EVALUATION OF SPRING 2019 SQUIRREL SURVEYS

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Saving Scotland's Red Squirrels is also grateful for the funding contributions of:

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1. SUMMARY

This report describes the monitoring of both red and grey squirrels undertaken by Saving Scotland's Red Squirrels (SSRS) during Spring 2019 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, and a contraction in grey-occupied areas, which are now localised to Aberdeen City. 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, although continued vigilance is needed to ensure this remains the case.

In the south of Scotland, for the first time since the survey began, there has been a decrease in the proportion of tetrads with grey-squirrel detection, whereas previously, the range of grey squirrels was steadily increasing: this finding is supported by an increase in the range of red squirrels between 2018 and 2019. Mapping results show that despite the presence of strong grey colonies in the South, red colonies are being maintained in Tweeddale and throughout Dumfries & Galloway. Although under constant pressure from grey squirrels in the southwestern Scottish Borders, red squirrels are still present across this region from Hawick to the River Esk, and can hopefully be protected and restored here as grey squirrel control networks become more established. Overall, red squirrels are maintaining their range in South Scotland apart from Berwickshire and the eastern half of Roxburghshire, where they have all but vanished.

The results from the 2019 survey give us fresh optimism that red squirrels can be protected across their current range in SSRS project areas as long as grey squirrel numbers can be adequately controlled.

2. AIM

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) where they are under threat from replacement by grey squirrels.

In order to provide evidence on which to assess the effectiveness of grey squirrel control on both red and grey squirrel populations, the project set up standardised spring surveys in North East Scotland and the Central Lowlands in 2011. In South Scotland the surveys were carried out for the first time in Spring 2013. In this report, we compare the spring 2019-survey results with the previous years' results (2018) and with the first year the survey ran.

We also report on a separate set of surveys carried out in the Aberdeen area, 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

We used feeder-box monitoring in a fixed set of locations arranged in 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. Three hair samples were collected from each feeder-box by volunteers a total of three times over a period of six weeks. 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. Where both species of squirrel were detected the tetrads were also included in the analyses regardless of number of hair-samples, since a full set of samples could not change the result. Results from other partial surveys were omitted from the analysis but are included in the mapping for interest, using a different symbol.

Comparisons were made between the 2019 survey results and those of the previous year (2018) using Replacement Indices (see below). We also compared the results of 2019 with those from 2012 in the North and from 2013 in the South) in order to look at change over a longer period of time.

For all analyses we combined the results from the North of Scotland (the North East, Argyll & Trossachs and Tayside), and analysed them 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" (Tables 2-4).

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:

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

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 2019 with 2018 (Table 1 below). We then compared results from 2019 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	89	6	14	14	123	133
	Spring 2019	84	7	14	11	116	139

Project Area	Survey season	Red squirrels only	Grey squirrels only	Both Species	Neither species	Total no. of tetrads completed	(Total including incomplete tetrads)
South	Spring 2013	40	15	7	25	87	102
	Spring 2014	42	18	8	18	84	99
	Spring 2015	30	18	14	23	85	102
	Spring 2016	40	28	10	14	92	96
	Spring 2017	41	27	8	3	79	98
	Spring 2018	28	32	17	9	86	101
	Spring 2019	38	30	14	13	95	103

North of Scotland 2018/2019

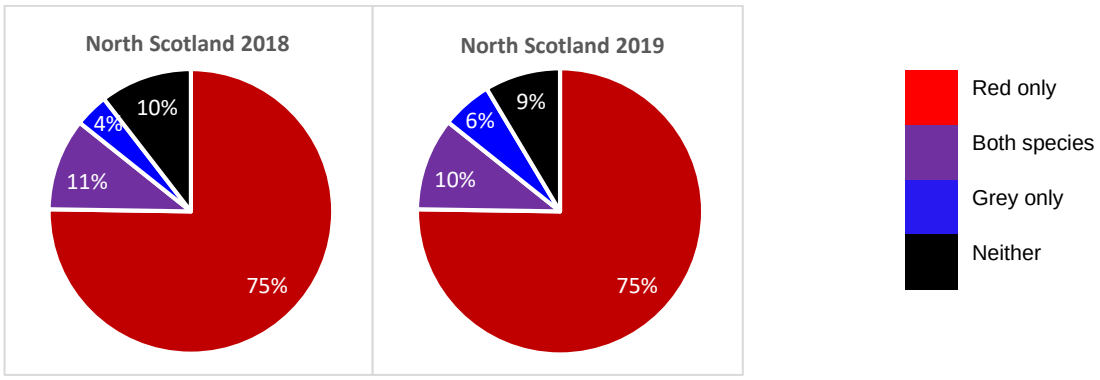
The Replacement Index matrix table for 2018/19 tetrads in North Scotland (Table 2), shows that the number of changes in favour of red squirrels (below the shaded diagonal) is very similar to the number of changes in favour of greys (above the shaded diagonal). The Replacement Index (RI) calculated from the table is close to zero change (RI= 0.01, a slight shift in favour of grey squirrels) detected between 2018 and 2019 for North Scotland. The same results are shown visually in Figure 1A as pie-charts.

Table 2: Matrix of changes in tetrad occupancy between 2018 and 2019 for the North of Scotland

North Scotland 2018/2019		Spring 2019				
		Red	**Both**	**Neither**	**Grey**	**Total**
Spring 2018	Red	72	2	4	1	79
	Both	2	8	0	1	11
	Neither	5	0	5	1	11
	Grey	0	1	0	3	4
	Total	79	11	9	6	105

Replacement Index = 0.01

Figure 1A: Proportion of paired tetrads recording red squirrels, grey squirrels, both species or neither for the North of Scotland. 2018/2019 (n=105)



