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Saving wildcats in Scotland: first releases of captive-bred European wildcats

Anthropogenic threats have pushed the European wildcat *Felis silvestris* population in Scotland to the brink of extinction. Unlike wildcat populations in western-central Europe, reinforcement through immigration is impossible, leaving conservation translocation the only viable option. The Saving Wildcats (SWAforLIFE, LIFE18 NAT/UK/000995) partnership was launched in 2020 to restore wildcat populations in Scotland through captive breeding/release and threat mitigation. Nineteen wildcats were soft-released into the Cairngorms National Park in Summer 2023. Post-release monitoring revealed high survival and reproduction during the first year. However, genetic testing confirmed interbreeding with wildcat-domestic cat hybrids in one litter and human-wildlife conflict remains a significant challenge to long-term recovery. The prevalence of suitable wildcat habitat in human-occupied areas increases the relative risks from hybrids/domestic cats and land management practices.

Wildcats in Scotland are a Critically Endangered sub-population of the European wildcat and Britain's last remaining native felid (Gerngross et al. 2023). Primary threats to their survival include habitat loss, prey declines, and human persecution, particularly due to predation on gamebirds and poultry (Macdonald et al. 2004). These pressures have significantly reduced and fragmented wildcat populations, leading to widespread introgressive hybridisation with domestic cats *Felis catus* (e.g. Daniels et al. 2001, Senn et al. 2019). There is evidence that in the last 70 years, hybridisation has accelerated (Howard-McCombe et al. 2023). Scotland is the only known region to have a 'hybrid swarm,' where the wildcat population is genetically and phenotypically continuous with domestic cats (Senn et al. 2019). Interbreeding with domestic cats also presents risks from disease transmission, although the population level impacts are currently unknown (Alves et al. 2023).

An independent status review by the IUCN Cat Specialist Group concluded that the wildcat population in Scotland is not viable without reinforcement from captive populations (Breitenmoser et al. 2019). Consequently, the EU LIFE-funded Saving Wildcats (SW) partnership project (2020–2026) was launched, led by the Royal Zoological Society of Scotland (RZSS).

The goal of SW is to prevent the extinction of wildcats in Scotland by restoring a viable population at a designated site within the Cairngorms National Park (CNP) using a combination of in-situ (wild) and ex-situ (captive) conservation approaches. The project aims to carry out the first trial releases of ca. 60 captive-bred wildcats between 2023 and 2025. Pre- and post-release monitoring will inform the release strategy and guide threat mitigation efforts including Trap-Neuter-Vaccinate-Return (TNVR) of feral domestic cats and engagement with landowners and gamekeepers. Here, we summarise the release of the first cohort in 2023 and the outcomes from the first year of post-release monitoring; further behavioural and ecological analyses will be published separately.

Release site

The project release site is the Cairngorms Connect (CC) landscape: a partnership of four neighbouring landowners (NatureScot, Forestry and Land Scotland, Royal Society for the Protection of Birds, and Wildland Ltd) covering 13% (590 km^2) of the CNP in northern Scotland (Fig. 1). Managed principally for ecosystem restoration, the land also supports farming, forestry, managed moorland, and recreation. Up to 70% of the land is covered by international conservation designations; releases in Natura 2000 sites (now "European Protected Sites" in Scotland) were a precondition of funding.

Ranging in altitude from 200–1,309 m, the site contains a mix of habitats including: native Scots pine *Pinus sylvestris* forest managed to provide a mosaic of age stands including areas of clearfell and windthrow; mixed and broadleaf woodland, dry and wet grassland at lower

elevations; and heathland, bog and montane vegetation on higher ground. Settlements comprise 0.02% of total landcover; road density is 0.3 km/km^2. Habitat modelling conducted by NatureScot for the 2019 EU LIFE application suggested around 220 km^2 of suitable wildcat habitat in CC, which could support a viable population of 40 wildcats (Littlewood et al. 2014).

CC is bordered by rural communities and small towns. Surrounding land ownership is dominated by private estates with a mix of farming, forestry and gamebird shooting, mainly non-native pheasants *Phasianus colchicus* and red-legged partridge *Alectoris rufa* in lowland areas, and native red grouse *Lagopus scotia* on the higher ground. Therefore, across the wider landscape, the risks from persecution and hybridisation are likely to be higher than in CC. The release site is close to the SW project base at the RZSS Highland Wildlife Park (HWP) (Fig. 1).

