



RESULTS OF SPRING 2016 SQUIRREL SURVEYS



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giving
nature
a home



ACKNOWLEDGEMENTS

The Saving Scotland's Red Squirrels Team thanks all the people who volunteered their valuable time to carry out these surveys as well as the painstaking work to identify all the hair samples. Thanks also to all those who helped make the feeder-boxes and assemble the survey packs. The surveys would not have been possible without your input. In addition, we greatly appreciate the access to woodlands granted by land managers throughout the Project area.

The Saving Scotland's Red Squirrels Team gratefully acknowledges the collaboration of our signatory partners: Scottish Wildlife Trust (lead partner), Scottish Natural Heritage, Forestry Commission Scotland, RSPB Scotland, Scottish Land & Estates and Red Squirrel Survival Trust, all of which are vital for the Project to be a success.

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

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1. SUMMARY

This report details the results of monitoring of both red and grey squirrels undertaken by Saving Scotland's Red Squirrels (SSRS) during Spring 2016. The results were compared with similar, annual surveys undertaken since 2011 in the North of Scotland and 2013 in the South of Scotland.

The results show that in the North of Scotland there has been a highly significant decline in the occurrence of grey squirrels since monitoring began in 2011. For the first time since monitoring in the North of Scotland began, this has been coupled with a short term but statistically significant increase in the occurrence of red squirrels when the 2016 results are compared with the results from the 2015 survey.

In the South of Scotland, red squirrels have expanded their occupancy as compared with grey squirrels for the first time since monitoring began in 2013, although this increase is not considered to be statistically significant. Overall, grey squirrel occupancy is shown to have increased to a statistically significant level across the region since 2013. We believe this to be associated with an exceptional masting year in the autumn of 2014, particularly as regards the superabundance of beech nuts. This led to increased over-winter survival and earlier breeding in 2015, which was evident in our 2015 trapping figures as a surge in grey squirrel numbers right across the country. In southern Scotland this seems to have resulted in a westwards spread of grey squirrels in 2015 into Dumfriesshire in our tetrad surveys. This westward drift has been maintained in 2016, but this needs to be balanced against our survey results for red squirrels, which have also done much better than the previous year.

2. AIM OF THIS REPORT

Saving Scotland's Red Squirrels (SSRS) is a project to stop the decline of Scotland's core red squirrel populations. North of the Central Belt 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 in and around Aberdeen, and by preventing their spread 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. In Aberdeenshire, grey squirrel control began in 2007 and in the Central Lowlands, control began in 2010.

South of the Central Belt, the initial aim of the project was to prevent the spread of squirrelpox (SQPV) northwards into the SQPV-free grey squirrels in the Central Belt. Unfortunately, while control efforts have significantly slowed the spread of the disease, it has been able to halt the spread altogether. We now expect a slow spread of Squirrelpox virus throughout grey squirrel populations in Scotland, apart from those in Aberdeen. However, the grey squirrel population control carried out to date has not only facilitated the persistence of red squirrels in the control areas, it has enabled these red squirrels to positively thrive. Consequently the project focus has now turned to protecting red squirrels in priority areas for red squirrel conservation (PARCs) under threat in southern Scotland.

Monitoring in the North East and the Central Lowlands was set up in 2011 to provide evidence on which to assess the effects of grey squirrel control on both red and grey squirrel populations. This document reports the results of the Spring 2016 surveys and compares them to results obtained in

each year between 2011 and 2015. We provide estimates of the level of change and assess whether the results suggest that our Red Squirrel Protection Network is achieving benefits for red squirrels.

In South Scotland, distribution monitoring was carried out for the first time in Spring 2013, with a view to detecting the relative distributions of red and grey squirrels, and repeated in 2014 and 2015. The Spring 2016 surveys continue the series of snapshots so that the short-term trends can now be seen.

3. METHODOLOGY

To determine red and grey squirrel presence in a particular area, monitoring tetrads (2km x 2km squares) were set up in 2011 for North East Scotland and the Central Lowlands (Argyll & Trossachs and Tayside), and in Spring 2013 for the Scottish Borders and Dumfries & Galloway. Each tetrad is identified by the grid reference of the southwestern 1km square. In each tetrad, four feeder-boxes were positioned to sample right across the square, 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.

Tetrads were considered to be 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 the samples collectively showed the presence of both species of squirrel.

Comparisons were made between survey results from consecutive years using Replacement indices (see below) and two-sample Binomial tests.

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

Replacement Index

In order to compare the results of pairs of tetrad surveys, we calculated a Replacement Index (RI) using a matrix showing the changes that occurred in each tetrad between two surveys. This index was devised by Usher *et al.* (1992) who used it to examine the dynamics of the two squirrel species within 10km grid squares for the whole of Britain from 1973 to 1988. Here we have adopted the index to summarise the complex of changes in the presence/absence of either squirrel species in each of the tetrads.

Following Usher *et al.* (1992) and Bryce (1997), the survey results from consecutive years were plotted in matrices such as those shown in Table 2 & Table 3 below. Only results from tetrads for which surveys had been completed in both years (“paired tetrads”) were used in these analyses. These matrices show all possible changes in the occupancy of the tetrads and how many fall into each of the four categories: “red squirrels only”, “both red and grey squirrels”, “neither species”, “grey squirrels only”. The rows describe the state of the tetrad during the earlier survey (Spring 2015 in Table 2) and the columns describe the tetrad during the later survey (Spring 2016 in Table 2). The shaded diagonal in

these matrices represent the status quo – no change in the occupancy of the tetrad. Figures above the shaded line represent changes in favour of grey squirrels and those below the line 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). Note that this index can range from +1 to -1, where either figure would represent a complete shift of occupancy from reds to greys (or both) or greys to reds (or both) respectively (Bryce 1997).

4. RESULTS

Table 1 sets out the number of tetrads detecting either squirrel species, both species or neither species in each year and these results are displayed graphically in

Figure 1 and Figure 2. The results for individual tetrads are presented in both mapped and tabular form in appendix 1 & appendix 2 respectively.

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	18	4	19	7	48	48
	Spring 2012	55	8	26	4	93	112
	Spring 2013	67	7	12	12	98	120
	Spring 2014	73	7	12	20	112	124
	Spring 2015	59	10	15	24	108	119
	Spring 2016	78	8	17	15	118	126
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

Figure 1: Proportion of tetrads with both species, either species or none detected for North Scotland

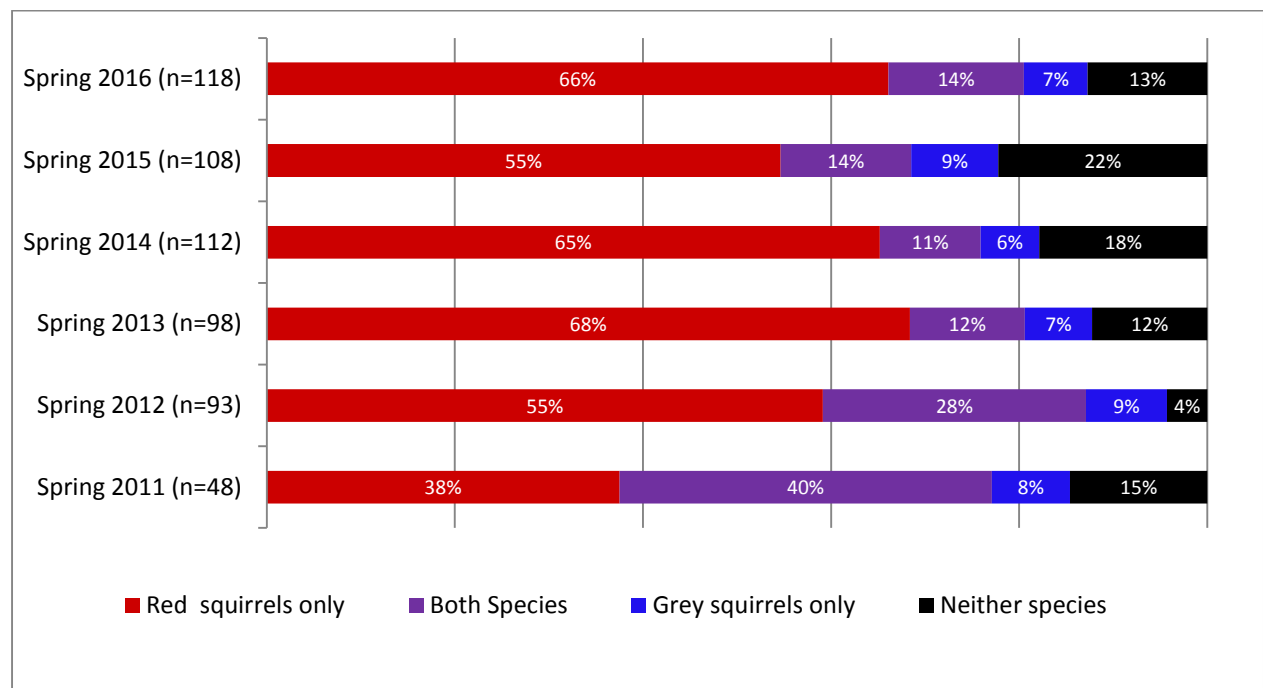
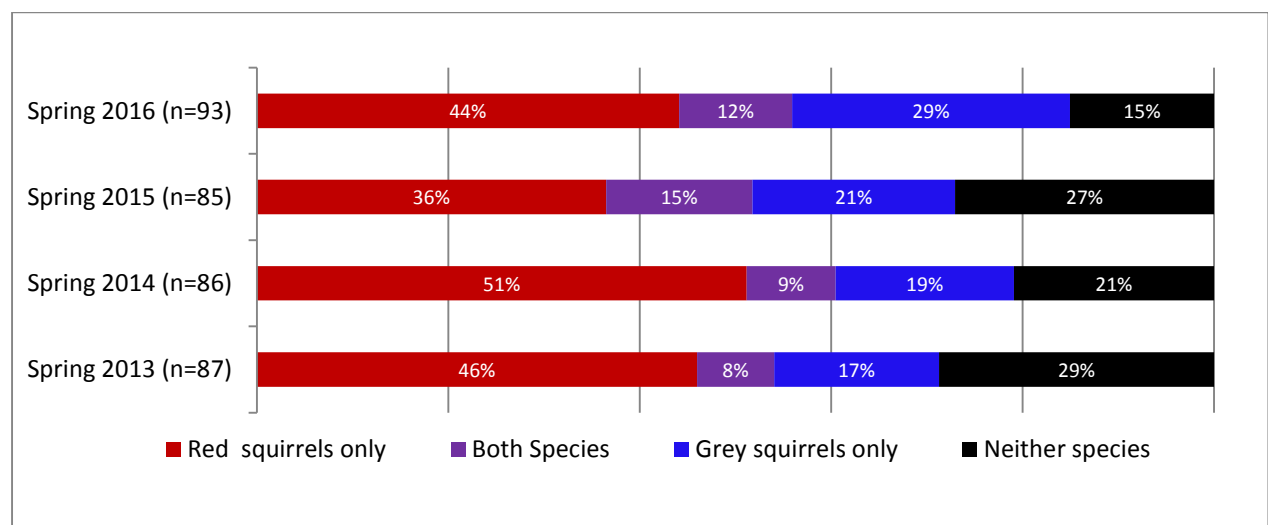


Figure 2: Proportion of tetrads with both species, either species or none detected for South Scotland



Replacement index

Matrices are presented for 2015/2016 for both the North (Table 2) and South of Scotland (Table 3) separately, and these results are presented graphically in Figure 3 & 4 respectively. Replacement indices for all pairs of consecutive years are presented in Table 4.