North of Scotland 2012/2019

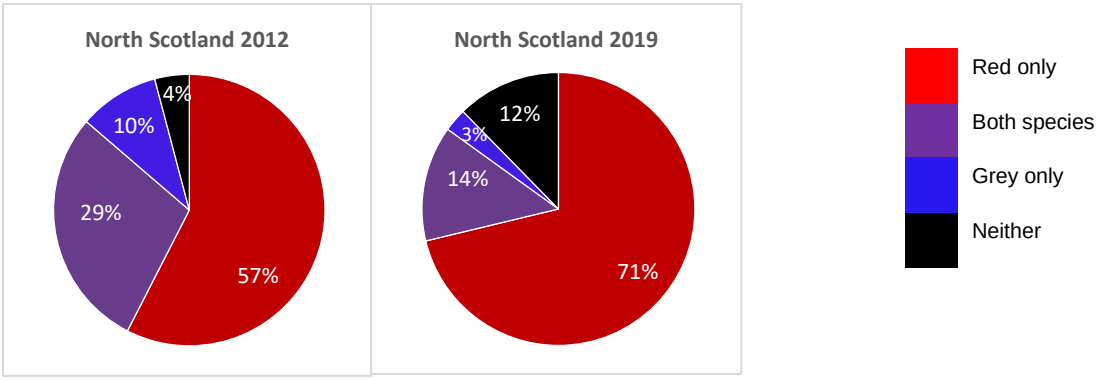
We then calculated the Replacement Index matrix for 2012/19. Table 3 shows a change in favour of red squirrels (RI=-0.15) when comparing the current year's survey data with 2012 results. The pie chart (Figure 1B) shows that this was largely due to the loss of grey squirrels from sites that both species previously occupied: Our statistical analyses indicates that the loss of grey squirrels is significant (not included in this report).

Table 3: Matrix of changes in tetrad occupancy between 2012 and 2019 for the North of Scotland

North Scotland 2012/2019		**Spring 2019**				
		Red	Both	Neither	Grey	**Total**
Spring 2012	Red	30	5	7	0	42
	Both	17	1	2	1	21
	Neither	3	0	0	0	3
	Grey	2	4	0	1	7
	Total	52	10	9	2	73

Replacement Index = -0.15

Figure 1B: Proportion of paired tetrads recording red squirrels, grey squirrels, both species or neither for the North of Scotland: 2012/2019 (n=73)



South Scotland 2018/2019

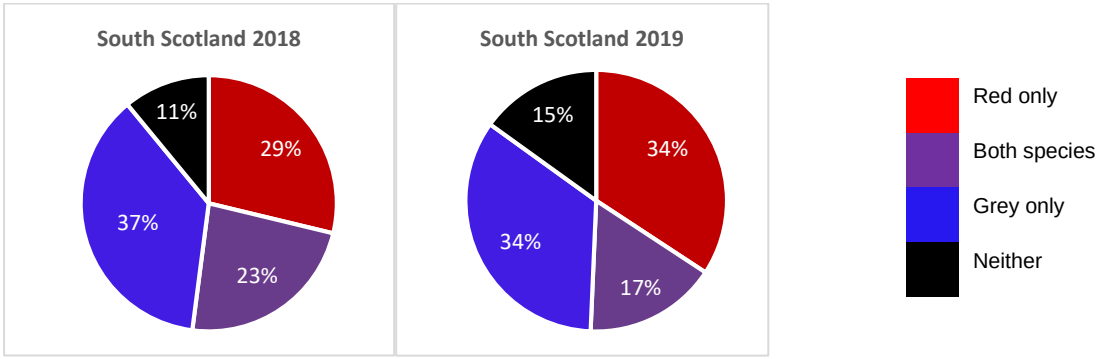
For South Scotland, from the full sample of 103 complete tetrads, 73 were surveyed in both 2018 and 2019. The Replacement Index (RI = -0.04) for these tetrads shows a slight shift in favour of red squirrels (Table 4), however, these changes were non-significant in our statistical analyses (not shown in this report). The negative replacement index is influenced by seven tetrads that were previously occupied by both or neither species, and are now occupied by reds (Figure 2A).

Table 4: Matrix of changes in tetrad occupancy between 2018 and 2019 for South Scotland

South Scotland 2018/2019		Spring 2019				
		Red	Both	Neither	Grey	**Total**
Spring 2018	Red	17	2	2	0	21
	Both	4	9	2	2	17
	Neither	3	0	4	1	8
	Grey	1	1	3	22	27
	Total	25	12	11	25	73

Replacement Index = -0.04

Figure 2A. Proportion of paired tetrads recording red squirrels, grey squirrels, both species or neither for South Scotland. 2018/2019 (n=73)



South Scotland 2013/2019

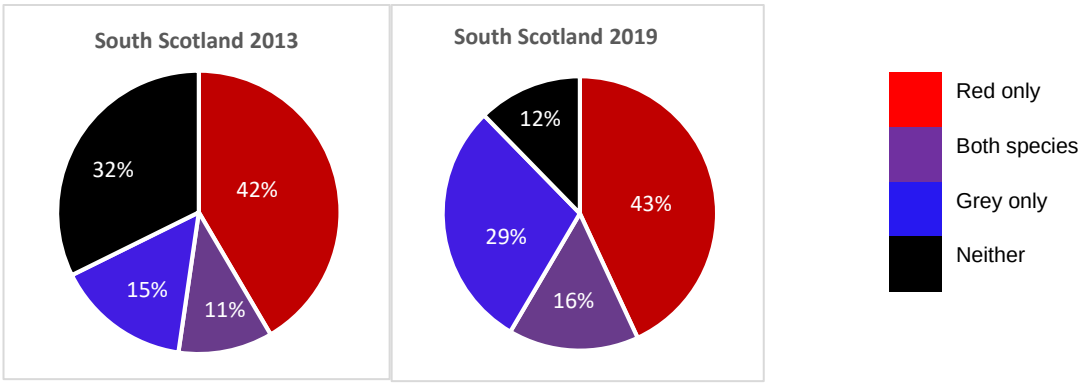
For the results of 65 tetrads that were survey in both 2019 and 2013, the RI of + 0.133 denotes a slight increase in grey squirrel occupancy (Table 5). The pie charts in Figure 2B suggest that this swing is due to grey squirrels expanding their range to areas where neither species were detected in 2013; at the same time, the proportion of tetrads occupied by red squirrels has increased slightly. Statistical analyses show that the increase in proportion of grey-occupied tetrads is significant (not shown in this report). 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 2019 for South Scotland