Methods

Wildcats were sourced from the UK captive population and bred at the purpose-built Conservation Breeding for Release Centre (CBRC) at the HWP (see Barclay et al. in prep). The CBRC design was based on other breeding-for-release facilities, including Iberian lynx *Lynx pardinus*, and comprises 16 breeding enclosures (14.4L x 6W x 4.5H m) and 20 larger pre-release enclosures (20 x 30 m). Ex-situ management prioritised a 'hands-off' approach. Kittens were born in spring 2022 and housed with their mothers in the breeding enclosures before being transferred singly or with same-sex siblings to pre-release enclosures at 6–9 months old. Feeding of live vertebrate prey is illegal in the UK (Animal health and welfare (Scotland) Act 2006) and captive animals were therefore fed a diet of dead rats, mice, quail and rabbit, and the occasional deer carcass (red *Cervus elaphus* and roe *Capreolus capreolus*).

Wildcats selected for release were screened for introgression from domestic cat using a combined genetic and phenotypic approach. All captive-bred wildcats and their parents exceeded the genetic threshold of estimated 75% genetic ancestry (Senn et al. 2019). Pelage scores (Kitchener 2005) were recorded by trained staff while wildcats were under anaesthesia; experts provided additional blinded scores from photographs, and the scores were combined into a mean pelage score (see Supporting Online Materials (SOM) for further details).

Thirteen soft-release pens (timber frame and wire mesh; dimensions 4.8 x 3.6 x 2.5 m) were built in groups of 2–4 at four different locations within the CC release site (Fig. 1; see SOM Methods and SOM Fig. F1). Locations prioritised suitable cover and prey habitat (coniferous or mixed woodland and grassland, with shrub understory and windthrow), access for construction, and minimal human disturbance.

Wildcats were trapped 2–3 weeks prior to release for health checks and GPS-collar fitting. GPS-radio collars (1A Light model, e-obs GmbH, Grünwald, Germany) were programmed to collect high-resolution GPS and accelerometer (ACC) data and were fitted by the field and veterinary teams. Once approved for release, cohorts of 2–4 wildcats were transferred to individual soft-release pens during summer 2023 and monitored with ex-situ management for up to seven days before the doors were opened at dawn (see SOM Fig. F1). Supplementary food (captive diet) was provided daily for at least one week post-release and continued with gradual reduction if utilised. Wildcats were tracked daily by SW field staff and volunteers, and systematic and opportunistic camera-traps were used to monitor body condition and behaviour. Wildcats were trapped for collar removal/replacement around 7–9 months post-release. Analyses were carried out in the program R (Version 4.2.1) using various R packages and QGIS (version 3.24). Releases were conducted under licence from NatureScot (licence number 220947). Reported values are mean ± standard deviation (SD) unless otherwise stated. For detailed Methods, see SOM.

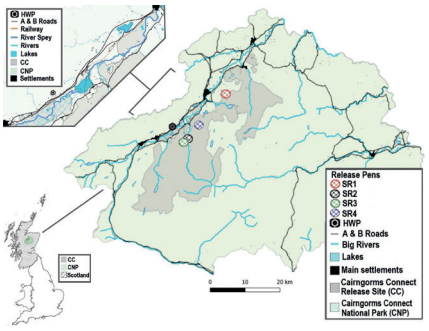

Fig. 1. Location of the Cairngorms Connect (CC) release site (57°10'06" N / 003°47'21"W) within the Cairngorms National Park (CNP), northern Scotland, showing the location of the Captive Breeding for Release Centre at the RZSS Highland Wildlife Park (HWP); the four soft-release pens (SR1–4); and the larger roads and rivers across the CNP. Inset map (top left) shows the location of the river Spey along the western boundary of CC.

Fig. 2. Camera trap image showing a GPS-collared wildcat leaving its soft-release pen (Photo Saving Wildcats).

Results and Discussion

Soft-release

Nineteen wildcats were released at four locations in CC between 12 June and 8 September 2023 (Fig. 1; SOM Table T1). Eighteen (8 male, 10 female) were captive bred in the CBRC and aged between 12–16 months at time of release. One wild-caught female wildcat (LOS22) was also released, aged approximately 6–7 years, having been taken into the conservation breeding programme by RZSS under government licence in 2018 as part of a national action plan (Campbell et al. 2023). Individuals took between <10 mins (n = 3) to 13 hrs (n = 1) to leave the soft-release pen (mean = 3.6 ± 3.5 hours; Fig. 2; SOM Table T1). Supplementary food was used by 7 of 19 wildcats for 56 ± 26 days with gradual food reduction (SOM Table T1).