One sample t-tests run for each of the regions reveal that none of the mean replacement indices are significantly different from 0 at the 5% level.

Table 2: Matrix of changes in tetrad occupancy between 2015 and 2016 for the North of Scotland

North Scotland 2015/2016		Spring 2016				
		Red	Both	Neither	Grey	Total
Spring 2015	Red	49	2	3	0	54
	Both	4	10	0	1	15
	Neither	12	1	7	1	21
	Grey	0	1	2	6	9
	Total	65	14	12	8	99

Figure 3: Proportion of paired tetrads both species, either species or none detected for the North of Scotland (n=99)

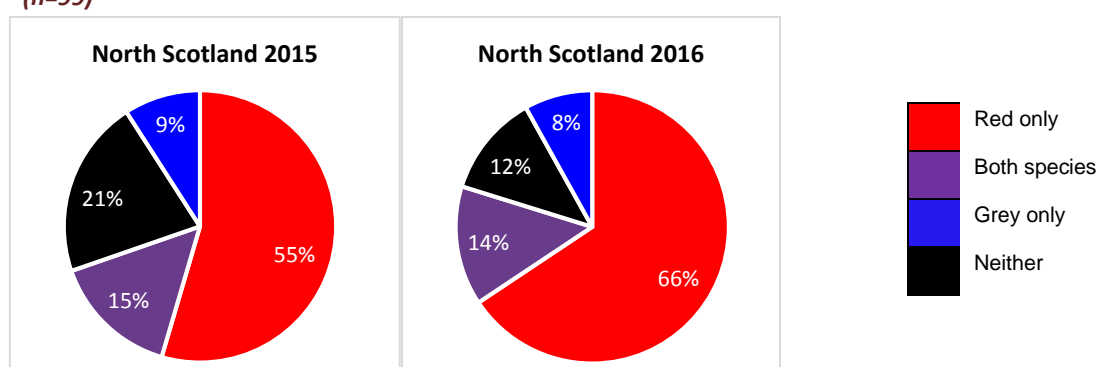


Table 3: Matrix of changes in tetrad occupancy between 2015 and 2016 for the South of Scotland

South Scotland 2015/2016		Spring 2016				
		Red	Both	Neither	Grey	Total
Spring 2015	Red	22	2	1	0	25
	Both	5	2	0	6	13
	Neither	5	2	9	3	19
	Grey	1	2	0	12	15
	Total	33	8	10	21	72

Figure 4: Proportion of paired tetrads with both species, either species or none detected for South Scotland (n=72)

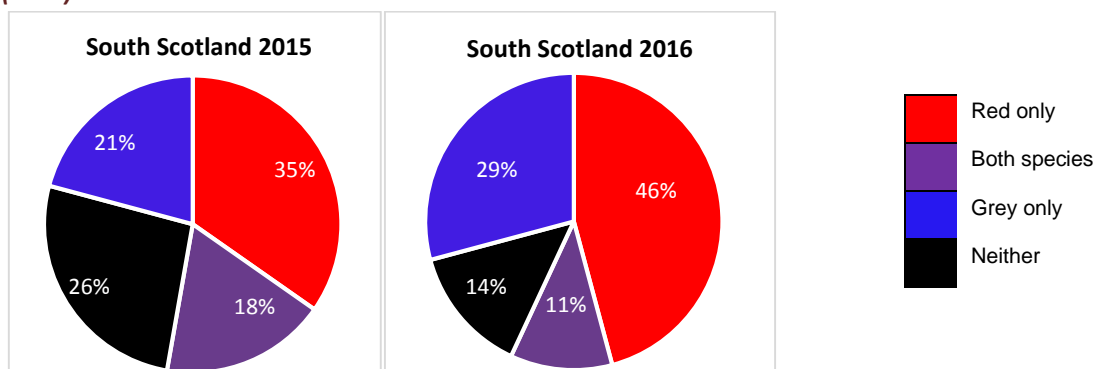


Table 4: Summary of Replacement Indices (n values in parentheses show the number of paired tetrads)

	North East	Argyll & Trossachs	Tayside	Whole North	Whole South
2011/2012	-0.62 (n=13)	-0.25 (n=25)	-0.25 (n=4)	-0.37 (n=42)	n/a
2012/2013	0.08 (n=27)	-0.04 (n=28)	-0.24 (n=21)	-0.05 (n=76)	n/a
2013/2014	0.04 (n=33)	-0.08 (n=27)	0.04 (n=26)	0.00 (n=86)	0.03 (n=74)
2014/2015	0.03 (n=45)	0.05 (n=21)	0.13 (n=27)	0.06 (n=93)	0.09 (n=66)
2015/2016	-0.26 (n=48)	0.00 (n=26)	-0.09 (n=25)	-0.14 (n=99)	-0.05 (n=72)
Mean	-0.15	-0.06	-0.08	-0.10	0.02

5. DISCUSSION

North Scotland

The results from North Scotland as a whole indicate that there has been a slight increase in the occupancy of red squirrels across the area when compared with the results from the Spring 2015 surveys. The results suggest that the change is due to red squirrels moving into areas that previously had neither species detected (Figures 1 & Figure 3).

The replacement indices (Tables 2-4) paint a similar picture. Across the whole of the North of Scotland, a negative replacement index (thus indicating a change in favour of red squirrels) was obtained when comparing paired tetrads from 2016 and 2015. This is in contrast to the replacement indices obtained when comparing 2014/2015 and 2013/2014 which were positive (change in favour of grey squirrels) and neutral (no change at all) respectively. It is encouraging to see that the mean replacement index for the whole of the North of Scotland is negative, suggesting an overall change in favour of red squirrels since monitoring started in 2011. This picture is confirmed by binomial tests (not presented), which show highly statistically significant reductions in the proportion of tetrads occupied by grey squirrels across the six year study period.

The broad trends seen across the whole of the north are reflected in the individual region (Table 4). Replacement Indices calculated for the North East and Tayside are both favourable for red squirrels for the 2015/2016 comparison, and the equivalent index for Argyll & Trossachs is zero, indicating no net change in occupancy. The mean replacement indices for all three regions are negative. Binomial tests run on data from the individual regions (not presented) show significant decreases in the proportion of tetrads occupied by grey squirrels between 2011 and 2012 in the North East and between 2012 and 2013 in Tayside. As a whole, the data suggest that following a sharp decline in grey squirrel occupancy during the early years of monitoring, subsequent grey squirrel control efforts have managed to constrain the species to this reduced range – presumably despite ongoing recruitment from the central belt. Over the same period, red squirrel occupancy in the area has either stayed constant or increased slightly.

South Scotland

Within the South of Scotland, the replacement index obtained when comparing paired tetrads from the 2015 and 2016 surveys is negative, indicating a slight change in squirrel occupancy in favour of

reds. This result is particularly encouraging following the 2013/2014 and 2014/2015 comparisons, both of which returned positive replacement indices in favour of grey squirrels. Figure 2 & 3 suggest that over the course of 2015 – 2016, both red and grey squirrels increased their occupancy within the area and that, similarly to the North of Scotland, these increases in range were due to both species being detected in areas where neither species were previously detected. Unfortunately, there was a slight decrease in the proportion of tetrads where both species were present together.

Despite the promising results of the 2016 spring survey, the mean replacement index for the south of Scotland is still positive, suggesting a trend of replacement in favour of grey squirrels over the four years of surveys. This picture is reinforced statistically – a comparison of the proportion of all completed tetrads occupied by grey squirrels in 2013 and 2016 (not presented) shows a statistically significant increase in the proportion of tetrads occupied by grey squirrels across this period. It is notable, however, that there has also been an increase in the proportion of tetrads occupied by red squirrels; this proportion has also increased, although not to a statistically significant degree.

With each passing year we learn more about squirrel population interactions and the effect on species range – thanks to the systematic data collected over the SSRS project period. This is essential in helping us to assess the effects of grey squirrel control on both red and grey squirrel populations, and to determine just how much effort will be necessary over the years to maintain the red squirrel population at viable size.

