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Response of incubating Golden and White-tailed Eagles to forest road traffic: results of a pilot study

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Very little work has taken place on the potential impact of vehicle disturbance on breeding Golden Eagles and White-tailed Eagles. Determining whether the routine use of vehicles on forest roads adversely impacts on these two species is important to help inform forest management in Scotland. In 2015–16, a pilot study was undertaken on the national forest estate in mainland Argyll and Lochaber which investigated the impact of routine forest road traffic on 13 incubating Golden Eagles and White-tailed Eagles.

Observations showed that incubating eagles sometimes responded to sound and visual stimuli from passing forest traffic. However, no discernible responses were recorded during 46 vehicles passes (61%), minor discernible responses were recorded during 29 vehicle passes (38%) and moderate discernible responses were only recorded once during vehicle passes (1%). Forest road traffic did not cause incubating eagles to leave or abandon any nests studied during periods of observation.

Detailed analyses were not considered realistic due to the small sample sizes and we recommend that further studies are carried out in Scotland into the effects of vehicle movements on additional pairs of incubating Golden Eagles and White-tailed Eagles.

Introduction

Assessing the potential effects of human disturbance on species such as raptors is a complex issue with variable results depending upon the circumstances and characteristics of both the human activity and the species (Grubb *et al.* 2010). In Scotland, all wild birds are legally protected, but some species are considered more sensitive to human disturbance than others and are specially protected under European, UK and Scottish legislation. Birds' avoidance of humans and human activities can have adverse effects on their breeding success, e.g. through chilling, overheating and desiccation of eggs or chicks and starvation of chicks and ultimately the abandonment of a territory (Steenhof *et al.* 2014).

Watson & Dennis (1992) subjectively assessed levels of human disturbance at over 300 Golden Eagle *Aquila chrysaetos* nests in Scotland. They found that eagles in territories where disturbance was classified as moderate or severe failed to rear chicks in 74% and 93% of occasions. However, their definitions of moderate and severe 'human disturbance' better reflected deliberate persecution of Golden Eagles i.e. egg collecting, use of poisons, killing of adults and destruction of nests, than occasional, accidental disturbance which was classified as low. Watson (2010) recognised that the consequences of unintentional disturbance on Golden Eagles in Scotland were difficult to quantify and largely anecdotal.

As a result of such concerns, a tool used by conservation managers is to designate 'buffer zones' or disturbance-free, protection zones around nest sites of potentially sensitive species where human activity is restricted at critical times of year (Camp *et al.* 1997). Determining suitable and appropriate management responses to potentially sensitive species nesting in actively managed

landscapes is a challenge faced by forest managers across Scotland. Whilst forest management practices may benefit bird habitats and species in the long-term, short-term direct and indirect disturbance from some forestry management activities could potentially impact on sensitive and specially protected bird species such as Golden Eagle and White-tailed Eagle *Haliaeetus albicilla*. A recognised method used to prescribe buffer zones for potentially sensitive bird species involves two basic measures of disturbance distance:

- 'Alert Distance' (AD) - the distance between the disturbance source and the bird; at the point where the bird changes its behaviour in response to the approaching disturbance source; and
- 'Flight Initiation Distance' (FID) - the point at which the bird flushes or flies away from the approaching disturbance source.

If used for informing management practices, understanding the potential influence of AD and FID on both nesting Golden Eagle and White-tailed Eagle should help minimise the potential effects of disturbance related to vehicle use on the national forest estate. Unfortunately, no rigorous studies into the sensitivity of nesting Golden Eagles or White-tailed Eagles to vehicle disturbance from forest road traffic or other types of road traffic have taken place. Recommendations for 'safe working distances' (essentially, buffer zones around potentially sensitive breeding sites) have been made for eagle nests, but vary widely without any objective justification (Ruddock & Whitfield 2007). Failure to recognise the limitations of available evidence is not only detrimental to understanding eagle ecology but it can undermine conservation efforts (Walker *in press*).