All 19 wildcats were tracked from release up until GPS-collar battery failure or mortality (n = 1), including two wildcats that hyperdispersed away from the release site. GPS collars lasted on average 213 ± 45 days or 7,515 ± 1,524 fixes and 99% of scheduled fixes were successful (SOM Table T2).

Table. 1. Overall mean (± SD) resident home range sizes (km^2) and dispersal (km) for captive-bred released male and female wildcats.

Sex	n	Resident HR size (km^2)*	Time to range residency (days)	Dispersal distance from release pen (km)	
				Max. distance	Dist. To HR edge
Female	10	5.6 ± 1.97	94 ± 55	10.4 ± 5.9	5.9 ± 3
Male	8	16.1 ± 13.2	52 ± 47	18 ± 10.6	10.6 ± 13.3

* Significant difference at p<0.05 (Kruskal-Wallis Chi-squared; d.f. = 1)

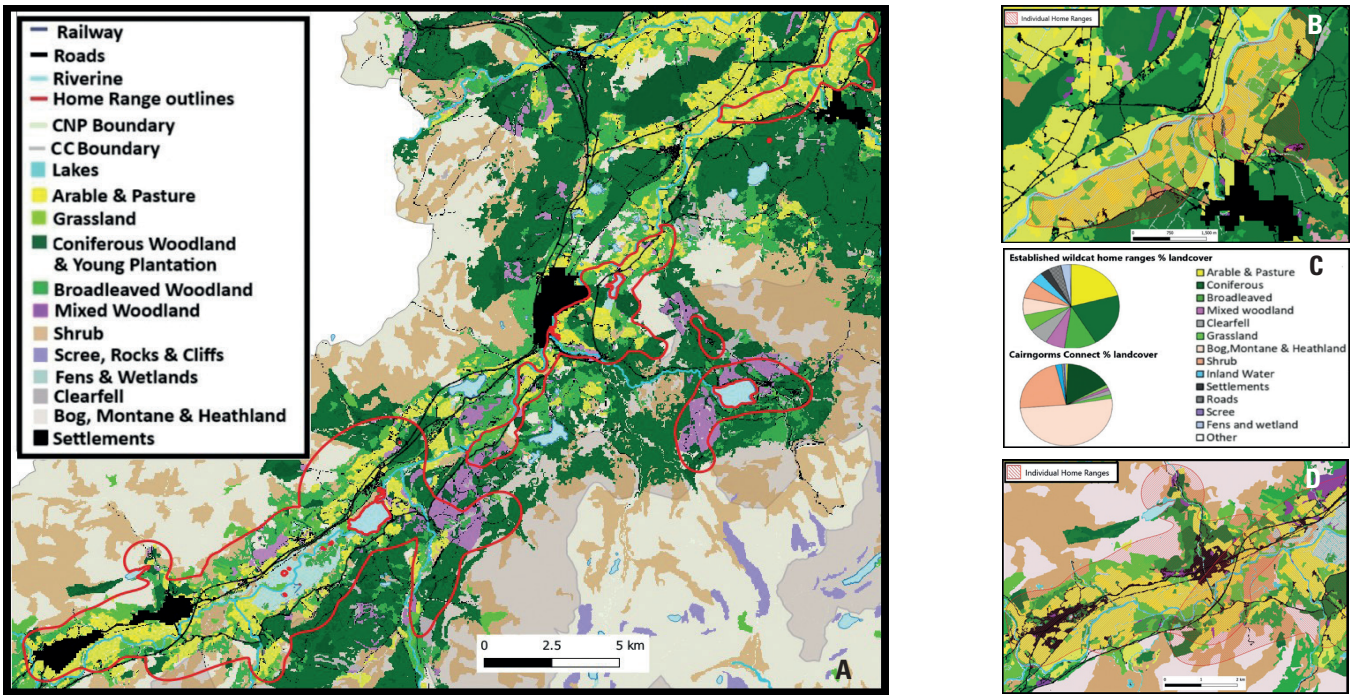

Fig. 3. Resident home ranges of captive-bred released wildcats along the western edge of the CC release site and associated main land-cover. A) The overall area covered by established wildcat home ranges is shown in red outline (n = 17); B) two overlapping wildcat female home ranges utilising riverine, arable/pasture, grassland and coniferous woodland edge habitat on the edge of CC; C) overall % landcover in established wildcat home ranges with the Cairngorms Connect (Other = industrial use); D) overlapping home ranges of two male and two female wildcats associated with arable/pasture, grassland and broadleaved/coniferous woodland edges, predominantly outside the CC release site (one male wildcat shows extensive overlap with human settlements).

