Saving the Red Squirrel

Landscape Scale Recovery

Edited by

Craig M. Shuttleworth Honorary Research Fellow, Bangor University

Peter W.W. Lurz The Royal (Dick) School of Veterinary Studies, The University of Edinburgh

Nikki Robinson Red Squirrels Trust Wales

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The Case Studies

In March 2020 we invited a range of conservation projects and scientific research groups to contribute to this publication. In order to streamline the submission, authors were asked to complete a standard template, which contained defined headings, a maximum word limit per section and standard tables to complete.

Within each case study, a short overview section is followed by a list of project aims to provide a foundation for the following longer sections within which the project activity is described. Each case study then presents (i) Success Indicators, (ii) Major Difficulties Faced, (iii) Major Lessons Learned, (iv) Success of the Project and (v) the Reasons for the Level of Success.

The final sections of each case study present key areas for future development and list any reports or published findings that would be useful additional reading.

Preface

This brilliant book is special. It brings together, in one important volume, a large body of scientific evidence, frontline experience and key insights on achieving landscape-scale recovery for red squirrel populations from the leading practitioners working in the UK today. It is an exceptional blend of authoritative contributions from experts with a wide range of perspectives: from volunteers, voluntary groups and landowners through to researchers, academics and leading figures in the professional red squirrel community.

The common thread which brings this diverse community together is a passion for red squirrels. They are united by their shared vision to secure a thriving and self-sustaining future for this amazing, iconic and fascinating species.

As our understanding and knowledge has improved, there has been a growing awareness and recognition that this ambition can only be achieved at a landscape-scale - simply because this is the scale at which the many factors that drive change in red squirrel populations operate.

In my view, the collective efforts of the ‘red squirrel community’ have made rapid and encouraging progress across all areas of activity in recent years: Firstly, to protect and conserve surviving red squirrel populations – and to now work towards their recovery at a landscape-scale. This is a positive and forward-looking approach which, in pragmatic terms, is the only way of securing the presence of red squirrels for the future.

Across the UK, particularly through better coordination of more effective grey squirrel control at a landscape-scale, there is a real sense that after decades of depressing decline and retreat to a few core areas, we are observing some optimistic signs of stabilisation in the range and population of red squirrels.

In some of these areas, thanks to a great deal of hard work by those involved and the application of new knowledge and innovative approaches, we’re also seeing the early signs of range expansion and population recovery.

These are huge and encouraging achievements by the red squirrel conservation community and they should be celebrated.

None of this has happened by accident, of course. It has been entirely thanks to the gargantuan effort and hard work of volunteers in local squirrel groups, of energetic and inspirational leaders like Craig Shuttleworth, of several conservation charities and many

woodland owners. All supported by the devolved administrations and their agencies, working through a multitude of partnership projects in the four devolved countries of the UK.

It's great to see that many of those who have led this effort have generously contributed their ideas, experience and expertise to this book.

We must also express our gratitude to the many thousands of anonymous people who have heroically played their part too, largely for no thanks or reward.

I would also like to recognise the vital role played by the many amazing private, public, corporate and individual funders whose philanthropy in backing red squirrel conservation has made possible all of the activity in recent decades. I hope the selflessness, vibrancy and achievements described in this book give future funders the confidence and inspiration to continue investing in red squirrel conservation because it makes a real difference for people, local communities and local economies as well as to red squirrels.

In describing the progress on landscape-scale approaches, this book also explores a number of emerging and exciting developments that could make a significant difference to the scale and speed of success in future, if we can find ways of applying them at scale. Fertility control, gene drives and the recovery of a native predator, the pine marten, could all become game-changers in the recovery red squirrels at a landscape-scale alongside traditional approaches to grey squirrel control.

A key element that underpins much of the success and progress of recent years has been the willingness to share best practice, experience and learning from all of the amazing projects across the UK. This book is the latest welcome contribution to that process of improving our collective effectiveness so that we get better outcomes for red squirrels.

There is so much more to do if we're going to achieve the vision for red squirrel recovery across the UK landscape. This inspiring book shows us how we can achieve it and that it is possible.

Stephen Trotter
Member of the UK Squirrel Accord Executive Committee
Trustee of the Red Squirrel Survival Trust
Chief Executive of Cumbria Wildlife Trust
Kendal, Cumbria, November 2020

Contents

Success Criteria: H - Highly Successful, S - Successful, P - Partially Successful

Editors' Note and Acknowledgments

SAVING THE RED SQUIRREL: LANDSCAPE SCALE RECOVERY

In 2015, we edited a series of red squirrel conservation case studies within the volume 'Shared experience of red squirrel conservation practice'. The book highlighted how community participation and learning had become central to successful regional red squirrel conservation programmes.

Since publication, it subsequently became apparent that by 2020 much had changed. The emergence of technological advancements such as immuno-contraception research and the clear impact that natural pine marten re-colonisation has had on the regional distribution of grey squirrels have had a high profile in media coverage. In addition, the scale of regional red squirrel recovery in the absence of pine marten has been impressive. This success is underpinned by the use of systematic camera trap monitoring, co-ordinated standardised approaches to grey squirrel control and greater community based conservation interventions. The voluntary sector has both led and empowered local communities and remains vital to the sustainability of red squirrel recovery within a continuing climate of funding uncertainty.

We are grateful to the contributors to this publication for sharing their experiences and for critically reviewing the factors leading to success and highlighting barriers that remain. Once again, we have taken a light touch towards editing so that authors can describe their projects in their own words. Case studies may therefore contain opinions and challenging views, which we hope will contribute to a wider debate, provide food for thought to strategic policy makers and allow all to contact as well as learn from the huge pool of experience. Most importantly, we hope that by providing a platform to show-case local conservation initiatives the material will help inspire others to evolve new projects.

We would like to extend our thanks to the Red Squirrel Survival Trust and the National Lottery Heritage Fund 'Magical Mammals' (OL-18-06694), Isle of Anglesey County Council and the Welsh Government's Landfill Disposals Tax Communities Scheme for facilitating the publication. We would also like to thank David Everest for his excellent proofreading, insights and inputs.