Ruddock & Whitfield (2007) reviewed the work done on disturbance distances for 26 'priority' species which breed in Scotland, including Golden Eagle and White-tailed Eagle, and investigated expert opinion, using it to bridge the gap between empirical evidence/data (little of which exists), conservation policy and practical guidance. Their report concluded with a recommendation that observers should measure disturbance distances of breeding birds as a useful mechanism to generate much needed empirical data on disturbance distances for a range of species. The divergence of opinion on disturbance distances in the expert opinion survey for Golden Eagle during incubation was greater than for any other species reviewed, extending from 10–50 m (four respondents) to 1,500–2,000 m (one respondent). The limited empirical evidence pointed to the upper limits revealed by expert opinion as being overly cautious and more research was clearly warranted.

In 2015 and 2016, the authors undertook a pilot study to investigate the response of incubating Golden Eagles and White-tailed Eagles to potential disturbance from forestry road traffic on Forest Enterprise Scotland (FES) land. The results of the pilot study will be used to inform forest management practices and help develop evidence-based protocols for the use of vehicles on FES roads in general proximity to eagle nests, with the aim of avoiding preventable detrimental disturbance to incubating eagles.

Golden Eagles and White-tailed Eagles are protected under Schedule 1 of the Wildlife and Countryside Act (1981 as amended) and Annex 1 of the EU Bird Directive. The Nature Conservation (Scotland) Act 2004 widens this and provides additional protection for both species in Scotland. Unfortunately, Golden Eagles and White-tailed Eagles suffer from illegal persecution in Scotland and it is likely that behaviours selected for or learned as a result of persecution create an avoidance of other human activities, so that persecution can sensitize birds to other less inimical forms of 'disturbance' (Ruddock & Whitfield 2007). As a consequence it is recognised that individual eagles may have different disturbance thresholds or respond differently to other eagles in similar situations.

Methods

The 2015–16 pilot study was undertaken with a Schedule 1 licence issued by Scottish Natural Heritage (SNH) under the terms and conditions of the Wildlife and Countryside Act 1981. Given

the direct persecution threat posed in Scotland (Watson 2010), the eagle nest locations are treated as confidential and letter coded to prevent their identification. Example photographs of one Golden Eagle and one White-tailed Eagle nest investigated are provided (Plates 14 and 15).

Site selection

Site selection was determined by local FES staff, who identified known eagle territories on the national forest estate and nest sites in relative proximity to nearby forest roads in mainland Argyll and Lochaber. In spring 2015, seven occupied Golden Eagle territories and one White-tailed Eagle territory were initially identified, where forestry roads occurred within *c.* 300–1,500 m of potential nest sites. Three Golden Eagle pairs switched nest sites (away from locations with forest roads in close proximity) and so the 2015 study was conducted on four Golden Eagle nests and one White-tailed Eagle nest. In spring 2016, four occupied Golden Eagle and two White-tailed Eagle territories were identified, where forestry roads occurred within *c.* 300–1,000 m of potential nest sites. Unfortunately, all four Golden Eagle pairs abandoned or switched nest sites and so the 2016 study was conducted on two White-tailed Eagle nests.

Estimated distances between forest roads and eagle nests were calculated using GIS. Estimated typical use of forest roads by public vehicles was provided local FES staff. Given the uncertainty regarding forestry vehicle effects on incubating eagles prior to the pilot study commencing, FCS operated a protective buffer around the eagle nest sites, meaning that forestry vehicles were not used on forest roads within *c.* 1 km of nests during the breeding season. Thus, forestry roads near to four of the seven nest sites (A, C, D and E) were considered quiet and had no official forestry vehicle use at all during the breeding season. The three remaining nests sites (B, F and G) had no official forestry vehicle use but some public vehicle use during the breeding season. A brief summary of each surveyed nest site is provided.

Site A description

The Site A nest site was c. 5 km up a forestry road from the nearest public road. The glen is quite popular with walkers and mountain bikers, although it was not clear how many members of the public got as far up the glen as the White-tailed Eagle nest. Estimated typical existing vehicle use of the forest road: weekly. The White-tailed Eagle nest was high up in a tree in a forest block overlooking the forest road, which was *c.* 270 m away downslope (Plates 12–13). When the bird was incubating it could see directly onto the downslope forest road, with perhaps c. 400 m length of road visible from the nest.

