

Dundonnell Red Squirrel Translocation: Results 2008-2011



Highland Foundation for Wildlife



January 2012

Summary

In winter 2008-2009, 44 red squirrels (*Sciurus vulgaris*) were live trapped in Moray and Strathspey and translocated to Wester Ross. All squirrels were successfully translocated with no deaths. They were released into the wild at Dundonnell, either by soft release (13 squirrels) or hard release (31 squirrels). Survival has been excellent, e.g. all four radio tracked individuals surviving at least until the following August, when the transmitter batteries were running down, and at least one individual known to have survived for 23 months. The squirrels have successfully bred every year since the translocation, with numerous sightings of pregnant and lactating squirrels and, later in the season, young squirrels. Drey building has been extensive, with both breeding and non-breeding dreys located across large parts of the woodland area. The squirrels have successfully colonised all of the surrounding woodland, and dispersal distances have been much further than expected. At least one squirrel made a surprising journey across open mountains to Leckmelm, an overland distance of approximately 16km. A female squirrel was released in its territory and they bred successfully, with young squirrels seen in 2009 and 2011.

Regular recording of squirrel numbers and activities has been carried out throughout the whole project by the estate gamekeeper, with numbers and frequency of sightings increasing each year. Our calculations give a total population estimate of 290-580 squirrels. This meets our original predictions and shows that the translocation has been successful and that the population is viable and self-sustaining. There have been 23 recorded mortalities, predominantly road deaths. The rate of mortality has increased each year and, although disappointing, gives further indication that the population size is large and able to sustain losses.

We consider the translocation to have been extremely successful, in that it has created a healthy and robust red squirrel population free from incursion by invasive grey squirrels (*Sciurus carolinensis*). We advise that further translocations are carried out based on the methods used at Dundonnell, to enable colonisation of other former areas of habitation and to increase the area of red squirrel range free from grey squirrels. The project is supported by the Highland Red Squirrel Group, which also supports further releases as soon as possible.

Contents

1. Background.....	1
2. Study Area.....	2
3. Methods.....	3
3.1. Capture of donor squirrels.....	3
3.2. Veterinary inspection.....	5
3.3. Translocation and release.....	8
3.3.1. Soft release.....	8
3.3.2. Hard release.....	9
3.3.3. Release sites.....	10
3.3.4. Release dates.....	11
3.4. Post release supplementary feeding.....	12
4. Monitoring.....	13
4.1. Live sightings.....	13
4.2. Feeding Sign Transects.....	16
4.3. Drey surveys.....	17
4.4. Radio-tracking.....	18
4.5. Live capture.....	22
4.6. Wild food surveys.....	24
5. Parameters of success.....	25
5.1. Dispersal.....	25
5.2. Breeding.....	28
5.3. Predation.....	28
5.4. Survival and Mortality.....	29
6. Population Estimation.....	31
7. Evaluation of Project.....	32
7.1. Limitations.....	33
7.2. Recommendations for the future.....	34
8. Conclusion.....	35

1. Background

Red squirrels are one of the most threatened mammals in the UK. They have suffered huge declines over the past 50 years, due to habitat loss and competition and disease transmission from the non-native American grey squirrel (*Sciurus carolinensis*). Approximately 75% of the UK population is now found in Scotland (SRSAP 2006). However, many Scottish populations are fragmented and many areas that were formerly occupied remain uncolonised.

In 2005 we were asked by Dundonnell Estate to examine the potential for re-establishing a viable population of red squirrels (*Sciurus vulgaris*) at Dundonnell by translocating animals from elsewhere in the Highlands. Subsequent fieldwork showed that the area provided much excellent squirrel habitat, plentiful food supplies and no competition from grey squirrels. It was big enough to establish a viable population and could provide a secure, disease-free refuge against further inroads by grey squirrels moving north and west in Scotland.

The UK Action Plan for red squirrels lists as the third of its objectives 'To re-establish red squirrel populations, where appropriate' (UKBAP 1995), and the need for experimental translocation projects with a view to wider use is specifically referred to in this action plan. The Dundonnell project would provide such field experience, which could be critical for future red squirrel conservation. It was deemed important that this was not just a one-off but was the forerunner of future work, and for this reason we proposed and agreed the following vision with SNH:

To re-establish red squirrels in suitable forests and woodlands to the north and west of the present range, in order to increase the distribution and overall population and to create refuges free from grey squirrels and associated diseases.

A proposal was submitted to SNH in October 2007 and a licence to trap and translocate up to 50 red squirrels was issued on 1st September 2008, with a proviso to agree trapping locations with SNH before beginning trapping.

2. Study Area

Dundonnell Estate comprises 13435 ha. It is located in the north-west Highlands, in Wester Ross. Red squirrels were last seen at Dundonnell in 1986 and it was one of the last sites where red squirrels were recorded in Wester Ross. There are at least 400 hectares of woodland within the estate and additional woodland on neighbouring land, including ca 50 hectares of mature planted Scots pine. Semi natural woodland (birch, sessile oak, hazel, rowan, aspen, wych elm, willows and other species) accounts for 250ha. Conifer plantations established in 1957-1962 are made up of 15 ha Scots pine, 35 ha lodgepole pine, 26.5 ha Sitka spruce, 20 ha European, Japanese and hybrid larch, plus small amounts of other conifers.

Policy woodlands of up to 200 years old, especially beech and European larch, but including oak, ash, elm, lime, sweet chestnut, horse chestnut and beech, extend to 60 ha. Most of the woodland is old, but a quarter is woodland planted in 1957 to 1962. There is an active forest plan encouraging a more natural and diverse woodland and, outside the policies, native species are favoured.

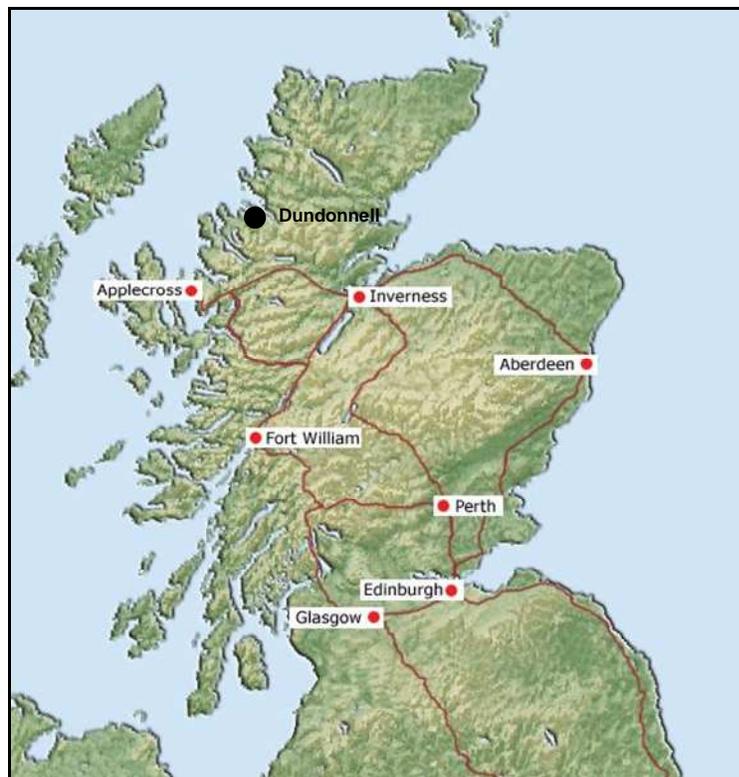


Figure 1: Location of Dundonnell

3. Methods

In 2007-2008 fieldwork was carried out on Dundonnell estate to identify the best places within the woodlands to release the squirrels. The project began the following year, with capture of donor squirrels commencing on 24/10/08.

3.1. Capture of donor squirrels

Donor red squirrels were caught in Moray and Strathspey, where there proved to be many potential donor sites. Squirrels frequently come to gardens with nut feeders and to visitor centre feeders, so were easy to capture. We sought and received approval from householders and land owners and used live traps to capture squirrels. Prior to the days chosen for trapping, de-activated traps were placed at sites with regularly-used nut feeders, so that squirrels could become used to walking inside the trap to take nuts from a container. Pilot trapping was carried out on 24/10/08-25/10/08 in Dunphail and Boat-of-Garten and six squirrels were caught, proving that the method was effective.

Trapping commenced on 05/11/08, with 12 squirrels caught from trapping sites in Carrbridge, Cromdale, Grantown-on-Spey and Dunphail. On 21/11/08 a further 14 squirrels were caught from sites in Logie, Edinkillie, Grantown-on-Spey, Cromdale and Carrbridge. In view of the lateness of the season, it was decided to delay capture of the remaining 18 squirrels until the days started to lengthen again in February. Four squirrels were caught in Moray on 09/03/09 and a further eight squirrels were trapped in Moray and Strathspey on 20/03/09. It was decided that trapping should not continue after this date, because the squirrels would soon be breeding, so only 44 squirrels rather than the target of 50 on the SNH licence were trapped. The maximum number of squirrels taken from any site was two.



Figure 2: Live traps set beside nut feeders



Figure 3: Squirrel caught in a live-trap

The 44 squirrels comprised 21 males and 23 females and were caught at a variety of locations: Boat-of-Garten: 7 squirrels, Carrbridge: 2 squirrels, Grantown-on-Spey/Cromdale: 10 squirrels, Dunphail and Edinkillie: 18 squirrels, and Logie: 7 squirrels.