Craig, Peter & Nikki
October 2020

The role of the European pine marten *(Martes martes)* in the conservation of the red squirrel *(Sciurus vulgaris)*

Queen's University, Belfast

Geographical area of work

Northern Ireland (all)

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Key partners

- Queen's University, Belfast
- National Museums NI
- Newry, Mourne and Down District Council
- National Trust
- All squirrel groups in Northern Ireland
- Northern Ireland Environment Agency

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	0
Volunteers involved with squirrel monitoring	70 Twining et al. 2020c used a team of 70 citizen scientists from throughout Northern Ireland to collect data from over 300 sites
Other Active Volunteers	0
Other info	Research conducted as part of PhD research. All work conducted by JPT and supervised by David Tosh. Volunteers were involved in collecting data reported in Twining et al. 2020c

Map of project land area

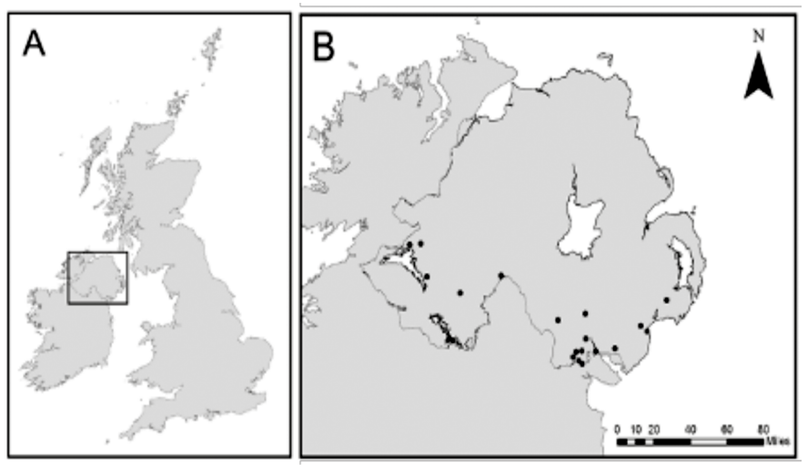

Figure 1. A) Map showing Northern Ireland within context of British Isles, **B)** Map showing 20 sampling sites across Northern Ireland, United Kingdom used in dietary studies investigating pine marten predation of squirrels (Twining et al. 2019; Twining et al. 2020a).

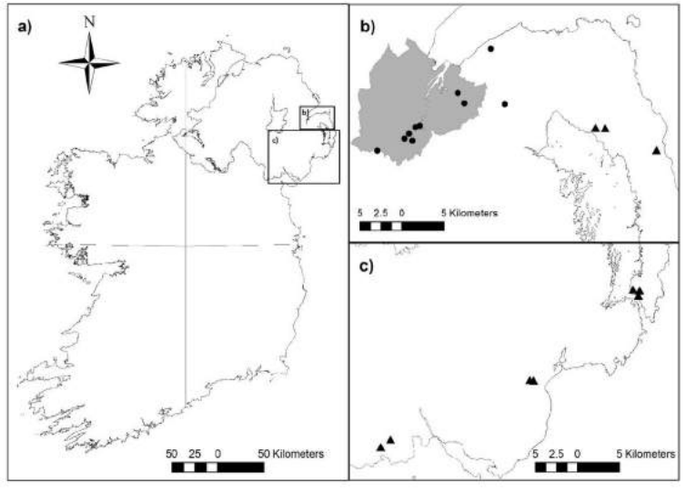

Figure 2. a) series of maps showing location of research on squirrel behavioural responses to the European pine marten (Twining et al. 2020b). a) Map showing location of Northern Ireland within Ireland; **b)** Map showing 13 study sites in the Lagan Valley and north Ards Peninsula in Co. Antrim and Co. Down; **c)** Map showing five study sites in south Ards Peninsula and the Mournes in Co. Down and two in the Ring of Gullion, Co. Armagh. Circles represent grey squirrel sites (*n* = 10), triangles represent red squirrel sites (*n* = 10).

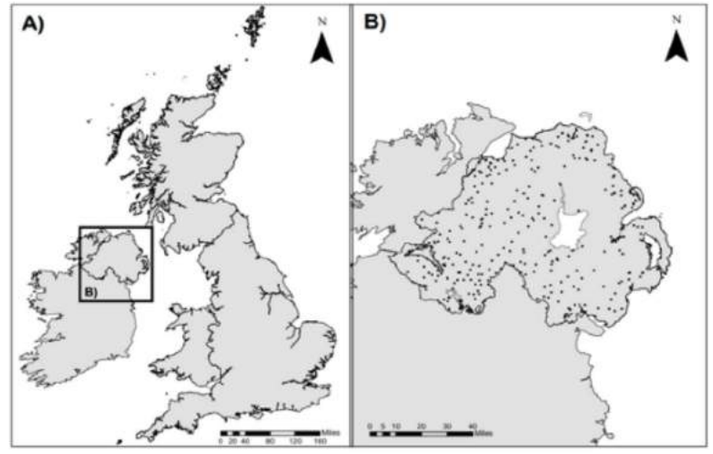

Figure 3. A) Map showing Northern Ireland within context of the British Isles. **B)** Map showing location of the 322 sampling sites used in the investigation of pine marten and squirrel distribution, interactions and co-occurrence in Northern Ireland (Twining et al. 2020c).

Introduction

In 1911 grey squirrels (*Sciurus carolinensis*) were introduced to the Castleforbes estate in Co. Longford. This represents the only known introduction of the species to the island of Ireland. From this point onwards, grey squirrels spread replacing the native red squirrel (*Sciurus vulgaris*) across much of its historic range in Ireland (O'Teangana et al. 2000). The first records of grey squirrels in Northern Ireland (NI) come from the 1970s and by the mid-2000s, grey squirrels occurred in all NI's six counties. However, despite declines, populations of red squirrels remained throughout the country with notable strongholds in west Fermanagh and the Glens of Antrim (O'Teangana et al. 2000; Carey et al. 2007). This situation led to concern over the long-term future of red squirrels in NI, but the recovery of the European pine marten (*Martes martes*) has raised hope that not all is lost.

