V80 2.0 MW (megawatt) turbines, with a total output of 72 MW. This can provide enough electricity to power 45,000 homes and mitigate the output of 173,000 tonnes of CO_2 per year (www.Airtricity.com).

In considering potential ornithological impacts of the project the Scottish Executive (now the Scottish Government) identified the requirement to monitor red kite and golden plover *(Pluvialis apricaria)* on the site as species listed in Annex 1 of the EU Directive on the Conservation of Wild Birds (79/409/EEC). Natural Research Projects Ltd (NRP) has been involved in ornithological monitoring at the site since 2002 and intensively since 2004.

The Study Area

The study area (Figure 1) is 28.3 km² in total. There are altitudinal differences of over 450 m with the highest point of the study area being at 662 m above sea level (a.s.l.) on Uamh Beag, while the lowest point is around 200 m at Loch Mahaick. The wind farm itself occupies around 4 km² and is situated between 360 m and 560 m a.s.l. The study area comprises the wind farm itself in the NE and a 'disturbed' zone in the SE, with the western half acting as a reference site. The study area lies mainly on ground owned by Doune and Moray Estates.

The main drainage is the Garvald Burn which runs south through the middle of the study area. It joins the Ardoch Burn at NN 713 069 which itself drains Loch Mahaick. The loch and surrounding vegetation was designated as a Site of Special Scientific Interest in 1986, chiefly for non-avian interests but also for holding significant numbers of pink-footed goose *(Anser brachyrynchus)* in winter. The Ardoch Burn itself is part of the River Teith Special Area of Conservation designated for lampreys *(Petromyzon marinus, Lampetra planeri, L. fluviatilis)* and Atlantic salmon *(Salmo salar)* (Register of Scotland, Joint Nature Conservation Committee 2014). Heather *(Calluna vulgaris)* dominated heath covers most of the study area above 300 m but areas of blaeberry *(Vaccinium myrtillus)* and *Molinia* grass are also present. Below this level, much of the habitat is semi-improved grass as well as bracken *(Pteridium aquilinum)*. Other than a Sitka spruce *(Picea sitchensis)* shelter belt there are few trees except a few patches in cleughs and around the farmsteads.

Land use is predominantly sheep grazing but cattle and horses are grazed on parts of the study area below 350 m. Red grouse *(Lagopus lagopus)* were formerly shot annually in and around the turbine area prior to construction. There is now no management for the benefit of grouse although some

red fox *(Vulpes vulpes)* control is carried out mainly for the benefit of lambs. Shooting of deer, both red *(Cervus elaphus)* and roe *(Capreolus capreolus)* is carried out around the study area.

Methods - Red kite studies

Aims of the Study

The final consent and planning permission issued by the Scottish Executive proposed a monitoring programme for kites. This was to be overseen by a steering group chaired by the Scottish Executive (now Scottish Government) and including members of Scottish Natural Heritage (SNH) and RSPB Scotland. The Braes of Doune Ornithology Steering Group subsequently met once or twice annually from 2005 – 2012 and also included staff from Natural Research Projects Ltd and SSE (formerly Airtricity). The group is now chaired by SNH. The purpose of this document is to report on the work of the steering group and report on the results of the monitoring programme as required by the final consent document (Scottish Executive 2004). The components of the proposed programme included:

1. A detailed radio-tagging study of red kites in the area to include assessments of demographic rates and general activity levels across the site.

2. Observations to identify activity of individual red kites in relation to each of the turbines.

3. Quantified studies of searches for collision casualties.

4. Analyses of the collision risks to kites from the operation of the wind farm based on ongoing data collected in 1. and 3. above.

5. Searches for available carrion and its removal from the area.

6. Establishment of feeding site(s) at distance from the turbines as mitigation measures.

Items 1 to 4. have so far been adopted and this document deals with these. Item 5 has been carried out by SSE staff and *ad hoc* by NRP and estate staff. Item 6 was considered to be un- feasible and unlikely to succeed early in the project's history. The overall project aimed to relate to issues of collision and displacement as a result of wind farm construction/operation.

The main aims of the kite radio tracking study were:

1. To quantify total daily flight activity of kites across the site at different times of the year.

2. To investigate levels of kite activity in relation to time of day, visibility and weather.

3. To determine any changes in ranging behaviour during the construction and operational phases of the wind farm at landscape scale.

4. To monitor flight behaviour of individual kites within the wind farm.

5. To test the accuracy of predicted mortality due to collision with the turbines.

The findings of this study were to hopefully inform decisions on wind farm construction in other parts of the UK where kites are present and to potentially inform decisions on suitable mitigation measures at this, and other sites, if applicable. The project was also closely co-ordinated with the wider RSPB Scotland/SNH kite project activities.

Collision Risk Modelling and Population Modelling

Prior to the main study beginning, vantage point work was carried out between November 2002 and September 2003. Data collected was used to prepare a collision risk model for kites at the site (Madders 2003). Based on an avoidance rate of 99.5% it was predicted that a kite would be killed at the development every 1.2 years (0.81 per year). Small adjustments to the model in relation to wind speed produced strike rates as low as 0.38 kites killed per year. Small changes to the avoidance rate (e.g. to 99.0%) doubled the predicted risk of strike to an estimated 1.17 kites killed per year. In broad terms the model suggested a figure of around one kite killed per year at the proposed development.

In addition, potential impacts on kite numbers were modelled to predict what effect additional wind farm related mortality would have on the expanding population (Madders and Fielding 2003). As with all models there are a number of assumptions but assuming one first year kite was killed per year, population growth was un-affected based on the productivity at that time. It was concluded that the population could tolerate low levels of mortality resulting from the wind farm, especially if it applied to first year birds. This was based on first year survival of 55% in 2003, a rate which has been subsequently exceeded.

Radio tagging and equipment

Kites were radio tagged with back mounted 22g radio transmitters. These were fitted to nestling kites, aged 5 – 6 weeks old, when nests were visited as part of the ongoing RSPB/Central Scotland Raptor Study Group monitoring programme for the population. Transmitters were attached with a harness of Teflon ribbon and had a battery life of 1.8 to 2.5 years although inevitably some of these

failed prematurely. The transmitters and harnesses were fitted to stay on for the life of the kite. Experience from other kite projects demonstrated that these did not interfere with mating, feeding or survival of the tagged individuals if fitted correctly. It was important to ensure that maximum body growth had been achieved before fitting these to chicks even if feather growth was incomplete. This method has been thoroughly tried and tested with other similar sized raptors (Kenward 2001).

Kites were tagged from as geographically wide a variety of nest sites as possible although the furthest sites from the wind farm were avoided. This was intended to help prevent any biases which may have occurred due to certain key nests or breeding pairs being over-represented. However, each year a balance had to be struck between using a wide variety of nests and fitting the desired number of transmitters due to suitability and availability of chicks. As a result often more than one nestling was used per nest.

The transmitters came complete with an activity switch, indicating if the bird was perched (slow signal) or flying (fast signal). A fast signal of continuous strength with no variation in volume from one point can often indicate a dead bird lying horizontally on the ground and this has led to the discovery of many dead birds during the reintroduction projects (Carter 2007, pers. obs).

The young kites were also fitted with PVC wing tags and a British Trust for Ornithology (BTO) ring as are all nestling kites wherever possible. Consistent with monitoring schemes for other British kite populations, nestlings were fitted with an area colour code on the left wing (red for Central Scotland) with a year colour code (e.g. orange for 2005, green for 2006) on the right. Each bird has its own letter, number or symbol as its individual identity (e.g. 41, 6H etc). As the birds usually have to be perched for their tags to be read there was little opportunity to identify study birds within the study area, although these markings were useful for monitoring birds in the wider countryside and for conservation monitoring purposes.

The fitting of tags to nestlings is dependent on the location and monitoring of kite nests throughout the spring and summer. NRP assisted RSPB Scotland, Central Scotland Raptor Study Group and Forestry Commission Scotland workers in this work and this task and later tagging work were considered a priority during June and early July.

Due to the study results coming mainly from sub-adult birds, an attempt was made to catch adult kites for radio tagging to gather data on foraging ranges of territorial and breeding birds. This method employed ‘box nets’ surrounding baits but was not successful in the brief period when this was tried.

The birds were monitored on the site using a Challenger 2000 receiver (manufactured by ATS) and a yagi aerial. This allowed a large number of frequencies to be entered and scanned. Latterly a digital Biotrack 'Sika' set was used. A vehicle-mounted roof aerial was also used for tracking work in the wider Central Scotland area to determine survival and movements.

Radio tracking

Radio tracking studies were carried out from February 2005 until January 2011.

For around the first year of the project, access to the proposed wind farm site was only possible by foot. The western half of the study area has few tracks accessible to vehicles. It is essential to use high points while radio tracking to get the best range and strength of signal (Kenward 2001) and the higher points of Uamh Mhor and Uamh Bheag were important to include in this regard. Therefore a walking route was the only way of evenly covering the study area (Figure 2). This route was ideally carried out alternately clock-wise and anti-clockwise. Due to factors such as low cloud, access issues, deep snow or short day length the main route was sometimes altered. The full route was attempted twice a week so long as weather and other factors permitted.

Locations were selected around the route to serve as fixed radio tracking points and these were used on every occasion visited. Typically these were prominent places on knolls, hilltops or open ground where good tracking was possible. There were originally 13 fixed tracking points, but these were later reduced to 11 due to access restrictions altering the original route and two of the original tracking points becoming inaccessible.

At each point the radio frequencies of all birds known or thought to be currently resident in the population were checked. The radio receiver was set on a 16 second scan. When the project started, with a sample of four birds, a minute was spent searching for each bird. As the birds which were detected were usually located within several seconds and with the practicalities of a growing sample size (potentially up to 45 birds at any one time) 16 seconds was considered a sensible amount of time to search for each individual at each tracking point. Once a kite's signal was detected in this search period, an effort would then be made to identify where the bird was.

Any recently missing birds that may potentially occur were still searched for. Any birds missing for more than 12 months and birds which were confirmed dead or resident elsewhere had their frequencies deleted from the radio receiver. The birds that were actually confirmed present in the population formed the contemporary sample size and this was reviewed every month.

The location of radio tagged birds was calculated, where possible, by triangulation. A number of bearings can be taken to establish where a tagged individual is and a location can be established where these cross (Kenward 2001). In reality, due to the nature of the birds activity over the site, triangulation to a six figure OS location was usually impossible. When the birds moved rapidly through the study area they could move hundreds of metres in the time it took for the tracker to move from one triangulation point to another and so frequently a four-figure reference was the most precise level of accuracy that could be attained. It was far easier to triangulate and precisely locate a perched bird, but perching opportunities (i.e. trees and fences) are very scarce in parts of the study area, especially in the northern half. Trials following kites to their exact positions outside the study area were made early in the study to determine accuracy of estimated locations, as were trials using a test radio transmitter placed in the wind farm site.

Each four-figure reference was given a category of estimated accuracy: 'Good' being highly likely/certain to be within the given square; 'Fair' being in or within 500m of it; and 'Poor' being in the square or within 1 km of it.

In periods of extreme weather, especially those with associated poor visibility, the walk route method was impractical and ultimately often proved pointless due to the behaviour of the birds under such conditions. In addition, during the construction phase of the project, the site was closed for Health and Safety reasons during periods of poor weather and no work was allowed in the eastern half of the study area. In poor conditions (e.g. cloud base ≤ 400m, moderate or greater precipitation, and/or Beaufort Wind Force ≥ 6) kites were searched for using the radio receiver and a roof mounted aerial positioned on the project vehicle. Every 10 minutes all kites actually or potentially present in the Central Scotland area were searched for. If any signals were detected these were then checked with the directional (yagi) aerial to establish if the birds were in the study area, and if so, their actual location identified. This method was also used in periods of prolonged and deep snow cover.

Radio tracking data was entered onto site visit forms recording each bird tracked. Records of the birds actually occurring within the study area were entered onto an Excel spreadsheet, including information on behaviour and weather conditions.

Staff working on the study also assisted RSPB Scotland in monitoring the kites at winter roosts. As well as determining the fate of radio tagged study individuals it also contributed to assessing the status of the whole population in relation to the presence of the wind farm. These were carried out once a month as a co-ordinated effort to estimate the size of the Central Scotland population. Data

regarding population growth derived from roost counts are not yet available and therefore are not included in this report. The roost monitoring did provide information on the movements of the study individuals in the wider countryside outside the study area and some of this data is incorporated into the results concerned with foraging patterns and distances.

Additional observations on radio tracking sessions

At each fixed tracking point a 360 degree visual scan lasting a minute was made to compare visual detection rates of kites compared to detection rates with radio tracking. These 'Point Counts' were carried out at each fixed tracking point on every occasion visited, provided visibility was adequate. These were also used to help build a picture of seasonal variations in use of the site.

In addition to the tracking work all kites seen on the route were recorded. These were checked to see if they were radio tagged, and if possible identified to age class by plumage or wing tag colour. Flying height was estimated for the initial observation and flight route was recorded on a visit map. Any relevant behaviour such as feeding was noted. Route counts were intended to help establish patterns of site use with regard to season and weather.

Vantage Point watches

Information on kite flight activity was collected during timed watches from strategic Vantage Points (VPs) using the methods described by Band *et al* (2007).

Six VPs were selected through a mix of GIS analysis and field trials, with the aim of maximising ground visibility within the flight activity survey area using the minimum number of points (Figure 3). The locations of four of the VPs had to be moved in late 2006 due to access issues around the development of the wind farm. The most recent arrangement of VPs shown in Figure 3 was the one that were maintained through the majority of the monitoring period. The vantage point observations dealt with in this report were carried out from September 2004 until November 2010 and October 2011 to March 2012. Initial VP observations were carried out in late 2002 and 2003 to provide data for the Collision Risk Model used to inform the Environmental Impact Assessment in support of the planning application.

Observers at VPs positioned themselves to minimise their effects on bird behaviour. A viewing arc not exceeding 180 degrees was scanned. Watches were undertaken during daylight hours by a single observer in a wide range of weather conditions, mainly in conditions of good ground visibility (> 2

km) and when the cloud base was higher than the most elevated parts of the survey area, but with some watches undertaken in visibility down to 500 m.