Table 1: Live-trapping data

Number	PIT tag	Location	Map Ref	Date	Time	Sex
1		Dunphail 2	NJ017470	24/10/08	1600	F
2		Boat-of-Garten (Grebe)	NH932190	24/10/08	1030	F
3		Boat-of-Garten (Grebe)	NH932190	24/10/08	1030	F
4		Boat-of-Garten (Dawn's)	NH937188	24/10/08	1030	M
5		Street of Kincardine	NH946179	24/10/08	1100	F
6		Dunphail 2	NJ017470	25/10/08	1120	M
7	2034719	Carrbridge	NH909225	05/11/08	1145	F
8	2031990	Strathspey Office	NJ039264	05/11/08	1205	M
9	2032742	Strathspey Office	NJ039264	05/11/08	1230	F
10	2033246	Spey Royal	NJ030270	05/11/08	1245	F
11	2479932	Cromdale-Speybank	NJ058285	05/11/08	1300	F
12	2484286	Cromdale-Speybank	NJ058285	05/11/08	1310	F
13	2483992	Dunphail Drive (8)	NJ020466	05/11/08	1330	F
14	2483449	Dunphail Smiddy	NJ009485	05/11/08	1340	F
15	2479688	Dunphail N Gate	NJ006490	05/11/08	1400	F
16	2482517	Dunphail N Gate	NJ006490	05/11/08	1415	M
17	2480570	Dunphail Castle	NJ005481	05/11/08	1430	M
18	2483728	Dunphail Castle	NJ005481	05/11/08	1450	F
19	8033691	Logie House	NJ006506	21/11/08	1145	M
20	8036887	Edinkillie	NJ025462	21/11/08	1200	M
21	8050946	Logie House	NJ006506	21/11/08	1210	M
22	8037602	Logie Scots pines	NJ004514	21/11/08	1220	M
23	8036896	Logie Scots pines	NJ004514	21/11/08	1235	F
24	8037755	Logie N Drive	NJ010516	21/11/08	1250	M
25	8037425	Logie N Drive	NJ010516	21/11/08	1340	F
26	8037159	Anagach	NJ053280	21/11/08	1350	M
27	8033147	Anagach	NJ053280	21/11/08	1405	M
28	8037185	Free Church Wd	NJ033273	21/11/08	1410	F
29	8004820	Free Church Wd	NJ033273	21/11/08	1420	M
30	8004937	Grantown	NJ038266	21/11/08	1430	F
31	8029854	Carrbridge Landmark	NH908223	21/11/08	1445	F
32	8027882	Edinkillie	NJ025462	21/11/08	1450	F
33		Dunphail	NJ013475	09/03/09	0845	F
34		Dunphail	NJ013475	09/03/09	0900	M
35		Dunphail Smiddy	NJ009485	09/03/09	0920	M
36		Dunphail (8)	NJ020466	09/03/09	0930	M
37	8033331	Middle Lodge	NJ014474	20/03/09	1115	F
38	8032946	Middle Lodge	NJ014474	20/03/09	1130	M
39	8033501	Edinkillie south	NJ015458	20/03/09	1145	M
40	8032950	Edinkillie south	NJ015458	20/03/09	1200	F
41	8032928	Logie middle pines	NJ005516	20/03/09	1210	F
42	8033605	Deshar Wood	NH935186	20/03/09	1220	M
43	8033649	Deshar Wood	NH935186	20/03/09	1230	M
44	8033622	Boat-of-Garten	NH937188	20/03/09	1250	M

3.2. Veterinary examination

34 squirrels were given a veterinary inspection at The Strathspey Veterinary Centre in Grantown-on-Spey. After capture, squirrels were kept in the traps inside a cardboard box or covered with dark cloth to prevent them being unnecessarily frightened. Once at the veterinary centre, each squirrel was transferred from the trap into a soft hessian sack, before being transferred into an inspection tube. Tubes were made from 1 inch square weld mesh, just over 2 inches in diameter and 9 inches long. The front end had a hinged cap, to release the animal after inspection. Squirrels were encouraged to enter the tube by folding the open end of the sack around the tube. A pencil or short stick was placed through the end of the tube behind the squirrel's back legs to prevent it coming out backwards. For squirrels that were radio-collared, a link of tubing was cut out in line with the squirrel's neck so that the radio collar could be fitted to the squirrel. Because one of the squirrels was very large and briefly became stuck in the tube after sedation, it was decided to run the remaining squirrels into an open plastic bottle used for sedating them. This proved to be very efficient and was used from then on.

Squirrels were sedated with isofluorane. Each squirrel was sexed, measured and weighed; blood and hair samples were taken for analysis; health condition, parasites and any features were recorded and eyes, ears and skin condition were assessed. Blood samples were taken for health condition examination and for future DNA studies. 34 squirrels were fitted with Trovan PIT tags, for future identification. It was not possible to fit all 44 with PIT tags as the veterinarian was not available. Four were fitted with Biotrack radio-tracking collars.

Just prior to recovering from the sedative, each squirrel was placed in a uniquely numbered nest box, containing fresh hay, nuts and cut up sweet apples. Before leaving the surgery, the lid of each box was carefully opened after inserting a metal grille, to check for recovery after sedation. All recovered rapidly. Great care was taken to be quiet and to be careful to reduce any stress.



Figure 4: Squirrel from bag into handling tube



Figure 5: Squirrel from handling tube into nest box

The results of the veterinary inspection are shown on the next page.

Table 2: Results of veterinary inspection.

Number	Sex	Weight (g)	Shin (mm)	Tail (mm)	Parasites	Notes
1	F	327		220	None	
2	F	355		235	None	Still some moult
3	F	323		225	None	Still some moult
4	M	324		240	None	Still some moult
5	F	361		230	None	Still some moult
6	M	332		223	None	
7	F	328	65	240	Fleas	
8	M	359	71	225	Fleas	
9	F	305	70	223	Fleas	Tail old shear
10	F	313	69	223	Fleas	
11	F	304	68	224	None	
12	F	272	67	224	None	
13	F	292	70	221	Fleas	
14	F	302	68	222	Fleas	Healing scab on nose
15	F	355	69	225	Fleas	
16	M?	333	70	223	None	
17	M	327	68	222	None	Long-healed broken tail end
18	F	334			None	
19	M	325	73	222	None	Scratch on lower eyelid
20	M	320	73	222	None	
21	M	430	70	225	None	
22	M	340	69	235	None	
23	F	320	76	230	Lice, ear mites	
24	M	355	76	230	Ticks, mites	
25	F	316	68	240	Ticks, mites	
26	M	354	75	222	Fleas, ticks	
27	M	324	68	225	None	
28	F	306	71	235	None	
29	M	335	72	245	Fleas	
30	F	288	70	225	Lice all over	Spot on applied for lice
31	F	333	75	260	Fleas	Large. Very grey flanks
32	F	308	75	240	None	Obvious nipples. Grey flanks
33	F	318			None	
34	M	328			None	
35	M	351			None	
36	M	347			None	
37	F	334	70	230	Ticks (4)	Pregnant?
38	M	298	68	222	Flea 1	
39	M	316	72	215	Ticks, fleas	Bottom teeth angled slightly
40	F	317	73	235	Ticks, fleas	Not pregnant
41	F	339	74	230	1 tick, 1 flea	In season
42	M	306	73	240	Fleas	
43	M	298	73	220	Fleas	
44	M	320	75	245	None	

All squirrels scored clear, bright eyes, clean ears and excellent skin, so these are not included in the table.

16 had fleas, five of the March catches had ticks, three had mites and two had lice. One from Grantown-on-Spey was badly affected by lice and was given 'Spot On' treatment. A small number had old injuries: two had tails with damaged ends, one had a healed scab on its nose and another had a scratched lower lid. One animal had its lower teeth angled slightly. One female on March 20th was pregnant, and it was possible to feel the tiny embryos. By this date, from the size of the testicles, it was obvious that males were also in breeding condition.

All were all in excellent condition and their weights were well in the higher range of squirrel weights. The mean weight of males was 334g, and of females 318g, which is above the mean recorded weights for red squirrels (males 279g, females 278g) (Harris & Yalden 2008).

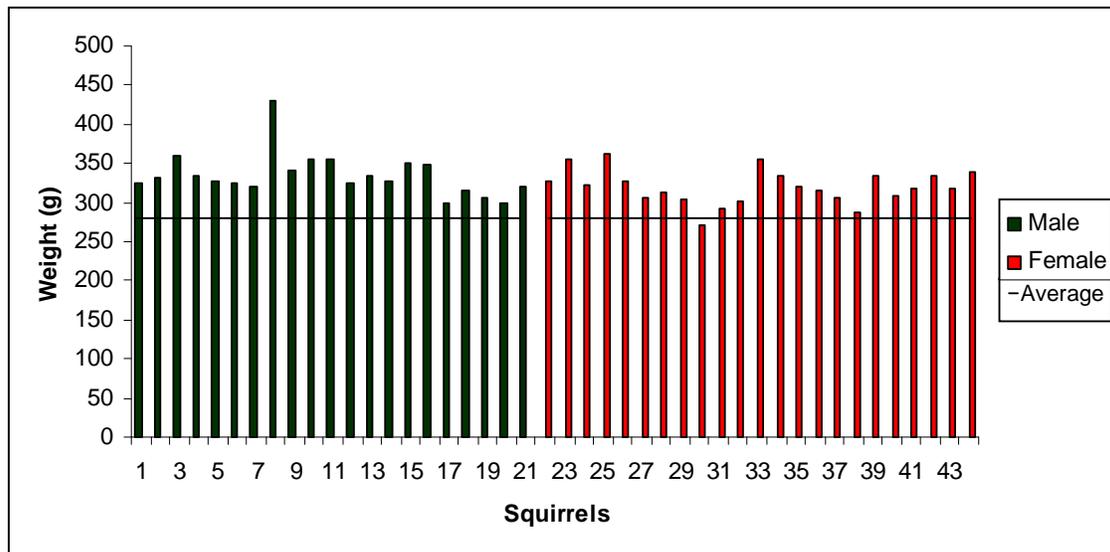


Figure 6: Weights of donor squirrels

3.3. Translocation and release

As soon as squirrels were trapped, the trap was covered in dark fabric or fitted back inside the cardboard box. It is important to keep diurnal animals in the dark, to replicate night time, as this is a way to reduce stress. The squirrels were in fact surprisingly unstressed, and some which were caught in the cage trap soon settled down and continued feeding from the nut feeder inside the trap.

Where necessary, trapped squirrels were kept overnight at Dunphail, in nesting boxes supplied with nuts and fresh apples. In the morning, all boxes were checked using the grille method and all squirrels were found to be in excellent condition. The squirrels were transported to Dundonnell in their individual numbered boxes, stacked carefully in a Hyundai Tucson 4x4. The distance is 92 miles and the journey takes just over two hours. All squirrels travelled well and were in great condition on arrival. No squirrels were lost during trapping or transportation.

We recommend that these methods are successful and that wild red squirrels can be safely trapped, examined and translocated.

Two methods of release were trialled at Dundonnell: soft release (13 squirrels) and hard release (30 squirrels).

3.3.1. Soft release

The soft release method involved keeping the translocated squirrels in a cage within the release area, to enable them to become used to the locality, before being released into the surrounding woodland. Once released, they were able to return to the cage for food and shelter. Cages contained nut feeders, food trays, nest boxes, drip water bottles and vegetation.

Two soft release cages were built: one in a corner of Scots pine woodland south of Geta Ban at NH114865 (Site 1) and one among mature beech trees at Geta Ban at NH113869 (Site 2). Site 1 was used for six squirrels and site 2 for eight squirrels.

The site 1 cage consisted of two compartments; with the main area measuring 1.8m x 2m x 1.8m. One end and part of the roof was of plywood construction, the floor was wooden and the rest of the cage was covered in 15mm square wire mesh. At the other end was a compartment 1m wide to allow a person to enter the cage without squirrels escaping. The outer door allowed access into this compartment and then the outer door was closed and bolted from the inside, before opening the door to the main compartment. Filling the nut feeders, the food tray and the drip water bottles could be carried out from the access compartment, without needing to enter the main squirrel cage. A folding hatch was located in the side of the cage close to a tree growing outside the cage, so that when squirrels were ready for release, the hatch could be left open and the squirrels could exit in their own free time. The outer door was locked and the area was kept quiet except when replenishing the feeders.



Figure 7: Site 1 soft release cage 8

The site 2 cage was much larger (10m x 10m x 2m). It surrounded the base of two beech trees as well as the remains of the dead canopy of a fallen Scots pine. It was covered in 2.5cm wire chicken mesh fixed onto fence posts and fencing wire. The cage was split in half by a wire mesh partition. The floor was natural earth, and mesh walls were dug into the ground with a skirt on the outside, to prevent access by predators. Nut feeders, nest boxes and drip water bottles were provided in both compartments, and accessed through a locked wire mesh door. Release was by leaving the doors open.

