



RESULTS OF SPRING 2018 SQUIRREL SURVEYS



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Heritage Lottery Fund, Scottish Natural Heritage, Dumfries and Galloway LEADER Programme, RSPB Scotland, Aberdeen Western Peripheral Route (Balmedie-Tipperty Grant Funded), Aberdeen City Council, Transport Scotland, Forest Enterprise Scotland, Forestry Commission Scotland, Loch Lomond and the Trossachs National Park Authority, and the many other members and supporters of the Scottish Wildlife Trust who have donated to the project.

1. SUMMARY

This report describes the monitoring of both red and grey squirrels undertaken by Saving Scotland's Red Squirrels (SSRS) during Spring 2018 and summarises the results. The results are compared with annual surveys undertaken since 2011 in the North of Scotland and since 2013 in the South of Scotland. In addition, the results of intensive grey squirrel detection surveys in North East Scotland are also presented.

In northern SSRS project areas the tetrad surveys show a significant decline in the occurrence of grey squirrels when compared with 2012. Overall, the mapping supports an increase in red squirrel occupancy in the North East, particularly in areas close to the City of Aberdeen. Across the Highland Line area, the trend shows a stabilisation of red squirrel occurrence in survey areas, and containment of grey squirrel range to that achieved by the early years of the grey squirrel population management work. Despite continuing recolonisation from grey squirrel populations from the Central Belt to the south, it appears that the SSRS project's target to prevent further incursion of grey squirrels into areas to the north of the Highland Line is successful, with suggestions of an expansion of red squirrel range in the Stirling area.

In the south of Scotland, overall, grey squirrel range is steadily increasing, with particular indications of increased range in the Hawick-Jedburgh and Sanquhar-New Galloway areas. For the first time the percentage occupancy of grey squirrels is higher than that of red squirrels in the surveys. Despite this, red squirrels appear to be maintaining their range, albeit with fluctuations around a steady annual percentage of tetrads detecting their presence.

2. AIM OF THIS REPORT

Saving Scotland's Red Squirrels is a project to stop the decline of Scotland's core red squirrel populations. In and around Aberdeen we aim to prevent the further replacement of red squirrels by grey squirrels by working to progressively reduce the geographic range and abundance of grey squirrels, aiming ultimately at complete eradication. In central Scotland along a broad zone bounded to the north by the Highland Line, we are working to prevent grey squirrels from spreading northwards from the Central Lowlands. This is achieved through a co-ordinated network of grey squirrel control at the interface between the red and grey squirrel distributions. Grey squirrel control began in Aberdeenshire in 2007, and in the Central Lowlands in 2010.

In South Scotland, the aim is to protect red squirrels in the project's priority areas for red squirrel conservation (PARCs) in southern Scotland where they are under threat from replacement by grey squirrels.

Annual spring monitoring in the North East and the Central Lowlands began in 2011 to provide evidence on which to assess the effectiveness of grey squirrel control on both red and grey squirrel populations. In South Scotland, distribution monitoring was carried out for the first time in Spring 2013. Here we compare the Spring 2018 surveys to results obtained in each year the surveys were completed between 2011 and 2017.

In the North East, the SSRS team and their volunteers carry out additional surveys aimed at detecting the shrinking grey squirrel populations centred on Aberdeen. These surveys are constantly evolving as the situation changes, and do not provide the same opportunities for annual comparisons as the Spring Surveys, but they are reported here in Appendix 2 since they provide additional information of interest.

3. METHODOLOGY

To determine red and grey squirrel presence in SSRS project areas, we used monitoring tetrads (2km x 2km squares). Each tetrad is identified by the grid reference of the south-western 1km square. In each tetrad, four feeder-boxes were positioned to sample right across the square (ideally), each with a sticky pad to collect hair-samples from visiting animals. Each feeder-box was checked by volunteers a total of three times over a period of six weeks and thus three hair samples were collected from each box. Hairs were identified under a microscope and each tetrad was consequently allocated to one of the following four categories: “red squirrels only”, “grey squirrels only”, “both species” or “neither” species detected.

Tetrads were considered complete (and therefore included in the analysis) if three samples were collected from each of the four feeder boxes – thus 12 hair samples per tetrad. Tetrads for which fewer than 12 hair samples were collected were also included in the analyses where both species of squirrel were detected, since a full set of samples could not change the result. Results from other partial surveys were omitted from the analysis, but are included for interest in the mapping using a different symbol.

Comparisons were made between the 2018 survey results and those of the previous year (2017) using Replacement indices (see below). We also compared the results of 2018 with the early years of the survey (2012 in the North, 2013 in the South) in order to gain an understanding of the change over a longer period of time.

For all analyses, the results from the North of Scotland (the North East, Argyll & Trossachs and Tayside combined) were treated separately from those from the South of Scotland (the Scottish Borders and Dumfries & Galloway and parts of Ayrshire and South Lanarkshire).

Replacement Index

To compare the results from a Spring Tetrad Survey with the results from any other year, we calculated a Replacement Index (RI) following Usher *et al.* (1992) and Bryce (1997). The survey results from any two years were plotted in a matrix showing all possible changes in the species occupying each tetrad by summarising results for each year in the categories: “red squirrels only”, “both red and grey squirrels”, “neither species”, “grey squirrels only” (Table 2 to Table 4 below).

The rows show the number of tetrads of each category detected in the earlier survey and the columns show the number of tetrads for each category during the later survey. The shaded diagonal represents no change in the occupancy category of the tetrad. Figures above the shaded diagonal boxes represent changes in favour of grey squirrels and those below represent changes in favour of red squirrels. Using these values, a Replacement Index was calculated as follows:

$$RI = \frac{(\text{sum of values above the diagonal}) - (\text{sum of values below the diagonal})}{(\text{the sum of all values in matrix except the "neither-neither" value})}$$

A positive index represents a change in tetrad occupancy in favour of grey squirrels – either due to the loss of red squirrels from the area or grey squirrels moving into the area. Conversely, **a negative index represents a change in favour of red squirrels** (Usher *et al.* 1992) through the loss of grey squirrels or the new occurrence of red squirrels. Note that this index can range from +1 to -1, where +1 would represent a complete shift to occupancy of all tetrads by greys (or neither species) and -1 a complete shift to reds (or neither species) occupying all tetrads (Bryce 1997).