Figure 4. Pine marten recovery in Northern Ireland has seen progressively wider distribution of this native predator.

Native to Britain and Ireland, the pine marten was once widespread but habitat loss and persecution in the 19th and 20th centuries led to severe declines (Langley and Yalden 1977; Tapper 1992). Confined to isolated populations in NI and western counties of Ireland, legal protection in both countries in the 1960s and 1980s appears to have sparked the reversal of this situation (O'Mahony et al. 2012; O'Sullivan 1983; Fairley 2001). Pine martens are now present in every county of the Republic of Ireland, with an estimated population of 3,000 individuals (O'Sullivan 1983; O'Mahony 2017). In NI, recovery was suspected but not documented until recent surveys in 2015 (Twining et al. 2020c) which show it is present in all six counties.

As the pine marten was recovering, anecdotal reports (Carey et al. 2007) suggested the pine marten may be responsible for declines in grey squirrel populations. Subsequent research in the midlands of Ireland documented this (Sheehy and Lawton, 2014; Lawton et al. 2015) via the occurrence of incidental sightings. A further quantitative investigation in Scotland, confirmed a correlation between pine marten density and decline of grey squirrel populations but did not report the cause (Sheehy et al. 2018). It had been hypothesised that pine marten suppressed grey squirrel populations when present but how this was done and whether it would benefit the red squirrel long-term was not clear. The research we report here was an attempt to answer how the pine marten was causing the decline of grey squirrels and determine whether it was happening at a wide-scale. All work was conducted in NI by the lead authors at Queen's University, Belfast and National Museums NI.

Project aims

This research aimed to provide further information on the interactions between the red squirrel, the grey squirrel, and the pine marten. It was hoped this research would help inform evidence-based management of the grey squirrel, and conservation of the red squirrel and the pine marten in Britain and Ireland.

- Investigate the direct and indirect effects of native predator driven reversal of squirrel species replacement.
- Model current distribution of the red squirrel, the grey squirrel, and the pine marten in NI.
- Produce clear management guidelines to facilitate pine marten recovery in fragmented and degraded landscapes such as those present in Britain and Ireland.
- Make predictions on the outcome of the recovery of the European pine marten with regard to grey squirrel eradication and red squirrel conservation in Britain and Ireland.

Figure 5. Research set out to see how the return of pine marten might affect red squirrel distribution.

Description of the project

This body of research involved five different investigations into the ecology of the European pine marten and its interactions with both native and non-native squirrels in Britain and Ireland. Experiments and observations were made to provide information that would explain how pine marten were having an impact on squirrels in Britain and Ireland.

The five elements of the work were:

I. Pine martens were trapped, collared and radio-tracked to collect information on population demographics, denning ecology and habitat use. This was done to inform long-term management actions that could maintain the continued recovery of the species.

II. A citizen science project working with 70 volunteers collected data on the distribution of the three species in NI. The information collected was used to create models that predicted the likelihood of the three different species occurring throughout NI.

III. An experimental investigation using the application of pine marten scent to baited feeders, monitored with camera traps investigated behavioural responses of both red and grey squirrel to the pine marten.

IV. A large-scale dietary investigation across the range of the pine marten in NI examined seasonal, geographic and habitat factors affecting the diet of the pine marten.

V. A review of IV. and all existing literature on pine marten predation of squirrels examined the occurrence of red and grey squirrels in the diet of the pine marten.

This research was conducted by the authors, with funding provided by the People's Trust of Endangered Species, the Challenge Fund, the Department of Learning, Newry, Mourne and Down District Council, Swift Ecology, Myotismart Ltd and crowdfunding.

Success indicators within the project

- Completion of data collection for all projects.
- Submission of PhD research thesis.
- Publication of results in peer reviewed journals.

Major difficulties faced

- Lack of funding.

Major lessons learned

- Pine martens predate both red and grey squirrels. However, they eat significantly more grey than red squirrels. Both species are targeted in spring and summer which aligns with squirrel breeding seasons. This suggests pine marten could be raiding squirrel dreys and targeting juveniles and/or females.
- Native red squirrels demonstrated anti-predator behaviours in response to the pine marten. Grey squirrels do not. A lack of response from grey squirrels to pine marten scent suggests naivety to the native predator. This likely facilitates the higher predation of grey squirrels found in the diet study and observed declines.
- Although pine marten recovery negatively impacts grey squirrels causing declines and positively effects red squirrel occurrence, pine marten alone will not likely eradicate grey squirrels. This is due to low forest cover and the pine marten's avoidance or non-use of urban areas, which grey squirrels exploit. Urban areas will therefore act as a refuge for grey squirrels unless control is increased in urban areas or pine martens start utilising towns and cities.
- Afforestation to address woefully low forest cover needs to move hand in hand with efforts to move away from monocultures of non-native species if pine marten recovery is to continue in NI/Ireland. If commercial plantations are to be maintained, then they should be supplemented with artificial den boxes to support recovery and reduce human-wildlife conflict.

Figures 6a, b, c. Den box studies were a key element in the research project.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Data collection was completed, PhD submitted and all investigations published.

Future project development

- Research has begged many further questions in need of answering for appropriate planning and management of species. It is important to understand and monitor longevity of pine marten's ability to control grey squirrels given strong selection pressure to adapt anti-predator behaviours.

- Human-led efforts require urgent further funding and focus in urban refugia, towns and parklands in order to secure meaningful future for red squirrel in Ireland.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting		★★★
Live traps		★★★
Kill traps		
Pine Marten (as natural grey squirrel predator)	★★★	★★★
Immuno-contraception (oral bait delivered via hoppers)		
Gene Drive (Selected inheritance manipulated so only male young are born)		
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

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Developing a contraceptive bait for grey squirrel control: Field trial measuring bait uptake in the Elwy Valley

The Animal and Plant Health Agency

Geographical area of work

Elwy valley, Denbighshire, Wales.