13 squirrels were released sequentially by this method. Squirrels caught at the same location were kept together in the cages. Squirrels were held in soft release cages for 6 days (2 squirrels), 7 days (1), 9 days (1), 12 days (7) and 16 days (2), to test whether the length of time held affected the success of the release. It was found that this had no effect. A plentiful supply of food was provided in squirrel feeders in the cages, topped up every few days. One squirrel was found dead in a nest box in one of the compartments of the large cage. The cause of death was not identified and a post mortem suggested it could have been due to stress.

3.3.2. Hard release

Hard release nest boxes were modelled on those used in the Anglesey Red Squirrel Project. They measured 30cm x 30cm x 40cm and were made of plywood, with a double overlap to fix them onto trees. Each box had drilled holes in the back at the top and bottom and was securely tied to the tree using strong nylon cord. The lids were hinged or fitted with a rubber flap hinge and were secured with double wire fastenings. A hole of 6.5cm diameter was drilled in the top corner. The boxes were used for translocating the squirrels and during translocation the holes were fitted with a cover held in place by two screws, which were removed after the box was fitted in its final release position. The nest boxes were filled loosely with hay, dead grass and moss, and when being used to transport and release squirrels, contained cut up sweet apples, carrot and nuts.



Figure 8: Transportation and hard release nest boxes

The hard-released squirrels, in their individual nest boxes, were located in suitable habitat in groups of 2, 3 or 4 within a 30m square. This was so that when exiting nest boxes, squirrels could see other nest boxes and, hopefully, squirrels, as well as nut feeders which were fitted to nest box trees and adjacent trees. Once all the nest boxes and nut feeders at a site had been fitted, the cover of each hole was unscrewed and a plug of moss and dry grass was placed loosely in the hole, so that the squirrels could push their own way out. The method proved to be very successful. Nut feeders were located and used very quickly by the squirrels, and this may have been enhanced by the fact that peanuts were scattered on the front platforms of the feeders and on prominent tree stumps close to the boxes on the first day. Thereafter, they were checked for use and filled up regularly.

Following this exercise, our recommendation is that hard release is the best technique for translocating red squirrels.

3.3.2. Release sites

Table 3: Red squirrel release sites.

Site	Map Ref.	Location	No. Releases	No. Nest Boxes	No. Feeders
1	NH114865	Small cage	6 (soft)	4	4
2	NH113869	Large cages	8 (soft)	6	7
3	NH114873	Top field	4	4	7
4	NH116866	Oak clearing	4	4	8
5	NH112860	Garden	2	2	3
6	NH113877	Mast lower	3	3	7
7	NH114878	Mast higher	3	3	4
8	NH110875	Bird hide	2	2	3
9	NH110885	End larches	2	2	2
10	NH123830	Mr King's wood	3	3	3
11	NH108863	Ballanore	3	3	3
12	NH163912	Leckmelm	1	1	1
Total			44	37	52

The furthest distance between releases sites (excluding Leckmelm) was 6.3km.

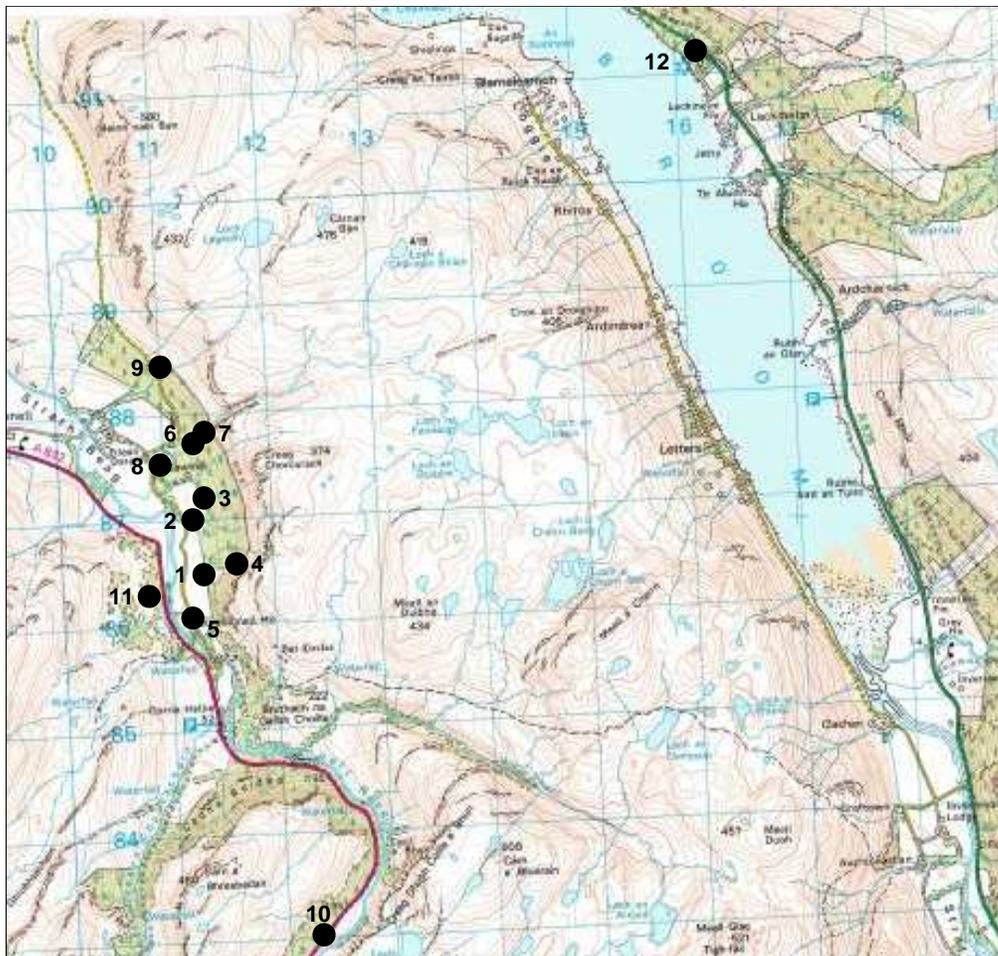


Figure 9: Locations of red squirrel release sites

3.3.3. Release dates

Red squirrels were released at Dundonnell between 25/10/08 and 20/03/09.

Table 4: Release data

Number	PIT tag	Sex	Radio	Date	Release Site	Release Type
1		F		(25/10/08) 06/11/08	1	Soft
2		F		(25/10/08) 06/11/08	2a	Soft
3		F		(25/10/08) 06/11/08	2a	Soft
4		M		(25/10/08) 06/11/08	2b	Soft
5		F		(25/10/08) 06/11/08	2b	Soft
6		M		(25/10/08) 06/11/08	1	Soft
7	2034719	F		06/11/08	3	Hard
8	2031990	M		(06/11/08) 22/11/08	1	Soft
9	2032742	F	173.209	(06/11/08) 22/11/08	1	Soft
10	2033246	F		06/11/08	3	Hard
11	2479932	F		06/11/08	3	Hard
12	2484286	F		06/11/08	3	Hard
13	2483992	F		06/11/08	2c	Hard
14	2483449	F		06/11/08	2c	Hard
15	2479688	F	173.317	06/11/08	4	Hard
16	2482517	M		06/11/08	4	Hard
17	2480570	M	173.256	06/11/08	4	Hard
18	2483728	F		06/11/08	4	Hard
19	8033691	M		(22/11/08) 28/11/08	2a	Soft
20	8036887	M		(22/11/08) 28/11/08	1	Soft
21	8050946	M		(22/11/08) 28/11/08	2a	Soft
22	8037602	M		(22/11/08) Died	2b	Soft
23	8036896	F		(22/11/08) 28/11/08	2b	Soft
24	8037755	M		22/11/08	6	Hard
25	8037425	F		22/11/08	6	Hard
26	8037159	M		22/11/08	6	Hard
27	8033147	M		22/11/08	7	Hard
28	8037185	F		22/11/08	7	Hard
29	8004820	M		22/11/08	7	Hard
30	8004937	F		22/11/08	5	Hard
31	8029854	F		22/11/08	5	Hard
32	8027882	F		(22/11/08) 04/12/08	1	Soft
33		F		09/03/09	8	Hard
34		M		09/03/09	8	Hard
35		M		09/03/09	9	Hard
36		M		09/03/09	9	Hard
37	8033331	F		20/03/09	10	Hard
38	8032946	M		20/03/09	10	Hard
39	8033501	M		20/03/09	11	Hard
40	8032950	F	173.335	20/03/09	11	Hard
41	8032928	F		20/03/09	12	Hard
42	8033605	M		20/03/09	11	Hard
43	8033649	M		20/03/09	10	Hard
44	8033622	M		20/03/09	2c	Hard

Dates in brackets refer to date released into cage. The second date gives the soft release date.

3.4. Post release supplementary feeding



Figure 10: Squirrel feeder

The squirrels were supplied with supplementary food throughout the first winter. This was deemed important, as many of them had come from gardens where they were regularly feeding at squirrel feeders. 63 standard model squirrel feeders, constructed from plywood with Perspex fronts, and holding about one pint of nuts, were used for the project at a total of 15 sites, mainly close to the nesting boxes. The feeders were topped up from 24/10/08 at intervals of up to one week, through to spring 2009. During this period, 18 bags of peanuts (bags weigh 25kg), 12 bags of sunflower seeds, 3 bags of whole maize (not favoured by squirrels), 2 bags of flaked maize and one bag of kibbled maize were used. Feeders were filled level so that it was easy to check whether squirrels had used them. Nearly every feeder was used and during the main winter period, most feeders were regularly used. At every release site, squirrels located the feeders very quickly.

Squirrels were noted burying nuts in late January 2009, and from early February, it was noted that peanuts were being selected with less use of sunflower seed. By 12/02/09, the squirrels were taking noticeably less food as Scots pine cones became available and larch flowers were sprouting. By 02/03/09, feeders were only being half used, and there was a slow down in the regularity of topping up. Gnawed larch cones were noted on 05/03/09. In April, feeders which were no longer used were removed. The aim was not to provide supplementary food in the second winter in the woodlands, as the squirrels should have laid in food supplies, and we wanted them to use wild food. Some squirrels located nut feeders for birds in several gardens in the area and started to use them, and in these places squirrel nut feeders were installed.

In July, fallen apples, pears, cherries and plums were placed in the remaining feeders at Ballanore and at King's wood, and these were taken by squirrels, as were brambles on 26/09/09. Squirrels were regularly seen feeding on beech mast and were also noted collecting acorns and opening Scots pine and larch cones, and we believe they were also eating various species of fungi.

Double sided sticky tape was fixed under the lids of many of the nut feeders from 18/12/08 and at Leckmelm on 18/01/09. Red squirrel hair was identified on most of the tapes when they were collected but, as they were the only species using the feeders, this was not surprising. Some samples were kept, in case of long term DNA studies, but it was decided to discontinue using this technique, because there is no potential for confusion with grey squirrels at Dundonnell.