South Scotland 2013/2019		Spring 2019				
		Red	Both	Neither	Grey	**Total**
Spring 2013	Red	21	4	2	0	27
	Both	1	4	0	2	7
	Neither	4	2	5	10	21
	Grey	2	0	1	7	10
	Total	28	10	8	19	65

Replacement Index = 0.133

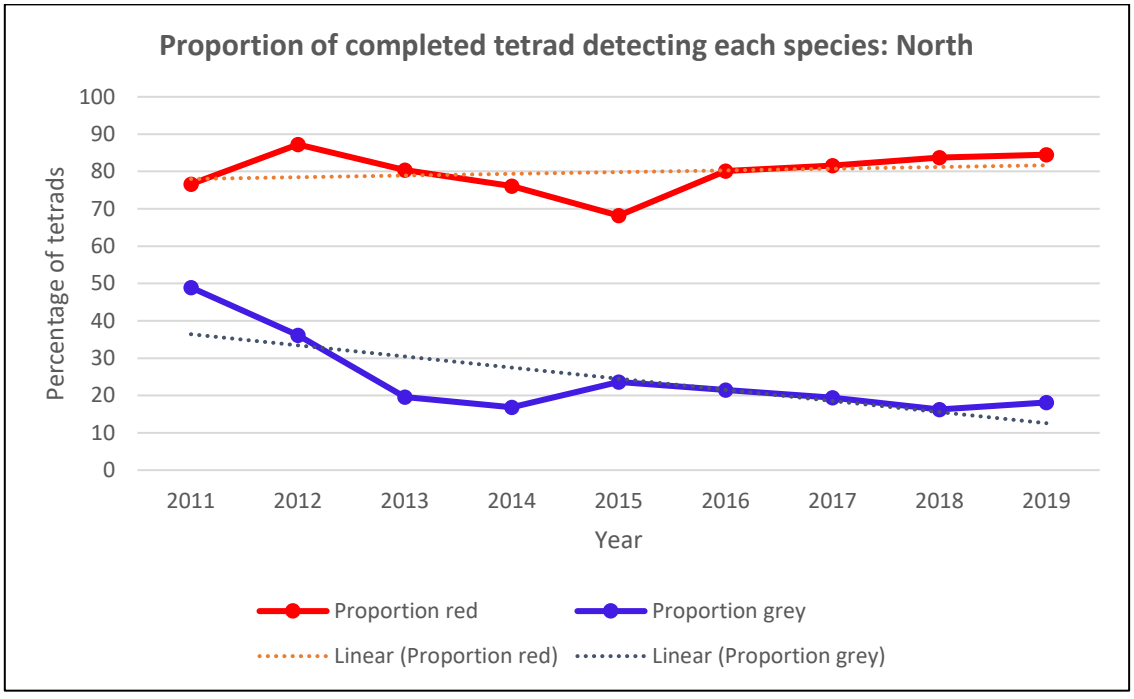
Figure 2B: Proportion of paired tetrads recording red squirrels, grey squirrels, both species or neither for South Scotland. 2013/2019 (n=65)



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.

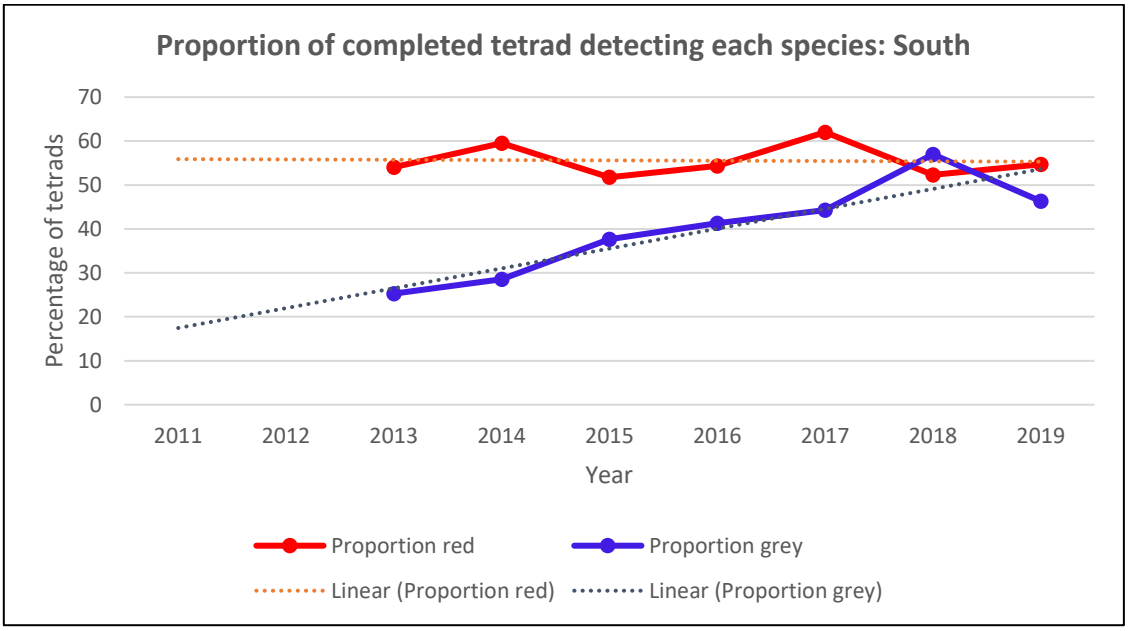
Figure 3. Proportion of completed tetrads detecting each species in North Scotland over time



The results from the combined samples from the northern half of the surveys show fluctuations around an almost constant 80% of the tetrads occupied by red squirrels, with a slight increase in proportion of reds over the last 3 years (Figure 3). The proportion of tetrads where greys have been detected shows a distinct decline over time. However, between 2018 and 2019 there was a slight

increase in the proportion of tetrads with grey squirrel detections, for the first time since 2014/15 (Figure 3).

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



By contrast, in South Scotland there was a distinct trend in increasing the detection of grey squirrels from 2013 through to 2018. Between 2018/2019 this trend underwent a shift to a decrease in the proportion of tetrads detecting greys (Figure 4). This is the first year, since the Spring Tetrad Surveys commenced, that South Scotland has seen a decrease in the proportion of tetrads where grey squirrels are detected. Furthermore, this has been accompanied by a slight increase in red squirrel detection between 2018/2019 (Figure 4) around a trend of 55-57% of tetrads surveyed.

