Saving an icon

Final report from the Developing Community Action phase of Saving Scotland's Red Squirrels

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SAVING SCOTLAND'S RED SQUIRRELS

Acknowledgements

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Contents

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PROJECT PARTNERSHIP

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1. Executive Summary

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Executive Summary

Saving Scotland's Red Squirrels – Developing Community Action (SSRS-DCA, 2017–22) was a five-year project aimed at developing a more affordable way to deliver strategically targeted and co-ordinated grey squirrel control over the long term to halt or reverse the decline of red squirrels over a wide area of Scotland. It followed eight years of prior work by the Saving Scotland's Red Squirrels partnership which established that strategic landscape-scale grey squirrel population management in Scotland could halt the decline of red squirrels regionally and could enable red squirrels to re-establish in many areas.

The project involved the following activity in three geographic regions:

1. North-East Scotland

A geographically isolated grey squirrel population centred on Aberdeen had been significantly reduced in range and density during previous phases of SSRS. SSRS-DCA aimed to further reduce grey squirrel abundance in the area and reach the point at which reactive trapping by a smaller staff team would be possible.

Monitoring in North-East Scotland was via a tiered monitoring system consisting of spring surveys (detection/non-detection surveys at fixed sites), intensive grey squirrel surveys and rapid response monitoring. It revealed a consistent trend of decreasing grey squirrel range over time, with the remaining distribution increasingly focused around central Aberdeen.

Despite an increase in control effort from 2018, the project did not reach the point where intensive trapping could be replaced by rapid response monitoring at all sites in Aberdeen City. In particular, northern parts of Aberdeen from Stoneywood to Bridge of Don still required repeated daily trapping at the end of SSRS-DCA.

During the 13 years of SSRS activity in this region, red squirrel populations have expanded into sites previously occupied by grey squirrels, and this trend continued during SSRS-DCA.

It is recommended that a small professional team be retained to complete the eradication of grey squirrels in Aberdeen.

2. Central Lowlands

Grey squirrel management in the Central Lowlands was focused around the project's 10km-wide Highland Line Control Zone. The aim was to continue co-ordinated strategic control of grey squirrels to contain any northerly spread of populations into areas where native red squirrels are currently thriving in the absence of greys.

Control work in this region was delivered by project staff, landowners controlling grey squirrels on their land under the Forestry Grant Scheme, and people operating under the project's trap-loan scheme.

Distribution mapping showed a retraction in the range of grey squirrels from its most northerly extent in 2009–10 to mainly occupying locations no further north than just above the project's notional Highland Line in 2021. The progressive reduction in the number of grey squirrels detected north of the Highland Line appeared to continue during SSRS-DCA, but grey squirrels were still evident just north of the Highland Line during the final year of the project. Spring survey evidence supported the finding of a large reduction in the northerly range of grey squirrels between 2012 and 2017, but suggested a possible small-scale range recovery from 2017 to 2019.

Grey squirrel control mapping combined with selective ongoing monitoring indicated that the control delivered during SSRS-DCA was largely successful, but highlighted the need to maintain the capability to be responsive to fluctuations in grey squirrel populations within or to the north of the Highland Line Control Zone.

Distribution mapping, surveys and grey squirrel control mapping all highlighted the incursion of grey squirrels north of the Angus–Aberdeenshire border into the Mearns area as being in need of special attention, as the most likely route for grey squirrels to access northern populations of red squirrels. It is recommended that a programme of sightings and monitoring is continued long-term, aimed at early detection of any further grey squirrels in the Mearns region, together with a southward expansion in the intensive monitoring and rapid response approach to include the northern stretches of Angus bordering the Mearns.

Red squirrel distribution across the Central Lowlands has remained relatively constant since 2009, with a small extension to their range within and to the south of Loch Lomond & The Trossachs National Park.

A secondary aim in this region was the widespread testing for squirrelpox in grey squirrels in order to track the spread of the virus through grey squirrel populations from Glasgow–Edinburgh northwards to the Highland Line. Monitoring indicated that the virus has not spread northwards from Glasgow–Edinburgh through the Central Lowlands grey squirrel population with the rapidity anticipated, with very few sites returning positive results. In 2021, all squirrelpox testing results in the region were negative. The squirrelpox monitoring results are reported and discussed in more detail in a separate report. It is recommended that the red squirrel conservation community considers whether squirrelpox monitoring is required in the future, and in what form.

3. South Scotland

In South Scotland, activity was focused within the project's Priority Areas for Red squirrel Conservation (PARCs), where the aim was to sustain healthy populations of red squirrels and to mobilise local people to carry out grey squirrel control and other red squirrel conservation activities. During SSRS-DCA, we reviewed PARC boundaries and created three new PARCs in Dumfries & Galloway.

Grey squirrel control was delivered by project staff, expanding in the second year to include work in the National Forest Estate, landowners operating under the Forestry Grant Scheme, and an increasing number of trained volunteers.

Mapping demonstrated an increase in the coverage of grey squirrel control measures and trapping figures showed a 2.5-fold increase in annual grey squirrel cull numbers between 2017 and 2021. Volunteer contribution increased from 1.3% of the reported culls in Year 1 to 27% in Year 4, when it exceeded the staff cull totals for the first time – a key result in demonstrating the success of SSRS-DCA. Forestry Grant Scheme participants contributed the largest proportion of recorded culls, increasing 1.5-fold over the project, but decreasing from 75% to 52% of the total annual cull as the contributions by staff and volunteers increased.

Reported red squirrel coverage in the PARCs showed steep fluctuations year to year. However, plotted coverage trends over the period 2009-2021 showed increases in six of the PARCs: Cree-Machars, Glenkens, Luce, Solway Forests, Teviot & Rule and Upper Tweed; coverage remaining relatively steady in two PARCs: Annan Valley and Esk Valley; and declining slightly in two others: Nithsdale and Berwickshire. Grey squirrel trends showed an increase in all PARCs, though this is likely to be influenced by data coming from increasing coverage by grey squirrel control measures, which by its nature is biased towards sites more likely to harbour grey squirrels rather than reds. Reported grey squirrel coverage increased faster than red squirrel coverage in the Solway Forests, Nith Valley and Annan Valley PARCs, possibly suggesting an increasing threat posed by grey squirrels to reds in these PARCs.

However, both mapping and data trends show red squirrels remained widely present in all but the tiny Berwickshire PARC and remained common in places where people live and travel.

In the wider area of South Scotland, a loss of reported red squirrel range from South and East Ayrshire, Berwickshire, eastern parts of Roxburghshire and mid-Nithsdale between the start of SSRS (2009/10) and the end of SSRS-DCA (2021) was recorded, in contrast to the distinct red squirrel presence in the PARCs save for Berwickshire.

Grey squirrels were widespread in all PARCs, and survey results suggest an increased spread in the range of grey squirrels into most of the Scottish Borders (possibly excepting the larger coniferous forests) by 2019, and an increased spread in Dumfries & Galloway into new areas previously unpopulated by grey squirrels.

In summary, although red squirrels remained widespread within PARCs (and likely in large conifer forests outside PARCs), it will remain a challenge to keep their populations buoyant even in the prioritised landscapes. Control measures to date have most likely been critical in retaining red squirrels in these landscapes.

Community engagement

Mobilising communities and landowners to carry out required grey squirrel control in PARCs was a key focus of SSRS-DCA. To achieve this, project staff developed and delivered enhanced communications, engagement, education, training, resourcing and support to volunteers and communities within PARCs.

During SSRS-DCA, 13 new volunteer groups were established in South Scotland, bringing the total number to 17 which, between them, cover virtually the entire area of the 10 PARCs. In 2018, the independent voluntary Red Squirrel Forum for South Scotland was formed to facilitate communication and best practice between the SSRS groups. We describe the process for instigating and developing groups, the training and support given to them, and illustrate some of the support collateral developed for them.

A key finding was the strongly supportive response of local people in volunteering for the demands of daily grey squirrel trap management. Sustaining sufficient volunteer delivery of this work is going to need continuing landscape-scale co-ordination and support to ensure that volunteer groups retain the skills and motivation to continue and that key locations in each of the PARCs have adequate grey squirrel control. Without that, Scotland risks losing its southern red squirrel population.

A further observation was an apparent preference by volunteers for practical contributions rather than data collection and recording, although there was continued growth in the use of the recording facilities available through the online Community Hub developed during SSRS-DCA.

To encourage public recording of squirrel sightings, a new week-long annual engagement initiative – the Great Scottish Squirrel Survey – was launched in 2019 to provide a snapshot of squirrel distribution across the country. Between 2019 and 2021, an average of 1,372 people submitted sightings during the survey period, recording an average of 1,843 squirrel sightings each year. The intention is to continue the Great Scottish Squirrel Survey in future years as an engaging “citizen science” event.

An online conference was hosted in the final year of SSRS-DCA to encourage local volunteer networks, international researchers and UK-wide policymakers to share expertise and learnings on red squirrel conservation. Recordings of conference talks are available online.

An important development for SSRS-DCA was the development of the online relational geo-referenced database to better manage our multiple streams of data, in combination with a website-based volunteer support system, the SSRS Community Hub. We provide an overview of the facilities offered by the Hub, details of the development of the Content Management System and information on some of the improvements and adjustments made to support volunteer red squirrel groups for the longer term.

Next steps

The SSRS-Transition Project (2022–24) immediately follows the completion of SSRS-DCA. During this two-year phase, staff will: continue the push towards grey squirrel eradication in Aberdeen; continue to contain the northerly spread of grey squirrels in the Highland Line Control Zone; and provide further support and training to the volunteer red squirrel networks in South Scotland.

An important task for the SSRS-Transition project is to identify how strategic population management of grey squirrels can be delivered and co-ordinated on a more permanent basis rather than relying on a series of grant-funded, time-limited projects as has been the case to date, with the aim of ensuring the future of northern Scotland’s red squirrel populations.

Key recommendations

Seventeen recommendations are made for the future of red squirrel conservation work in Scotland, including:

- Aberdeen eradication work should continue to be delivered by a small professional team until zero grey squirrels can be detected in the city and its surrounds.
- Consistent professional grey squirrel control and monitoring be maintained across the Highland Line to ensure continued protection of core red-only squirrel populations.
- The grey squirrel control programme in South Scotland should remain co-ordinated and its effects on both red and grey squirrels monitored.
- Volunteer support in the form of training, co-ordination and feedback must be maintained to ensure continued motivation of volunteers.
- Several professional grey squirrel controllers should continue to be employed to work in important parts of PARCs that are difficult for volunteers to cover.
- Collaboration across the border with the projects in northern England, which are engaged in similar activities to retain widespread red squirrel populations in their landscapes, should continue so that lessons learned can be shared and applied rapidly.
- The SSRS Community Hub and relational database developed during SSRS-DCA should continue to gather data from control and monitoring work. There should be a plan for how data will be used to inform the planning and co-ordination of ongoing red squirrel protection measures.
- The Scottish Squirrel Group – consisting of a wide range of government departments, agencies and NGOs – should be reconvened in order to resume oversight of squirrel management in Scotland.

2. Introduction

Introduction

This project, *Saving Scotland's Red Squirrels – Developing Community Action* (SSRS-DCA), focused upon one of our most charismatic and well-loved mammals – the red squirrel (*Sciurus vulgaris*). Once widespread, red squirrels have undergone a catastrophic population decline primarily due to competition from the non-native, invasive American grey squirrel (*Sciurus carolinensis*). There are now only c. 160,000 red squirrels remaining in the UK, of which 120,000 occur in Scotland. Saving Scotland's Red Squirrels (SSRS) was formed to reverse this decline and to create the conditions for this mammal to thrive into the future.

Our Vision

"Red squirrels are thriving in South Scotland, the Highlands and Grampian, Argyll and northern Tayside/Stirling and have become a successful symbol of Scotland's ongoing commitment to protecting wildlife for future generations."

Over the eight years prior to SSRS-DCA, the innovative SSRS partnership trial project established that it is possible to halt the decline of red squirrels over a wide area via strategically targeted and co-ordinated landscape-scale grey squirrel control and even to successfully enable reds to re-establish in many areas.

To secure the conservation gains achieved by 2017, and a lasting future for red squirrels in Scotland and the UK, it was recognised that a continued grey squirrel control programme would be needed over the long term. The SSRS Project Partners had reached a point of understanding of the scale of the conservation challenge and the associated costs in delivering this programme long-term. A "silver bullet" solution such as an oral vaccine for squirrelpox, a contraceptive for grey squirrels, or a natural predator favouring grey squirrels over reds as prey (e.g. pine marten) was likely to be many years away. SSRS-DCA was a five-year project (2017–22) aimed at developing a more affordable way to deliver this programme in the long term.

3.
Project Aims

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Project Aims

The primary aim of SSRS-DCA was to develop and implement a sustainable programme of red squirrel protection capable of securing the long-term survival of core red squirrel populations across Scotland. To do this, the five-year project aimed to recruit and equip communities to take on a vital role in the long-term protection of red squirrels in key areas across the country, to be maintained through a robust legacy strategy.

By the end of SSRS-DCA in March 2022, the aim was to have moved away from reliance on a large team of paid staff towards creating communities and voluntary networks in focal project areas who were motivated and capable of acting together to contribute substantially towards the protection of red squirrels in their local area, and thus to the long-term survival of major red squirrel populations across Scotland. The volunteer networks were seen as a way of enabling Saving Scotland's Red Squirrels to downsize its project-funded staff team to a much smaller professional field team backed by a small support team.

By capturing the natural enthusiasm that local people have for the charismatic red squirrel, SSRS-DCA aimed to galvanise communities of volunteers and land managers to act together to protect red squirrels in their area. This would:

- protect and enhance the legacy of increased red squirrel populations brought about by the work of SSRS and other projects prior to 2017
- enable people to make an important ecological impact
- make the red squirrel population more resilient to changes and safeguard important populations for Scotland
- enable the project to refocus a smaller professional grey squirrel control staff to the highest strategic priority for the long term (defending the Highland Line).

3.1 Regional aims

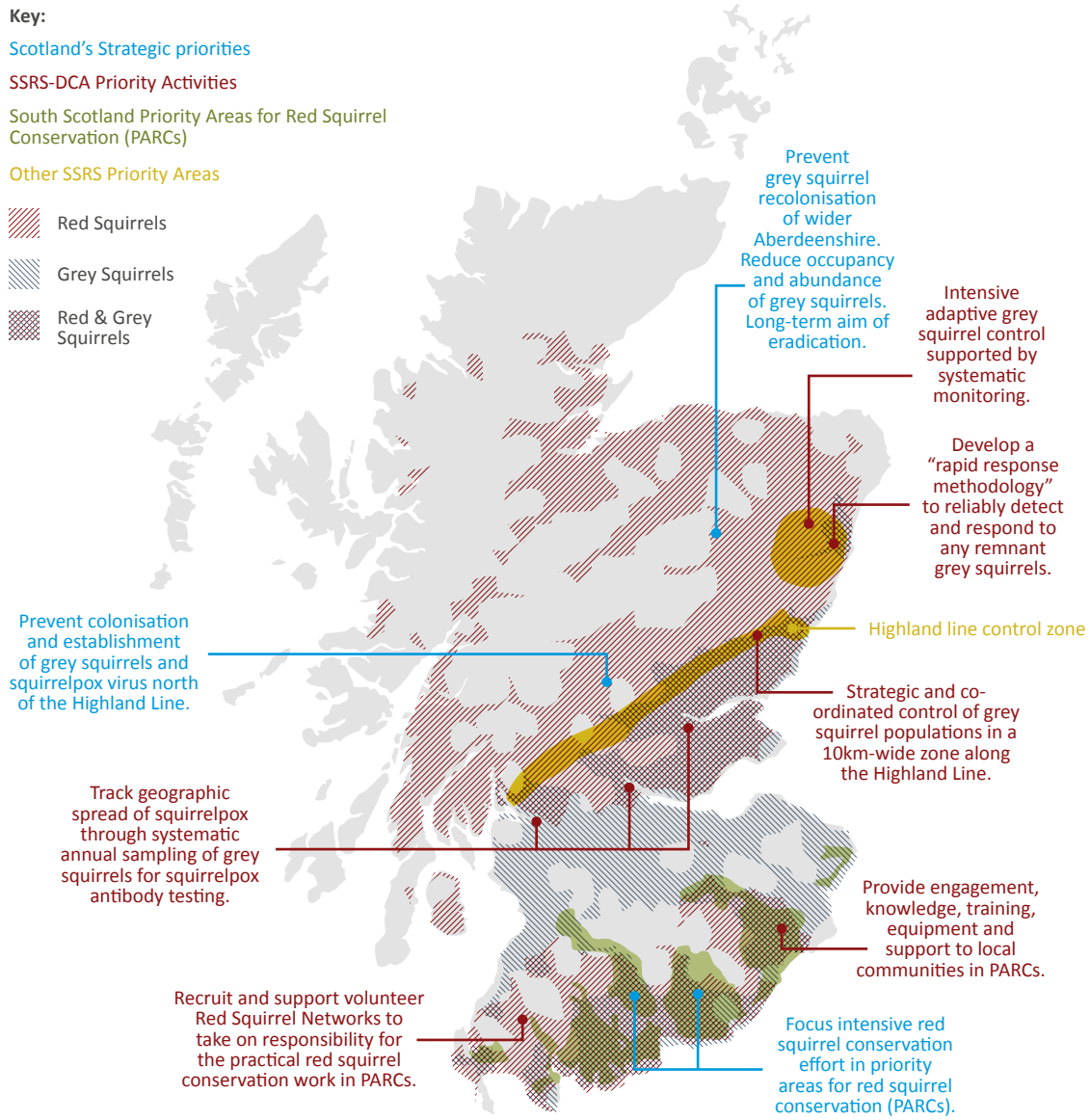
The project involved activity in the following key areas:

1. **North-East Scotland:** In Aberdeen City and Aberdeenshire, where earlier project activity had already significantly reduced grey squirrel populations, it had not proven possible to predict the timescale for achievement of eradication of this isolated population of grey squirrels in North East Scotland. The ambition for SSRS-DCA was to reach a point where a reduced level of mainly reactive trapping by a smaller staff team would be possible, in response to grey squirrel detection by ongoing intensive monitoring to be delivered by local community volunteers.
2. **Central Lowlands:** The aim was to deliver the strategic and co-ordinated control of grey squirrels necessary to prevent their re-establishment north of the Highland Line, where they would pose a threat to Scotland's core grey-free red squirrel populations in highland Scotland. It was anticipated that professional control would always be needed to deliver the essential control work in this region. However, the aim was to support this work by intensive public engagement activities to generate public support and involvement.
3. **South Scotland:** Intensive conservation effort was focused on agreed priority areas for red squirrel conservation (PARCs). The aim was to mobilise communities and landowners to act together to protect red squirrels in their local area. There was to be a strong emphasis on engaging and supporting local people, including land managers, to take on responsibility for the practical conservation work involved in looking after their local red squirrel populations, fostering a sense of ownership and pride in their role in the conservation of this charismatic species.

Public and community support for the work of Saving Scotland's Red Squirrels has been key to many of the achievements up to 2017, through support for project activities and contributing many hours of their time. However, to reach a point where communities were capable of taking over significant parts of work that have hitherto relied on paid staff, it would require a step-change in the level of SSRS engagement and training. Therefore SSRS-DCA aimed to invest increased financial resources in communications, engagement, training, systems and strategies to enable communities and volunteers to take on the vital role for the long-term protection of red squirrels in key areas across the country. We aimed to ensure that communities developed the organisational and management capabilities to sustain and support these networks in the long term, enabling local people to make a lasting ecological impact on important red squirrel populations for Scotland, and making this charismatic species more resilient to change.

As an aid to the long-term delivery of the communications, engagement and training delivered within the SSRS-DCA period, the project aimed to develop an innovative new online data management and volunteer support system, the SSRS Community Hub, which would be designed to enable communities to sustainably manage their own efforts with a much-reduced project staff input in the future.

3.2 Long-term strategic priorities

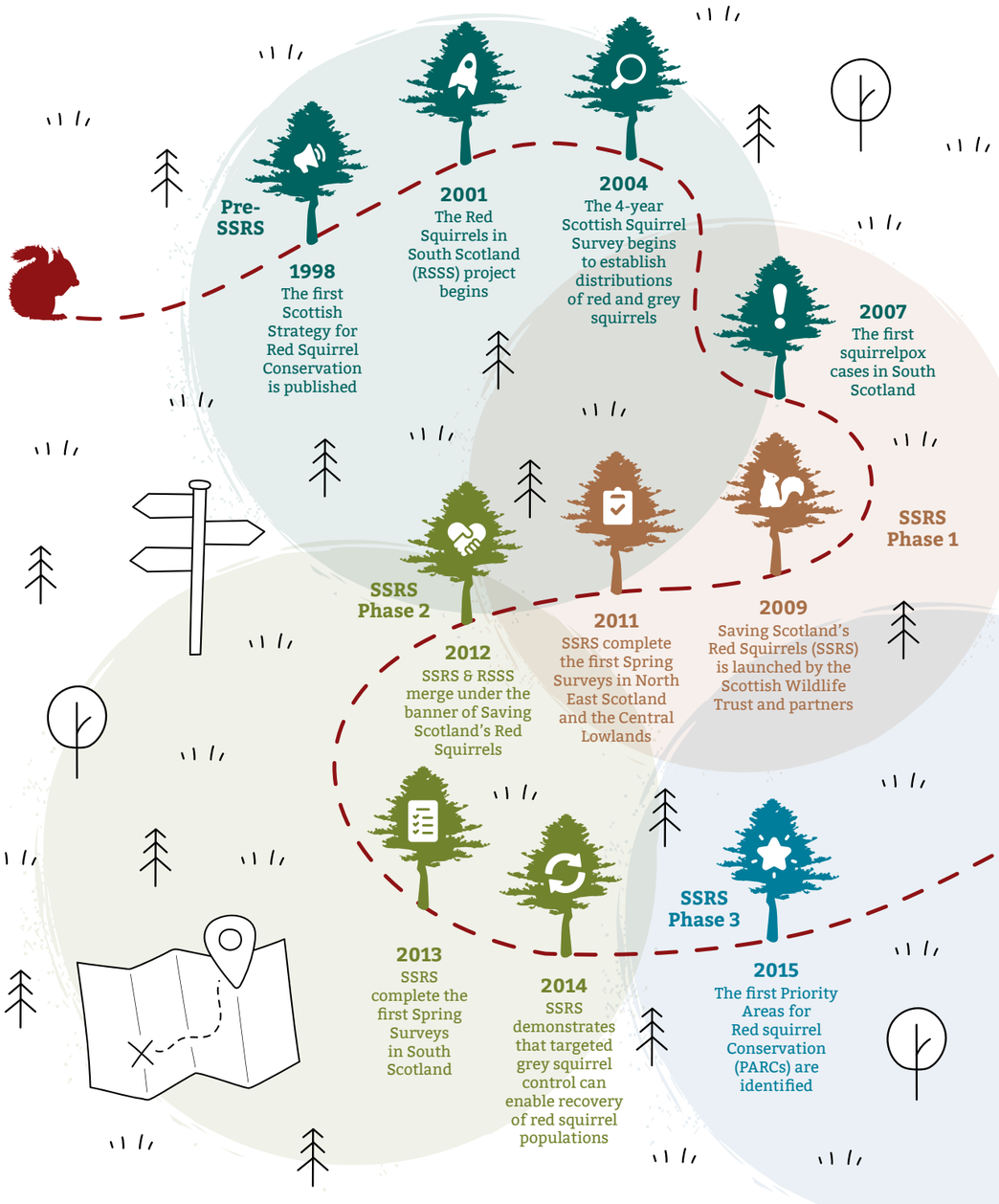


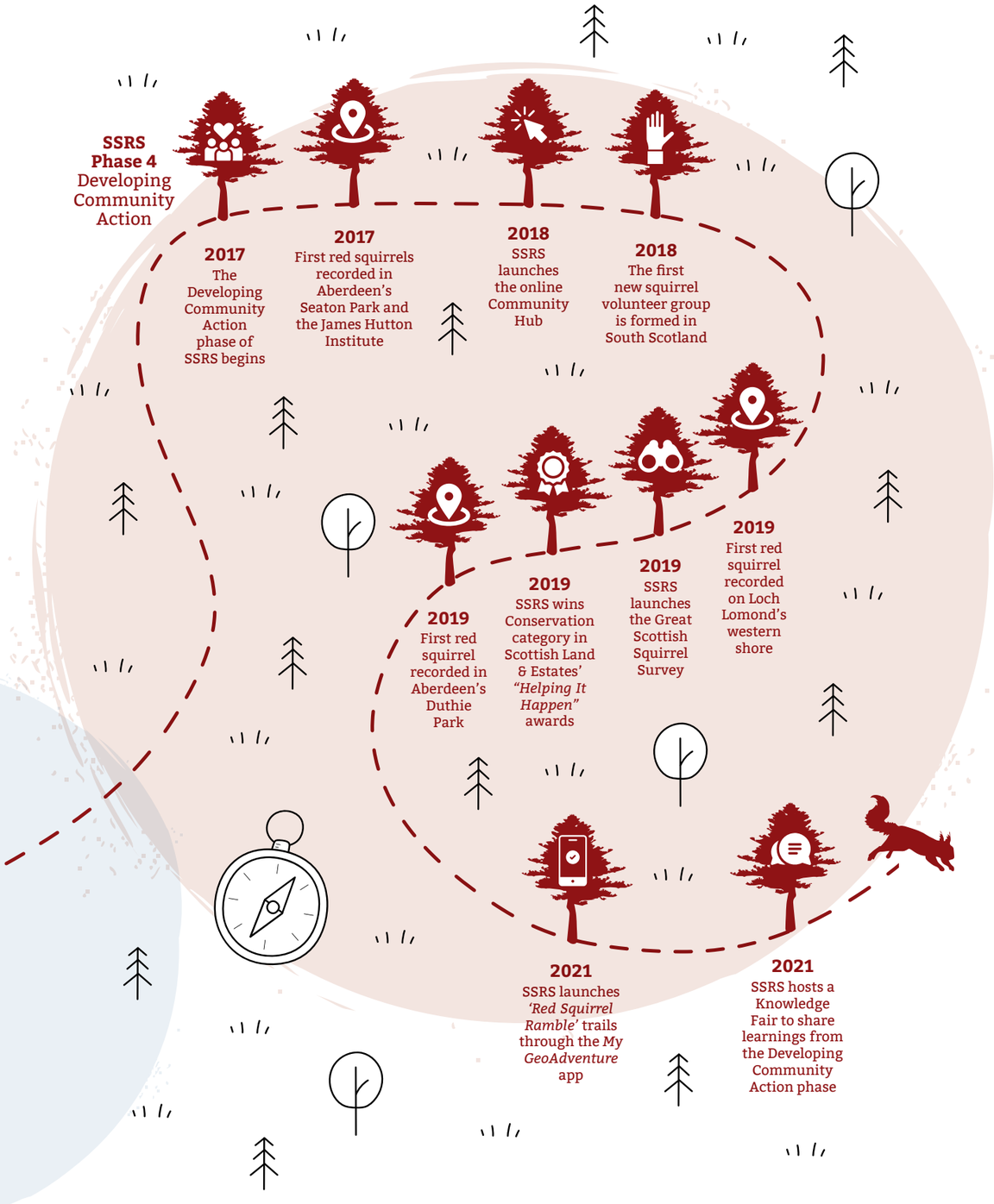
Map 1. SSRS priority areas and squirrel distributions (2017-2022) in Scotland

4.
Project Milestones

Project Milestones

The Saving Scotland's Red Squirrels project was initiated to play an essential role in the delivery of the Scottish Strategy for Red Squirrel Conservation, preventing the loss of some of the most important red squirrel populations in Scotland. The project aimed to provide strategic grey squirrel management and to engage the public in the plight of our native red squirrel. Throughout its multiple phases, the project has celebrated various successes and achievements towards those aims.





5. Methodology

Methodology

5.1 Grey squirrel control

Grey squirrel control is delivered in accordance with the SSRS Standard Operating Procedures for Grey Squirrel Control, chiefly through live-trapping in cage-traps, coupled with humane dispatch of the grey squirrels caught at the trap-side. This enables the release of red squirrels and any other unintended captives unharmed. Traps are checked twice a day to minimise the time the animal is restrained in the trap. It is crucial that protected red squirrels, which may be caught at most of the sites covered by SSRS, are not harmed by the process, but it is also essential for the humane treatment of the grey squirrel catch that animals are not held captive for a prolonged period.

Some members of the SSRS Team also employed "free-shooting" of grey squirrels – i.e. stalking and shooting of free-living grey squirrels, including greys visiting specially positioned feeders. This could only be done by trained staff holding the correct firearms certification and proof of competency on land for which they held written access permission from landowners. It also needed to comply with SSRS-approved procedures. Free-shooting, which occurred from 2019 onwards, tended to be employed in autumn and winter to provide control effort at times of year when trapping was less effective.

An important contribution to the landscape-scale grey squirrel control effort, particularly in the Central Lowlands and South Scotland, was delivered by large numbers of landowners operating under the Scottish Forestry Grant scheme's Sustainable Management of Forests option, which specifically funds targeted control of grey squirrels in areas where they are a threat to red squirrel populations. SSRS Conservation Officers promoted the scheme to landowners in the focal areas and assisted with the preparation of the grant applications. The eligible landscapes were guided by the SSRS Partnership's agreed target landscapes.

A third element was a trap-loan scheme run by the project, providing training and traps to householders and volunteer controllers in project areas. In the confined landscape of Aberdeen, this primarily took the form of householders hosting traps in their gardens, baiting and setting traps and releasing any non-target animals. When a grey squirrel was captured, expert humane dispatch was carried out by an on-call team of SSRS staff in the North-East. In the more extensive target landscapes of Central Lowlands and South Scotland, volunteer trappers were trained to carry out the dispatch to SSRS project standards.

A SSRS Trapping Report (Tonkin and Tipple 2022[1]) reports on the levels and coverage of grey squirrel control effort achieved by staff, landowners and volunteers over five years (2017–21) of SSRS-DCA.

5.2 Monitoring

Spring tetrad surveys

Since 2011, volunteer-delivered Spring Presence/Absence Surveys[2] had been carried out annually across the North-East and the Central Lowlands in c. 150 survey tetrads (2x2km squares), with a further 100 tetrads added covering South Scotland in 2013. The tetrads in the North-East and Central Lowlands were mainly sited in places most likely to detect squirrel species change, i.e. in places currently occupied by grey squirrels but where project activity might bring about a change to red squirrel occupancy. These were in areas of grey squirrel-preferred habitat, i.e. dominated by large-seeded broadleaved trees like beech or oak, or mixed conifers including larch, Norway spruce and Scots pine. There were also a small number of sites which were "red-only" at the start and likely to remain so if the project was successful, and a small number where grey squirrels were likely to remain dominant since they were outside of our control areas.

[1] Tonkin, M. and Tipple, N. 2022. *Saving Scotland's Red Squirrels: Trapping Report for Years 2017–2021*.
[2] More strictly, this was a detection versus non-detection survey, since absence could not be proved by the methodology.

In South Scotland, Spring Surveys started in 2013. A different sampling approach was taken, aiming at covering all types of habitat according to predominance across the region, including the large conifer forests that it was thought excluded grey squirrels at that time. The sample was weighted towards the sites where change might be detected: three survey-tetrads were selected in each 10km square in which grey squirrel control was to be targeted, and only one survey-tetrad per 10km square in other areas.

In each survey location, we selected four sites across the tetrad to place a feeder-box containing a hair-collection pad, from which the species leaving it could later be identified. The four feeder-boxes were checked every two weeks over a six-week period, collecting the sticky pad and replacing it each time. We used all 12 hair samples (three from each of four boxes) to class the tetrad as: red squirrel only; both species; grey squirrel only; or neither species. Although detection of the situation across the entire tetrad area was not perfect, it was theoretically possible for any resident squirrel to encounter at least one of the boxes over the six-week period as part of its normal ranging behaviour. We endeavoured to sample at the same sites annually to this protocol, to obtain a standardised sample, although this was not always possible for the whole set of feeder-boxes, for example due to forest or farming operations, windthrow or lack of a local volunteer. Spring (March–April) was chosen as the only fixed point in the population's year, a time when the adult population was at the level that had survived the winter, but before the new spring litters had joined the population.

A survey report was produced each year comparing results with previous years since 2011. The reports combine the data for the two northern project areas (North-East plus Central Lowlands) in order to obtain a sample of sufficient size for analysis. The South Scotland project area, where the Spring Survey only began in 2013, was analysed separately. The report was intended to inform project work and to share the information with volunteers and stakeholders.

As well as the monitoring function, the Spring Surveys were a great engagement tool, as most of the work was volunteer-delivered, with many volunteers becoming passionate about their "patch". During SSRS-DCA, Spring Surveys continued to be delivered during the first three years 2017–19, but were cancelled in 2020 and 2021 due to the Covid-19 pandemic restrictions on outdoor activity applying at the critical time of year.

Operational surveys

Other monitoring to provide ongoing feedback to inform grey squirrel control operations differed between regions, according to the aim of the monitoring. All used feeder-boxes fitted with either hair-collection pads or trail cameras to enable species identification of visiting animals.

Reporting of sightings

Reporting of sightings via the SSRS-DCA website reporting page was extremely important for general background information on red and grey squirrel geographical distributions right across Scotland. For the SSRS Project Team, the public sightings were crucial in detecting the presence of grey squirrels in sites that needed to be kept clear of the species. The new sightings were monitored by the Team weekly, enabling the control team to follow up, where necessary, on any grey squirrels appearing in new sites within their region.

5.3 Data collection

Multiple streams of data were collected in order to evaluate delivery and outcomes.

- Grey squirrel control data: trapping effort (number of trap-days per month) and grey squirrel capture numbers. Red squirrels (caught and released unharmed) were also recorded. Similar data were collected from staff and, where possible, from volunteers and from landowners on the FGS grant scheme.
- Spring Survey data: volunteers submitted data and hair-samples for identification from each of their visits to the four feeder-boxes in their allocated tetrad. Staff added information from each feeder-box visit to a database for analysis for the annual Spring Survey Reports, produced from 2012 until 2019.
- Operational Survey data: these data were collected to inform trapping. They were difficult to analyse but added valuable distribution data to the database.
- Sightings data: sightings added by the public direct to the reporting page of the website formed a valuable additional set of data. This was enhanced by the Great Scottish Squirrel Survey event held each autumn, 2019 to 2021.

- Squirrelpox testing data: in the Central Lowlands, information was collected on the number of squirrelpox sample squares successfully sampled, the number of samples collected, and the result of the ELISA[3] squirrelpox testing for each sample.
- Engagement data: Information on volunteer involvement was collected throughout the project but was especially important in South Scotland. Information included group membership, training received, paperwork completed and hours contributed. A detailed description of this information is provided in the sections of this report dealing with the online Community Hub.

NB: All distribution data derived from data streams were added to the Scottish Squirrel Database, curated by the Scottish Wildlife Trust, and most were also shared to the National Biodiversity Network (NBN) database for public availability. Note that grey squirrel control data on the NBN are at a coarser resolution than sightings or survey data, so that they cannot be easily located.

[3] ELISA = Enzyme-linked immunosorbent assay: the test used by the Moredun Research Institute to assess specific squirrelpox virus antibody level in grey squirrel blood samples.

6.
North-East Scotland

North-East Scotland

North-East Scotland encompassed Aberdeen City and Aberdeenshire, where grey squirrels accidentally released in Aberdeen in the late 1960s had spread out along Deeside as far as Ballater, along Donside as far as Alford, northwards to Ellon and southwards to Stonehaven. Earlier SSRS project work had already reduced the spread significantly and had seen red squirrels start to return to Aberdeen City.

6.1 Objectives

1. Progress towards the eradication of grey squirrels from North-East Scotland by systematic reduction of geographic range, occupancy and abundance of grey squirrels, through adaptive grey squirrel control by professional Grey Squirrel Officers, to reach a point where a reduced level of mainly reactive trapping would be possible, in response to grey squirrel detection by ongoing intensive monitoring. Note that it was not expected that eradication could be reached in this timeframe.
2. Develop and establish a year-round monitoring scheme, deliverable by volunteers post-SSRS-DCA, to reliably detect the remaining grey squirrel populations, and an appropriate mechanism to deliver the required professional rapid response control.

Two key assumptions were made:

1. As remaining grey squirrel densities fell in response to the control measures, the amount of effort required would also be reduced, allowing for a reduced staff team after the end of the project.
2. The staff team would be able to counter any natural population increases that occurred during the project as a result of natural cycles in food abundance, by early intervention to prevent successful spring breeding seasons.

In this system, resources unused by a reduced grey squirrel population limited by control measures would be available to encourage a recovery of red squirrels.

Note that it was recognised that there was a risk that the above assumptions may not be met, which would require revised plans to meet any deviation from the expected outcomes. For instance, it was unknown how grey squirrel populations respond to falling densities: there was the possibility that they may reach breeding maturity earlier, or produce more litters of young per year, or become less readily trapped.

6.2 Activity during SSRS-DCA

Strategic grey squirrel control

A team of two NLHF-funded Grey Squirrel Officers (GSOs) and an additional Forestry and Land Scotland-funded Monitoring and Control Officer, led by the North-East Conservation Officer, continued to evolve the adaptive grey squirrel control approach already in progress since 2007. Most control now occurred within urban parts of Aberdeen, and the team had devised innovative approaches to trapping to cope with the challenges of high human footfall at some of the urban sites.[4]

In 2017, co-operating landowners completed work under Forestry Grant Scheme five-year funded contracts, four of them in rural Aberdeenshire, and one within the Aberdeen City local authority area. Very few captured grey squirrels were being reported, and all the contracts had been completed by the end of 2019. The four Aberdeenshire estates did not re-apply due to lack of evidence of grey squirrel presence; however, the estate in Aberdeen City began a new contract in 2021.

[4] Willis, S. 2015. "Grey squirrel control in the urban landscape". In: Shuttleworth, Lurz and Halliwell (eds), *Shared Experience of Red Squirrel Conservation Practice* (European Squirrel Initiative).

In 2017, the project worked with up to 27 householder trap-loanees caring for active traps in Aberdeen gardens at any one time, although the numbers on the books were much larger, into the hundreds; the number of active loans increased to 48 during 2019, and in 2021 as many as 72 trap-loanees were active. The increases were partly due to a targeted effort to recruit sightings participants to the scheme, and to an increase in people who could monitor traps from home during lockdowns in 2020 and 2021, as well as an increased requirement for control in 2020.

The coverage and the outputs achieved over the five years are presented in more detail in the SSRS-DCA Five-Year Trapping Report (2017–21)[5]. A review in 2020 (Woodfin 2021)[6] gives further information.