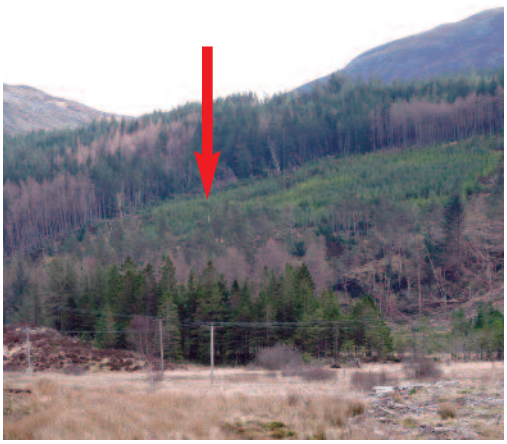

Plate 11. View towards the tree nest from the observer's hidden location, Site A, 2015. © *Peter Cosgrove*

Plate 12. View of the White-tailed Eagle tree nest, Site A, 2015. © *Peter Cosgrove*

Site B description

The Site B nest site was *c.* 2.5 km up a forestry road from the nearest public road. The glen is regularly used by people, with relatively moderate volumes of daily traffic e.g. postal service, farm traffic etc. Estimated typical existing vehicle use of the forest road: daily. The Golden Eagle nest was on a crag, above a forest block overlooking the forest road, which was *c.* 670 m away downslope. When the bird was incubating it could see directly onto the forest road, with perhaps *c.* 500 m length of forest road potentially visible from the nest.

Site C description

The Site C nest site was *c.* 5 km up a forestry road from the nearest public road. The glen is relatively quiet, with limited public use. Estimated typical existing vehicle use of the forest road: monthly. The Golden Eagle nest was on a cliff, above a forest block overlooking the main forest road, which was *c.* 970 m downslope. When the bird was incubating it could see directly onto the downslope forest road, with perhaps *c.* 80 m and *c.* 280 m sections of road visible from the nest at 1,035 m and 1,150 m distances respectively.

Site D description

The Site D nest site was *c.* 6 km up a forestry road from the nearest public road. The glen is relatively quiet, with limited public use. Estimated typical existing vehicle use of the forest road: monthly. The Golden Eagle nest was high up on a cliff at the end of a forest block overlooking the forest road, which was *c.* 350 m away downslope (Photos 3–4). When the bird was incubating it could see directly onto the downslope forest road, with perhaps *c.* 300–400 m length of forest road visible from the nest.

Plate 13. View through a forestry block towards the cliff nest from the observer's location, Site D, 2015. © *Peter Cosgrove*

Plate 14. View of the Golden Eagle cliff nest, Site D, 2015. © *Peter Cosgrove*

Site E description

The Site E nest site was *c.* 6 km up a forestry road from the nearest public road. The glen is relatively quiet, though the forest road is publicly advertised as a tourist driving route. Estimated typical existing vehicle use of the forest road: daily. The Golden Eagle nest was on a cliff, above a forest block overlooking the forest road, which was *c.* 520 m away upslope. When the bird was incubating it could see directly onto the downslope forest road, with perhaps *c.* 300–400 m length of road visible from the nest, at a distance of *c.* 900 m away. The closest part of the forest road to the nest was visually shielded by mature conifers.

Site F description
The Site F nest was *c.* 100 m from the nearest (minor) public road, with the forestry road running alongside the nest within 50 m of it. The White-tailed Eagle nest was located in the main fork of a wind-snapped Scots Pine *Pinus silvestris* in a clump of mixed conifers. Estimated typical existing vehicle use of the forest road: daily. The forestry road was immediately adjacent to, and at the same height as, the nest. When the bird was incubating it could see directly onto the adjacent forest road at eye level, with perhaps *c.* 200 m length of forest road visible from the nest.