N.B. These results must be viewed with caution. They are not from a constant set of tetrads that were surveyed in all years, and changing tetrad locations produce the appearance of change when there has been no actual change in squirrel occupancy. The Replacement Indices look at change within each individual square, so are more reliable. Nevertheless, this (Figures 3 & 4) is an interesting picture 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 have fluctuated year to year, overall representing a sustained change in favour of red squirrels since the start of the series, but with the occasional slight change in favour of grey squirrels.

The 2019 survey results show a small shift in favour of grey squirrels (RI =+0.01) since 2018, with loss of reds from a few tetrads previously supporting both species, and the movement of greys into tetrads

where neither species previously occurred. However, when comparing 2019 with 2012, there has been an increase in red-squirrel detection, and the proportion of tetrads where reds have been detected has been steadily increasing since 2015 (Figures 1A, 1B & 3).

South Scotland

For the first time the results from South Scotland showed a change in favour of reds when comparing consecutive years' survey results (2019 vs 2018) (Table 4), in contrast to all previous spring survey reports. In the 2019 survey, we see a decrease in the percentage of tetrads detecting greys for the first time since the survey began (Figure 4). We will need further survey results to determine if the increased SSRS volunteer network activity in South Scotland is having a positive effect on the population of red squirrels in the South.

Figure 4 suggests that red-squirrel detection has remained stable, fluctuating around a steady proportion of approximately 56% of sampled tetrads since the start of the surveys in the South. For grey squirrels we have seen was a steady increase in occupancy from approximately 26% of tetrads in 2013 to 55% in 2018, but in 2019 for the first time, we can see a decrease in the proportion of tetrads detecting greys to 46% occupancy.

The mapping (Appendix 1) shows grey-squirrels spread over most of the Teviot and Rule project priority area, although red squirrels remain widespread. This highlights SSRS's continued need for getting more joined-up, landscape-scale, grey-squirrel-control under way in these areas in order to maintain the remaining red squirrels of southern Scotland. The overall decrease in proportion of tetrads detecting grey squirrels, and a change in favour of red-detection, gives hope that increasing activity by SSRS volunteers will have a positive impact on the red squirrel population in South Scotland.

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 the 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

Bryce, J. (1997) Changes in the distributions of Red and Grey Squirrels in Scotland. *Mammal Review.* **27**, 171-176.

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 2019 – Maps showing comparisons between the earliest and most recent survey years for each project region

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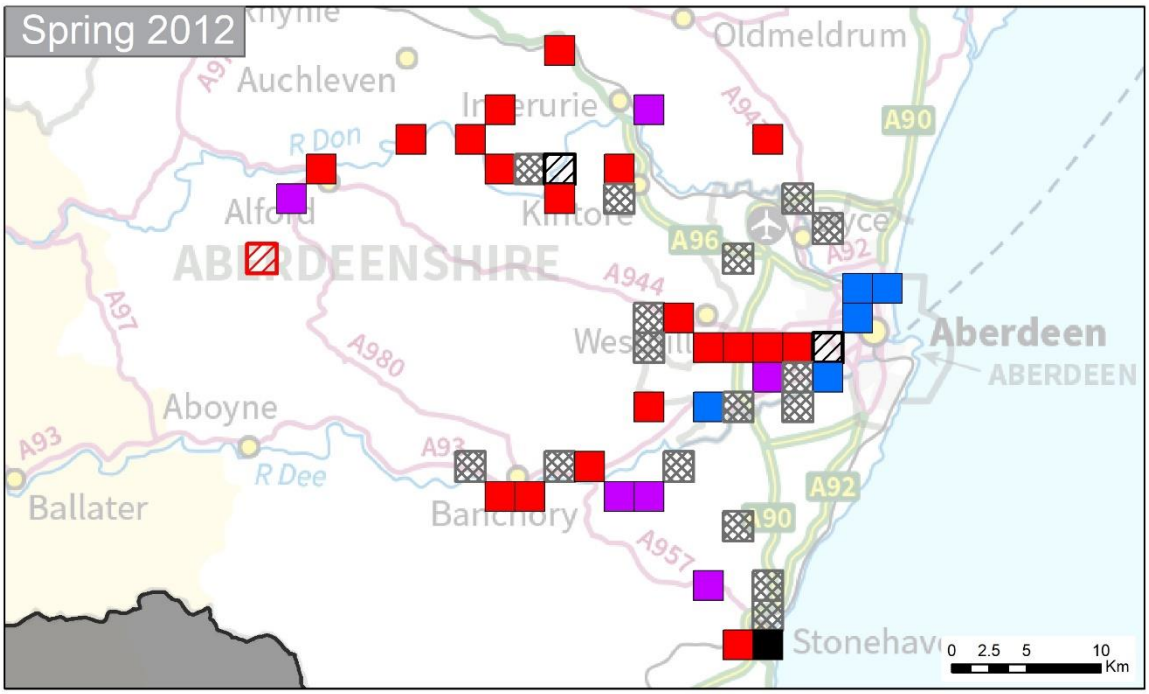
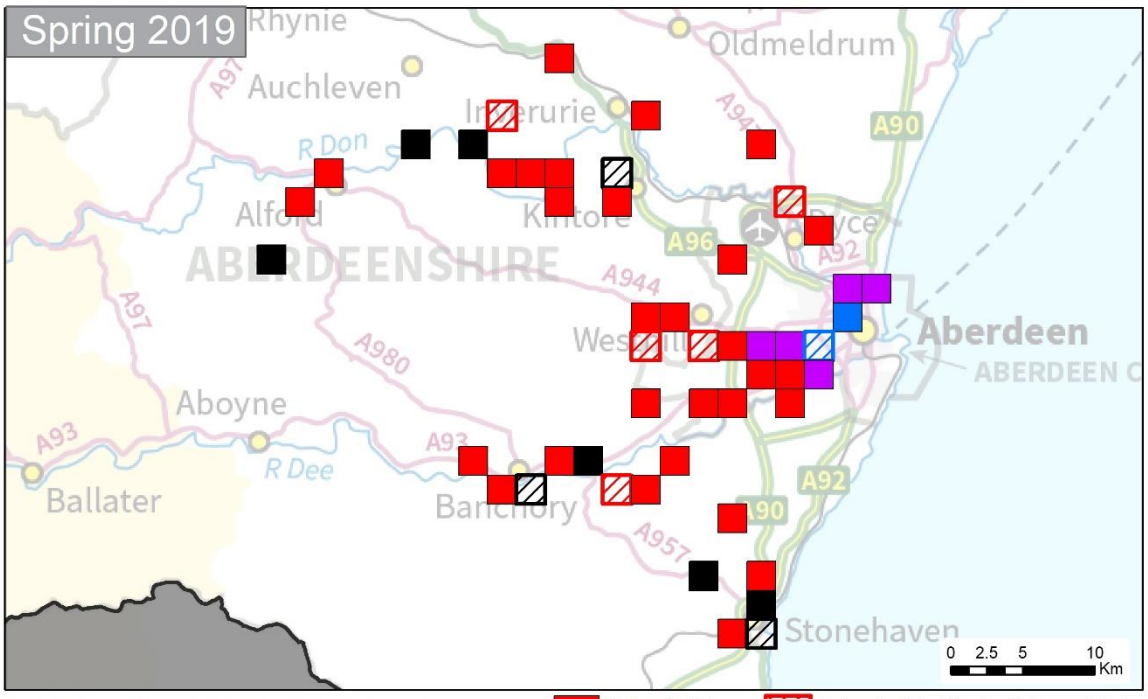
Tetrad Results - North East