Monitoring

During the five years of SSRS-DCA, a tiered monitoring system provided ongoing information on the distribution and levels of the grey squirrel population to guide the grey squirrel trapping effort.

Spring tetrad surveys

These were carried out annually from 2011 to 2019 in 50 survey tetrads across Aberdeenshire to provide a comparison between years as part of the project-wide Spring Surveys.

Intensive grey squirrel surveys

In 2015, a second tier of monitoring, covering suitable grey squirrel habitat within about 10km of central Aberdeen, was initiated. This consisted of individual feeder-boxes that ran for six weeks each spring alongside the Spring Surveys, and aimed at building up a detailed picture of red and grey squirrel distribution immediately surrounding Aberdeen in sites not covered by the spring tetrad surveys. A smaller subset of these surveys was repeated in autumn in specific woodlands adjacent to the new Aberdeen Western Peripheral Route as part of the scheme's mitigation funding agreement with SSRS. In time, boxes where no grey squirrels were detected over several years were stood down. The pandemic restrictions impacted these surveys in 2020, and to a lesser extent in 2021.

Rapid response surveys

At the majority of remaining rural Aberdeenshire trapping sites, the predominant catch was red squirrel by-catch by 2018, making the trapping of the very occasional grey squirrel very inefficient. A third tier of monitoring that aimed to remedy this was set up, replacing the trap at each site with a monitoring box, and only setting a trap when a grey squirrel was detected. Monitoring by staff initially occurred every two weeks, with the frequency reducing if no greys were detected. When a box detected a grey squirrel, a check frequency of two-week intervals was resumed, and the cycle started again. This freed up staff time for intensive trapping in the urban sites where grey squirrels were still constantly present.

By 2020, volunteers had been recruited to carry out most of the monitoring, and the system was adjusted to suit the volunteer workforce. Once a trapping location had met the criteria to be managed through ongoing monitoring with rapid response trapping, the feeders placed at the trap sites were monitored every two weeks by the volunteers regardless of whether grey squirrels were detected or not. Grey squirrel detection was then responded to by staff trapping at the site.

6.3 Progress during SSRS-DCA

Grey squirrel status

We used a combination of all our datasets to examine whether the grey squirrel population in Aberdeenshire was reduced in geographic extent over the period 2009 to 2021, and whether contraction in their range continued during the 2017–21 period of SSRS-DCA.

[5] Tonkin, M. and Tipple, N. 2022. *Saving Scotland's Red Squirrels: Trapping Report for Years 2017–2021.*
[6] Woodfin, S. 2021. "Saving Scotland's Red Squirrels in North-East Scotland: restoring urban reds". In: Shuttleworth, Lurz and Robinson (eds), *Saving the Red Squirrel: Landscape Scale Recovery* (Red Squirrel Survival Trust).

Grey squirrel control mapping

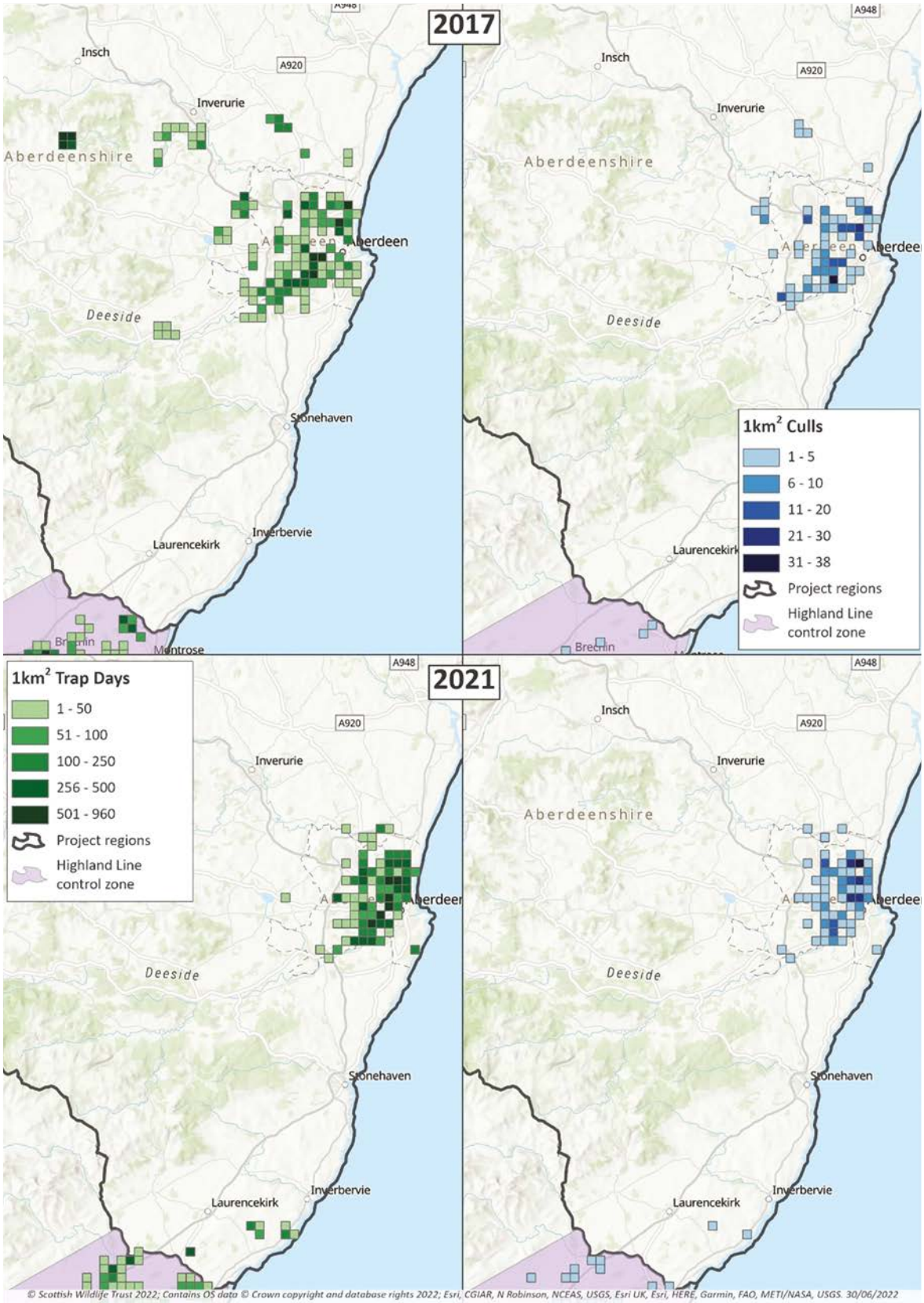
The mapping of the distribution of trapping effort and captures for 2017 and 2021 (Maps 2a-d) shows a contraction of grey squirrel captures to almost completely within the Aberdeen City boundary. However, a significant distribution of grey squirrels remains within the city. Because of the responsive nature of the trapping effort, seeking to focus the most intense trapping where the most grey squirrels are found, and increasingly limiting trapping in other sites to responding to grey squirrel detection by the rapid response monitoring, analysis of the control data to determine effects of trapping on grey squirrel abundance is very complex. However, spatially explicit modelling carried out prior to SSRS-DCA used SSRS trapping data to evaluate the effect of SSRS grey squirrel control efforts in an Aberdeenshire study site. It concluded that grey squirrel capture rates (a proxy for abundance) were significantly reduced in those areas with the greatest control efforts, and suggested that SSRS work had at that time been effective in reducing grey squirrel abundance to relatively low densities at the time of the analysis (Oliver 2013).[7]

Bayesian modelling of SSRS North-East control data from the period 2007–16 (Roos 2017[8]) agreed that the trapping had reduced the capture rate of grey squirrels, and further that it was significantly correlated with an increase in capture rate of red squirrels over the same period. Finally, occupancy modelling using SSRS tetrad monitoring data (Porton et al. 2020[9]) showed that trapping in a tetrad and the surrounding area was linked to a greatly increased probability of subsequent grey squirrel absence from the tetrad, and that trapping surrounding the tetrad reduced the effect of habitat connectivity on recolonisation. Although each of these studies carried a number of caveats, not least that it was not possible to prove a causal relationship between control work and changing squirrel numbers/occupancy (i.e. they could not rule out other unknown causative factors), the fact that three different approaches arrived at much the same assessment of the work provides some comfort in accepting that the control work has reduced the density and distribution of grey squirrels.

[7] Oliver, M. 2013. "Saving Scotland's Red Squirrels Project Phase 2 Data Analysis: Modelling changes in grey squirrel capture rates in response to spatial cumulative control effort. SSRS contract report." In: Tonkin, M., Bamforth, L. and Ramoo, K. 2014. *Evaluation of Grey Squirrel Control in the Saving Scotland's Red Squirrels Partnership Project (Phase Two) 2nd Report 2009–2013.*

[8] Roos, S. 2017. *Preliminary Squirrel Report for the SWT.* RSPB Centre for Conservation Science report to SSRS

[9] Porton, G. et al. 2020. *Evaluation of the Progress of Saving Scotland's Red Squirrels towards its Region-Specific Management Aims, Accounting for Imperfect Detection.* Report funded by the People's Trust for Endangered Species internship.



Maps 2a-d. Trapping coverage and grey squirrel captures by SSRS staff, volunteers and landowners in North-East Scotland, 2017 and 2021

Measurement of extent of geographic distribution of grey squirrels around Aberdeen

The effectiveness of the control work having been thus previously established, a simple metric was devised to demonstrate how the geographical extent of the grey squirrel population in the North-East has been progressively reduced over time: linear distance from a central point in Aberdeen (NJ925065) of all of the distributional data points for grey squirrel (trapping, surveys, sightings) over the period 2009 to 2021 was measured, and the mean distance for each calendar year was then calculated (Table 1), shown in Figure 1.

Note that the distances measured omit grey squirrels detected in southern Aberdeenshire, since those animals are part of the Highland Line population, rather than originating from the population which has spread out from Aberdeen.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
N	724	1,511	1,327	1,153	5,46	7,61	1,567	929	757	1,023	952	1,079	508
Mean	8,292	5,877	6,025	6,649	6,566	5,790	5,397	5,355	4,650	5,045	4,229	3,797	3,890
Max	36,065	55,097	30,484	39,363	45,126	33,907	90,009	89,988	20,562	38,194	20,097	51,063	9,470
Min	1,271	510	460	1,089	1,237	490	490	504	1,066	960	1,070	775	1,022
Std Dev	6,679	5,236	5,128	5,128	5,792	4,846	5,693	4,793	3,328	3,733	2,081	3,137	1,490

Table 1. Distance of grey squirrel locations (from trapping, survey and sightings records) in the North-East to central point in Aberdeen City (NJ925065) where N is the number in the sample, and Std Dev is one standard deviation from the mean.

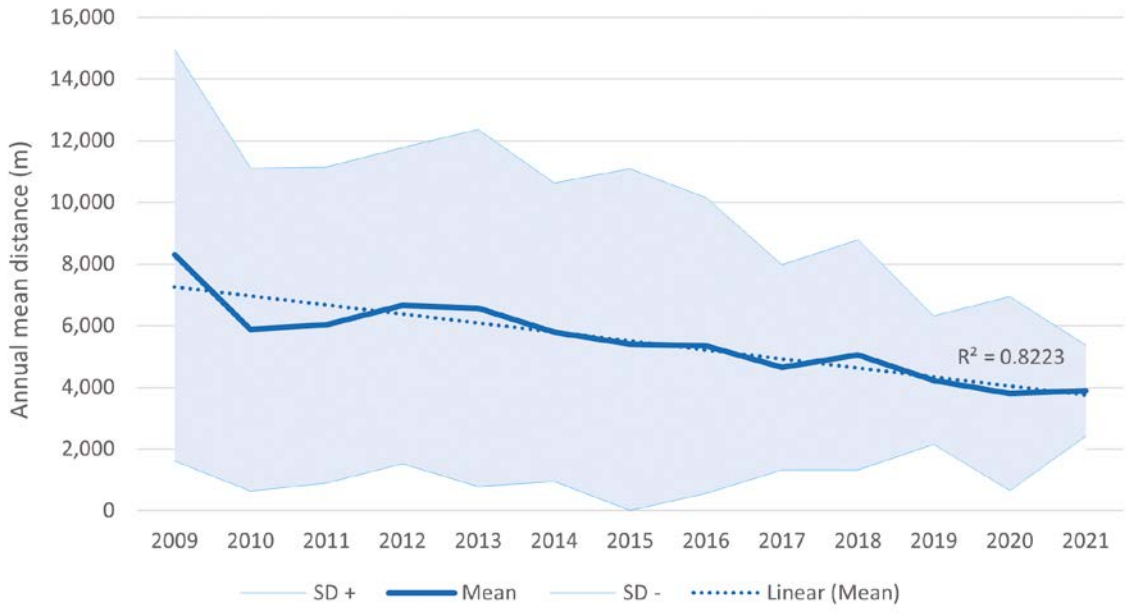


Figure 1. Mean distance of grey squirrel distributions from the point NJ095065 in the centre of Aberdeen. The pale blue shading indicates the variation in the distance measurements, with a calculated 1 Standard Deviation either side of the mean, i.e., including c.68% of the annual grey squirrel records.

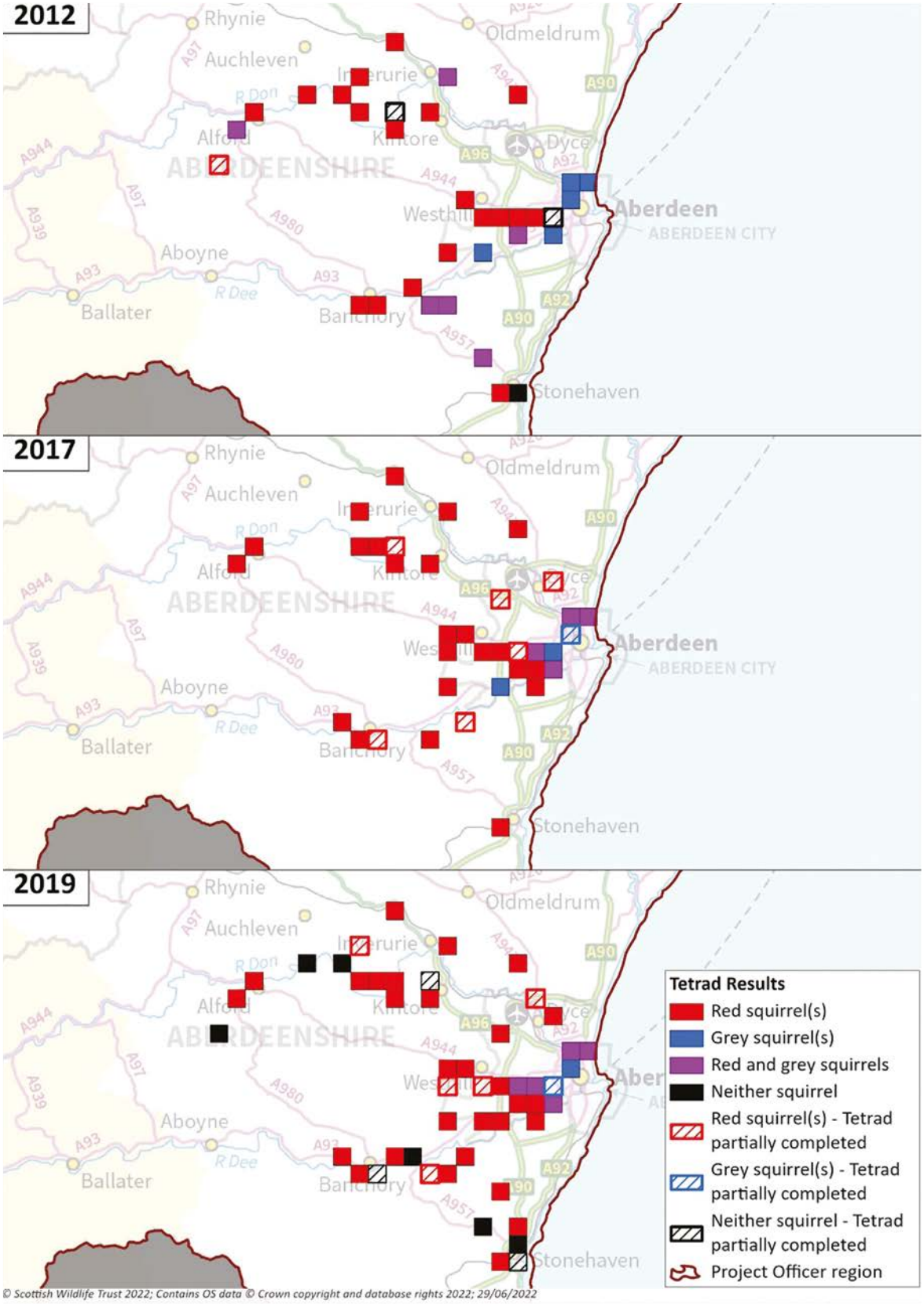
The overall trend for mean distance from central Aberdeen shows a clear decline with time from an average of about 8.3km from the centre in 2009 to about 3.9km in 2021. There is a great deal of variation in the individual measurements each year (see the maximum and minimum measurements in relation to the mean), with standard deviations relatively large compared with the mean, but the overall trend is of decline, which can be seen to continue during the SSRS-DCA period 2017–21 (Figure 1). The r^2 value indicates that about 82% of the change in mean distance is explained by the number of years since the start of SSRS activity in North-East Scotland.

This simple relationship suggests a successful compression of grey squirrel geographic range in North-East Scotland, and therefore a reduction in the grey squirrel threat to Scotland's red squirrels over the years the SSRS project has been active.

Spring tetrad surveys

The spring tetrad surveys were intended to be a standard method of evaluation of the outcome of SSRS work through until spring 2021. Whereas all other data sources were subject to the confounding effects of responsive trapping, the tetrad surveys sampled the same sites in the same way using the same effort each year, so that we could detect where the control work was making a difference. Unfortunately, the Covid-19 pandemic restrictions prevented the surveys from being completed in 2020 and 2021. Here, we use the spring survey maps from 2012 (the second year of the surveys), 2017 (the first year of SSRS-DCA) and 2019 (the year of the final spring tetrad survey) to illustrate changes in squirrel distribution in the North-East (Maps 3a-c).

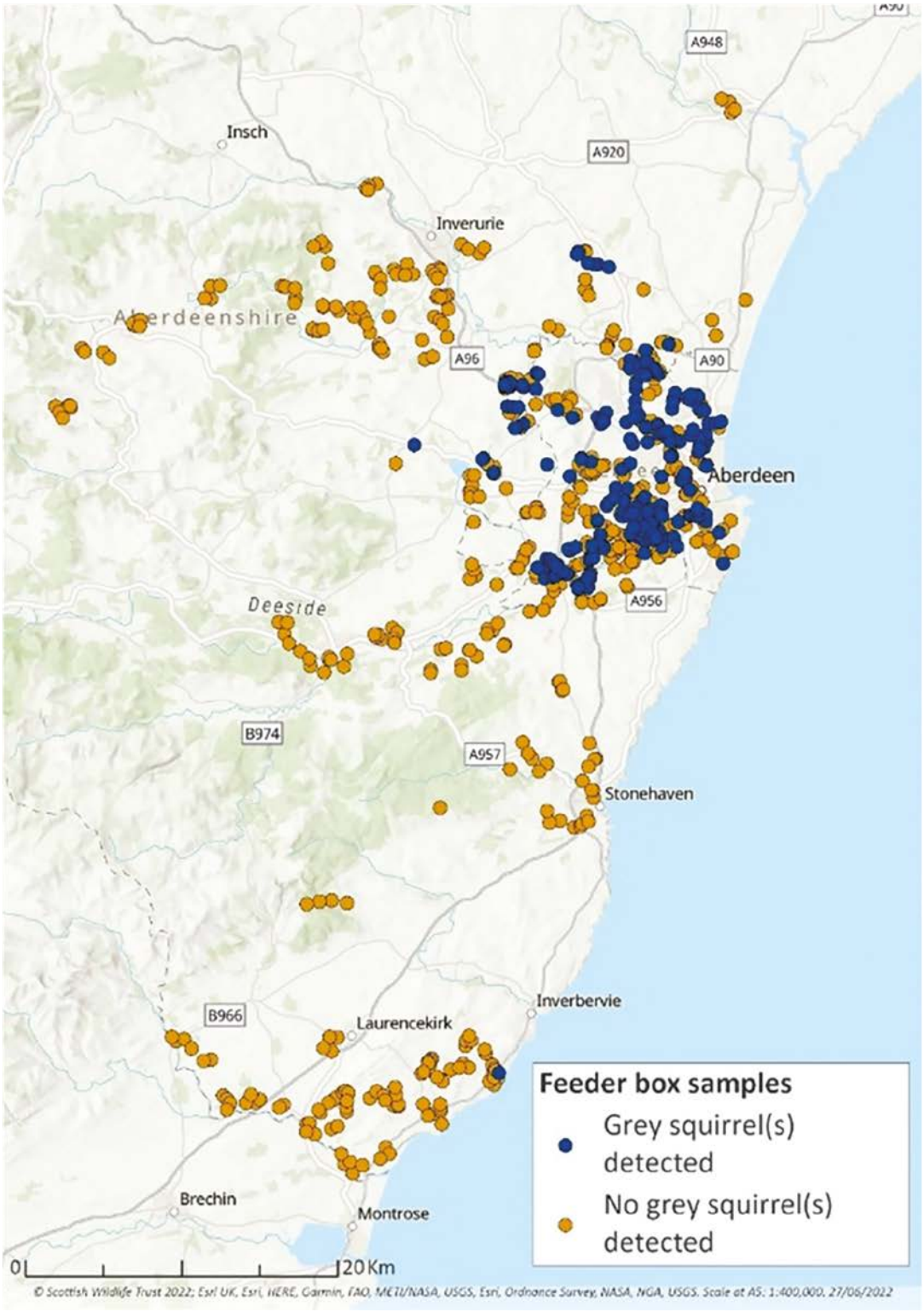
By 2012, the control work in Aberdeenshire had already been under way for five years. However, grey squirrels were still detected near Alford and Inverurie on Donside, near Kirkton of Durris on South Deeside and at Rickarton near Stonehaven. By 2017, we were only detecting grey squirrels within the bounds of the Aberdeen City local authority boundary, as far out on Deeside as Peterculter. By 2019, the most distant detections were in the city park of Hazlehead to the west, and the built-up area of Bridge of Don in north Aberdeen. Although the sample is too small to carry statistical significance, the survey provides yet another indication of the success of the project in reducing overspill of grey squirrels from Aberdeen to a minimum. The loss of the surveys in the two years following was a bitter blow.



Maps 3a-c. Spring tetrad survey results for 2012, 2017 and 2019 in North-East Scotland

Intensive grey squirrel surveys and rapid response surveys

These two surveys were intended to inform the trapping operations, and were not designed to be queried in detail. However, with 415 feeder-box sites involved, a great deal of work was involved in setting up the feeder-boxes: mapping habitat, finding land ownership and obtaining access permission, recruiting and training survey volunteers where possible and co-ordinating the distribution of equipment and supplies. Initially this operational monitoring was delivered mainly by staff, but from 2021 onwards the vast majority of sampling was volunteer delivered. Map 4 shows the coverage achieved over the period since the start of these surveys.



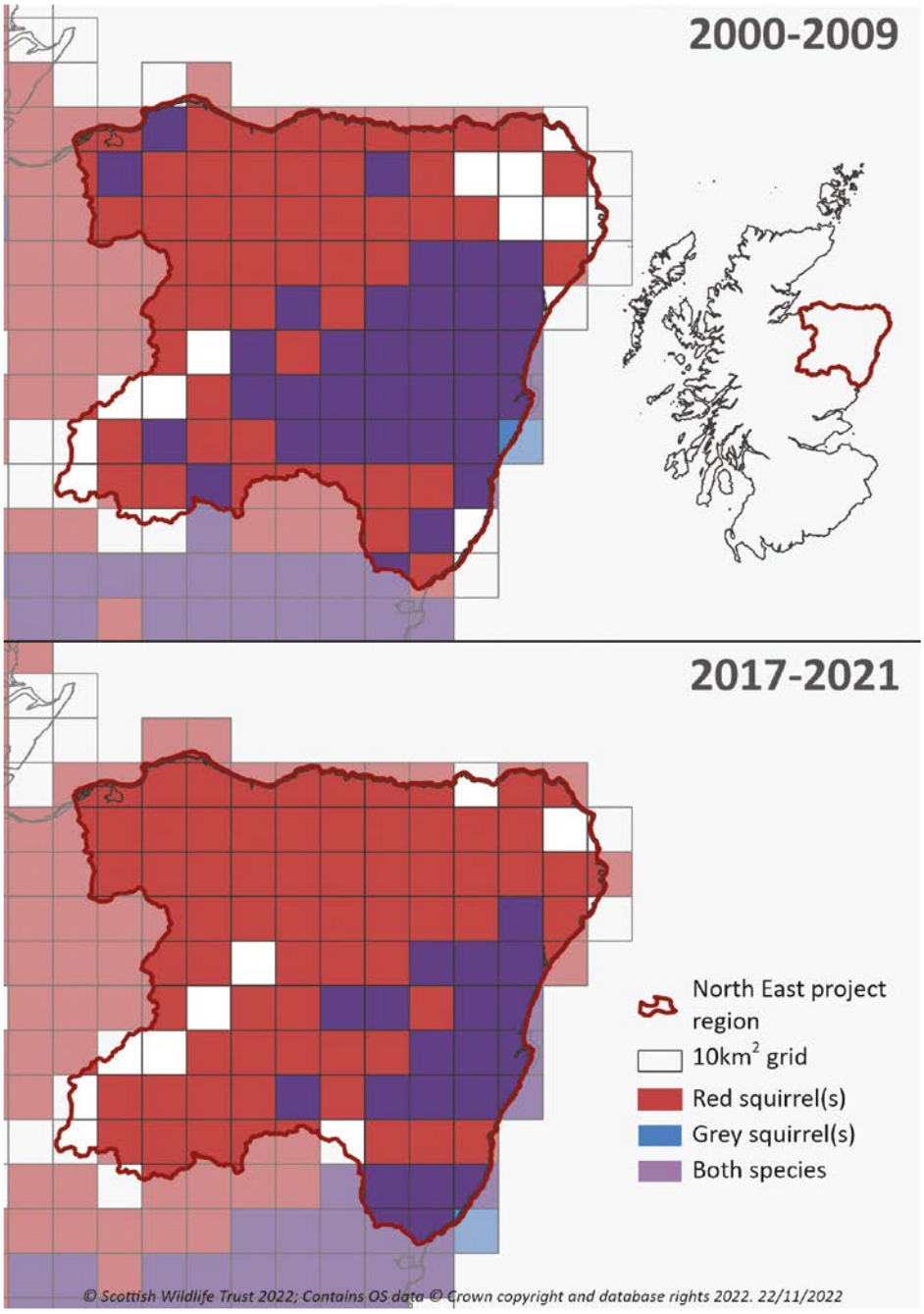
Map 4. Coverage achieved by rapid response monitoring and intensive grey squirrel control surveys.

10 kilometre-square mapping

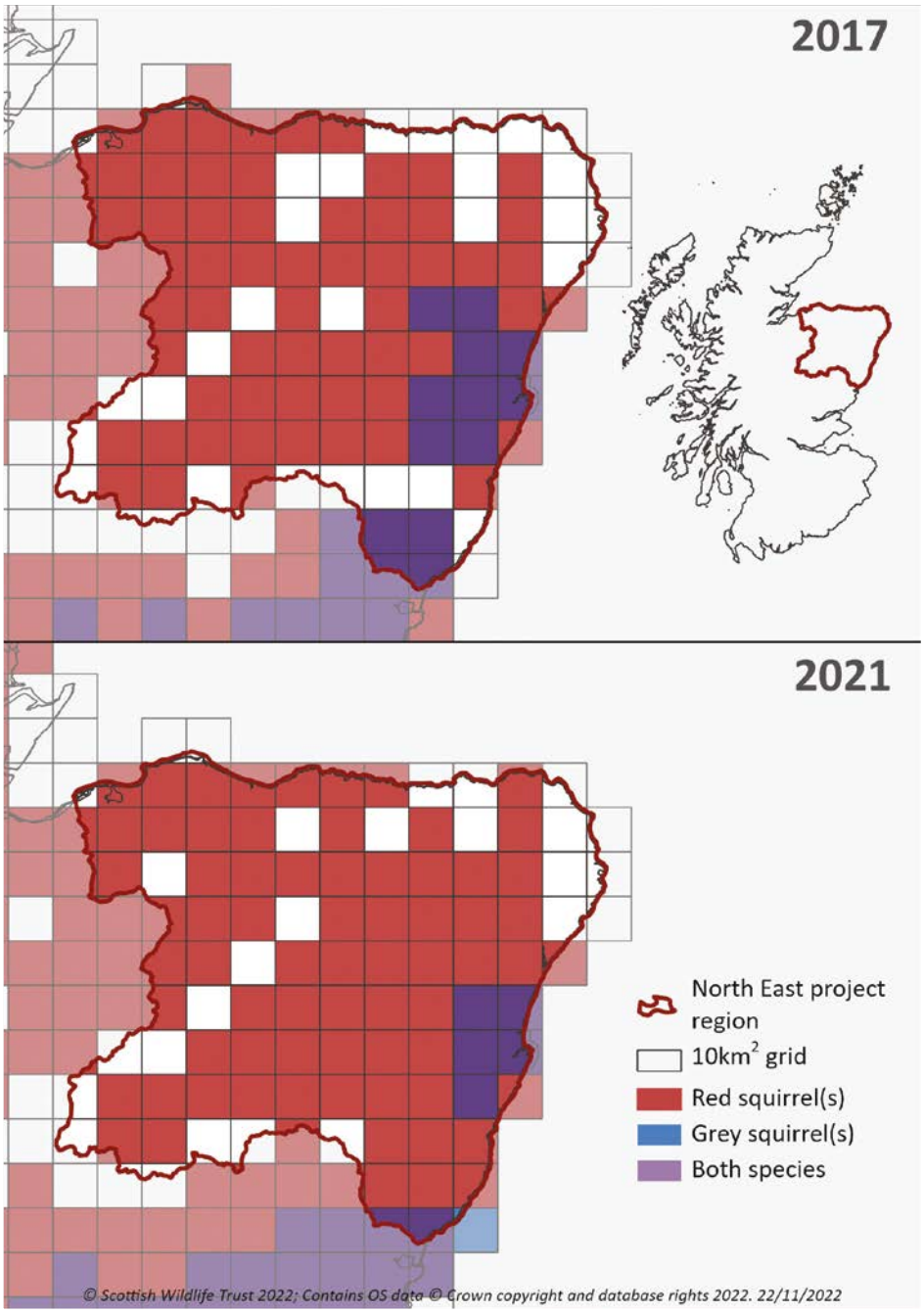
To further visualise the reduction in grey squirrel distribution, we plotted 10km-square mapping of both grey and red squirrel distribution records from trapping, monitoring and sightings reports, where grey squirrels are shown in blue, red squirrels in red, and the overlap squares in which both species occur in purple (Maps 5a & 5b and 6a & 6b) for two different comparisons:

- 2000–09, the period before the SSRS project, in comparison with 2017–21, the period of the SSRS-DCA project (Maps 5a & b): these maps show a disappearance of grey squirrels from squares in Highland and Moray, and a reduced distribution in Aberdeenshire outside of Aberdeen.
- 2017, the first year of SSRS-DCA in comparison with 2021, the final year of SSRS-DCA (Maps 6a & 6b), illustrates the further contraction of grey squirrel range during the project to focus very much on the City of Aberdeen.

The records include sightings, survey records and grey squirrel control records.



Maps 5a & 5b. 10km-square mapping of red and grey squirrels in North-East Scotland from the 10 years up to the start year of the SSRS project compared with the combined records for the SSRS-DCA five-year period.



Maps 6a & 6b. 10km-square mapping of red and grey squirrels in North-East Scotland comparing the start year (2017) of SSRS-DCA with the end year (2021).

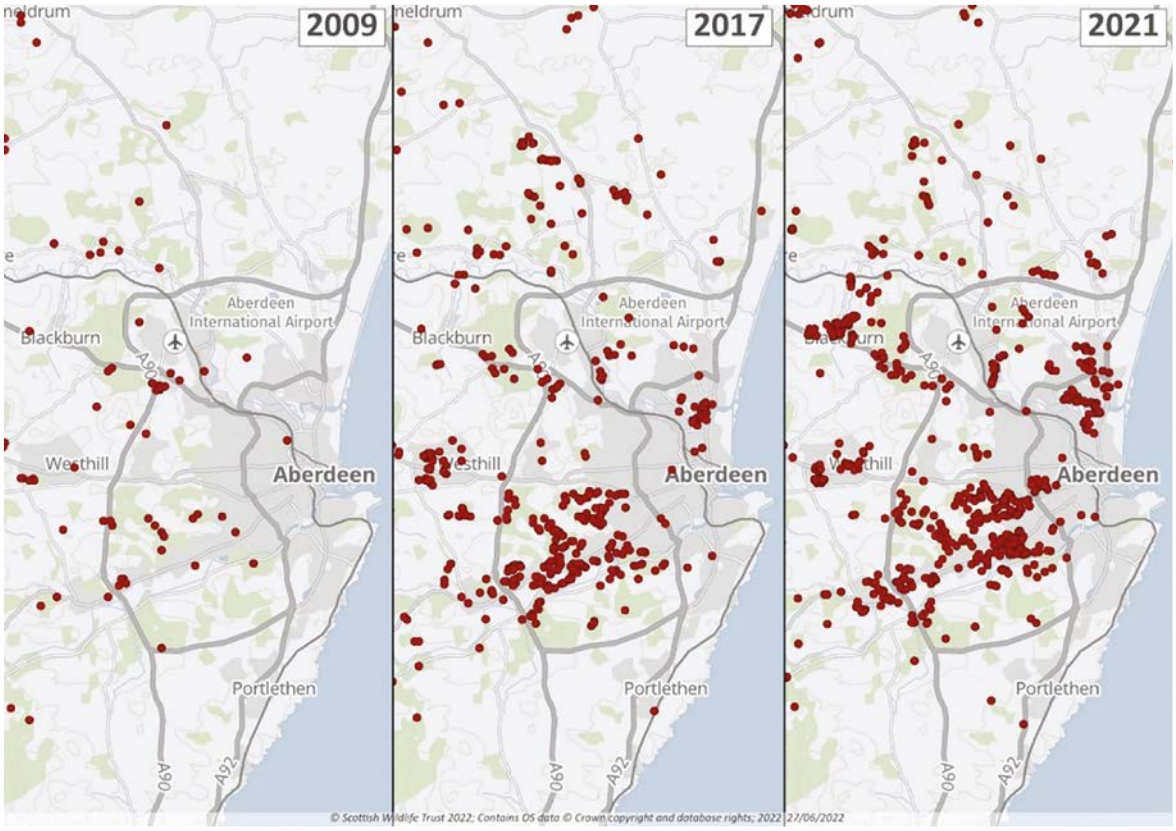
Red squirrel status

It is of critical importance that the management of grey squirrel populations in North-East Scotland has a beneficial effect on red squirrels. Here, the monitoring data and some evidence from captures of red squirrels caught as by-catch in the grey squirrel trapping activity were used to demonstrate the impact on red squirrels.

The spring survey mapping (Maps 3a-c), the 10km-square mapping (Maps 5a & 5b and 6a & 6b) and distribution mapping of individual red squirrel records (Maps 7a-c) show that red squirrels were never far away from Aberdeen. Over the course of the SSRS project, red squirrel sightings in parks and gardens ever nearer the centre of Aberdeen were spotted, detected by monitoring boxes or caught (temporarily) in traps. The red squirrel distribution mapping (Maps 7a-c) clearly shows the increasing presence in urban Aberdeen by 2021.

In fact, the project experiences increasing problems with red squirrels "trap-blocking", where a captured red squirrel takes that trap out of operation as a grey squirrel control tool. Red squirrels are released unharmed, and therefore may return to traps repeatedly. Although all traps are deliberately set in sites preferred by grey squirrels, and techniques are used to minimise the attractiveness of the traps to red squirrels, the SSRS North-East team has had to trial various means of actively deterring red squirrels from entering traps, so far without success. Indeed, the Rapid Response Monitoring has been part of the effort to minimise red-squirrel capture, by setting a trap to catch at these sites only when a grey squirrel has been detected. As SSRS moves closer to eradication of grey squirrels from Aberdeen, the trap-blocking problem will increase in importance, and techniques are badly needed that make the trapping more selective.

In conclusion, the reduction in the threat posed by Aberdeenshire grey squirrels to Scotland's core red squirrel populations has continued through SSRS-DCA activity, and Aberdeenshire red squirrel populations are responding positively to the change.



Maps 7a-c. Comparison of red squirrel distributions in Aberdeen in 2009, 2017 and 2021

6.4 Challenges and reflections

At the outset of SSRS-DCA, we aimed at reducing the grey squirrel population in the North-East to a level where we could hand on the monitoring work to volunteers, with a professional rapid response controller or small team to remove the remaining grey squirrels as they were detected. However, there was always a level of unpredictability around the achievement of this ambition within the timescale of the SSRS-DCA project – not least that this is the first documented attempt at a rodent eradication in a mainland urban environment in Britain (Bryce and Tonkin 2017[10]) or elsewhere - and the unknowns were many. The main challenges which were unpredictable or had an unpredictable level of impact are listed below.

The Covid-19 pandemic 2020–22

In March 2020, a global coronavirus pandemic precipitated the UK and Scottish Governments to implement a strict "lockdown" of the population, with people confined to their homes for their own protection except for certain emergency situations. SSRS had to immediately suspend all outdoor working from 23 March 2020. While staff were able to resume outdoor lone-working on 1 June, volunteers remained confined (except for work on their own land) until 15 July 2020, and access to national forest properties was not permitted until mid-August. Private landowners working alone on their own land were able to continue trapping in some instances. Overall, this suspension meant that grey squirrel control measures were suspended for the period late March to end of May, and the pandemic continued to impact face-to-face project activities until the spring of 2022.

A periodic grey squirrel population boom

In 2020, trapping could not occur during the period 23 March to end of May, coinciding with the spring breeding season for grey squirrels. Unfortunately, 2020 was also a year of grey squirrel population boom following a superabundant beech-seed and acorn crop in autumn 2019. The autumn abundance allowed squirrels to enter winter and to survive winter conditions in better body condition, an effect compounded by the mild winter conditions of 2019–20. This in turn led to higher survival, earlier breeding, a greater proportion of females breeding in the following January–March, and better survival of young leaving the nest in April–May.