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Key partners

- Ian Danby, British Association for Shooting and Conservation (BASC)
- Sarah Pinnell, British Association for Shooting and Conservation (BASC)
- Lee Oliver, The Deer Initiative
- Giovanna Massei, The Animal and Plant Health Agency (APHA)
- Craig Shuttleworth, Bangor University
- Kay Haw, The UK Squirrel Accord (UKSA). For a full list of signatories, see https://squirrelaccord.uk/about/partners/
- The volunteers. We would like to thank all of the volunteers involved in the delivery of this study

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	6 Live trap and remove over three weeks
Other Active Volunteers	5 Grey squirrel population monitoring through baiting remote cameras (one week) 1 Analysis of squirrel photos 5 Deployment of bait marker in hoppers (two weeks)

Project land area

The study site was a 28 hectare mature broadleaf woodland located in the river Elwy valley. The wood was two kilometres in length and between 50 and 220 metres in width. The wood was split into two study areas, A and B. In area A, remote cameras were deployed to provide a grey squirrel (*Sciurus carolinensis*) population estimate using remote cameras. A bait marker was deployed using hoppers followed by a live trapping operation to remove grey squirrels. In area B, there was also a live trapping operation and removal of grey squirrels.

Introduction

In 2014, the UK Government, through Defra and the Forestry Commission, produced a management plan for the grey squirrel, which included research into the use of fertility control to reduce their populations. In 2017, the UK Squirrel Accord (UKSA, https://squirrelaccord.uk) funded a study, led by the Animal and Plant Health Agency (APHA), into the development of a contraceptive bait for grey squirrels (Massei 2018). UKSA is a partnership of 39 conservation and forestry organisations, Government agencies and companies which aims to secure and expand the UK red squirrel population and ensure UK woodlands flourish.

As part of the research, APHA delivered a bait, designed to simulate a contraceptive,, to over 77% of the grey squirrel populations in two small (6 to 10 hectare) woodlands in Yorkshire. They also developed a method to accurately measure the population size of grey squirrels in several woodlands, through the use of remote cameras, providing a useful tool for measuring the effectiveness of wildlife control or predicting the effort required for successful control.

The purpose of this study was to test whether the bait delivery and camera methodology could be transferred from APHA to volunteers and whether the results could be replicated in a different geographical region, in a larger area of woodland. The Elwy valley in Wales is predominantly woodland and farmland where grey squirrels exist at high densities. As a result, some parts of the area suffer significant amounts of tree damage. It was therefore chosen as a suitable area in which to conduct the study.

Figure 1. Photo from a remote camera deployed to measure the grey squirrel population size in the wood. The population was estimated as 69, 76 squirrels were subsequently trapped and removed.

Project aims

- To assess the proportion of a grey squirrel population that it would be possible to deliver a contraceptive bait to.
- To test a remote camera method for estimating squirrel densities against a known number of squirrels removed, to provide a method of indicating the effort required to control squirrels in areas.
- To assess whether bait delivery and population analysis methods, developed and tested by APHA, could be transferred effectively to volunteer groups.

Description of the project

The field study was conducted over seven weeks in June and July 2019. The Deer Initiative selected a suitable study wood, based on accessibility, size and evidence of grey squirrel presence and secured landowner permissions. The wood was split into two 14 hectare areas, A and B. For each part of the trial, a number of suitable volunteers were selected by BASC. Field training, including data recording and sample collection, was provided by APHA and training to humanely trap and dispatch grey squirrels was provided by BASC with additional advice from Craig Shuttleworth.

To estimate the squirrel population size, fourteen Reconyx Hyperfire HC500/HS2X remote cameras were deployed across area A by five volunteers. Cameras were placed evenly across the area and were fixed to trees, approximately one metre above the ground, focussed on a bait pile of maize and peanuts. The bait was replenished by 1-2 volunteers over three days and the cameras removed on the fourth day. Over the four days, the cameras took over 50,000 photos of squirrels and other animals. Each photo was analysed by a volunteer and categorised as containing a squirrel or other animal using Reconyx MapView Professional™ software. A total of 6,523 squirrel photos were taken on day two and three of the trial. These data were used to calculate an index based on the number of squirrel photos taken per camera per day. When calibrated against previous indices and known numbers of squirrels removed from woodlands, the population estimate for area A was 69 squirrels.

Figure 2. Squirrel bait hopper used to measure bait uptake by grey squirrels, monitored by a remote camera. Only grey squirrels were photographed accessing the hopper bait.

Figure 3. Grey squirrel feeding from a bait hopper. In total, 71% of the grey squirrels in a 14 ha area of woodland fed from the 42 hoppers deployed.

To simulate the deployment of a contraceptive bait, five volunteers, led by APHA and BASC, deployed forty two squirrel-specific bait hoppers evenly across the wood, fixed to one metre high wooden stands. The hoppers were custom-designed by APHA and NatureCounters and consisted of a metal tube containing a 3D-printed plastic bait compartment. The bait was accessed by lifting a 70 g door. The design was based on a hopper developed by the Forestry Commission to deliver the rodenticide Warfarin to grey squirrels (Mayle, Ferryman & Pepper, 2007) and aimed to restrict access to bait by other animals. A remote camera was used to monitor each hopper.

To measure bait uptake by squirrels, the bait marker Rhodamine B was mixed with hazelnut paste at a concentration of 0.18 % w/w. The bait marker, when ingested, causes hair to fluoresce under ultraviolet (UV) light. To simulate the deployment of a contraceptive, two volunteers baited the hoppers with hazelnut paste for one week. The following week the volunteers baited each hopper with 40 g of Rhodamine B bait, once a day for four consecutive days, weighing the bait in and out each time. Between 60 and 68% of the bait deployed on each day was removed by grey squirrels, confirmed by the remote cameras.