SAVING SCOTLAND'S RED SQUIRRELS

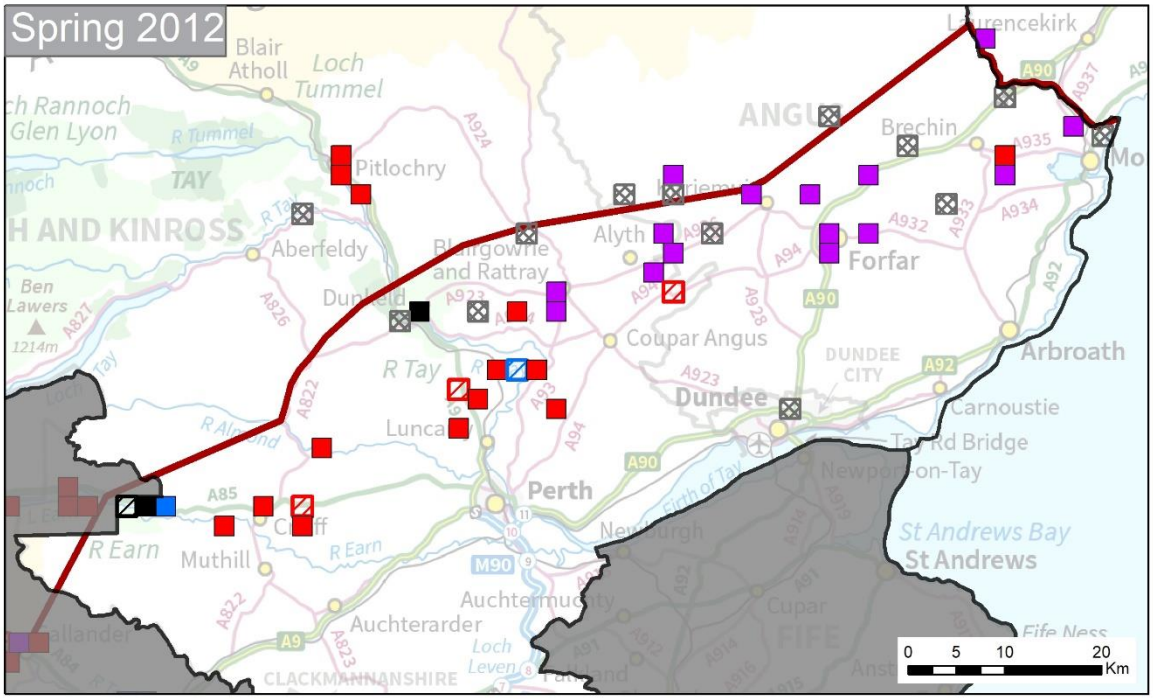


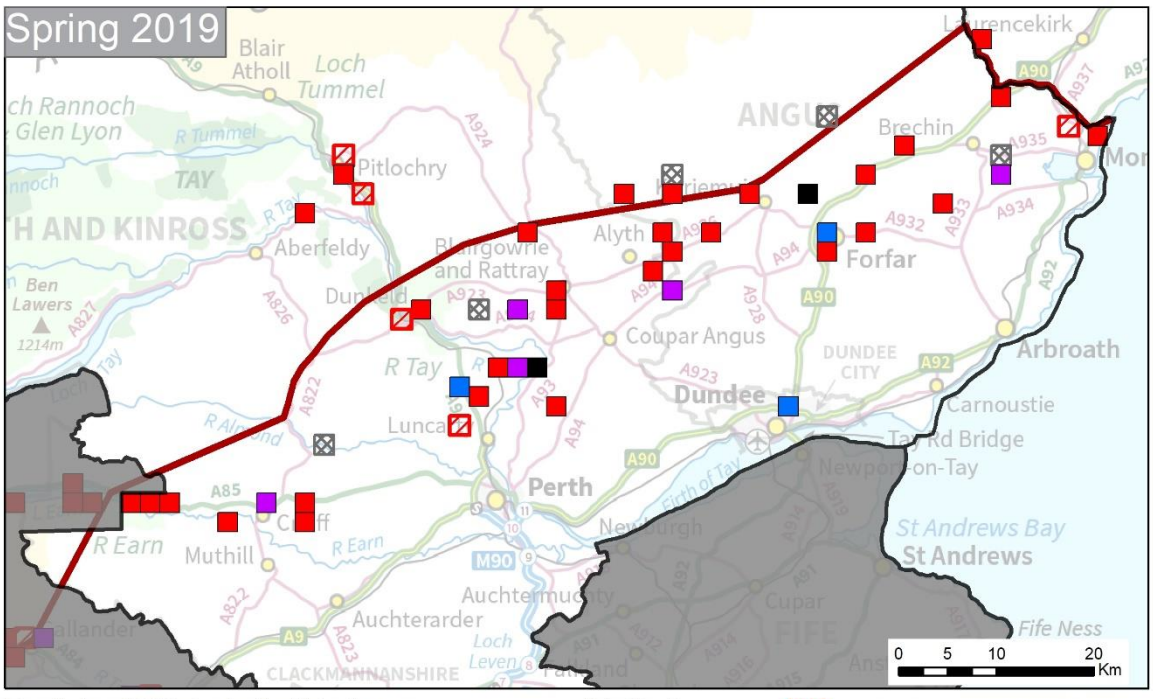


Results from SSRS standardised tetrad surveys
© Scottish Wildlife Trust 2019.
Contains OS data
© Crown copyright and database right 2019.
Date: 02/12/2019