A total of 1486 hours observation was undertaken from all six VPs. A wide range of meteorological conditions were sampled, including rain and snow showers, cloud cover from 0-100% and wind speeds up to Beaufort Scale Force 6. Detailed weather data is not included in this report but is available on request.

During each watch, two hierarchical recording methods were used, as follows:

Focal bird sampling. The viewing arc was scanned constantly until a kite was detected in flight. Once detected, the bird was followed until it ceased flying or was lost to view. The time the bird was initially detected and the time it spent in flight (to the nearest second) were recorded. The route followed by the bird was plotted in the field onto a 1:25,000 scale map, with the direction of flight indicated. Routes were plotted regardless of whether or not the bird was within the survey area. The bird's flying elevation above the ground was estimated at the point of detection and at 15 second intervals thereafter, using a countdown timer with an audible alarm. Flying elevation was classified as <10 m, 10-50 m, 50-100 m, 100-150 m, or >150 m. More recently the 10 - 50m band was split into 10-30 m and 30-50m to allow a more precise assessment of flight height. Where simultaneous flight activity by a number of birds was observed and it was not possible to plot individual flight lines, areas of flight activity were plotted on the field maps. The only other species to have flight activity recorded in this manner were golden eagles *(Aquila chrysaetos)* and white-tailed eagles *(Haliaeetus albicilla)*, both sighted infrequently at the site.

Activity summaries. At the end of each 5 minute period, flight activity within the survey area by kites as well as species of lesser conservation importance (Secondary Species) was summarised. The number of birds recorded in any one period was the minimum number of individuals that could account for the activity observed. The height, direction and number of individuals involved in notable bird movements (e.g. gull flights) were recorded. This report does not deal with activity levels of secondary species, the steering group having not yet identified a need to analyse this data at time of writing.

Data were entered in the field onto recording sheets and later transferred to Excel spreadsheets. Maps of flight activity by kites were compiled for each watch. Each flying bout was numbered consecutively and cross-referenced to the relevant flight-path on the map.

Methods – Wind Farm Mortality Studies

Turbine searches

Turbine searches were carried out to detect turbine related kite deaths at the site in order to monitor collision rates. Searches were carried out February 2007 – January 2011 and October 2011 – March 2012. Searches were carried out once a week on average. Factors such as snow cover meant that sometimes searches were not feasible and so additional searches were carried out in subsequent weeks to catch up.

Studies carried out in the USA indicated that the majority of birds hit by turbines remain within 63m of the structure (Young *et al.* 2003). On the basis of this finding, workers on several US projects searched an area 126 - 140m around each turbine. A square plot 130m x 130m was considered appropriate for the Braes of Doune site (Duffy and Steward 2008). This was covered with search transects 10m apart, with the searcher looking 5m on either side. This transect interval was considered suitable to detect a bird the size of a kite. Plots took two to three hours to search methodically in this manner. A searcher was employed one day per week to carry out turbine searches. As 36 turbines were erected, three or four were searched once a week in rotation, so that all 36 were covered roughly once every 12 weeks. The height of the turbines at Braes of Doune was 65m at the hub of the blades, with the blades themselves being 40m long. This was a good match with the height of the turbines, and therefore the search plot size, in the US studies (Johnson *et. al.* 2003).

Although the searches were specifically designed to detect kite mortality, strikes or potential strikes of all other species were noted as it was considered a rare opportunity to record turbine related mortality at a Scottish wind farm. Any carcasses or remains found had their position noted with GPS to a ten-figure reference and those of key species were photographed. The state of each carcass was be recorded using the following condition categories, following Johnson *et. al.* 2003:

> Intact – a carcass that is completely intact, is not badly de-composed and shows little or no sign of being predated or scavenged.
>
> Scavenged – an entire carcass showing signs of being fed upon by a predator or scavenger or a dismembered carcass (portions) in one location (e.g. wings, skeletal remains, legs, pieces of skin, etc.).

Feather patch – ten or more feathers at one location indicating predation or scavenging. If only feathers are found, 10 or more total feathers or two or more primaries must be discovered to consider the observation a casualty.

All carcasses or parts found near turbines or met masts were considered wind farm related casualties unless another cause of death was apparent. Carcasses of kites and other key species were dealt with under special protocols (Duffy 2006). Carcasses of other species were frozen for potential post-mortem analyses. All red kites and other key species were immediately taken for post-mortem, at either the Veterinary Laboratory Agency lab at Lasswade, near Edinburgh or the Scottish Agricultural College Laboratory at Auchencruive near Ayr.

Searcher Efficiency and Carcass Removal Trials

These trials were carried out to investigate a) the efficiency of the searcher in locating carcasses and b) estimate rates of scavenging in the area. This was intended to help to estimate how many bird strike victims were missed by the turbine search method.

The two trials were carried out in similar habitat to the wind farm but outside both it and the wider study area. This was to avoid any suggestion that carrion left out for the trials was attracting kites to the area and influencing their behaviour as well as to prevent any related risk of turbine related mortality. There is also evidence that searcher efficiency can be influenced by height and type of vegetation (Morrison 2002). An area to the east of the turbines and study area around NN 7410 was chosen, being of similar altitude and heather height to the wind farm.

Carcasses were left out in the trial area by one worker and searched for by another later the same day. The searcher was unaware of the position of the carcasses. The search was carried out on the same day as carcass positioning as it was initially feared that foxes may remove some of the carcasses on the first night thus biasing the search results.

An area equivalent to that covered over a day's routine turbine searches was chosen in the area mentioned above. This was marked out in three adjacent plots, each 130 m x 130 m. The plots were searched in exactly the same manner as the turbine searches and searching the three plots was equivalent to a routine day's turbine search.

Pheasants (*Phasianus colchicus*) were initially chosen as an appropriate available species to use due to their general weight (due to regulations involving the disposal of dead domestic stock it is not possible to use species such as hens for this work). Pheasants weigh 750g – 1700 g (Snow and

Perrins 1998) which is a similar weight range to kites (720 g – 1600 g, Carter 2007). Females were mostly used as their colouration is broadly similar to that of kites. These were readily available from local sources during the winter and were frozen for use later in the year. Typically three carcasses were positioned in each plot at random, pre-chosen locations and these were logged with a GPS unit. The GPS location was also noted to establish if any carcasses had been moved by scavengers. Each carcass was marked with a leg ring or metal tag to prevent confusion if they were moved from their original position.

After the initial search trial day the carcasses were left to establish how long they persisted in the study plots. In early trials the carcass sites were then visited until all had disappeared or were reduced to feathers or the most minimal remains. Other tasks prevented daily visits so carcasses were checked at Days 1, 3, 5, 10, 15, 20 after positioning and after this point, as frequently as possible. On some occasions snow fall interrupted this routine. Apart from the practical reasons of access and finding the carcasses in snow, it was felt that it would be useful to see how carcasses persisted in a variety of naturally occurring conditions, so carcasses were left in place.

In later trials the carcasses and subsequent remains were visited at the same frequency up to day 20 then every five days, then 10 days up to the end of a 90 day period. This was to establish what was left and detectable after the full 90 day search interval per turbine at the wind farm itself.

The trials were conducted throughout the year to allow for seasonal differences in scavenging rates and vegetation height. It was initially felt that scavenging by foxes would be a major factor in carcass removal and so trial sessions were chosen to coincide with key times in the fox 'calendar': spring (cubbing time); early autumn (presence of dispersed/dispersing young); late winter (time of high food stress). Snow cover influenced the exact timing of the spring and winter trials.

Pheasants were used in the initial trials due to them being the closest easily available analogue to kite carcasses. However, Smallwood (2007) suggests that carcasses often used in US studies, such as poultry, game birds or pigeons, are actually more palatable to scavengers than raptor carcasses which may give a pessimistic impression of how long the latter would persist. As a result it was decided to secure a safe (i.e. free of poisons or high levels of pollutants) supply of common buzzard *(Buteo buteo)* carcasses to act as a more accurate analogue for dead kites. A government agricultural science lab was suggested as a source and a supply was secured in 2010 for the later rounds of trials.

Results – Red Kite Studies

Radio Tracking Study

Marking individuals for study

Eighty-one nestlings from 26 territories were fitted with radio transmitters between 2004 and 2009 (Table 1). In addition three injured and subsequently rehabilitated birds in their second calendar year were also tagged and released giving a total of 84 marked study individuals. Due to some of the 2004 cohort drifting off before the study properly started and two birds dying of poisoning on point of fledging, the actual usable study sample was 79. Some of these birds drifted off from the area or died within a few months of fledging so finally 64 birds were monitored for a meaningful length of time (i.e. > 6 months). The 81 nestlings tagged represented a quarter of the known young produced by the Central Scotland kite population in the 2004 – 2009 period. In addition a number of radio tagged individuals from other populations were temporarily present in the Central Scotland area and these were also monitored for some time, especially in the first year of the study.

Radio tracking

A total of 379 radio tracking 'walk-round' visits were made between February 2005 and January 2011, comprising 2407 hours of coverage. During these visits a total of 7876 radio contacts were made, with 2147 (27.2%) of these from birds within the study area. In total 81 individuals were recorded within the study area by the above method. This total included 13 birds from other populations, eight from northern Scotland, four from Aberdeenshire and one from north-east England.

Of the sample of 79 Central Scotland birds, 69 (87.3%) of them were recorded within the study area with 51 (64.5%) recorded within the development area itself, including the pre-construction period. Using the sample of the 64 birds present for > 6 months, 60 (93.7%) were tracked within the study area with 47 (73.4%) passing through the wind farm. Annual proportions of each cohort passing through the turbine area do not indicate any clear trend of avoidance (Table 2). As coverage was not daily, these figures should be taken as minimums. These data suggest the vast majority of sub-adult birds passed through the development and were therefore potentially vulnerable to turbine strike.

None of the immigrant or transient birds were recorded within the wind farm site itself, pre- or post-construction. However, most of these remained in the population for 6 months or less and so provided relatively few results.

There were 36 visits where tracking was carried out from fixed points due to access or weather problems, totalling 96.75 hours. This produced 28 records from 13 individuals. There were five records of birds within the wind farm although three were from one individual in a short space of time. There were four tracking records made during *ad hoc* work including one of an individual in the wind farm not recorded through the other methods.

Changes in site use

Radio tracking results appear to hint at displacement from some parts of the development to the non-developed parts of the study area. Figure 4 shows the number of radio tracking fixes by km². In the pie charts the blue segments represent pre-construction, white represents the construction period and red represents post-construction. Size of the segments is based on a percentage (rather than total count), this allows comparisons when changing the length of periods (otherwise a small period would inevitably have a small segment). The size of the pie charts is proportional to the number of observations per km^2 during the three periods.

Weather and site use

Radio tracking consistently revealed that the kites were very inactive early in the day only to become more mobile as wind speeds apparently increased as the morning progressed. Superficially 'good' days in the winter (clear, frosty, with no rain or cloud) were usually un-productive for tracking or seeing kites in the study area, while those which were cloudy, slightly damp but breezy were usually more productive. The kites appeared to be most active in Beaufort Wind Scale Forces 3 – 4. Note however that this was a best estimate of wind speed made by an observer on the ground, with height above ground and altitude probably making considerable differences even with a short distance between the kite and observer. Higher wind speeds are often associated with severe conditions when visits were less likely to be made and so this may have slightly biased against recording birds at the upper end of the scale. In general kites seemed to be most active in moderate wind speeds and this is consistent with observations of kites elsewhere.

There were a few occasions when there was a relatively high degree of kite activity but little wind. It is likely that the birds used thermals on these occasions, usually in warm weather. Observations of groups of kites circling uphill sometimes with buzzards or ravens suggested this.

There was no clear evidence that wind direction influenced kite activity over the site, with numbers of tracking records and sightings in proportion to the frequency that each wind direction occurred.

Very wet and windy conditions reduced kite activity. As an example, on one occasion three birds were tracked from a fixed point in bad weather (total, low cloud cover, constant rain and Beaufort Scale Force 5 wind) over a five hour period on 22 September 2005. Of 58 signals received 43 (74.1 %) indicated the birds were perched and they remained in the area of the communal roosts in this period. The proportion of signals indicating perching ranged from 70% to 77.7% in the three individuals. On 26 September 2005 the same three individuals were even less active in heavy rain, with 82 – 100% of their signals indicating perching. On two dates around the same time, all three individuals were tracked within the study area in the same time period (10.00 – 15.00) in bright breezy conditions.

There were some occasions when kites used the study area in wet conditions with poor visibility. Birds were sometimes seen flying uphill into drizzle, mist and haze in the spring and summer. One of the first birds to be monitored during the study, R/Y 41, was followed from its roost moving through the study area in such conditions in June 2005, and other kites were seen in association with it on several occasions. Such behaviour was much rarer in winter with the radio tagged birds more likely to remain at lower altitudes in similar conditions. It is possible that short day length was also a factor in limiting movement.

There were virtually no records of kites, either visually or through radio tracking, on the site through periods of prolonged snow cover, especially in the 2009-10 and 2010-11 winters.