Here we first compared the survey results from 2018 with 2017 (Table 2 and Table 4 below). We then compared results from 2018 with the first year of the full survey (Table 3 and Table 5). Only results from tetrads with surveys completed in both years (“paired tetrads”) were used in the analyses.

4. RESULTS

Table 1 sets out the number of tetrads detecting red squirrel, grey squirrel, both species or neither species in each year. The results for individual tetrads are presented as mapping in Appendix 1.

Table 1: Results summary

Project Area	Survey season	Red squirrels only	Grey squirrels only	Both Species	Neither species	Total no. of tetrads completed	(Total including incomplete tetrads)
North	Spring 2011	17	4	19	7	47	50
	Spring 2012	56	8	26	4	94	105
	Spring 2013	66	7	12	12	97	115
	Spring 2014	74	7	12	20	113	121
	Spring 2015	60	11	15	24	110	121
	Spring 2016	80	9	17	15	121	129
	Spring 2017	69	5	15	14	103	127
	Spring 2018	67	5	13	15	100	125
South	Spring 2013	40	15	7	25	87	102
	Spring 2014	44	16	8	18	86	99
	Spring 2015	31	18	13	23	85	102
	Spring 2016	41	27	11	14	93	96
	Spring 2017	42	26	8	4	80	98
	Spring 2018	28	30	17	10	85	100

Replacement index – North of Scotland

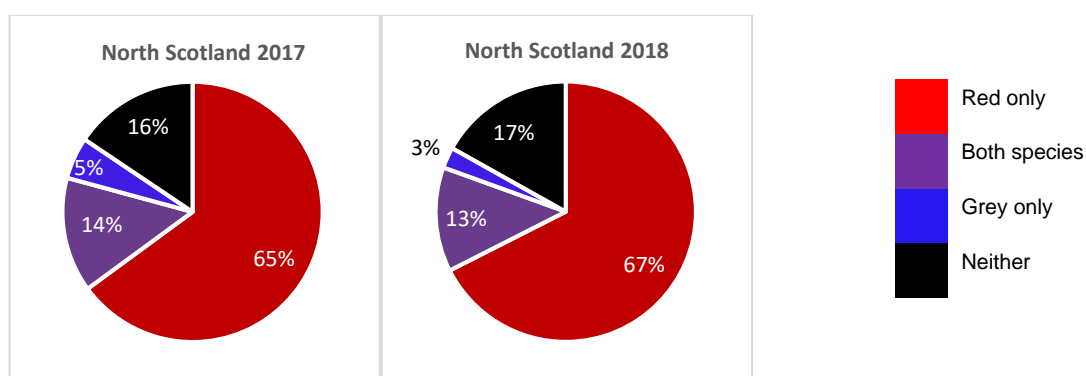
The Replacement Index matrix table for 2017/18, giving the number of tetrads in each change category for the North of Scotland (Table 2), shows that the number of changes in favour of red squirrels between 2017 and 2018 (below the shaded diagonal) is very similar to the number of changes in favour of greys for the same two years (above the shaded diagonal). The Replacement Index (RI) calculated from the table is very close to zero change (-0.056) and indicates that there is very little difference between the 2017 and 2018 results. Although small, these changes have been favourable to red squirrels. The same results are shown visually in Figure 1A as pie-charts.

Table 2: Matrix of changes in tetrad occupancy between 2017 and 2018 for the North of Scotland

North Scotland 2017/2018		Spring 2018				
		Red	Both	Neither	Grey	Total
Spring 2017	Red	42	3	5	0	50
	Both	4	6	0	1	11
	Neither	6	0	6	0	12
	Grey	0	1	2	1	4
	Total	52	10	13	2	77

Replacement Index = -0.056

Figure 1A: Proportion of paired tetrads recording red squirrels, grey squirrels, both species or neither for the North of Scotland. 2017/2018 (n=77)



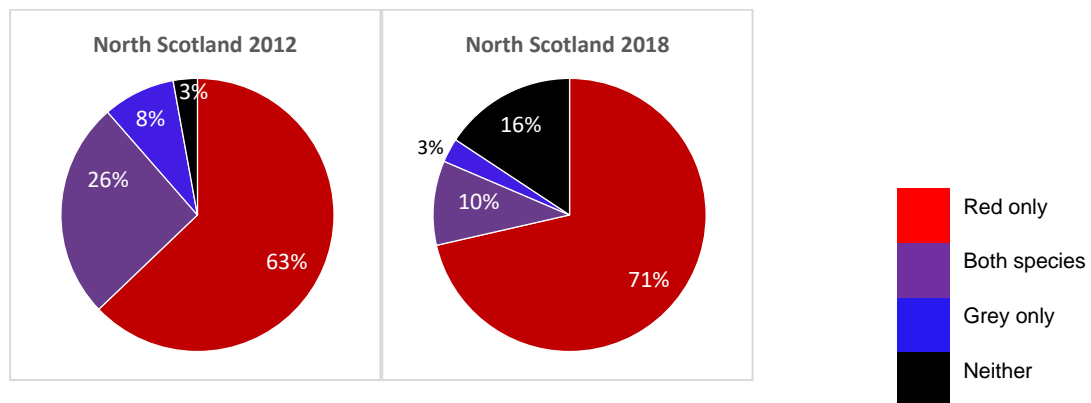
We then calculated the Replacement Index matrix for 2012/18. Table 3 shows a change in favour of red squirrels (RI=-0.10). The pie chart (Figure 1B) shows that this was largely due to the loss of grey squirrels from sites where previously both species occurred. Statistical analysis (not shown here) shows that this loss of grey squirrels was significant.

Table 3: Matrix of changes in tetrad occupancy between 2012 and 2018 for the North of Scotland

North Scotland 2012/2018		Spring 2018				
		Red	Both	Neither	Grey	Total
Spring 2012	Red	35	2	7	0	44
	Both	14	1	3	0	18
	Neither	1	0	1	0	2
	Grey	0	4	0	2	6
	Total	50	7	11	2	70

Replacement Index = -0.10

Figure 1B: Proportion of paired tetrads recording red squirrels, grey squirrels, both species or neither for the North of Scotland: 2012/2018 (n=70)



Replacement index – South Scotland

For South Scotland, from the full sample of 85 complete tetrads, only 59 were surveyed in both 2017 and 2018. The matrix for these (Table 4) shows a definite shift in favour of grey squirrels and the replacement index of 0.18 is the greatest replacement index between consecutive years in favour of greys in the history of these surveys. Figure 2A suggests that the replacement index may be due to an increase in tetrads where grey squirrels now occur alongside reds where previously only reds occurred.