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

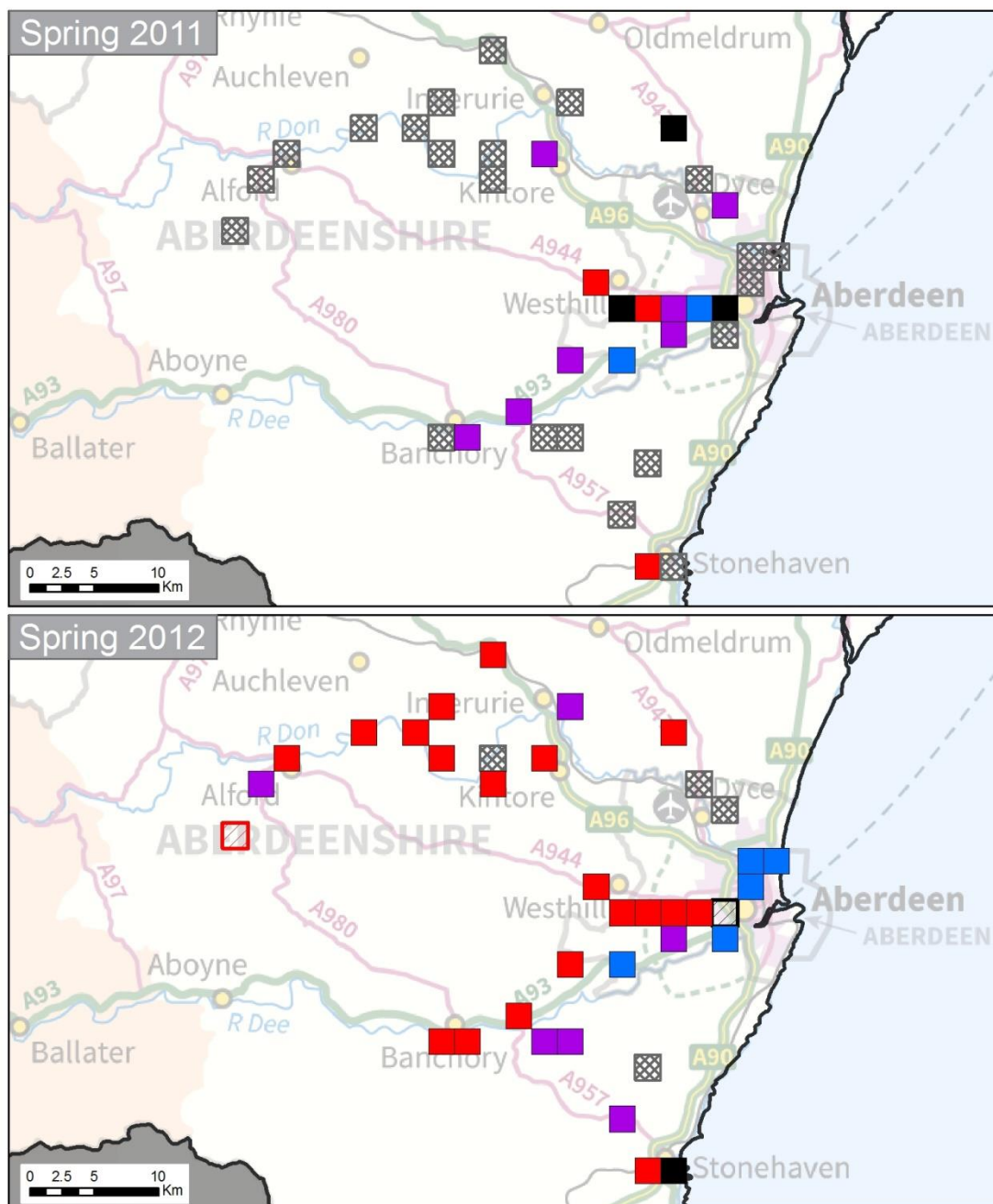
- Bryce, J. (1997) Changes in the distributions of Red and Grey Squirrels in Scotland. *Mammal Review*, **27**, 171-176.
- Usher, M.B., Crawford, T.J. & Banwell, J.L. (1992) An American invasion of Great Britain: The case of the native and alien squirrel (*Sciurus*) species. *Conservation Biology*, **6**, 108-115.

7. APPENDIX 1

Tetrad Results 2016 – Maps showing comparisons between years



Tetrad Results - North East



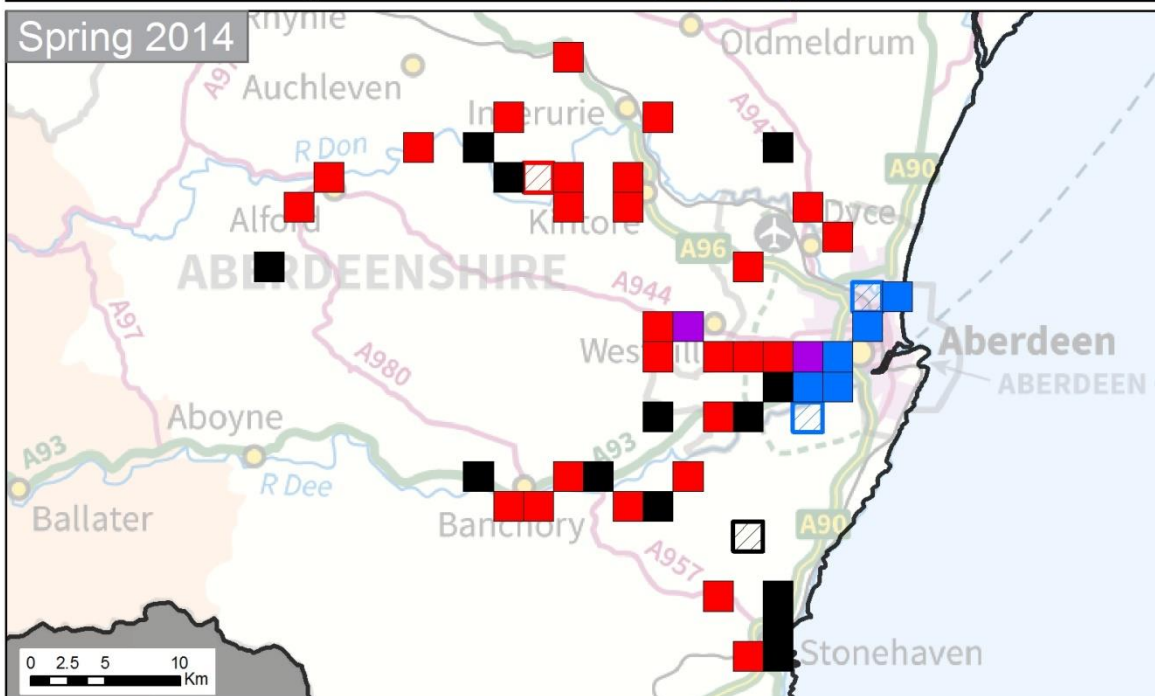
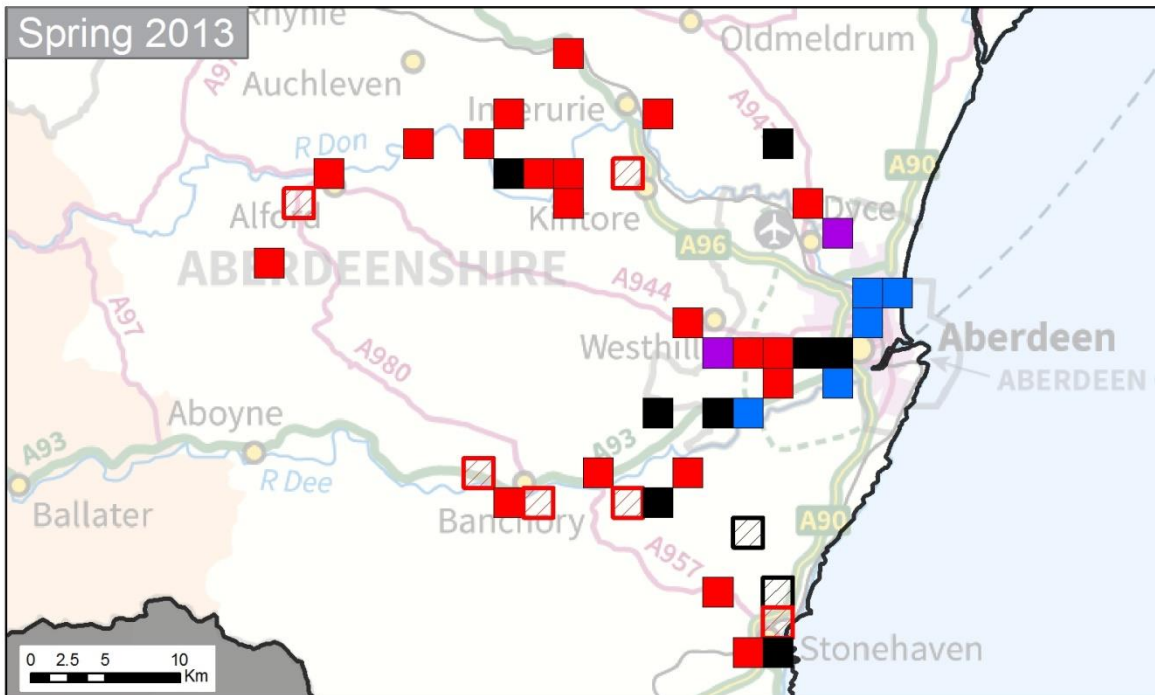
Results from SSRS standardised tetrad surveys
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Date: 12/08/2014

Tetrad Results (complete)

- Red squirrel(s)
- Grey squirrel(s)
- Red & Grey squirrel(s)
- Neither squirrel

Tetrad Results (partial)