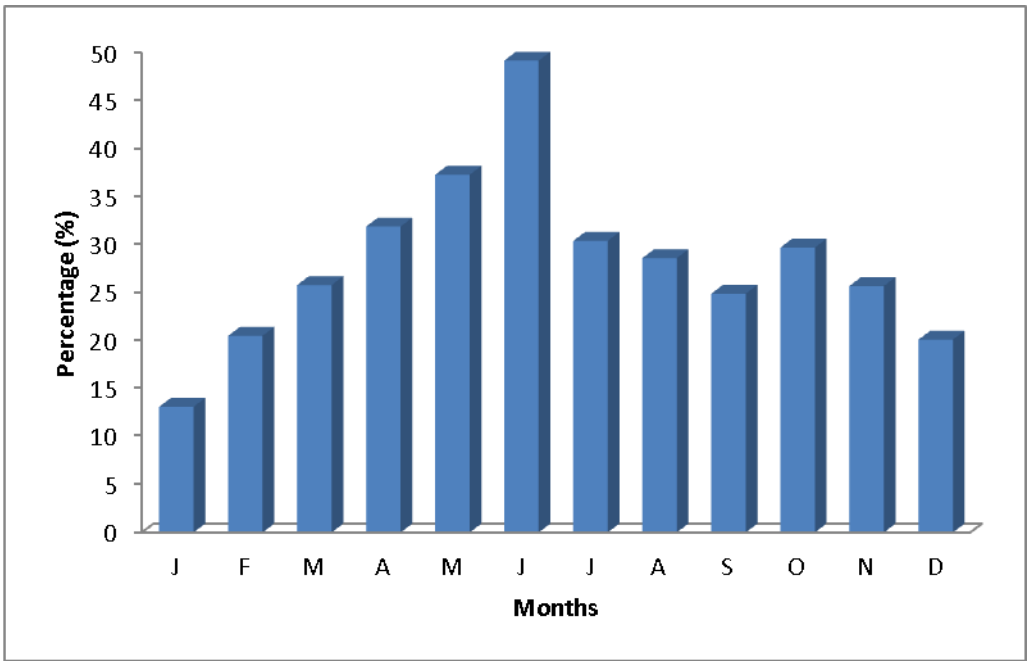
Site use in relation to season

There appeared to be seasonal peaks in activity throughout the year (Diagram 1). Factors such as better weather, longer day length and increased feeding opportunities (lamb mortality and after-births, abundance of invertebrates, reptiles and amphibians) are likely explanations for the peak in spring/summer activity in the tagged sub-adult birds. This, and the need to provision young with food, is also likely to be an important factor for adult birds.

In most years, and for all years combined, there was a peak of activity in autumn. This may have related to a late summer lull in activity due to older birds moulting in the post breeding period or to more autumn activity from younger birds moving between roost areas.

The lower levels of activity in winter are likely due to unsuitable weather and the lack of some of the feeding opportunities mentioned above. The abundance of sightings during tracking sessions followed the same seasonal pattern as the radio tracking results.

Diagram 1. Seasonal variation in site use as determined by radio tracking
Values represent the percentage of all radio tracking fixes that were from kites within the study area, all years combined 2005 - 2011.



Foraging patterns and distances

The proximity of the communal roosts in the Doune area to the southern edge of the study area gave the opportunity to follow the movements of kites from their roosts and in their daily ranging activities. A typical pattern was for the birds to be detected early in the morning at the communal roosts or close by with the birds becoming more active and moving north as the morning progressed. Weather and season determined how rapidly this happened, as described above.

Birds frequently moved from their roosts north through or around the study area to Glen Artney and returning again in the mid - to late afternoon. There were variations in this with some birds remaining in roosts to the north of the study area or doing the opposite daily route from the same northern roosts. Birds roosting at Doune and travelling to Glen Artney and back would have to cover 30 km to do this by the shortest route and so would cover over twice this distance in the course of a day. The kites did sometimes travel south to forage but almost invariably would move north from Doune.

One 2008 bred individual which provided a lot of data in September and October 2008 gave a good picture of how far the kites can range in relation to the wind farm. On the 18 days when it was tracked in this period its location ranged from the wind farm itself (three occasions) to the Campsie Fells (once, 30 km south of the wind farm) to a roost near Comrie (10 km north of the wind farm). On the 21 occasions when its roost location was known or searched for, it roosted on nine occasions

at Doune and two near Comrie. On 10 occasions its roost site was unknown, but as it was absent from the Doune roosts it almost certainly would have roosted at Comrie or another roost north of the development.

Survival of the radio tagged study kites

Over 80% of the total sample tagged as nestlings survived to the end of their 1st calendar year (i.e. year of hatching) with at least 65% surviving to the end of their second calendar year (Table 3). The survival of the 2007 cohort was especially good. Two of the 15 birds disappeared in late summer of that year, a time when young birds often disperse, while the remaining 13 (86.6%) survived and remained in the area until 2009. At least nine (60%) of these remained alive in the area to the end of 2009, by which point radio tags were beginning to fail.

Seven (8.8%) kites from the studied sample of 79 were retrieved dead in the 2005 – 2009 period. Two of these were victims of poisoning, although it was not established whether this was caused by deliberate or accidental poisoning due to the unusual substance used. One was found dead with a leg injury consistent with it being caught in a leg hold trap and then released. The causes of death of three more were unknown, while one was killed by turbine strike at the wind farm itself. Two of the fatalities were detected by radio tracking work carried out through the study while the turbine casualty was found during the routine turbine searches. Assuming the latter turbine casualty was the only radio tagged victim of such mortality it represents 1.2% of the study sample.

Kite observations

During the course of the work a wealth of other observations on kites were made which were relevant to the study. Those below are included for their relevance to mortality, disturbance or activity levels across the site.

Sightings

All kite sightings in the general study area were noted during the 379 visits regardless of them being study individuals or not. There were a total of 1251 sightings, equating to 0.52 kites per hour of fieldwork. A sub-set of these were the birds detected on the visual scans made at tracking points. During 2228 minute-scans 314 birds were seen, 0.14 kites per minute (8.4 kites per hour), or one kite per 7.1 minutes. As these scans were of uniform effort and made in good visibility (≥ 1km) this result probably provides a more accurate indicator of encounter rate than the mobile counts.

Kites and turbines

The kites appeared to be indifferent to the presence of the turbines from the beginning of construction. The first two turbines were completed (but not operational) between 2 and 15 June 2006. On 15 June 2006 12 kites in total were seen flying between and just over the two turbines, at heights ranging from 50 m to 150 m. This was over a two hour period and while construction work carried on throughout the site.

There were several cases where kites were seen to apparently avoid moving turbine blades. On 29 June 2010 an adult kite was seen approaching the wind farm from the east, flying at a height of between 10 and 50 m. The bird flew towards Turbine 7. The kite was then seen to take evasive action as the down sweep from the turbine blades from that turbine almost struck the bird. The kite carried on its way as if nothing had occurred. On at least one occasion a kite was seen to 'steady itself' after flying behind an operational turbine as if an area of turbulence had affected its flight. Other raptors such as kestrels were also seen doing this. A kite was seen to make a sudden movement in flight near a turbine blade in January 2012, although again, turbulence could have been the cause.

On two occasions kites were reported to be seen actually moving through turning blades. On 10 August 2009 a kite was seen flying inside the zone containing the rotating blades of Turbine 3. The rotor blades on Turbine 3 were turning at a very slow speed due to the almost calm conditions in that area of the wind farm (120 seconds to complete 120 degrees of turn). The turbine was probably actually turned off with the blades 'free wheeling'. The kite flew directly towards the turbine from the south west. Just in front of the turbine it started to turn and crossed between the blades at a height of 75 – 80m before coming back through between them and continuing to circle off to the south east.

On 26 November 2008 a kite was seen apparently foraging in the wind farm. It was then seen flying so close to Turbine 16 that it appeared to be hit by the outer third part of one of the blades. It turned suddenly and momentarily dropped out of sight. The bird immediately re-appeared and flew on undeterred and headed for Turbine 17. Here it appeared to fly between two blades near to the central cone. It was observed in front of the first blade and being obscured by the second blade. It continued to fly near turbines for another five minutes. The bird may have encountered air turbulence at Turbine 16 as the bird was apparently unharmed and was subsequently seen flying east out of the development. On another occasion in October 2009 a kite was seen flying through

the stationary blades of a turbine while a second tried to land on a stationary blade of the same one. It could not grip on due to the smooth rounded surface and immediately flew off.

Territorial and breeding behaviour

Pairs of kites exhibiting territorial behaviour were seen within the study area from 2005 although these could have been pairs from the closest existing territories. A young pair of kites were seen near a nest lined with wool in spring 2005 but did not breed there. There appeared to be an adult male on territory in the study area during 2006.

The first attempted breeding of kites within the study area occurred in 2009. A pair consisting of a 2006-bred male and un-tagged female took up territory within the study area in March and built a nest. The pair was seen copulating some distance from the nest site on the 3 April and behaviour indicated the female was incubating by 16 April. The nest was found to have failed on 3 May. The nest had been a flimsy structure built relatively low in a conifer and had collapsed. The remains of two eggs were found on the ground, the nest having probably collapsed a couple of days earlier. The pair remained around the nest area for the rest of the spring and summer. This breeding attempt was the closest to the wind farm at that time, 2.2 km from the nearest turbine. The pair built another nest and laid eggs in 2010 only 1.2 km from the wind farm but this nest also collapsed. The male killed by turbine strike in November 2010 was thought to be the male from this pair (see 'Red Kite Fatalities').

A pair nested in a similar location in 2011 again failing, but this time appeared to get as far as the early chick stage. Many kite nests in central Scotland failed in late May 2011 due to a severe gale (Duncan Orr-Ewing pers comm.), and this was the probable cause of failure at this site.

Communal Roosting

A small communal roost was discovered early on in the study at the southern edge of the study area. This was used for several years partly as a pre-roosting area but also for roosting itself and up to 20 birds were recorded. The roost was usually used in the spring and summer between 2005 and 2008. It was at its highest level of use in 2006 when the main construction compound was only 300m away with the associated noise and traffic. There was no obvious reason for this site's abandonment as a roost but small ephemeral summer roosts are often established by sub-adult non-breeding birds (Carter 2007).

Feeding behaviour

Numerous observations of kites feeding within the study area were made. These included kites feeding on items such as lizards (*Zootoca viviparous*) (G. Connelly pers comm.) and moths (Duffy 2009). Sheep carrion was a more common and predictable food source and attracted birds to the wind farm area before, during and after construction. On one occasion ten kites were seen at a sheep carcass in June 2006 only 300 m from the wind farm while it was under active construction. On 1 November 2008 eight kites were seen in the completed wind farm attracted to two sheep carcasses, with a single bird attracted to both the following day.

Deer carrion also attracted kites into the completed development. Ten kite flights were recorded around, and close to, a turbine during a three hour vantage point watch in October 2009. When the area was inspected, the discarded feet of a culled red deer were found. The carcass of a large red deer calf (possibly the result of poaching) was found in the central wind farm in December 2009, its presence detected by the behaviour of a kite, along with a buzzard and carrion crow *(Corvus corone)*.

Such carcasses were subsequently removed by site staff, NRP or estate staff. This illustrated that such food sources could be a factor which increases strike risk to kites. No turbines were operational during the November 2008 incident due to calm, frosty winter weather.

Results - Vantage Point watches

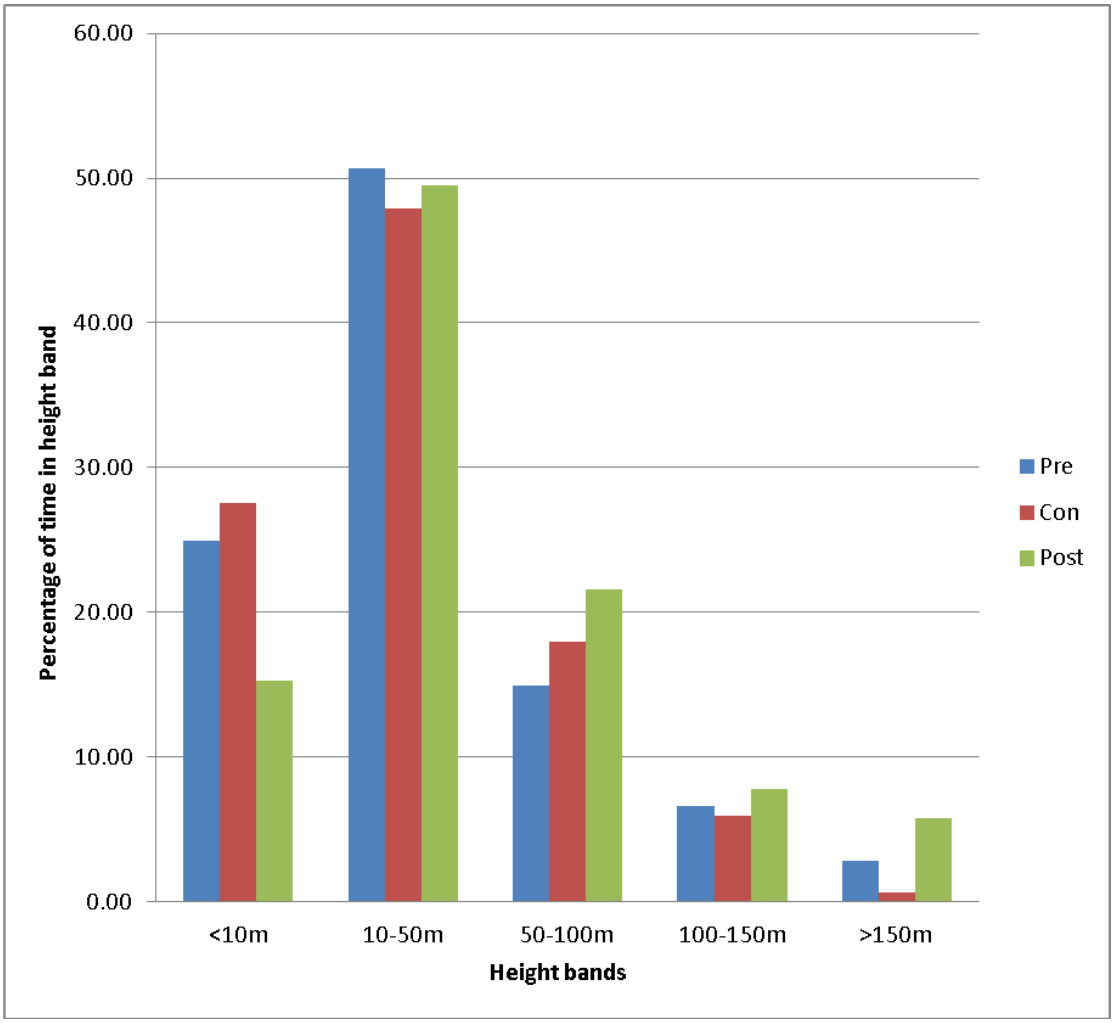
A total of 1264 timed flights were recorded from 1486 hours of observation (in 556 sessions) between September 2004 and March 2012. Full details of survey effort and monthly results are given in Appendix 1 and 2.