The week following bait deployment, four volunteers, led by BASC, removed the hoppers and installed forty two live-capture squirrel cage traps across area A and thirty eight traps across area B. Trapping was conducted by 3-4 volunteers per day, with traps set to capture squirrels on consecutive days for 19 days. Any squirrel trapped was dispatched by volunteers using a humane method and a hair sample taken from the flank and sent to APHA to be analysed using a UV microscope, to determine the proportion of individuals that had consumed the bait.

In area A, 76 squirrels were removed and 54 (71%) tested positive for the bait marker, including 23 out of 34 females removed. In area B, 57 squirrels were removed, 56 were sampled and 6 (11%) tested positive. In the last week of trapping, only three squirrels were trapped, therefore it was assumed over 90% of the squirrels had been removed from both areas.

We conclude that, using trained volunteers to conduct the work, the camera index method can predict the number of squirrels to be removed from a wood to an accuracy of over 90% and that it would be possible to deliver a contraceptive bait to the majority of male and female squirrels in a wood using hoppers. There was little movement into and out of the baited area, therefore contraceptive deployment strategies should target entire squirrel habitats to ensure effective control.

Success indicators within the project

- The ability to accurately predict the number of squirrels removed from a wood using a remote camera index method delivered by volunteers.

- The ability to deliver a bait to the majority of grey squirrels in a wood using squirrel specific hoppers, baited by volunteers.

Major difficulties faced

- Despite the fact that initially more volunteers signed up for the study than were required, personal commitments and the physical and time demands of the work meant that it was difficult to secure enough volunteers for the squirrel trapping and BASC operatives had to stand in for a number of days in area B. This meant it was only trapped for 18 days, rather than 19. Although this did not affect the overall delivery of our study, these findings are consistent with a wider issue concerning recruiting volunteers and maintaining their engagement to control grey squirrels through trap and dispatch. Trapping requires consistent commitment that not all volunteers are able to provide.

- In addition, many volunteers, particularly those who are not affiliated to organisations such as BASC, find the act of dispatching squirrels difficult or unpleasant. One main benefit of using contraceptive baits to control squirrels over culling through trap and remove is that baiting requires less effort in terms of time commitment e.g. a bait could be potentially deployed once every few weeks rather than trapping every day. In addition baiting hoppers, for many volunteers, is a more straightforward and acceptable task to undertake, which should result in greater recruitment. This is supported by the findings of a survey conducted by Forest Research into public perceptions of grey squirrel control, where members of the public were much more likely to be in favour of using contraceptives rather than culling as a method of control (Dunn et al., 2018).

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Our two key indicators of success were met and they were consistent with results previously obtained by APHA scientists.

Future project development

- Field trials to measure the quantity of bait taken by individual squirrels on each visit and the number and frequency of feeding visits made by squirrels per day, to inform potential contraceptive dose rates.

- Field trials to further test the species specificity of the hoppers, including the possibility of using weighted doors to exclude red squirrels from hoppers so they can be used in areas where there are both red and grey squirrels.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting		★ ★
Live traps	★ ★	★ ★
Kill traps		★
Pine Marten (as natural grey predator)		★
Immuno-contraception (oral bait delivered via hoppers)	★ ★ ★	★ ★ ★
Gene Drive (Selected inheritance manipulated so only male young are born)		★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		★ ★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

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Gene drives for controlling invasive grey squirrel in the UK

The Roslin Institute (University of Edinburgh)

Geographical area of work

Midlothian, Scotland

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Website: https://www.ed.ac.uk/roslin/animal-genetic-engineering

Key partners

- **European Squirrel Initiative (ESI).** ESI have been the primary funders of this first phase of the project and through this relationship we established a link with Dr Craig Shuttleworth, who provides guidance on squirrel parameters within our population simulations.
- **Highlander Lab** (Roslin Institute, University of Edinburgh). Lead by Dr Gregor Gorjanc, the Highlander Lab is developing and applying computational tools to simulate gene drive strategies in UK squirrel populations.
- **Edinburgh Innovations**. Edinburgh Innovations is a subsidiary of the University of Edinburgh and assists with business development within the project.

Figure 1. The Roslin Institute at the University of Edinburgh Easter Bush Campus

Todate, gene drive technology in vertebrates has been limited to laboratory contained mice. At Roslin (Figure 1), we have developed a proof-of-concept split gene drive mouse model targeting female reproduction. Our work on developing gene drive in grey squirrels is early stage and focusing on in silico population modelling and reagent development in a grey squirrel cell line we have established at Roslin. It is likely that the first applications of the gene drive as a vertebrate pest management will be in geographically-isolated populations of invasive rodents, such as the grey squirrel in the UK.

Investigating team

Figure 2. Mr Gus McFarlane (left) and Prof Bruce Whitelaw (right) in the lab at the Roslin Institute.

Professor Bruce Whitelaw (PI) (Figure 2)
Professor in Animal Biotechnology and Interim Director of the Roslin Institute

Mr Gus McFarlane
PhD student investigating CRISPR-based gene drives for vertebrate pest management

Dr Gregor Gorjanc
Group Leader of the Highlander Lab (Population modeller)

Dr Craig Shuttleworth
Research Fellow (Ecologist and squirrel expert)

Dr Simon Lillico
Senior Research Fellow (Molecular biologist)

Ms Nicky Faber
MSc student modelling CRISPR-based gene drives in UK grey squirrel

Introduction

A manageable and robust strategy to secure the future of the red squirrel (*Sciurus vulgaris*) through effective control of the grey squirrel (*Sciurus carolinensis*) remains to be established. Clustered regularly interspaced short palindromic repeats (CRISPR) based gene drives may offer a humane, species-specific and cost-effective control strategy.

The gene drive concept has emerged from observations that naturally occurring selfish genetic elements, such as transposons, are preferentially inherited at frequencies greater than predicted by Mendelian inheritance. This ‘super-Mendelian’ inheritance allows these elements to drive through a population even if they reduce the fitness of an individual organism. The recent development of CRISPR gene-editing tools has allowed for the development of synthetic gene drives.