Table 4: Matrix of changes in tetrad occupancy between 2017 and 2018 for South Scotland

South Scotland 2017/2018		Spring 2018			
		Red	Both	Neither	Grey
Spring 2017	Red	17	8	3	1
	Both	0	7	0	1
	Neither	1	0	2	0
	Grey	0	0	2	17
	Total	18	15	7	19

Replacement Index = 0.18

Figure 2A. Proportion of paired tetrads recording red squirrels, grey squirrels, both species or neither for South Scotland. 2017/2018 (n=59)

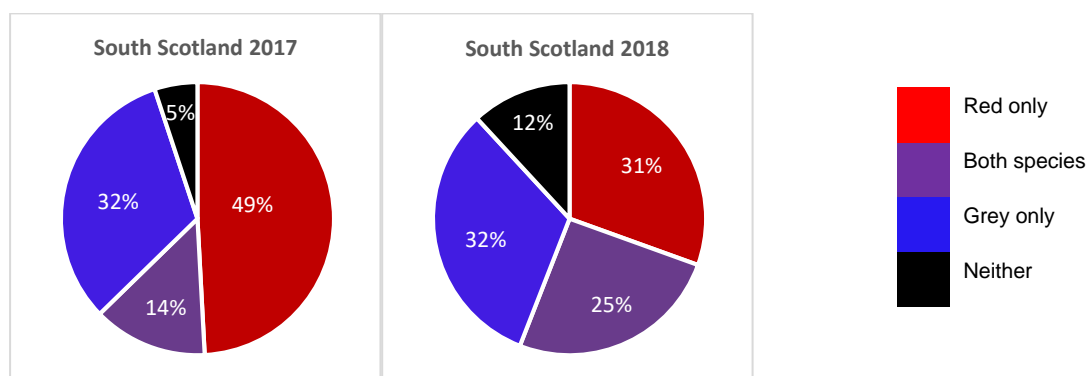
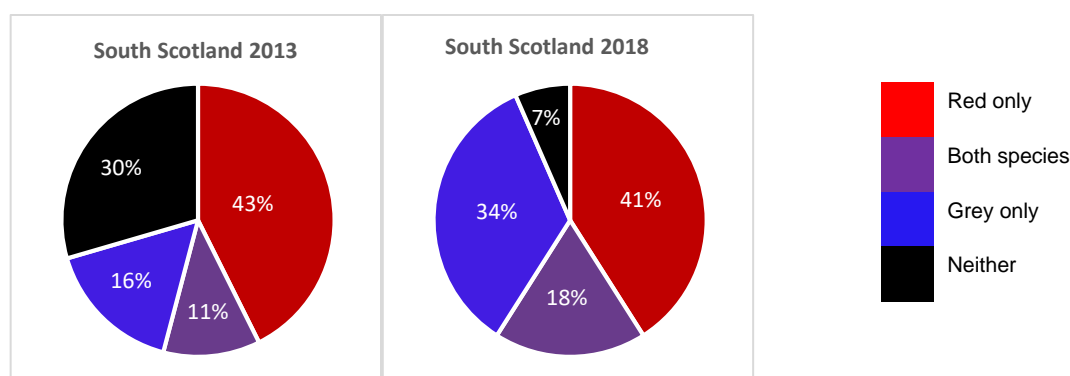


Figure 2B: Proportion of paired tetrads recording red squirrels, grey squirrels, both species or neither for South Scotland. 2013/2018 (n=61)



When comparing the results of 61 paired tetrads between the beginning of survey in 2013 and 2018, the matrix (Table 5) shows a distinct swing towards grey squirrel occupancy (RI=0.19). Statistical tests (not shown here) indicate that this is *a highly significant increase*. Figure 2B shows grey squirrels have expanded their range to areas where no squirrels or only red squirrels were previously detected. The mapping in Appendix 1 indicates a clear expansion of grey squirrel range in the Hawick-Jedburgh area and the Sanquhar-New Galloway areas. Notably, however, there was no significant difference between the proportions of tetrads containing reds over the same time scale, so we can say that red squirrel occupancy appears to have remained stable.

Table 5: Matrix of changes in tetrad occupancy between 2013 and 2018 for South Scotland

South Scotland 2013/2018		Spring 2018				
		Red	Both	Neither	Grey	Total
Spring 2013	Red	18	5	2	1	26
	Both	0	5	0	2	7
	Neither	6	1	2	9	18
	Grey	1	0	0	9	10
	Total	25	11	4	21	61

Replacement Index = 0.19

Comparison of proportions of red squirrels and grey squirrels in the complete annual sample

The comparisons above are restricted to tetrads which were sampled in both years (“paired tetrads”). Because these omitted a substantial proportion of the total annual samples, we also looked at the proportion (% of the total survey squares completed) of reds and greys in the whole sample for each year. Figures 3 and 4 depict the trends over the survey period for North and South Scotland respectively. The results from the combined samples from the northern half of the surveys show fluctuations around an almost horizontal line (the *status quo*) for the proportion of tetrads in which red squirrels were detected. The proportions of greys show a distinct decline, however.

Figure 3. Proportion of completed tetrads detecting each species in North Scotland over time