Site G description
The Site G nest was *c.* 200 m from the nearest forest roads (one 200 m north of it and one 200 m south of it). The White-tailed Eagle nest was located in a conifer tree within a conifer plantation between the two forest roads. There was a working quarry adjacent to the forest road to the south, *c.* 200 m from the nest. Estimated typical existing vehicle use of the forest roads: daily. Vehicle passes took place firstly on the forest road to the south, then on the forest road to the north, though it was not possible to get closer than about 500 m to the nest along the forest road to the north, as it was blocked along its eastern section. When the bird was incubating it could see directly onto two forest roads, with perhaps *c.* 200–300 m length of forest road visible from the nest.

Survey methodology

Local FES staff checked eagle territory occupancy in February–March in both years and confirmed nest site locations in late March and early April (i.e. birds sitting on a nest and so presumably laying and/or incubating eggs). The FES staff also identified potentially suitable locations where observers could watch the incubating eagles without disturbing them or causing them to alter their behaviour. Care was taken to ensure that the access route to each observation point was not visible to the incubating birds.

Teams of two surveyors walked to the predetermined locations to watch the nests using a telescope. A 30 minute minimum settling down period was allowed to ensure that the birds were not alerted to the presence of, or alarmed by, the observers arriving at the predetermined (hidden) observation location. In practice, the observers did not record any eagle behaviour that suggested the birds were aware of the presence of the observers. The distance between the observers and the eagles' nests varied due to topographical features, but was estimated to be:

- Site A - *c.* 500 m separation between the observers and 2015 White-tailed Eagle nest.
- Site B - *c.* 1,300 m separation between the observers and 2015 Golden Eagle nest.
- Site C - *c.* 1,000 m separation between the observers and 2015 Golden Eagle nest.
- Site D - *c.* 1,400 m separation between the observers and 2015 Golden Eagle nest.
- Site E - *c.* 800 m separation between the observers and 2015 Golden Eagle nest.
- Site F - *c.* 1,000 m separation between the observers and 2016 White-tailed Eagle nest.
- Site G - *c.* 350 m separation between the observers and 2016 White-tailed Eagle nest.

Using two-way radios, forestry vehicles drove slowly (all vehicles complied with a 15 mph maximum speed limit) along forest roads and past adjacent eagle nests - in effect mimicking the 'normal' transit passage of forestry vehicles along a forest road. Whilst this was taking place one observer liaised with the driver, kept time with a watch and recorded the location and activity of the vehicle on the road, while the other observer constantly watched the eagle through a telescope and recorded any changes in the birds' behaviour. Due to logistical considerations, it was not possible to use the same vehicles at all seven widely dispersed locations. The vehicles used were a timber wagon and FES pick-up (Plates 16–17). At two of the three sites where a timber wagon was unavailable, a pick-up with a trailer was used to mimic the rattling sound of an empty timber wagon.

Plate 15 (above). The timber wagon used in this study. © *Peter Cosgrove.* **Plate 16 (below).** The FES pick-up used in this study. © *Peter Cosgrove*

Once well beyond the nest and out of sight of an incubating eagle, the vehicle driver stopped at a convenient location for a break (the duration of which varied between vehicles and site) and turned the vehicle around. The vehicle returned along the same route and stopped at the closest point along the forest road to the nest and visible to the incubating eagle. The vehicle stopped for an average of five minutes with its engine switched off during which time the driver did not get out of the vehicle.

Four potential categories of discernible eagle response to vehicles were recorded on field sheets by observers:

- Category 1 - No reaction to vehicle.
- Category 2 - Minor reaction, bird aware of vehicle, but remains on eggs, turns and looks in direction of vehicle and perhaps bobs head (AD).
- Category 3 - Moderate reaction, bird alert, stands up, gets off eggs in alarm, perhaps moves around, but not does leave nest in response to vehicle (AD-FID).
- Category 4 - Major reaction, bird flushed and leaves nest in alarm and response to vehicle (FID).

It was agreed prior to the study commencing that if the incubating eagles flushed (FID) at any time, the investigation at that nest would immediately stop to avoid further preventable disturbance.

Results

The surveys were conducted between 7 and 15 April 2015 and 14–15 April 2016 during a period of dry weather, avoiding hot, wet or cold conditions; as per Hardey *et al.* (2013) survey recommendations for Golden Eagles. In practice all surveys were conducted during dry weather, providing optimal conditions throughout the survey periods. Tables 1–7 summarise the eagles' responses to vehicle movements at each of the nest sites investigated.