- Red squirrel(s)
- Neither squirrel
- Tetrad not surveyed



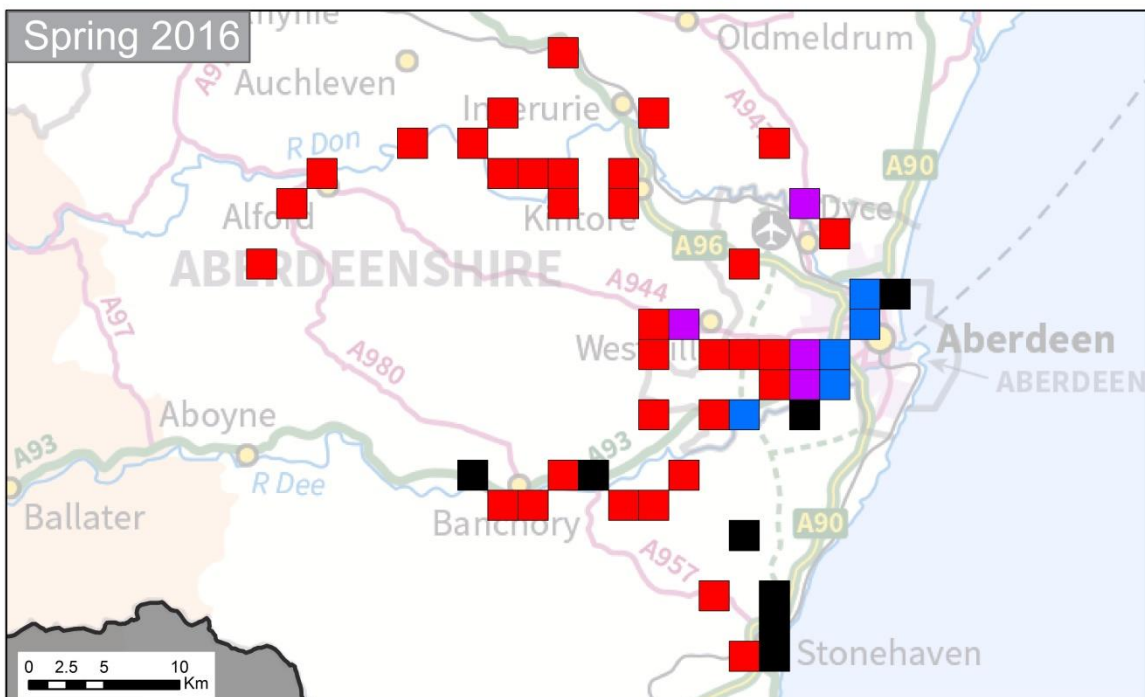
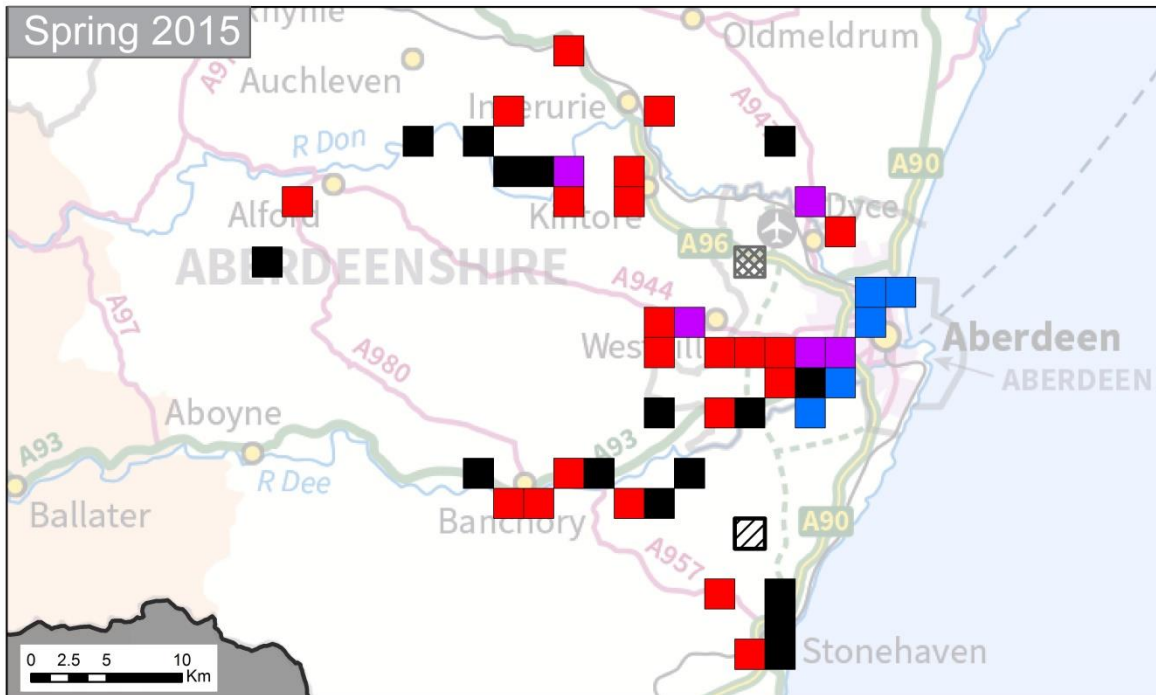
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Date: 12/08/2014

Tetrad
Results
(complete)

Red squirrel(s)
Grey squirrel(s)
Red & Grey squirrel(s)
Neither squirrel

Tetrad
Results
(partial)

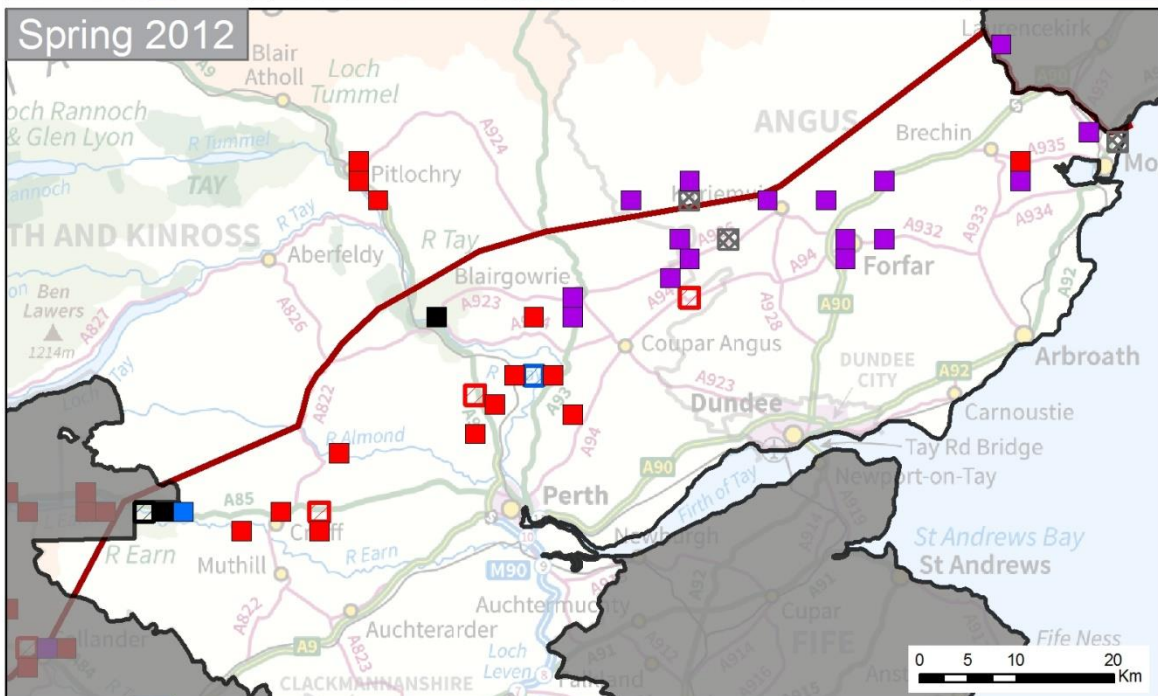
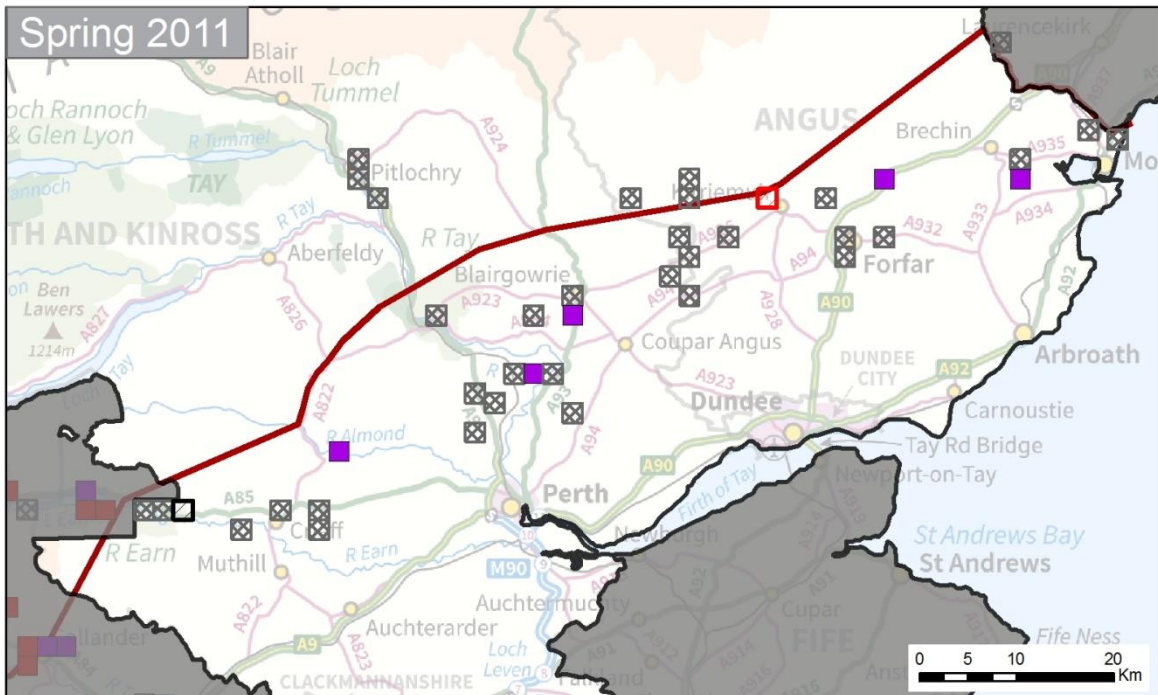
Red squirrel(s)
Grey squirrel(s)
Neither squirrel