4. MONITORING

Following the release of squirrels at Dundonnell, a record was kept of all sightings and activities relating to the squirrels. The head keeper, Alasdair Macdonald, kept a daily red squirrel log of his activities and sightings. These are summarised below and involved reports on 518 dates between 25/10/08 and 17/06/11. Additionally, Roy Dennis attempted systematic transects, carried out drey surveys, monitored wild food availability and carried out radio-tracking of the collared squirrels.

4.1. Live sightings

Figures denote individual squirrels and do not include repeat sightings.

Year	Month	Days	No. squirrels seen			Max squirrels in day	% days squirrels seen	Average no. squirrels/day seen
			1	2	3+			
2008	November	22	5	3	1	4	41	0.68
	December	13	4	0	0	1	31	0.31
	Total/Av.	35	9	3	1	4	36	0.50
2009	January	15	5	4	2	3	73	1.27
	February	22	12	3	3	4	82	1.27
	March	21	3	5	3	3	52	1.05
	April	23	11	8	2	3	93	1.43
	May	24	7	3	1	4	46	0.71
	June	22	6	7	1	4	64	1.09
	July	14	10	0	1	3	79	0.93
	August	24	9	5	1	3	62	0.92
	September	26	10	10	2	4	85	1.42
	October	20	9	6	2	4	85	1.40
	November	11	3	0	1	3	36	0.55
	December	11	3	0	1	7	36	0.91
	Total/Av.	233	88	51	20	7	66	1.08
2010	January	6	3	0	0	1	50	0.50
	February	7	2	1	1	4	57	1.14
	March	11	3	3	1	3	64	1.09
	April	7	4	0	1	5	71	1.29
	May	12	3	4	3	3	83	1.67
	June	11	6	3	2	5	100	2.00
	July	21	6	6	4	6	76	1.62
	August	18	5	4	5	12	78	2.61
	September	14	10	4	0	2	100	1.29
	October	7	4	2	1	3	100	1.57
	November	16	6	7	2	6	94	1.88
	December	12	3	9	0	2	100	1.75
Total/Av.	142	55	43	20	12	81	1.53	
2011	January	15	1	12	1	4	93	1.93
	February	15	2	3	2	7	47	1.33
	March	14	4	4	3	25	79	3.07
	April	11	8	0	3	8	100	2.36
	May	17	7	3	6	6	94	2.24
	June	13	2	7	3	4	92	2.15
Total/Av.	85	24	29	18	25	84	2.18	

Table 5: Live sightings by head keeper, Alasdair MacDonald, between 25/10/08 and 17/06/11.

Reports on squirrel sightings have been received for 518 dates since the translocation took place. Although sightings were ad hoc and surveys not carried out systematically, a number of conclusions can be inferred from the data.

1: There has been an increase in the percentage of report days on which squirrels were seen.

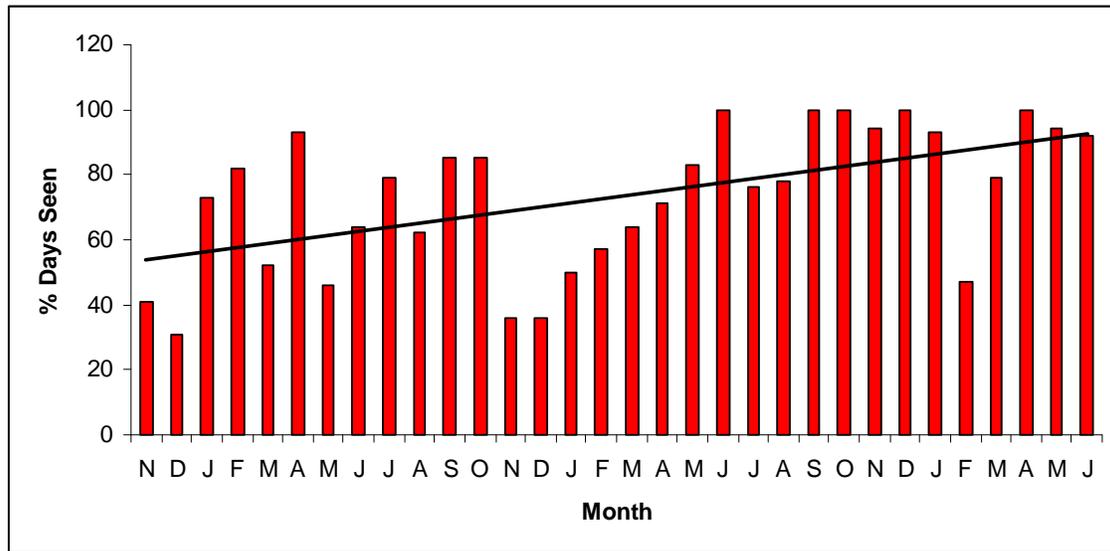


Figure 11: Percentage of report days on which squirrels were seen

Squirrels have been seen in every month since the translocation took place however, in 2008, squirrels were only seen on an average of 36% of dates. By 2009, after 1 season’s breeding, this had almost doubled, to 66%. The following year it had increased again, to 81%, and in 2011 it continued to increase, to 84%. This gives evidence that the size of the squirrel population has increased year on year since its introduction in 2008.

2. There has been an increase in the average number of squirrels seen per report day.

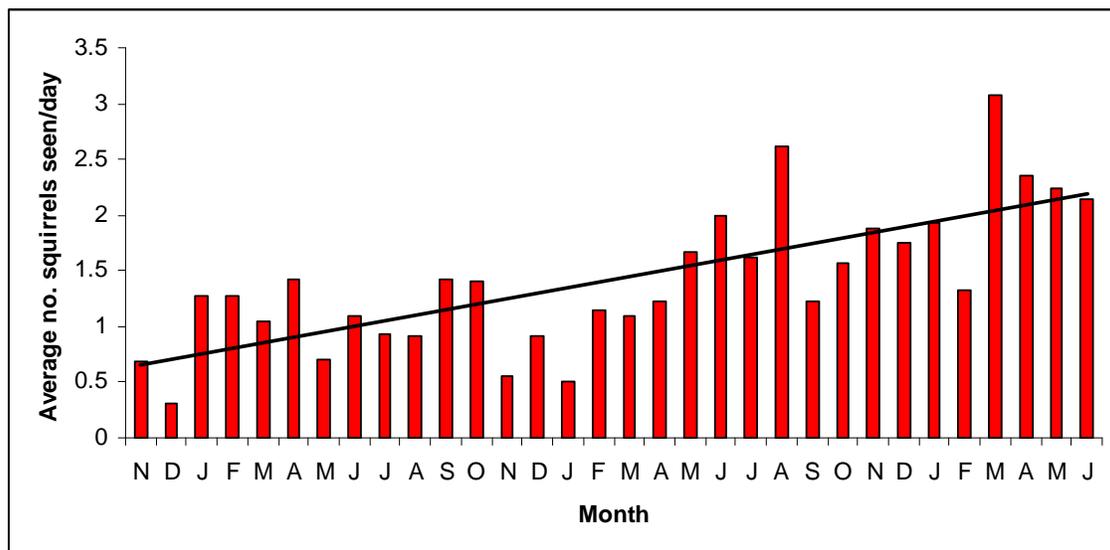


Figure 12: Average no. squirrels seen per report day

The average number of squirrels seen per report day is another critical parameter in terms of evaluating the success of the translocation, and this has also increased every year. It has risen from 0.5 in 2008 to 1.08 in 2009, 1.52 in 2010 and 2.18 in 2011, an overall increase of more than 4 times.

3. There has been a noted increase in the maximum number of squirrels seen.

As would be expected, given the clear increase in population, another parameter that has increased each year is the maximum number of squirrels that were seen in any one day. This has risen from 4 in 2008 to 7 in 2009, 12 in 2010, and then more than doubled in 2011 to 25. 20 of this 25 were caught on one of the trapping days, so this figure is slightly different to the others, which were wild sightings, but the fact that the figure has increased year on year clearly shows that the population is flourishing and appears to be expanding.

These figures are one offs and, although useful in demonstrating a minimum number of squirrels present, do not give much indication of overall trends. However, the total number of times a particular number of squirrels were seen is more meaningful. In 2009 and 2010 3+ squirrels were seen on at least 20 occasions, and in 2011 3+ were seen on 18 occasions in only 6 months, proving that the population has, at the very least, maintained itself.

An even better indication of success is the fact that the number of months where more than 4 squirrels were seen has increased year on year. More than 4 were not seen at all in 2008 and only once in 2009. However in 2010 it happened on 5 occasions and in 2011 on 4 occasions in only a 6 month period, again proving that the population appears both to have maintained itself and to have increased.

On 03/12/09, a drey survey was conducted in a limited area, following leaf fall from deciduous trees. Nine squirrels were seen at the following locations: NH109876 (1 squirrel), NH105877 (1 squirrel), NH104881 (2 adults and 2 juveniles), an adult about 100 metres to the north, NH106877 (1 adult) and NH107877 (1 juvenile). These were all seen in less than 5% of the total woodland area.

If this is extrapolated to cover the whole range of squirrel habitation, a population size of at least 180 is given.

4.2. Feeding Sign Transects

On 15/05/09, systematic feeding transects, as detailed in Forestry Commission Practice Note 11, were attempted in some of the main squirrel locations, but it proved very difficult because of the terrain (long heather, long grass, brash, hillsides, etc) and the dense nature of the spruce and Douglas fir. In our opinion, traditional transect work on squirrels is of limited value at Dundonnell. Only one squirrel-opened cone was found during the six transects completed that day. Details are as follows.

Site No.	Grid Reference	Start Point	Tree Species	Squirrel Signs	Notes
10	NH108863	57 48.111N, 5 09.197W (600m ²)	Scots pine, lodgepole pine, larch	None	Larch had lots of new and old cones, Scots pine lots of flowers. Lodgepole few flowers
11	NH108863	57 49.559N, 5 11.123W (900m)	Scots pine	1 freshly eaten Scots pine cone	V. hard to find cones on ground as lots of heather. Lots of Scots pine flowers
4	NH116866	57 49.724N, 5 10.541W (800m)	Spruce, oak	None	
7	NH114878	200m	Spruce	None	V hard to search for cones
3	NH114873		Spruce, Scots pine, larch	None	
Road side	NH114855	400m	Larch, Scots pine	None	

Table 6: Details of transects carried out on 15/05/09

However, evidence of squirrel feeding has been seen on numerous occasions, proving that the squirrels are finding widespread natural food.