Ordinarily, the control measures implemented annually by SSRS are sufficient to contain any unusual productivity of grey squirrels by interrupting their spring breeding and intercepting movements of the larger overwintered cohort. The most successful trapping months are March to July, therefore the timing of the Covid-19 restrictions was unfortunate for the prospects of containing the developing boom in grey squirrel numbers.

In the Aberdeen area, this led to a resurgence in grey squirrel densities in the city, and to several occurrences of grey squirrels detected at long distances from the city where they have not been seen for some years. This has stretched the staff team in dealing with these far-flung individuals. An increasing challenge which became pressing during 2020 was the increase in grey squirrel sightings in the Mearns area of southern Aberdeenshire. These were not grey squirrels overspilling from Aberdeen City, but instead were part of an expanding population of grey squirrels in Angus, to the south of the county border spreading towards Aberdeen. Although part of the Highland Line defence, the spread represented a sufficient threat to the work centred on Aberdeen that staff from the North-East Team were diverted to work in the Mearns. With some members of the team diverted, it left a depleted staff team to tackle the numbers in the city or to train volunteers to contribute to a rapid response system to come into place post-SSRS-DCA.

[10] Bryce, J. and Tonkin, M. 2017. "Containment of invasive grey squirrels in Scotland: meeting the challenge". IUCN Species Survival Commission 2019 No. 62, pp. 180–186, ref. 40. Island Invasives 2017 Conference, Dundee.

Unexpected usage of marginal habitat patches by urban grey squirrels

In 2021, an opportunity arose to collaborate with researchers from the University of the Highlands and Islands, using GPS[11] collars and radio-tracking to monitor the movements of grey squirrels in Aberdeen's urban environment, in order to facilitate better targeting of control measures. This Master of Research work, which will inform us more on the spatial ecology of this low-density urban population of grey squirrels in Aberdeen, was funded by Forestry and Land Scotland and is due to complete in September 2022. Although the work is yet unpublished, preliminary analysis has highlighted that breeding females can occupy much smaller patches of urban trees than expected over an extended period, whereas males are highly mobile, and home ranges up to ten times larger than published grey squirrel home ranges have been observed. This suggests that there is a greater population of grey squirrels remaining in the city than hitherto appreciated, and that greater coverage by the project of all potential habitat is required.

Impact of high public footfall

As the sites we need to trap in become increasingly urban, the greater the issues become with conducting the grey squirrel control in such a way that it is not impacted by the proximity of members of the public or their dogs. Even well-disposed people can impede the success of control work just by passing near traps. This issue can be expected to continue to increase, and will require ingenuity in developing ways of intercepting grey squirrels when people are nearby.

Trap-shy individuals

In any population eradication, it is important that all target individuals are susceptible to the control methodology. Most trapped mammal populations contain an element of trap-shy individuals, which are inevitably the ones left towards the end of an eradication effort. The project will need to find additional methods of detecting these individuals and alternative ways of removing them from the remaining population.

In summary, contrary to expectations that as grey squirrel population declined there would be a decreasing level of staffing needed to manage the situation, what we have learned through the SSRS-DCA project is that as grey squirrel densities fall, it has the effect of greatly increasing the effort required to detect them. It is now realised that the levels of work required will always need a small, specifically tasked control team until zero grey squirrels can be detected in the city and its surrounds over a timescale yet to be specified, for which the project will seek scientific advice. This will need to be followed by post-eradication monitoring (with associated rapid response for any positive records) for a number of years, also in accordance with scientific advice.

[11] Global Positioning Satellite units to allow the squirrels to be tracked by the researchers.

7.
Central Lowlands

Central Lowlands

The SSRS project in the Central Lowlands has a focus of effort in the Highland Line Control Zone, the 10-kilometre-wide stretch of landscape to the south of a notional Highland Line running from the west coast at Helensburgh to the east coast near Montrose (see Map 1). The Highland Line runs approximately along a topographical divide between the upland landscapes with conifers and moorland and the fertile lowland farmlands with mixed broadleaved woodlands ideal for grey squirrels. The upland landscape provides a partial barrier to the northward spread of grey squirrels, assisting SSRS efforts to contain grey squirrels to the south of the Highland Line. In practice, the project works to the north of the Highland Line when required to remove grey squirrels that have been detected further north; and public outreach may stretch south to include Dundee, Bridge of Allan, Stirling and Dumbarton.

7.1 Objectives

1. Deliver the strategic and co-ordinated control of grey squirrels necessary to prevent their establishment north of the Highland Line, where they would pose a threat to Scotland's core grey-free red squirrel populations in highland Scotland.
2. Commission modelling work to help determine what scale of control work will be needed over the long term to protect Highland red squirrels from grey squirrel replacement and from squirrelpox disease.
3. Carry out squirrelpox testing of grey squirrels in accordance with a systematic sampling scheme covering the landscape from the Central Belt to the Highland Line in order to track any northward spread of the virus through the Lowland grey squirrel population, where it could pose a threat to remaining red squirrel populations in the region.

Assumptions

1. An assumption made while planning the grey squirrel management work was that there would inevitably be occasional incursions of grey squirrels north of the Highland Line. These would need to be detected and removed, demanding constant vigilance. This was to be achieved through educating the public to be aware of the threats grey squirrels pose to native red squirrels and encouraging them to report their squirrel sightings to the SSRS website reporting page.

   From this assumption arises the question of how we should determine whether or not we are being successful in containing the spread of grey squirrels. The approach the project has chosen to take is to assess whether grey squirrel distribution north of the Highland Line (excluding the Aberdeenshire population) is less extensive than before the initial years of control measures (2010–12) had made an obvious impact on the extent of grey squirrel distributions. Maintaining the reduced extent of geographical range would constitute success.
2. If grey squirrel range could be successfully contained, the probability of squirrelpox spread to red squirrels to the north of the Line would be extremely low. Hence the trapping was intended to contain both the grey squirrel competitor and the spread of the virus. Furthermore, if grey squirrel densities could be kept very low within the 10km-wide Highland Line Control Zone, local red squirrel populations would benefit from increased habitat availability and reduced probability of squirrelpox infection, and there would be smaller grey squirrel populations to be a source of dispersing squirrels heading northwards.

7.2 Activity during SSRS-DCA

Strategic grey squirrel control

Two SSRS teams covered the work in the Central Lowlands:

- **Tayside:** A Conservation Officer co-ordinated the efforts of a team of four grey squirrel controllers (Grey Squirrel Officers and self-employed contractors – grouped as "GSOs" for convenience). The GSOs focused their grey squirrel population management work in the Tayside section of a 10km-wide Highland Line Control Zone.

  Note that the Mearns lowland farming region of southern Aberdeenshire actually lies to the south of the geographical Highland Boundary Fault, but the need to maintain maximum separation between the isolated Aberdeen grey squirrel population and that of the rest of Scotland led the project to adopt the county border as the eastern end of the Highland Line for grey squirrel control purposes to prevent establishment of grey squirrel populations further north than this.

  GSOs undertook blood sampling of grey squirrels for squirrelpox testing in sample sites within the Highland Line Control Zone, while volunteers contributed further squirrelpox samples from monitoring sites further south.

- **Stirlingshire, Argyll and the Trossachs:** A Conservation Officer, based at the Loch Lomond & The Trossachs National Park office in Balloch, managed a single GSO to manage the much smaller grey squirrel presence in the area. In addition to grey squirrel population management in a few key areas, the GSO was tasked with the systematic squirrelpox monitoring of sites from Glasgow to Falkirk as well as in some of the squirrelpox sample sites across the western stretches of the Highland Line Control Zone.

In most years, the GSOs were seasonally active from March to July or August, covering the most productive trapping season, but in some years longer contracts were given by way of adjustments for time lost, for example to the pandemic lockdown.

Across the Central Lowlands, between 32 and 46 co-operating landowners completed work under Forestry Grant Scheme five-year funded contracts: between 25 and 39 of them in Tayside, and seven to nine operating in Stirlingshire, Argyll and the Trossachs. The number of contracts fell during the five-year project as earlier contracts finished and renewed contacts became less viable for the landowners due to the reduced grey squirrel presence. In most cases alternative coverage, either voluntarily, or in some cases by project staff, was continued in order to prevent a rebound in the grey squirrel numbers. In a few cases there were no further grey squirrels detected, making the landholding ineligible for the grant.

A trap-loan scheme ran across both regions of the Central Lowlands grey squirrel control zone. Some recipients were trained and willing to carry out their own dispatch of grey squirrels. However, increasingly, as more urban areas were covered, the project recruited householders to look after traps in their gardens. The dispatch was delivered either by one of the staff team or by a local trained dispatcher working voluntarily. In 2017, 18 trap-loans were active, rising to 56 in 2018, 56 in 2019, 26 in 2020, and 108 in 2021. (Note that these figures reflect those reporting trapping activity, and did not include those who were part of the scheme but not currently deploying their traps.)

The coverage and the outputs achieved over the five years are presented in more detail in the SSRS-DCA Five-Year Trapping Report (2017–21)[12] and in the work previously reviewed by Collis and MacMaster 2021.[13]

[12] Tonkin, M. and Tipple, N. 2022. *Saving Scotland's Red Squirrels: Trapping Report for Years 2017–2021.*
[13] Collis, M.-A. and MacMaster, A.-M. 2021. "Saving Scotland's red squirrels in the Central Lowlands: holding the Highland Line". In: Shuttleworth, Lurz and Robinson (eds), *Saving the Red Squirrel: Landscape Scale Recovery* (Red Squirrel Survival Trust).

Monitoring

In the Central Lowlands, the main forms of monitoring were:

Spring tetrad surveys

These were carried out annually from 2011 to 2019, eventually covering 86 sampling sites across the Central Lowlands, with sampling weighted towards those areas that were most likely to register a change of species.

Squirrelpox virus monitoring

This started in the Central Lowlands in 2012, sampling at approximately regular geographical intervals across the whole area of Scotland occupied by grey squirrels, sampling in one 10km square from each square in a 20x20km grid mapped across the landscape. From each sample square, the project aimed to collect a minimum of 10 blood samples per annum. The blood samples were sent to the Moredun Research Institute for immunological testing for specific squirrelpox virus antibodies. A detailed account of the results of the squirrelpox monitoring has been reported separately in Tonkin 2021[14] and thus will not be covered in detail in this report.

Sightings reporting

This was important in detecting presence of grey squirrels in sites that needed to be kept clear of the species. Grey squirrel sightings in new sites within or to the north of the Highland Line control zone could be followed directly by trapping, or by setting up a feeder-box to monitor for continued presence to trigger trapping, or by recruitment of a trap-loan volunteer to help with the removal of grey squirrels at the site.

7.3 Progress during SSRS-DCA

Grey squirrel status

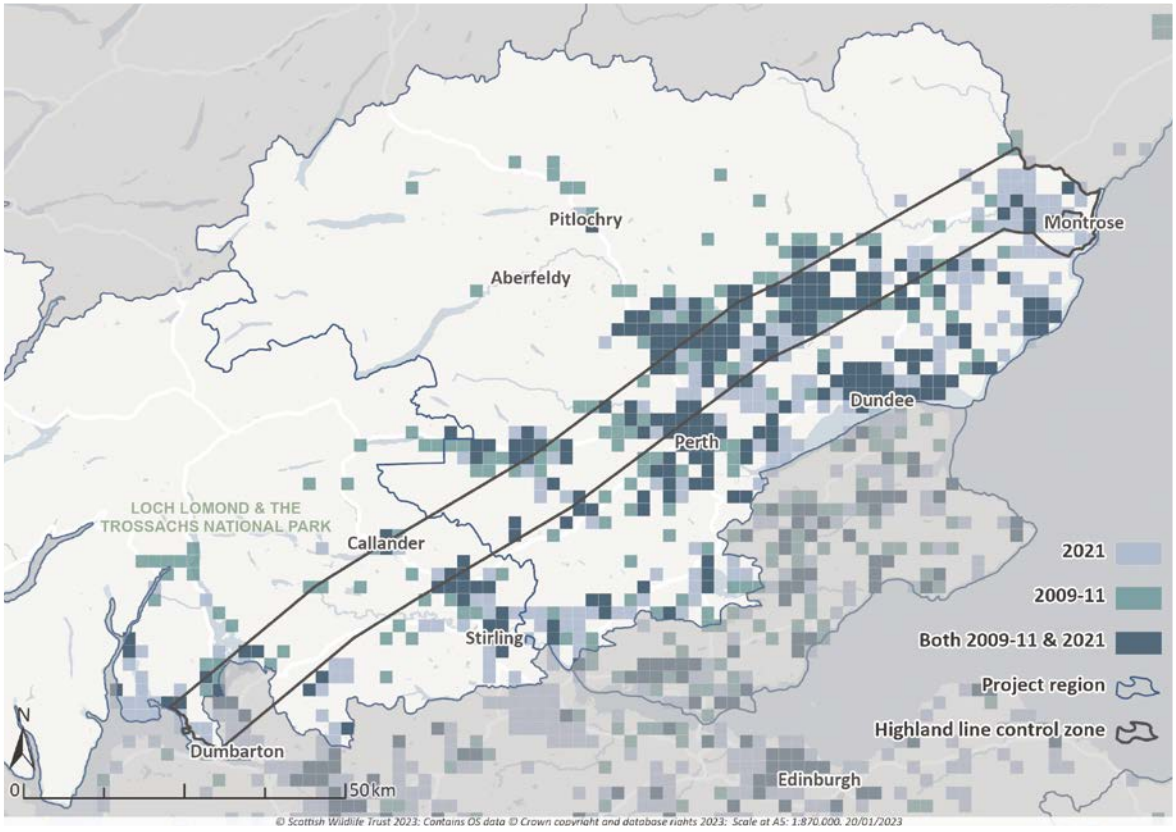
Several datasets provided information on the relative success of the grey squirrel containment effort along the Highland Line.

Distribution mapping

We used 2km square mapping (Map 8) to compare grey squirrel distributions in 2021 with the situation at the start of SSRS, combining the records from 2009–11 to achieve a comparable sample size (1,091 distribution records) to that received in 2021 (1,410 records). Distribution records included sightings, survey results and trapping results.

The comparison shows a retraction of grey squirrel range between the start of SSRS and 2021 in a number of key areas to the north of the Highland Line Control Zone: notably at west Loch Lomond at Tarbet (a key dispersal corridor into Argyll), in the Loch Voil and Loch Earn area, in the River Garry Valley as far north as Blair Atholl (main dispersal route into highland Perthshire), and in the Angus Glens, particularly Glen Shee and Glen Isla (dispersal routes into Grampian and potentially the Highlands).

[14] Tonkin, M. 2021. *Squirrelpox Detection in the Central Lowlands 2017–2020*. SSRS Project Report published on the SSRS website.



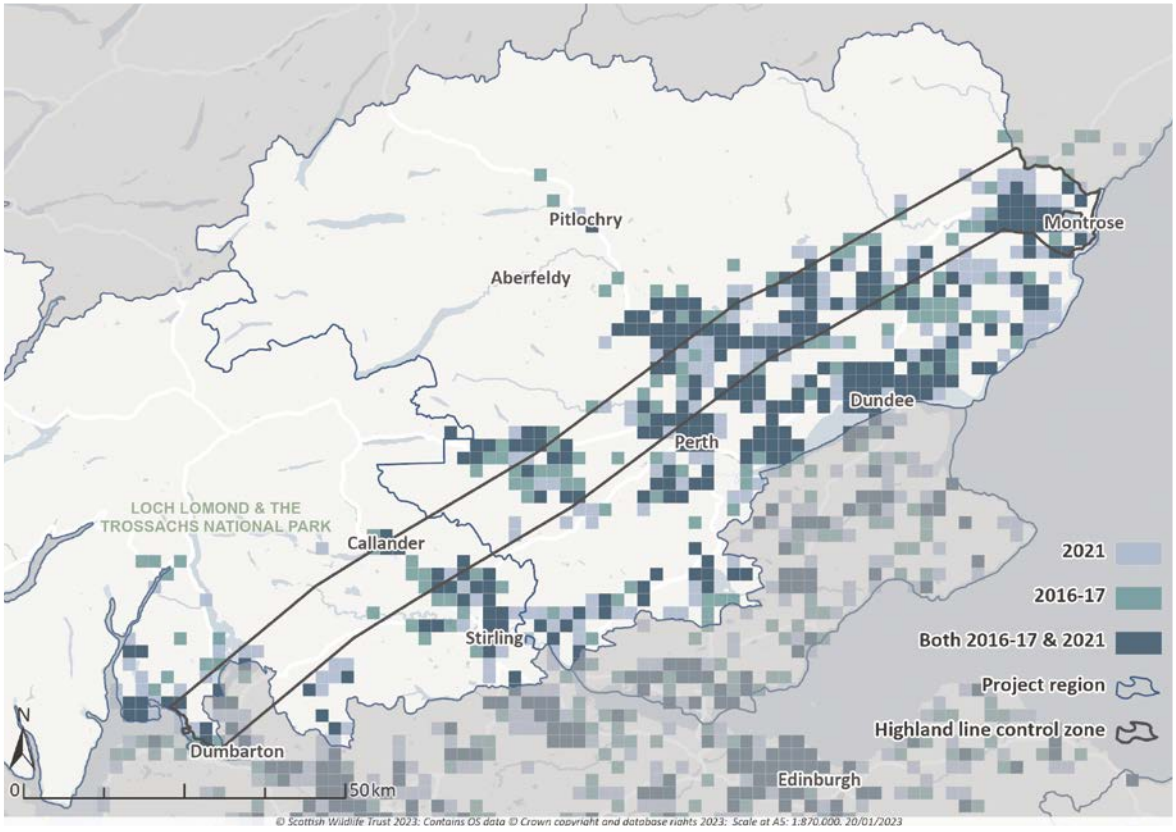
Map 8. Distributions of grey squirrels in the Central Lowlands comparing 2021 with 2009–11. Includes sightings, survey and trapping results.

Notable contraction of grey squirrel range also occurred within the Highland Line Control Zone between Balmaha on east Loch Lomond and Callander, and also to the south of the Highland Line Control Zone between Buchlyvie and Gargunnock in the Forth Valley. While the SSRS project and its landowner partners can claim some credit for the containment of grey squirrels in this area, it is likely that the recovery of pine martens across the region will have had an impact, particularly within Loch Lomond & The Trossachs National Park.

This contrasts starkly with the situation at the eastern end of the Highland Line, the weakest point in the defences protecting all of northern Scotland's red squirrels, since it is here that dispersal northwards through the lowland landscape towards Aberdeen is easiest for grey squirrels. Since the start of SSRS, the whole of Angus between Arbroath and Montrose has been colonised by grey squirrels, expanding their range into the area around Brechin and Montrose, and across the border into the lowland Mearns area of Aberdeenshire.

Very little control work has occurred in Angus to the south of the project's focus in the Highland Line Control Zone, allowing the grey squirrel population to expand freely. Seasonal control within the Control Zone has been insufficient to prevent low-level incursions northwards into the Mearns. In the final two years of SSRS-DCA, monitoring and control in the Mearns intensified and was successful in locating and removing some of this small number of grey squirrels.

We then used 2km square mapping to compare the situation in 2021 at the end of the SSRS-DCA project with the years 2016–17 at the start of the project (Map 9). Again, we combined the years 2016–17 to achieve a more comparable sample size (1,150 records) with 2021 (1,410 records).



Map 9. Distributions of grey squirrels in the Central Lowlands comparing 2021 with 2016–17. Includes sightings, survey and trapping results.

The distribution of grey squirrels over the two time periods looks very similar. 2km-square mapping shows some retraction of grey squirrel distribution north of the Highland Line – at Tarbet and Luss on west Loch Lomond, parts of western Strathearn, in the corridor of the rivers Tay and Garry and in part of the Mearns area of Aberdeenshire.

As with all other project areas, there were several long-distance dispersals of grey squirrels detected following the 2020 population boom, mostly in the Tay–Garry valleys and the shore of Loch Long and Gare Loch. From the follow-up monitoring and publicity around the Tay–Garry sightings, it seems likely that they represent individuals or small numbers. The project was only able to remove one grey squirrel from Pitlochry in early 2021, despite intensive efforts to detect their whereabouts following the initial sightings at Pitlochry, Aberfeldy and Strathbraan. Ongoing vigilance will be needed to continually assess the level of threat and remove any surviving individuals as quickly as possible.

Smaller extensions in range can be seen at the lower Angus Glens and in the eastern part of the Mearns. There was also a consolidation of the population in the Montrose area.

Overall, however, the comparative mapping of the combined distribution data for grey squirrels suggests there has been very minor change in grey squirrel distribution over the five years of the SSRS-DCA project. Despite the challenges brought about by the pandemic lockdown restrictions and an especially productive season for grey squirrels in 2020, the project has been largely successful in containing the geographic range of established grey squirrel populations. Notwithstanding, heightened alert will need to be maintained in the Mearns in the future as a critical point in the defence of Grampian red squirrels.

Spring tetrad surveys

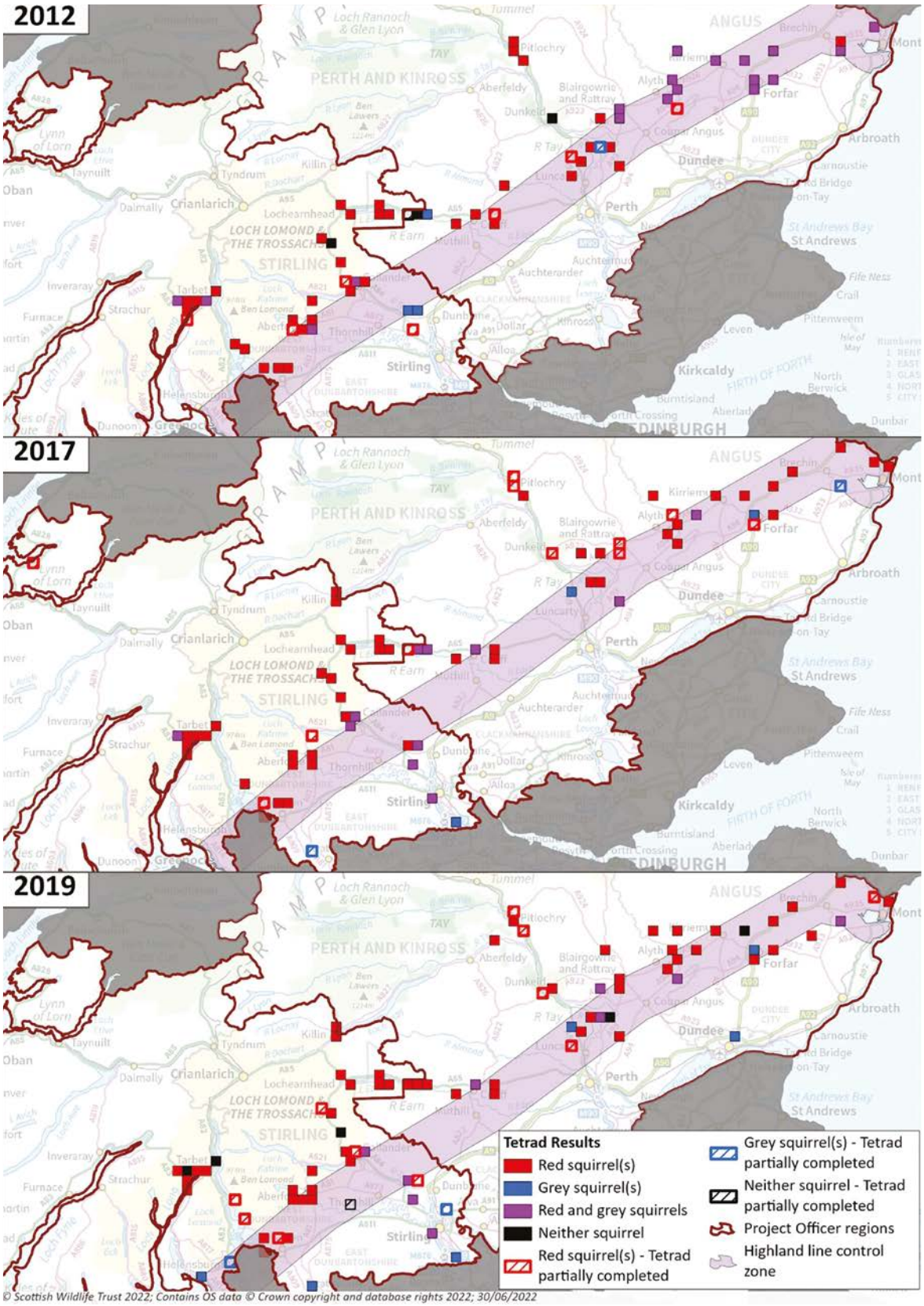
Spring tetrad surveys at between 69 and 85 sites across the Central Lowlands were carried out from 2012 to 2019, and at a smaller number of sites in 2011 (see Tipple and Tonkin 2020[15]). We selected mapping from 2012 as the start of the full monitoring sample, 2017 and 2019 (the start of SSRS-DCA and the last survey completed) to explore the changes (Maps 10a-c).

The tetrad survey sites show red squirrels distributed across much of the region sampled. Grey squirrels were not detected in 2017 in most of the tetrads where they had occurred in 2012. Detection of grey squirrels was also very low in 2019, suggesting a sustained containment compared with 2012.

However, analysis by Porton et al. (2020[16]) suggested a possibility that low detectability did not necessarily indicate complete absence. Using occupancy modelling, which accounts for varying probability of detection between sites, they investigated the changes in occupancy of red and grey squirrels in the Central Lowlands using the SSRS spring tetrad data collected between 2013 and 2018 (i.e. omitting the years of rapid reduction of grey squirrels in 2010–12). They detected increased occupancy by grey squirrels, together with a small decrease in red occupancy, in tetrads above the Highland boundary line. However, they noted that an increase in occupancy did not necessarily equate to an increase in abundance, particularly as it was accompanied by decreased probability of detection over time (suggesting a density decrease). Nevertheless, it did indicate some grey squirrel recolonisation of areas north of the Highland Line over the period since 2013.

It is unfortunate that the Spring Surveys were not able to be run in 2020 and 2021 due to the Covid-19 pandemic. It would have been useful to have checked whether the standardised surveys were able to detect any signs of further range expansion.

[15] Tipple, N. and Tonkin, M. 2020. *Evaluation of Spring 2019 Squirrel Surveys.*
[16] Porton, G. et al. 2020. *Evaluation of the Progress of Saving Scotland's Red Squirrels towards its Region-Specific Management Aims, Accounting for Imperfect Detection*. Report funded by the People's Trust for Endangered Species internship.



Maps 10a-c. Spring tetrad survey results for 2012, 2017 and 2019 in the Central Lowlands

Grey squirrel control mapping

The distributions of trapping effort and captures from 2017 and 2021 were mapped for comparison. (Note that the SSRS-DCA Five-Year Trapping Report[17] covers all years and examines other aspects of the trapping work.) Trapping effort is measured in trap-days (one trap-day is equivalent to one trap being set for one day). Maps 11a-d show a consistent geographic distribution of trapping effort in both periods, but with more trap-days and more contiguity of trapping by 2021, almost doubling the effort within and to the north of the Highland Line Control Zone from 2017 to 2021. About 50% of the trapping was delivered by landowners under the Forestry Grant Scheme, working with a consistent deployment of traps over the five years of their grant contracts. The sites which could not be covered by landowners were filled mostly by project staff, with the assistance of an increasing number of volunteers with traps in their gardens. The mapping shows the key dispersal route north of the line in Strathtay (centred on Dunkeld) receiving a comparable level of trapping in both time periods, greater focus along the Strathearn dispersal route around Comrie and Crieff in 2021 and a small amount of trapping in the Mearns dispersal route, north of Montrose, by 2021. The dispersal route into Argyll along Loch Long and Gare Loch was also subject to increased trapping focus by 2021. A comparison of the effort and capture maps show that grey squirrels were not caught at all trapping sites, reflecting the precautionary approach taken to check for colonisation of wider suitable habitat. This suggests that the effort in the trapped sites was more than sufficient to keep the local population in check. Increasingly the project has turned to camera-trapping to check previously cleared woodland, only trapping when a grey squirrel has been detected.

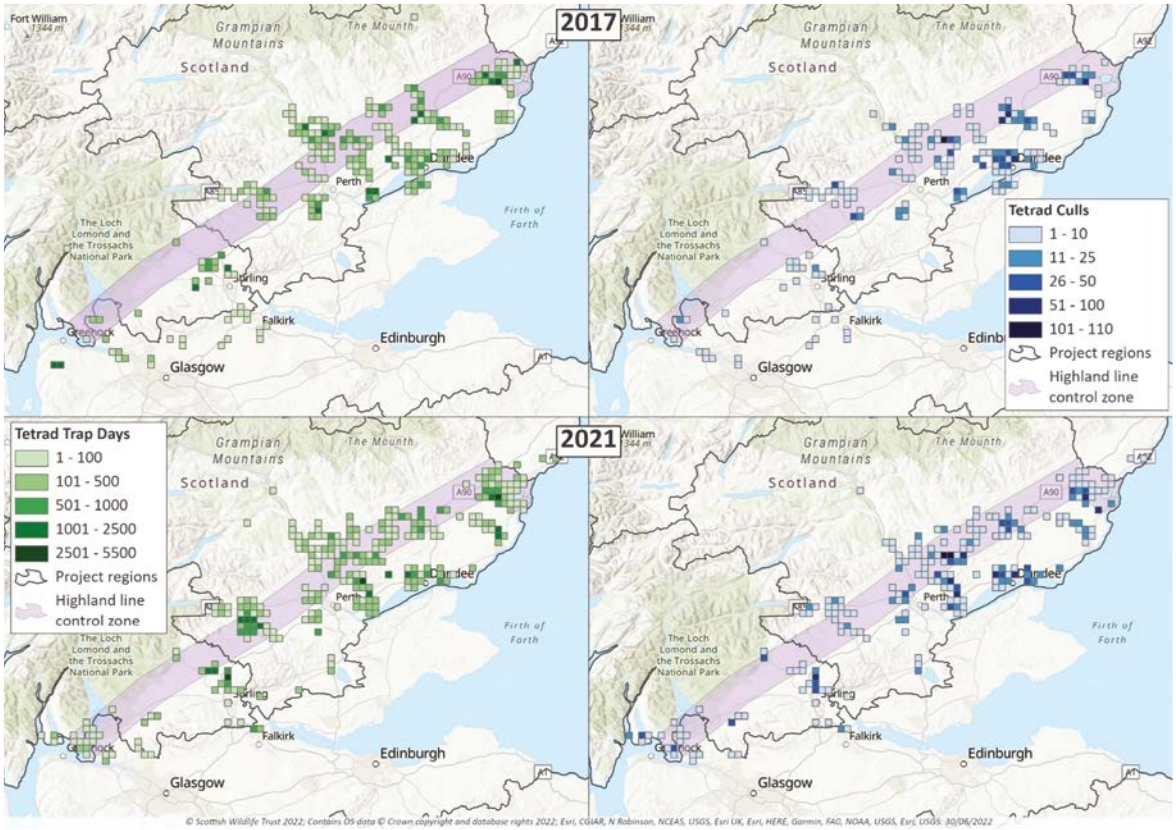
Note that the maps show considerable trapping occurring well south of the Highland Line Control Zone. On the west side of the region this is largely due to trapping specifically for blood sampling for squirrelpox testing, but from Stirling eastwards, volunteer trappers and a few FGS recipients continue to trap to protect their local red squirrels.

Overall, the control mapping indicates that containment efforts have been largely successful, and underscores the need to remain responsive to the fluctuations in grey squirrel populations within or to the north of the Highland Line control zone.

Generalised Linear Mixed Model analysis, aimed at statistically testing the effectiveness of SSRS trapping efforts in Tayside, examined the project's 2010–12 trapping data from a defined 54km^2 study area south of Dunkeld (Oliver 2013).[18] The work confirmed that the cumulative control effort had significantly reduced the threat posed by grey squirrels within the study landscape, subject to the continuance of trapping pressure to pre-empt reinvasion by grey squirrels from the wider landscape.

Spatially explicit individual-based deterministic modelling (White et al. 2017[19]) investigated different scales of control work across the Central Lowlands in order to assess the viability of grey squirrel control along the Highland Line over the long term. The mathematical model used research-based red and grey squirrel population parameters to model population processes in a realistic Highland Line landscape with habitat data derived from digital landcover datasets. Individual squirrels' life events were subjected to different levels of probability to replicate real-world systems.

[17] Tonkin, M. and Tipple, N. 2022. *Saving Scotland's Red Squirrels: Trapping Report for Years 2017–2021.*
[18] Oliver, M. 2013. "Saving Scotland's Red Squirrels Project Phase 2 Data Analysis: Modelling changes in grey squirrel capture rates in response to spatial cumulative control effort. SSRS contract report." In: Tonkin, M., Bamforth, L. and Ramoo, K. 2014. *Evaluation of Grey Squirrel Control in the Saving Scotland's Red Squirrels Partnership Project (Phase Two) 2nd Report 2009–2013.*
[19] White, A., Lurz, P. and Boots, M. 2017. *Grey Squirrel Control along the Highland Line: A Model Analysis*. Heriot Watt University Report. NERC Innovation grant NE/M021319/1.



Maps 11a-d. Trapping coverage and grey squirrel captures by SSRS staff, volunteers and landowners in the Central Lowlands 2017–21.

After running the model up to 35 years from initial control measures, the authors concluded that grey squirrel control is an effective method of preventing northward grey squirrel expansion if applied at the levels delivered at the time by the SSRS project and its collaborating network of landowners and volunteers (based on 2016 estimates of levels of SSRS control). The model confirmed that the Highland Line topography, with its associated change from lowland farming landscape with broadleaved woodlands to upland landscapes with conifer or moorland, offered relative protection from the threat of grey squirrels moving northwards to displace Highland red squirrels. While a medium-intensity level of trapping could prevent dispersal across most of the Highland Line, high-intensity trapping was required in the zone from west Dunkeld through Blairgowrie to Alyth to prevent grey squirrels evading capture and spreading northwards. Furthermore, they identified the lowland landscape of the Mearns of Aberdeenshire as a possible route for grey squirrel dispersal and establishment in the Highlands.

In the model, the level of control recommended by year 10 of the control effort was of the order of 60,000 trap-days per year across the whole Highland Line Control Zone. The minimum level of recorded control delivered to this region (Highland Line Control Zone, plus Strathtay, Strathearn and Gare Loch north of the Zone) during the SSRS-DCA project was between 26,409 trap-days in 2017 and 49,723 trap-days in 2021 (equating to years 9 to 13 in the model). These are minimum figures, since we were not able to collect all trap records from landowners working under the Forestry Grant Scheme.

It should be noted, however, that the SSRS trapping maps omit pre-baiting. All SSRS traps are pre-baited for a varying period before being set to catch. During this period, they are monitored for squirrel usage, sometimes using baited trail-cams as well or instead. In several sites where grey squirrels used to occur, most of the traps on pre-bait now never need to be activated to catch, as squirrels are not taking the bait, or only red squirrels are detected on camera. Monitoring in this way, usually checking the images weekly or fortnightly, is a much more effective use of staff time than trapping at unproductive sites, which requires twice daily visits while the traps are open to catch. Staff, volunteers and FGS-funded landowners delivered between 7,708 and 22,899 recorded pre-bait days per annum. This takes trap-deployment time to between 34,117 in 2017, building to around or more than 60,000 days of trap-deployment for all subsequent years, reaching 72,622 pre-bait plus trap days in 2021. Note that volunteers and landowners did not all consistently record pre-bait days, so the numbers above are minimum figures.

Thus, in practice, the constraints on staffing required that best use was made of the staff time available, which included monitoring (rather than trap-setting) until a grey squirrel was detected as described above, and closing the traps when they had caught no further grey squirrels at a site for three consecutive days, so that effort could shift to the next location.

It is highly likely that the grey squirrel population boom of 2020, combined with the lack of control measures in spring and reduced control for the remainder of the summer, enabled grey squirrels to spread unconfined for a time, reaching Pitlochry, Aberfeldy, the Angus Glens and the west side of Loch Lomond, Gare Loch and the head of Loch Long, as well as breeding being detected for the first time in the Mearns. Once pandemic restrictions had eased, considerable effort invested in tracking these down and attempting removal was only partially successful, and ongoing sightings and feeder-box monitoring will be required to detect further grey squirrels and prevent establishment of new populations centred on these sites. It is worth noting that in many cases in previous years nothing further is detected of these long-distance dispersers, and there is a cost/benefit assessment required as to how long to pursue each one, as opposed to general vigilance.

Squirrelpox virus monitoring

Between 2017 and 2021, SSRS staff and volunteers collected grey squirrel blood samples for squirrelpox antibody testing from between 16 and 23 samples sites across the Central Lowlands. The sample sites were distributed from Glasgow and Edinburgh northwards to the Highland Line. Previous sampling work in the region, starting in 2013, had established that squirrelpox was extremely limited in its distribution through Central Lowlands grey squirrels, having been found only at Plean (south of Stirling), Bearsden and Erskine (in Glasgow), and one at south Loch Lomond.

The 2017–21 sampling returned positive results for squirrelpox from Plean, near Stirling (in 2017), Erskine, north-west Glasgow (in 2018) and one faintly positive test out of a sample of 10 from Strathallan, to the north of Auchterarder (in 2019). The latter site was trapped again the following year, but very few grey squirrels remained. The few that were caught tested negative.

In 2020, a dead red squirrel found near Comrie in Strathearn tested positive for squirrelpox using electron microscopy and pcr (polymerase chain reaction) testing. Subsequent testing of grey squirrel blood samples from Comrie and the surrounding area detected no further incidence of the virus, making the red squirrel result hard to interpret.

In 2021, all of the samples taken from 23 sample squares tested negative.

A more detailed account of squirrelpox testing in the Central Lowlands can be found in Tonkin (2021).[20]

In summary, the project found that the spread of squirrelpox northwards in the Central Lowlands was much slower and much more sporadic than expected from experience in South Scotland, where the spread had been rapid. By the end of 2021, it appeared therefore that the threat of squirrelpox to red squirrels both north and south of the Highland Line was negligible from the outskirts of Edinburgh and Glasgow northwards.

[20] Tonkin, M. 2021. *Squirrelpox Detection in the Central Lowlands 2017–2020*. SSRS Project Report published on the SSRS website.

Was grey squirrel containment successful?