Table 1. Summary of White-tailed Eagle field data collected by observers at Site A, April 2015. Response category: 1 = no discernible reaction i.e. does not move in relation to vehicle pass; * = possible heading bobbing, but begins to preen during vehicle pass and male flies in with food shortly afterwards at 10:10 and then leaves; 2 = minor discernible reaction i.e. looks towards vehicle as it passes; 3 = moderate discernible reaction i.e. when vehicle stops at closest point to nest between 11:07–11:11 female glances towards road at 11:08, at 11:09 stares at stationary vehicles and bobs head, at 11:10 stands up off eggs, stares at vehicle and bobs head, at 11:11 sits back down to incubate once vehicle leaves. Red = female.

Number	Time	Vehicle	Response category
1	09:12	Pick-up	1
2	09:23	Pick-up	1
3	10:01	Empty timber wagon	1*
4	10:56	Loaded timber wagon	1
5	11:04	Pick-up	3
6	11:19	Pick-up	2
7	13:15	Empty timber wagon	2
8	14:11	Loaded timber wagon	2

Table 2. Summary of Golden Eagle field data collected by observers at Site B, April 2015. Response category: 1 = no discernible reaction i.e. does not move in relation to vehicle pass; * = quad bike and dog nothing to do with planned test, ** = no reaction during incubation change over to vehicle pass; *** = preens during vehicle pass. 2 = minor discernible reaction i.e. looks towards vehicle as it passes and bobs head. Red = female; blue = male.

Number	Time	Vehicle	Response category
1	13:10	Empty timber wagon	1
2	13:40	Loaded timber wagon	1
3	13:50	Man on quad bike with dog running alongside	1*
4	14:10	Empty timber wagon	1
5	14:25	Pick-up	1
	14:25	Changeover occurs	1**
6	15:47	Loaded timber wagon	1
7	15:51	Pick-up	1***
8	15:58	Loaded timber wagon	1
9	16:05	Loaded timber wagon	2
10	16:10	Loaded timber wagon	1
11	16:25	Loaded timber wagon	1

Table 3. Summary of Golden Eagle field data collected by observers at Site C, April 2015. Response category: 1 = no discernible reaction i.e. does not move in relation to vehicle pass. 2 = minor discernible reaction i.e. looks towards vehicle as it passes and bobs head. Red = female; blue = male.

Number	Time	Vehicle	Response category
1	10:15	Empty timber wagon	1
2	10:30	Empty timber wagon	2
3	10:38	Empty timber wagon	2
4	10:50	Empty timber wagon	2
5	11:00	Empty timber wagon	1
	11:02	Change over occurs	
6	11:18	Empty timber wagon	2
7	11:25	Empty timber wagon	1
8	11:45	Empty timber wagon	1
9	11:52	Empty timber wagon	1
10	12:05	Empty timber wagon	2

Table 3. continued.

Number	Time	Vehicle	Response category
11	12:15	Empty timber wagon	1
12	12:20	Empty timber wagon	1
	12:21	Change over occurs	
13	14:15	Empty timber wagon	1
14	14:18	Empty timber wagon	2
15	14:24	Empty timber wagon	2
16	14:33	Empty timber wagon	1
17	14:40	Empty timber wagon	2

Table 4. Summary of Golden Eagle field data collected by observers at Site D, April 2015. Response category: 1 = no discernible reaction i.e. does not move in relation to vehicle pass; 2 = minor discernible reaction i.e. looks towards vehicle as it passes. * = male flies in with food and takes over incubation, shortly after vehicle pass. Red = female; blue = male.

Number	Time	Vehicle	Response category
1	13:21	Pick-up	2
2	13:43	Pick-up	2
	13:47	Change over occurs	*
3	14:28	Pick-up	1
4	14:52	Pick-up	1

Table 5. Summary of Golden Eagle field data collected by observers at Site E, April 2015. Response category: 1 = no discernible reaction i.e. does not move in relation to vehicle pass; 2 = minor discernible reaction i.e. looks towards vehicle as it passes. Red = female; blue = male.