Prior to construction, concentrations of flight activity appeared highest along the ridge to the north-west of the turbine area and in parts of the southern end of the study area (Figures 5 & 9). The latter concentrations may have been partly due to key sheep management areas within the study area, such as lambing fields. Flight activity was lower in the development area during the construction period (Figures 6 & 10). This may have been due to disturbance although kites continued to be seen within the development area during construction.

A large amount of kite activity was recorded within the completed development (Figure 7) superficially suggesting that it was not a deterrent to the birds. More detailed analysis suggested that flight activity was initially low in the post-construction period (Figure 11) but after 2009 there was a high area of flight density in the south-east of the development (Figure 12).

Kites spent 50% of their time in the 10 m to 50 m height band in all three periods (Diagram 2). In the early months of the project, when height band stratification was different, kites spent 61.2% of their time between 10 m and 100 m. In the final months of the project when stratification was broken down further the birds were found to have spent 51% of their time between 30 m and 100 m in height (broken down as 30 m - 50 m and 50 m - 100 m in the field). This indicates that kites do spend a large proportion of their time within rotor swept height of the Braes of Doune turbines (25 m – 105 m).

Diagram 2 . Proportion of time spent by kites in different height bands.
Data used from all vantage points, all study area, September 2004 – November 2010



Results – Wind Farm Mortality Studies

Turbine searches

A total of 536 turbine searches were carried out between February 2007 and January 2012. There was an eight month gap in coverage in 2011 and frequent gaps of up to a month due to snow cover,

especially in the 2009-10 winter. Every turbine was searched 15 times except for four which received 14 searches. The searches detected one red kite carcass in April 2010, described below.

In addition, a total of 69 carcasses or sets of remains were found as a result of the searches comprising 18 species (Table 5). Remains were found at 27 of the 36 turbines. The most commonly found species was red grouse but it was presumed that the majority of these were killed by causes other than turbine strike.

Red kite fatalities

Three kites were found dead as a result of turbine strike. The first was discovered on 2 July 2007 at Turbine 44, in the west of the development, during an ad hoc visit to the site.

At 11.08 hours a kite was seen circling low beside Turbine 44 as if over a carrion source. It soon flew off west and when the site was investigated a dead kite was discovered. The bird had lost its wing tags but its BTO ring established that it had been wing tagged 'Red/White H' in 2002 as a nestling, and was hatched about 7 km from the wind farm. Having lost its wing tags it has not been identified in recent years and so it was not known if it was a breeding bird in 2007. It was however of breeding age and biometrics taken on the date of ringing indicated it was a female.

The bird lay on its back with a damaged right wing, evidently broken in two places. The upper and lower mandibles were slightly out of alignment. The bird was fresh with no smell of decomposition. There were no signs of scavenging and it was suspected the bird had died earlier that day or maybe the previous evening. The bird lay 28 m from the turbine. The bird was taken for a post-mortem examination the same day which revealed it had a fractured skull, the probable cause of death (Alasdair Wood pers comm.). This probably accounted for the non-alignment of the mandibles. The turbine was facing south when the bird was found, but it may have faced a different direction when the bird was hit. There were frequent showers and mist that day with visibility down to a few hundred metres at times, but there was no evidence that visibility was a factor.

The second fatality was found as a result of the turbine search method. It was found on 27 April 2010 during a routine turbine search at Turbine 17 on the north-east side of the development. The bird had been cut in two with the front half, including the wings, missing. The bird's ring indicated it was a 2008 bird bred near Argaty Red Kites feeding station. The bird was one of the study individuals, known as 93/08 and had a radio transmitter. There was no trace of the transmitter or harness and radio tracking on the day and beforehand had not detected any signal from it. It is probable that it had been badly damaged by the impact. With the possibility that the transmitter

continued to work very weakly, further tracking and visual searches were made the following day, but this and subsequent searches found no trace of the other remains. The bird was last recorded on 12 March 2010 less than 10 km from where it died and had been routinely searched for with the other study individuals in the intervening period. The bird was quite decomposed, but as it was lying in a peat hag and sheltered from recent cool winds, it may have been a quite recent casualty. It is also possible that it may have died in March and been covered by the snow that fell late that month and lay into early April.

This individual was the most recorded bird of its cohort on the study area as a whole (54 records) and within the wind farm itself (five records). Of 82 birds tracked within the study area it was the 14th most recorded bird there. It had been tracked twice previously in the area where it died, once in March 2009 and once in April 2009 and was recorded in the study area in all months of the year except July.

The bird was taken for post-mortem (PM) the following day. Although the PM result stated that it was not possible to say what had killed the bird, it is difficult to believe that this was anything else other than a turbine strike and the bisected nature of the carcass is entirely consistent with other wind farm fatalities at this site and elsewhere.

There had been maintenance work at the turbine where the bird was killed for a number of weeks before the carcass was discovered. Shelter had been provided for workmen next to the turbine and as a result there was a great deal of litter around the area, so much that the workers were disciplined by the site manager. It is tempting to speculate that food waste in the litter may have attracted the kite directly to the vicinity of the turbine or indirectly through it attracting rodents or other scavengers.

A third kite was found killed at the wind farm on 1 November 2010. This time the bird was found by an SSE employee at Turbine 5 while doing routine site inspections. The remains of the bird were found at around 11.10 hours, the carcass having been absent from the same spot 30 minutes earlier when the staff member previously passed by. The time of death must have been around 11.00 hours. The bird was wing-tagged, Red/Green 1H, and was in its fifth calendar year. It was suspected that this was the male of the pair which had unsuccessfully attempted breeding south of the wind farm during the previous two years. It was hatched in 2006 at a nest about 6 km from the development.

The bird's remains were in three sections spread over around a 50 m trail, and pieces of internal organ and traces of blood were also found. The remains were distributed in a line which ran roughly east to west, and about 20 m to the north of the turbine.

This event provided some interesting data on the circumstances of a strike because of the known time of the event. Weather conditions were good, with 50% cloud cover, a cloud base of 550 m, dry, with good visibility and a southerly wind of Beaufort Force 3. Therefore there was no possibility that the bird collided with the turbine in poor visibility or was blown into it by strong winds. The turbine was facing south south-east (172°) and the debris trail was parallel to the turbine blade sweep. The wind speed was 5.1 m per second, approximately 10 mph around the time of the strike, and the turbine was turning at 50 revolutions per minute. This is actually quite slow for these turbines according to site staff (Charlie McCluckie pers. com.) so high rotation speed was not a factor. A positive aspect of the incident was that the turbine involved was quickly shut down for a period by the site manager, after the remains initially attracted four other kites.

Other turbine strikes

A number of other strike victims were found by wind farm staff, by *ad hoc* visits or during the course of other fieldwork (Table 6). This included two of the red kite fatalities described above.

The loss of other raptors to turbine strike is of interest and in some cases an unexpected result. The loss of three merlins (*Falco columbarius*), a species often regarded as one which spends much of its time below rotor swept height, was a particular surprise. Impact studies on this species in relation to wind farm developments may be required in future, as having a UK population of 1200 or so pairs (Hardey *et al.* 2009), merlins are in fact currently rarer at a UK level than kites (1800 – 2000 pairs, RSPB Scotland).

The loss of several kestrels is less of a surprise as these are regular victims of turbine strike elsewhere (e.g. Barrios and Rodriguez 2004), but the likely deaths of two peregrines (*Falco peregrinus*) at the development was also as unexpected as the merlin casualties.

Searcher Efficiency

Over the course of the seven trials where the turbine searcher was tested for efficiency there were potentially 72 carcasses/part carcasses to be located (56 pheasant, 16 buzzards). Of these 60 (83%) were found by the searcher. Buzzards and half buzzard carcasses were detected at greater distances on average than pheasants and buzzards had a higher overall detection rate. All 16 carcasses were

detected by the searcher in Trials 1 – 7 whereas 44 (78.5%) of 56 pheasant carcasses were found. Buzzard carcasses were detected 11 m on average from the searcher while pheasants were detected on average 5.46 m away.

The detection distance of buzzard carcasses compares well with the transect spacing of 10 m in the turbine search plots and the high detection rate of buzzards indicated a strong chance of finding recent kite fatalities using the turbine search method employed at the development.

Carcass Removal Trials

Results of the Carcass Removal Trials are summarised below. Some of results described are a result of analysis carried out for work in preparation for publication, e.g. Urquhart *et al*. (in prep). A total of nine trials were completed to test for the rate of carcass removal involving 56 pheasant and 40 buzzard carcasses. Of the 40 buzzard carcasses, only 6 carcasses were removed by scavengers with the remaining carcasses or feather patches persisting until the end of the observation period.

There were seasonal differences in the persistence of pheasant carcasses. Analysis showed that in Autumn the carcasses of pheasants were removed faster, with almost 77% disappearing in the first 5 days, than in Spring. In Spring only 46% of pheasant carcasses were removed in the first 5 days, reflecting a lower carcass removal probability throughout the sampling period.

Unsurprisingly, snow cover prevented carcasses from being scavenged. During one winter trial tracks showed that a fox passed 10 m from a pheasant carcass apparently failing to detect it, and had travelled through all the trial plots. Although snow undoubtedly made some carcasses persist longer than normal it was decided to leave these covered and in place as this would be a regular naturally occurring event every winter.

There were also significant differences between species in relation to season. Buzzard carcasses persisted significantly longer in the Autumn (average 69.65 days) than pheasants (average 5.2 days). Pooling the data from all seasons showed that buzzard carcasses persisted significantly longer than pheasants, averaging 63.5 days to 9.2 days respectively (Urquhart *et al.* In prep). The resulting rates showing the difference in rates of carcass removal between raptors and game-birds was similar to that provided by Smallwood (2007) who undertook similar trials. This is probably due to buzzard carcasses being less palatable to scavengers than pheasants.

There was observed evidence suggesting that buzzard carcasses were less desirable to foxes than pheasants. In one case a fox moved a buzzard carcass 3 m without feeding on it, its behaviour

revealed by tracks in bare peat. Fox signs were detected at buzzard carcasses on other occasions without any scavenging taking place.

In the earlier trials (Trials 1 – 4) birds were the principal scavengers with buzzard, carrion crow, kite and raven *(Corvus corax)* recorded within the plots. The latter two species were the most commonly recorded and those responsible for most of the scavenging. On one occasion a kite was flushed from a pheasant carcass. Ravens were established as major scavengers through signs such as faeces and small feathers as well as sight records. The impression was that avian scavengers found the carcasses quicker than foxes and disposed of most of the more edible parts before foxes found them. Scats and scents indicated that foxes had found the last remains or feather patches. Fox signs were recorded in the plots throughout all the trials and foxes had a greater role in scavenging in Trials 5, 6 & 7.

One buzzard carcass was scavenged by another raptor, almost certainly another buzzard. The carcass had been partly plucked and dragged 3 m leaving a trail of feathers. The breast area had been eaten at. Feather damage was not consistent with that caused by foxes and there was a fresh raptor pellet 0.5 m from the carcass which contained vole remains. The pellet was not a typical kite one, suggesting a buzzard was the scavenger.

Analysis of Carcass Removal Trial results

The completion of Carcass Removal Trials in Autumn 2013 allowed final statistical analysis on the results to be carried out, and a revised kite fatality estimate made. These are currently also under preparation for publication (Urquhart *in prep*). The three documented red kite fatalities during the 50 months monitoring, equated to 0.72 fatalities per annum. As a result of this work the new adjusted annual fatality estimate for red kite at the Braes of Doune wind farm is 1.02 birds per annum. This compares well with the original Collision Risk Modelling carried out in 2003 (p.8) which also predicted around one kite killed per anum (0.81 – 1.17 per anum depending on avoidance rate).

Discussion & Conclusions

Impact on the kite population

Survival of the radio tagged study population (80% in first year, with 65% remaining at the end of the second year, all cohorts combined) was comparable to other populations where wind farms were not present. Survival in first year birds in England 1989 - 94 was 80%, with 60% survival of first year birds in pre-1989 Wales (Carter 2007). The number of birds remaining alive in the population in their

second year in this study was lower than in some other studies (e.g. 94% in Year 2 of the English study) but dispersal may partly account for this. Scottish sub-adult kites are more dispersive than those in southern of England and Wales, probably due to them being reintroduced from northern European populations (Evans *et al.* 2002). Scottish kite populations also suffer higher levels of persecution than those in southern England (Smart *et al.* 2010) and this may partly be why survival to the end of the second year was lower. Premature transmitter failure is another factor which produces lower 'survival' rates amongst radio tagged birds and several cases of this were recorded, the birds being identified by their wing tags whilst not giving a radio signal.

In 2010 the Central Scotland population of kites consisted of 62 known breeding pairs (124 adults) (RSPB Scotland) and at a realistic estimate, around 65 - 70 sub adult birds from the previous two breeding seasons. The likely number of breeding birds and potential breeders was therefore at least around 190 birds, the two wind farm fatalities in that year representing 1.05% of that figure. In addition to that population estimate, 93 young were reared that year.

Turbine related kite deaths should also be placed in the context of other mortality particularly illegal persecution and accidental poisoning. For example the kite killed at the development in 2007 was one of 17 from the Central Scotland population found dead that year, with at least 11 of these having died as a result of some kind of poisoning (D. Cameron / RSPB Scotland). This included at least two long established and productive breeding adults.

The overall conclusion reached is that the wind farm has not caused enough mortality to significantly restrict population growth amongst the Central Scotland kites, and even the loss of two breeding birds would seem insignificant in the context of survival rates, numbers of young produced and other causes of mortality. Madders and Fielding (2003) concluded that the kite population could withstand low levels of mortality arising from the wind farm particularly if it applied to first year birds. This was based on a survival rate of 55% for first year birds which, as demonstrated above, is lower than the actual observed survival rate.

Although the Braes of Doune development on its own may have no significant impact on the population's expansion, there is the possibility of cumulative effects in the future. Although the Braes of Doune is the only wind farm centrally in the range of the Central Scotland kite population there are now four others which are at the periphery and at least one (Earlsburn in the Gargunnock Hills) that has regular kite activity (pers obs). There are plans to expand these existing wind farms and build others in the Ochil, Gargunnock and Fintry Hills, all of which are likely to be within the future range of the local kite population even if they are not already.