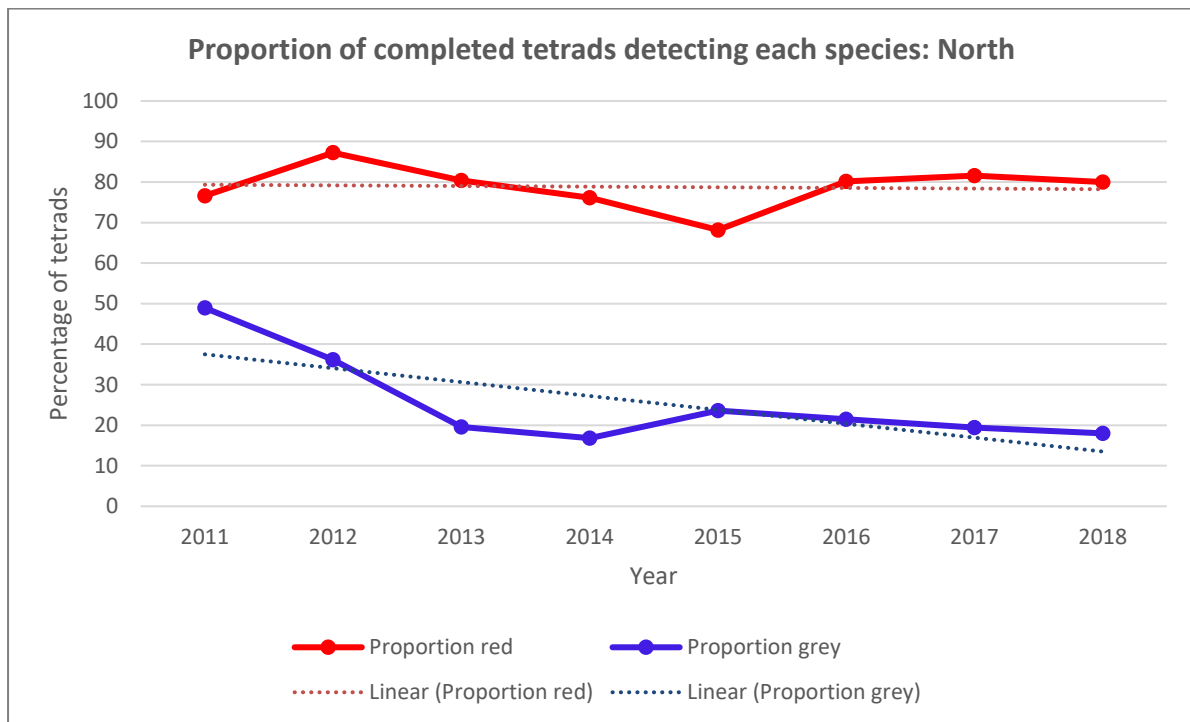
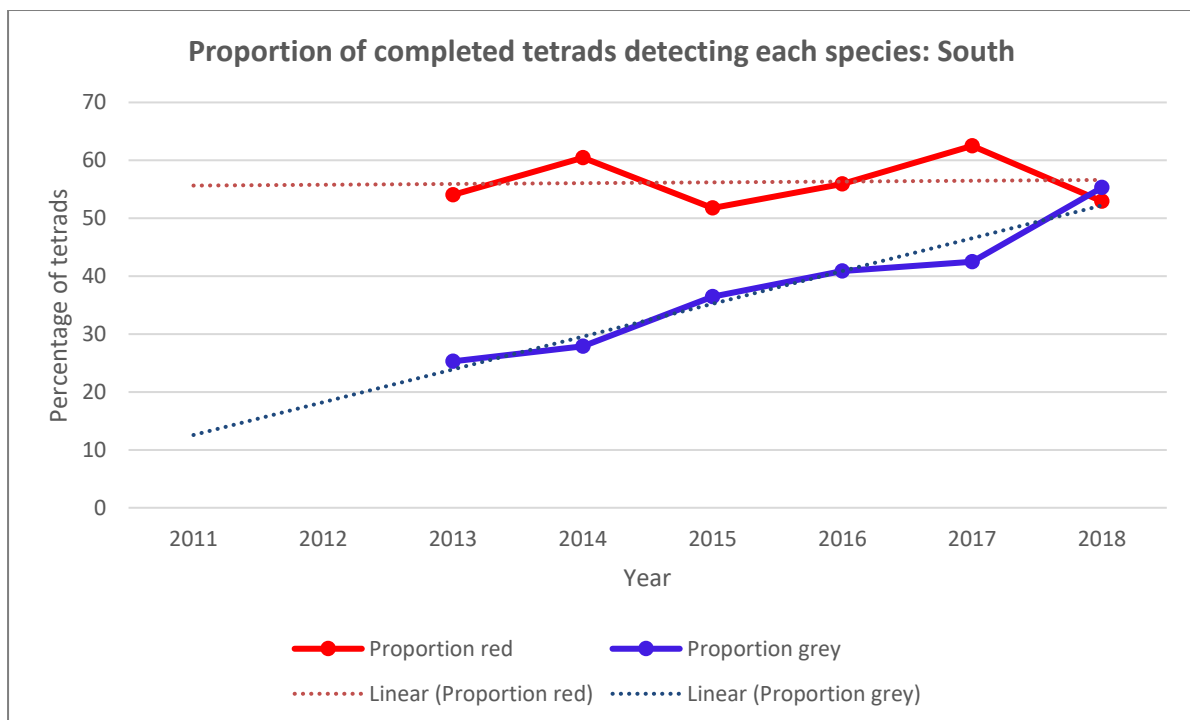


Figure 4: Proportion of completed tetrads detecting each species in South Scotland over time



By contrast, in the South Scotland, there is a distinct trend for increasing detection of grey squirrels in the sample. The proportion of tetrads occupied by grey squirrels in the south of Scotland in 2018 was now greater than the proportion containing reds – the first time this has occurred in these surveys.

N.B. These records are not from tetrads that were all surveyed in all years, and changing tetrad locations can influence results when there has been no actual change in squirrel occupancy, so must be interpreted with caution. The Replacement Indices look at change within each individual square, so are more reliable. Nevertheless, this (Fig.3 & 4) was an interesting picture that was worth sharing.

5. DISCUSSION

North Scotland

The results from the analyses (Tables 1, 2 & 3, Figures 1A & B and 3) show that red squirrel populations across the northern half of the SSRS project has fluctuated year to year, but overall represents a sustained change in favour of red squirrels. The Replacement Indices calculated between 2018 and 2017 and between 2018 and 2012 were negative – which equates to a positive result for red squirrels in 2018.

The picture for grey squirrels (Figures 1A & B and 3) was one of significant reduction of grey squirrel occurrence in the early years of the project up to 2013, then fluctuating around a constant level, likely in response to annual variations in food availability, until 2018.

South Scotland

Overall the results from the South of Scotland (Tables 1, 4 & 5, Figures 2A & B and 4 and the mapping in Appendix 1), show quite a shift in favour of grey squirrels between the start of the surveys in 2013 and the current survey in 2018. However, red squirrel occurrence in the surveys only declined slightly since 2017, and Figure 4 shows a slight increase for reds in 2018 when compared with 2013.