Number	Time	Vehicle	Response category
1	10:39	Pick-up	2
2	11:31	Empty timber wagon	1
3	11:53	Pick-up	2
	12:13	Change over occurs	
4	13:27	Loaded timber wagon	1
5	14:12	Empty timber wagon	1
6	15:08	Loaded timber wagon	1

Table 6. Summary of White-tailed Eagle field data collected by observers at Site F, April 2016. Response category: 1 = no discernible reaction i.e. does not move in relation to vehicle pass; 2 = minor discernible reaction i.e. looks towards vehicle as it passes. * = becomes alert, looks around, then settles back down in nest; ** = lifts head up, looks around, then settles back down and ignores vehicle; *** = already standing up moving nest material before, during and after the vehicle pass. Red = female; blue = male.

Number	Time	Vehicle	Response category
1	11:25	Pick-up & trailer	2*
2	11:33	Council bin lorry on public road	2**
3	11:40	Pick-up & trailer	2
4	11:50	Transit van on public road	2
5	12:28	Pick-up & trailer	2
6	12:38	Pick-up & trailer	1***
7	12:43	Transit van on public road	1
8	12:46	Pick-up & trailer	1
9	13:12	Pick-up & trailer	2*
	13:16	Change over occurs	
10	13:20	Pick-up & trailer	1
11	13:25	Pick-up & trailer	1
12	13:50	Pick-up & trailer	2
13	13:59	Pick-up & trailer	1
14	14:05	Pick-up & trailer	2
15	14:14	Landrover	2
16	14:23	Pick-up & trailer	2
17	14:32	Pick-up & trailer	1
18	14:37	Pick-up & trailer	2

Table 7. Summary of White-tailed Eagle field data collected by observers at Site G, April 2016. Response category: 1 = no discernible reaction i.e. does not move in relation to vehicle pass; 2 = minor discernible reaction i.e. looks towards vehicle as it passes. Red = female; blue = male.

(a) South forest road

Number	Time	Vehicle	Response category
1	10:59	Pick-up & trailer	2*
2	11:17	Pick-up & trailer	1
3	11:42	Pick-up & trailer	1**
4	12:10	Pick-up & trailer	1
	12:15	Change over occurs	
5	13:05	Pick-up & trailer	1
6	13:25	Pick-up & trailer	1

* = becomes alert, sits up and looks around; ** = Moves around nest rearranging nest material before, during and after vehicle pass - no change in behaviour during vehicle pass.

(b) North forest road

Number	Time	Vehicle	Response category
1	13:40	Pick-up & trailer	1
2	13:54	Pick-up & trailer	1
3	14:10	Pick-up & trailer	1*
4	14:25	Pick-up & trailer	1*
5	14:40	Pick-up & trailer	2
	15:00	Change over occurs	
6	15:18	Pick-up & trailer	1

* = moves around nest changing position on eggs, before and during vehicle pass.

Table 8. Pilot study summary statistics 2015–16.

Species	Number of incubating birds	Number of vehicle passes	Number of responses per response category
Golden Eagle	8	38	1 = 25, 2 = 13, 3 = 0, 4 =0
White-tailed Eagle	5	38	1 = 21, 2 = 16, 3 = 1, 4 = 0

Discussion

The 2015–16 pilot study has provided empirical data for the first time on responses of incubating Golden Eagles and White-tailed Eagles to routine forest road traffic. Although the pilot study was undertaken on a relatively small number of incubating Golden and White-tailed Eagles (13 individuals) and vehicle passes (38 for each species), several important findings were made:

- Forest road traffic did not cause eagles to leave or abandon any of the nests studied. Consequently the welfare of the birds was maintained throughout the pilot study whilst valuable data was collected.
- No FID distances were identified within the range of distances studied: Golden Eagle 350–970 m; White-tailed Eagle 50–270 m.
- Direct observations showed that incubating Golden Eagle and White-tailed Eagle sometimes responded to both sound and visual stimuli from forest road traffic.
- Individual eagles exhibited different responses to the same type of vehicle activity at different times.
- It was not possible to determine if birds responded at a particular threshold distance because the birds' reactions were either non-existent or very minor and subtle to detect at the range of distances studied. The greatest reactions recorded were usually when vehicles were closest to nests and often (but not always) when they stopped, e.g. head bobbing response.
- No discernible responses (Category 1) were recorded during 46 vehicle passes (61%), i.e. there was no observable response from incubating birds to forest vehicles passing by nests in over half of observations.
- Minor reaction responses (Category 2) were recorded during 29 vehicle passes (38%); usually manifested by an incubating bird looking towards a forestry vehicle. Sometimes the incubating birds also bobbed their heads at a passing or stationary vehicle.