The data presented on the map figures do show reduced activity around the development after construction. It is tempting to interpret this as avoidance but another explanation could be the changing dynamics of the kite population. As the population has increased the kites' range has expanded north and east away from the turbine area and as a result more, and larger, communal roosts have been established further away from the wind farm. As a result a larger proportion of the sub adult birds are 'held' further away to the north-east where they forage along the upland edge. There may actually be less activity around the development for this reason, as fewer birds pass through the site on the way to the roosting areas near Doune. As release work began in 1996 with first breeding in 1998, the Braes of Doune studies have seen the kite population and its range double in size and so it is hardly surprising that there have been changes in level of use in the uplands around the development.

This change in the patterns of movements and site use could be responsible for the disappointing lack of results from radio tagged birds during some latter periods of the study. At times the majority of the radio tagged study birds would be roosting in the Crieff and Comrie area for prolonged periods and so not venturing into the study area.

It would certainly be counter-intuitive to imagine the presence of the turbines as a deterrent to the birds flying through the development when flight activity is still regularly observed from a variety of individual kites when the wind farm is fully operational.

Findings regarding the use of the site by kites in relation to season and weather match those made in some earlier studies in Central Scotland (Thirwell 2000, Wilson 2000). It could be expected that mortality is most likely to occur in the spring and summer although the casualty in November 2010 indicates this is not necessarily the case.

Postscript

The remains of an third calendar-year kite were found on 28 March 2014 during the course of other work at the site. The scavenged remains of the bird were found 115 m east of Turbine 5 where another kite was killed in 2010. The bird was identified by its wing tags and ring and is the fourth kite fatality since 2007.

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Turbine searches were carried out by Mike Steward. Mick Marquiss identified remains of avian strike fatalities, John Haddow and Anne Youngman identified the bat casualties.

GIS support and analysis has been provided by Stephanie Proven, David McLeod, David Scott, Fiona Leckie and Louise Mitchell. Results of carcass trials were analysed by Blair Urquhart.

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Tables

Table 1. Numbers of kites radio tagged for the Braes of Doune study

Year	2004	2005	2006	2007	2008	2009	Total tagged/studied
Territory							
1	-	2	2	1	-	-	5/5
2	(1)	-	-	1	-	1	3/2
4	-	-	1	2	1	-	4/4
7	-	-	2	1	1	2	6/6
8	-	2	1	2	-	1	6/6
9	-	1	-	-	1	1	3/3
10	-	1	-	1	2	1	5/5
11	-	1	2	1	1	1	6/6
12	-	2	1	-	2	2	7/7
13	(1)	1	-	-	-	-	2/1
16	-	(2)	-	-	-	-	2/0
17	-	2	1	1	-	-	4/4
24	-	2	2	-	-	-	4/4
26	1	-	-	-	-	-	1/1
27	-	-	-	-	-	1	1/1
28	-	-	-	-	1	-	1/1
29	(1)	1	-	-	-	-	2/1
33	-	-	1	1	-	-	2/2
36	-	-	1	2	1	1	5/5
37	-	-	-	1	-	1	2/2
38	-	1	-	1	-	-	2/2
40	-	-	-	-	-	1	1/1
41	-	1	-	-	1	-	2/2
62	-	-	-	-	2	-	2/2
69	-	-	-	-	2	-	2/2
72	-	-	-	-	-	1	1/1
Rehabilitated	1	-	1*	-	-	1**	3/3
Total nestlings tagged	4	19	14	15	15	14	81
Total kites radio tagged	5	19	15	15	15	15	84
Total used in study	2	17	15	15	15	15	79
Total known cohort	32	28	44	59	75	74	312
% known cohort tagged	15.6	67.8	34.1	25.4	20.0	18.9	26.6
% known cohort studied	6.25	60.7	34.1	25.4	20.0	18.9	25.3

Cohort is the total number of young produced by the central Scotland kite population in that year.

Those in brackets were radio tagged but not used in the study. * Reared in 2006, actually tagged in 2007.

** Of 2008 north Scotland origin, so excluded from cohort figures in last three rows, % samples based on 83 birds

Table 2. Study kites recorded in the study area by radio tracking, 2005 - 2011

The Adjusted Sample excludes birds which died, disappeared or left the population within 6 months of fledging.

These birds may simply not have been recorded in the study/wind farm areas because of their brief presence in the population.

Cohort	Total	No. recorded in Study Area	No. Recorded in wind farm	Adjusted	No. recorded in Study Area	No. recorded in wind farm
2004	2	2 (100)	1 (50)	2	2 (100)	1 (50)
2005	17	14 (82.3)	13 (76.5)	13	12 (92.3)	12 (92.3)
2006	15	14 (99.3)	11 (78.6)	11	11(100)	9 (81.8)
2007	15	14 (99.3)	10 (66.6)	13	13 (100)	10 (76.9)
2008	15	12 (80.0)	8 (53.3)	12	10 (83.3)	7 (58.3)
2009	14	13 (92.8)	8 (57.1)	12	12 (100)	8 (66.6)
Blue/Black	1	0 (0.0)	0 (0.0)	1	0 (0.0)	0 (0.0)
Total	**79**	**69 (87.3)**	**51 (64.5)**	**64**	**60 (93.7)**	**47 (73.4)**

Table 3. Minimum survival rates of radio tagged nestlings in their first two calendar years

Surviving birds included those known alive in other populations. The small pilot sample of 2004 has been omitted.

Cohort	No. monitored	Alive at end of year 1 (%)	Alive at end of year 2 (%)
2005 (Pre-construction)	17	16 (94.1)	12 (70.5)
2006	14	11 (78.5)	7 (50.0)
2007	15	13 (86.6)	13 (86.6)
2008	15	10 (66.6)	9 (60.0)
2009	14	13 (92.8)	9 (64.2)
Total	75	63 (84.0)	50 (66.6)
Total –post construction cohorts	58	47 (81.0)	38 (65.5)

Table 4. Abundance of kites on the Braes of Doune study area in relation to wind farm construction as determined through vantage point watches

Note these apply to the whole study area not only the development area.

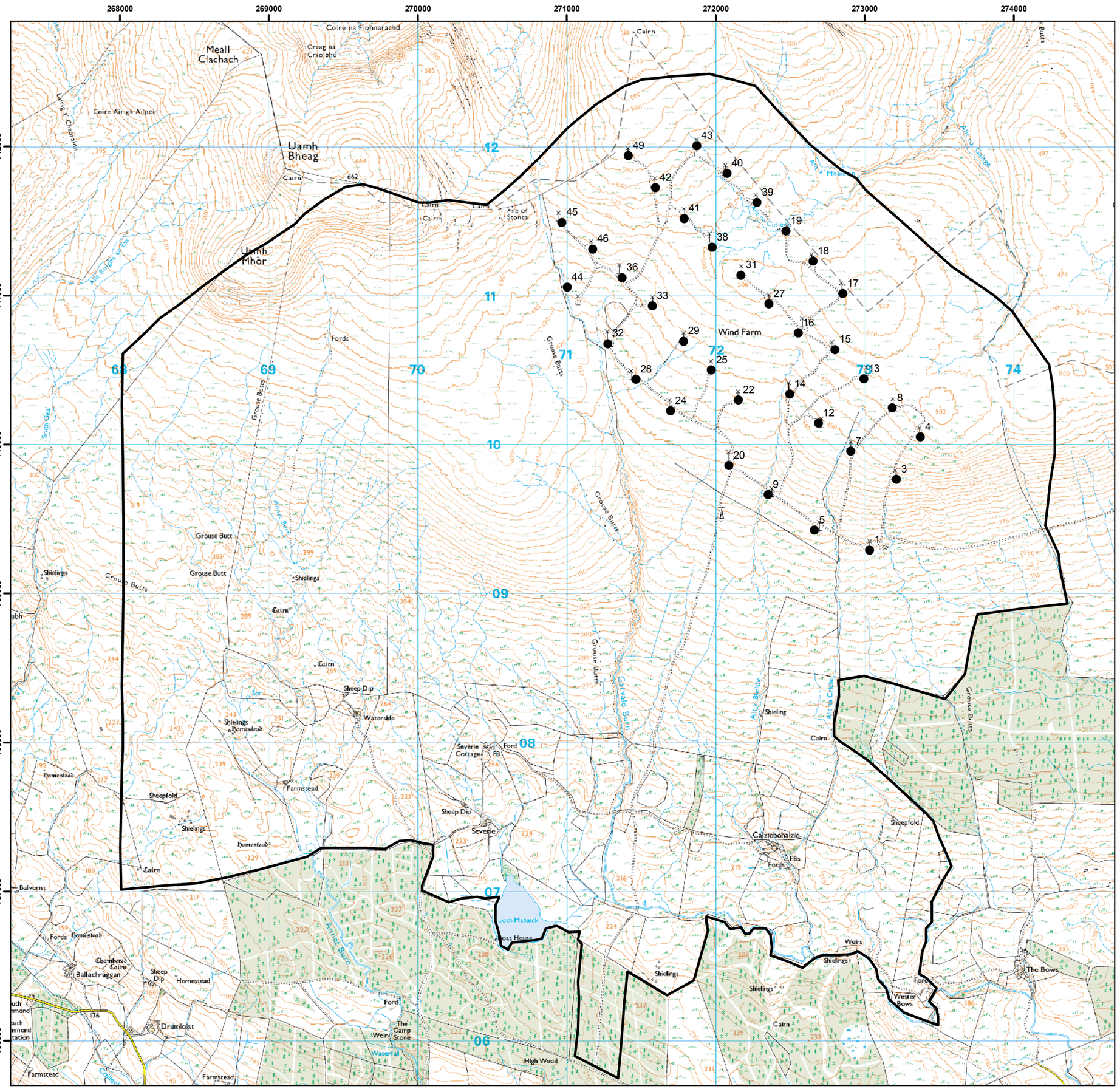
Time periods	Number of 5 minute intervals at vantage points	Number of 5 minute intervals that Red kites were observed at vantage points	% Occurrence
Pre-construction (Sep 2004- May 2006)	5027	511	10.16
Construction (June 2006- February 2007)	1893	220	11.62
Post-construction (February 2007- January 2012)	9033	1089	12.05
Total	15953	1820	11.40

Table 5. Remains and carcasses found through systematic turbine searches at Braes of Doune wind farm

Species	Number	Percent of Total	Turbine strike?	Comments
Gannet *(Morus bassanus)*	1	1.4	?	This species has been seen near the site
Red kite *(Milvus milvus)*	1	1.4	Yes	
Kestrel *Falco tinnunculus)*	1	1.4	Yes	
Merlin *(Falco columbarius)*	2	2.8	Yes	
Peregrine *(Falco peregrinus)*	2	2.8	?	Likely strike victims, other causes unlikely?
Red grouse *(Lagopus lagopus)*	46	66.5	At least one	Most are probably non-turbine related mortality
Common gull *(Larus canus)*	1	1.4	?	
Wood pigeon *(Columba palumbus)*	1	1.4	At least one	
Pigeon sp.	1	1.4	?	
Long-eared owl *(Asio otus)*	1	1.4	?	
Meadow pipit *(Anthus pratensis)*	5	7.2	Some	
Song thrush *(Turdus philomelos)*	1	1.4	?	Migrant ?– not recorded alive on the site
Chiffchaff *(Phylloscopus collybita)*	1	1.4	?	
Willow warbler *(Phylloscopus trochilus)*	1	1.4	?	
Corvid sp.	1	1.4	?	
Siskin *(Carduelis spinus)*	1	1.4	?	
Soprano pipestrelle *(Pipistrellus pygmaeus)*	2	2.8	Yes	
Total	69	100		

Table 6. Other carcasses and remains at Braes of Doune wind farm

Species	Number	Percent of Total	Turbine strike?	Comments
Little grebe	1	5.8	?	
Red kite *(Milvus milvus)*	2	11.7	Yes	
Buzzard *(Buteo buteo)*	1	5.8	Yes	
Kestrel *Falco tinnunculus)*	4	23.5	Three, probably all	
Merlin *(Falco columbarius)*	1	5.8	Yes	
Red grouse *(Lagopus lagopus)*	2	11.7	One	Hit tower rather than blades
Common gull *(Larus canus)*	2	11.7	?	
Wood pigeon *(Columba palumbus)*	2	11.7	?	
Meadow pipit *(Anthus pratensis)*	1	5.8	Yes	
Daubentons Bat *(Myotis daubentonii)*	1	5.8	Yes	
Total	17	100		