- Red squirrel(s)
- Grey squirrel(s)
- Red_Grey squirrel(s)
- Neither squirrel
- Red squirrel(s) - Tetrad partially completed
- Grey squirrel(s) - Tetrad partially completed
- Neither squirrel - Tetrad partially completed
- Tetrad not surveyed

Tetrad Results - Tayside





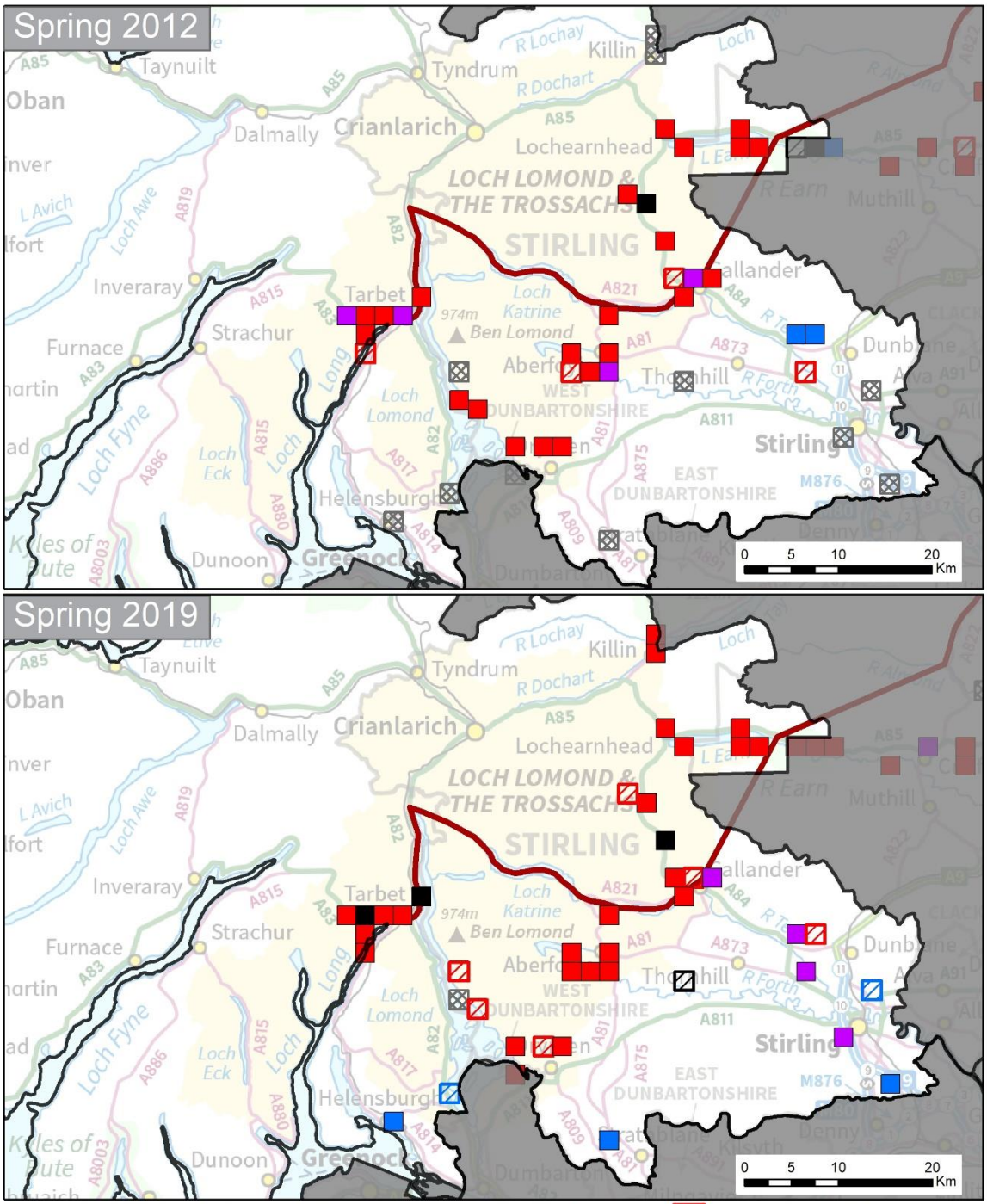
Results from SSRS standardised tetrad surveys