One potential application of CRISPR gene drives is to manage or eradicate populations of invasive pests by skewing the sex-ratio of the breeding population. In most vertebrate pests, including grey squirrel, female reproductive performance is responsible for maintaining the overall population size. CRISPR-based gene drives could be deployed to spread female infertility through non-native invasive grey squirrel populations. In this way, it is possible to manipulate the reproductive performance of this pest leading to an efficient, cost-effective and humane means of population suppression.

At Roslin, we initiated our investigation into gene drive technology by developing a mouse model and performing in silico modelling of gene drive in wild mouse populations. With the knowledge gained from our initial mouse project, we have expanded our research programme to include grey squirrel, with the aim of developing a safe and effective grey squirrel control strategy to secure the future of the native red squirrel.

Project aims

Overall, this project aims to assess how gene drives could be safely deployed to control the invasive grey squirrel in the UK. To achieve this, we set out to:

- Design and model several localisable CRISPR-based gene drives in UK grey squirrel.
- Establish a grey squirrel cell line to develop gene drive reagents.
- Gain further data to more accurately engage with public, political and regulatory parties.
- Establish the feasibility of transitioning to in vivo trials of the technology in a contained population of grey squirrel.

Description of the project

This project is lead by Prof Bruce Whitelaw with scientific management provided by Mr Gus McFarlane. Gus's stipend for this project was paid for by the Biotechnology and Biological Sciences Research Council through the Flexibile Talent Mobility Account and operating costs are generously covered by the European Squirrel Initiative and Roslin Institute internal funding.

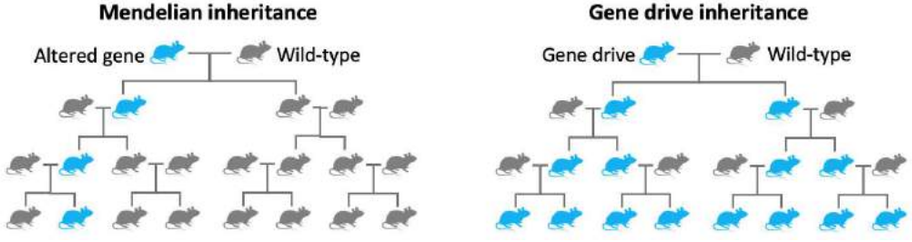

Figure 3. Mendelian inheritance vs Gene drive inheritance

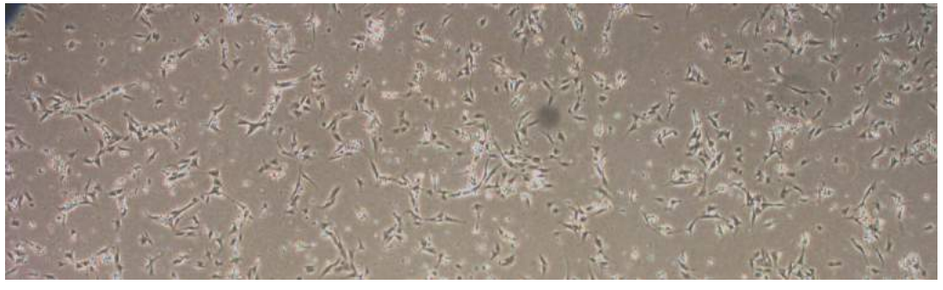

Figure 4. Testis-derived grey squirrel cells in culture at 40x.

To initiate the development of gene drive in grey squirrel, the investigating team met to brainstorm potential gene drive strategies (Figure 3 & 4) based on the our expertise in genome editing tools, target genes, reproductive biology, as well as the information available on published gene drive designs in insects.

Our team of population modellers lead by Dr Gregor Gorjanc and supported by Ms Nicky Faber, then went about modelling each of our proposed gene drive designs in computational simulations of grey squirrel population to gain insight into how each strategy behaves at a population wide level.

Based on the success of each strategy within the simulations, we narrowed down our candidate gene drive strategies to two designs. These show very promising results but we will continue to extend and refine our modelling of these strategies by incorporating further spatial and temporal parameters into our simulations.

In the wet lab, Mr Gus McFarlane and Dr Simon Lillico have developed the reagents to engineer our two gene drive strategies in a testis-derived grey squirrel cell line we have established. This process involves culturing squirrel cells, screening CRISPR genome editing tools in these cells, building DNA gene drive elements and finally engineering and validating the systems in the cell line. These validated reagents could now be used downstream to generate a gene drive grey squirrel for in vivo testing.

Our findings from this project will be summarised in a report for the European Squirrel Initiative and published within a peer reviewed scientific journal. Our project was recently highlighted in mainstream media channels and we will continue to distribute and engage with media and social channels as this project evolves. We believe gaining and maintain public trust throughout the development of this technology is critical to its success.

Success indications within the project

- Identification of at least one efficient and localisable gene drive approach for managing grey squirrel with our population simulations.
- Establishment of a grey squirrel cell line for developing and testing reagents.
- Continued engagement with media, the public and regulators on the technology.

Major difficulties faced

- Gene drive technology in vertebrates is in its infancy. Fortunately, there are a number of labs around the world working on gene drives in mice. Several unknowns, including the optimal expression pattern for the gene drive element remain to be established. However, squirrels being rodents, it is likely that much of this insight gained from the work on mice will be applicable to squirrel gene drive development.

- At the outset of this project there was no published grey squirrel genome. Over the course of this project, the Sanger institute published the grey squirrel genome which has expedited our gene drive design process and reagent development. This was serendipitous timing. A high-quality reference genome is critical to gene drive design and development.

- Although we are fortunate to have financial support from the European Squirrel Initiative, securing ongoing funding for this project is challenging. This project falls outside the standard remit for most major research funding organisations and could be considered too contentious for many conservation funding bodies. It is likely this project will require translational funding support for it to advance to in vivo trials.

Major lessons learned

- The development of a CRISPR-based gene drive in any species requires a multidisciplinary team of statistical modellers, bioinformaticians, molecular biologists, ecologists, conservation and communications experts. We are fortunate that the Roslin Institute and the broader University of Edinburgh has the full complement of expertise to undertake this project. Although the sheer breadth of expertise required creates logistical challenges.