Braes of Doune Windfarm

Figure 1.
Study area boundary

Key

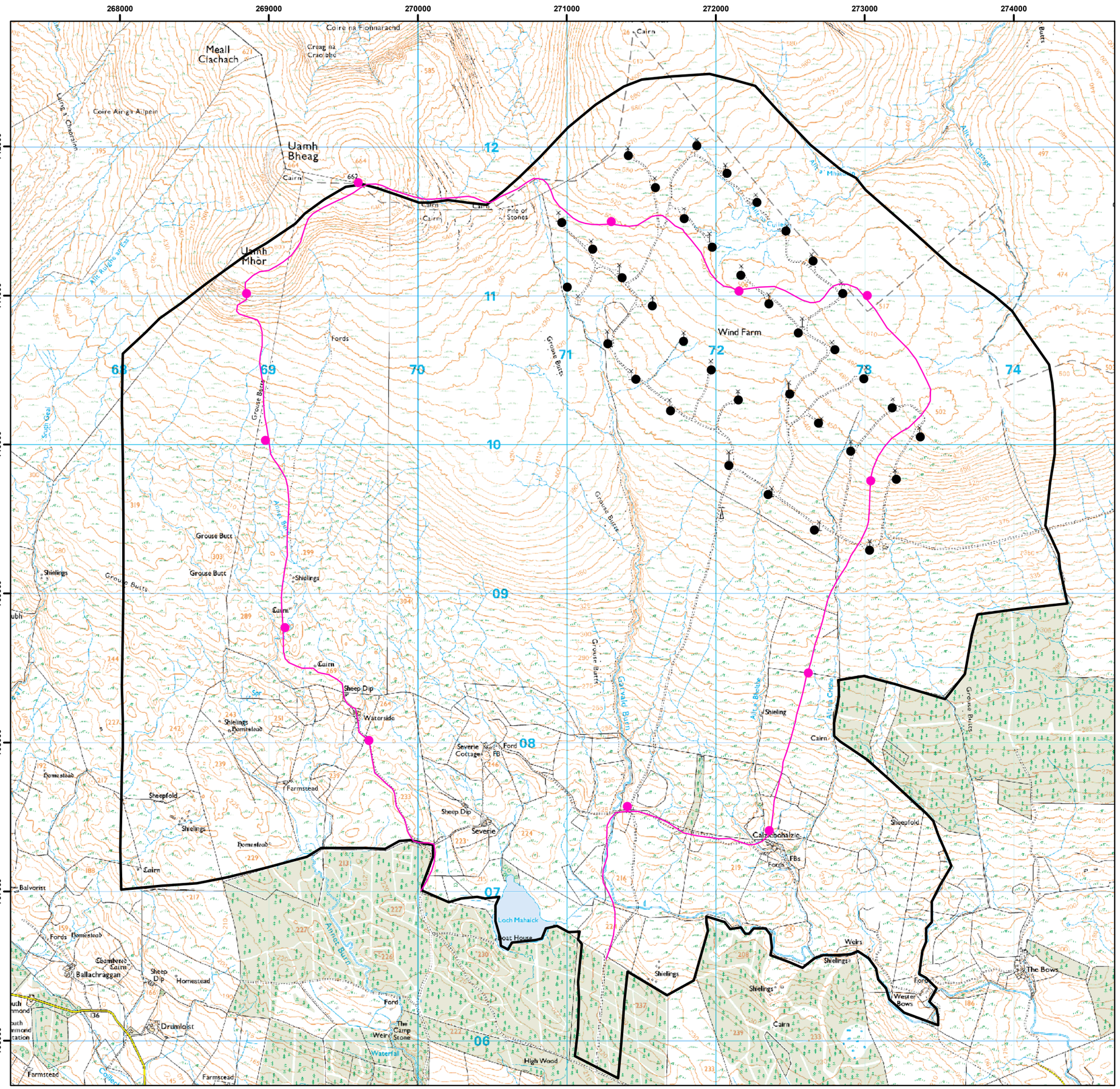
- Turbine location
- Survey boundary

0 500 1,000 Metres

N
W E
S

Date: 01/03/2012

Source: NRP Ltd



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Braes of Doune Windfarm

Figure 2.
Radio tracking walk route and fixed tracking points

Key

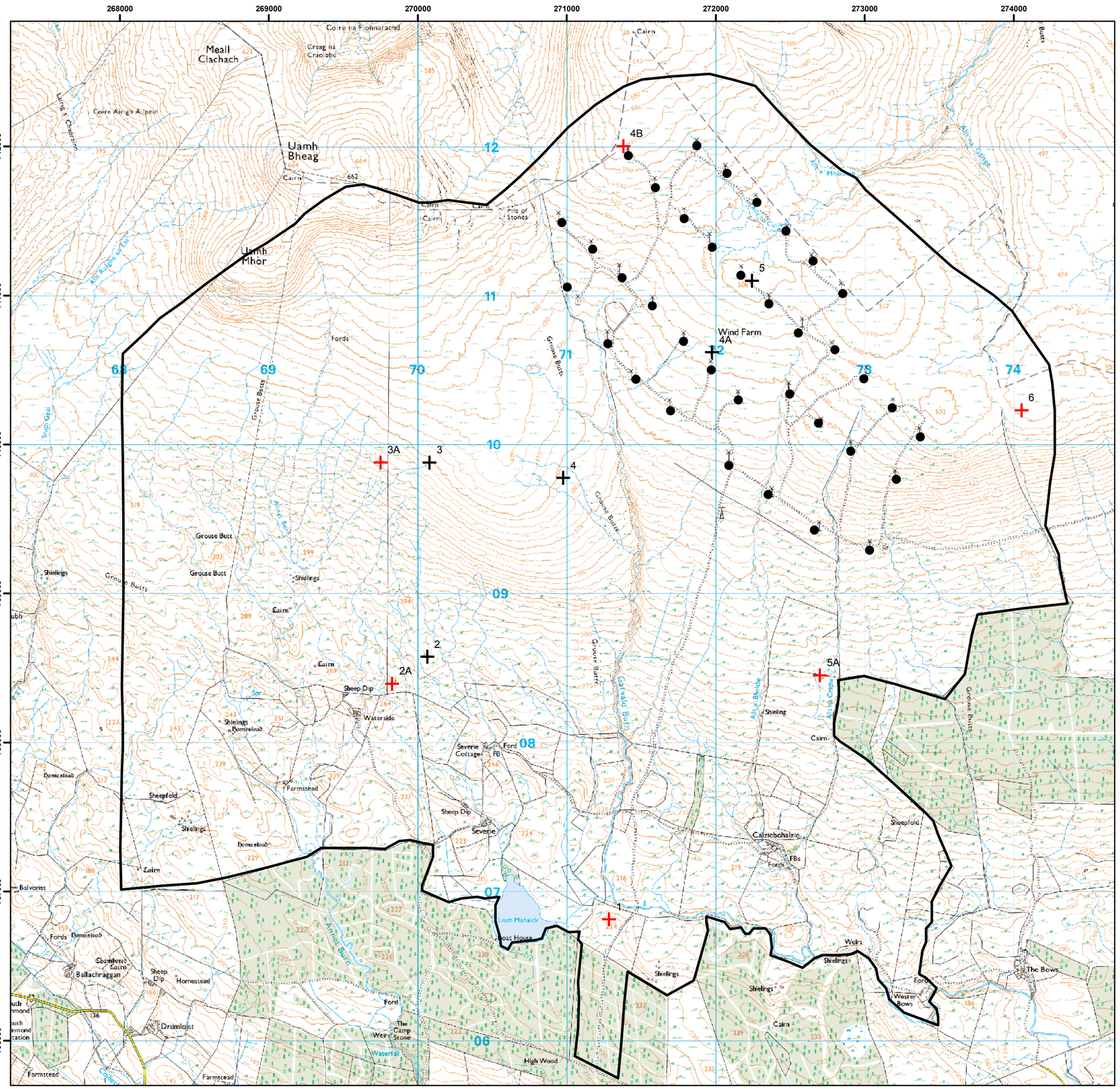
- Radio tracking walk route
- Fixed tracking location
- Turbine location
- Survey boundary

0 500 1,000 Metres

N
W E
S

Date: 01/03/2012

Source: NRP Ltd



Braes of Doune Windfarm

Figure 3.
Vantage Point locations

Key

- + Current Vantage Point location
- + Previous Vantage Point location
- ● Turbine location
- Survey boundary

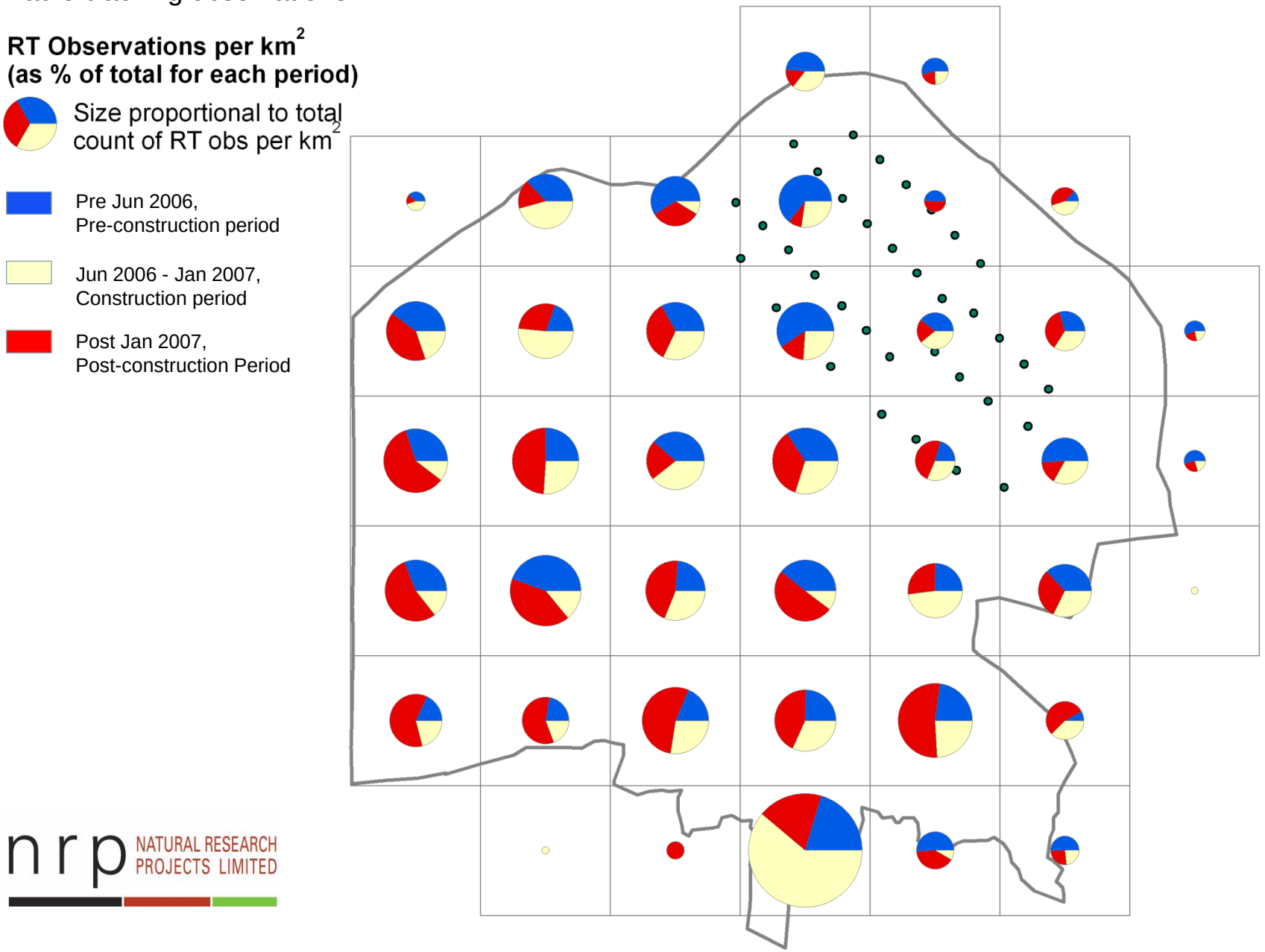
0 500 1,000 Metres

N W E S

Date: 01/03/2012

Source: NRP Ltd

Figure 4.
Radio-tracking observations



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Braes of Doune Windfarm

Figure 5.
Red kite flights observed during the pre-construction phase Sept 2004 - May 2006

Legend

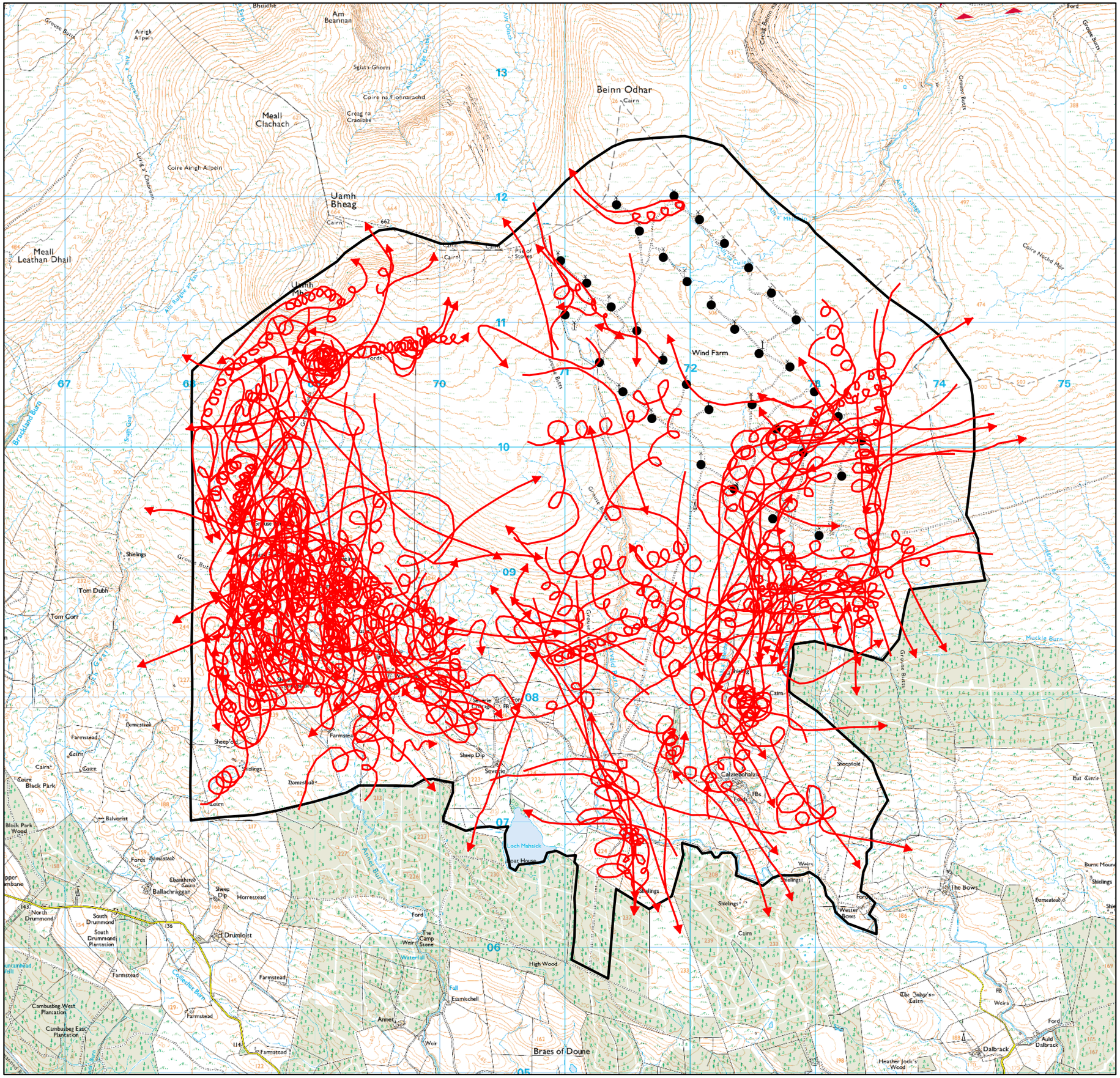
- Flight line
- Turbine
- Survey boundary