The mapping shows clustered areas of grey squirrel colonisation around Hawick-Jedburgh and Sanquhar-New Galloway. It flags up the urgency for getting more joined-up landscape-scale grey squirrel control under way in these areas in order to maintain the red squirrels of southern Scotland. The fact the red squirrels are showing little sign of serious decline gives us cause for hope that this can still be done.

Survey Volunteers

To find out what's changed in your tetrad over the years, join the Community Hub at <https://scottishsquirrels.org.uk/>, and sign up for Volunteer Group. You'll be added to the Feeder Box Survey Group where you can use the interactive map to view results from all previous years.

Saving Scotland's Red Squirrels wishes to thank all the volunteers who gave up their time to help us collect this data, and all those landowners who co-operated by allowing us access to their land, without which this research would not be possible.

6. REFERENCES

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Usher, M.B., Crawford, T.J. & Banwell, J.L. (1992) An American invasion of Great Britain: The case of the native and alien squirrel (*Sciurus*) species. *Conservation Biology*, **6**, 108-115.

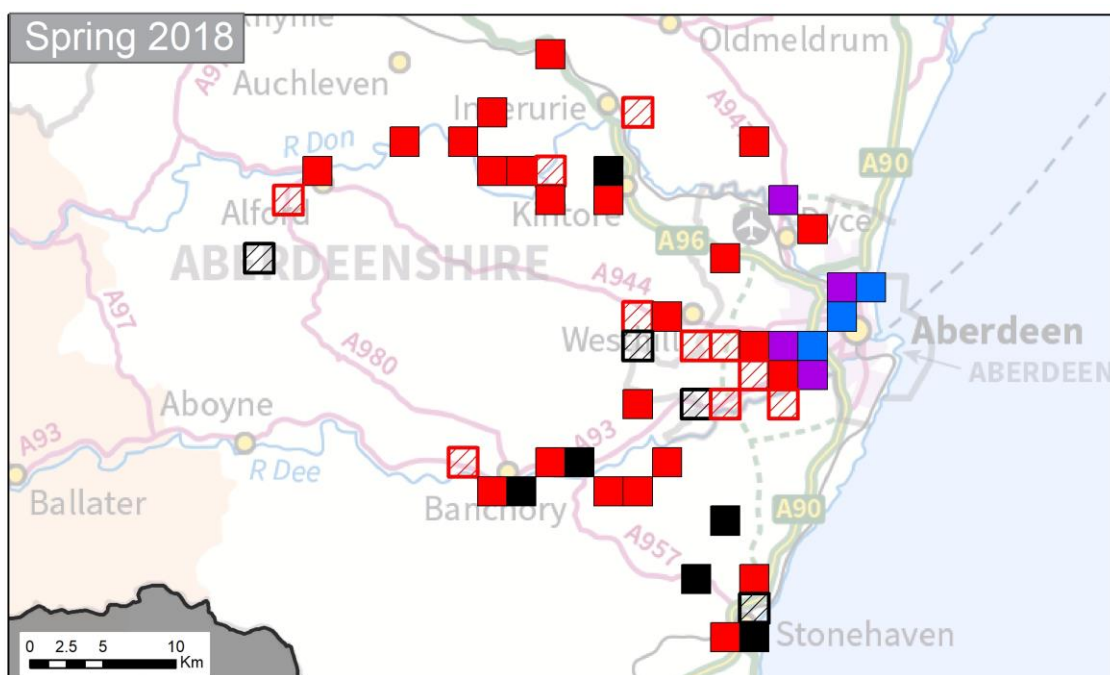
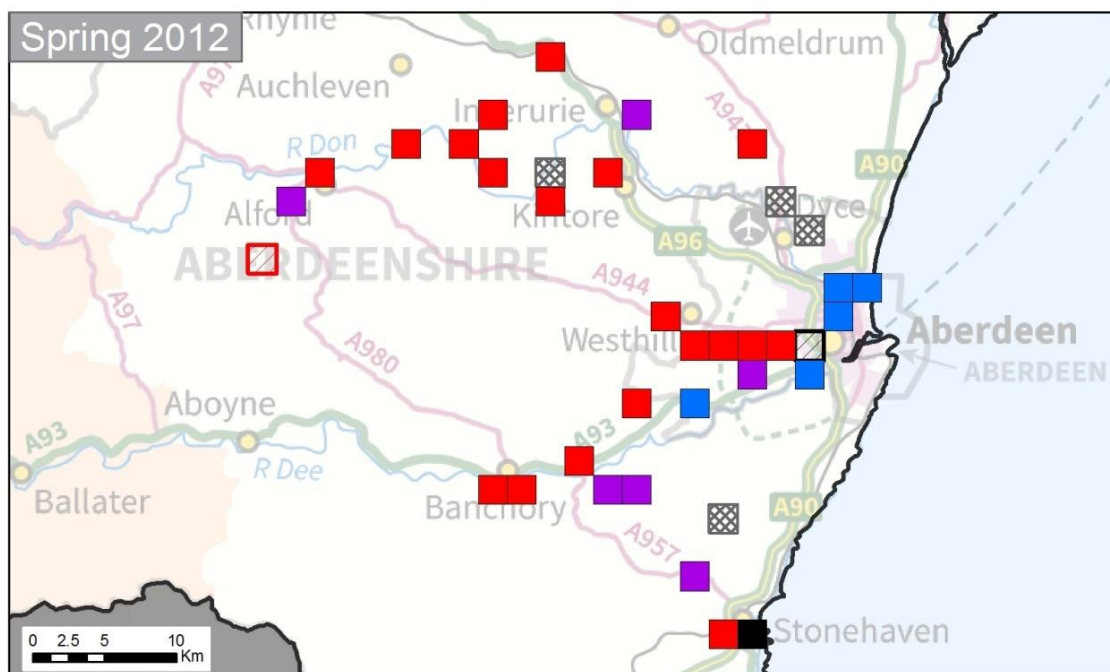
7. APPENDIX 1

Tetrad Results 2018 – Maps showing comparisons between the earliest and most recent survey years for each project region

Please note that due to the late receipt of some samples, the 2018 maps below display data that were not included in the analysis above.