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Date: 16/11/2016

Tetrad Results

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



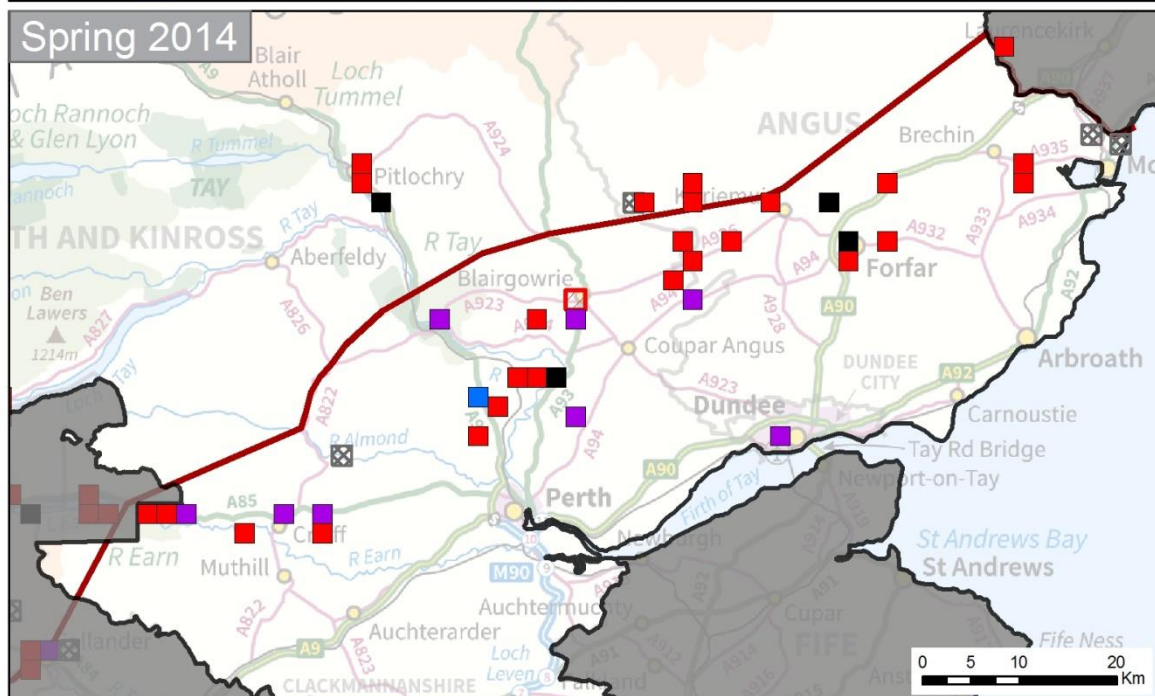
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Date: 12/08/2014

**Tetrad
Results
(complete)**





- Red squirrel(s)
- Grey squirrel(s)
- Red & Grey squirrel(s)
- Neither squirrel

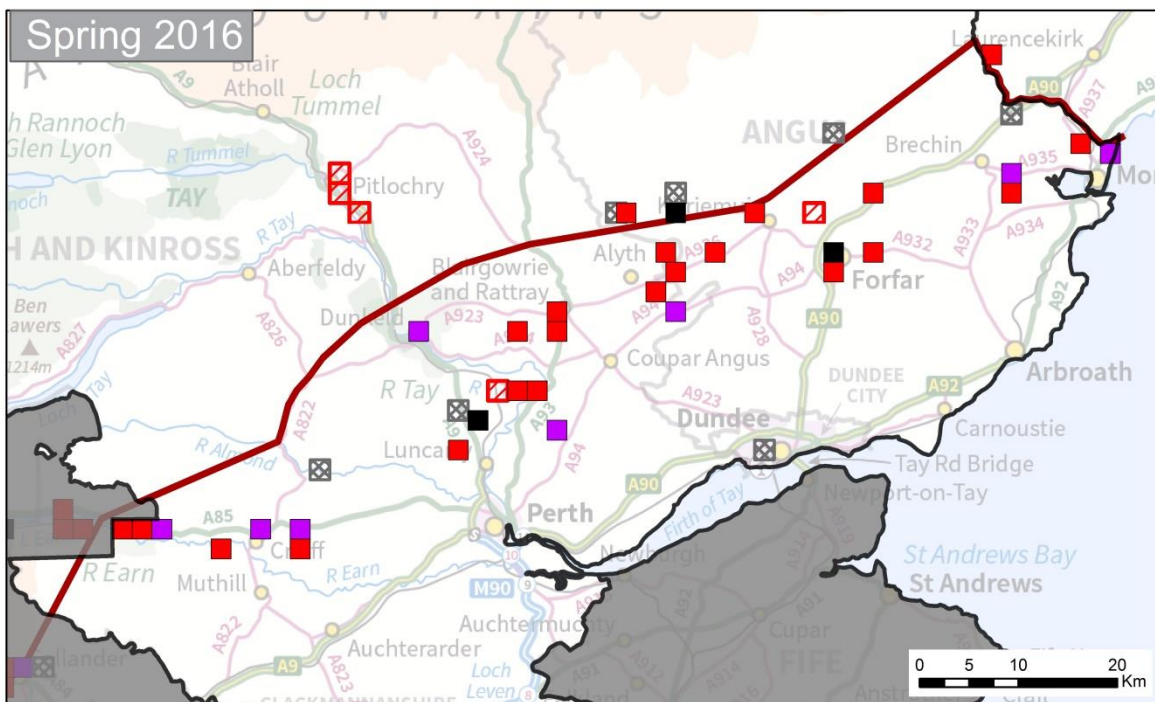
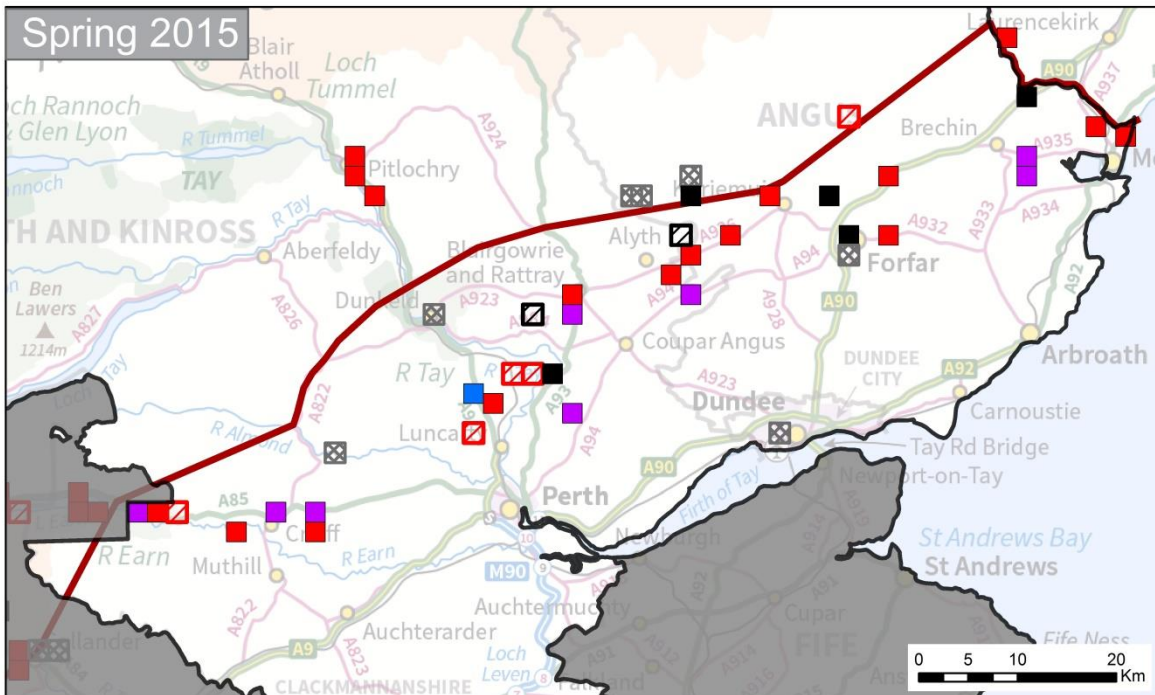
**Tetrad
Results
(partial)**

- Red squirrel(s)
- Grey squirrel(s)
- Neither squirrel
- Tetrad not surveyed
- Red squirrel protection line



Tetrad Results (partial)