0 500 1,000 Metres

N
W E
S

Date: 07/03/2014

Source: NRP Ltd



Braes of Doune Windfarm

Figure 6.
Red kite flights observed during the construction phase
Jun 2006 - Feb 2007

Legend

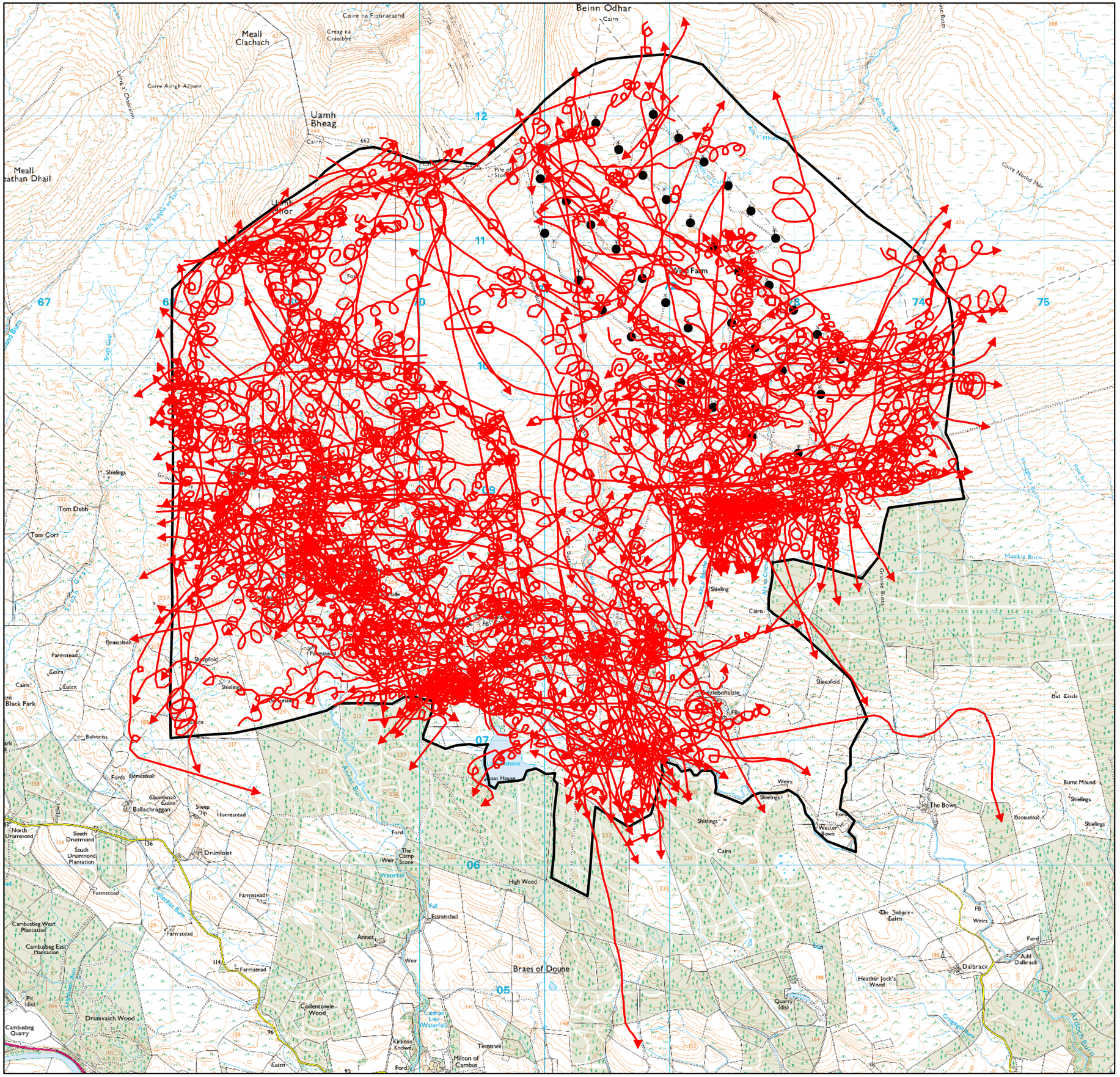
- Flight line
- Turbine
- Survey boundary

0 500 1,000 Metres

N
W E
S

Date: 07/03/2014

Source: NRP Ltd



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Braes of Doune Windfarm

Figure 7.
Red kite flights observed during the post construction phase Mar 2007 - May 2009

Legend

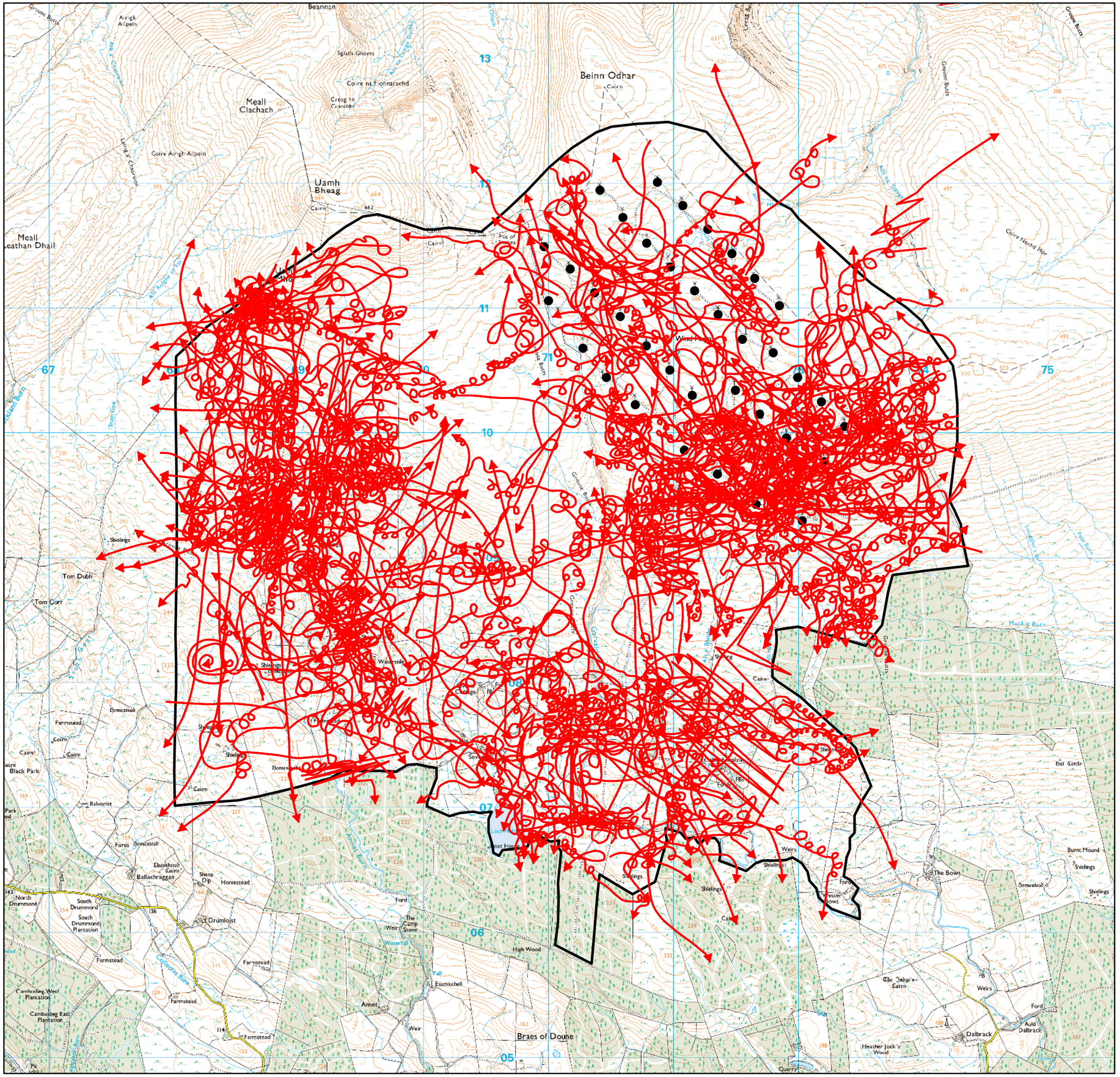
- Flight line
- Turbine
- Survey boundary

0 500 1,000 Metres

N
W E
S

Date: 07/03/2014

Source: NRP Ltd



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Braes of Doune Windfarm

Figure 8.
Red kite flights observed during the post construction phase Jun 2009 - Mar 2012

Legend

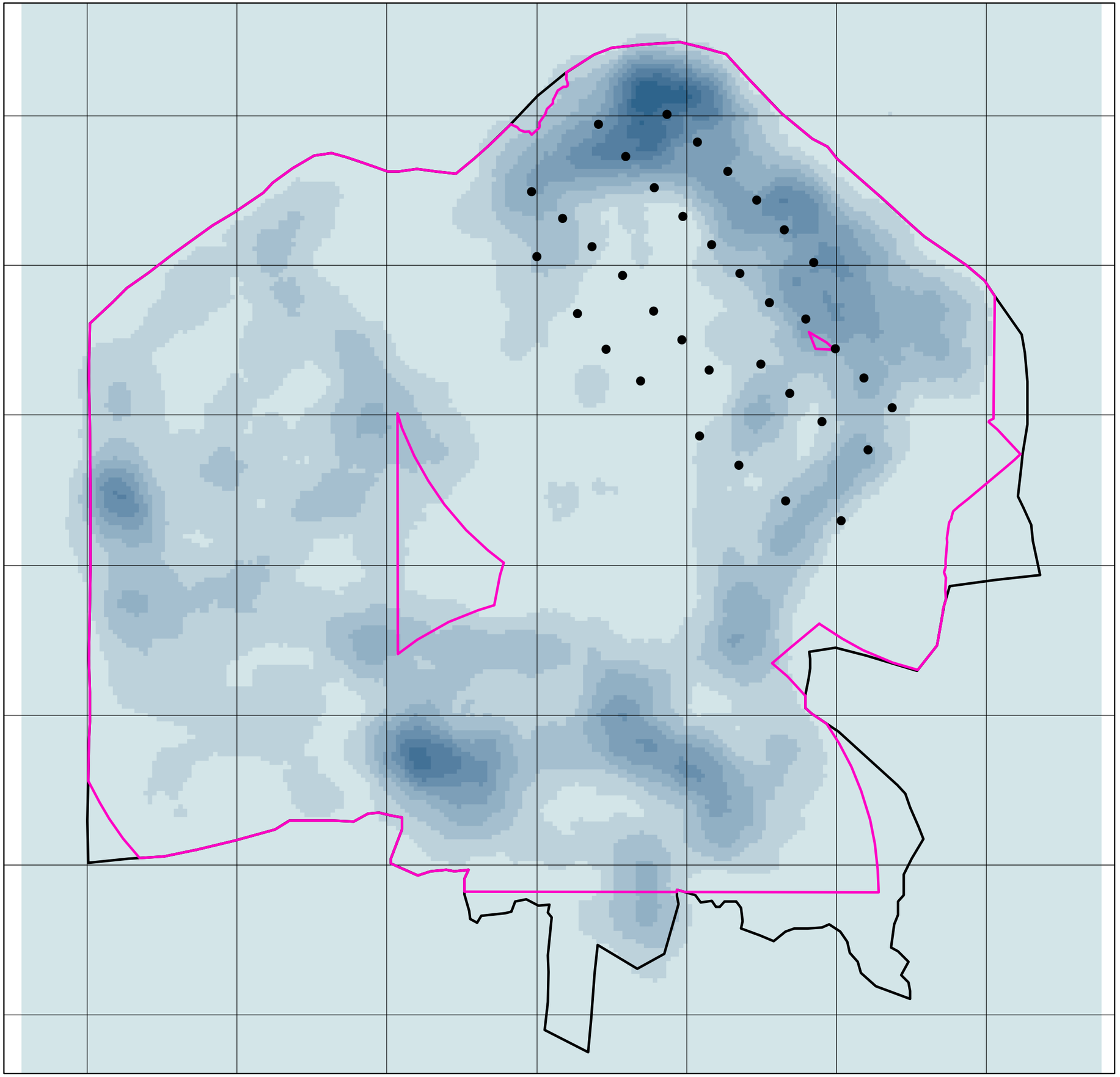
- Flight line
- Turbine
- Survey boundary