Taking the evidence of the distribution mapping, the spring surveys and the trapping data together, the indications are that the work during the 2017–21 SSRS-DCA project has successfully maintained sufficient containment of the reduced grey squirrel range achieved in the early years 2009–12 of the SSRS project. The grey squirrel distribution north of the notional Highland Line in 2021, the final year of SSRS-DCA, was very similar to that in 2017. It should be understood that there will be a continued need to detect and tackle breaches of the containment line over the long term. As long as vigilance is maintained along all the incursion routes – preferably by volunteer-run feeder-boxes with trail-cameras, and by public sightings reporting supported by regular publicity to remind people of the need for reporting – it should be possible to prevent grey squirrels from establishing productive populations north of the Highland Line.

In the Mearns area, intensive monitoring will be increasingly needed, as it appears that the Angus grey squirrel population is now well established right up to the River South Esk. It will be necessary to continue to recruit volunteer and grant-funded landowner grey squirrel control in Angus to the south of the Highland Line Control Zone in the future, to reduce the overspill of grey squirrels into this high-risk corridor connecting to Aberdeen and the north of Scotland.

Red squirrel status

The grey squirrel control work's main purpose is to protect red squirrels north of the Highland Line. However, benefits may also be brought to the red squirrel populations within the Control Zone. The main sources of information on red squirrel distribution come from public sightings and the Spring Surveys, with additional records coming in from the trapping and operational monitoring. We combined distribution records from all sources to produce 2km-square-based mapping of red squirrel distributions for two comparisons (Maps 12 and 13):

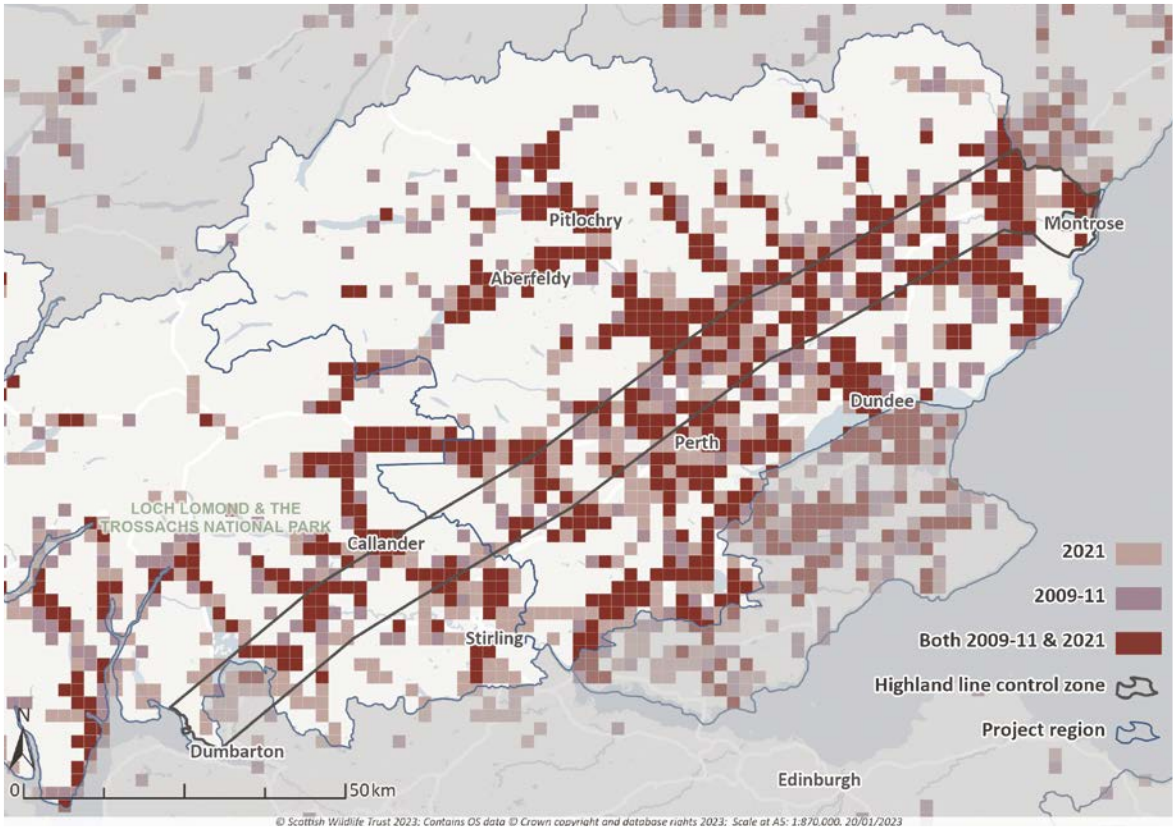
- 2009–11 vs 2021: the situation at the start of SSRS compared with the final year of SSRS-DCA
- 2016–17 vs 2021: the situation at the start of SSRS-DCA compared with the final year.

In Map 12, it is apparent that the distribution of red squirrels across the Central Lowlands of Scotland is largely similar to the situation at the start of SSRS in 2009 over most of the region. There does appear to have been a retreat of red squirrels from the Loch Rannoch, Loch Tummel, Glen Garry and Glen Tilt area between 2009 and 2021, but, given the sparse human populations in these areas this may be an artefact of the sightings reporting. The same uncertainties around the grey squirrel sightings reporting may also apply, but generally local people in red squirrel areas are much more alert to the appearance of grey squirrels in their midst.

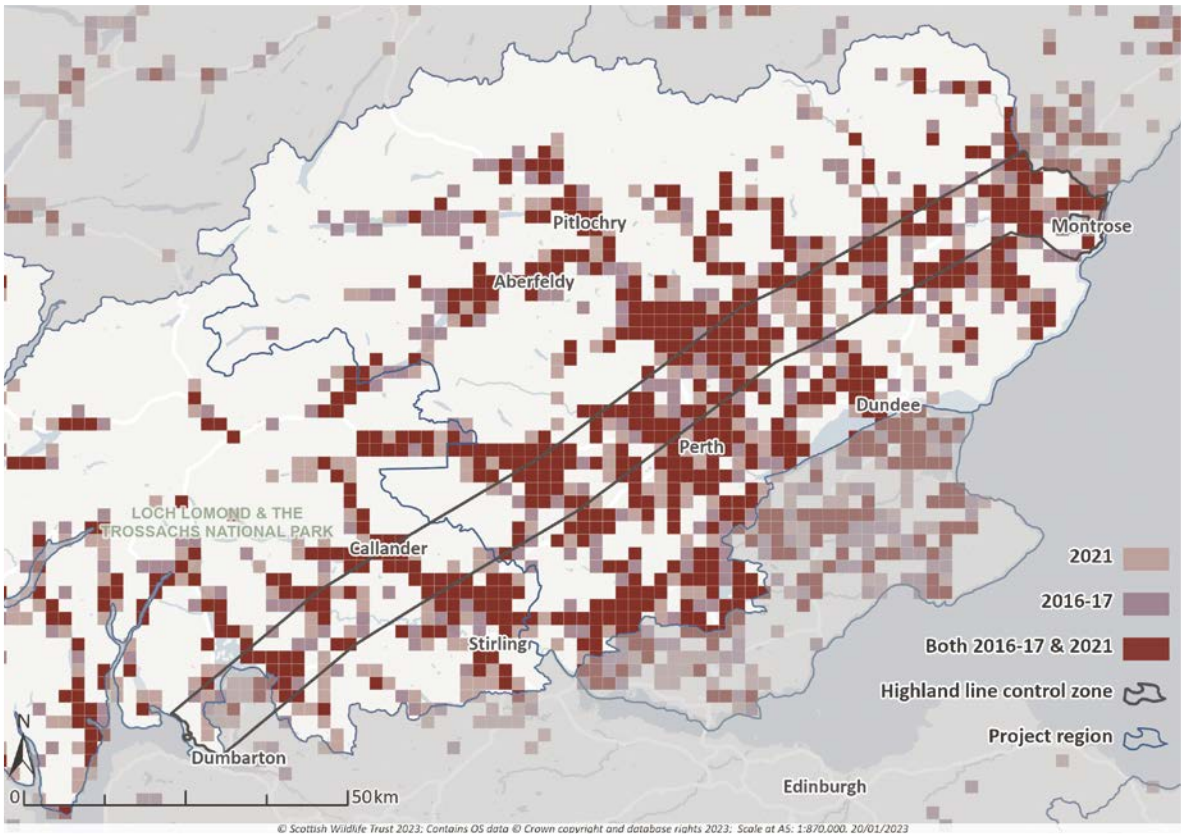
On the other hand, there were red squirrels sighted as far south as Dumbarton, Mugdock and Falkirk in 2021. From Map 13, it is evident that this expansion of the reds' range had already occurred by 2016–17. This followed grey squirrel control measures intensifying to the south of Loch Lomond & The Trossachs National Park as a measure to prevent spread of squirrelpox northwards. Around Stirling, control measures by both SSRS staff and volunteer groups have also increased, with a resulting increase in local red squirrels over the project period. Anecdotally, many residents within the Highland Line Control Zone have reported recovery locally of red squirrels after many years' absence.

There is evidence that the spread of pine martens in the region may be having a constraining impact on the grey squirrel population, allowing red squirrels to recolonise some of the areas from which grey squirrels had displaced them. Sheehy et al. 2018[21] modelled the relationships between occupancy and pine marten density-weighted connectivity for grey squirrels and red squirrels in three parts of Scotland, including the Central region. Non-native grey squirrel presence was strongly negatively affected by connectivity to individual pine martens, whereas the presence of the native red squirrel was positively affected.

[21] Sheehy, E. et al. 2018. "The enemy of my enemy is my friend: native pine marten recovery reverses decline of the red squirrel by suppressing grey squirrel populations". Proc. R. Soc. B., 285: 20172603.http://dx.doi.org/10.1098/rspb.2017.2603



Map 12. Distributions of red squirrels in the Central Lowlands comparing 2021 with 2009–11



Map 13. Distributions of red squirrels in the Central Lowlands comparing 2021 with 2016–17

7.4 Challenges and reflections

In the Central Lowlands, the main new learning that came from the SSRS-DCA work was our observation that squirrelpox virus is not spreading through the region's grey squirrel populations as rapidly as it spread to the south of Edinburgh and Glasgow. The explanation for this is not clear. It may be that grey squirrels exist at higher densities in South Scotland, facilitating more rapid spread between grey squirrels. However, SSRS observed that the disease spread very rapidly along the Nith Valley in Dumfries & Galloway, where squirrel densities were very low.

An alternative explanation may lie with the co-occurrence of pine martens with squirrels over much of the Central Lowlands. Work by Schuchert et al. 2014[22] suggests that the reduction of grey squirrel densities by human-mediated control measures is associated with a decrease in frequency of occurrence of squirrelpox disease in the population. Sheehy et al. (op. cit.) speculate that pine marten-mediated reduction of grey squirrel density might either reduce or even eradicate the virus in local grey squirrel populations.

The squirrelpox testing work undertaken by SSRS in the Central Lowlands was intended to provide an early warning for local people in areas where red squirrels still exist, e.g. Clackmannanshire, Fife and Kinross etc., that squirrelpox was spreading towards their locality through the grey squirrel population. However, it has so far been unnecessary to provide such warnings, although a Squirrelpox Information Evening was held by the project on 2 December 2021 to provide people in the region with an understanding of squirrelpox and how it could be countered, in case of the eventuality in the future.

As SSRS moves forwards, the red squirrel conservation community needs to consider whether squirrelpox monitoring is required to continue, and in what form. Further, Sheehy et al. (op. cit.) suggest that an urgent applied research priority is to establish whether the expected reduction of squirrelpox prevalence in grey squirrels by control measures is sufficient to preclude the transmission of squirrelpox virus to important red squirrel populations.

[22] Schuchert, P. et al. 2014. "Landscape scale impacts of culling upon a European grey squirrel population: can trapping reduce population size and decrease the threat of squirrelpox virus infection for the native red squirrel?" Biol. Invasions 16, 2381–2391 (doi:10.1007/s10530-014-0671-8).

8.
South Scotland

South Scotland

The SSRS project's ecological aim in South Scotland was to deliver the grey squirrel control required to sustain healthy red squirrel populations in priority areas for red squirrel conservation. Grey squirrel control was initiated in South Scotland in 2006 and aimed at containment of squirrelpox, which first arrived in Scotland from south of the border in 2005. When the aim of preventing the spread of squirrelpox to the Central Belt was recognised as being unachievable within the available resources, the project refocused the work in South Scotland in 2014 towards protection of the remaining red squirrels in eight very large selected landscapes, which we called Priority Areas for Red squirrel Conservation, or PARCs. The challenge that faced the project was how to maintain over the long term the grey squirrel management needed in the PARCs to protect red squirrels, in a funding environment that was becoming more challenging.

The *Saving Scotland's Red Squirrels – Developing Community Action* (SSRS-DCA) project aimed to develop a more sustainable way to deliver this programme long-term. This was to be achieved by moving away from reliance on a large team of paid staff towards creating communities that were motivated and trained to contribute substantially towards the protection of red squirrels in the PARCs, and thus to the long-term survival of major red squirrel populations across southern Scotland. The building, equipping and training of the networks of volunteers are covered elsewhere in this report. This section of the report provides information on the levels and coverage of grey squirrel control effort achieved in the PARCs over the five years of SSRS-DCA and examines whether it was effective at creating conditions in which red squirrels could persist and thrive.

8.1 Objectives

1. Deliver the control of grey squirrels required to sustain healthy populations of red squirrels in prioritised areas in order to retain much of the current geographic spread of red squirrels in southern Scotland.
2. Review the previous suite of eight PARCs to ensure all are still fit for purpose and continue to provide for the current needs of red squirrel conservation in the region.

Assumption

- An assumption made while planning the grey squirrel management work was that there would inevitably be a continuation of grey squirrel populations – at a reduced level – within the PARCs, through breeding by surviving squirrels and immigration from the surrounding uncontrolled landscape, such that grey squirrel control will need to be sustained over the long term.

8.2 Activity during SSRS-DCA

The PARCs

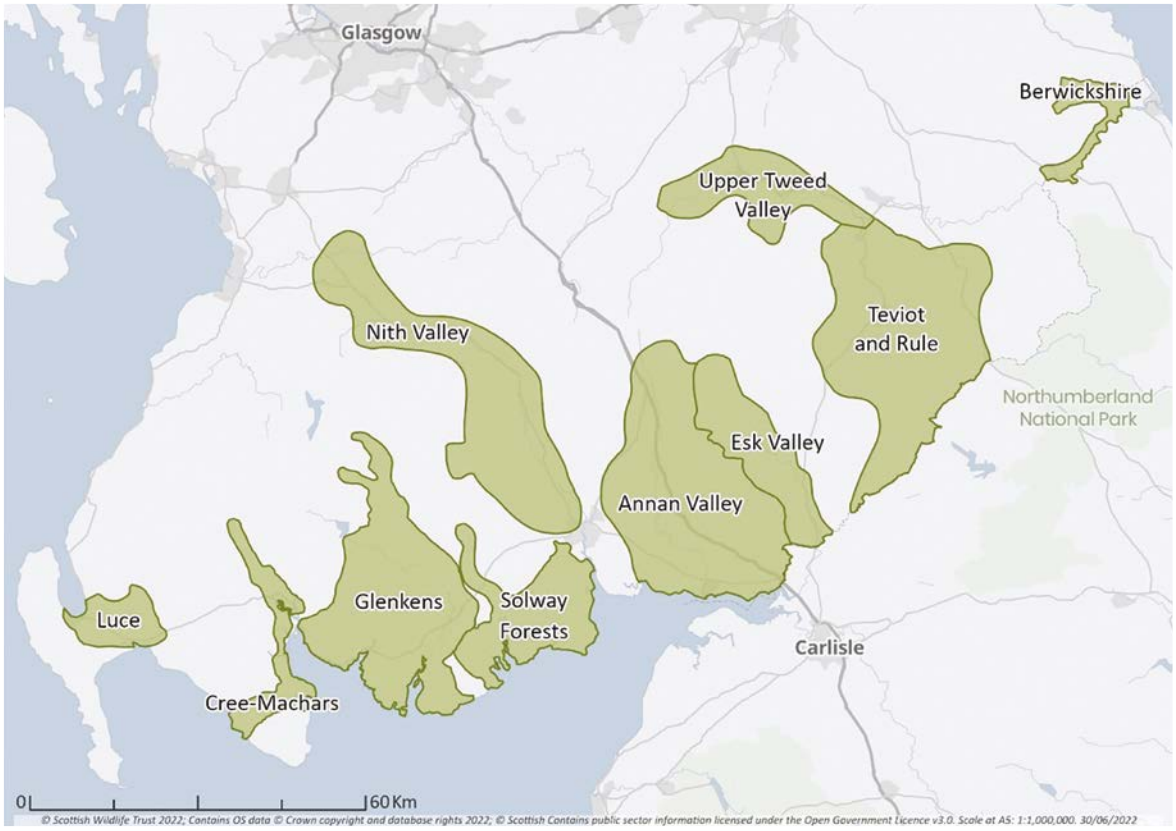
PARCs were introduced in 2014 as a new approach to red squirrel conservation action in southern Scotland aimed at targeting limited project resources to the areas where they will provide the greatest benefit to red squirrel populations in the region.

SSRS aimed to create enduring networks of red squirrel protection measures within the PARCs. To remain effective, the PARCs retain some flexibility so that they can be adapted to changing situations. In 2019, several of the original PARC boundaries were reviewed and new ones instigated to protect red squirrels in areas newly coming under threat from grey squirrel incursion.

Decisions were based on a variety of factors including the presence of healthy red squirrel populations, the urgency of threat from grey squirrels, support and co-operation from local landowners, the presence of existing volunteers and red squirrel network groups, and sufficient human populations from which new volunteer networks could develop. The resulting 10 PARC boundaries are shown in Map 14.

Many of the PARCs sit alongside or include large upland conifer forests, where red squirrels have a natural advantage over grey squirrels. These include Galloway Forest Park, Solway Forests, Ae Forest, Eskdalemuir, Craik, Wauchope and the Tweed Valley forests. The PARCs generally occupy lower-lying areas with greater accessibility to local people, and with concentrations of habitat that are favoured by grey squirrels (in which red squirrels are often excluded by the presence of greys).

By targeting efforts to the grey squirrel's preferred woodland, we can create reservoirs of high-quality habitat for red squirrels to reoccupy. This creates breeding populations of the native species as a source for recolonising conifer forests, should the populations there happen to come under pressure owing to seed-crop failure. In better conifer-seed years, red squirrels in the forests would likewise be able to colonise neighbouring lowland PARC areas. This complementary system aims to better secure the species' future in South Scotland.



Map 14. Priority areas for red squirrel conservation (PARCs)

Strategic and co-ordinated grey squirrel control work

Two SSRS Teams covered the work in South Scotland.

The Scottish Borders (South-East): A Conservation Officer co-ordinated the efforts of a team of two Grey Squirrel Officers (GSOs), who focused their efforts in the Tweed and the Teviot & Rule PARCs. In the summer of 2018, the permanent GSOs were joined by two seasonal GSOs, funded separately by Forestry and Land Scotland, working on or adjacent to the National Forest Estate areas within the Tweed and Teviot & Rule PARCs. Seasonal GSOs were thereafter appointed every year 2019–21 to cover the March–July season, although the core team fluctuated through absences and appointment of cover posts to mitigate the effects. The Berwickshire PARC was covered by the very experienced cross-border volunteer group, Save Our Squirrels Berwick.

Alongside the Conservation Officer, a Community Engagement Officer for the South-East worked to recruit and support volunteer red squirrel protection workers and helped them to set up functioning Red Squirrel Protection Networks or Groups. Grey squirrel control was increasingly delivered by these groups.

Dumfries & Galloway (South-West): A Conservation Officer initially managed a single GSO covering the Annan Valley PARC. In 2018, a seasonal GSO funded by Forestry and Land Scotland was appointed to cover the new Solway Forests PARC, becoming a full-time / year-round post in early 2020. Towards the end of October 2018, a second GSO was appointed to cover the Nithsdale PARC, and in 2020–21 a further seasonal GSO covered the new Luce PARC. The Esk Valley, Glenkens and Cree–Machars PARCs were entirely covered by volunteer control work, while the Luce PARC had several committed volunteers complementing the work of the seasonal GSO.

Initially a single Community Engagement Officer, based in Dumfries & Galloway, covered the volunteer support for the whole of South Scotland. In practice, the travel distances and a lack of direct east–west routes made this role impractical, and most of the work in 2017 was directed at Dumfries & Galloway. The role was then split into two part-time roles each covering either the South-East or the South-West. In due course, the case for the roles to become full-time was demonstrated, and the South-East and South-West teams acquired a full-time Community Engagement Officer each.

Across the whole region of South Scotland, between 43 and 54 co-operating landowners were controlling grey squirrels on their land under Forestry Grant Scheme five-year funded contracts.

A trap-loan scheme was already under operation across the region, with most recipients able to carry out both the trapping and the humane dispatch following instruction in the project's Standard Operating Procedures. Throughout the five years of SSRS-DCA, the Teams in the South worked to recruit, equip and train whole new cohorts of volunteer controllers, fulfilling various different roles: Volunteer Grey Squirrel Officer, Volunteer Grey Squirrel Control Trainer, Volunteer Grey Squirrel Dispatcher and Volunteer Grey Squirrel Trap Host. The varied roles allowed volunteers with different levels of commitment and time available to be involved with the project's main mechanism for protecting red squirrels to the extent that best suited them.

By the end of March 2022, there were 188 active trap-loanees in South-East Scotland registered on the SSRS online Community Hub, and 219 in the South-West. This under-represents the number of people involved in the scheme over the five years, as unfortunately the Hub only provides a snapshot figure for those active at the current time. People who were involved but have handed their trap back, for example because the last grey squirrel has been removed, or the recipient is moving from the area, etc., are marked as inactive and therefore not counted. Many trap-loan participants from the years prior to SSRS-DCA fall into this category alongside former SSRS-DCA participants.

The coverage and the outputs achieved over the five years are presented in more detail in the SSRS-DCA Five-Year Trapping Report (2017–21)[23] and in the earlier review of the work by the SSRS South Team (Sinclair et al. 2021[24]).

[23] Tonkin, M. and Tipple, N. 2022. Saving Scotland's Red Squirrels: Trapping Report for Years 2017–2021.
[24] Sinclair, G. et al. 2021. "Saving Scotland's red squirrels in Southern Scotland: PARCs and people". In: Shuttleworth, Lurz and Robinson (eds), *Saving the Red Squirrel: Landscape Scale Recovery* (Red Squirrel Survival Trust).

Monitoring

In South Scotland, the chief forms of monitoring were:

Spring tetrad surveys

These were carried out annually from 2013 to 2019 in approximately 100 tetrads across the region.

Sightings reporting

As well as being important in the monitoring of grey squirrels' presence in the PARCs, this also represented an opportunity to make contact with the recorder to explore whether they were prepared to join the trap-loan scheme to help with the removal of grey squirrels at the site.

Trail cameras

A small number of trail-cameras acquired by the volunteer red squirrel networks were used by volunteers to monitor sites of interest to inform their own trapping control activities.

Squirrelpox outbreak checks

Diseased red squirrels, or individuals found dead on roads, were sent to the Royal (Dick) School of Veterinary Medicine for post-mortem as part of their long-term wildlife health survey of wild red squirrels. The post-mortem reports were mainly used by SSRS to confirm and record cases of suspected squirrelpox disease, so that appropriate action could be taken to contain any outbreaks.

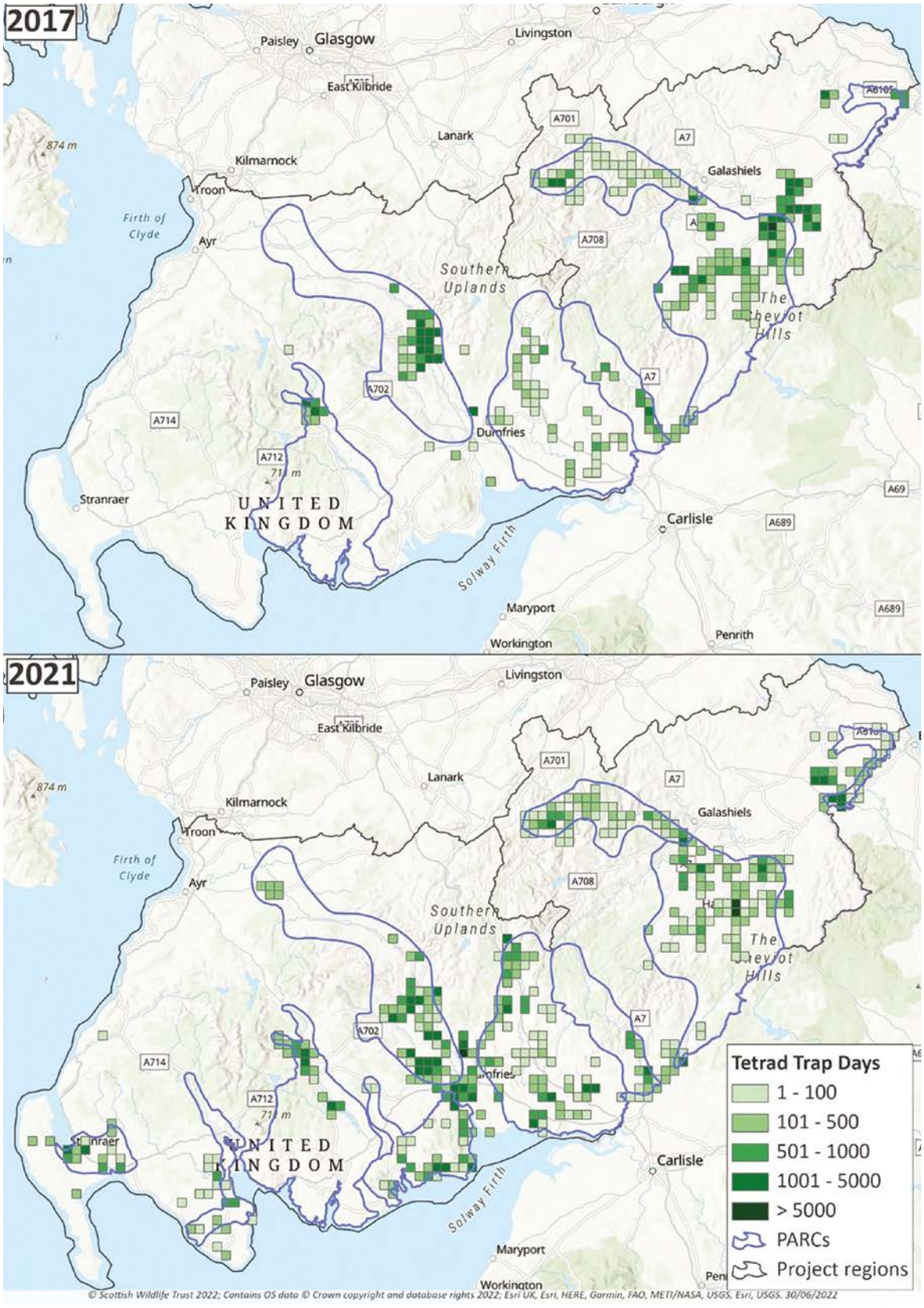
8.3 Progress during SSRS-DCA

Grey squirrel status

Coverage of PARCs by grey squirrel control measures

We used mapping to assess the coverage and intensity achieved by the control measures over the five years of SSRS-DCA, and to assess the number of culled grey squirrels reported in the SSRS-DCA Trapping Report for Years 2017–21 (Tonkin and Tipple 2022, op. cit.). Two maps showing coverage in the first and last years of SSRS-DCA are given here to illustrate the work (Maps 15a & b).

In 2017, trapping was clustered in seven of the eight original PARCs. By 2021, coverage included the newer Dumfries & Galloway PARCs of Solway Forests, Cree–Machars and Luce, in response to a perceived increase in grey squirrel threat to more areas of Dumfries & Galloway.



Maps 15a & b. Trapping coverage by SSRS staff, volunteers and landowners in South Scotland, 2017–21

Contributors to grey squirrel control – trends over time

An important element to understanding how successful SSRS-DCA has been over its five years is to look at the development of community delivery of the primary red squirrel protection mechanism – i.e. targeted grey squirrel population control – across the project.

Table 2 breaks down the numbers of all grey squirrels reported culled across South Scotland by trapping or "free-shooting" by SSRS staff, landowners trapping under Forestry Grant Scheme funding, and the growing band of SSRS volunteers trained and ready to undertake trapping of their own.

	By GSOs		By volunteers		By FGS		Total
	No. culled	% total	No. culled	% total	No. culled	% total	No. culled
2017	660	23.7	37	1.3	2,092	75.0	**2,789**
2018	951	28.0	518	15.3	1,923	56.7	**3,392**
2019	1,106	30.3	901	24.7	1,638	44.9	**3,645**
2020	1,517	21.7	1,886	27.0	3,575	51.2	**6,978**
2021	1,599	23.4	1,697	24.8	3,537	51.8	**6,833**

Table 2. Split of reported annual cull numbers across SSRS Grey Squirrel Officers (GSOs), volunteers (including volunteer landowners) and FGS-funded landowners in South Scotland

** Note that FGS and volunteer totals are incomplete due to the difficulty of collecting in data from all involved. Between 15 and 28% of FGS-funded landowner trapping data and an unknown percentage of volunteer data were not received and cannot be quantified.*

Table 2 shows the total annual cull growing throughout the first four years despite the problems caused to the trapping effort by the Covid-19 lockdown in 2020, and then levelling off in year 5. The contribution to the cull by SSRS staff also rose year-on-year, in line with an increase in the number of grey squirrel control staff between 2017 and 2020. This followed a recognition that to deliver control and training across South Scotland, there was a need for additional Grey Squirrel Officers, whom we were able to appoint under new funding from Forestry and Land Scotland (FLS).

However, part of the sudden increase in cull numbers in 2020 was due to a superabundant beech crop in autumn 2019, leading to an explosion of grey squirrel numbers in summer 2020, just when the Covid-19 lockdown prevented staff and volunteers from carrying out the usual early spring grey squirrel control. The control work accounted for sustained high numbers in 2021. It will be important to collect similar records over the next few years, to assess whether the boom in grey squirrel numbers is sustained into the future or returns to pre-"boom" levels.

The bar chart below in Figure 2 illustrates the important contribution of funded landowners to the delivery of consistent landscape-scale control effort, contributing significantly to annual cull numbers. Although the grant scheme limits the adaptability of the landowner control effort to changing populations and conditions, it does add valuable land coverage by a large number of traps, which greatly assists the reduction of grey squirrel populations overall, accounting for more than half the total cull over this period. Trapping by landowners similarly appears to have had a relatively stable cull contribution over the first three years, followed by almost a doubling in productivity in 2020 and 2021 despite there being only three to four additional landowners submitting records in these two years than in 2018.

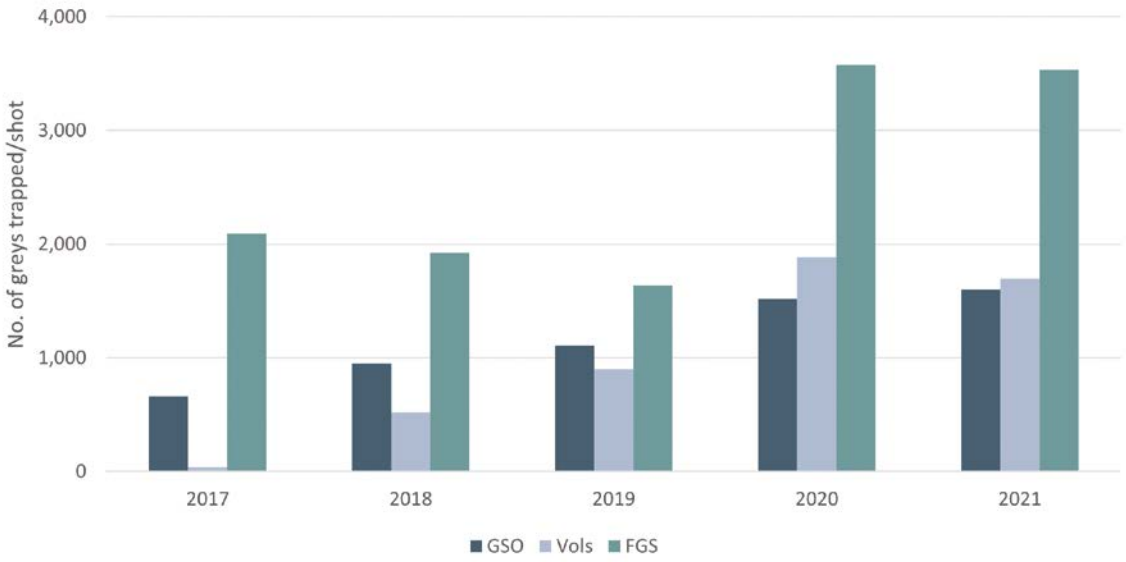


Figure 2. Contribution to total cull by GSOs, volunteers and FGS recipients in South Scotland.

A key finding from the above data is the steady increase in the number of grey squirrels culled by SSRS volunteers, shown in red in the bar chart, topping the contribution by SSRS staff in 2020 and 2021. This is a critical element in demonstrating that the Developing Community Action project has been successful in its stated aim of creating a volunteer workforce in South Scotland who are trained and motivated to protect red squirrels in their own locale, and is a credit to the impressive contribution made by our volunteers and supporting staff.

Red and grey squirrel trends in the PARCs

For each PARC, we used a count of the 1km grid squares with each species of squirrel to explore trends in species occurrence over the time since grey squirrel control began in South Scotland (2009-2021), as indicated by any of our methods of detection: sightings, surveys or trapping. The charts in Figure 3 show these trends, where the number of 1km grid squares where each species was detected in any year was expressed as a percentage of the total number of 1km-square grid squares in the PARC. It should be noted that while each chart shows interesting changes, caution is required against interpreting the results too literally, because of the flaws in the ad hoc methods of data collection:

- Grey squirrel control bias: The sampling was influenced by the grey squirrel control results, which are obviously targeted at sites and habitats where grey squirrels are thought to be most abundant. This selects against areas that are much more suited to red squirrels.
- Observer location bias: A long-established issue for squirrel recording is that the sightings data is very much biased towards the locations where people live and travel. Very few sightings come from the interiors of large forests, in which it is likely that red squirrels predominate and are in most cases likely the only species found there. The SSRS spring tetrad surveys that ran in South Scotland from 2013 to 2019, which sampled in accordance with all the available type of habitat, including in large conifer forests, supported this, finding a prevalence of red squirrel-only results in these sites.
- Observer awareness bias: It has been repeatedly observed that publicity asking the public for their records stimulates an influx of records. When the public understands that there is a grey squirrel problem in their locale, the reporting of sightings tends to consist of a greater proportion of grey squirrels. In Dumfries & Galloway, project staff had been aware that red squirrels were under-represented in reporting, and grey squirrel sightings reporting predominated. An appeal for red squirrel sightings brought a flood of reports of red squirrels once locals learned that we needed those records too.

Thus, the sightings records, which are so valuable in early detection of a species in new locations, often provide skewed information regarding the existing range.

In Figure 3, all the charts, except those for Nithsdale and Berwickshire, show that the proportion of different 1km grid squares where red squirrels were found were either on an increasing trend or remaining more or less steady.

Increases in red squirrel detection across the PARCs are notable in Cree–Machars, Glenkens, Luce, Solway Forests, Teviot & Rule and Upper Tweed. In all of these PARCs, the percentage of 1km squares with grey squirrel records also increased, therefore we can assume that in these PARCs a large part of the increase in coverage by red squirrels was due to an increase in public participation in recording. Indeed, in Upper Tweed, Glenkens, Luce and Cree–Machars the trend lines (dotted lines) for red and grey squirrels run parallel, i.e. the increases for reds and greys are happening at the same rate, which suggests this increase is due to the widening involvement of people in reporting both species as awareness of the plight of red squirrels increased.

In the Annan and Esk Valley PARCs, the percentage area where reds were recorded stayed the same, while in the Nith Valley and Berwickshire PARCs the trend lines show a slight decline.

Annan Valley

The area covered by red squirrels increased during 2012–13, but declined again and has since been sustained across the same geographical coverage until 2021, despite the increase in area where grey squirrels have been detected increasing from 2016, eventually overtaking red squirrels to reach 16% of PARC km-squares in 2020.

Berwickshire

Red squirrels occur across a very restricted landscape in the Berwickshire PARC, around 4% of a small PARC area, whereas grey squirrels are reported to occur in up to 30% of the km-squares. Berwickshire's main function is as a buffer between the predominantly grey squirrel population of the Scottish county of Berwickshire and a priority red squirrel population just to the south in England, based on the Kyloe Reserve. The Save Our Squirrel Berwick group patrols the border along the Tweed and into the River Whiteadder, working alongside two key estates controlling grey squirrels under the Forestry Grant Scheme. A small population of red squirrels persists in the buffer area (i.e. the Berwickshire PARC). Grey squirrel detection likely reflects changes in grey squirrel control effort over time.

Cree–Machars

This PARC was defined in 2019, to patrol the incursion routes of the River Cree valley woodlands and the forest corridors of the Machars peninsula, seeking to protect the red squirrel populations of Galloway Forest Park through which the Cree Valley runs, and the wider red squirrel populations to the east in Dumfries & Galloway. Records of both red and grey squirrels have increased as the attention of local people was brought to the grey squirrel problem, and recording of both species covered an increased proportion of the PARC over time. Red squirrels appear to be more widely spread than grey squirrels, even in this key grey squirrel incursion route.

Esk Valley

The Esk Valley PARC sits along one of the key river woodland corridors for grey squirrel incursion into Scotland from the English side of the border, with Scottish Forestry's Red Squirrel Stronghold of Eskdalemuir occupying the northern half of the PARC. Grey squirrel status in the PARC depends on the level of control measures applied both within the PARC and across the English landscape to the south. Grey squirrels were reported from less than 10% of the PARC area, from locales preferred by both grey squirrels and people. The increasing trend in reported grey squirrel coverage over the last five years is most likely due to the increase of reported control measures.

Red squirrel records, with an even smaller coverage, have fluctuated wildly on a slightly increasing trend since 2009, but with a sharp decline in 2021. Most of the PARCs show the same sharp red squirrel dip in 2021, sometimes in greys as well: it will require future recording to determine whether this decline is sustained, a temporary dip or an artefact of recording by a project in its final year. Whilst the low red squirrel coverage may reflect red squirrel presence in human-inhabited areas, it is unlikely to be indicative of presence across the PARC's forests as a whole, dominated as they are by commercial conifers.

Glenkens

The Glenkens PARC covers the key grey squirrel dispersal corridors of the Ken-Dee valley, Fleet Valley and coastal Dumfries and Galloway. It includes the Scottish Forestry Red Squirrel Stronghold of Fleet Valley, part of the Galloway Forest Park. It is the focus of work for four Red Squirrel Networks: Glenkens, Gatehouse of Fleet, Kirkcudbright and Castle Douglas. Despite relatively large coverage by good lowland grey squirrel-preferred habitat, reported red squirrel coverage has remained buoyant throughout the reported period, particularly during the SSRS-DCA period when reported red coverage greatly exceeds that of grey squirrels.