- Moderate reaction responses (Category 3) were recorded during one vehicle pass (1%). A White-tailed Eagle at Site A exhibited clearly agitated behaviour towards a FES pick-up that stopped opposite the nest. The same bird exhibited no such response to the same vehicle (and also timber wagons) passing along the route at other times. This suggests that the individual female perceived a stationary vehicle in full view at distance 270 m to be a threat on this one occasion.
- No major reaction responses (Category 4) were recorded during vehicle passes at any nest.
- White-tailed Eagle and Golden Eagle partners continued to provide food and occasionally sticks to incubating birds. Typical changeover behaviour also took also place during the study period.

Limitations

The following variables were not investigated by the 2015–16 pilot study:

- Changes in response to disturbance stimuli on different dates and under different weather conditions.
- Detailed analyses were not undertaken because the small sample sizes meant it was not possible to tease out the effects of context (species, bird, nest site, distance or vehicle type).
- Changes in response to disturbance stimuli during different parts of the breeding season (i.e. adults with chicks). The period immediately prior to egg laying, during egg laying and incubation is widely considered to be the most sensitive period in many raptors' breeding cycle (e.g. Hardey *et al.* 2013) and is therefore the period when disturbance effects would potentially be most pronounced. Studies into the potential impact of, for example, vehicle movements on nests with chicks is problematic and more difficult to measure because both parents are often away from the nest foraging. Furthermore, the adults often visit the nest for very short periods of time and hence it would be challenging to determine if an eagle flew off after delivering a prey item (or was indeed kept away from a nest) by, for example, a vehicle moving or stationary along an adjacent forest road.
- The response of incubating eagles to vehicle doors being slammed or drivers getting out of vehicles.
- This study did not consider any potential cumulative effects of multiple vehicle movements over days or weeks. Incubation is likely to be the most sensitive period of the breeding season and the time when vehicle movements should be kept to a minimum. The sensitivity of the nest site is likely to decrease as the breeding season progresses as family ties/bonds with the chicks develop, i.e. adults are considered less likely to abandon chicks than eggs, although this was not tested.

Whilst buffer zones are widely recognised as a method by which to prevent the disturbance of legally-protected and potentially sensitive bird species, most are not based on direct empirical evidence. Such management tools can incur significant costs to the public purse and local communities. In the case of FES, large buffer zones around eagle nests can necessitate the diversion of forest road traffic on to longer, more circuitous routes or block access to substantial forest areas for several months a year. Timber transport lorries cost approximately £2.50 per mile to run on forest roads and long diversions can increase costs significantly over several months of operation. Further issues can arise when timber lorries are prevented from using timber transport routes within forests and are diverted on to public roads. This can result in significant deterioration of the public roads and serious inconvenience to local communities through which the lorries have to pass.

Large buffer zones can also result in the rescheduling of forest operations elsewhere within the forest (such as tree felling) to periods of the year when rain and snowfall make operations more expensive. Operations at such times of the year create their own environmental risks with runoff and pollution of local watercourses more likely. Buffer zones should therefore be well founded in design to prevent actual disturbance of potentially sensitive species. Consequently, the nature and scale of such buffers should be based on evidence of effect when available and not conjecture or speculation.

What little has been published on accidental disturbance of breeding Golden Eagles and White-tailed Eagles is of limited value to informing management of vehicle use on forest roads in Scotland. For example, Grubb *et al.* (2010) investigated the response of incubating Golden Eagles to heli-skiing and military helicopters in northern Utah, USA. They watched 303 helicopter passes between 0–3,000 m (horizontal distance) in 22 nesting territories and found no effect on early courtship, nest repair or subsequent nesting success. No response occurred in 66% of passes and incubating birds watched helicopters in 30% of observations. Neither their observations nor testing indicated that special management restrictions were required for helicopters flying near Golden Eagle nests in northern Utah.