Survival and health

Survival rate was high: 18 of 19 released wildcats survived at least ten months post-release (95%) at which point two males were lost, possibly dispersed. The wild-caught female (LOS22) died one-month post-release of a uterine infection (pyometra). Two wildcats were fed in-situ around 1-month post-release in response to suspected injury and/or malnutrition highlighted by monitoring data (SOM Table T1). Both showed improved body condition and behaviour (increased activity and exploration) after several weeks of feeding.

Wildcats trapped for recollaring were assessed for health and body condition 7–9 months post-release (n = 13). Trapping effort for all wildcats (n = 18) was 62 trap nights (number of traps set x number of nights) at 37 locations; traps were pre-baited for an average of 18 nights; five individuals were not successfully trapped. Four individuals had mild dental disease; three individuals had superficial trap injuries to their claws; no other clinical signs of injuries or disease were detected. Re-captured wildcats were tested for the following pathogens, with a negative result: Feline herpes virus, Feline calicivirus, *Chlamydophila felis*, Feline leukaemia virus, and Feline immunodeficiency virus. Average weight gain for males was 21% (n = 6) and for females 24% (n = 7). The modal Body Condition Score (Laflamme 1997) increased from 4 (moderately thin) to 5 (ideal) (n = 13). See SOM Table T2 for further details.

Fig. 4. Camera trap image of a released female wildcat (HAG22) with her first litter of kittens in the wild (Photo Saving Wildcats).

Dispersal and establishment of home ranges

Seventeen wildcats established home ranges (HR) in the River Spey corridor to the west of CC, and 5 of those 17 individuals (1 female, 4 males) established home ranges on the western side of the River Spey (Fig. 3). The river constrained the majority of home ranges, although some individuals regularly cross via road bridges. Two male wildcats regularly returned to the CBRC, posing a potential biosecurity and disturbance risk for captive wildcats.

The mean maximum dispersal distance from the release pen was 15.1 ± 12.2 km, with no significant difference between males and females (Table 1). Mean resident HR size was 10.2 ± 10.1 km^2. Males had significantly larger HRs (16.1 ± 13.2 km^2) than females (5.6 ± 1.97 km^2). Individuals took on average 94.4 ± 58 days to reach start of residency. Although females took longer to settle, this difference was not significant (Table 1; see also SOM Table T3).

Two wildcats hyperdispersed after release: a male wildcat (WIL22) travelled 45 km east over the Cairngorm mountains (elevation of 1,309 m) before settling in the eastern CNP, and the wild-caught female (LOS22) dispersed 39 km to the north-east before she died (SOM Table T3).

Habitat-use

Most wildcats did not establish home ranges in the CC release site; only 28% of the total resident home ranges overlapped with CC (Fig. 3). The spatial distribution of HRs can be partly explained by habitat selection. Released wildcats selected a mix of riparian, grassland, arable and pasture, and mixed/broadleaf woodland habitats and avoided bog, heathland, wetlands, montane habitats, and coniferous woodland (exceptions being clearfell — productive habitat for field voles *Micro-*

tus agrestis — and windthrow, which provides cover; SOM Fig. F2 and SOM Table T4). Similar habitat preferences have been demonstrated for hybrid wildcats in Scotland (Kilshaw et al. 2023). Within the overall HR's, 2.4% of the total landcover comprised settlements/buildings (SOM Fig. F2) and mean road density was 2.12 km/km^2.

Feeding behaviour and diet

Diet metabarcoding from scat collection is ongoing. GPS and camera-trap data revealed habitat-use and behaviour of wildcats consistent with predation of field voles, which were abundant in grassland and clearfell habitat and reached a cyclical population peak in Summer 2023 (X. Lambin, pers. comm.) and rabbits *Oryctolagus caniculus*, which are locally concentrated on the west of the River Spey. Scavenging and caching of carrion was also identified, particularly roe deer and brown hares *Lepus europaeus* (wildcats were also observed predating adult brown hares). Nine wildcats occupied game-shooting estates, frequently clustering around rearing pens before and after gamebirds were released. Gamekeepers reported predation and disturbance of pheasants by wildcats including two instances of entering "closed" rearing pens (confirmed by GPS data). Five wildcats are known to have predated domestic chickens and ducks in several rural communities. Predation/disturbance of domestic poultry and gamebirds, and other impacts on gamebird shooting, has caused conflict within local and land management communities.