Date	Location	Cone Species	Number
02/04/09	Small release cage	Scots pine	Several
18/05/09	Ballanore	Scots pine	1
13/06/09	Near Site 1	Scots pine	Several
16/06/09	Ballanore	Scots pine	1
02/07/09	Mast	Scots pine	1
19/07/09	Site 7	Scots pine	1
11/08/09	Site 9	Fungi	Tooth marks
03/05/10	Large release cage	Scots pine	Widespread
11/05/10	Mast	Scots pine	Several
27/05/10	Top site	Scots pine	Several
21/06/10	Top site	Spruce	Several
29/06/10	Aidas	Larch	Widespread
14/07/10	Mast	Scots pine	Several
05/08/10	Brackloch	Spruce	Several
14/08/10	Top edge of wood	Larch	Widespread
15/08/10	Road near Dundonnell Hotel	Scots pine	Widespread
05/11/10	Cemetery	Oak	Squirrel seen collecting acorns
16/11/10	Hatchery	Oak	Squirrel seen collecting acorns
18/01/11	Mast	Scots pine	Several
08/02/11	Target	Larch	Several
20/02/11	Black Wood	Scots pine	Several
24/02/11	Brackloch	Spruce	Several
04/04/11	Keppoch	Larch & Oak	Widespread
12/06/11	Near mast	Scots pine	Several
01/11/11	Small release cage	Scots pine	Widespread
01/11/11	Big larches	Larch	Young squirrel feeding
01/11/11	West end	Scots pine	Widespread

Table 7: Casual sightings of evidence of squirrel feeding

4.3. Drey surveys

The first squirrel seen carrying leaves in its mouth was at Dundonnell House garden on 27/01/09. During walk-throughs in winter and spring it was very difficult to locate any squirrel dreys, because the canopies of Sitka spruce and Douglas fir were so thick and high up that it was impossible to see them. Dundonnell is also fortunate in having many ancient broadleaf trees containing holes, ideal for use by red squirrels but not always obvious to observers.

The first drey was found on 16/06/09 at Ballanore (NH 113857) in a larch tree, and two more were found two days later. A similar drey was found in a larch tree at site 6 on 21/08/09 and another new drey at site 7 on 05/11/09. A drey survey was carried out on 03/12/09, the results of which are shown below. 800m of ground was surveyed.

Approximate location	No. dreys found					Total
	Beech	Larch	Oak	Sycamore	Scots pine	
NH 109874	4	0	0	0	0	4
NH 111882	1	1	1	1	0	4
NH 113869	3	1	0	0	1	5
NH 114865	0	3	0	0	0	3
NH 113857	0	7	0	0	0	7
NH 127838	0	1	0	0	0	1
Total	8	13	1	1	1	24

Table 8: Results of drey survey on 03/12/09

24 dreys were found in total. Of these, at least 13 were large summer dreys used for breeding. The dreys in beech trees near the cemetery were at the same location where radio-tagged female squirrel 15 was seen carrying nest material in the summer. We believe that this female built two summer dreys for two different broods of young. In 2011, two new summer dreys were located high in beech trees in the same area. A variety of materials were seen adorning dreys, including sheep wool, grass and honeysuckle. Larch trees were the most favoured location for dreys, with 54.2% of dreys built in this species.

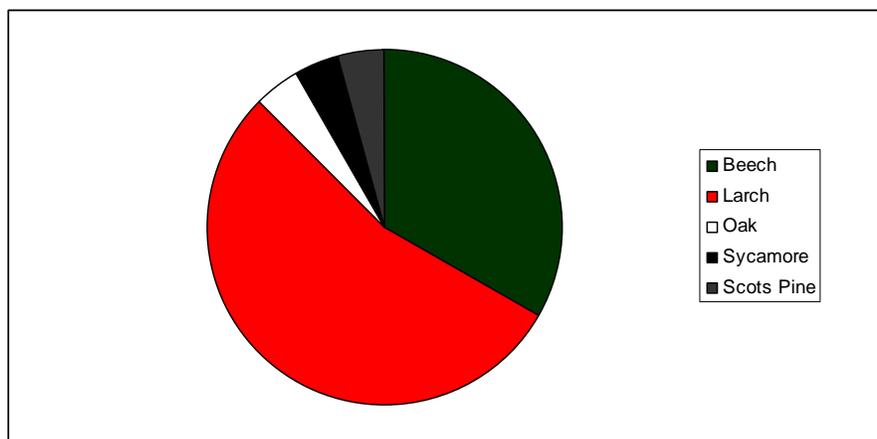


Figure 12: Tree species in which dreys were found

Squirrels can have several dreys (Gurnell *et al.* 2004), so it is not clear what population size the 24 dreys represented and, additionally, Gurnell *et al.* 2004 state that drey surveys only give a poor-moderate estimate of population density. Given this and the small size of the area surveyed it would be futile and inaccurate to attempt to estimate a total breeding population from extrapolation of the data.

The main conclusion to be drawn from this data is that the presence of dreys proves ⁷ that the Dundonnell red squirrels are demonstrating normal breeding behaviour.

4.4. Radio-tracking

As part of the initial release, four squirrels were fitted with Biotrack TW3 radio transmitters mounted on brass collars designed for red squirrels. On some occasions, no signals were picked up and it was thought that the squirrels were in holes inside large trees, although they might have been out of range in a new area. This particularly applied to squirrel number 9.

No	PIT tag	Sex	Weight (g)	Radio No.	Release Date	Release Site	Release Type	No. days tracked	Maximum movement (m)	Fate
9	2032742	F	305	173.209	(06/11/08) 22/11/08	1	Soft	320	750	Battery died
15	2479688	F	355	173.317	06/11/08	4	Hard	296	960	RD
17	2480570	M	327	173.256	06/11/08	4	Hard	318	900	Battery died
40	8032950	F	317	173.335	20/03/09	11	Hard	205	200	RD

Table 9: Details of radio-collared squirrels. RD = road death.

Two females ranged quite widely and moved to breeding areas 960 and 600m from release sites, while the third female (released in March) remained in a small range of less than 4ha. The male also remained mainly within one wood except for one trip of 900m and back.

Three of the radio-tracked squirrels survived from November 2008 to at least the end of August 2009, and two to 20th September 2009, when batteries started running down. This was very encouraging and, if comparable with squirrels without radio collars, suggests an excellent survival of translocated squirrels. One radio-tracked squirrel was found killed on the road on 15/11/08, and one released in March 2009 was found freshly killed on the road on 26/10/09.

The individual squirrel data is given on the next pages. The maps show locations joined by lines but of course squirrels may have moved in any direction between points – the maps are for giving an indication of ranges.

Number 9 (173.210) female from Spey Bridge, Grantown-on-Spey

Squirrel number 9 was put into the small cage for soft release on 06/11/08 and released into the wood on 22/11/08. She spent most of her time in woods within 600m of the release cage. She continued to be located in this area and main wood through the summer up to 22/08/09. No further signals were received after this date, most likely due to battery exhaustion. She was tracked over 320 days during which time she made several journeys of up to 750m. We searched trees in the locality on 03/12/09 and found at least two breeding dreys in very tall beeches where she had tracked on 18/05/09, indicating that she probably bred in this area.

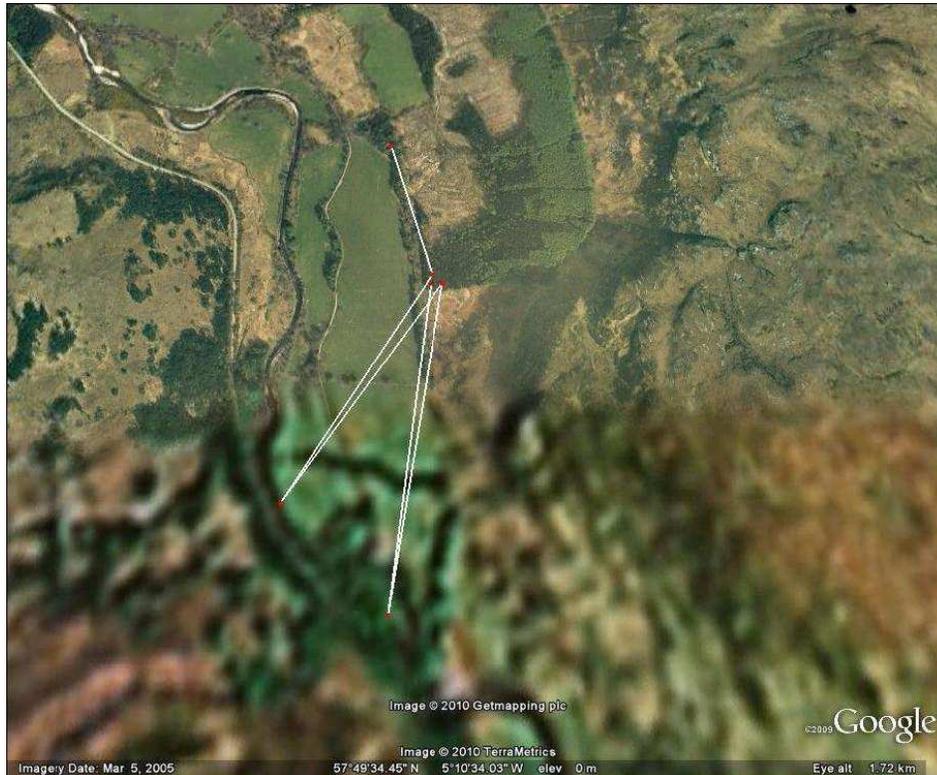


Figure 14: Locations of squirrel No.9

Number 15 (173.317) female from Dunphail, Moray

Squirrel number 15 was hand released on 06/11/08 at site 4 in top of the wood above the small cage. She spent most of her time in the wood near site 4. She was found at Brach Loch on 17/06/09 and 06/07/09 and observed with a mouthful of woody nest material on 03/08/09. She was found freshly dead on the road on 21/11/09. A visit to this area on 03/12/09 revealed two breeding-type dreys high up in tall beeches and three smaller nest platforms. She probably bred twice at this location, which is 960m from the release site. She survived for 374 days, with tracking to 296 days.



Figure 15: Locations of squirrel No.15

Number 17 (173.256) male from Dunphail, Moray

Squirrel number 17 was hand released on 06/11/08 at site 4 in top of the wood above the small cage. On 06/12/08, a fast beep near site 4 suggested he was sleeping in a drey high in dense Sitka spruce, and again on 18/12/12. This squirrel stayed in the main release wood throughout the tracking period, except for one known movement of 900m and back. The radio battery probably ran out and the squirrel tracked over a period of 318 days.