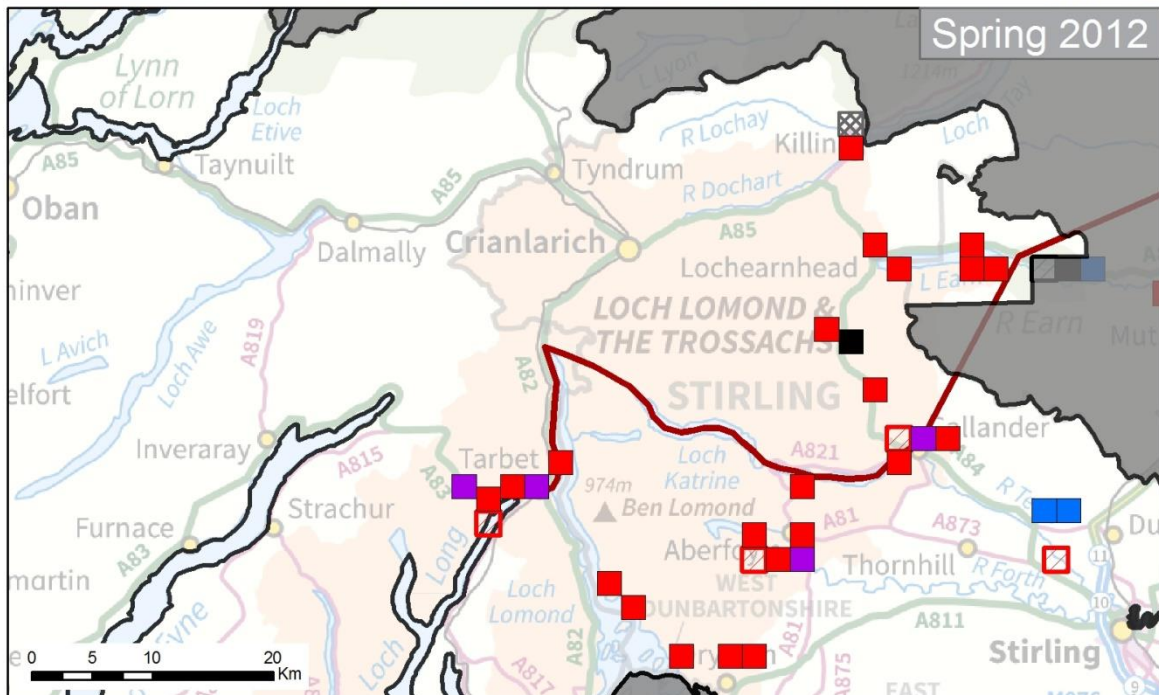
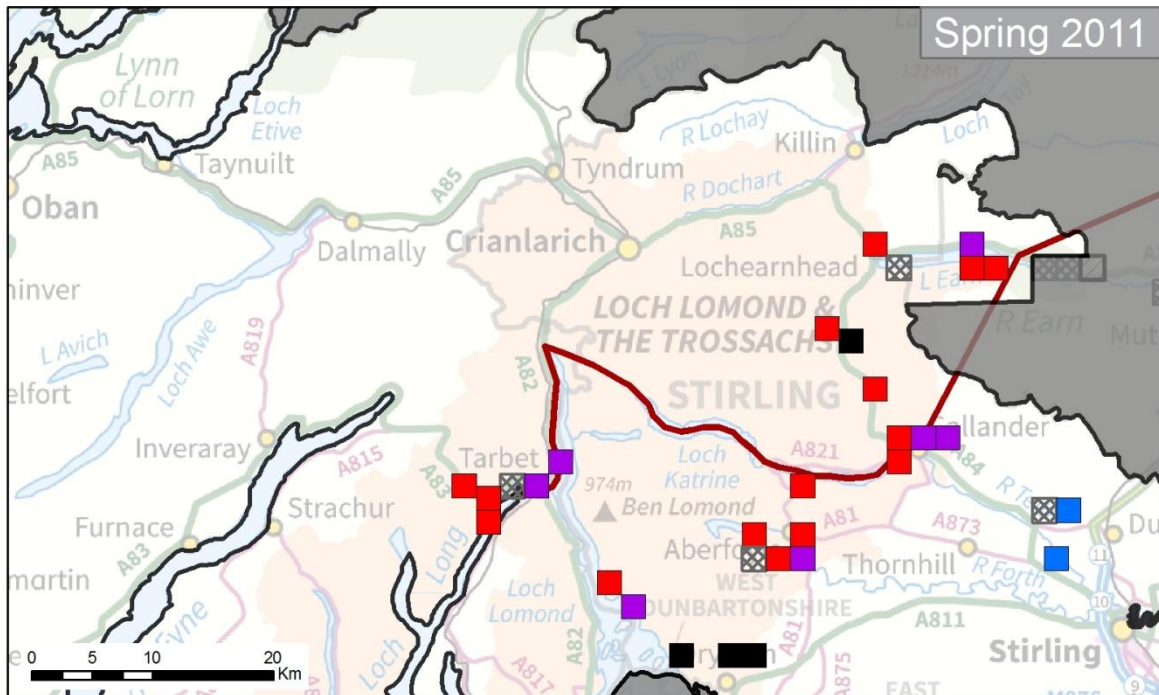
-  Red squirrel(s)
-  Neither squirrel
-  Tetrad not surveyed
-  Red squirrel protection line



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Tetrad Results

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



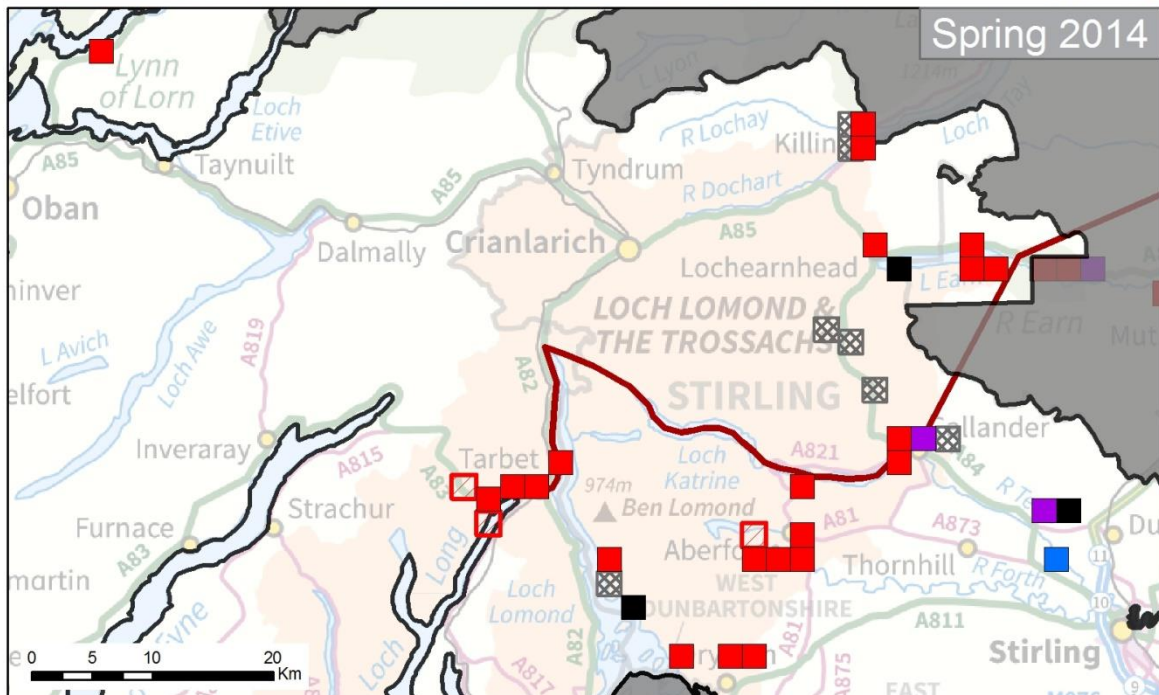
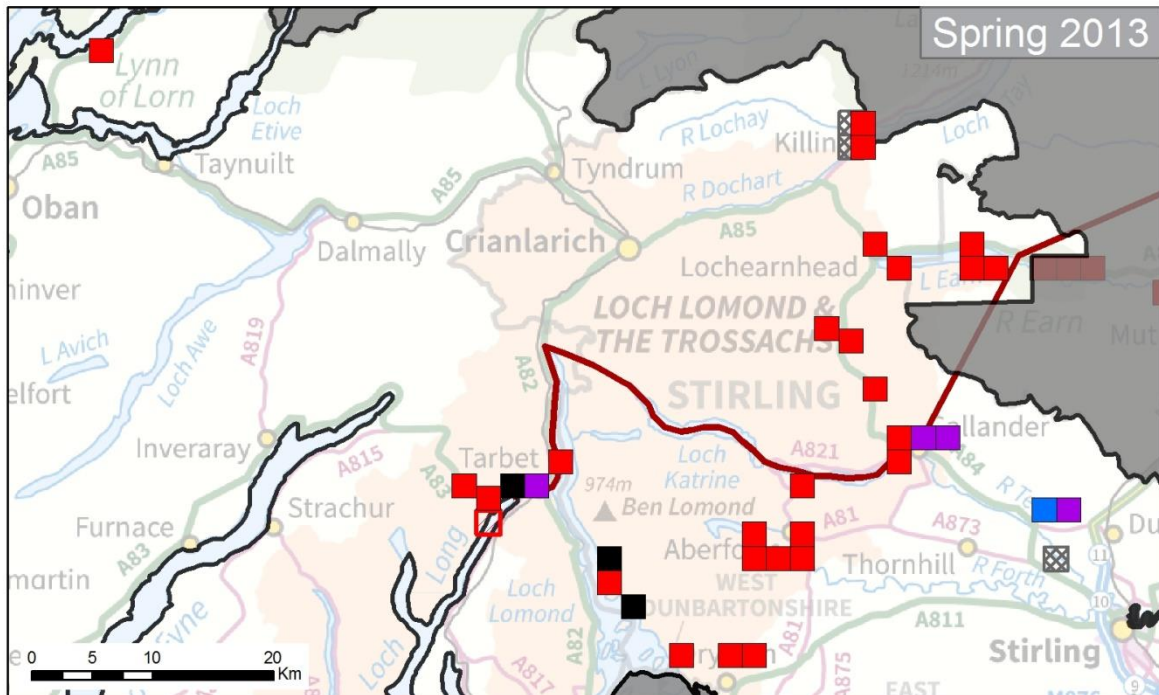
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**Tetrad
Results
(complete)**

Red squirrel(s)
Grey squirrel(s)
Red & grey squirrel(s)
Neither squirrel

**Tetrad
Results
(partial)**

Red squirrel(s)
Neither squirrel
Tetrad not surveyed
Red squirrel protection line