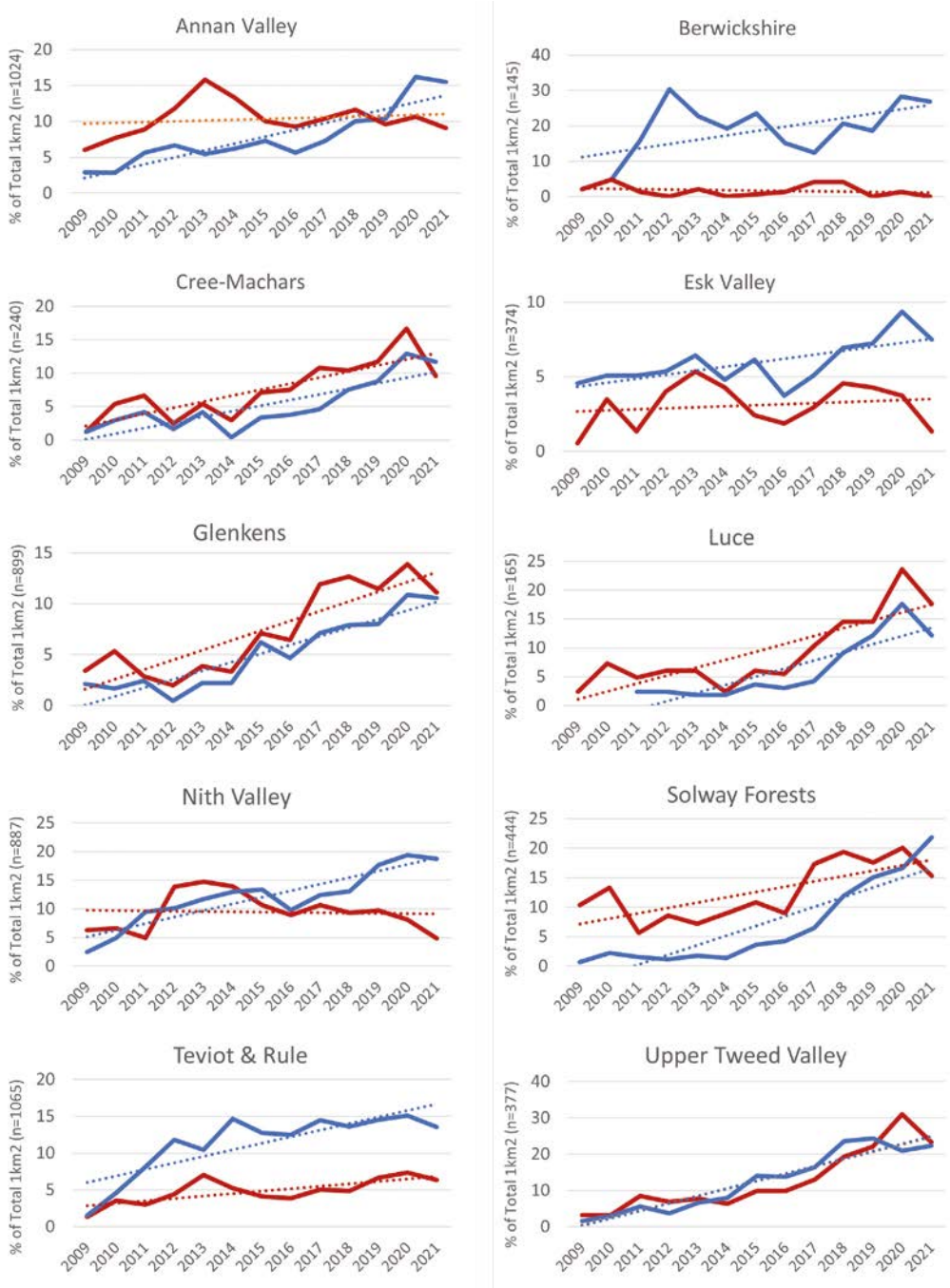


Figure 3. Percentage (%) of 1km² in which red and grey squirrels were detected in Priority Areas for Red Squirrel Conservation (PARCs) in South Scotland

Luce

The Luce PARC fulfils a similar role to the Cree–Machars PARC, serving to interrupt incursion of grey squirrels from Ayrshire via the coastal route by Stranraer, where there is a large area of ideal grey squirrel woodland. It was first trapped in 2020. The coverage by red squirrels outweighed that of grey squirrels within the PARC, and it should be noted that both Cree Valley and Luce are surrounded by habitat much more suited to red squirrels and where only very occasional grey squirrels are detected and removed. The Machars (or Whithorn Peninsula) has more widely-spread grey squirrels through very fragmented habitat, but there is potential for grey squirrels to be removed from the peninsula with the Cree–Machars PARC acting as a buffer.

Nith Valley

Over the SSRS-DCA project period, the grey squirrel has evidently prospered in the Nith Valley. The challenge posed by grey squirrels and the difficulty in recruiting sufficient grey squirrel control coverage over such a large area appears to have been overwhelming for the red squirrel population. Most of this PARC's woodlands cover is broadleaved – i.e. grey-squirrel-preferred habitat, with very little conifer – although it is neighbouring the large conifer forests of Ae and Mabie.

However, when Grey Squirrel Officer control was consistently applied to the middle and southern regions of Nithsdale during SSRS-DCA, red squirrels very quickly moved in and flourished. The unfortunate hiatus in control work in spring of 2020 set the programme almost back to the start, but again red squirrels recovered rapidly when control was resumed. One of the focal points for the two-year SSRS Transition Project that follows SSRS-DCA is to recruit, train and support a new cohort of grey squirrel control volunteers to cover the Nithsdale PARC to help secure the red squirrel's future here.

Solway Forests

Grey squirrels have historically been very scarce in the Solway Forests area. At the start of SSRS-DCA, an increasing risk to red squirrels was perceived after the 2015 UK-wide grey squirrel population boom, with grey squirrels increasing in frequency on the eastern side of Dumfries & Galloway. Solway Forest PARC was SSRS-DCA's first new PARC, and trapping began here in 2018, mostly at the eastern end, but also in the Kippford area. Both species of squirrel have been reported from an increasing proportion of the PARC as awareness of the situation spread, but it is worrying to see that grey squirrels were being reported from more km-squares in 2021 than red squirrels. Grey squirrels have also been increasingly reported from Mabie Forest. Scanning westwards across the steep forests of the Solway area, few squirrels have been recorded until Dalbeattie Forest is reached, where greys occur but red squirrels still dominate.

Teviot & Rule

Recording of grey squirrels has occurred in a greater proportion of Teviot & Rule's landscape than red squirrels since 2009. However, whereas grey squirrel recording has increased since the start of projects controlling grey squirrels in the Borders, the proportion of landscape with greys reported has remained at much the same level over the years 2017–21. Red squirrel fluctuations have been very similar to those of greys over much of that time, but were recorded from only around 5 or 6% of the km-squares, whereas grey squirrels were reported from around 15% of 1km grid squares.

Upper Tweed

For Upper Tweed, the trend lines for red and grey squirrels are almost identical, suggesting equal prevalence of grid squares containing red and grey squirrels in the records. In the final two years of SSRS-DCA, red squirrels were recorded in more 1km grid squares (24–30% of all 1km grid squares in this small PARC) than grey squirrels, at 21–23%.

Thus, the recording of squirrels in the PARCs in South Scotland presents a mixed picture. Red squirrels do still exist and are frequently seen in all the PARCs except the Berwickshire PARC, but there appear to be increasing threats from grey squirrels in the Annan, Esk, Nith and Solway Forests PARCs. As the PARCs generally cover the types of habitat that favour grey squirrels, that red squirrels survive at all in some of the PARCs is almost certainly due to a combination of human-mediated grey squirrel population management, in some places pine marten-mediated grey squirrel population suppression, and the existence of large neighbouring areas of conifer-dominated habitat where grey squirrels struggle to gain a permanent foothold, but which provide a reserve of red squirrels to repopulate the PARCs.

The question as to whether it would be better to choose the conifer-dominated areas for the PARCs, where red squirrels have the advantage, presents itself. In fact, this has been tried before, with a system of more than 20 Priority Woodlands selected by the Red Squirrels in South Scotland Project in 2005. However, it proved too difficult even to survey the areas adequately, because of distance from human population centres, lack of forest access roads suited to ordinary vehicles, the density of many of the stands and the hazardous nature of actively managed forests with continual forest operations in progress. Furthermore, the commercial forest habitat was often very poor habitat for red squirrels, supporting them at very low densities, leading to vulnerability to random climatic or food-availability impacts on populations, as well as the sometimes catastrophic impacts of the clear-felling and replanting regimes on red squirrels and other wildlife. Where survey was difficult for the non-professional, grey squirrel control would be near to impossible for a volunteer workforce. There would also be no community motivating factor provided by the delight of seeing red squirrels in one's local landscape.

Bringing red squirrels to people's living environments, where the habitat often supports greater densities of red squirrels than the commercial conifer blocks, provides a larger, wider-spread and more robust population of red squirrels that is better able to withstand the various environmental threats that will inevitably challenge their continued existence in the South Scotland landscape.

At the same time, the red squirrel provided SSRS-DCA with a charismatic tool to engage a wide range of people in active nature conservation, and a source of pleasure, interest and satisfaction to the many people involved or living in the PARCs.

Red and grey squirrel population trends across South Scotland

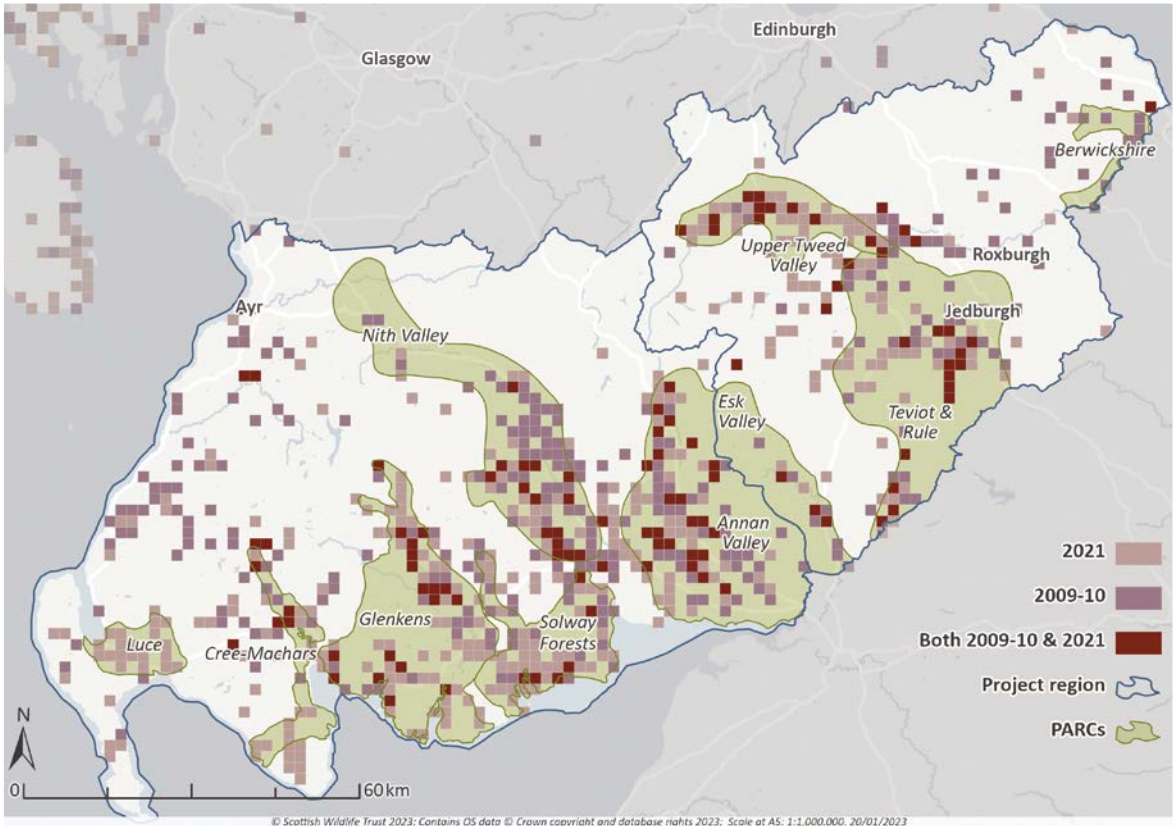
The general trends of the entire red and grey squirrel populations across South Scotland will have a continuous impact on the relative success of the PARCs' strategy for retaining significant healthy populations of red squirrels. By the same token, the degree of success in the PARCs will also have an effect on the wider South Scotland population – including, as already discussed, the large conifer blocks where grey squirrels struggle to persist.

We used 2km grid-square mapping (Maps 16 to 19) to compare the distributions of red and grey squirrels separately over the whole of South Scotland over three time-windows:

- 2009–10, covering the situation at the beginning of grey squirrel control work in the south of Scotland
- 2017, the first year of SSRS-DCA
- 2021, the last year of SSRS-DCA.

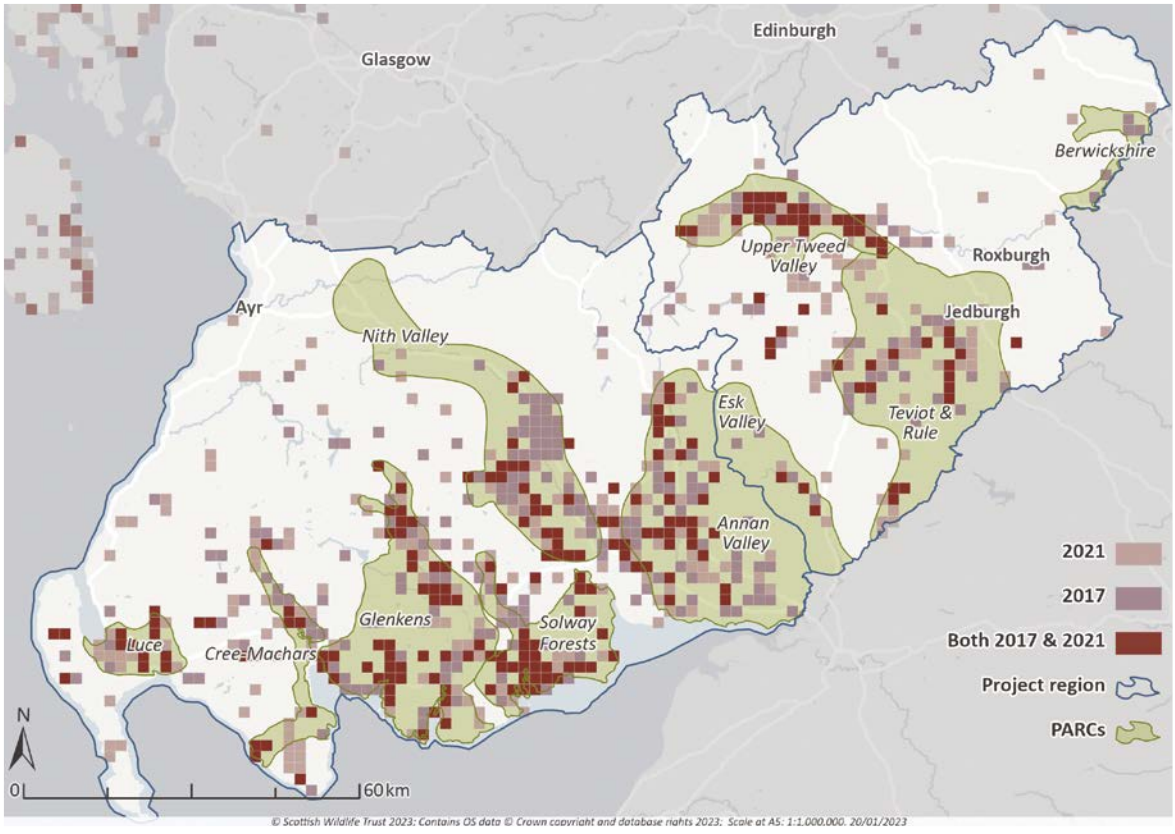
We then calculated a) the number of 1km grid squares; and b) the number of 10km grid squares in South Scotland in which each species was detected annually over the period 2009 to 2021 (Figures 4 to 5). Finally, we compared the results from these with the Spring Survey mapping from 2013, 2017 and 2019.

Mapping includes all records from sightings, surveys and trapping by-catch



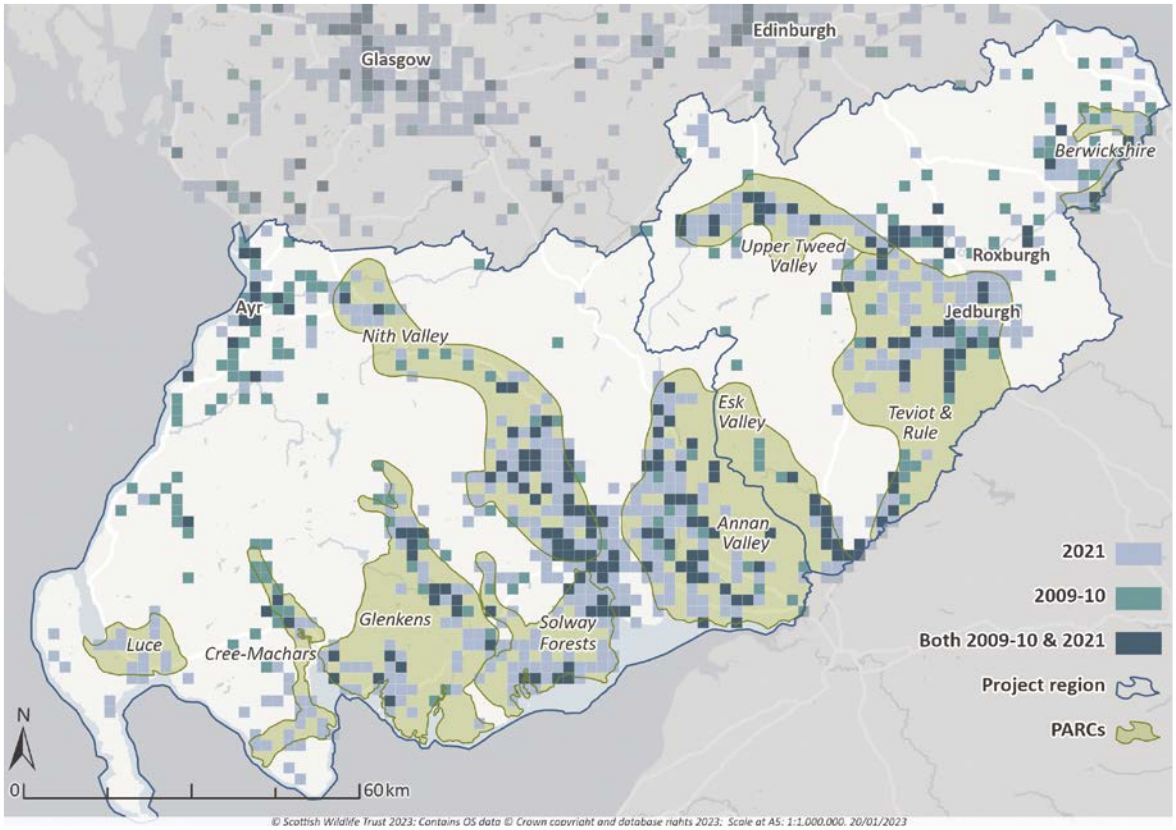
Map 16. Distribution records of red squirrels by 2km grid square in South Scotland comparing 2021 with 2009–10

Map 16 compares red squirrel distribution records from 2021 with records from 2009–10. This shows a loss of recorded red squirrel range across South Scotland during this period, chiefly from South and East Ayrshire on the west coast, from Berwickshire and eastern parts of Roxburghshire, and from mid-Nithsdale and parts of the Annan Valley. Apparent gains for reds in the Solway Forests, Cree–Machars and Luce PARCs between 2009–10 and 2021 are likely due to increasing awareness of red squirrels in these areas rather than changes in squirrel distribution. Map 17, comparing results from 2017 with 2021, shows that the mid-Nithsdale losses have occurred between 2017 and 2021, as have those in the Berwickshire PARC, but otherwise red squirrels can still be seen to occur widely within the PARCs by 2021.

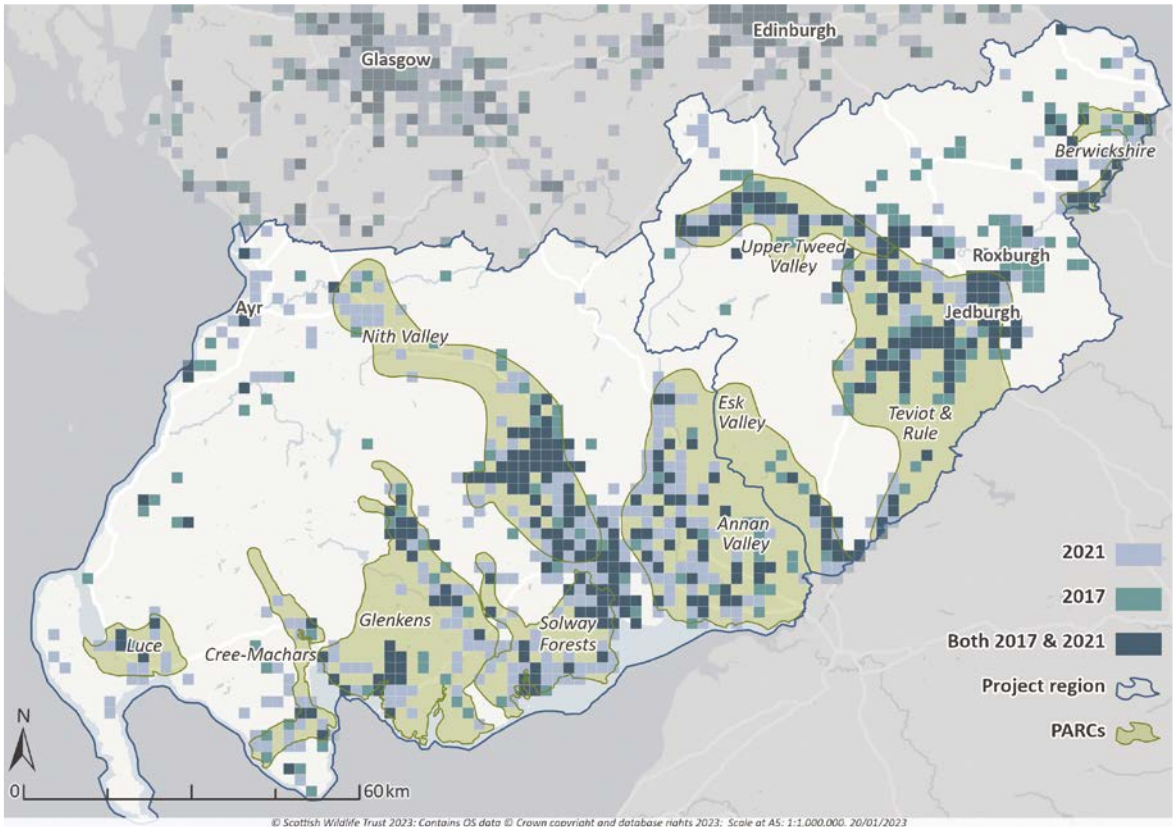


Map 17. Distribution records by 2km grid-square of red squirrels in South Scotland comparing 2021 with 2017

The grey squirrel distribution shows an increasing distribution over time (Maps 18 and 19), indicated by the blue squares in each map, chiefly by infilling grid squares where it had not previously been detected. Similar to red squirrels, there appears to have been little recording of greys in Ayrshire during the SSRS-DCA period, and possibly also in Roxburghshire east of Jedburgh in 2021. Caution in interpreting the mapped changes is needed, bearing in mind the intense focus on grey squirrel control within the PARCs during the project, and the tendency therefore for recording more often in the grey squirrel's preferred habitat rather than the red's, and within the PARCs rather than elsewhere.



Map 18. Distribution records by 2km grid-square of grey squirrels in South Scotland comparing 2021 with 2009–10



Map 19. Distribution records by 2km grid square of grey squirrels in South Scotland comparing 2021 with 2017

Red squirrels were detected in 14,873 different 1km squares and 185 different 10km squares over the period from 2009 to 2021 (Figure 4). Both the number of 1km and 10km grid squares where red squirrels were detected show a fluctuating but steadily increasing trend over the 13 years since the start of grey squirrel control work by projects in the region. Number of records is not always the determining factor for number of grid squares recorded, since by far the greatest number of records annually came from 2012 to 2014. However, given the picture of spatial decline indicated by the mapping, it is reasonable to conclude that the increase in number of grid squares where red squirrels were detected in the 2017–20 period is as a result of intensified reporting brought about by the focused work to develop community action, particularly in the new PARCs.

The drop-off in 2021 is more difficult to explain, but is noticeable in the grey squirrel records also (Figure 5) and all the plots in Figure 3. This could be due to incomplete collection of 2021 records from all sources by the time these data were produced, a fall in recorder activity during the final year of SSRS-DCA, or that squirrels were having a poor year.

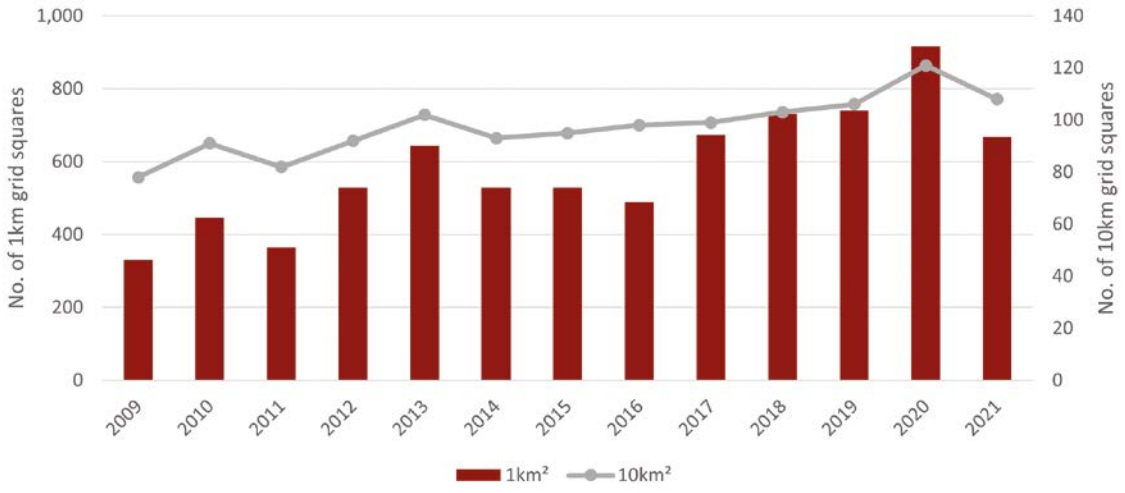


Figure 4. Number of grid squares where red squirrels were detected each year 2009 to 2021

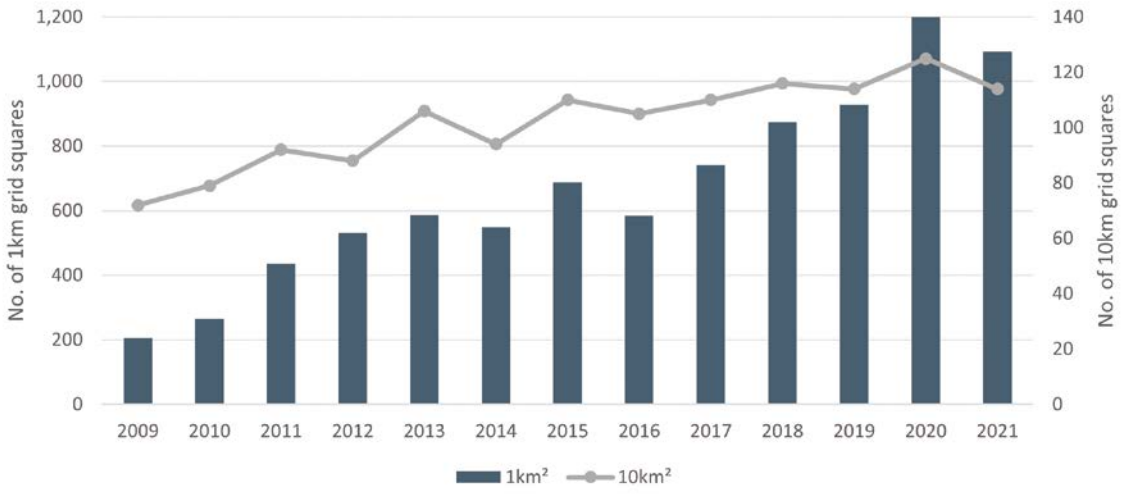
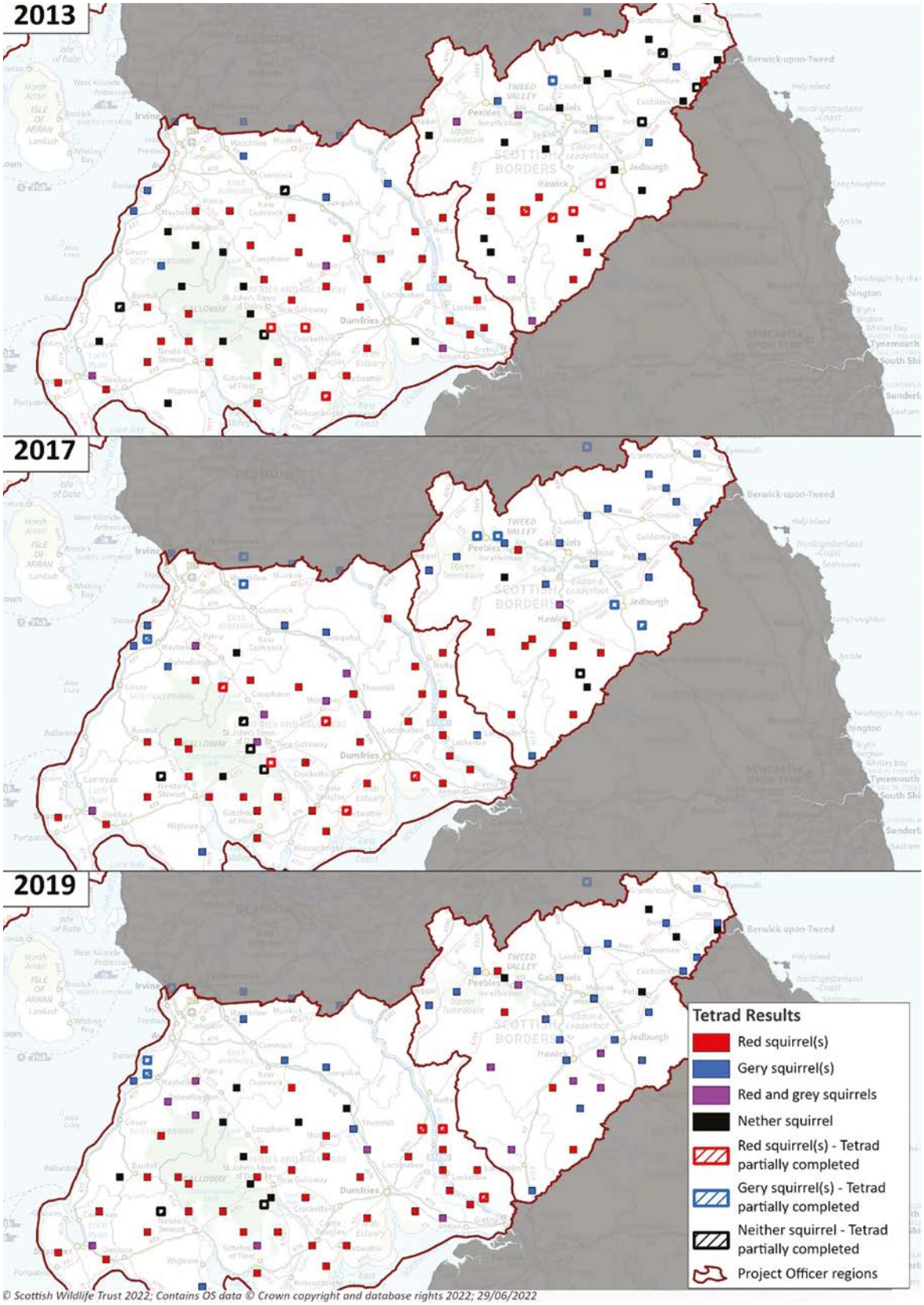


Figure 5. Number of grid squares where grey squirrels were detected each year 2009 to 2021

Grey squirrels, which from 2015 onwards were much more frequently recorded than red squirrels, also showed a fluctuating but steadily increasing trend over both scales of data over the period. They were recorded in many more 1km grid squares than red squirrels but in similar numbers of 10km grid squares (right-hand scale in the graphs). This almost certainly reflects the contribution made by the trapping records and the bias generated by targeting trapping at sites favouring grey squirrels within the 10km squares.

The Spring Survey results (Maps 20a-c) broadly support the same trends, albeit from a shorter timescale, 2013 to 2019. In 2013 (Map 20a), the first year of the Spring Surveys in South Scotland, the results suggested that red squirrels occupied most of Dumfries & Galloway, and the southern half of the Scottish Borders, with grey squirrels occupying the northern half of the Scottish Borders almost exclusively. By 2017, grey squirrels had encroached further on northern and eastern sample sites of Dumfries & Galloway and northern sites in Roxburghshire (Map 20b). By 2019 (Map 20c), grey squirrels were detected at most of the Borders sites that had only detected reds in the 2017 survey, and several sites had lost their red squirrels altogether from the survey results. At the same time, a small number of sites in the heart of Dumfries & Galloway detected both species.



Maps 20a-c. Spring tetrad survey results for 2013, 2017 and 2019 in South Scotland

Interpreting the results

Despite the difficulties and biases introduced by using unstructured sightings and trapping recording, the combined evidence suggests that red squirrels still occur widely across South Scotland, having already been lost from most of Berwickshire and parts of Ayrshire prior to the SSRS-DCA project. The Spring Survey results support this trend, but the series was truncated by the pandemic restrictions, so that we do not have survey information for 2020 or 2021. However, the Spring Surveys suggested that although red squirrels occurred widely, there may be a downward trend in red squirrel coverage in some of the PARCs.

Porton et al. 2020,[25] using occupancy modelling to analyse SSRS tetrad survey results, concluded that grey squirrel occupancy had increased over the period 2013 to 2018 in South Scotland, where the species had a very high probability of colonisation; however, the modelling suggested that red squirrel occupancy remained stable in the region, although there was a small decrease inside some of the PARCs, coinciding perhaps with the SSRS findings of decreasing coverage by SSRS records in the Nith Valley and Berwickshire PARCs.

From all the evidence, the balance of probability is that SSRS work within the PARCs has helped to retain red squirrels in these selected landscapes, although it is difficult to prove a causal link between grey squirrel control measures and retention of red squirrels. It is also likely that the trend of increasing grey squirrel range and occupancy that has occurred outside the PARCs would have been much greater within the PARCs themselves in the absence of grey squirrel population management. In the Annan Valley, Esk Valley, Nith Valley, Solway Forests and Teviot & Rule PARCs, the higher increase rate in 1km grid-square coverage by grey squirrels compared to red squirrels may be an artefact of the considerable increase in grey squirrel control records resulting in more sites where grey squirrels were detected; however, the trends across South Scotland as a whole may indicate an increasing requirement for grey squirrel control within these particular PARCs to keep the red squirrels safe from being edged out.

White and Lurz (2018)[26] used mathematical modelling in specific South Scotland landscapes to examine the realistic, spatial dynamics of red and grey squirrels and squirrelpox. They concluded that grey squirrel control in broadleaf-dominated habitats and corridors can prevent grey squirrel expansion into red squirrel strongholds and some of the PARCS, and that, if at a sufficiently high level, the control allows red squirrels to return to broadleaf habitats in human-populated regions. Their trapping scenario, which was more limited than that delivered by SSRS, indicates that without control, the Luce and Solway Forests PARCs and southern parts of the Glenkens PARC would all become dominated by grey squirrels within a few decades. We can infer, therefore, that these PARCs will need to keep up grey squirrel control indefinitely to keep current levels of red squirrels. Annan Valley would likely retain their red squirrels and keep greys at bay using White and Lurz's (op. cit.) "medium level" of control. In the Tweed Valley, the authors suggest that red squirrels appear to be able to survive without control, and go on to suggest that the level of control applied here would determine how much of the red squirrel population would remain. The Nith, Esk Valley, Teviot & Rule and Berwickshire PARCs were not considered by the authors in this work.

In the light of the modelling results, the continuing replacement by grey squirrels of reds outside the PARCs that we have observed provides justification for the selection of priority areas in order to focus limited effort. However, to continue to be successful at holding on to healthy populations of red squirrels in priority areas, those still working in the PARCs may have to further prioritise which parts are most profitable to protect, e.g. the Nith Valley may benefit from reducing its extent to cover an area no further north than Sanquhar, in order to focus effort. Collaboration across the border with the projects in northern England, which are engaged in similar activities to retain widespread red squirrel populations in their landscapes, needs to continue so that lessons learned can be shared and applied rapidly.

[25] Porton, G. et al. 2020. *Evaluation of the Progress of Saving Scotland's Red Squirrels towards its Region-Specific Management Aims, Accounting for Imperfect Detection*. Report funded by the People's Trust for Endangered Species internship.
[26] White, A. and Lurz, P. 2018. *Grey Squirrel Control in Southern Scotland: A Model Analysis*. A Heriot Watt University Report for Forest Enterprise, an agency of Forestry Commission Scotland, in collaboration with Scottish Wildlife Trust, Scottish Natural Heritage, Saving Scotland's Red Squirrels and the University of Edinburgh.

Squirrelpox outbreak management

During the course of the SSRS-DCA project, several small incidences of squirrelpox disease occurred in red squirrels. These occurred in each year 2017 to 2021 of the SSRS-DCA project, ranging from three identified cases in 2017 to 16 cases in 2019. The majority of incidences (see Table 3) was in Dumfries & Galloway, chiefly in sites near the Solway coast in the PARCs of Solway Forests and Glenkens, but also sporadically further inland. In the Borders, there were sporadic cases across the Tweed Valley PARC.