Date: 29/11/2019

Tetrad Results

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

Tetrad Results - Argyll & Trossachs



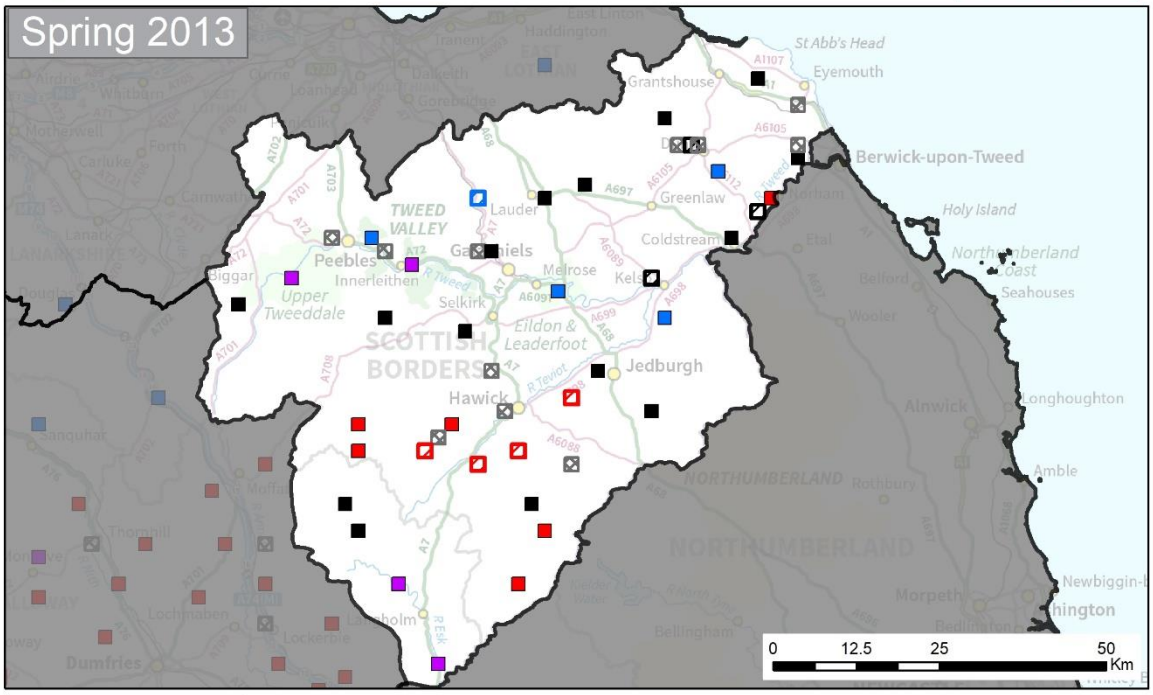
Results from SSRS standardised tetrad surveys