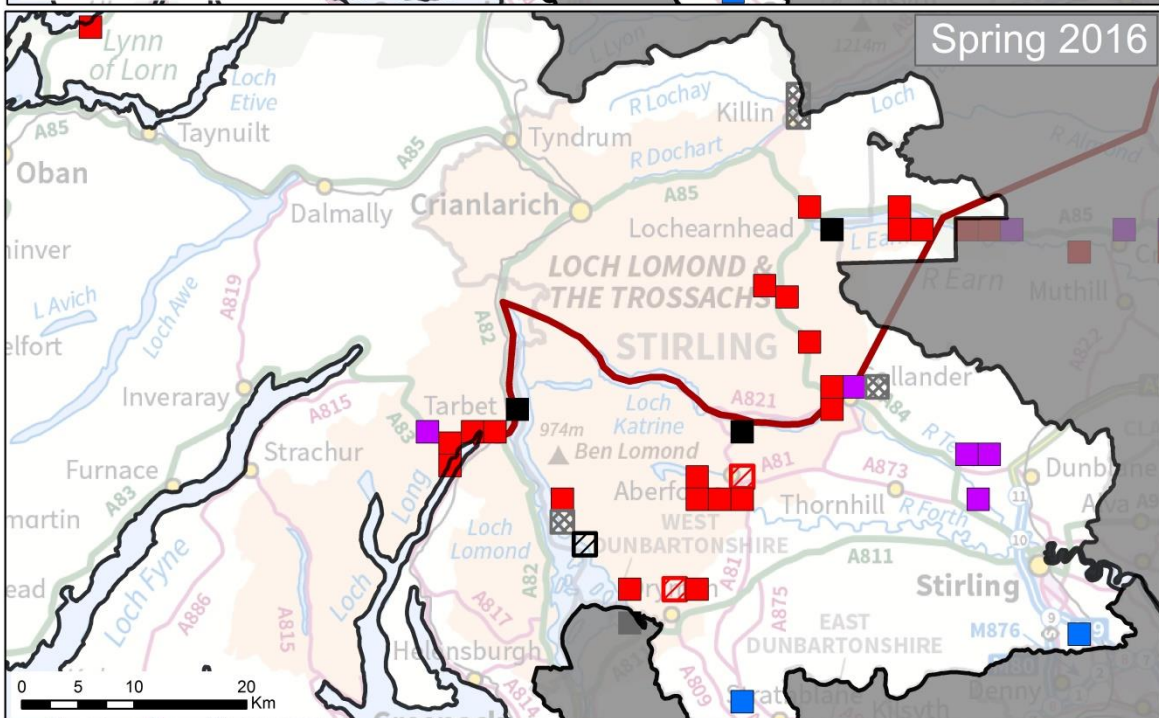
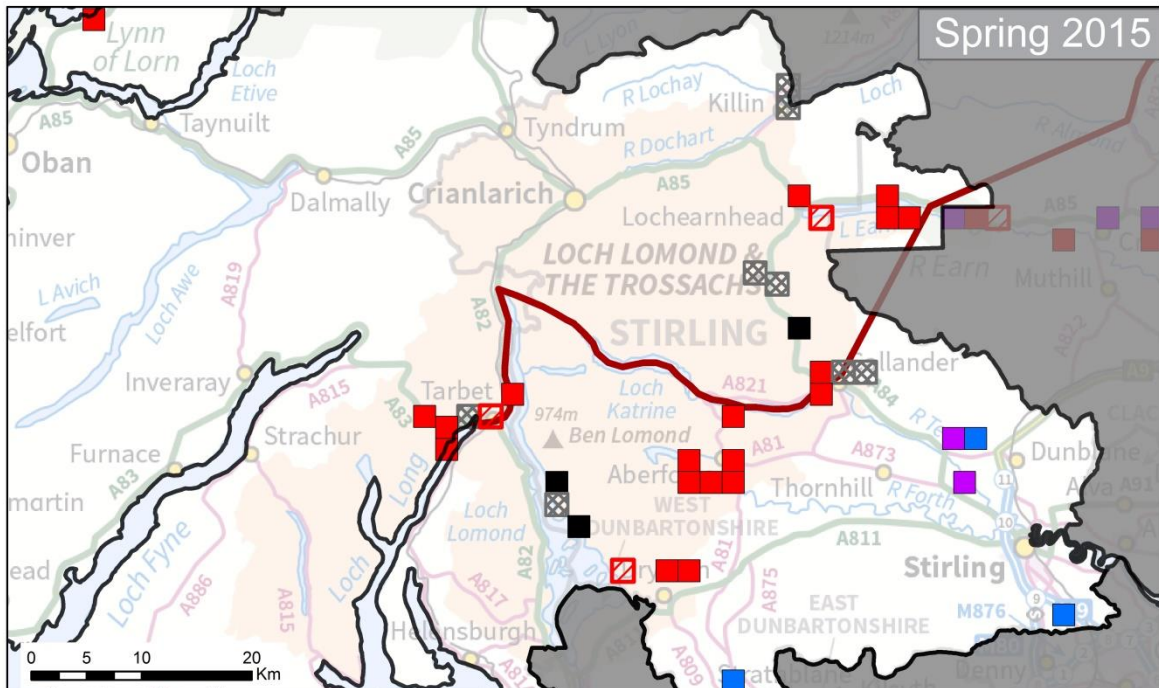
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Tetrad
Results
(complete)

Red squirrel(s)
Grey squirrel(s)
Red & Grey squirrel(s)
Neither squirrel

Tetrad
Results
(partial)

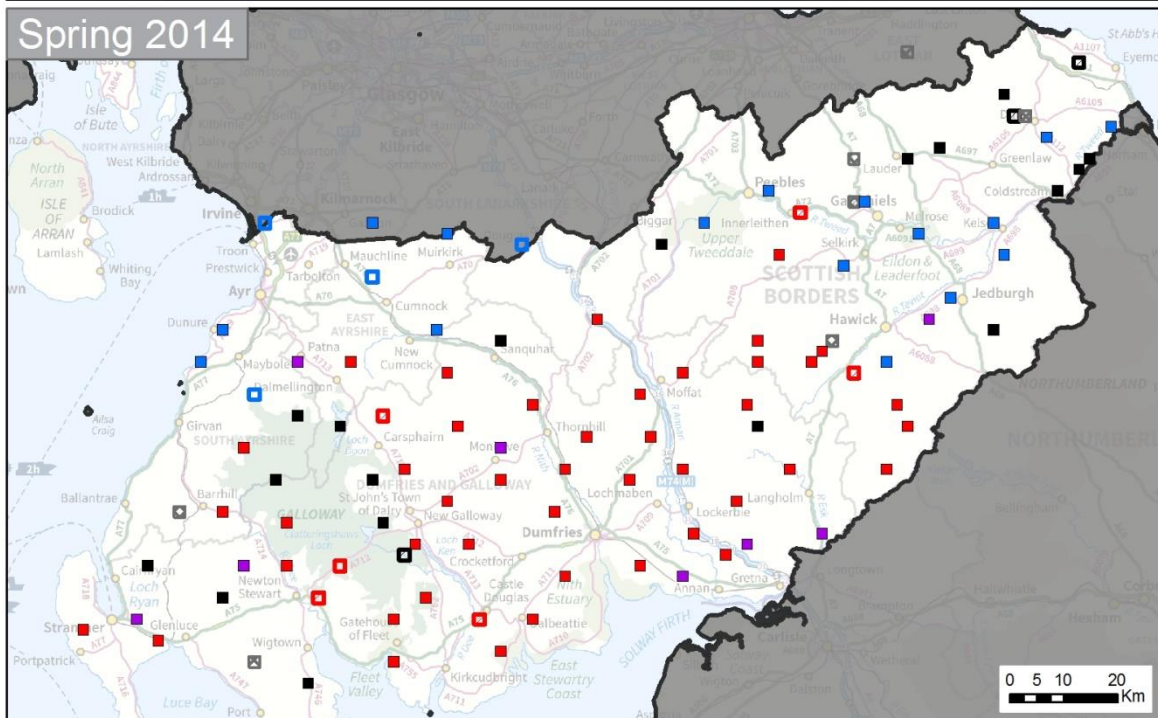
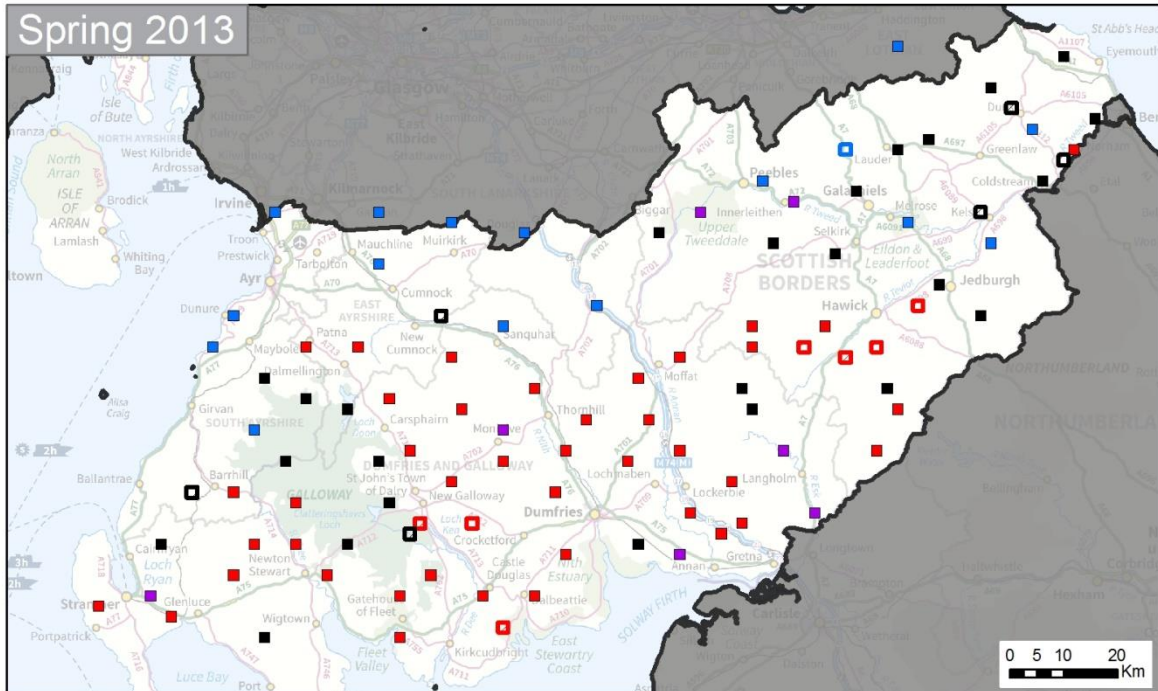
Red squirrel(s)
Tetrad not surveyed
Red squirrel protection line