	2017	2018	2019	2020	2021	Total
Dumfries & Galloway	2	2	16	12	3	**35**
Annan Valley	2		2	2		**6**
Glenkens			4	7	3	**14**
Solway Forests		1	10	2		**13**
Not in a PARC		1		1		**2**
Scottish Borders	1	2		1	6	**10**
Teviot & Rule					1	**1**
Tweed Valley	1	2		1	5	**9**
Total	**3**	**4**	**16**	**13**	**9**	**45**

Table 3. Squirrelpox cases by year, region and PARC

The SSRS local staff and volunteers' main response involves:

- Publicity disseminated among local people, highlighting the need to withdraw wildlife feeders from gardens until the danger is over, to avoid creating sites for disease transfer.
- Removing, if possible, any live diseased red squirrels for veterinary examination. Unfortunately, euthanasia is required in most cases. The cadaver is sent for post-mortem to investigate the cause of death. Post-mortems are carried out by the Royal (Dick) School of Veterinary Studies as part of a long-term wildlife health monitoring programme, and squirrelpox is confirmed by vets at the Animal and Plant Health Agency using electron microscopy or pcr testing.
- Encouraging local volunteers to focus the grey squirrel control measures around the site, to remove any further grey squirrel carriers of the disease.

Further information on squirrelpox disease and on the SSRS response to suspected disease in red squirrels can be found on the SSRS website.[27]

These simple measures appear to have been sufficient to avoid whole-scale population collapse among red squirrels, as had been seen before in the UK at sites with large densities of grey squirrels present. In all cases, local red squirrel populations have recovered fairly quickly, as would be expected in locations where grey squirrels have never been present at high density and where densities are actively kept low by local control efforts, and where contiguous areas are supporting healthy red squirrels to quickly recolonise.

[27] https://scottishsquirrels.org.uk/scotlands-red-squirrels/

8.4 Challenges and reflections

In terms of squirrel ecology, many of the key pieces of learning had already occurred during the long history of red squirrel conservation projects in South Scotland. However, the SSRS-DCA project brought us a new appreciation of just how vulnerable red squirrels in South Scotland are to chance environmental changes. Sudden proliferation of grey squirrels as a consequence of an unusual glut in food supply accompanied by a rapid expansion of geographic range, such as we saw in 2015 and 2020, has been very characteristic of the species and its colonisation of the UK since the 19th century.

Other sudden changes, such as the restructuring of the red squirrel's forest strongholds, e.g. the removal of larch in the face of larch die-back disease, may have another detrimental effect on the viability of red squirrels in the conifer forests affected. In this event, the reservoirs of red squirrels in traditional grey squirrel habitats, such as those brought about by the work of the SSRS-DCA project, will be a vital lifeline for red squirrel survival in the region.

One of the challenges that affected all areas, but South Scotland in particular because of the emphasis on volunteer work, was the collection of control data from volunteer grey squirrel control participants. Initially, data were collected directly from trap-loan participants via phone-calls or email, but this was time-consuming and usually far from complete. Once the Hub was operational, it took a great deal of encouragement, training and support to persuade volunteer grey squirrel control participants to report their data via the Hub. A huge amount of work by the South Scotland teams, the SSRS Data Officer and Communications and Engagement Officer, including adjustments to the collection functionality of the Hub, gradually overcame some of this resistance, but many participants still do not submit data.

The training of key individuals in each Volunteer Network to enter the data for others in the group increased the volume of data collected on the Hub, and the proportion of control work being recorded continues to increase. However, the data are still incomplete, and volunteers who are not part of a group may still not wish to provide their data to the Hub. Thus, all figures regarding the amount of control effort and the number of grey squirrels culled will be underestimates of the true volunteer contribution to this demanding work. Unfortunately, there are also some gaps in the landowner records.

9. Communications and Engagement

Communications and Engagement

9.1 Objectives

Public and community support for the work of SSRS has been essential to the project since the outset. However, in order to develop community networks who were capable of taking on the vital role of long-term protection of red squirrels in key areas, SSRS-DCA needed to increase the level and quality of communications, engagement and training and to ensure that communities developed the skills, expertise, protocols and organisation required.

The following summarises the target outcomes for our communications and engagement work:

South Scotland

- to have empowered local communities to be responsible for conservation action to protect local priority populations of red squirrels by contributing to grey squirrel control and maintaining public awareness of the ongoing red squirrel conservation issue
- to have networks of landowners in the key areas trapping on their land under ongoing funding contracts.

Central Lowlands

- to have involved local individual volunteers, communities and land managers in the grey squirrel control work to prevent northward incursions of grey squirrels across the Highland Line, and in the survey work to monitor responses of red and grey squirrel populations.

North-East

- to have a robust monitoring system in place with a rapid response mechanism to effectively detect and remove remaining populations of grey squirrels
- to have increased the involvement of volunteers in the ongoing monitoring work and control efforts
- to have gained widespread public understanding of the need to report squirrel sightings as part of the essential grey squirrel detection work.

Wider communications

- to have increased wider public understanding of the need for targeted grey squirrel control action to secure red squirrel populations across Scotland
- to have put in place an online communications hub to enable ongoing communication and feedback to participants following SSRS-DCA.

9.2 Activity during SSRS-DCA

Before the DCA phase began, SSRS was already supported by over 446 volunteers and local communities, primarily through our trap-loan scheme and annual Spring Survey. The aim of this project phase was not only to recruit more volunteers but also to improve the volunteering experience overall through a streamlined registration and training process, better data management, more feedback and inclusion.

Common volunteering roles

- Trap loanee: someone who volunteers to host a trap in their garden and (in most cases) check it themselves at least twice a day. When a grey squirrel is caught, trap loanees will either carry out dispatch themselves or immediately call upon the assistance of a member of the SSRS team or of a designated grey squirrel control volunteer.
- Grey squirrel control volunteer: volunteers who take a more active role in grey squirrel control, from trapping on other people's land to being an "on-call dispatcher" for local trap loanees. They may also be trained to train other volunteers.
- Survey and monitoring volunteers: volunteers who took part in the annual Spring Surveys or local operational monitoring such as autumn surveys in the North-East.
- Community engagement volunteers: volunteers who assisted SSRS at events, or took part in events for their local group.
- Community Hub admin: volunteers who take on administrative responsibilities for their group's space on the Hub, and/or verify squirrel sightings in their local area.
- Regional Data Officers: Volunteer Network Admins who have been granted full read-only access to all sightings, control and survey data in their region to facilitate landscape-scale monitoring, reporting and analyses.

"I do two survey squares in the north of Aberdeen, and scrambling through fallen branches and sliding down muddy slopes is worth it to know that reds are gaining ground and greys are being kept at bay … since the feeder boxes are slightly off the beaten track, I usually find myself stopping, listening and watching the woodland from a perspective that I'd otherwise not have experienced. I even watched a small sparrowhawk which perched on a branch less than 20 feet away to inspect me while I cleaned a box a few days back."

Colin Walker, Spring Survey participant

"I currently possess two jobs (one full-time and one part-time), so finding the time to go out and volunteer is often challenging, but I find that being out in the woods, even if only for a couple of hours, gives me a nice break from my typically busy weekly schedule – making it well worth the effort."

Rachel King, North-East survey volunteer

Images © SSRS and Rebecca Witt

Volunteers in action (L–R): operational survey volunteer, North-East; Spring Survey volunteer, South-East; Spring Survey volunteer, South-West; media volunteer, North-East

Building a volunteer network in South Scotland

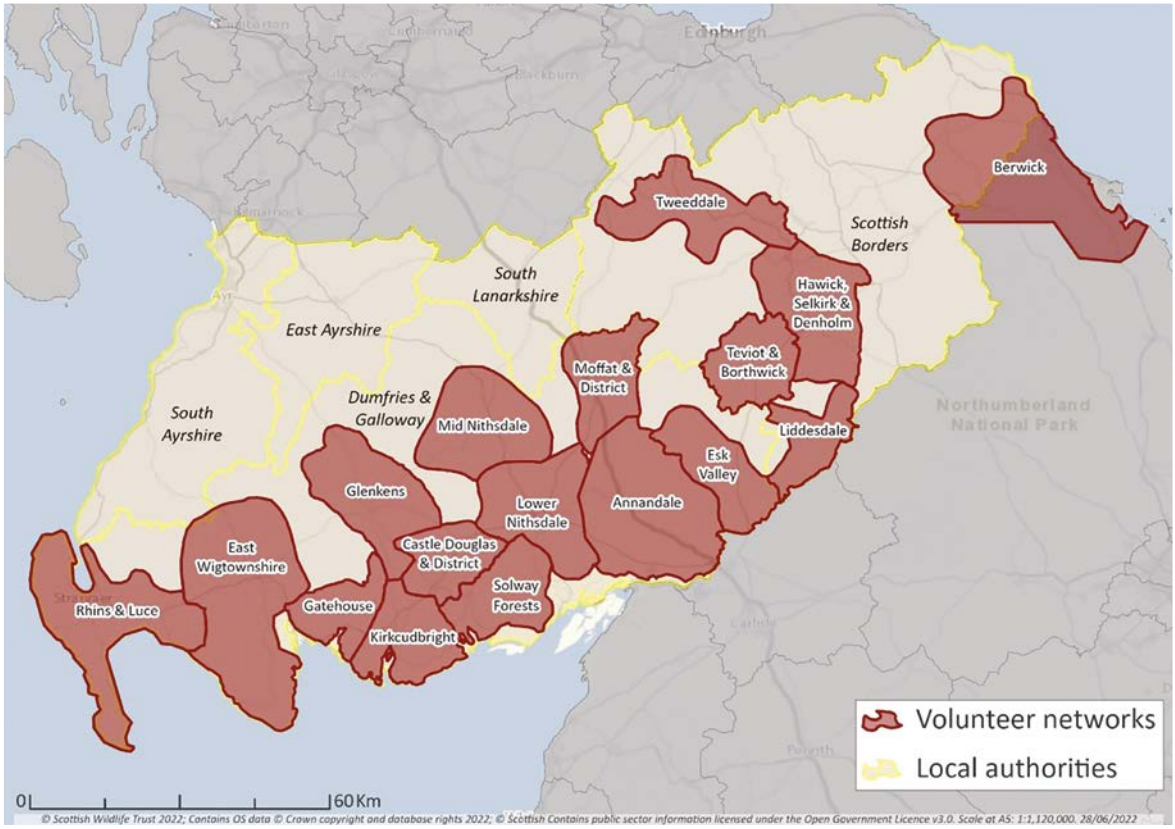
Recruiting volunteers

In April 2017, four of the current volunteer groups were already operating in South Scotland:

- Gatehouse Squirrel Group
- Glenkens Red Squirrel Group
- Annandale Red Squirrel Group
- Save our Squirrels Berwick (operating cross-border)

By 2022, SSRS was supporting an additional 13 groups, providing almost complete coverage of the project's priority areas in the region (PARCs):

- Castle Douglas and District Red Squirrel Group
- East Wigtownshire Red Squirrel Group
- Esk Valley Red Squirrel Network
- Hawick, Selkirk and Denholm Red Squirrel Network
- Kirkcudbright Red Squirrel Group
- Liddesdale Red Squirrel Network
- Lower Nithsdale Red Squirrel Group
- Mid-Nithsdale Red Squirrel Network
- Moffat and District Red Squirrel Network
- Rhins and Luce Red Squirrel Network
- Solway Forests Red Squirrel Network
- Teviot and Borthwick Red Squirrel Network
- Tweeddale Red Squirrel Network



Map 21. Volunteer Networks in south Scotland

The formation of groups was always led by those in the community, and although the original plan set a target of 30 groups (with an average of 15 volunteers each), a preference for larger groups with more geographical coverage meant that the project was still able to achieve its goals through supporting this smaller number.

Each group has its own story, but a typical "volunteer network recruitment" process would be as follows:

1. One or more engagement opportunities with the wider target community, for example an information stand at a village fair led by the regional SSRS team. Conversations with locals and collecting of contact details.
2. A locally advertised red squirrel talk, with an invitation extended to existing contacts. This talk would include our vision for the local area and a call to action. More contact details collected.
3. An initial meeting with all interested individuals to begin to formulate a plan of action, e.g. the group's mission, geographical boundary, volunteering roles, potential leaders. Early meetings were open to the public and were locally advertised. Once a group was established, they were encouraged to keep at least some meetings open to welcome new members.

"I am proud to be involved with such a group, and excited about what we can achieve in the years to come with a good core of volunteers with their varied and wide range of skills."

David Miller, East Wigtownshire Red Squirrel Group

Training and support

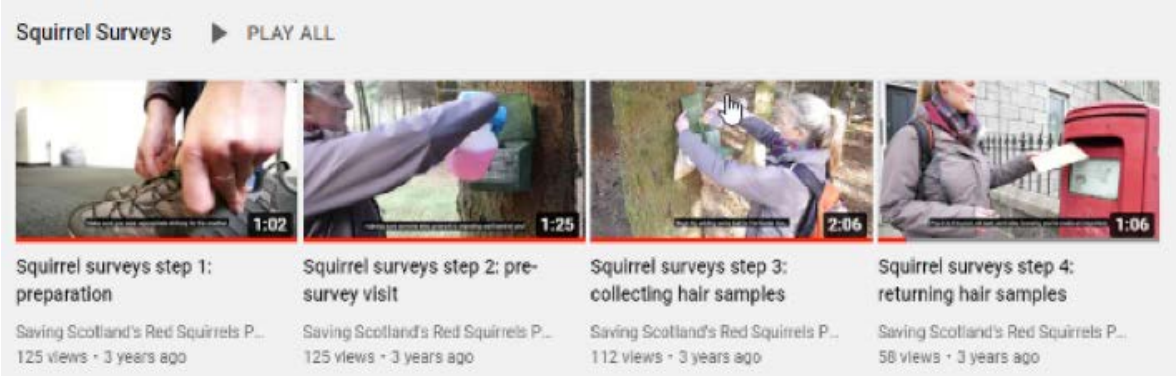
Once a new group was formed, the Community Engagement Officer and Conservation Officer would work with them to identify additional training needs and determine what equipment the group would require. Each group was offered a one-off "start-up" budget, and an annual "maintenance" budget in the subsequent years of the DCA phase. Initially, most of our groups did not have access to a bank account. Therefore, groups would request items from a catalogue which would then be ordered in bulk by the Project Administrator.

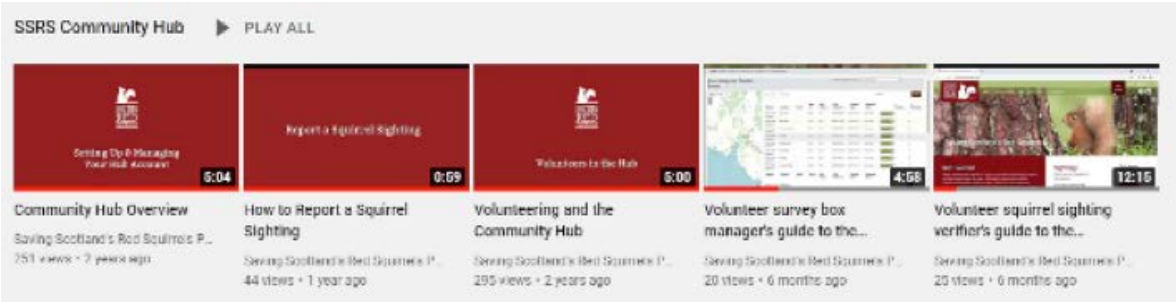
As well as one-to-one training and workshops, a range of training guides and videos were created throughout the course of the DCA phase, available via the Community Hub.

Training of volunteers

All our volunteers go through an induction process and are fully trained to carry out their responsibilities. Much of this training is carried out on a one-to-one basis, for example showing someone how to safely set up a trap in their garden, shadowing a member of staff on their routine trapping fieldwork, or going out to a survey site to show the location and operation of feeder-boxes. Although often very labour-intensive, this highly tailored training and shadowing experience is essential to ensure that all volunteers can follow our strict protocol safely and humanely.

In-person training is complemented by a suite of training resources, for example a grey squirrel control trapping protocol, Spring Survey how-to videos, and user guides to submitting data on the Community Hub.





Examples of training videos for volunteers

Grey squirrel control workshop, September 2017

Hair analysis workshop, April 2018

Social media training, August 2020

Fundraising training, September 2021

Images © SSRS and Darren Flint

"It was really great, and very useful! I hadn't really considered tagging my posts before, so I'm trying to remember to do that now. It also gave me ideas of pages to follow and resources for sharing during squirrel week."

Social media training participant

"I thought the [fundraising] training was excellent. The trainer herself was really what made the course: she was outstanding! It was also great to get to interact with other volunteers from other networks and to swap strategies."

Cat, Tweeddale Group

Examples of downloadable guides for volunteers

In 2018, many of the more established volunteer groups recognised the need for knowledge-sharing between the groups. They formed the "Red Squirrel Forum for South Scotland"[28] to create a collaborative support network for volunteer groups across South Scotland and to give all volunteers a collective voice. It encompasses all volunteers working for each of the Squirrel Groups or Networks in South Scotland. The Forum committee meets regularly to keep all affiliated volunteer groups up to date with developments and to make any decisions required. They have also hosted annual conferences with presentations by, for example, Forum members, SSRS staff, invited scientists talking on a relevant subject, or representatives of Northern England red squirrel volunteer groups sharing expertise. During the Covid restrictions, the Forum hosted three region-wide online meetings, with almost all the squirrel groups represented.

An important development was an "Offers and Needs" chart, detailing the skills available within the membership of each volunteer group, and the gaps in knowledge or skills with which each group needs assistance. This was designed to encourage the exchange of advice and the establishment of trainer–trainee partnerships across the groups, in order to make best use of the skills many groups already have. The chart gives groups full visibility of where expertise lies, as well as of who is asking for help on what.

The Forum also enabled a funding application to be made on behalf of all the groups, securing a grant enabling each group to obtain a thermal imager and a number of camera-traps.

"Within the network of networks that is the Red Squirrel Forum for South Scotland, there must be people with many different backgrounds and experience: teachers for all ages, website editors, social media advocates, community fundraisers, recruiting sergeants, etc."

Peter Garson

Squirrel Champions

We could not save Scotland's red squirrels without the generosity and determination of our volunteers and the inspirational everyday work that local red squirrel groups undertake. Regional staff identified 14 volunteers in the South-West and 11 volunteers in the South-East that they would consider "Squirrel Champions" – volunteers taking a leading role in managing their local group, maintaining a network of volunteers across the region and promoting the red squirrel conservation cause.

Special recognition was given to one of these inspirational volunteers in 2018, when the Scottish Wildlife Trust gave Saving Scotland's Red Squirrels volunteer Rob Asbridge, Chair of the Kirkcudbright Red Squirrel Group, the "Rusty Bog" Volunteer Award for the work he had put into helping to protect the red squirrels in his area, including the construction of a community base and red squirrel hide for the local community to better enjoy and value their local red squirrels.

Dr Peter Garson, Chair of the Gatehouse Squirrel Group, was recognised as the 2020 Species Champion in the Scottish Wildlife Trust's Trustees' Awards for Volunteering. This award not only celebrated Peter's immense dedication and drive but also stands as an inspiration to volunteers and communities across Scotland uniting to play their crucial role in conserving local red squirrels.

"Conservation volunteers self-select: their boundless enthusiasm for knowledge and great willingness to engage in all sorts of activities gives me a great buzz as a Squirrel Group Chair! After moving to a new area after retirement, being part of a Squirrel Group quickly brought me into contact with dozens of like-minded folk; this has been very good for my soul!"

Peter Garson

[28] https://www.southscotlandsquirrels.org.uk/

Images © Eliska Robson and SSRS

Peter Garson (Gatehouse) and Rob Asbridge (Kirkcudbright) receive volunteer awards from the Scottish Wildlife Trust for their work as Squirrel Champions

Success of the network-building

Most of South Scotland's volunteer Red Squirrel Networks had attained independent status by the end of March 2022 (in terms of having: a written constitution or terms of reference; key individuals to facilitate co-ordination and management of the group; a group bank account; and insurance for group activities). Of the 17 groups in South Scotland, three groups did not have these in place, and further development of their capabilities was required. For example, the Annandale, Esk Valley, Castle Douglas and Mid-Nithsdale groups were still in need of assistance to recruit appropriate volunteers for both group co-ordination and essential conservation activities; and all groups required some consolidation of their grey squirrel control skills.

Overall, the aim of building in five years a network of voluntary red squirrel conservation groups to cover priority red squirrel populations across South Scotland must be counted a success. Equivalent groups in northern England (over 30 at the current time) have evolved, with the support of The Wildlife Trusts' Red Alert Northern England project and successor projects, over more than 30 years, and continue to require complementary engagement campaigns, grey squirrel control work, annual monitoring and data collation, analysis and feedback by the current Red Squirrels Northern England project for successful red squirrel conservation in the region. With suitable long-term support, the South Scotland volunteer red squirrel networks have the potential to play an important role, alongside the grant-funded landowner efforts, in protecting Scotland's southern red squirrel population.

Raising awareness

Community engagement

The project has engaged with communities across all project regions, with annual targets for a range of activities including talks, fairs and guided walks. Many of these engagement opportunities were proactively sought and organised by the team; but, as the project's profile grew within priority communities, invitations from stakeholders and other community groups presented further opportunities. In the south of Scotland, established groups would organise and run their own events, initially with support from SSRS staff, but soon becoming independent of that support.

During the lockdown period, in-person events were no longer possible, so engagement moved online through Zoom talks, webinars and Facebook livestreams.

Events always included a call to action, from as simple as "report a squirrel sighting" to "help us form a volunteer group in your local area".

Images © SSRS and Bill Ferguson

Community engagement events (L–R):

Drum Castle Bioblitz, Aberdeenshire, July 2018; Royal Highland Show (with Scottish Land & Estates), August 2018; Fun Run organised by the Solway Forests Red Squirrel Network, July 2018

Dundee Flower Festival, September 2019; Wigtown Show, August 2018; Survey volunteer gathering, Balloch, May 2019

Border College class field trip, March 2020; Illustrated talk, Montrose, March 2020; Guided walk organised by the Hawick, Teviot & Rule Red Squirrel Network, September 2021

Digital trails

The project consistently met or exceeded engagement targets in most categories, but struggled with guided walks. Guided walks require a greater amount of staff time for planning and promotion, and the "return on investment" in terms of both attendance and volunteer recruitment made them difficult for the team to prioritise.

To help overcome this issue, we created a series of digital self-guided walks – one for each priority area – to offer an alternative that would also have the potential to reach a different audience. Using an existing platform, the MyGeoadventure app, users could download a route through a popular squirrel-spotting spot, collecting facts, quiz questions and tokens along the way. The trails were launched in July 2021, at a time when organising "in-person" events was still difficult, and promoted via social media, the SSRS website, on-site posters and a press release sent to local press in each area. By the end of the project, the digital trails had been downloaded 65 times (13 average per trail).

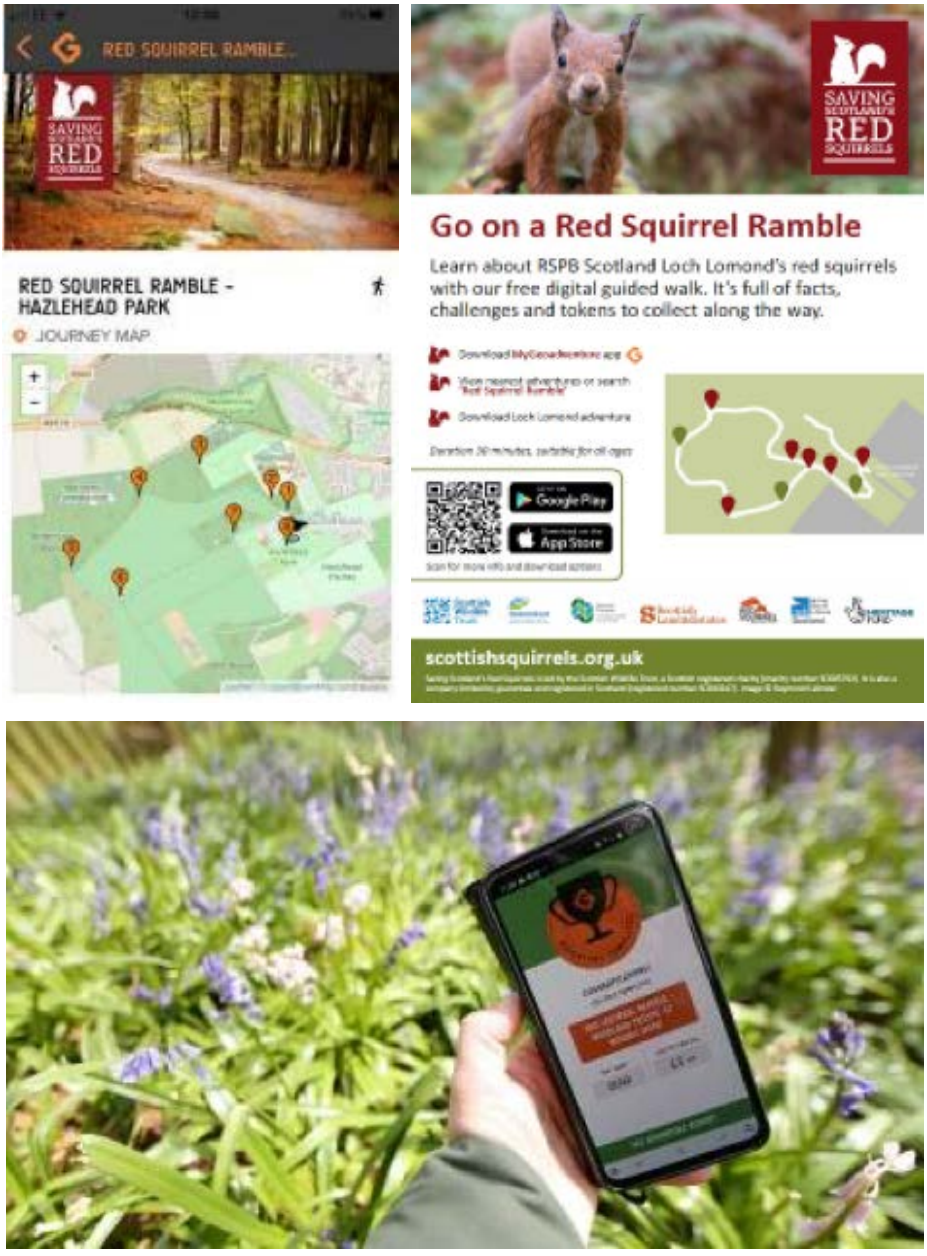


Image © SSRS

Screenshot, poster and promotional image from the launch of the Digital Trails

Engaging with stakeholders

As well as wider community outreach, the project plan also set out goals to engage with specific stakeholders including volunteers, landowners, partners and other organisations that could get involved in our efforts to save Scotland's red squirrels.

Over the course of the five years, SSRS developed close relationships with a variety of stakeholders, from planning shared communications with the Scottish Invasive Species Initiative to having the Scottish Men's Sheds Association become a main supplier of survey feeder-boxes.

Toolkits

In the first two years of the project, a trio of stakeholder toolkits was created:

- General stakeholders:[29] sent to a large (~400) mailing list of like-minded organisations, visitor attractions and community groups, this toolkit communicated the project's key messages, shared ideas for ways to collaborate, and signposted available resources such as posters, newsletter article templates and social media graphics. Those who responded were later invited to a stakeholder networking and workshop day at Edinburgh Zoo, attended by 27 people.
- Landowners: a general toolkit introducing the project and its aims, outlining how landowners could get involved. These toolkits were used throughout the project when forming new relationships with landowners.
- Landowners: a toolkit for landowners eligible for the Forestry Grant Scheme, covering the same general information, but also outlining how the project could assist with accessing the grant.

Sample pages from the stakeholder toolkits

[29] https://scottishsquirrels.org.uk/wp-content/uploads/2019/10/201909_SSRS-Stakeholder-Toolkit_02-GENERAL.pdf

Squirrelpox in the Central Lowlands

A specific objective was to engage with landowners in the Central Lowlands around the topic of squirrelpox. Originally intended for Year 2, the bulk of the campaign was delayed until Year 5. An information document (or "toolkit")[30] was shared with the project's approximately 350 landowner contacts across the Highland Line priority areas. This was followed up with a webinar later in the year, attended by 17 individuals. The recording of this webinar has since had over 100 views. Both the toolkit and webinar explained the history of squirrelpox spread in Scotland, how SSRS has been monitoring the situation and what landowners can do to help, both now and when the disease eventually reaches the area.

Screenshots from a squirrelpox webinar

Networking and engagement events

All images © SSRS

Stakeholder engagement (L–R):

Red Squirrel Forum for South Scotland networking day, October 2018; Spring survey volunteers' day, Aberdeen, February 2019; Galashiels Men's Sheds providing feederboxes for the Spring Survey, March 2019; Stakeholder networking and workshop day, Edinburgh Zoo, May 2019

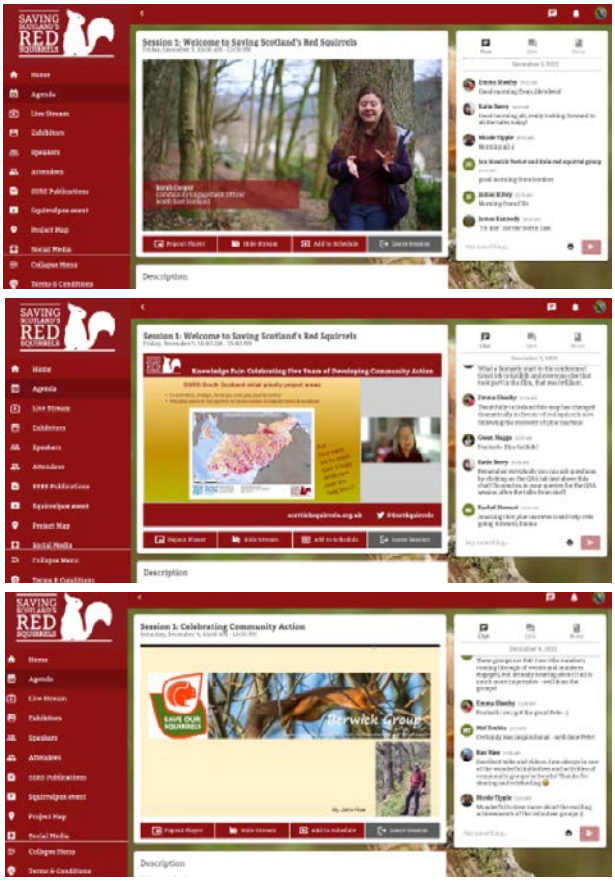
[30] https://scottishsquirrels.org.uk/wp-content/uploads/2021/03/Squirrelpox-Action-in-the-Central-Lowlands-Toolkit.pdf

In Year 5 of the project, it was envisaged that SSRS would organise an end-of-project conference to complement the annual 'Knowledge Fairs' that were organised between 2016 and 2020 by Red Squirrels United (an EU LIFE and NLHF-funded project working to conserve red squirrel populations in nine key areas across northern England, Northern Ireland and Wales). Our plan was to hold an event to engage all stakeholders, from the local volunteer networks to international researchers and UK-wide policymakers, providing the opportunity for these groups to share expertise and learnings on red squirrel conservation.

By the summer of 2021, it was clear that there was still a high degree of risk related to the Covid pandemic in organising large in-person events, so the decision was made to organise an entirely online event. A two-day Knowledge Fair was organised using the CrowdComms platform, which enabled live and pre-recorded talks, breakout Zoom workshops and virtual exhibitors, as well as live chat and Q&A. The programme covered five topics:

1. Welcome to Saving Scotland's Red Squirrels: an overview of the project and all that had been achieved over the past five years
2. Around the UK: updates from other red squirrel projects around the country (Northern England, Northern Ireland and the Highlands)
3. Science and Research: updates and insights from academia, covering topics such as fertility control and the impact of pine martens on red and grey squirrel populations
4. Celebrating Community Action: stories from some our stakeholders, including the Forestry Grant Scheme and South Scotland volunteer networks
5. Looking to the Future: lessons learned from the DCA phase, and the long-term future of red squirrel conservation in Scotland.

113 people attended across the two days, with more viewing the recorded presentations[31] at a later date. Based on our feedback survey of 26 respondents, 54% were volunteers, 24% partners, 8% landowners and 14% other stakeholders.



Selected images from the SSRS Knowledge Fair, December 2021

[31] https://www.youtube.com/watch?v=FvxKw2UGt5s&list=PL6xe3HRDWqqtanAFOBhY4I4phKZmVUdES

Engaging the wider public

Media

The project has generated many positive and awareness-raising news stories throughout the five-year period, both through national and local press releases and through direct liaison with relevant publications and journalists. Over the period, 33 press releases were issued, with common themes including spring survey results, exciting red squirrel sightings, concerning grey squirrel sightings, and calls to be vigilant in areas affected by squirrelpox outbreaks. These stories were routinely published in national media including the BBC News website, BBC Radio Scotland, *The Scotsman* and STV, as well as key local press in priority areas such as the *Press & Journal* (Aberdeen) and *The Courier* (Tayside). Staff conducted 38 media interviews for print, radio and television news, and guest articles were written for specialist publications including *BBC Wildlife Magazine, Scottish Gamekeeper Association Magazine* and *Living Woods Magazine.*

THE PRESS AND JOURNAL
Red squirrel seen in North-east garden for the first time in 30 years

BBC NEWS
Scotland's red squirrel numbers stabilise

BBC NEWS
Red squirrels: Call to 'step up' fight to protect species

THE SCOTSMAN
Red squirrels now under threat in Scotland's south

THE COURIER
Concern as grey squirrels spotted in key red squirrel conservation areas in Mearns

DAILY RECORD
Highland Perthshire residents urged to be red-y to save local squirrels

Selected press coverage throughout the DCA period

STV News, Aberdeen, September 2018; "Secret Scotland" with Susan Calman, Kirkcudbright, October 2020

Squirrel sightings

- Simple call to action, something anyone could do
- First step to getting more involved
- Over 60,000 in project phase
- The trend-lines indicate an increasing general awareness of the need to record squirrels, with the number of recorders per quarter almost tripling over the course of the DCA project and the number of sightings per quarter increasing almost five-fold.

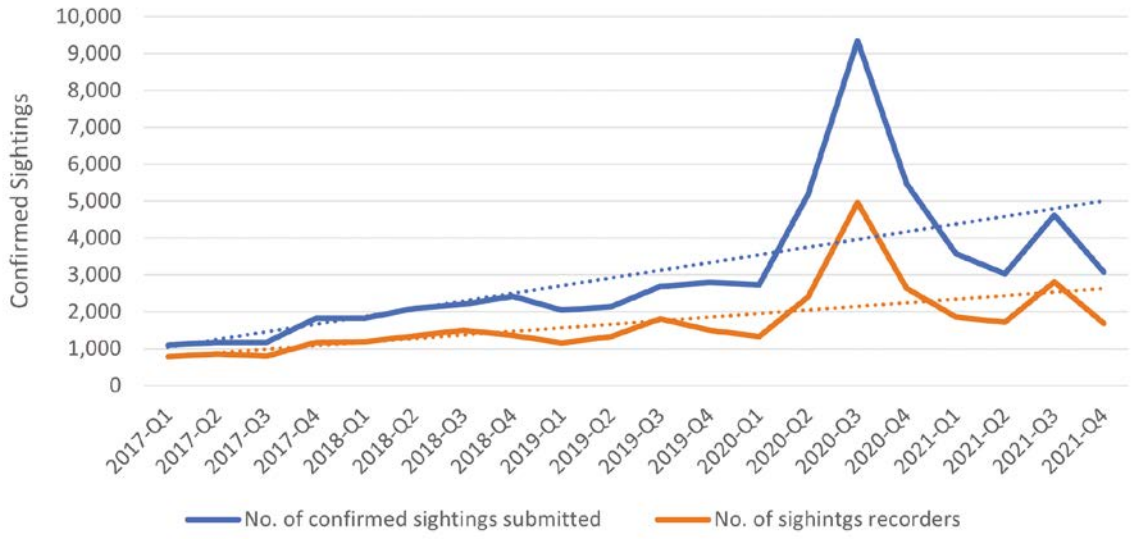


Figure 6. Number of confirmed sightings submitted through the SSRS website alongside the number of sightings recorders during the SSRS-DCA phase

The Great Scottish Squirrel Survey

September 2019 saw the launch of the first annual "Great Scottish Squirrel Survey" campaign: a call for everyone in Scotland to go outdoors, explore nature and report squirrel sightings on the SSRS website during "National Red Squirrel Week". Although the reporting of squirrel sightings was promoted year-round, this special publicity campaign was designed to boost awareness, draw media attention and increase engagement with the project. A programme of events was delivered to coincide with the campaign, although in 2020 and 2021 these events were mostly online due to lockdown restrictions.

A variety of tools were utilised to engage the public, including:

- A stakeholder toolkit,[32] delivered to partners, volunteer groups, selected landowners and all others who responded to the original project toolkit
- Branded posters and leaflets distributed in project areas
- Social media graphics, animations and videos (including promoted posts)
- Pitches to leading media (BBC Landward, BBC Out of Doors) and a national press release.

[32] https://scottishsquirrels.org.uk/wp-content/uploads/2021/07/202107_Great-Scottish-Squirrel-Survey-2021_06-TOOLKIT.pdf

In 2019, 631 people took part by reporting a squirrel sighting during the campaign week, rising to 2,186 people the following year. In 2021, 1,099 people took part. This dramatic rise then fall in participation is most likely due to lockdown restrictions acting as an additional motivation to find something new to do while spending time outdoors in the local area. Indeed, squirrel sightings rose significantly in 2020 as a whole.

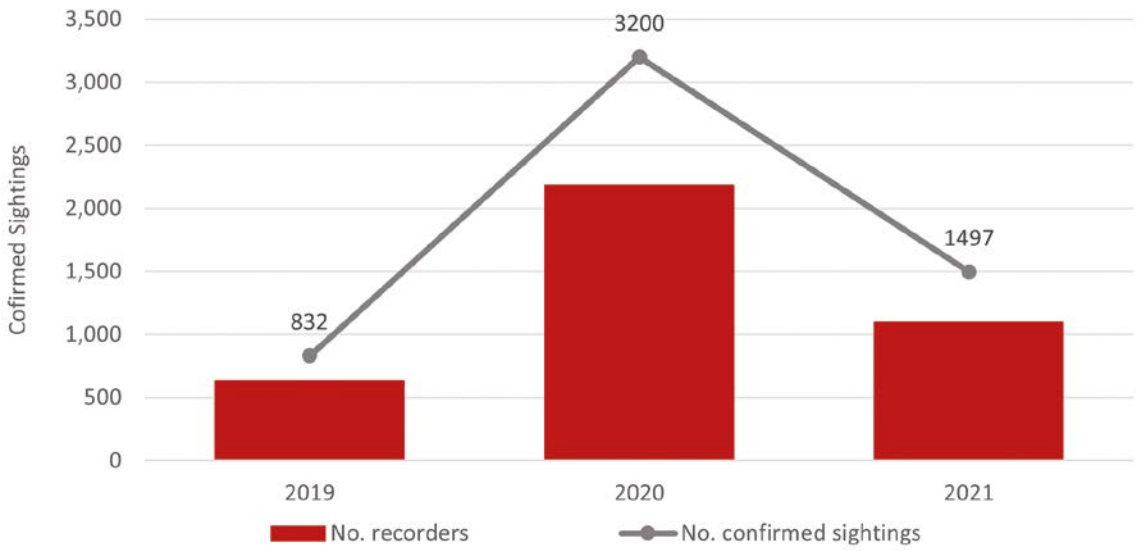


Figure 7. No. confirmed sightings and recorders during the Great Scottish Squirrel Surveys in 2019 to 2021.