- Our squirrel project has recently caught considerable media attention, including a Sunday Times page 3 article. This led to widespread discussion about gene drive technology for management of grey squirrel. Through this process, it become clear that an accurate and coherent message from investigators, university representatives and partnering organisations is vital for maintaining public, institutional and political support.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure:

- We have identified two gene drive strategies for localised population control of grey squirrels. Both candidate strategies show promising findings in population simulations.

- We have established a grey squirrel cell line and developed and validated preliminary reagents for engineering a gene drive in grey squirrel.

- The data from this project has increased the accuracy of the information we can convey through public, political and regulatory engagement.

- The major risks to the success of this endeavour will come within the next phases of this project, which include in vivo testing and field trials. Technical challenges, such as securing appropriate animal housing and establishing embryological procedures for testing in animals. Successfully transitioning to field trials will be dependent on the political climate.

Future project development

- Expand and refine modelling of gene drives in grey squirrel and make recommendations for release and monitoring protocols. We are exploring options to fund a PhD studentship focused on these objectives.

- Secure funding for in vivo trials in a contained squirrel population. We are investigating several strategies for genome engineering grey squirrel to harbour a gene drive constructs. These include conventional embryo microinjection and viral-based genome engineering strategies.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting		
Live capture traps		
Kill traps		
Pine Marten (as natural grey predator)		
Immuno-contraception (oral bait delivered via hoppers)		
Gene Drive (Selected inheritance manipulated so only male young are born)	★★★	★★★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

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Red Squirrels United LIFE14 NAT/UK/000467, HG-10510

The Wildlife Trusts

Geographical area of work

Red Squirrels United (RSU) worked across nine areas in the UK:

England: The Kielder Forest Red Squirrel Stronghold and north Merseyside

Wales: Anglesey and northern Gwynedd, Clocaenog Forest, Twyi Forest

Northern Ireland: North West Northern Ireland (Derry/Londonderry), the Glens of Antrim, The Mourne Mountains/plains and County Fermanagh.

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Key partners

RSU was a partnership of eight organisations including:

- Forest Research
- Newcastle University
- Northumberland Wildlife Trust
- Red Squirrels Trust Wales
- The Wildlife Trust of Lancashire, Manchester and Merseyside
- The Wildlife Trust of South and West Wales
- The Wildlife Trusts
- Ulster Wildlife

Key collaborators included:

- Animal and Plant Health Agency
- Northern Ireland Environment Agency
- Natural Resources Wales
- Forestry England
- UK Squirrel Accord

Resources

Typical Resource available	Number of people	
Paid Contractors (7-12 months)	19 Full-time equivalents throughout lifetime of project	This included 10 rangers undertaking grey squirrel control, eight red squirrel monitoring/community engagement officers, researchers and project management/support staff. Note: There was some crossover in roles with RS/CE officers undertaking GS control and rangers hosting training/community engagement activity as necessary.
Other info here	44,000 hours were contributed by volunteers across grey squirrel control, red squirrel monitoring and community engagement	Many volunteers undertook a variety of tasks hence RSU calculated hours rather than individual tasks/people.

Map of project land area

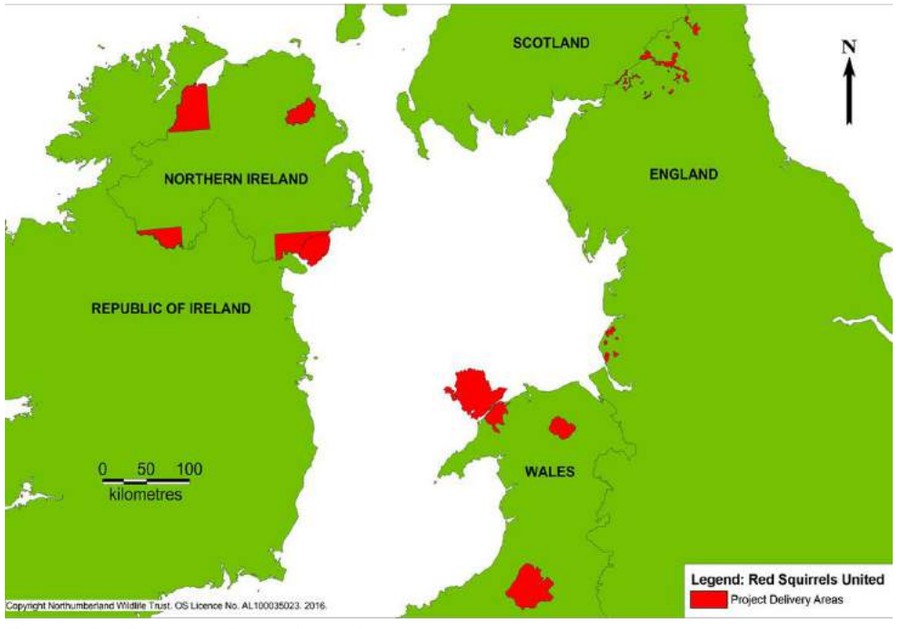

Figure 1. Red Squirrels United project delivery areas.

The landscapes (Figure 1) Red Squirrels United (RSU) worked across were highly varied including coastal urban areas, remote upland conifer forests, islands, mountains and coastal plains. The coastal areas of north Merseyside featured small fragmented woodlands across an urban landscape whereas the large, upland conifer forests of Clocaenog, Twyi and Kielder Forests were highly remote with a low human population density. Two project areas (the Mournes and northern Gwynedd) contained coastal and mountain boundaries and represented a mix of urban and rural landscapes. Woodlands varied from large state-owned conifer forests to smaller privately-owned mixed or broadleaf woodlands. RSU worked to undertake grey squirrel (*Sciurus carolinensis*) control and red squirrel (*Sciurus vulgaris*) conservation in 156,890ha of woodland.