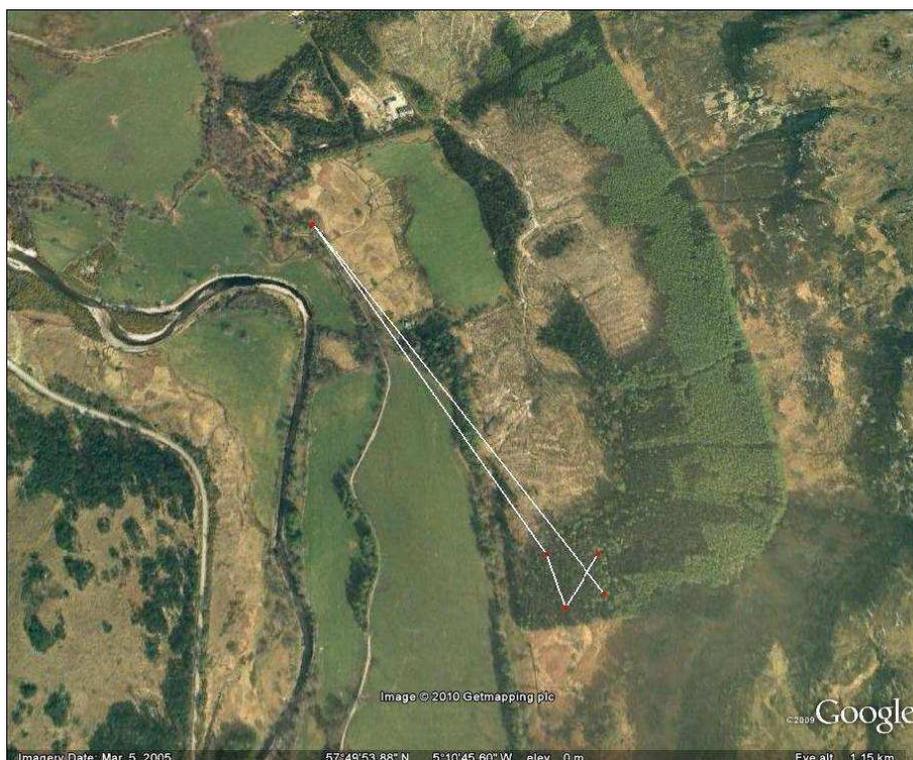


Figure 16: Locations of squirrel No. 17

Number 40 (173.335) female, from Logie, Moray

Squirrel number 40 was hand released in Ballanore Wood on 20/03/09, and regularly crossed the main road. She reared two broods of young, and was only seen in a small area between the release site in Ballanore pinewood and a nearby garden and along the roadside: a distance of several hundred metres or less. She was found freshly dead on the road on 26/10/09. The radio worked for 205 days and the squirrel survived for 220 days.

4.5. Live capture

In 2011 a live-trapping project was carried out under SNH licence, to check for microchips from the original stock and to assess the condition of a sample of squirrels. Trapping occurred 16-17/03/11.

Live traps were set at seven localities throughout the whole woodland area at Dundonnell on 11/03/11. The distance between the furthest traps was approximately 7km. All the traps were cable-tied in a non-active state and baited with peanuts. Traps were activated early in the morning on 16/03/11. 14 squirrels were caught on the 16th and four on the 17th, one of which was a re-trap.

Each squirrel was sexed, aged and weighed, the tail measured, and health condition, parasites and any features recorded on protocol sheets. Squirrels were checked for presence of a microchip with a Trovan chip reader and a small notch of fur was cut from the end of the tail for re-trap identification, before being released at its capture site.

Location	Date	Micro chip	Age	Sex	Weight (g)	Tail (mm)	Condition	Notes
Site 2	16/03/11	No	Adult	F	320	240	Very good	No obvious nipples
Power line	16/03/11	Escaped						
Power line	16/03/11	No	Adult	M	339	245	Very good	Large testicles
Power line	16/03/11	No	Adult	M	262	230	Very good	Half size testicles
Site 6	16/03/11	No	Sub-adult	M	320	220	Good - moulting winter coat	
Site 6	16/03/11	No	Sub-adult	F	295	220	Good - moulting winter coat	No obvious nipples
Site 6	16/03/11	No	Adult	F	323	220	Very good	No obvious nipples
Site 7	16/03/11	No	Adult	F	329	245	Very good	No obvious nipples
Site 7	16/03/11	No	Adult	F	322	-	Very good	No obvious nipples
Site 1	16/03/11	No	Adult	F	351	240	Very good	No obvious nipples
Site 4	16/03/11	No	Adult	F	285	245	Very good	No obvious nipples
Power line	16/03/11	No	Adult	M	307	220	Very good	Large testicles
Site 1	16/03/11	No	Adult	F	367	225	Very good	No obvious nipples
Site 4	16/03/11	No	Sub-adult	M	265	230	Very good	Small testicles
Darach	17/03/11	No	Adult	M	302	230	Very good	Large testicles
Darach	17/03/11	No	Adult	M	310	225	Very good	Large testicles
Site 7	17/03/11 Recapture	No	Adult	F	333	230	Very good	No obvious nipples.
Site 2	17/03/11	No	Adult	F	311	240	Very good	No obvious nipples

Table 15: Results of live trapping 16-17/03/11. Locations relate to original release location numbers or to the power line NH105889 or keeper's house at Eilean Darach NH105880.

18 squirrels were caught, seven males and nine different females. One female was a short term recapture. All were in very good body condition. None carried any cuts or damage and, unlike when we trapped the original donor squirrels, no obvious external parasites were noted. Two sub-adults were noted as still moulting their winter coats. The males were exhibiting breeding condition, with testes noted as large in 66% of the sample. None of the females showed obvious nipples, so were not suckling young. Female weights ranged from 285 to 351g, with an average of 323g (donor stock average weight 318g), and males ranged from 262g-339g, with an average of 301g (donor stock average 334g). No squirrels were found carrying a microchip.

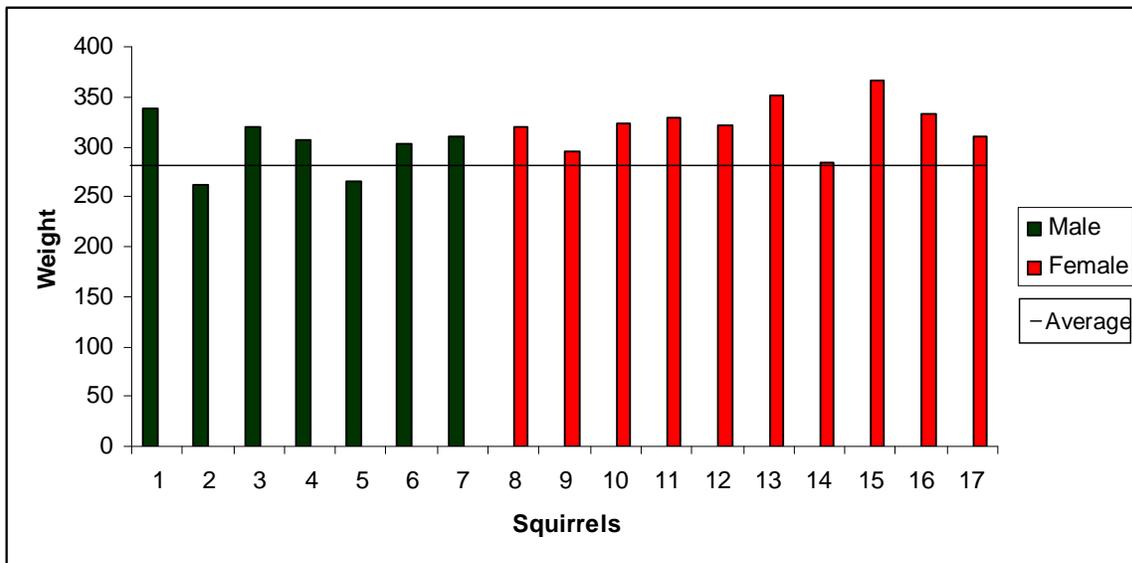


Figure 17: Weights of squirrels live-trapped on 16-17/03/11

The Dundonnell squirrel population is clearly thriving, with 88% of the sample above the average weights recorded for red squirrels.

In addition to the 17 squirrels live trapped at 7 different trapping sites at least another 12 squirrels were seen, giving a total of 29 squirrels recorded during the trapping operation. The furthest traps were 7km apart but most of the woodland was not visited, in fact the trapping areas covered only 5-10% of the woodland used by the new population of squirrels. The craft shop, where approximately 20 squirrels visit multiple bird-feeders, was not used for live-trapping. If this figure is extrapolated to cover the whole area of squirrel habitation, a crude population estimation can be made:

29 squirrels in 5% of inhabited area = total population size of 580

29 squirrels in 10% of inhabited area = 290

The average of these two figures gives a total population estimate of 435.

4.6. Wild food surveys

One of the issues that were examined thoroughly during the initial fieldwork was the availability of wild foods for red squirrels. The wide variety of tree species at Dundonnell enhances the opportunities for seed production, especially in years when one species may fail; it also extends the season of cone and seed availability. Additionally, the woods provide a range of alternative foods including berries and fungi. Red squirrels often cache fungi in trees for use throughout the year. The potential food supply at Dundonnell was considered to be good to excellent.

Species	1999-2000	2004-2005	2005-2006	2006-2007	2008	2009	2010	2011
<i>Pinus sylvestris</i>	5	3	5	4	2-3	4	3	3
<i>Pinus contorta</i>	—	—	—	—	1-2	—	3	—
<i>Picea sitchensis</i>	—	4	0	5	1-2	4	3	1-2
<i>Picea abies</i>	—	—	—	—	—	5	—	—
<i>Abies procera</i>	—	—	—	—	—	5	—	—
<i>Larix decidua</i>	—	3	0	3	3-4	3	4	1
<i>Larix kaempferi</i>	—	4	0	—	—	—	—	—
<i>Fagus sylvatica</i>	—	—	—	—	0	5	1	2
<i>Quercus robur</i>	—	—	—	—	3	2-3	4	1
<i>Castanea sativa</i>	—	—	—	—	3	3	2	—
<i>Sorbus acuparia</i>	—	—	—	—	—	5	—	—
<i>Corylus avellana</i>	—	—	—	—	—	—	4	—

Table 11: Wild food availability at Dundonnell 1999-2011. 1999-2007 data from David C Jardine, Forest District Manager of the Inverness Forest District of Forestry Commission Scotland. 0 = no cones. 5 = most cones. — = data unknown.

The wild food supply has fluctuated quite considerably since the translocation in late 2008. 2009 was an excellent year, with most species having a good-excellent crop. 2010 was average-good and 2011 was very poor. Wild food variability is normal and is part of why squirrel numbers, as with many rodents, show large scale fluctuations in population size between years (Wauters *et al.* 2008).

5. PARAMETERS OF SUCCESS

5.1. Dispersal

There appears to have been quite a wide variation in the dispersal distances of the original translocated squirrels. The radio tracked squirrels made maximum journeys of 1100m, 900m and 750m, while a fourth radio collared animal did not travel more than 200m from its release site. Squirrel No. 43, a male released at site 10 on 20/03/09, was found freshly killed on the road near Ballanore cottage on 07/06/09, a distance of at least 3.7km. In 2008 one squirrel made a quite astonishing journey to Leckmelm on the other side of Loch Broom, an overland distance of approximately 16km. In 2011 3 squirrels were seen at Letters, a distance of at least 4km.