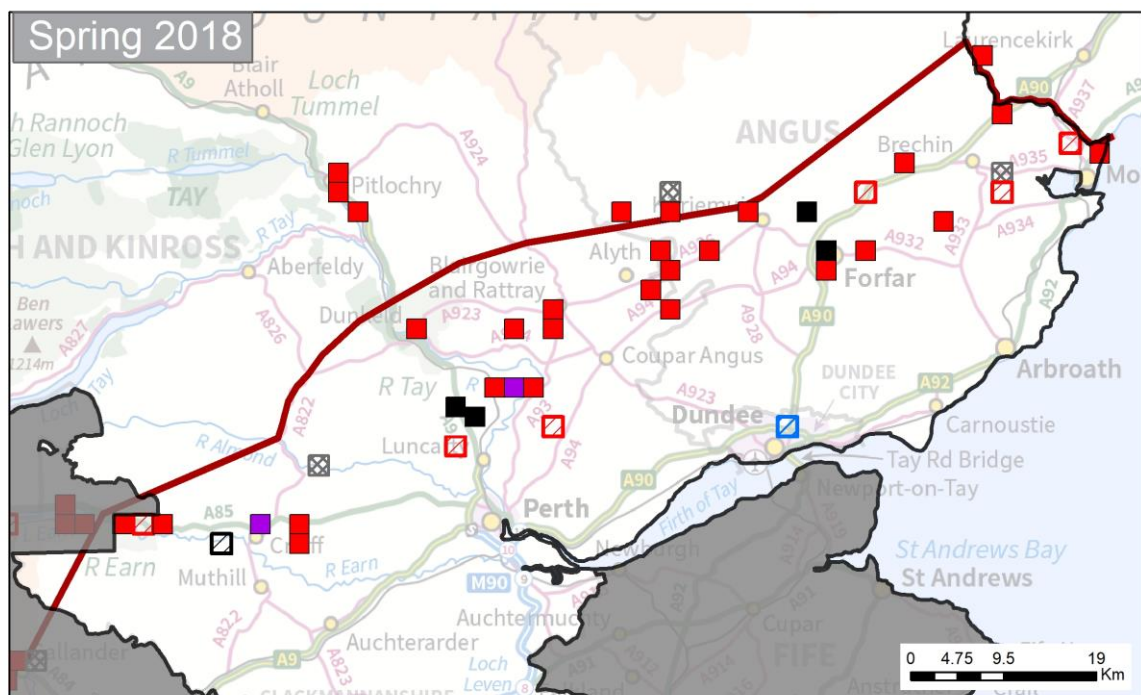
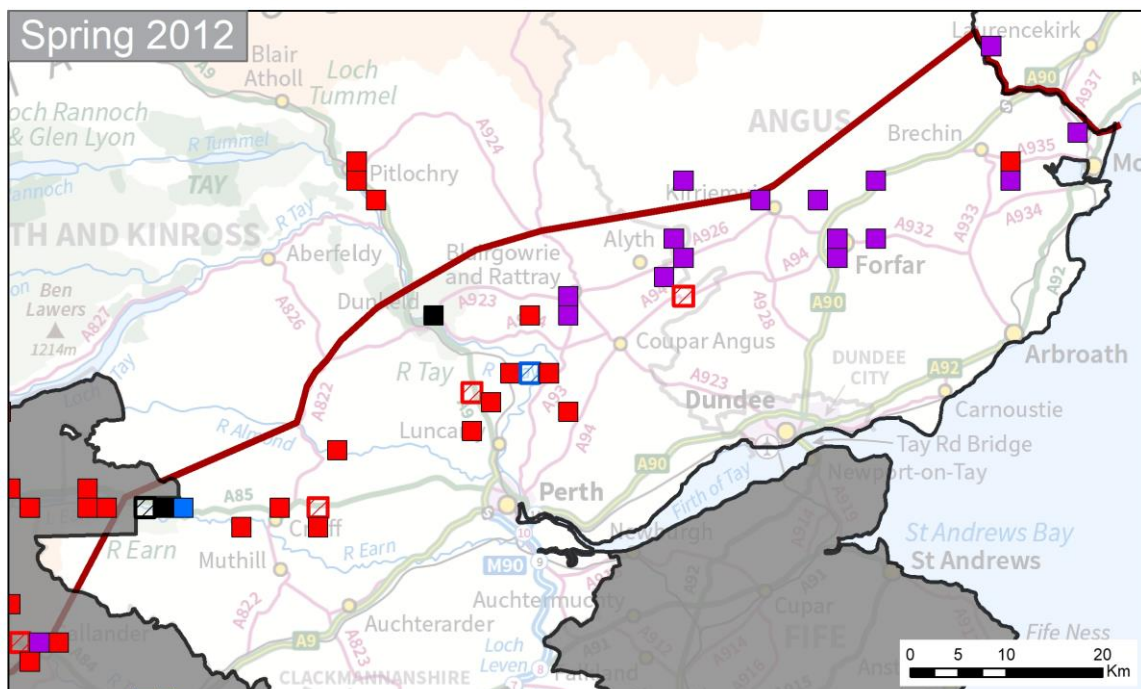


Tetrad Results - North East



Results from SSRS standardised tetrad surveys
Contains OS data
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Date: 24/10/2018