The use of breeding success (outcomes) as a proxy for direct observation of birds incubating has been reported for disturbance studies. For example, using 40 years of breeding data on Golden Eagles in Idaho, Steenhof *et al.* (2014) investigated whether the proportion of territories and pairs producing young changed over time in relation to 'off highway vehicle' (OHV) use. They found that after a dramatic increase in OHV use from 1999–2009, occupancy and nesting success in close proximity declined significantly compared to territories not impacted by OHV. Their research, which was based on nesting success and not on nest observations, could not determine which types of OHV use were most disturbing or identify disturbance thresholds at which Golden Eagles abandoned their eggs, young or territories. OHV use in the study area centred around all-terrain 4-wheel vehicles, dirt-bikes and rock crawlers operating off road, which were often used to access (formerly) remote areas for camping, fishing and shooting. Thus, the Golden Eagle's negative response to increased OHV use may have been associated with human activities of OHV users other than vehicle use per se.

In Finland, conservation interventions aimed at protecting nest sites of White-tailed Eagles were based around general concerns that disturbance posed by human encroachment and forestry practices adversely affected their breeding success. Santangeli *et al.* (2013) set out to evaluate this approach and found that neither nest occupancy nor breeding success of White-tailed Eagles was affected by the protection afforded to land around the nesting site. In addition, the type of forestry management at the nest site or the presence and vicinity of anthropogenic infrastructures i.e. roads and buildings within 300 m of nests did not have any apparent negative effect on nesting White-tailed Eagles. Once again, the use of breeding success (outcomes) as a proxy for direct observation of nesting birds was used to infer impacts. However, Santangeli *et al.* (2013) did suggest that the situation in Finland might be different to other places due to the low levels of disturbance early in the breeding season because of snow and ice cover.

Much of the forestry land where White-tailed Eagles nest in Finland is highly valuable for timber production and recreation and this, along with an increasing and expanding White-tailed Eagle population, meant that the money that would be needed for protecting nest sites through exclusion zones would be large. The Finnish study showed that such expensive protection measures (i.e. large buffer zones around nests) do not benefit White-tailed Eagles and were considered unnecessary in Finland, with the recommendation that scarce conservation resources should be directed elsewhere. Instead, they suggested that a voluntary scheme with forest managers could be developed to avoid unnecessary impacts.

Recommendations

- It is recommended that further studies are carried out in Scotland into the effects of vehicle movements on additional pairs of incubating Golden Eagles and White-tailed Eagles to increase the sample size of birds studied. Ideally, such tests should be conducted in both morning and afternoon as this allows for males and females to change incubation duties and so increase the sample size of birds studied at each nest.

- The evidence from this pilot study (acknowledging relatively small sample sizes) indicates that routine use of forest roads by moving forestry vehicles does not cause adverse disturbance to incubating Golden Eagles and White-tailed Eagles at the distances studied.
- There is some evidence from this study of an adverse reaction from an incubating White-tailed Eagle to a vehicle stopping close to a nest (*c.* 270 m away). Given that nesting Golden Eagles are widely considered to be more sensitive than White-tailed Eagles, no forest vehicles should be allowed to stop near nests with incubating Golden Eagles and White-tailed Eagles. Therefore, if forest roads near eagle nests are to be used during the breeding season, then the initial evidence from this pilot study suggests that strictly enforced 'no-stopping zones' should be created on forest roads near to active nests. The current study did not provide an empirical basis for determining what 'near to' meant and further work is required to answer this. However, a vehicle stopping within 270 m of a White-tailed Eagle nest caused an adverse response from an incubating female.
- FES should update their published guidance entitled '*Forest operations and birds in Scottish forests*' (FCS 2006) to reflect the response of incubating Golden Eagles and White-tailed Eagles to forest road traffic. Further work to understand the impacts of disturbance on White-tailed Eagles should be undertaken as part of the national action plan for this species.

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