Leckmelm Squirrel

One squirrel was seen at Letters on 08/12/08, a journey of at least 4 km from Dundonnell, over moorland and mountain terrain considered unfriendly for squirrels. It was then seen elsewhere at garden feeders on that side of Loch Broom on subsequent days and almost certainly the same squirrel reached Leckmelm on 30/12/08, where it regularly fed at squirrel feeders. It was identified as a male. It was debated whether or not to catch the squirrel and return it to Dundonnell, or to leave it at Leckmelm, and it was decided that the latter was the better option, as it would be more favourable to local people who had become very interested in the new arrival. It was subsequently decided to release a female squirrel at Leckmelm, in the hope that they would pair up. The female was released into the garden whilst the male was feeding at a feeder. From that point on both squirrels were seen most days in this garden at the nut feeders through to 05/05/09 and clearly formed a breeding pair. Later in the summer, young squirrels were seen but, in August, two squirrels were killed on the fast road to Ullapool, which passes close to the house. One of the remains was examined. It did not have a PIT tag and appeared to be a young squirrel. No squirrels were seen at the garden in the autumn, but wild food was plentiful in the surrounding forests. In January 2010 a squirrel was seen in Forestry Commission woods 9km to the south. A squirrel was seen in the original garden in May 2010 and two throughout June, with subsequent breeding in 2011. Three squirrels were seen in the garden in December 2011. A squirrel reached Altnaharrie, probably from Dundonnell, on 21st July 2010 and there have been occasional sightings between Lael and Leckmelm, so the Dundonnell project has inadvertently resulted in the small-scale re-establishment of squirrels in woods between Lael and Ullapool.



Figure 18: Probable movement of red squirrel from Dundonnell to Leckmelm

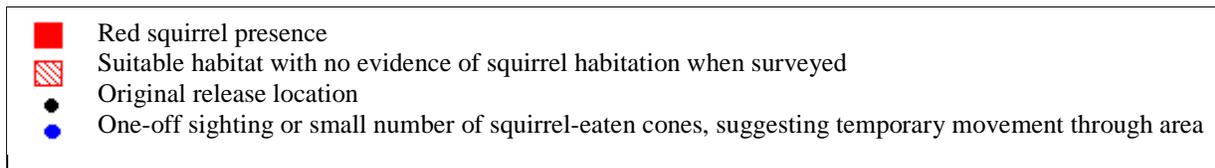
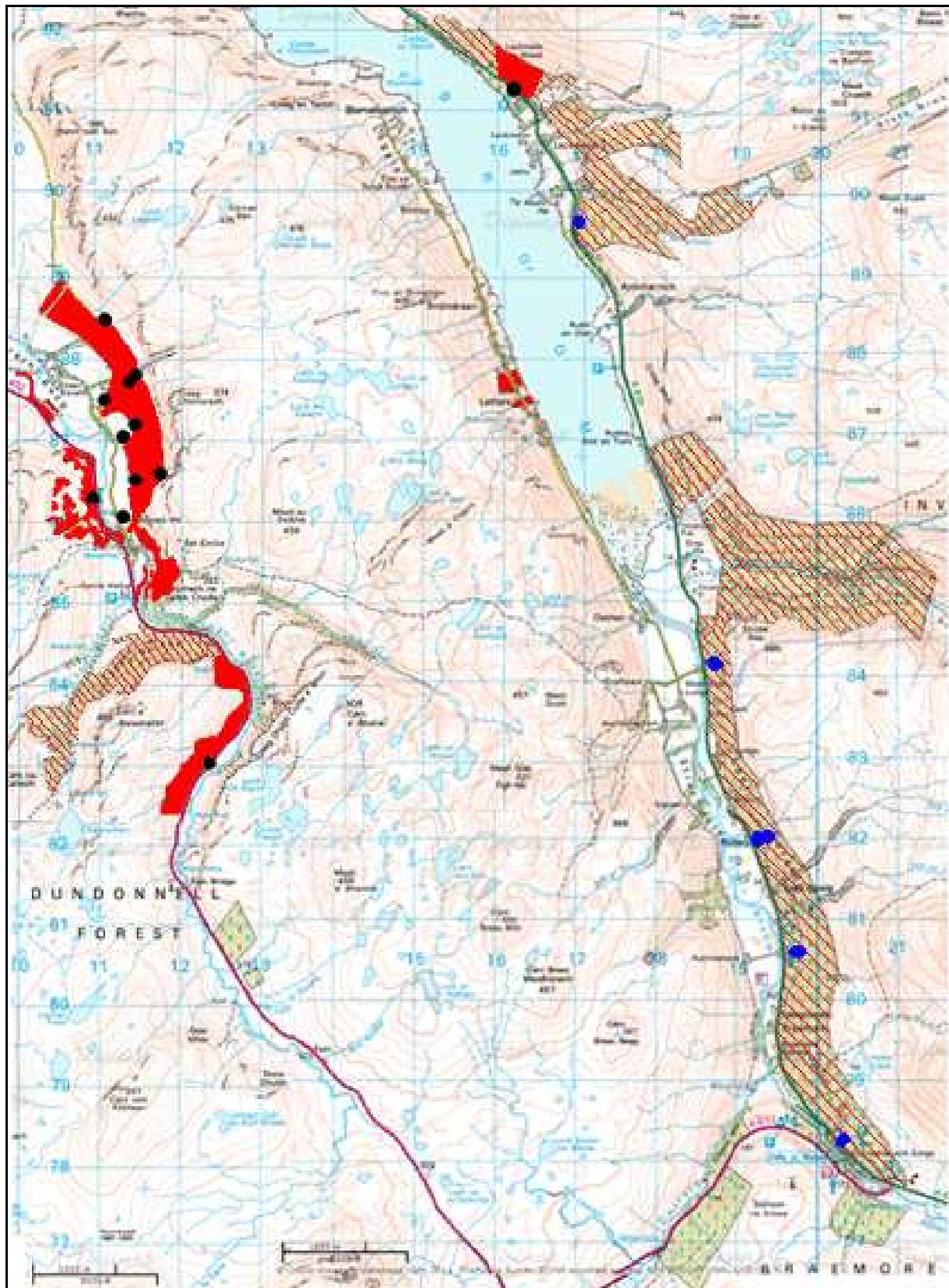


Figure 19: Area inhabited by Dundonnell red squirrels in relation to original release sites

Figure 19 shows the total area now inhabited by the Dundonnell red squirrels. It clearly demonstrates that the squirrels have dispersed from their original release sites and colonised all available habitat nearby. Additionally, as already described, at least one squirrel made a most unexpected journey to Leckmelm and others have travelled to Letters.

Surveys through the woodland between Ullapool and Braemore junction have shown evidence of squirrel presence at at least 6 sites through the woodland; either one-off sightings or small numbers of cones eaten by squirrels. We believe that squirrels have travelled through these areas but are not present permanently or, if so, only in very limited numbers. There are, however, four squirrels which are permanently resident at the Leckmelm release site and frequent feeders there. The woodland on the Leckmelm side contains ample suitable squirrel habitat and, we believe, should have squirrels translocated to it from the Dundonnell population. We believe the area could support 420-640 red squirrels, with variations based on seed crops ranging from 200-1000 animals and that this should be initiated with a translocation of 25 individuals from Dundonnell.

The fact that the population has expanded and colonised such a vast area clearly demonstrates that the translocation has been successful and that the squirrels are healthy and demonstrating normal dispersal behaviour.

4.2. Breeding

The main use of nesting boxes was for the hard release of red squirrels, but it was discovered in the Anglesey Red Squirrel Project that some female squirrels will use the boxes for breeding. They were also available for squirrels of both sexes to use for shelter. However, although 44 nest boxes were available, it does not appear that they were utilised by the squirrels for breeding. On 18/05/09 27 boxes were checked for signs of occupancy. The hay in one box at site 4 had recently been moved, but that was the only sign of recent use in any of the boxes, with no signs of any nest building. It appears that in woodland such as at Dundonnell, where there are numerous places to build dreys, the boxes are unattractive for breeding. However, ample other evidence was seen of breeding in the first year (2009) and beyond, as detailed below: Evidence of breeding includes females with obvious nipples (clearly lactating) and sightings of alive and dead young squirrels.

Year	Dates during which evidence of breeding seen
2009	17 May – 03 December
2010	12 July – 05 November
2011	17 April – 15 June (data to 17 June)

Table 12: Details of breeding 2009-2011

Evidence of breeding was seen across at least 12 sites. Radio-collared squirrel no. 40 was known to have two broods of young in 2009 and it appears from the date range during which young squirrels were seen in 2010 that both a summer and autumn brood were produced. 2011 saw the earliest young to date, in mid April, so it is likely that there will again have been two broods.

Young were seen at Leckmelm in 2009 and 2011, showing that the pair of squirrels there also bred successfully.

The fact that the squirrels have bred each year and across so many sites gives further proof that the translocation has been successful.

4.3. Predation

No pine martens (*Martes martes*) were seen at squirrel feeders in winter 2008 or spring 2009. The first one was seen feeding at the site 10 nut feeders (King's wood) on 11-12/06/09, and 06/07/09. Pine marten droppings were seen at site 4 on 19/07/09 and at Brack Loch on 19/07/09 and 11/08/09. One squirrel tooth was found in a pine marten scat in King's wood 2011. Although pine martens were regularly seen at the feeders at Leckmelm we did not feel that they were a major predator. The other potential predators were fox (*Vulpes vulpes*) and common buzzard (*Buteo buteo*), but there was no evidence found of predation by these species.

4.4. Survival and Mortality

The following table gives all known red squirrel mortalities between 25/10/08 and 17/06/11. These are primarily dead squirrels found by Alasdair MacDonald, the head keeper, and a few others that were reported to him. There will, of course, have been others that he did not hear about, so the following data should be interpreted as a minimum number of deaths.

Year	Date	Squirrel no.	Sex	PIT tag	Age	Cause of death	Notes
2008	01/12/08	22	M	8037602	Adult	Probably stress	No obvious cause of death
2009	07/06/09	43	M	8033649	Adult	Road death	At least 3.7km from release site. Weight at capture 298g; weight at death 294g.
	29/08/09	---		None	Young	Road death	Leckmelm
	13/10/09	---	M	None		Road death	Weight: 368g
	24/10/09		F	None	Adult	Road death	Prominent teats
	26/10/09	40	F	8032950	Adult	Road death	Radio collar broken by car
	09/11/09	---		None	Young	Road death	
	17/11/09		M	None		Road death	
	21/11/09	15	F	2479688	Adult	Road death	Radio collar 317 still intact. Weight 364g
2010	01/04/10					Road death	
	02/04/10					Road death	
	07/07/10		M			Road death	
	19/07/10		M			Road death	
	27/08/10			None	Young	Road death	Weight 325g
	12/09/10					Electrocuted	
	12/09/10					Electrocuted	
	12/09/10					Electrocuted	
	14/09/10			None		Road death	
	11/10/10			None		Road death	
	13/10/10				Young	Road death	
2011	21/02/11		F			Road death	
	28/02/11					Road death	
	01/04/11		M	None		Road death	

Table 13: Details of Dundonnell squirrel mortality 2008-2011

No squirrels died during trapping or translocation. Male squirrel number 22 was found dead in a nest box in the larger cage on 01/12/08. There were no obvious signs of injury; it weighed 340g on 21/11/08 and 333g when dead. A post mortem revealed no obvious cause of death. It was in very good body condition and had been feeding, and there was no evidence of predation. There was no evidence of any disease and it was believed that stress could have been a major factor. The problem may have been in placing two squirrels from each donor site together in the soft release process, assuming that two squirrels from one place would 'know' each other. It may be that two squirrels were put together which did not 'like each other' and the less dominant was at risk.