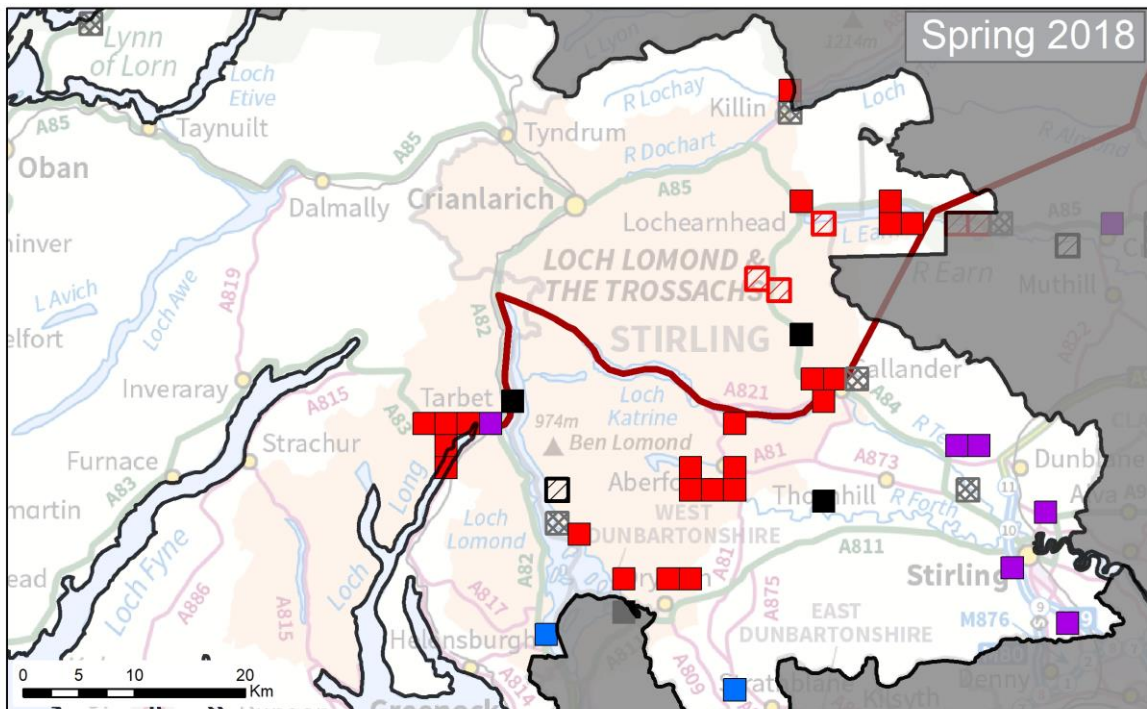
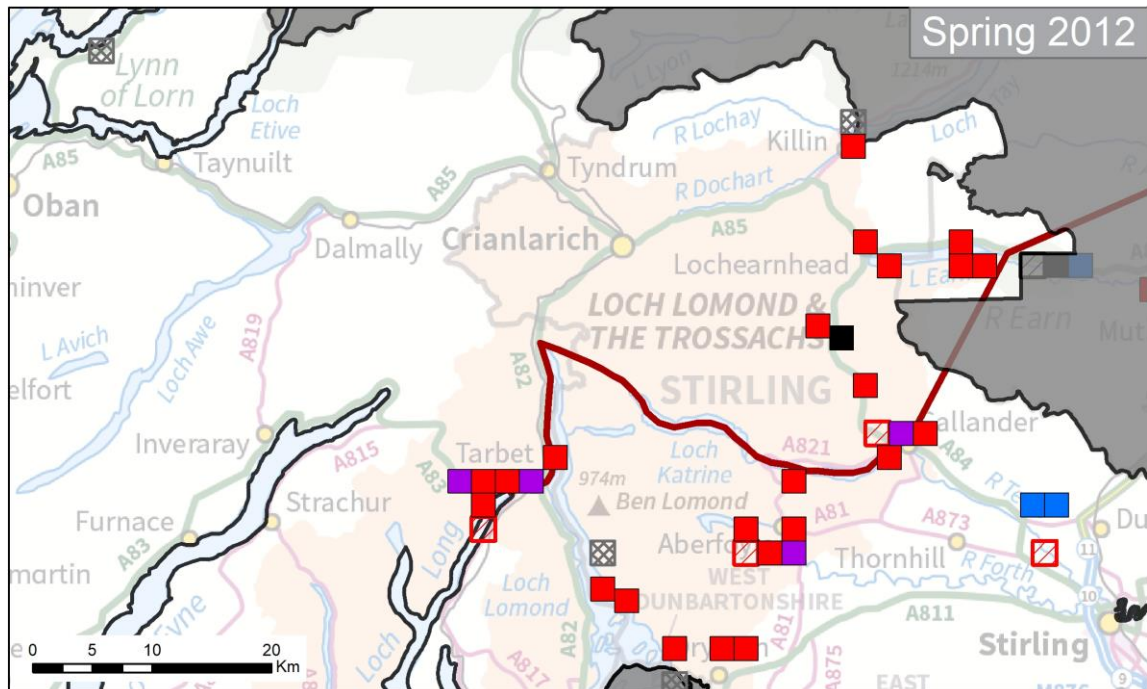




Results from SSRS standardised tetrad surveys
Contains OS data
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Date: 24/10/2018

Tetrad Results

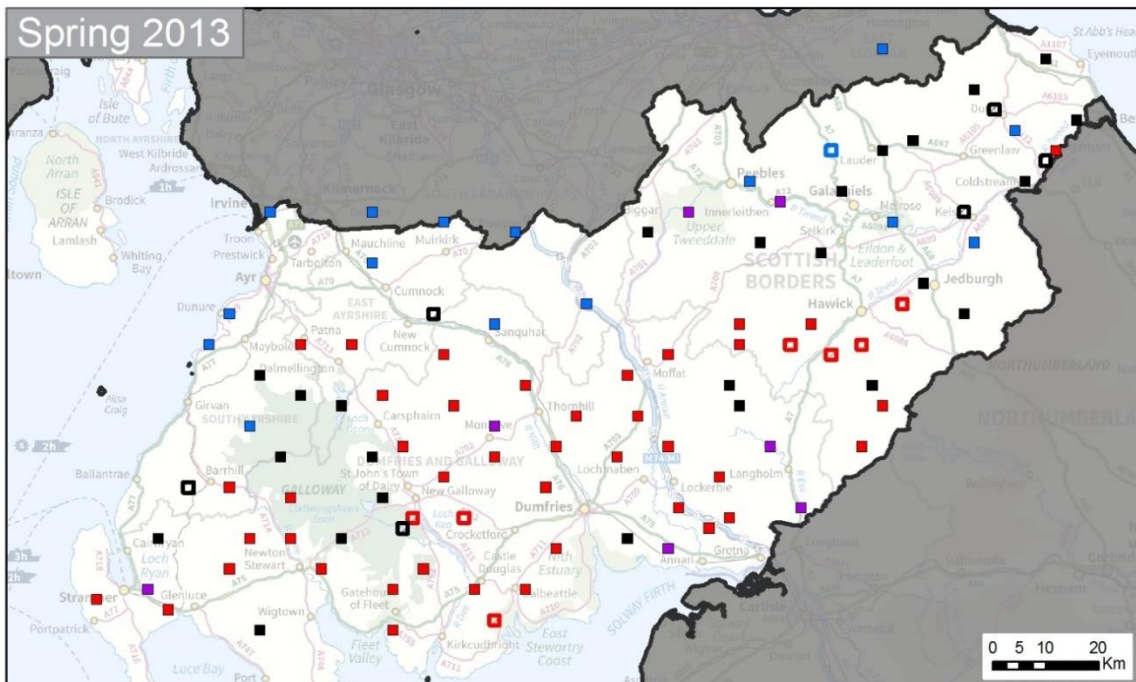
■ Red squirrel(s)	 Red squirrel(s) - Tetrad partially completed
■ Grey squirrel(s)	 Grey squirrel(s) - Tetrad partially completed
■ Red and Grey squirrels	 Neither squirrel - Tetrad partially completed
■ Neither squirrel	 Tetrad not surveyed
	— Red squirrel protection line