Great Scottish Squirrel Survey social media graphics

Images © SSRS and Bill Ferguson

Great Scottish Squirrel Survey events (L–R):

Dundee Flower Festival, 2019; Information stall, Balmaha, 2019; Guided walk organised by Hawick, Selkirk & Denholm group, 2021; Poster for Facebook livestream events, 2021

Results infographic

9.3 Progress during SSRS-DCA

Key Performance Indicator	Achieved?	Outcome
Create a network of 800 people actively volunteering their time to the project, with a particular focus on South Scotland.		By March 2022, 1,497 people were listed as "active volunteers" on the SSRS Hub, 659 of whom were active in South Scotland. Volunteer roles ranged from grey squirrel control co-ordinating and operational surveys to community engagement and office admin.
Deliver 430 talks, walks and events for an average of 24 people, reaching an audience of 10,320 over the five-year project.		Over the course of the five years, the SSRS team delivered 375 events, reaching an estimated audience of 14,891. An additional 774 engagement opportunities, which substituted for some of the KPI events that were less productive, were also completed, including 1:1 training and volunteer meetings, which reached an additional audience of 4,285.
Provide support and materials to SSRS-DCA staff operating in key target regions to help them engage with communities and stakeholders active across Aberdeen, the Central Lowlands and Southern Scotland.		Following a project rebrand, a suite of branded materials was created which included posters, leaflets, presentation templates and display panels to support staff carrying out engagement activities. Support materials such as FAQ sheets and a Sharepoint "enquiries toolkit" also improved staff confidence when engaging with the public. The Project Administrator provided logistical support to regional staff delivering events.
Engage with stakeholders (c. 200 organisations) across Scotland to build awareness of, and support for, SSRS-DCA.		A stakeholder toolkit was delivered to 395 relevant organisations, community groups and businesses. Over the course of the five years, 32 stakeholder events were delivered, ranging from meetings with individual organisations to larger workshops and networking days, which reached an audience of 577.
Recruit 20 champions from the volunteer network to deliver a programme of fundraising activity from Years 3 to 5.		Delivery on this target did not work out as planned. Many of the local groups were active raising funds through a variety of means – local events (such as coffee mornings, raffles, guided walks, sale of calendars); partnerships with local sponsors; engagement with landscape partnerships; funding applications to charitable trusts – and opted to keep their funding and their accounting as a group responsibility rather than part of SSRS.
Deliver additional fundraising (c. £30,000) throughout the five-year project and beyond.		As above.
Recruit 10 champions from the volunteer network to support social media channels by Year 5.		Regional staff identified 13 volunteers – five in the South-West and eight in the South-East – who by the end of the five years were successfully using social media to promote the work of their volunteer networks and raise awareness of the red squirrel conservation cause.

Key Performance Indicator	Achieved?	Outcome
Provide over 100 training opportunities for volunteers.		71 training workshops were delivered across the project, reaching an audience of 610, and a further 510 training sessions were conducted with individual volunteers and network groups, reaching an audience of 839. Training opportunities included survey work, squirrel hair identification for surveys, grey squirrel control skills and know-how, BASC safe use of air weapons training, fundraising, use of the SSRS Hub training, first aid, public engagement, working with volunteer groups, use of thermal imagers for squirrel detection, and website training.
Use of the online Community Hub by at least 60% of project volunteers.		By the end of the five years, 505 active volunteers had registered accounts on the Community Hub (43% of total active volunteers).
Raise awareness among Scotland's general population of the need for urgent conservation action to protect Scotland's red squirrel population via sustained media coverage (target: 580 articles to be secured across the project).		401 pieces of national coverage and 1,368 pieces of regional coverage across the project (1,769 total). 28% of pieces focused specifically on the North-East, 12% on the Central Lowlands and 12% on the South.
Secure 340 pieces of Tier 1 media coverage across Scotland.		731 pieces of Tier 1 media were published – Tier 1 being defined as national media, top regional media in target areas, top wildlife and conservation media and key stakeholder titles.
522 articles to include one key message.		615 articles and news pieces were noted to contain one or more key messages.
406 articles to include more than one key message.		440 articles and news pieces were noted to contain two or more key messages.
Enhance social media presence by increasing follower numbers by 25% over each year.		At the beginning of DCA, the project had a Facebook page with ~4,500 followers. A Twitter account was launched in Year 1, and by the end of Year 5 total social media following was 14,678, with an average increase of 26% each year.
Increase website traffic from 37,000 to 70,000 unique users.		The highest annual traffic was in Year 5, with 67,945 unique users visiting the website.

9.4 Challenges and reflections

Like almost all conservation projects, lockdown had a significant impact on our work. From a communications and engagement point of view, the suspension of the Spring Survey was a particularly great loss. Not only did it mean that a large cohort of our volunteers could no longer contribute to the project, the Spring Survey had also provided a fantastic pool of resources to promote our work and entice more people to join in: images, videos and guest blogs. The Spring Survey was also popular with the media – both the process and the results which were published each following year.

The pandemic also posed significant challenges in meeting annual events targets, with large countryside events cancelled, and social distancing and travel restrictions making even small outdoor gatherings difficult or impossible. However, once the team had adjusted to the new way of working, a small number of online talks and workshops kept up some momentum, in particular around the Great Scottish Squirrel Survey week.

Our South Scotland volunteer groups struggled to stay connected in the early days of the pandemic, with many key players unfamiliar or uncomfortable with the idea of meeting virtually. Concerted effort was made by the Community Engagement Officers to support groups to organise meetings using the SSRS Zoom account, and within a short space of time most of the groups were not only comfortable using the technology, but could also see how going online made their meetings more accessible. With our volunteer groups spread out across a large rural landscape, Zoom also created more opportunities for networking and knowledge-sharing, for example a workshop where groups shared their experiences of engaging with local schools.

The decision to host the Knowledge Fair online no doubt hampered our ambitions for the event to be a great networking opportunity. Although many viewers enjoyed using the CrowdComms chat bar, private messaging was rarely utilised. However, an advantage to hosting the event online was that it was more accessible to volunteers and stakeholders across the country. While the overall costs were comparable, more people were engaged with than would have been possible in a real venue. In our feedback survey, almost half of respondents said they would prefer a future event to be hybrid, with the remainder evenly split between online and in-person.

"I didn't want my grandchildren to grow up seeing grey squirrels, and only pictures of red squirrels in nature books! … I have had a great deal of enjoyment through my volunteering with the Glenkens Red Squirrel Group and derive much satisfaction from the many comments I receive from people who are supportive of the Group's work."

Bob Peace

"The ultimate reward is when someone tells me they have seen a red squirrel for the first time in many years. To see these lovely little animals holding their own in the face of the problems caused by their grey American cousins is pleasing, and to know that I've played a very small part in the effort to protect them is extremely satisfying."

Andrew Vickery, Spring Survey volunteer (Scottish Borders)

"I think that everyone [at the RSSSF] acknowledged that using the [bulk upload] sheets was much easier for inputting numerous records than via the Hub input, which people felt was more clunky. My feeling is, as groups become more established, taking on more field work, your Excel sheets are really going to come into their own. As an aside, everyone appreciated all the work that you have put in on the Hub database, making it more user-friendly."

John Rae

Impacts of Covid-19 (L–R):

Volunteer suspension announcement; poster for virtual volunteer group meeting; online schools engagement knowledge share; call for more sightings to mitigate loss of Spring Survey (social media graphic)

Challenges / lessons learnt

Our aim to develop a network of volunteer groups across the south of Scotland has been largely successful, with almost complete geographical coverage and, despite some setbacks, almost all groups ready to operate independently by the end of the five-year period. This was an ambitious aim and was not without its challenges.

Firstly, recruiting, establishing and maintaining support for volunteer groups is a highly intensive process, particularly when spread across such a large geographical range as Dumfries & Galloway and the Scottish Borders. Encouraging promising individuals to take on a leadership role and become a "Squirrel Champion" is particularly challenging, and requires significant staff input for relationship-building and support. Once established, the stability and momentum of a group can be hampered if key volunteers leave, or lose motivation, or if their circumstances change. Changing the Community Engagement Officer role from one to two full-time positions helped mitigate some of these challenges, as did trying to foster more than one Champion within each group.

Our volunteer network was made up of highly passionate and motivated people, several of whom have been active in red squirrel volunteering for many years. Volunteers were very aware of both the urgent need to protect red squirrels from the spread of grey squirrels, and the need to capitalise on this five-year opportunity. This is exactly what a project like Developing Community Action needed, but it did mean that expectations were very high, which needed managing with a range of strategies including the creation of an FAQ space on the website.[33]

All volunteer groups in the south of Scotland were made aware that Developing Community Action was a five-year funding phase and that the ambition was that volunteer groups would be equipped to continue protecting red squirrels beyond the duration of the project. However, the exact "decoupling" process was not fully defined at the beginning, and with uncertainty over the future of SSRS lasting right up to the final month of the DCA phase there was also uncertainty over questions such as whether each group would need to fund its own insurance, with pressure put on regional staff to provide answers. More advanced planning and decision-making, with more communication, would have eased the transition. Regardless, by the end of the DCA phase most groups were ready to operate independently.

From the experience throughout the SSRS-DCA project work with South Scotland volunteers, it has been recognised that individuals and networks will need support and encouragement in the future if they are to remain engaged in the project activities. Without this, there is a high risk of volunteers becoming disillusioned and demotivated if the results of their efforts and enterprise are not evaluated and fed back to them. The online SSRS Community Hub described in the next section is an important element of the ongoing support required, but our original plan also recognised the strategic importance of retaining one Community Engagement Officer post during the 10-year legacy phase to continue to engage with volunteers and the public, and to provide feedback, training and development, and to deliver the communications strategy.

[33] https://scottishsquirrels.org.uk/about/volunteerfaqs/

10.
The Community Hub

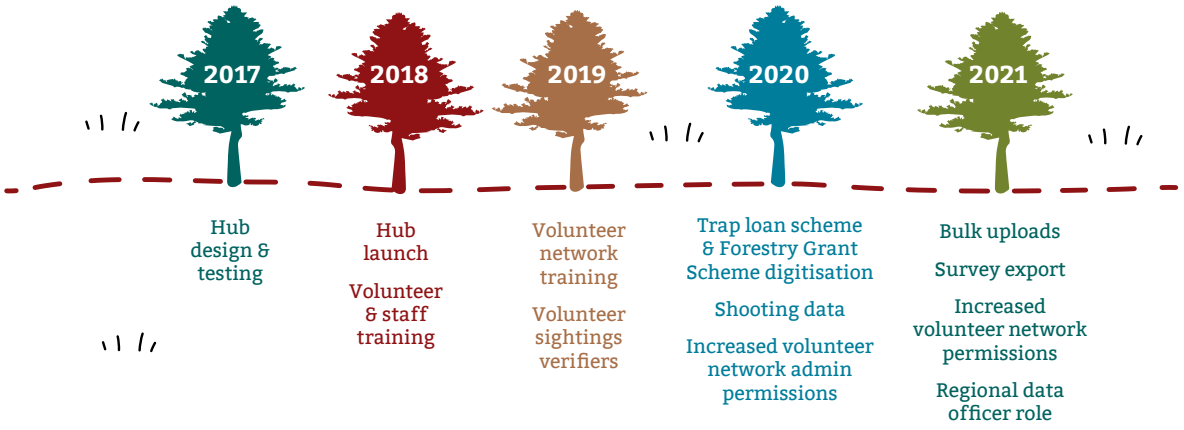
The Community Hub

10.1 Objectives

A key element of SSRS-DCA was the development of an online "Community Hub" that would facilitate volunteer recruitment, provide an online source of resources and information, and provide a space for both staff and volunteers to submit and manage their squirrel data.

Specific objectives of the hub were to:

- improve the quality and value of recorded information through standardised web forms for data collection
- reduce the time that SSRS-DCA staff have to dedicate to the capture, curation and analysis of data
- reduce the time that SSRS-DCA staff have to dedicate to the recruitment, administration and management of the volunteer base
- enhance the monitoring and evaluation functions of the project.

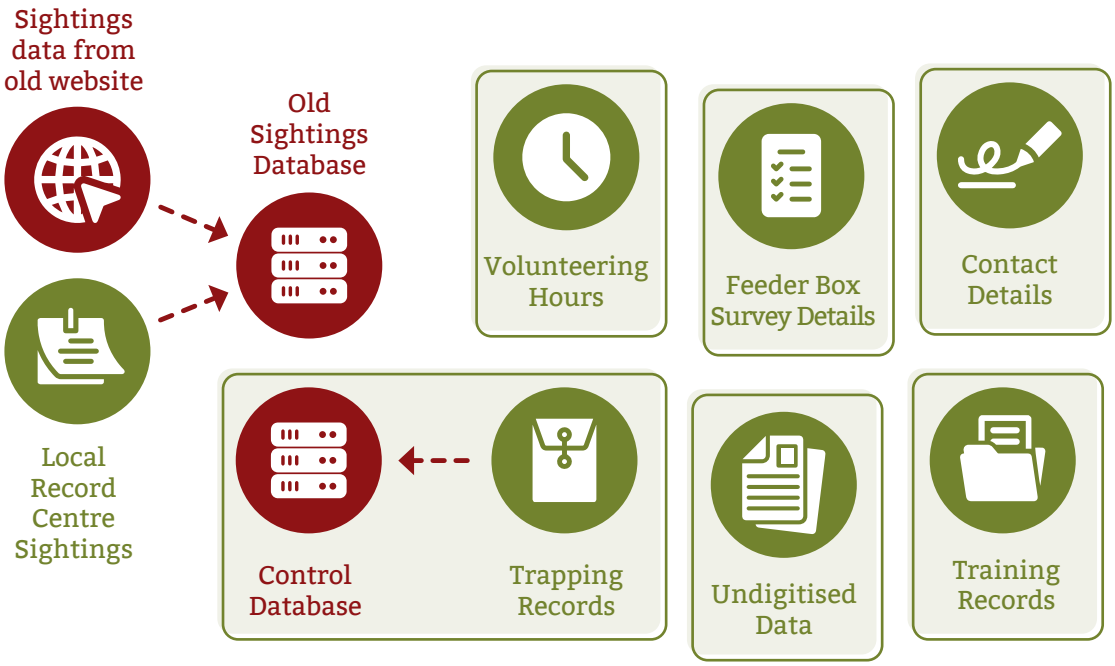


Timeline of community hub milestones

10.2 Activity during SSRS-DCA

Developing the Community Hub

Prior to SSRS-DCA, trapping records were imported to a standalone Access database. A lot of data remained unprocessed, having been received in a variety of formats such as scanned PDFs, Word documents and spreadsheets. Distribution records collected by the project or by local environmental record centres were uploaded to a separate database, the Scottish Squirrel Database. There were further disparate recording systems for feeder-box survey data and for volunteering information including contact details, training records and volunteer hours. Systems had been developed organically as the need for each arose. SSRS data were therefore spread across multiple parallel and overlapping recording systems, making it difficult to access and retrieve information.



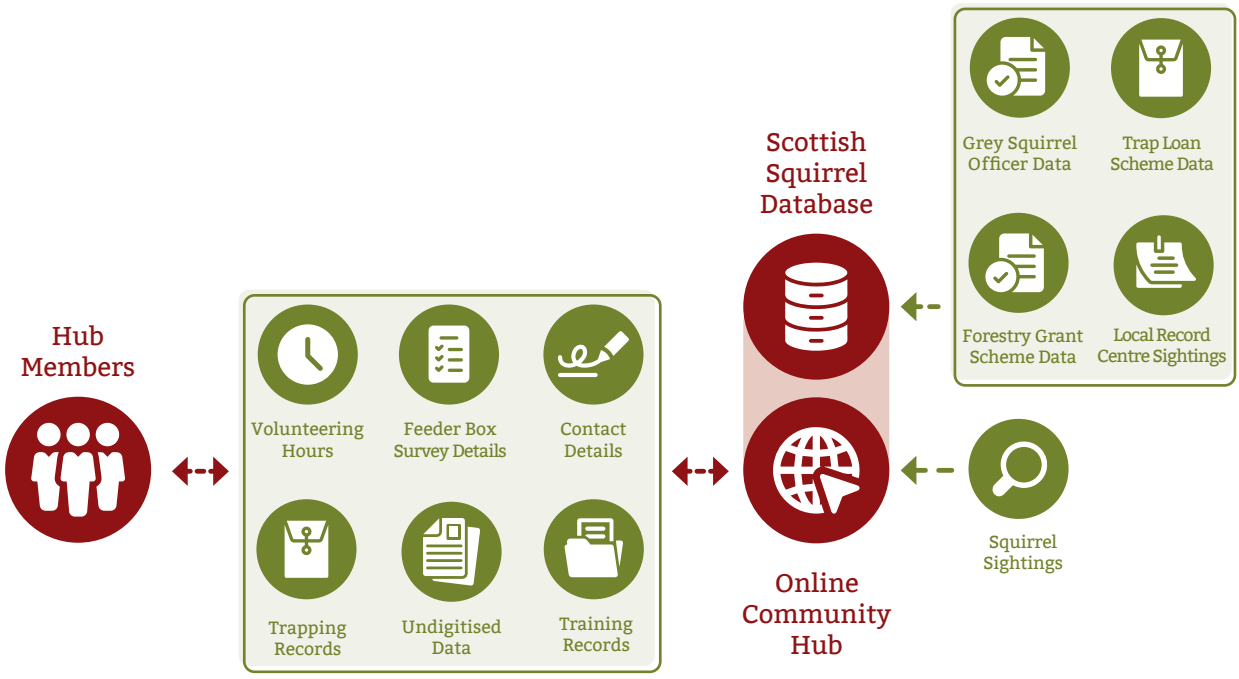
Pre-hub dataflows

A data management review was commissioned during the development phase of the project to identify issues and limitations of the system and provide recommendations for a data capture and management system that would better meet requirements. ExeGesIS Spatial Data Management (ESDM – esdm.co.uk) conducted the review via analysis of existing main datasets, interviews with a range of staff and liaison with a specialist agency, BIG, commissioned to review communications and community engagement plans. The output of this review was a functional specification for a new SSRS Community Hub and geo-referenced data management system.

Development of the Hub was a considerable undertaking. It involved designing the interface, the multiple user journeys and role permissions required, and designing a database that could pool many complex datasets together from a variety of sources in different formats, ensuring that personal and sensitive data were handled and stored in a manner compliant with General Data Protection Regulations (GDPR).

A mainly Agile approach was taken for the development of the Hub, with subsets of functionality delivered at regular intervals, and feedback and revision stages built into the process. While a Minimum Viable Product had been specified during the project development phase, this approach allowed for the scope of the Hub to adapt and evolve as functionality was developed and tested.

The Hub allows staff and volunteers to add sightings, control and survey data, as well as contact details (in accordance with GDPR), training records and volunteer hours. This streamlines data collection and reduces the need for double-processing records: volunteers can add data directly through the website, rather than passing on records to staff who in turn need to transcribe and quality-check the data for upload. All records entered onto the Hub are automatically added to the Scottish Squirrel Database, a nationwide dataset for squirrel records in Scotland that is secure, protected and backed up daily for resilience. As well as direct data entry via the Hub, several types of data can also be bulk uploaded through the data management system. All historic data were imported to the database, creating a centralised space for SSRS data and making data far easier to access, analyse and share.



Post-hub dataflows

Having all SSRS data pooled into one database allows the data team to set up queries that do the data transformations and preparation needed to: extract figures for reporting; pull data to create maps and tools for staff; generate datasets to share with scientists and researchers; and prepare an annual dataset of squirrel records to upload to the National Biodiversity Network (NBN).

The Hub also includes a library of downloadable resources, from volunteering paperwork to risk assessments, training videos and templates for future reference by volunteers and groups.

Hub user types

The Community Hub is set up to accommodate different user types, with different roles having access to different content on the Hub:

Squirrel spotter: users who report squirrel sightings while logged in are able to view their sightings records. Having access to their records helps squirrel spotters feel more included in the project and can often act as a first step towards becoming a more active volunteer.

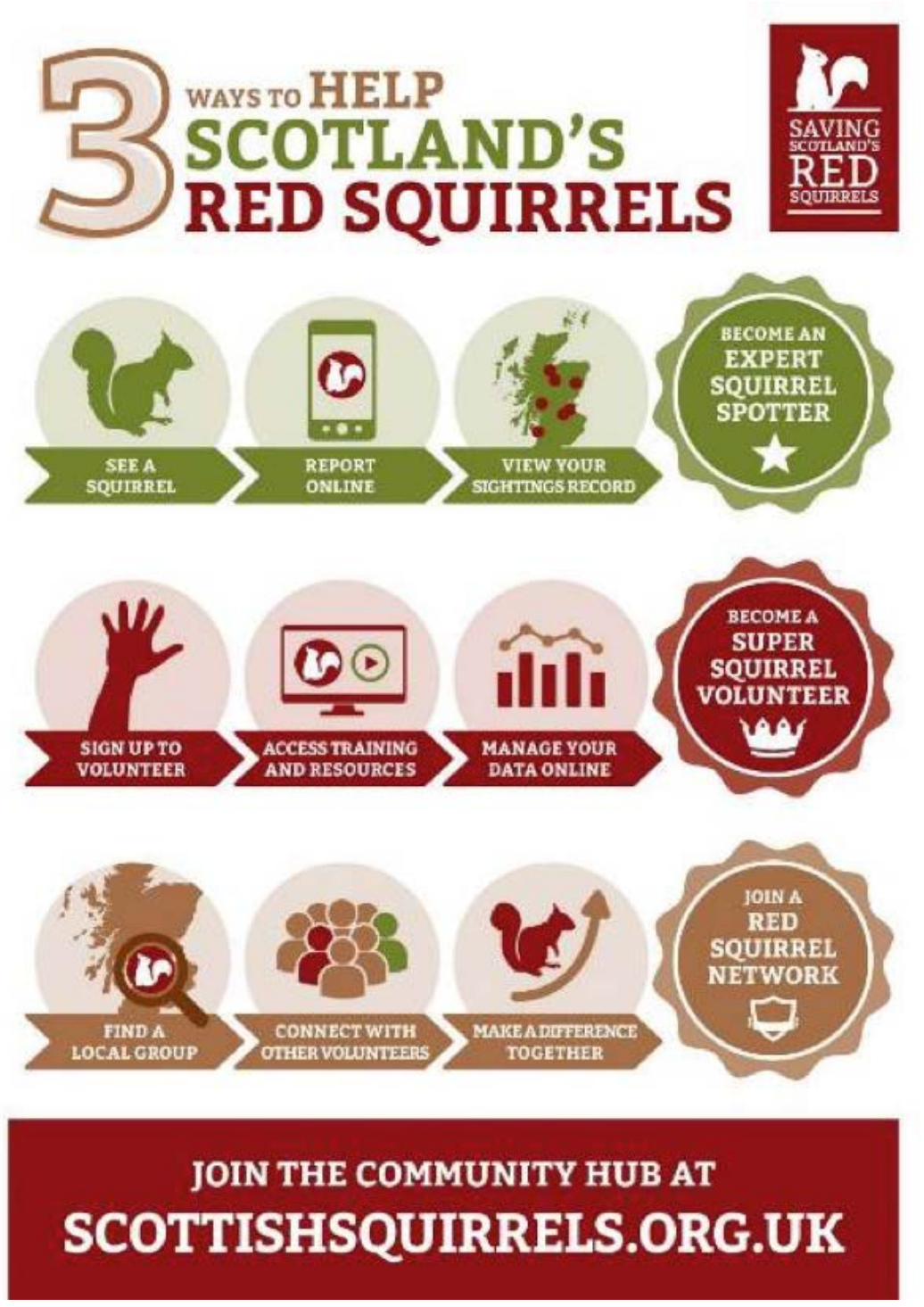
SSRS volunteer: registered volunteers can use the Hub to view their training record, submit volunteering hours and, if applicable, submit survey and/or grey squirrel control data directly to the project. Volunteers are added to private groups on the Hub where they can view both their own data and data from across the country, showing them how collectively we are making an impact.

South Scotland volunteer network member: volunteers in the south of Scotland also had the option to join their local group's space on the Hub. Members can view their group's data, and Group Admins can edit their group's page, respond to messages, manage members and upload documents.

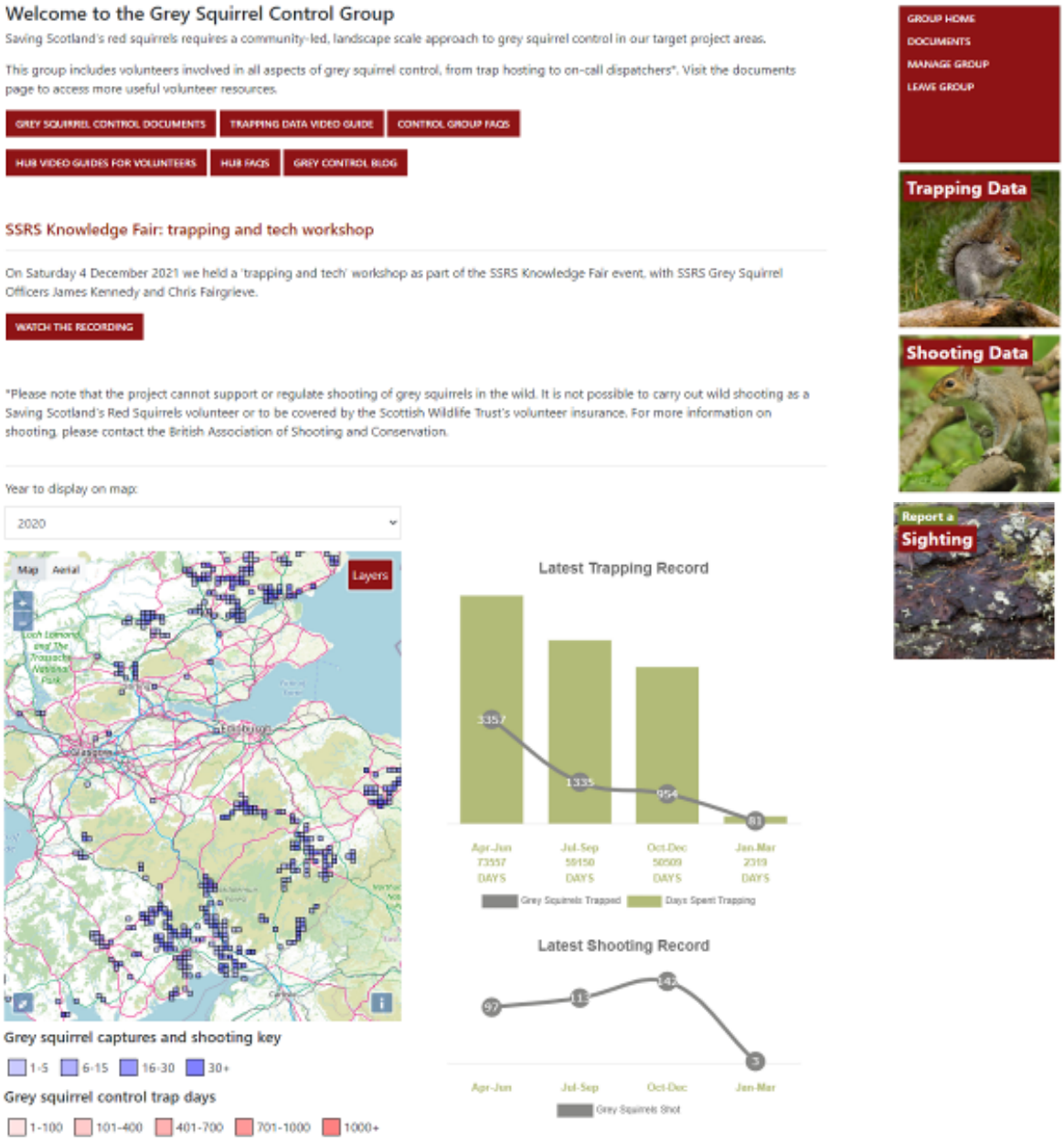
Launch and uptake of the Community Hub

The Community Hub was integrated within a revamped and rebranded SSRS website (scottishsquirrels.org.uk) and launched in September 2018.

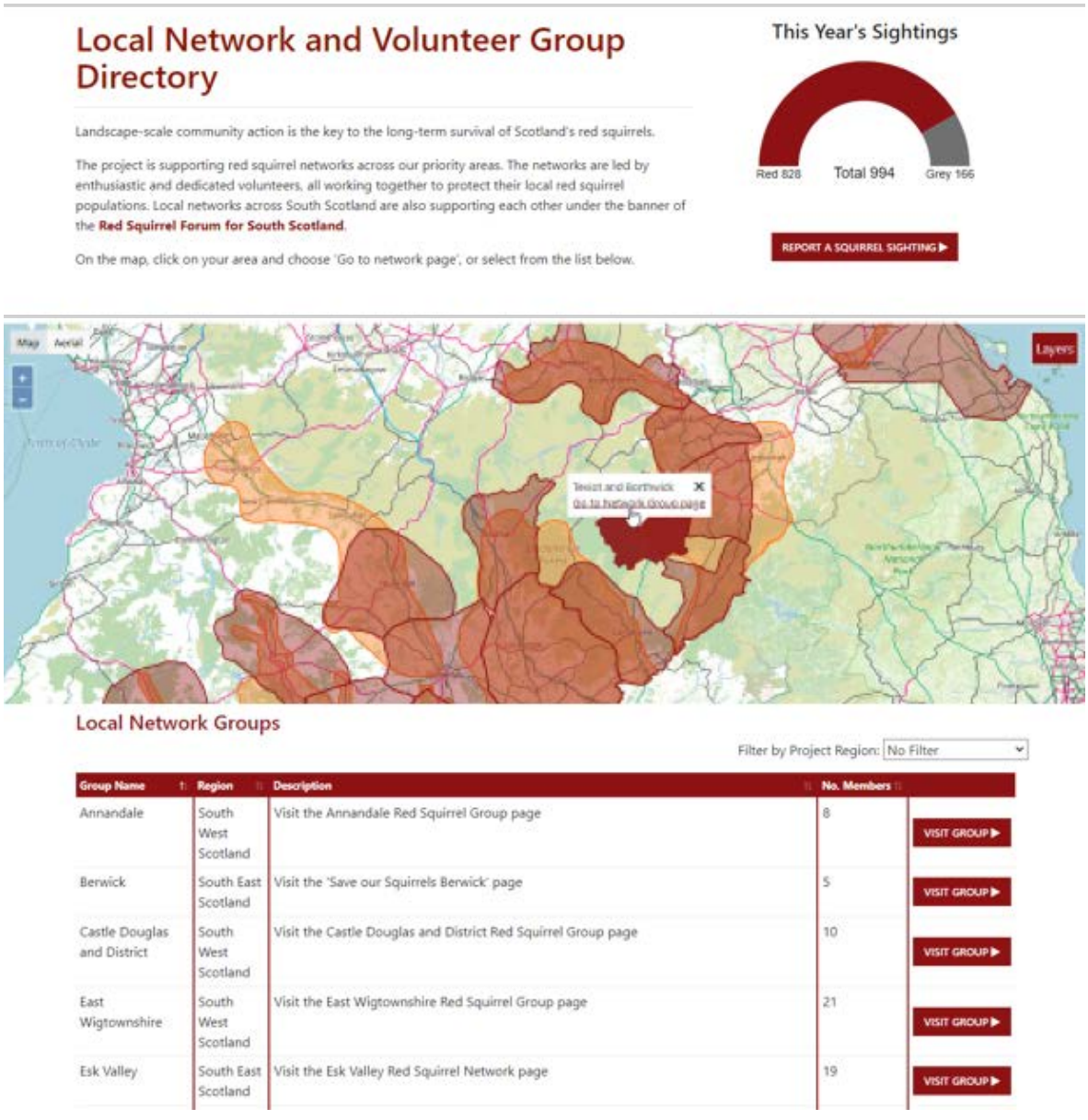
To facilitate uptake and training on the Hub, a range of user guides and videos was created to help both staff and volunteers with differing levels of access to Hub features. Throughout 2019, the SSRS Communications & Engagement Officer and Data Officer travelled around Scotland delivering presentations and training workshops to both staff and volunteers. It was particularly important that newly-forming volunteer groups received this training – and our experience was that new volunteers (and staff) were far more receptive to the Hub, as they did not have the additional challenge of having to "unlearn" their previous data-recording methods.



Infographic to promote the launch of the Community Hub



Private Hub group for grey squirrel control volunteers



Directory of SSRS volunteer groups with links to each group's space on the Hub

In the year following the launch of the Community Hub in September 2018, scottishsquirrels.org.uk saw a 232% increase in annual page views, partly due to increased promotion and publicity but also because the site became a much richer engagement tool with more reasons to visit and spend time on it. In the year following the launch, the bounce rate for the site (percentage of visitors who navigate away from the site after viewing only one page) dropped from 70% to 48%, also demonstrating a higher level of engagement.

By March 2022, 2,760 users had registered accounts on the Community Hub. 211 users had joined a South Scotland Volunteer Network Group on the Hub, 217 volunteers were members of the grey squirrel control group and 140 were members of the feeder-box survey group. However, there was a lower-than-expected uptake of the Hub by volunteers, with only 43% using the Hub at the end of SSRS-DCA. Despite the low uptake, Hub registrations continue to increase, and the number of people logging into the Hub each quarter continues to rise (Figure 8):

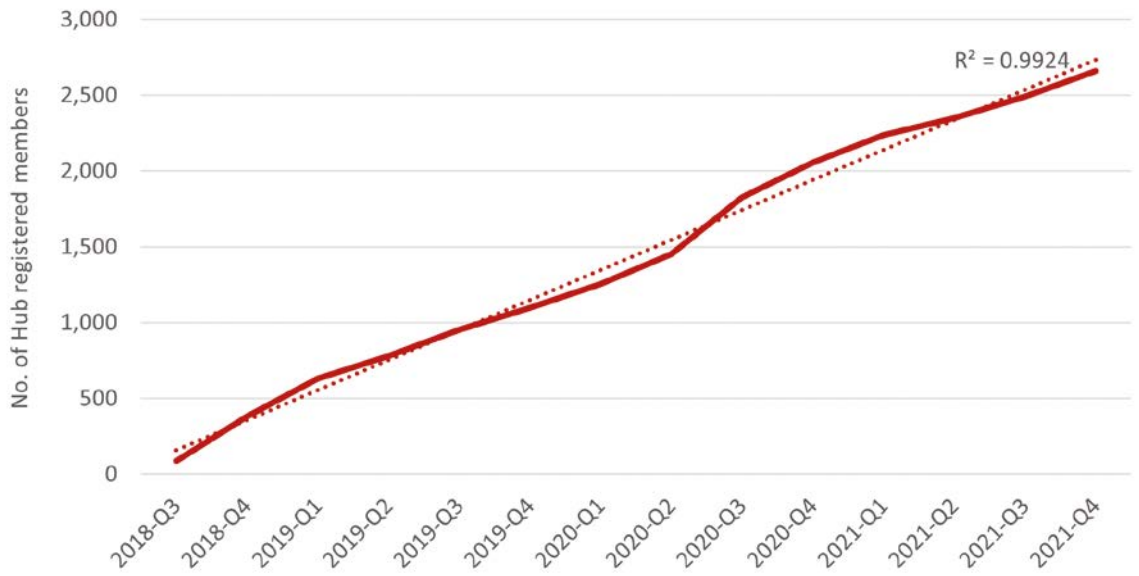


Figure 8. The cumulative number of Hub-registered members.

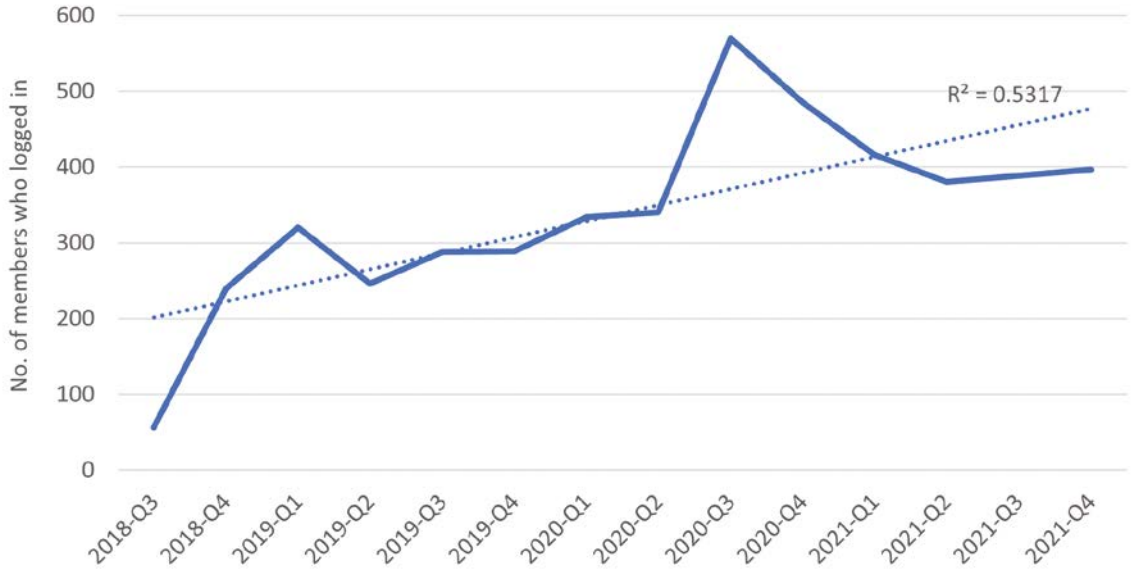


Figure 9. The number of members who logged in. There is a spike in logins in 2020 that represents when the nation went into lockdown and more time was spent online.

"In running the Hub for our group, I can see so much more of what the group does, its scope and scale and the enormous effort that goes on within our group of volunteers."