The most disappointing cause of death was road casualties on public roads, with 19 squirrels killed. The movement of passing vehicles tends to concentrate beech mast and other seeds along road verges, providing a bumper feeding site, and red squirrels spend a lot of time running along

the ground, rather than in trees. Road signs warning of red squirrels were erected beside the roads on 03/10/08 and are still present, and local people said that they slowed down at this part of road in order to protect the squirrels. Rope bridges were discussed but it was thought they could be a road hazard, and may not work in any case in this locality.

Three squirrels were electrocuted at the craft shop while jumping to a garden tree from the overhead electricity pole. The risk was removed immediately and there have been no further casualties.

Although unfortunate in terms of loss of squirrels, the rate of mortality indicates that there is a robust population and the fact that there are new deaths each year proves that the population is reproducing. There were 8 mortalities in 2009, 11 in 2010 and 3 in 6 months of 2011, a period during which there were 2 mortalities in 2010. The fact that the rate of mortality has increased year on year indicates that the population is expanding or at the very least maintaining itself.

A PIT tagged squirrel was killed on the road in February 2011. This squirrel survived for 23 months, giving further proof that the conditions at Dundonnell are excellent for squirrels. 18 of the mortalities were squirrels that were not PIT tagged. They were therefore squirrels which had been born and reared at Dundonnell, further evidence that squirrels are breeding and that the translocation has been successful.

6. POPULATION ESTIMATION

Systematic surveys to estimate population size have not been carried out at Dundonnell. There are a number of accepted methods for surveying red squirrels (hair tube surveys, visual surveys, feeding transects and drey surveys), however it is widely acknowledged that these are inaccurate. Data for the relationship between hair tube visits and population size is only available for plantations dominated by Sitka spruce (*Picea sitchensis*) (Gurnell *et al.* 2004) and Dundonnell estate comprises mixed woodland. This method is therefore not suitable. The accuracy of straight line visual transects is hindered by the fact that detection probability is low (Gurnell *et al.* 2004) and only small numbers of squirrels are seen on individual transects, making population estimation very difficult, if not impossible (Gurnell *et al.* 2001). Visual transects only give a moderate estimate of density at best (Gurnell *et al.* 2001, Gurnell *et al.* 2004) and, regardless, as explained in Section 3.2., the terrain at Dundonnell is not suitable for carrying out these transects. Similarly, the terrain is not suitable for sweeping the forest floor to conduct feeding transects. These are also regarded as being complex and inaccurate (Gurnell *et al.* 2004). Finally, drey counts only give a poor-moderate estimate of density (Gurnell *et al.* 2004). Dreys can be hard to spot and squirrels may nest in tree holes rather than dreys (Gurnell *et al.* 2001): as explained previously, Dundonnell has many old oaks suitable for this. Additionally, dreys are semi-permanent and therefore cannot be related to time (Gurnell *et al.* 2004). Dundonnell also contains large areas of conifer plantations which are unsuitable for drey surveys.

Although the size of the population has not been estimated systematically, detailed notes of sightings have been maintained. These, together with live capture studies enable calculation of a crude population estimate.

Live sightings

The live sighting data collected by Alastair Macdonald cannot be used for population estimation as it was not carried out systematically and the observation times and localities varied between counts. However, it is useful in terms of indicating that the population appears to have increased each year.

During a drey survey carried out on 03/12/09, 9 squirrels were seen in less than 5% of the total area. If this is extrapolated to cover the whole range of squirrel habitation, a population size of at least 180 is given. This was carried out only a year after the translocation took place and the live sightings data indicates that the population has increased since 2009, so the true number is likely to be significantly higher than this.

Live-trapping

Squirrels were live-trapped and released in March 2011. No micro-chipped squirrels were detected from the 34 chipped animals released in October and November 2008, suggesting high recruitment and/or loss of the original donor stock. Red squirrels have relatively short lives so it

would be surprising if many of the founders were still alive, while their offspring now dominate in the population.

The data could not be used to calculate population estimates as it did not meet the assumptions or requirements of either closed or open mark-capture-recapture models. However, it proved useful in giving an index of squirrel abundance. In addition to the 17 squirrels live trapped at 7 different trapping sites at least another 12 squirrels were seen, giving a total of 29 squirrels recorded during the trapping operation. Trapping only covered 5-10% of the total woodland area and extrapolation to cover the entire area of squirrel habitation gives a population estimate of 290 (10%) – 580 (5%).

In the 2007 Feasibility Study, we estimated that a future population in the main Dundonnell woods (500 ha), using the median density of 0.8 squirrels per hectare, could be 320 full grown red squirrels, with fluctuations due to wild food ranging from 80 to 640 animals. These numbers would easily maintain a viable population.

Our calculations give a crude population estimate of 290-580, indicating that the population estimation was correct and has successfully been met.

Therefore, given the accepted inaccuracy of current methods of red squirrel population estimation, we believe that the clear flourishing and expansion of the Dundonnell population demonstrates that the translocation has been a success and that it forms a blueprint for future translocations.

7. EVALUATION OF PROJECT

We consider the Dundonnell translocation to have been very successful. Live-trapping, transportation and release methods have been successfully trialled. No squirrels died during trapping or transportation, and only one died during captivity prior to its soft release.

Supplementary feeding through the first winter likely contributed to the high survival seen in this project and encouraged squirrels to stay within the release locations. Squirrels successfully overwintered and bred in the first year after translocation, and in every year since. They rapidly colonised the whole of Dundonnell woods and also areas beyond, of their own volition. There is now a viable and self-sustaining population.

No evidence of high predation has been recorded although small numbers of pine martens live in the area and a red squirrel tooth was found in a marten scat. Using data up to June 2011, 19 squirrels have been killed on roads, many of these young squirrels that were born at Dundonnell. This is disappointing, but serves as a further good indicator that the population is successfully reproducing and maintaining itself.

88% of live-trapped squirrels in 2011 were above the average weights given for red squirrels, proving that food is plentiful and that the squirrel population is healthy.

Local people have shown a great interest in the project and have supported it through supplying extra feeders for squirrels and providing information on squirrel sightings and road deaths. The Highland Red Squirrel Group have supported the project throughout and written a letter to SNH supporting future releases.

7.1. Limitations

It has not been possible to monitor red squirrels in the accepted ways. However, it is widely acknowledged that population estimation of squirrels is extremely difficult and that the accepted methods are often inaccurate. Given that our own methods of monitoring have proved there to be a robust, healthy, self-sustaining population, we do not consider this to be a problem.

7.2. Recommendations for the future

- Following the successful restoration of a viable population of red squirrels to Dundonnell, we recommend that action is now taken on the Vision for red squirrels in the North and West Highlands by a rolling programme of translocations.
- From our experience at Dundonnell, 44 squirrels in a founding population were sufficient to create a viable population. Approximately 40 to 50 squirrels are sufficient for a translocation to be successful, although even fewer can be sufficient.
- Following trials of both soft and hard release we recommend hard release from nest boxes in September and October. The breeding season has not started at this point, there is plenty of good forage, and it gives ample time for squirrels to collect and store food for winter. Squirrels should be released from nest boxes in groups of two to four distributed through suitable woods.
- Supplementary feeding should be used to increase survival probability in the first year after translocation. Four to eight feeders should be located beside each group of nest boxes. Donor squirrels are probably best taken from supplementary feeding locations where they are used to using feeders with peanuts and other seeds.
- Traditional census techniques were found to be very difficult in the woodland terrain experienced in Wester Ross. Improved techniques to estimate population sizes and fluctuations are required.
- Squirrel populations experience large natural fluctuations due to wild food availability (Wauters *et al.* 2008). Therefore, when populations in a donor area are high, removal of squirrels has little effect on local populations and should not be viewed as a barrier to future translocations.

9. CONCLUSION

The Dundonnell red squirrel translocation has been a clear success. 44 red squirrels were live trapped and translocated with no deaths, proving that successful translocation of red squirrels is possible and relatively simple. Both soft release and hard release methods were successful, although we recommend hard release for future translocations, as one animal died during soft release, we believe due to stress. Food supplementation during the first winter meant that the squirrels had a readily available and easily accessible food supply, which we believe contributed to the high survival rate of translocated squirrels.

Squirrels successfully bred each year after the translocation and there have been numerous sightings of pregnant and lactating squirrels every year and, later in the year, young squirrels across a large number of sites. Squirrels have colonised all of the surrounding woodland and dispersed much further than expected, with one squirrel making an astonishing journey to Leckmelm, an overland distance of approximately 16km. A female was released into its territory and the pair successfully bred, with young squirrels seen in 2009 and 2011.

23 mortalities have been recorded, the majority of which were road deaths. 82.6% of mortalities were from non-PIT tagged squirrels, the majority of which had been born at Dundonnell, giving further evidence that the population is breeding and sustaining itself.

Traditional census techniques were found to be very difficult in the woodland terrain experienced in Wester Ross. Drey surveys were the most successful and these will be carried out in 2012 and 2013 in an attempt to gain an additional estimate of population size. Data has clearly demonstrated that the population is healthy and appears to have increased in size each year, with squirrels seen both more frequently and in higher numbers. Extrapolation of data from live-trapping carried out in 2011 gives a total population estimate of 290-580, which is what was indicated from feasibility studies to be the carrying capacity.

We believe that the field experience has been invaluable and has shown that translocation can be successful in areas without grey squirrel competition. This should help with moving towards the long term vision, which is to re-establish red squirrels in suitable forests and woodlands to the north and west of the present range, in order to increase the distribution and overall population of the species, and to create further refuges free from grey squirrels and associated diseases. Further translocations should start on a rolling programme as soon as possible.

Acknowledgements

Many thanks to everyone who has helped with the project, given permissions and helped to live trap squirrels, provided veterinary examinations and lent other support to the project. We are very grateful to the following for allowing us to live trap red squirrels: Dunphail and Logie Estates in Moray, Strathspey Estate and Frank Law, Anagach Woods, Landmark Visitor Centre, private gardens in Grantown-on-Spey, Boat-of-Garten and Carrbridge – all in Strathspey. The Inverness district of the Forestry Commission and several other estates also gave permission, but we have not used those locations yet. Special thanks to Anna Meredith, Jane Harley and Gabby Bongard for the excellent veterinary work. Dr. Craig Shuttleworth gave important advice, and we are grateful to help and advice from Tamara Lawton, Lesley Cranna, Dr. Mhairi Cole and Ben Ross of Scottish Natural Heritage; and Ian Collier and Juliet Robinson of the Highland Red Squirrel Group. We are also very grateful to others who have helped in many ways or offered trapping locations. The project was principally funded by Dundonnell Estate and the major fieldwork and management on the ground was carried out by Alasdair McDonald, the estate gamekeeper. Jane Rice and Donald Rice encouraged us to examine the potential for restoration and have supported the project from its inception.

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