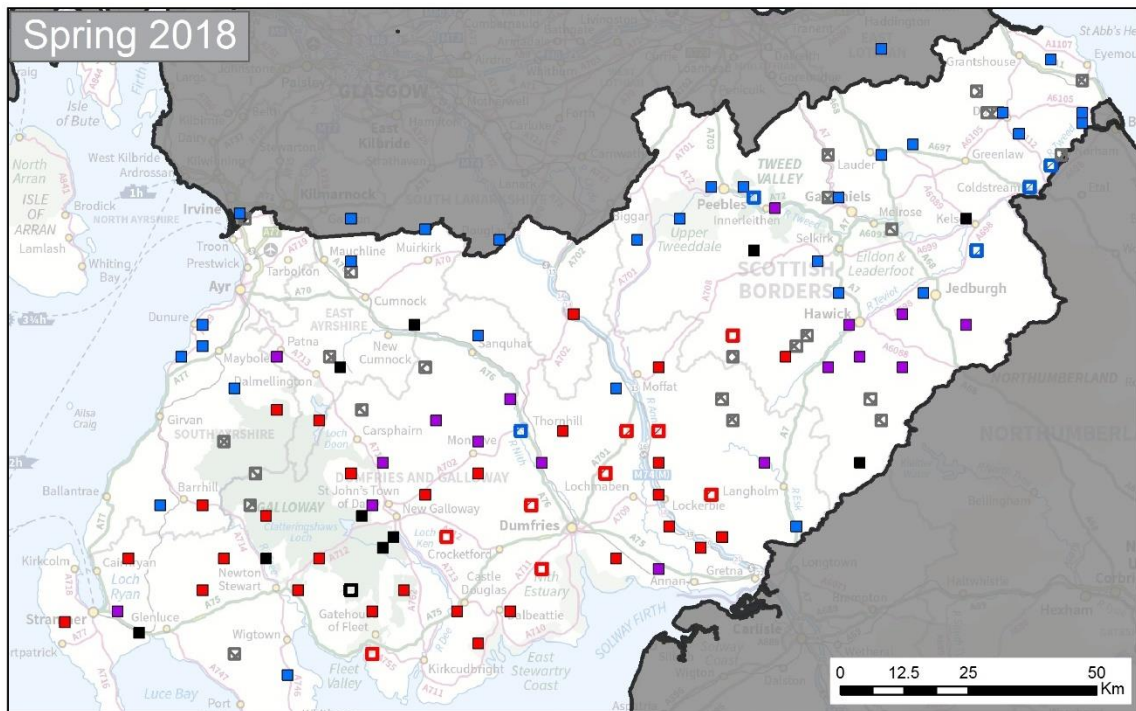
Results from SSRS standardised tetrad surveys
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Date: 24/10/2018



Spring 2013



Spring 2018



Results from SSRS standardised tetrad surveys
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Date: 24/10/2018



8. APPENDIX 2. INTENSIVE GREY SQUIRREL DETECTION SURVEY IN NORTH EAST SCOTLAND

Background

Since 2015 an independent presence-absence survey has been carried out in the North East Scotland aimed at detecting grey squirrels to inform grey squirrel control activities. A secondary aim is to build up a detailed picture of red and grey squirrel distribution across the region including in stretches of landscape not covered by the Spring Tetrad surveys.

Methodology

For these surveys, all significant areas of large-seeded broadleaved trees (c. 10ha or greater) and all small patches of habitat with good connectivity were targeted for survey, including broadleaved shelter belts around/within conifer blocks, from identification on 1:25,000 OS maps. Type of woodland was assessed using aerial photography on Google Maps. Sightings records, trapping records, and survey results that SSRS already held were collated and mapped and woodland stock maps consulted. This was followed up by ground-truthing the woodlands by driving/walking them to assess the habitat(s) present, the approximate age (i.e. new plantation or ancient woodland), and presence of squirrels evident from sightings or field signs. Whilst visiting the wood, posters were put up asking for sightings.

Feeder boxes were deployed in all woodlands at a density of 1-3 per 10 ha. with more in habitat bottlenecks. In large blocks of conifer of cone-bearing age, areas of mature large-seeded broadleaved trees were prioritised.

The project also deployed feeder-box surveys within the built-up areas of the city at a density of at least one per ha., selecting the most likely habitat for grey squirrels. By 2016 there were 240 boxes across the city and shire, and surveys were carried out twice a year, in spring and autumn. In spring 2017 feeder box sampling across the region was reduced to 137 boxes, covering the same area but at a lower intensity (duplicate boxes in small habitat patches were thinned down to a single box, and boxes which had never detected any squirrels over a number of years were also removed).

As with the Spring Tetrad Surveys, the feeder boxes were baited and equipped with a sticky hair-trap tab and visited three times at two week intervals. Following hair identification each feeder-box was allocated to one of the four categories: “red squirrels only”, “grey squirrels only”, “both species” or “neither” species.

Results

The spring 2018 survey results from 104 completed survey boxes indicate that red and grey squirrels across the North East have remained stable since 2017. There have been small changes in both grey and red squirrel distribution, in particular more signs of the recovery of red squirrels further into Aberdeen City. Red distribution has increased around North and South Deeside with no “grey only” results in Peterculter and Cults and no squirrels detected in the Cove area. The red squirrel populations in Countesswells, Hazlehead Park, Seaton Park and Scotsmoor have all been maintained and the increase in “both squirrel” status for survey sites indicates red squirrel expansion within the city. The occasional individual grey squirrel disperser and small sub population are still being detected in

Aberdeenshire, in Blackburn and Straloch, but these are being managed to prevent establishment and should be removed in time as overall grey squirrel density in the city reduces.

This tallies with the findings of the Spring Tetrad Surveys that grey squirrels have declined in Aberdeenshire and Aberdeen City over the period of the project and red squirrels are successfully re-establishing across the region.

Map showing the squirrel species detected at 104 single feeder-boxes in the Intensive Grey Squirrel Surveys in Spring 2018