0 500 1,000 Metres

N
W E
S

Date: 07/03/2014

Source: NRP Ltd



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Braes of Doune Windfarm

Figure 9.
Flight density pre-construction
Sept 2004 - May 2006

Legend

- Turbine
- Viewshed area (visible to 2km)
- Survey boundary

Flight duration

- Low
- High

0 500 1,000 Metres

N W E S

Date: 07/03/2014

Source: NRP Ltd

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Braes of Doune Windfarm

Figure 10.
Flight density during construction
Jun 2006 - Feb 2007

Legend

- Turbine
- Viewshed area (visible to 2km)
- Survey boundary

Flight duration

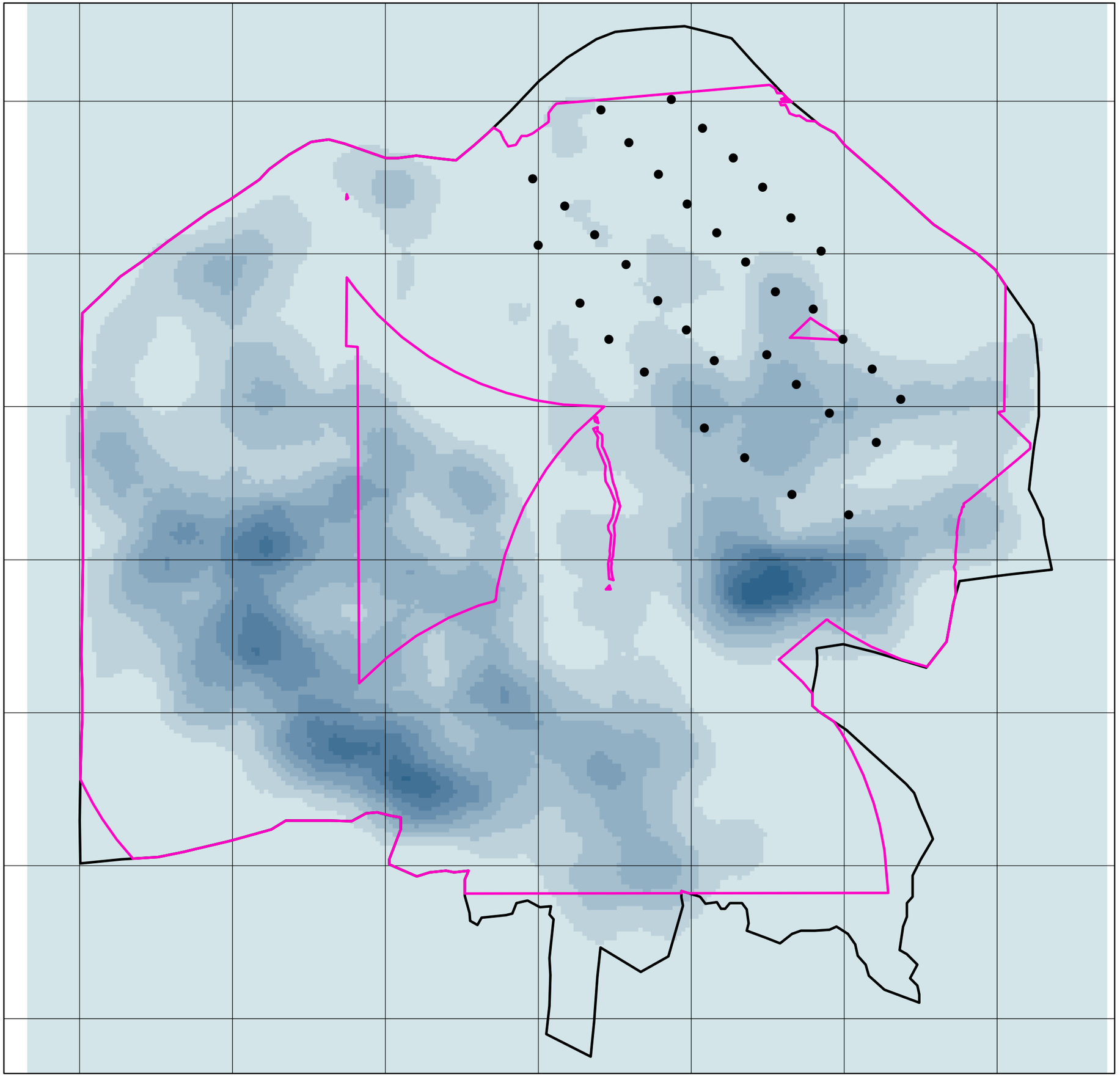
- Low
- High

0 500 1,000 Metres

N W E S

Date: 07/03/2014

Source: NRP Ltd



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Braes of Doune Windfarm

Figure 11.
Flight density post construction
March 07 - May 09

Legend

- Turbine
- Viewshed area (visible to 2km)
- Survey boundary

Flight duration

- Low
- High

0 500 1,000 Metres

N W E S

Date: 07/03/2014

Source: NRP Ltd

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Braes of Doune Windfarm

Figure 12.
Flight density post construction
Jun 2009 - Mar 2012

Legend

- Turbine
- Viewshed area (visible to 2km)
- Survey boundary

Flight duration

- Low
- High

0 500 1,000 Metres

N
W E
S

Date: 07/03/2014

Source: NRP Ltd

Appendix1. Survey effort to detect kite flight activity at Vantage Points at the Braes of Doune Wind Farm

Survey effort is broken down by month and year. Figures are in hours

	2004				2005											
VP	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.00	6.00	5.41	-	6.00	6.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	-
2	3.00	6.00	6.00	3.00	6.00	6.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.50	3.00
3	3.00	6.00	5.41	3.00	6.00	6.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	-	2.50	3.00
4	3.00	6.00	4.00	-	6.00	6.00	-	6.00	3.00	3.00	3.00	3.00	3.00	-	3.00	-
5	3.00	6.00	3.00	3.00	6.00	6.00	3.00	-	6.00	3.00	3.00	-	3.00	3.00	3.00	-
6	3.00	6.00	3.00	-	6.00	6.00	-	3.00	3.00	3.00	3.00	3.08	3.00	3.00	3.00	3.00
Grand Total	18.00	36.00	26.83	9.00	36.00	36.00	12.00	18.00	21.00	18.00	18.00	15.08	18.00	12.00	17.00	9.00

	2006											
VP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VP1	6.00	3.00	3.00	3.00	3.00	2.50	3.00	3.00	3.00	3.00	3.00	2.50
VP2A	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.50	2.50
VP3A	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.75	2.00
VP4A	3.00	-	-	-	-	-	-	-	-	-	-	-
VP4B	-	6.00	3.00	-	6.00	-	6.00	3.00	3.00	3.00	2.75	-
VP5	3.00	6.00	3.00	3.00	-	-	-	-	-	-	-	-
VP5A	-	-	-	-	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.50
VP6	3.00	3.00	3.00	-	6.00		6.00	3.00	3.00	3.00	2.50	3.00
Grand total	21.00	24.00	18.00	12.00	24.00	11.50	24.00	18.00	18.00	18.00	16.50	12.50

	2007											
VP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VP1	3.00	3.00	3.00	3.00	2.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00
VP2A	3.00	3.00	3.00	3.00	2.00	4.00	3.00	3.00	3.00	3.08	3.00	2.50
VP3A	3.00	3.50	3.00	3.00	3.00	3.00	3.00	3.00	3.00	1.33	2.58	3.00
VP4B	5.83	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
VP5A	2.91	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.50	3.00
VP6	3.00	3.00	3.00	3.00	-	6.00	3.00	3.00	3.00	3.00	3.08	3.00
Grand total	20.75	18.50	18.00	18.00	13.00	23.00	18.00	18.00	18.00	16.41	17.16	17.50

	2008											
VP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VP1	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
VP2A	3.00	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
VP3A	-	6.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
VP4B	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
VP5A	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
VP6	-	5.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Grand total	12.00	22.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00

	2009											
VP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VP1	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
VP2A	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.00	2.00
VP3A	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.25	3.00
VP4B	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
VP5A	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	-
VP6	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Grand total	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.25	14.00

	2010											
VP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GVP1	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	-
GVP2A	4.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	-
GVP3A	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	-	6.00	-
GVP4B	3.00	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	-
GVP5A	6.00	3.00	3.00	3.00	3.00	3.00	3.00	1.75	3.92	3.00	3.00	-
GVP6	-	6.00	4.00	3.00	3.00	3.00	3.00	3.00	2.33	3.00	3.00	-
Grand total	19.00	20.00	19.00	18.00	18.00	18.00	18.00	16.75	18.25	15.00	21.00	-

	2011												2012		
VP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
GVP1	-	-	-	-	-	-	-	-	-	3.00	3.00	3.00	3.00		6.00
GVP2A	-	-	-	-	-	-	-	-	-	3.00	3.00	3.00	3.00	3.00	3.00
GVP3A	-	-	-	-	-	-	-	-	-	3.00	3.00	-	6.00	3.00	3.00
GVP4B	-	-	-	-	-	-	-	-	-	3.00	3.00	3.00	3.00	3.00	3.00
GVP5A	-	-	-	-	-	-	-	-	-	3.00	3.00	1.50	4.50		6.00
GVP6	-	-	-	-	-	-	-	-	-	3.00	3.00	3.00	3.00	3.00	3.00
Grand total	-	-	-	-	-	-	-	-	-	18.00	18.00	13.50	19.50	12.00	24.00

Appendix 2. Kite flight activity at Braes of Doune wind farm 2004 - 2012

Note changes in height bands due to revised methodology and changes in location of vantage points as described in the text.

September 2004- Feb 2005 pre-construction							
Sep-Mar	**VP. no**	**No. flights**	**No. of birds**	**Duration**	**<10m**	**10-100m**	**>100m**
Sep-Mar	1	30	30	9057	1176	6720	1160
	2	26	26	8126	1552	5949	623
	3	22	22	6348	974	4064	1309
	4	17	17	6917	181	2250	4485
	5	25	26	11608	1320	6706	3581
	6	21	21	5908	850	3675	1382
Sep-Mar Total		141	142	47964	6048	29346	12568

Pre-construction March 2005- May 2006									
Season	**VP no.**	**No. of flights**	**No. of birds**	**Duration**	**<10m**	**10-50m**	**50-100m**	**100-150m**	**150m+**
Apr-Aug	1	26	26	7874	2471	3249	776	663	715
	2	13	13	3136	260	1882	673	306	15
	3	25	25	4003	1276	1723	813	191	
	4	23	23	6981	2832	2637	839	419	254
	5	10	10	2294	619	951	317	407	
	6	17	17	2213	77	867	774	325	170
	2A	9	9	1060	400	507	107	46	
	3A	8	8	1796	807	959	30		
	5A	1	1	55		55			
Apr-Aug Total		132	132	29412	8742	12830	4329	2357	1154
Sep-Mar	1	24	24	5276	810	3503	780	183	

	2	9	9	3489	243	2302	533	411	
	3	2	2	1005	150	750	105		
	4	6	6	1663	15	1170	292	184	
	5	17	17	3763	703	2279	780		
	6	3	3	199	33	165			
	2A	2	2	927	410	486	30		
	3A	2	2	380	95	285			
Sep-Mar Total		65	65	16702	2459	10939	2524	780	

Construction period June 2006- Feb 2007									
Season	**VP. No**	**No of flights**	**Number of birds**	**Duration**	**<10m**	**10-50m**	**50-100m**	**100-150m**	**>150m**
Apr-Aug	1	12	12	1644	15	997	522	110	
	2A	15	15	4270	740	2359	1171		
	3A	23	23	7483	3573	3512	398		
	4B	8	8	986	47	250	235	376	78
	5A	14	14	3565	477	1924	1133	31	
	6	4	4	305	32	225	48		
Apr-Aug Total		76	76	18253	4884	9267	3507	517	78
Sep- Mar	1	14	14	2927	391	1143	845	548	
	2	7	7	1767	861	861	45		
	2A	19	19	3149	935	1949	265		
	3A	11	11	3182	780	1515	627	260	
	4B	2	2	321		199	122		
	5A	13	13	3857	1574	1281	509	432	61
	6	4	4	816		272	257	287	
Sep-Mar Total		70	70	16019	4541	7220	2670	1527	61

Post construction period March 2007- May 2009									
Season	**VP no.**	**No of flights**	**No of birds**	**Duration**	**<10m**	**10-50m**	**50-100m**	**100-150m**	**150m+**
Apr-Aug	1	45	45	7937	772	3460	1683	818	1204
	4	3	3	1877	45	439	272	515	606
	5	3	3	1877	106	1771			
	6	11	11	1504		380	332	428	364
	2A	53	53	11040	631	4868	3432	1524	585
	3A	51	52	10236	1584	3377	2770	1027	1478
	4B	25	25	3730	69	725	1382	898	656
	5A	28	28	5671	808	2533	1305	466	559
Apr-Aug Total		219	220	43872	4015	17553	11176	5676	5452
Sep-Mar	1	54	54	12238	2858	4675	2777	1790	138
	6	21	21	3753	867	1293	489	489	615
	2A	56	61	23493	7743	10540	4532	678	
	3A	19	19	5319	582	1733	1441	444	1119
	4A	1	1	189		31	158		
	4B	16	16	2613	582	1039	992		
	5A	49	49	14584	6831	5185	2261	307	
Sep-Mar Total		216	221	62189	19463	24496	12650	3708	1872

June 2009-Nov 2010 - post construction									
Season	**GVP.no**	**No. of flights**	**No. of birds**	**Duration**	**<10m**	**10-50m**	**50-100m**	**100-150m**	**>150m**
Apr-Aug	GVP1	20	20	3640	175	2120	1069	200	76
	GVP2A	37	45	6936	1130	4292	911	271	332
	GVP3A	40	40	7253	451	4598	1304	549	351
	GVP4B	12	12	1830	15	357	803	361	294
	GVP5A	20	20	5118	316	3948	779	75	
	GVP6	12	12	1472	54	685	206	263	264
Apr-Aug Total		141	149	26249	2141	16000	5072	1719	1317
Sep-Mar	GVP1	42	44	10374	393	5788	2937	442	814
	GVP2A	26	28	6759	123	4002	2056	125	453
	GVP3A	18	18	3437	138	3111	173	15	
	GVP4B	15	15	1621	5	1335	190	91	
	GVP5A	40	41	12420	380	10084	1504	452	
	GVP6	16	22	2415	31	1707	432	245	
Sep- Mar Total		157	168	37026	1070	26027	7292	1370	1267

October 2011-March 2012 - post construction										
Season	**GVP.no**	**No. of flights**	**No. of birds**	**Duration**	**<10m**	**10-30m**	**30-50m**	**50-100m**	**100-150m**	**>150m**
Sep-Mar	GVP1	14	14	2945	190	760	442	766	362	425
	GVP2A	9	9	2505	12	142	357	812	517	665
	GVP3A	5	5	572	31	165	225	151		
	GVP4B	4	4	726		16	221	289	170	30
	GVP5A	7	7	1547	211	248	336	396	355	
	GVP6	8	8	899	16	253	202	319	109	
Sep-Mar Total		47	47	9194	460	1585	1783	2734	1512	1120