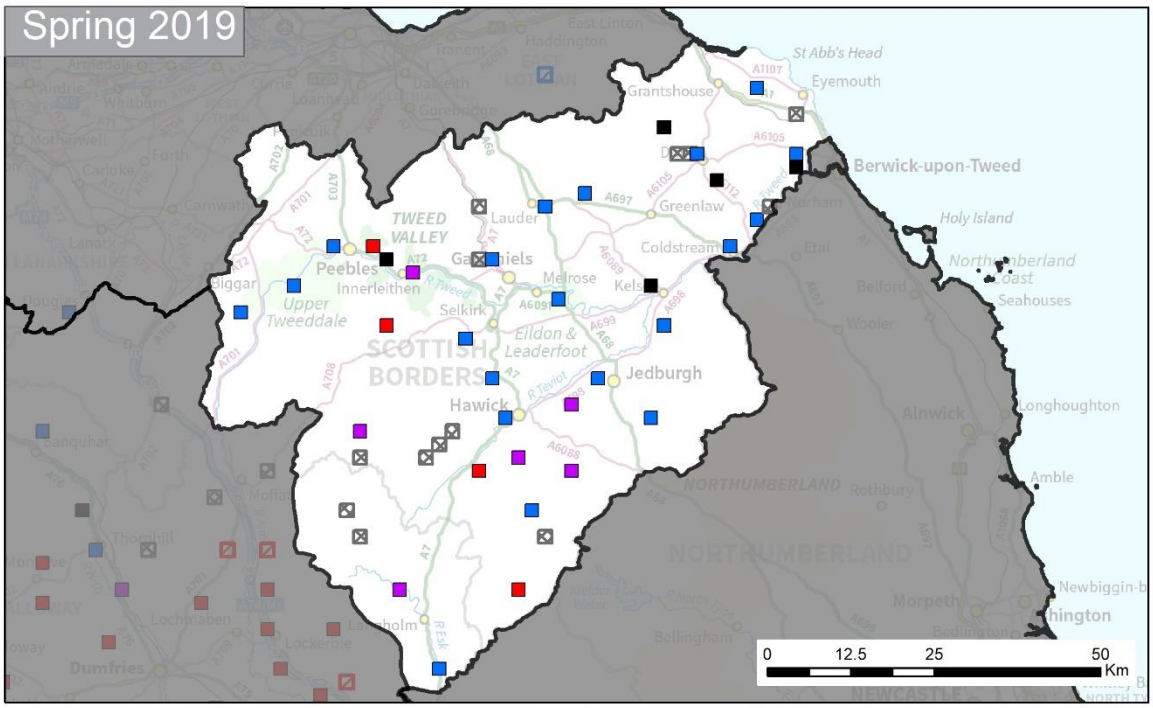
Date: 02/12/2019

Tetrad Results

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

Tetrad Results - South East Scotland



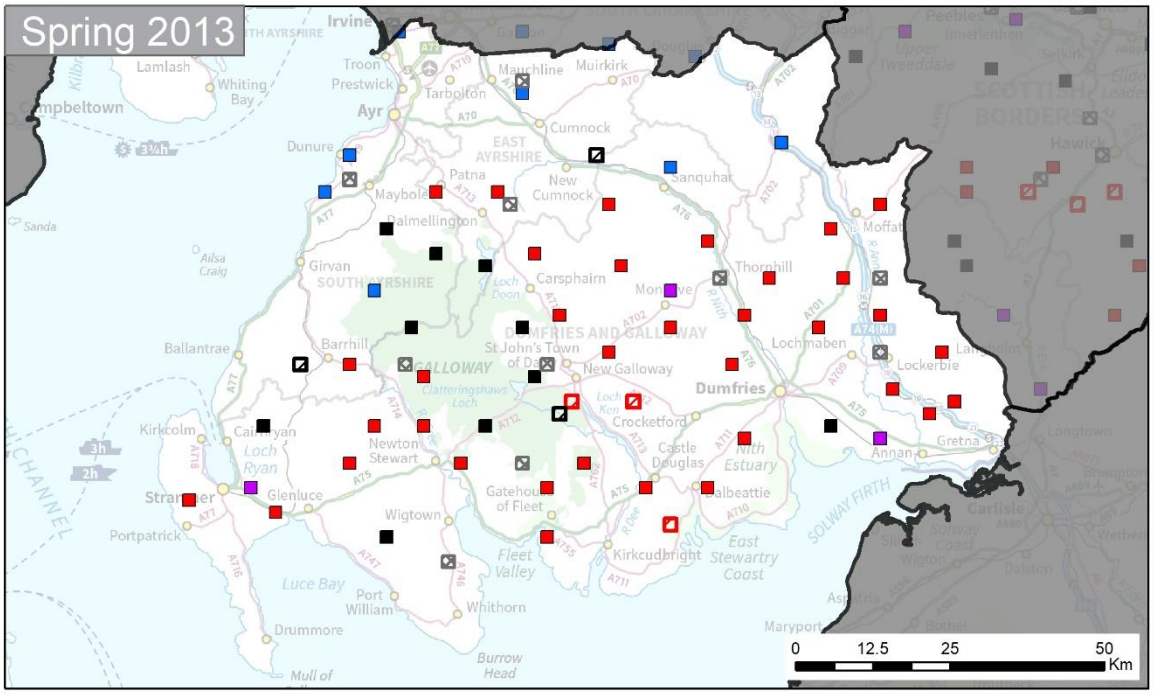


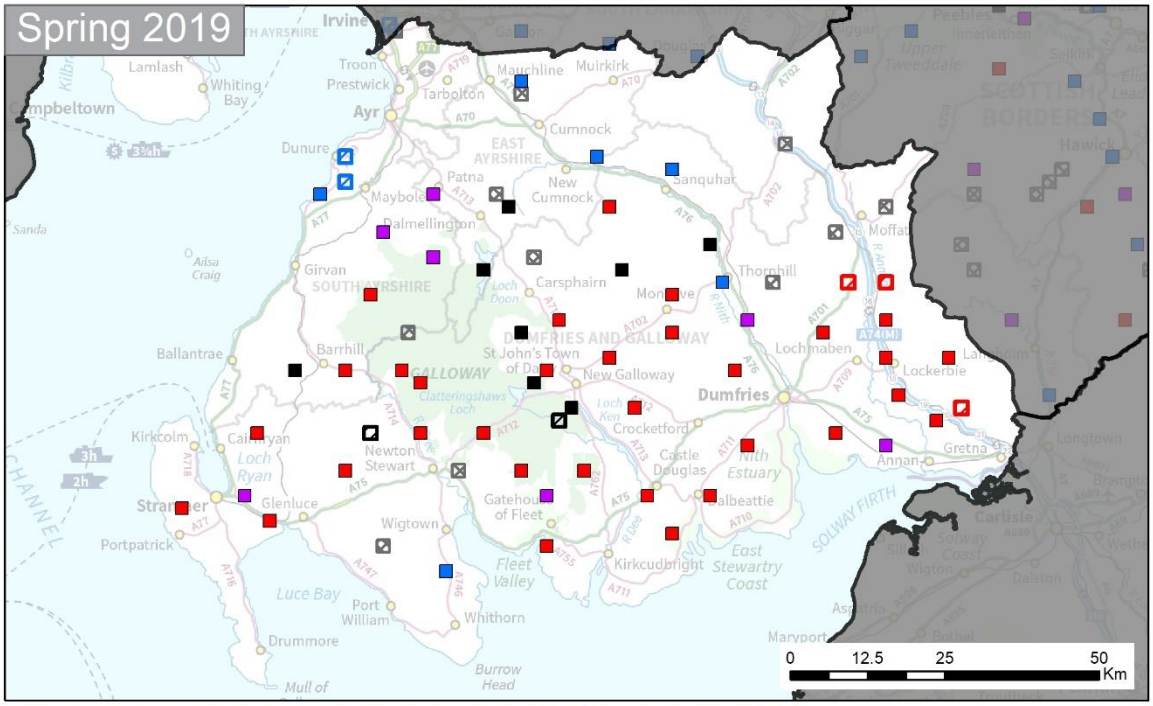
Results from SSRS standardised tetrad surveys

Date: 17/12/2019

- Red squirrel(s)
- Grey squirrel(s)
- Red_Grey squirrel(s)
- Neither squirrel
- Red squirrel(s) - Tetrad partially completed
- Grey squirrel(s) - Tetrad partially completed
- Neither squirrel - Tetrad partially completed
- Tetrad not surveyed

Tetrad Results - South West Scotland





Results from SSRS standardised tetrad surveys

Date: 17/12/2019

- Red squirrel(s)
- Grey squirrel(s)
- Red_Grey squirrel(s)
- Neither squirrel
- Red squirrel(s) - Tetrad partially completed
- Grey squirrel(s) - Tetrad partially completed
- Neither squirrel - Tetrad partially completed
- Tetrad not surveyed

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 approx. 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 in the first instance. In large blocks of conifer of cone-bearing age, areas of mature large-seeded broadleaved trees were prioritised and feeder boxes deployed at a density of around 1-3 per 10 ha. especially in habitat bottlenecks.

Once the rural areas were covered, 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, 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) and in 2018 the autumn surveying ceased at the full capacity with 44 boxes in some specific areas being monitored in 2019 for funding commitments.

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 2019 survey results from 126 completed survey boxes closely mirror those from 2018, indicating that red and grey squirrels across the North East have remained stable. There have been small changes in both grey and red squirrel distribution.

Red distribution has remained stable across the survey area with populations in Countesswells, Hazlehead Park, Seaton Park and Scotsmoor all been maintaining. Expansion of red squirrels has

been seen on the river Dee with red squirrels being detected along Inchgarth reservoir and Robert Gordon University on North Deeside and in Tollohill on South Deeside.

The small sub population of grey squirrel in Blackburn, Aberdeenshire is still being detected but these are being managed to prevent further establishment and should be removed in time following the efforts of a volunteer Grey Squirrel Officer. Grey squirrels in Straloch and on South Deeside have now been removed with no “grey only” sites being detected along the south bank of the river Dee.

This tallies with the findings of the Spring Tetrad surveys that both red and grey squirrel populations remain consistent across the region, however, from trapping data we know that in certain areas grey squirrel populations are at a very much lower density. We expect to see further reduction of grey squirrel occupancy in coming years.

Map showing the squirrel species detected at 126 single feeder-boxes in the Intensive Grey Squirrel Surveys in Spring 2019