Lesley Turney, Solway Forests Red Squirrel Network

Improving the Community Hub

Volunteer Sightings Verifiers

In 2019, in order to create resilience in the sightings data collection facility on the Hub, a new Hub role was created for "Volunteer Sightings Verifiers" to help staff process the large volume of public sightings submitted through the website on a continual basis. Volunteer verifiers can log onto the Hub to get full access and edit rights to sightings submitted within their remit area: verifiers check details of the sighting and location, and then confirm the record, or investigate it further with the recorder in order to verify its validity; or, in a few cases where information does not support validity, it is marked "invalid" and is not included in the Scottish Squirrel Database or the sightings map on the Hub. It is important to check the validity of records in this way, as all confirmed records are uploaded to the National Biodiversity Network (NBN) Atlas where they can be downloaded for research purposes, aiding science, research, forest and built development planning and helping to build a nationwide picture of trends in squirrel distributions. Granting volunteers access to sightings data gives them greater responsibilities and the tools they need to effectively manage and monitor red squirrel conservation in their remit area. Prior to the Hub, there were between one and three volunteers who helped with sightings verifications. By the end of 2021-Q4, there were 21 volunteer verifiers who in total verified 9,169 sightings during the DCA period (see figures 10 and 11).

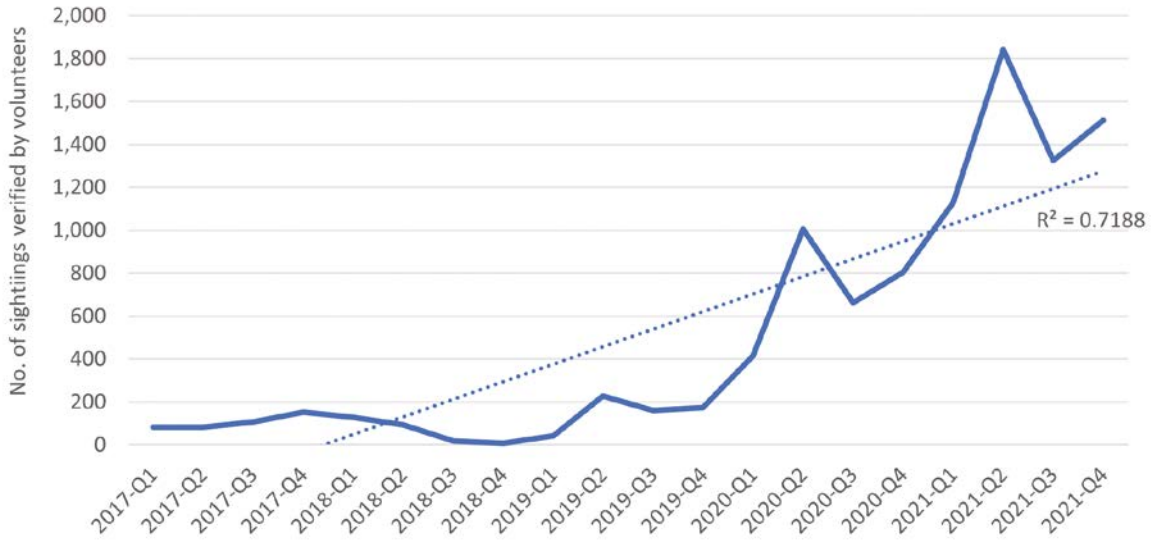


Figure 10. The number of sightings submitted via the Hub that have been verified by volunteers

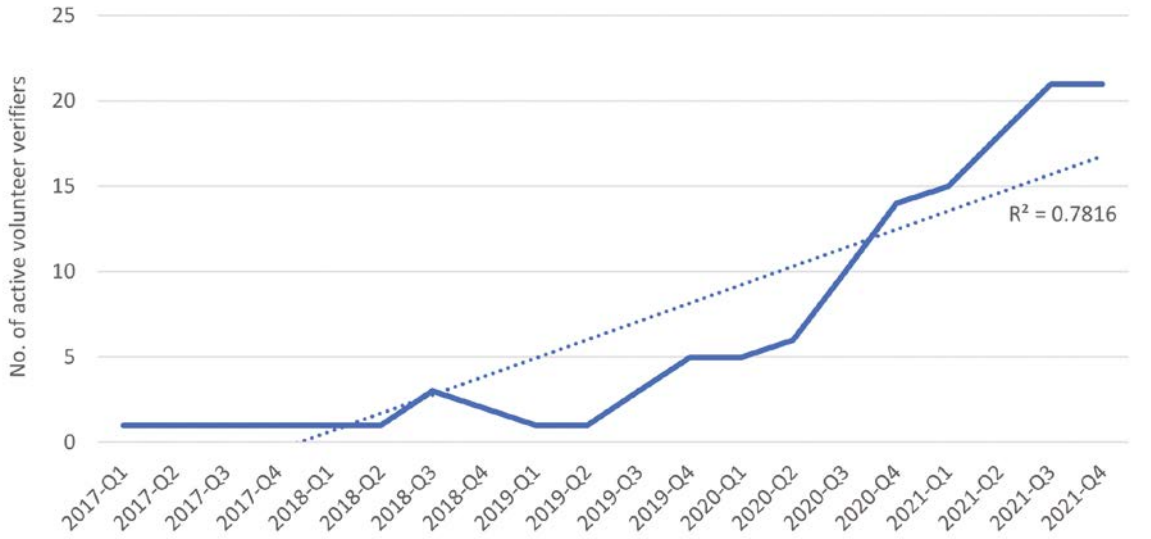


Figure 11. The number of volunteers verifying sightings during the SSRS-DCA project

Shooting records

In 2020, the Hub was updated with a new space to record shooting data after recognising that some volunteers shoot as a form of grey squirrel control and required a place to record this data. Although volunteers could not use shooting as part of their SSRS activity, there were a few people who utilised free-shooting of grey squirrels on their own account and under their own insurance and landowner arrangements. This was generating useful data on grey squirrel management which, to obtain a complete picture, the project needed to record. We identified this update as one of the key requirements for volunteers in the South who felt it was essential for their effective engagement with the platform.

Network administrators

To prepare our volunteer networks for independence, we increased the permission rights that the Network Admins have on the Hub, providing them access and oversight to data from members of their group to help with planning and monitoring activities within their area. This allowed Network Admins to view, assign, edit and export group members' trapping, shooting and feeder-box data, with similar permissions to SSRS staff but restricted to group members' data only.

Bulk uploads

Despite the developments made, the number of people submitting grey squirrel control data via the Hub was still low. Volunteers with a high level of trapping and shooting activity found entering their data onto the Hub one record at a time was too cumbersome and time-consuming. To combat this, bulk upload functions were added for Network Admins to upload trapping and shooting data from their network members: Network Admins can now collate control data from their group and upload all new records to the Hub direct from an Excel spreadsheet in one operation. This feature helps groups with a high volume of trapping data to assist group members who are not so "tech-savvy" to upload their data on their behalf. This development was welcomed by the volunteer groups, but uptake has been slow: by the end of DCA, only 13 shooting records had been submitted through the bulk upload function, and six trapping sessions. However, by the end of June 2022, 148 new shooting records and 70 trapping sessions were bulk uploaded, showing a gradual adoption of these new functions as the groups become accustomed to the Hub.

In total, volunteers have manually submitted 3,741 trapping and shooting records via the Hub; the volunteer Network Admins have bulk uploaded a total of 237 trapping and shooting records and verified 416 records (table 4). Prior to the Hub, the SSRS Data Officer was solely responsible for digitising, quality-checking and importing control records to a local database, with a lot of data missing or not fit for import due to essential data fields being low-quality or missing. The Hub standardises data collection and ensures records come through in the same established format, improving quality and compatibility. This reduces the workload of SSRS staff, particularly as the data submitted by volunteers increases over the years following SSRS-DCA.

Trapping sessions manually entered by volunteers	3,499
Trapping sessions bulk uploaded by Network Admins	76
Trapping sessions verified by volunteers	255
Shooting records manually entered by volunteers	242
Shooting records bulk uploaded by Network Admins	161
Shooting records verified by Network Admins	161
Public sightings verified by volunteers	9,169

Table 4. Total numbers of control records submitted to the Hub, and verified, by volunteers up until the end of 2022-Q1

Regional Data Officer

The last major piece of Hub development work that took place during DCA was the creation of a new role, Regional Data Officer, for volunteers. Regional Data Officers have been granted read-only access to data that falls within South Scotland to help with reporting, analysis, planning and monitoring on a landscape scale, as volunteers in the South take on more responsibilities and independence in the SSRS Transition Phase. The Regional Data Officers can view and download all sightings, trapping, shooting, and feeder-box survey data from South Scotland.

The DCA Hub development work appears to have resulted in a slight increase in the number of records submitted via the Hub, but uptake of the facility is still slow. Despite the work already undertaken to meet volunteer expectations, SSRS staff are still receiving requests for further development work and the occasional complaint about the efficiency of the Hub. For future projects of a similar nature, it is recommended that time and money is not spent on development work unless volunteers can provide some level of evidence for the scale of the demand and requirement for development, to avoid money being spent on functions that are rarely used. For example, in 2019, among the key features requested by Network Admins as essential for effectively monitoring and planning their groups' work was the ability to add feeder-box data to the Hub. After complicated development work to roll out this feature, only seven feeder-boxes have been set up by the network groups in the South.

10.3 Challenges and reflections

The Community Hub is a unique online space in the conservation field, with few previous case studies to draw experience from. Its development came with several challenges, including:

- The complexity of the site meant that the original specification did not fully capture all the requirements that emerged during the development process. Therefore, significantly more time was spent developing the Hub than was originally expected, causing the project to run over budget. The Community Hub developers, ExeGesIS, were flexible and supportive in their approach, working with SSRS to ensure that they provided requirements and functions that were missing from the original specification. Furthermore, they provided a significant in-kind contribution towards the project, helping to reduce the cost. For future projects of a similar nature, it is recommended that a fully Agile approach is taken with system development, with full involvement from appropriate staff to provide essential feedback and testing throughout development, ensuring that a full User Acceptance Test is performed prior to launch, even if that delays the launch date.
- Creating a smooth user journey for different types of volunteer was difficult to achieve within the limits of an off-the-shelf platform ("BuddyPress"). In some cases, there were more steps for potential volunteers to follow than desirable.
- There have been issues with the quality of some data inputted by volunteers. For example, at times, trapping end dates are left blank on trapping sessions, or volunteers combine multiple traps into one trap-record using a centralised grid reference. This means we are unable to accurately measure trapping effort and captures rates using volunteer datasets, limiting the power of SSRS nationwide reporting and analyses. Furthermore, the bulk of SSRS trap loan scheme participants in the South do not share their data with SSRS, despite it being a condition in the trap loan agreement.
    - Mitigation: Encouragement, training and manuals are provided to volunteers to try to ensure they record data as accurately as possible, and greater powers have been granted to Network Administrators in the South so they can analyse data from their groups. This should encourage volunteers to submit their trap loan data to better inform the groups' planning and reporting. The number of trap loan scheme participants in South Scotland returning trapping results has risen from seven in 2017 to 30 in 2021, peaking at 35 in 2020.

- There were very high expectations of the potential functionality of the hub, which, combined with misunderstanding of how complex it is to develop each new function, resulted in some negativity around it not delivering upon expectations. Assumptions from users and those involved in the development of the hub led to teething issues in the first few months. Furthermore, in the final stages of development, the User Acceptance Test (UAT) was poorly timed alongside the SSRS spring survey, owing to overrun in the procurement and delivery processes, meaning that staff and volunteers were too busy to fully test the Hub before launch. It would have been beneficial if Hub development had been factored into staff / regional workplans at the project planning stage. However, no amount of testing could replicate real-world usage.
- Many staff and long-standing volunteers were resistant to changing the way things had "always been done", and/or were intimidated by the high level of functionality of the site and discouraged by the initial teething issues. Great efforts were made to accommodate the needs of volunteers via a series of updates and adjustments to the Hub, balancing this with staff and project requirements. Managing the expectations of staff and volunteers more effectively from the outset, by being clear on minimum functionality, may have alleviated this to some extent. While the Community Hub and online database provide unrivalled functionality and have revolutionised data collection and management for the project, future projects should investigate whether a range of off-the-shelf technologies may provide the functionality required in a simpler and cheaper way (accepting less functionality, as has been described here). The challenge would then be the technology behind the scenes linking up the data as required to provide the information needed for reporting.

"I don't think that many people appreciate that you have taken a recording system that was completely dysfunctional and really not fit for the task it was meant to be doing, to a recording system that is fully joined up, holistic and world class.

Over the years, we have seen the incremental improvements and increases that you have introduced, and it's only when you stand back and see the whole that you realise the huge task you had taken on and how much work and effort that you have put into it.

I personally believe that with the addition of [Regional Data Officers] having access to all the records in South Scotland, with the exception of people's personal information, it will be a game-changer, both from being able to access the data for seeing the overall situation and using that to monitor progress and to influence future work, but also to encourage groups to keep entering their records to build that picture. It will be important to use your database to give groups something that they find useful and encouraging and that might evolve over time."

John Rae

11. The Future of Saving Scotland's Red Squirrels

The Future of Saving Scotland's Red Squirrels

Immediately following on from SSRS-DCA is a further two-year phase of SSRS, the SSRS Transition Project. This project provides the opportunity to embed this established grey squirrel management work as the permanent ongoing wildlife management role of an organisation with an allocated annual budget from public funds, in tandem with support for operations to remove this invasive non-native species from public and private land in the strategic areas identified in the Scottish Strategy for Red Squirrel Conservation.

North-East Scotland

In Aberdeen City and Shire, the project work will continue to reduce numbers and spread of grey squirrels in the area. It is most unlikely that eradication (zero grey squirrel detection) can be achieved in two more years, but potentially the project can reach a stage when "rapid response" monitoring is the main activity, with control only to respond to grey squirrel detection by the monitoring. The SSRS North-East Team will be augmented by an additional Monitoring and Control Officer to cover the Mearns, allowing the existing team of four to have greater focus on the Aberdeen city grey squirrel populations.

It is anticipated that, as numbers of grey squirrels fall, the effort needed to detect and remove remaining squirrels will increase. In order to better understand this process, SSRS will commission scientific data-driven advice defining the milestones and key performance indicators en route to the successful eradication of this isolated mainland population of grey squirrels, enabling the North-East Team to better understand what progress they are making and what remains to be done.

Due to the species' reproductive biology and dispersal behaviour, intensive rapid response monitoring will be needed until eradication is reached. The scientific advice should include recommendations for the minimum essential "post-eradication" monitoring that will need to be delivered, and over what timeline, in relation to the eradication milestones.

The eradication programme will require professional grey squirrel control staff until eradication is achieved. Therefore, SSRS-Transition will need to plan how the Grey Squirrel Control Officers will be organised and supported until they are no longer required.

The Transition project will seek to embed the delivery of the monitoring within a supported volunteer structure. Since 2020, the North-East Team has recruited and trained around 45 new volunteers who carry out the monitoring side of the rapid response monitoring on a fortnightly basis. Monitoring at this level of intensity would not be possible without the help of volunteers, and the team will continue to recruit and train additional volunteers for the duration of the Transition project.

Central Lowlands

SSRS staff will continue to deliver the same or improved levels of co-ordinated landscape-scale control work across the Highland Line Control Zone, as required to protect Scotland's core red squirrel populations in Grampian, the Highlands and Argyll. Particular effort will be focused on the Mearns cross-border area of South Aberdeenshire and Angus, as one of the Highland Line locations most vulnerable to ingress of grey squirrels towards Aberdeen. Other ingress routes to the Highlands, such as the Strathtay and Tummel corridors, Strathardle, Loch Earn and west Loch Lomond/Gare Loch will also be closely monitored, and focused control delivered. This is the critical work that will be needed over future decades to secure Scotland's priority red squirrel population, and the SSRS Partnership will need to devise long-term funding and a long-term delivery system for this control.

Landowners currently working under the Forestry Grant Scheme across the Highland Line Control Zone will continue their contracts. It will be important that they are encouraged to apply for follow-up contracts when the current ones expire, and SSRS partner organisations will need to assist SSRS staff to do so.

SSRS staff will continue to deliver engagement work in the Central Lowlands, to maintain public awareness and support. The future plan for the long term will need to identify how this essential support will continue to be provided.

South Scotland

SSRS will continue supporting work in South Scotland, providing co-ordination and advice for the ongoing red squirrel conservation work across the region, with mentoring and support for the new volunteer groups. The volunteer groups which are not yet independent of the project will be given further support to address barriers towards independent status, focusing on the Castle Douglas, Mid-Nithsdale, Esk Valley and Annandale groups, where voluntary grey squirrel control skills are still lacking, but including other groups as capacity allows.

The project aims to have all volunteer red squirrel protection groups fully independent by the end of two years, and to have in place a plan for delivery of the ongoing support and co-ordination that will be required by these essential conservation delivery groups for the long-term future.

Monitoring

With the interruption of the very labour-intensive SSRS Spring Surveys through 2020–22, this simple means of monitoring the progress of SSRS grey squirrel population management work and its effects on red squirrels has been lost. The SSRS Transition project needs to address this with some urgency. Therefore, it will work with SSRS Partners to identify the minimum level of squirrel distribution monitoring necessary to assess the efficacy of the control programme in maintaining Scotland's core red squirrel populations and to inform the focus of grey squirrel management over the future decades, to include a plan for how the monitoring will be delivered.

Grant systems to support grey squirrel control

Another key piece of work for the SSRS Transition Project Partners will be to inform and influence the design of future grant systems for support of landowners undertaking grey squirrel control. For the greatest impact of this important landscape-scale work, the grants system needs to assimilate SSRS expertise and advice for its future schemes.

Long-term delivery

It is essential to continue to deliver long-term the work to protect Scotland's red squirrels from further erosion by grey squirrel replacement – work which hitherto has been delivered by SSRS through a series of funded projects of limited duration, with all the challenges to maintaining continuity that this entails and the high levels of staff turnover that results from the uncertainty attaching to fixed-term staff posts. Therefore, SSRS will research and identify agencies or other bodies who could develop the long-term capability to deliver and co-ordinate strategically critical grey squirrel population management via a professional grey squirrel control team, grant-funded landowners and volunteers.

12. Recommendations

Recommendations

The UK is a country with a limited native mammal fauna, many species of which have already been lost. It is not sufficient to allow red squirrels, a flagship species for wildlife conservation, to persist only as remnant populations in remote parts of Britain. We have a biodiversity duty to avoid the loss of the red squirrel from its last widespread "red-only" population, still flourishing right across the Highlands, Argyll, Grampian and northern parts of Tayside and Stirlingshire.

In addition, if we can sustain the extensive red squirrel population spanning the Anglo–Scottish border in the face of grey squirrel competition until a novel means of managing grey squirrels is developed, this would be the first step in restoring the red squirrel to parts of Scotland from which it has already been lost.

The Saving Scotland's Red Squirrel project since 2009 has made great strides in taking Scotland's red squirrels to a more secure situation. The work to demonstrate that protecting key red squirrel populations is possible has now been done by SSRS. The techniques, procedures and protocols for essential grey squirrel management work, together with data collection, interpretation and feedback, have been developed; voluntary red squirrel conservation groups have been established, equipped and trained; and the support systems and collateral for both the grey squirrel management and public engagement work of the groups have been produced.

What is required now is mainstreamed, regular, and reliable funding, beyond the uncertainty of annual grant cycles, to deliver consistent professional grey squirrel management work and volunteer support in key areas.

Key recommendations

North-East Scotland

1. The eradication of the isolated Aberdeen grey squirrel population should be seen through to completion. To leave even a small population unmanaged in Aberdeen would risk the rebound of this invasive non-native species into Scotland's core red squirrel population and greatly increase the costs of protecting the native Scottish mammal. Once the eradication is complete, Scotland's only grey squirrels would be those to the south of the Highland Line, and any limited resources available could be focused on the grey squirrel containment in this area into the future.
2. The SSRS work in Aberdeen is the first documented effort to eradicate an invasive grey squirrel population from a mainland urban environment, and thus it is unknown how a grey squirrel population under pressure will respond to falling densities, or what additional difficulties the built environment will introduce when only a few grey squirrels remain. Predicting a meaningful timescale to eradication is likely, therefore, to be impossible.
   However, there is potential for the work to provide a learning opportunity of applicability to the management of invasive non-native species (INNS) worldwide. Equally, it will be important to make use of the practical expertise of existing successful INNS eradication practitioners to help avoid pitfalls and improve the efficiency of the process. The work is likely to require new approaches to removal of trap-shy individual grey squirrels, and to carrying out the work in an urban setting, and may require household pest-control techniques coupled with enforcement.
3. It is crucial that the Aberdeen eradication work continues to be delivered by a small, specifically tasked professional team until zero grey squirrels can be detected in the city and its surrounds via ongoing monitoring for a number of years. Volunteers cannot be expected to provide the instant response to grey squirrel detections, nor to provide the intensive control approaches that will be needed to avoid rebound of grey squirrels into areas already cleared.

4. The Mearns area of south Aberdeenshire should be maintained as a grey-free zone. The Mearns landscape has been identified as the most porous point along the Highland Line for grey squirrel incursion northwards, and the distance between the Angus border and Aberdeen is only about 30 miles – not far for grey squirrels, whose individual dispersal distances may be up to 20 miles. Ongoing monitoring to detect early recolonisation will need to be maintained.

The Highland Line

5. It has been frequently noted, during the 13 years of SSRS to date, that **co-ordinated, sustained landscape-scale grey squirrel control** will be required across the Highland Line for the long term, until such time that an alternative more cost-effective or more efficient control measure is developed. While the need for ongoing control measures across the Highland Line landscape has been largely accepted, the critical need for co-ordination of this work needs to be addressed with urgency during the SSRS Transition Phase to avoid the risk of neglect. From piecemeal approaches to grey squirrel control applied in the past, it was clear that any positive outcomes are quickly reversed when grey squirrel control stops, as empty habitat acts as a sink for excess production in neighbouring grey squirrel populations to fill. To be successful, there needs to be somebody tasked with maintaining a constant overview of control measures, to ensure they are strategically located and co-ordinated in response to monitoring of the incoming control data, i.e. the equivalent of the SSRS Conservation Officer role.

South Scotland

6. In South Scotland, for the grey squirrel management work of the volunteers to be effective, ongoing support will be needed. Our original model for delivery for red squirrel conservation beyond the lifetime of the NLHF-funded Developing Community Action project was the continuation of a minimum of one full-time Community Engagement post to provide ongoing essential support of the volunteer networks in South Scotland, to include adequate feedback, training and development for existing volunteers and recruitment of fresh volunteers as others move on. This will be the minimum requirement.

7. To successfully maintain the red squirrel populations in the South Scotland Priority Areas for Red Squirrel Conservation, a small number of professional Grey Squirrel Control staff is needed to cover locations inaccessible to volunteers, for example because of landowner restrictions, long distances, number of traps required, the lack of suitable vehicles for the terrain and, crucially, other demands on the volunteers' time.
   The Grey Squirrel Officers could potentially be supported by contributions from landowners on the grant scheme, in order to cover their own land and areas further afield, for the good of all.
   In the PARCs, forestry enterprises who employ professionals to manage deer during the autumn and winter could consider extending the contracts to include grey squirrel management.

8. Evidence is emerging of the beneficial effect of pine marten recovery on the fortunes of red squirrel where it competes with grey squirrel. There is enormous potential for recovery of pine martens in South Scotland and other areas of the country to be more rapid than it has been to date. Information campaigns targeting landowners about the benefits of pine martens in red squirrel conservation efforts should be undertaken in strategic areas. Encouragement and advice to support pine martens across the landscape, such as the provision of artificial den boxes where natural denning sites are scarce, and properly secured poultry and gamebirds to avoid predation conflicts should also be considered.

All areas

9. A critical requirement for the SSRS Partners will be to identify the minimum level of squirrel distribution monitoring necessary to assess the success of the control programme in maintaining Scotland's core red squirrel populations and to inform the focus of grey squirrel management over the future decades, to include a plan for how the monitoring will be delivered.
   Accepting that the Spring Surveys carried out by SSRS were too onerous a system to run without a specific organisation to provide co-ordination, materials, mapping and reporting, a more manageable form of monitoring could be similar to the monthly garden surveys run by SSRS's Gatehouse Squirrel Group, or the tetrad surveys run by the Red Squirrels Northern England project, where specific sites are monitored over a particular timescale during the spring.

10. As SSRS moves forwards, the red squirrel conservation community needs to consider whether squirrelpox monitoring is required to continue, in what form, and how it is to be delivered.

11. A key piece of work for the SSRS Project Partners will be to inform and influence the design of future grant systems for support of landowners undertaking grey squirrel control on private land. For the greatest impact of this important landscape-scale work, the grants system needs to assimilate SSRS expertise and advice for its future schemes.

12. For the last 12 years, the adoption of Forestry Grant contracts by landowners to fund grey squirrel control in accordance with Scotland's strategic priorities has been largely in response to engagement and advocacy by the SSRS Project Team, including provision of detailed support with applications, trap placement and reporting of results, inter alia. Although most of the required landowners in the priority areas will now have experience of the scheme, it will still be essential to continue to provide advocacy and support. SSRS has worked with Scottish Land and Estates to help it provide generic support to its members, but there will need to be ways to recruit and support owners of land who are not part of SLE to sustain this important arm of the work long-term.

13. The SSRS Community Hub and relational database developed during SSRS-DCA will continue to be managed by the Scottish Wildlife Trust for continuing volunteer support and widespread data submission, curation, summary and reporting. It will remain as a key engagement tool for community networks and volunteers as well as for ecological data management. It will require ongoing monitoring, maintenance and development.
However, to realise its potential, there must be a plan for how the collected data will be managed, summarised and used to inform the planning and co-ordination of ongoing red squirrel protection measures.

14. The SSRS Partner organisations will need to work together and with other organisations and stakeholders to maximise volunteer engagement and co-ordination, continuously developing and strengthening volunteer networks, and engaging with the public, sharing progress/achievements, and maintaining the profile of red squirrel conservation action. The Communications Plan and a suite of engagement materials are already developed to continue appropriate methods of engagement.

15. The Great Scottish Squirrel Survey (GSSS) is a useful tool for public engagement, which also creates a snapshot of red and grey squirrel distributions in Scotland over the course of a week and should continue to be delivered by the Scottish Wildlife Trust in the first instance. There is potential for working with the UK Squirrel Accord to expand the reach of the GSSS to cover all of the UK, or widening its impact via events organised by volunteer groups and partner organisations, the introduction of more challenges for participants, links with schools, or celebrity endorsement.

16. As plans take shape for the longer-term future of red squirrel conservation in Scotland, it is the right moment to reconvene the Scottish Squirrel Group (SSG) and review its membership and Terms of Reference. The SSG consisted of organisations and individuals representative of a wide range of Government departments, agencies and NGOs, and was a forum for discussion for the regional squirrel groups, for the promotion of squirrel management, and for the identification of research needs.
The primary role of the SSG was to facilitate communications and to co-ordinate activities with a view to conserving red squirrels in Scotland and to promote a consistent and positive approach to the management of red and grey squirrels. Its previous objectives included encouraging co-ordination of regional red squirrel conservation strategies; encouraging best practice guides for squirrel management and effective woodland design and management to minimise the risks of bark stripping damage; identifying gaps in knowledge and research needs; encouraging sound squirrel management training; and monitoring the effectiveness of management.
Key considerations for a reconvened SSG might include the future of Scottish squirrel monitoring, squirrelpox monitoring, the Forestry Grant Scheme for grey squirrel control support, the future potential of the SSRS Hub and the continued education and engagement of the public with squirrel conservation issues, including the wider application of the Great Scottish Squirrel Survey.
The Group meetings halted during the Covid-19 pandemic, but with the advent of much more widely available digital meeting platforms it is timely that it resumes its twice-yearly meetings.

17. A key priority for the Scottish Squirrel Group will be the necessary review and updates of the 2015 Scottish Strategy for Red Squirrels Conservation, in the light of SSRS achievements and the changes in delivery systems for the essential activity identified in the strategy.

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Appendices

Appendices

Appendix 1: Background information

Once Britain's "common" squirrel (*Sciurus vulgaris*, the Latin name, translates as "common squirrel"), its inexorable disappearance across increasing areas of England and Wales over the 20th century has been well documented. The key cause of red squirrel decline in the UK has been competitive replacement by the introduced American grey squirrel (*Sciurus carolinensis*). This is classed as an "invasive non-native species" in the UK and has replaced the native species over most of England and Wales. Grey squirrels compete with the native red squirrels for food and living space, over time replacing them in most woodland types. Grey squirrels also act as the natural host of squirrelpox virus, which is readily transmitted to red squirrels, in which it causes disease that is invariably fatal.

The expansion of grey squirrel populations has been slower in Scotland than in the rest of the UK. The species was introduced to a few lowland sites in Scotland, but by the end of the 20th century red squirrels had all but disappeared from the Central Belt of Scotland, and greys were continuing to spread through the Scottish Borders, Dumfries & Galloway, Ayrshire, Stirlingshire, Perthshire and Angus. A separate population of grey squirrels, introduced accidentally into Aberdeen in the 1970s, became established in the Aberdeenshire countryside, posing a threat to Scotland's core red squirrel populations of Grampian and the Highlands.

In 2005 a new threat, in the form of squirrelpox disease, spread northwards over the border from England. This disease is carried without ill-effect by grey squirrels, but it spreads readily to red squirrels, in which it causes severe disease which is rapidly fatal in virtually all known cases. Its arrival in Scotland has thus greatly increased the vulnerability of our red squirrels.

Appendix 2: Strategic context

In 1996, the Joint Nature Conservation Committee published the UK *Strategy for Red Squirrel Conservation* as a framework for red squirrel conservation throughout the UK. A strategy for Scotland, The Scottish Squirrel Strategy[34] (first produced in 2004 and now in its third edition), outlines regional aims for red squirrel conservation in Scotland and identifies the activities necessary to achieve them, including grey squirrel control, survey and monitoring, addressing the threat of squirrelpox virus, habitat management and public awareness-raising.

In 2006, the Scottish Government's Red Squirrel Action Plan 2006–11 set out detailed costed action in an integrated approach to the long-term conservation of red squirrels in Scotland, to deliver the key conservation action. The need for evidence to quantify the level of control required to depress or eradicate grey squirrels to encourage red squirrel conservation was explicitly identified.

Around the same time, Scottish Forestry (then called Forestry Commission Scotland) developed its *Red Squirrel Strongholds* initiative, in which 19 forest networks were identified for long-term habitat restructuring to enhance their carrying capacity for red squirrels, intended as long-term refuges for red squirrels in the event that population management should fail to halt the spread of grey squirrels. The strongholds are currently undergoing review.

In 2015, the Scottish Government published its *Scotland's Biodiversity – a Route Map to 2020*,[35] listing Saving Scotland's Red Squirrels one of six high-profile wildlife projects in the section Priority Project 9: Conservation of Priority Species.

[34] https://www.nature.scot/sites/default/files/2018-09/Scottish Strategy for Red Squirrel Conservation - June 2015.pdf
[35] https://www.cbd.int/doc/nbsap/Scotland-Route-Map-to-Biodiversity.pdf

Appendix 3: SSRS project phases

SSRS Phase 1 (2009–12)

In April 2009, the *Saving Scotland's Red Squirrels* (SSRS) partnership project was launched. The Scottish Wildlife Trust, in partnership with Scottish Natural Heritage, Forestry Commission Scotland, Scottish Land & Estates, later joined by Red Squirrel Survival Trust and RSPB Scotland, set up a national trial which aimed to establish the viability of securing the remaining red squirrel populations in Scotland. It aimed at halting the spread of grey squirrels in key landscapes, improving access to information on woodland management for red squirrels, increasing public awareness of problems faced by the red squirrel, and collecting evidence to help determine whether targeted grey squirrel control could be effective as a sustainable measure to underpin red squirrel conservation.

Its regional aims were:

- to halt continued expansion of grey squirrels northwards from the Central Lowlands in line with the natural barriers identified in the SNH consultation document *Protecting Scotland's Red Squirrels: a draft strategy for grey squirrel control* (2009),
- to reverse the spread of grey squirrels outwards from Aberdeen, and
- to contain or significantly slow the spread of squirrelpox disease in southern Scotland.

The SSRS project showed that cumulative trapping effort could indeed be effective in reducing grey squirrel numbers locally, enabling a recolonisation by red squirrels.

In South Scotland, the management action carried out under the earlier *Red Squirrels in South Scotland* (RSSS) project was shown to be effective at limiting the severity of squirrelpox outbreaks in red squirrels, with continued presence of healthy red squirrels at several outbreak sites in subsequent years. Control efforts appeared to decrease the rate of spread of squirrelpox through South Scotland's grey squirrels, but not to halt the spread of the disease altogether.

In 2011, seropositive grey squirrels appeared for the first time on the eastern Anglo–Scottish border and began to spread rapidly northwards through Berwickshire.

SSRS Phase 2 (2012–14)

The second phase of SSRS continued with the same specific regional aims. In addition, a systematic sampling network was set up to establish the distribution of the squirrelpox virus and its seroprevalence in grey squirrel populations in South Scotland and the Central Lowlands.

A new scheme for presence/absence monitoring began across South Scotland, similar to that already in place in the Central Lowlands and North-East. This revealed that red squirrels still occurred widely across southern Scotland, especially in Dumfries & Galloway and the western Scottish Borders. Together with other evidence, SSRS used this finding to demonstrate that work to date had allowed red squirrels to recover and to thrive in southern Scottish landscapes where grey squirrel densities are kept very low, even with the widespread presence of squirrelpox.

In 2013, scientists used mathematical modelling of squirrel population processes and squirrelpox disease data to explore the patterns of squirrelpox virus spread in Scotland hitherto and to predict the likely future spread (White et al. 2016). This supported SSRS observations that intensive grey squirrel control work had slowed the northward spread of squirrelpox disease from southern Scotland, but predicted that it was extremely unlikely that the eventual spread of the disease throughout Central Lowlands grey squirrel populations could be prevented.

SSRS Phase 3 (2014–17)

Phase 3 continued with the regional aims for the North-East and the Central Lowlands.

In South Scotland, we changed the focus of work from containment of squirrelpox spread to concentrate on red squirrel conservation work in a limited number of landscapes. The project ceased to monitor for squirrelpox in South Scotland, where the disease was now considered endemic in the grey squirrel population. However, squirrelpox sampling continued to track the potential northward spread of the disease through the grey squirrel populations of the Central Lowlands.

Appendix 4: SSRS-DCA staffing structure

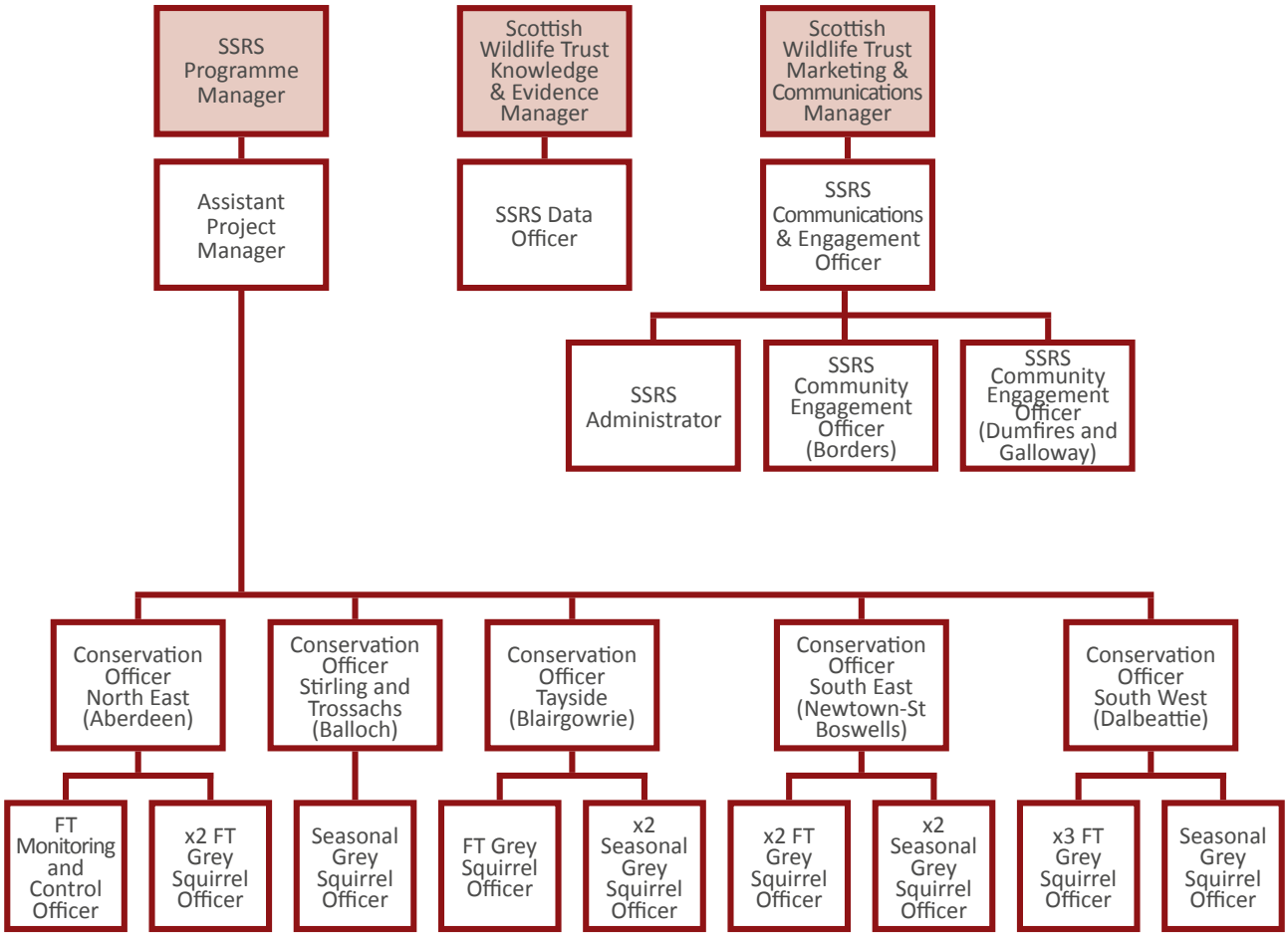

Figure 9. Schematic view of SSRS-DCA staffing structure

PROJECT PARTNERSHIP

FUNDER

The Saving Scotland's Red Squirrels partnership includes the Scottish Wildlife Trust, Scottish Natural Heritage, Forestry Commission Scotland, Royal Society for the Protection of Birds (Scotland), Scottish Land & Estates and the Red Squirrel Survival Trust.