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Tetrad Results

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



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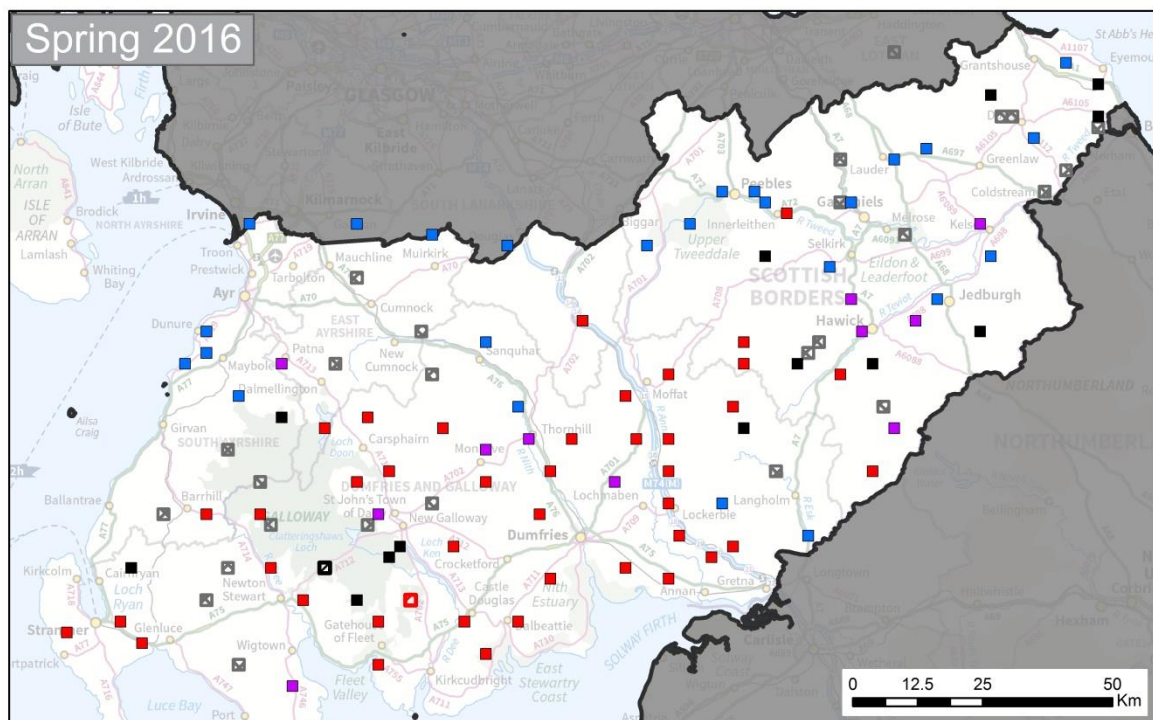
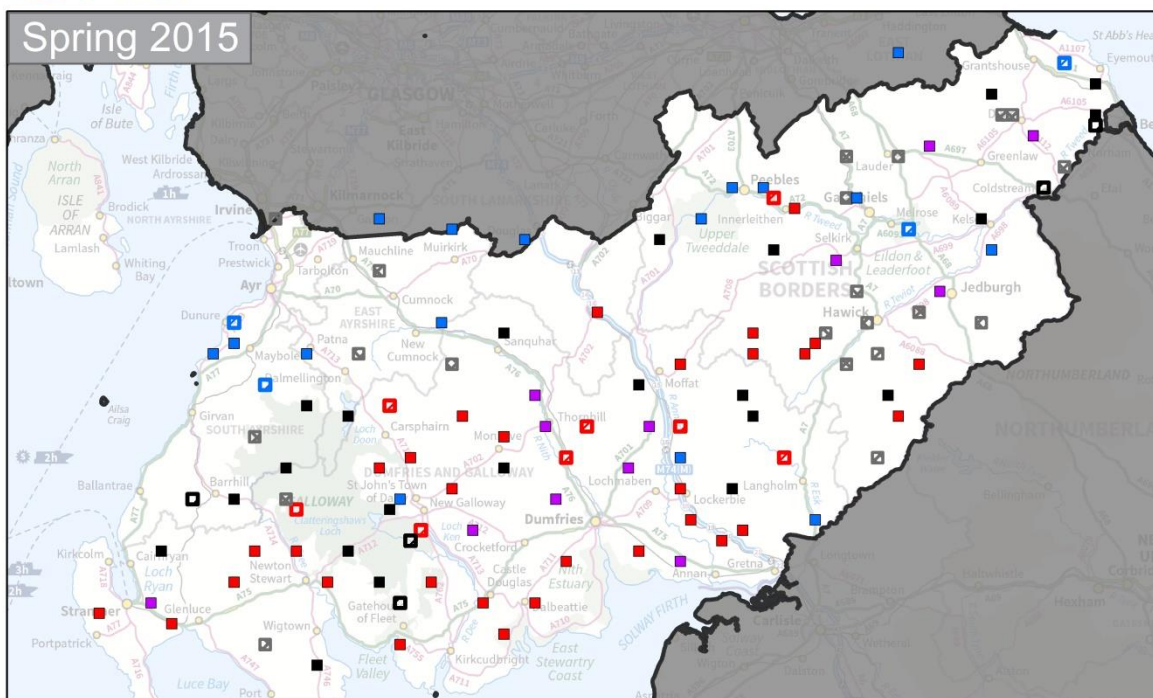
**Tetrad
Results
(complete)**

Red squirrel(s)
Grey squirrel(s)
Red & Grey squirrel(s) (partial)
Neither squirrel

**Tetrad
Results**

Red squirrel(s)
Grey squirrel(s)
Neither squirrel

⊠ Tetrad not surveyed



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Date: 16/11/2016



8. APPENDIX 2

Tetrad results – Tables

NORTH SCOTLAND					
North East		Argyll & Trossachs		Tayside	
Tetrad	Species	Tetrad	Species	Tetrad	Species
NJ5210	Red only	NM9440	Red only	NN7222	Red only
NJ5414	Red only	NN2404	Both species	NN7422	Red only
NJ5616	Red only	NN2601	Red only	NN7622	Both species
NJ6218	Red only	NN2603	Red only	NN8220	Red only
NJ6618	Red only	NN2804	Red only	NN8622	Both species
NJ6816	Red only	NN3004	Red only	NN9020	Red only
NJ6820	Red only	NN3206	Neither species	NN9022	Both species
NJ7016	Red only	NN4800	Red only	NN9456	Red only
NJ7214	Red only	NN5200	Red only	NN9458	Red only
NJ7216	Red only	NN5204	Neither species	NN9654	Red only
NJ7224	Red only	NN5417	Red only	NO0242	Both species
NJ7614	Red only	NN5616	Red only	NO0630	Red only
NJ7616	Red only	NN5632	Red only	NO0833	Neither species
NJ7800	Red only	NN5634	Red only	NO1036	Red only
NJ7804	Red only	NN5812	Red only	NO1236	Red only
NJ7806	Red only	NN5824	Red only	NO1242	Red only
NJ7820	Red only	NN6006	Red only	NO1436	Red only
NJ8006	Both species	NN6008	Red only	NO1632	Both species
NJ8200	Red only	NN6022	Neither species	NO1642	Red only
NJ8204	Red only	NN6208	Both species	NO1644	Red only
NJ8400	Grey only	NN6622	Red only	NO2354	Red only
NJ8404	Red only	NN6624	Red only	NO2646	Red only
NJ8410	Red only	NN6822	Red only	NO2750	Red only
NJ8602	Red only	NN7202	Both species	NO2844	Both species
NJ8604	Red only	NN7402	Both species	NO2848	Red only
NJ8618	Red only	NN7690	Grey only	NO2854	Neither species
NJ8800	Neither species	NS3698	Red only	NO3250	Red only
NJ8802	Both species	NS3894	Neither species	NO3654	Red only
NJ8804	Both species	NS4287	Neither species	NO4254	Red only
NJ8814	Both species	NS4290	Red only	NO4448	Red only
NJ9002	Grey only	NS4690	Red only	NO4450	Neither species
NJ9004	Grey only	NS4890	Red only	NO4850	Red only
NJ9012	Red only	NS4898	Red only	NO4856	Red only
NJ9206	Grey only	NS5098	Red only	NO6070	Red only
NJ9208	Grey only	NS5280	Grey only	NO6256	Red only
NJ9408	Neither species	NS5298	Red only	NO6258	Both species
NO6696	Neither species	NS7398	Both species	NO6961	Red only
NO6894	Red only	NS8286	Grey only	NO7260	Both species
NO7094	Red only				
NO7296	Red only				
NO7496	Neither species				
NO7694	Red only				
NO7894	Red only				
NO8096	Red only				
NO8288	Red only				
NO8484	Red only				
NO8492	Neither species				
NO8684	Neither species				
NO8686	Neither species				
NO8688	Neither species				

Note - Tetrads listed in **bold** were partially completed (less than 3 visits per box and one or less species recorded) and were therefore excluded from analyses.

SOUTH SCOTLAND			
Tetrad	Species	Tetrad	Species
NS2208	Grey only	NX0058	Red only
NS2610	Grey only	NX1060	Red only
NS2614	Grey only	NX1270	Neither species
NS3202	Grey only	NX1456	Red only
NS3434	Grey only	NX2680	Red only
NS4008	Both species	NX3680	Red only
NS5206	Neither species	NX3870	Red only
NS5426	Grey only	NX4098	Neither species
NS5434	Grey only	NX4248	Both species
NS6832	Grey only	NX4464	Red only
NS7812	Grey only	NX4870	Neither species
NS8230	Grey only	NX4896	Red only
NS8400	Grey only	NX5464	Neither species
NS9616	Red only	NX5486	Red only
NT0402	Red only	NX5698	Red only
NT0830	Grey only	NX5852	Red only
NT1206	Red only	NX5860	Red only
NT1634	Grey only	NX5880	Both species
NT2240	Grey only	NX6072	Neither species
NT2400	Red only	NX6088	Red only
NT2608	Red only	NX6274	Neither species
NT2612	Red only	NX6464	Red only
NT2840	Grey only	NX7096	Red only
NT3028	Neither species	NX7274	Red only
NT3038	Grey only	NX7460	Red only
NT3436	Red only	NX7854	Red only
NT3608	Neither species	NX7886	Red only
NT4226	Grey only	NX7892	Both species
NT4406	Red only	NX8460	Red only
NT4620	Both species	NX8694	Both species
NT4638	Grey only	NX8880	Red only
NT4814	Both species	NX9068	Red only
NT5008	Neither species	NX9088	Red only
NT5446	Grey only	NX9494	Red only
NT5806	Grey only	NY0286	Both species
NT5816	Both species	NY0470	Red only
NT6048	Grey only	NY0694	Red only
NT6220	Grey only	NY1268	Red only
NT7014	Neither species	NY1282	Red only
NT7034	Both species	NY1288	Red only
NT7228	Grey only	NY1294	Red only
NT7258	Neither species	NY1476	Red only
NT7854	Grey only	NY2072	Red only
NT8050	Grey only	NY2282	Grey only
NT8664	Grey only	NY2474	Red only
NT9254	Neither species	NY2696	Neither species
NT9260	Neither species	NY3876	Grey only
		NY5088	Red only
		NY5496	Both species

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