Reproduction

Camera-trap footage confirmed at least 24 kittens were born to 7 released females between April–August 2024 (Fig. 4). GPS and ACC data were used to identify potential birth periods (Kilshaw et al. in prep; SOM Fig. F3). The average litter size at point of first observation was three. Two females had second litters in August, despite evidence that at least some individuals from the first litter had survived to dispersal age. Natal den locations could only be approximated for females with working GPS collars (n = 5): all were in areas of dense vegetation, and two females likely gave birth underground.

Wildcat home ranges overlapped on average with 3 ± 2 other wildcats (SOM Table T5). Home range overlap between males and females during the breeding season suggests that five of seven females could have bred with a released male wildcat, and two male wildcats (RAN22 and RUM22) likely fathered multiple litters (SOM Table T5 and Fig. F4). Seven wildcat home ranges overlapped that of an opposite-sex sibling (SOM Table T5).

Genetic testing of two litters has confirmed wildcat paternity but could not at present identify the father (Table 2). However, two females had no opportunity to breed with any released male wildcats (SOM Fig. F4) and genetic testing of a kitten (IC0327) from one of these females has confirmed interbreeding with a hybrid wildcat (Table 2 and Fig. 5). All 24 kittens showed wildcat-type coat markings (pelage) rather than domestic cat coloration, although it is not possible to rule out hybridisation based on phenotype alone (Fig. 5).

We have no information about potential reproduction between released male wildcats and domestic cats/hybrids, but home range overlap with farms and human settlements suggests a lack of spatial barriers (Fig. 3 and SOM Fig. F4).

Fig. 5. Wild-born kittens from two female wildcats. Genetic tests revealed likely paternity of A) IC0327 was wildcat-hybrid and B) IC0348 was wildcat (Photo Saving Wildcats).

Conclusions

Captive breeding and release can be an effective strategy for wildcat conservation with individuals successfully adapting to life in the wild and reproducing. Favourable weather and abundant prey likely contributed to high survival in summer 2023, alongside intensive monitoring and supportive management. GPS collars and camera traps provided valuable data about ecology and behaviour. The establishment of resident home ranges primarily on the western edges/outside CC, where habitat is more diverse and productive with relatively higher prey population densities (including rabbits and pheasant), suggests that the interior of CC may provide sub-optimal habitat for wildcats. These more productive areas are also dominated by human occupation and land-use. Spatial overlap between human and wildcat populations exposes released wildcats and their offspring to relatively greater risks from domestic cats/hybrids, disturbance, road mortality, and human-wildlife conflict arising from predation of gamebirds and poultry. Future population restoration efforts and long-term success depend on finding ways to mitigate these anthropogenic threats and would benefit from wildcat-specific habitat restoration efforts.

It remains too early to evaluate the success of the project in terms of the long-term viability of the reintroduced population, particularly given the ongoing risk of hybridisation. SW will proceed with further wildcat releases in 2024 and 2025, supported by continued individual- and population-level monitoring through to October 2031. A national strategy is currently being developed to underpin and guide these conservation efforts.

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Table. 2. Hybrid (Q) scores for five wild-born kittens. LQB and UBQ scores represent the 90% confidence intervals around these estimates and quantify the proportion of wildcat ancestry based on 35 diagnostic markers (SNPs – single nucleotide polymorphisms). The Q score of the individual in bold indicates hybrid paternity.

Sample ID	Sample source	Mother UID	Q	LBQ	UBQ
IC0322	Dead - killed on road	CLA22	0.962	0.882	1
IC0322	**Live - trapped for sample**	**MAR22**	**0.711**	**0.596**	**0.817**
IC0330	Live - trapped for sample	ARW22	0.963	0.899	1
IC0331	Live - trapped for sample	ARW22	0.891	0.899	0.968
IC0348	Live - trapped for sample	ARW22	0.885	0.78	0.968

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Supporting Online Material SOM Methods, Table T1-T5 and Figures F1–F4 are available at www.catsg.org.

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