Introduction

Figure 2. Red squirrels benefitted from grey squirrel control © C Thody

All RSU project areas contained both red (Figure 2) and grey squirrels at varying densities. The project worked across the three red squirrel focal areas in Wales – Anglesey, Clocaenog Forest in northeast Wales and the Twyi Forest in mid-Wales. Anglesey was declared free from grey squirrels in 2013 following a successful eradication project and a small population of red squirrels established on the adjacent Gwynedd mainland in 2009. Clocaenog Forest contained a small remnant red squirrel population and fragmented red squirrel populations were present in the Twyi Forest. Clocaenog and Twyi both contained

grey squirrels. The Kielder Forest Red Squirrel Stronghold in northern England was the only forest complex in England to be free from grey squirrels supporting a population of red squirrels. The Sefton Stronghold contained the southernmost mainland population of red squirrels with grey squirrels also present in the area. Red and grey squirrels were present in all areas across Northern Ireland (NI). Grey squirrels were present in very low numbers in Co Fermanagh which also contained the highest population of red squirrels and pine marten (*Martes martes*) in NI. Pine marten were also present in the Clocaenog and Twyi Forests, the Mournes, Glens of Antrim and sighted on camera traps in the Kielder Forest complex throughout the latter part of RSU. The landscapes RSU worked across were highly diverse ranging from urban and coastal areas to remote upland forests. RSU was funded through LIFE14 and the National Lottery Heritage Fund and ran from 2016-2020. The project utilised paid staff and volunteers.

Project aims

- Tackling Invasive Alien Species (IAS) colonisation prevention.
- Developing rapid response/early warning approaches.
- Maximising the impact of control/eradication approaches.
- Aiding the development of comprehensive IAS management frameworks.

Description of the project

Figure 3. Volunteers deployed camera traps to monitor red and grey squirrels © RSNE

Figure 4. Lancashire Wildlife Trust trained dogs to locate the bodies of dead red squirrels so that infection screening could be carried out. © Holly Peek

RSU was a multi-partner collaboration operating at a landscape-scale level across the UK from 2016-2020. Although red squirrel conservation had been going on for many years within the UK, RSU represented the first opportunity to harness some of these initiatives under a collaborative umbrella resulting in increased impact and stronger outcomes (Figures 3 & 4). The primary focus of RSU was IAS management through landscape-scale grey squirrel control with the aim of suppressing, preventing the spread or eradicating grey squirrel populations across all project areas. Methods varied across the project areas, but live-capture cage trapping was the predominant approach with supplementary shooting depending on seasonality and natural food abundance etc. All grey squirrel control data was collated and sent to Newcastle University to assess the impact of control activity. Grey squirrel tissue samples were harvested and sent to the Animal and Plant Health Agency (APHA) for infection (adenovirus and Squirrelpox) screening to assess viral prevalence.

Allied to this was a strong community engagement programme which sought to create new voluntary groups, support existing and new volunteers through training and equipment and increase community awareness of the issues facing red squirrels. This was achieved through engaging with schools, community talks and events. To assist grey squirrel detection, early warning and rapid response networks were established across all project areas with the aim of being community led by project end. Many of these were linked into formal red squirrel monitoring programmes which assessed distribution and range across project areas.

Grey squirrel control was undertaken by paid staff/contractors and volunteers with a majority of the red squirrel monitoring undertaken by volunteers. Volunteers played a key role in RSU and seven new community groups were established with an eighth rejuvenated and constituted. RSU conducted social science research to assess public attitudes towards red and grey squirrels and their management and examined social acceptability of control mechanisms. RSU established many connections with other projects in the IAS community and hosted annual Knowledge Fairs. These two-day residential events drew together stakeholders from across the IAS community in the UK and Europe and were held over a weekend to maximise community participation. The Knowledge Fairs represented a unique opportunity to bring together conservationists, community groups, researchers, academics and government departments (Figure 5) and facilitated cross-sectoral knowledge sharing, lesson learning and best practice. Through the Knowledge Fairs, many connections were brokered providing volunteers with the opportunity to liaise with groups from different areas.

Figure 5. Annual Knowledge fairs were a great opportunity for volunteers to learn from each other.
© P Muldoon.

RSU made a significant contribution to the broader IAS community through mutual collaboration and engagement, published papers, inputs to government consultations and sharing best practice. RSU produced best practice guides, videos and hosted several webinars to empower practitioners and community groups with knowledge on red and grey squirrel ecology, woodland management, disease identification, camera trapping and monitoring programmes. Strong press coverage was achieved across the project at regional and national levels with several appearances on national TV programmes such as BBC Springwatch and Countryfile. Novel approaches were also facilitated through the programme including the use of detection dogs in conservation, use of a Kania 2000 spring trap in conjunction with a live-capture trap and non-invasive methods of infection detection using hair.

Success indicators within the project

- Absence of red squirrel disease outbreaks such as sSquirrelpox disease.
- Community-led early warning and rapid response networks established.
- Red squirrel populations remain stable or increase.
- Grey squirrel populations suppressed or eradicated.

Major difficulties faced

- Delays in securing match funding postponed staff recruitment and programme delivery.
- Complex tender processes meant a prime opportunity to control grey squirrels was lost contributing to the unsuccessful eradication effort in Gwynedd.
- Rapid response to all reported grey squirrel incursion was challenging in the Kielder Forest stronghold complex due to resource available and distance and time involved.
- The outdated 1967 Forestry Act does not allow for conditions to protect flora and fauna to be added to tree felling licenses which led to several incidences of tree felling in red squirrel areas during the breeding season.

Major lessons learned

- Strong community support for proactive invasive mammal detection and removal is essential.
- Projects need to empower volunteers with skills, equipment and protocols.
- Established self-sustaining local volunteer groups welcome opportunities to network.
- Bespoke local management approaches to invasive species facilitated regional variation.
- RSU successfully shared lessons with European and international projects.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- An independent evaluation found that RSU generated £11.5 million of total benefits based on social, ecological and economic factors (against a budget of approx. £3 million) representing excellent value for money.
- Demonstrated successful landscape-scale collaborative partnership working.
- Grey squirrel populations were suppressed, and red squirrel populations were either maintained as stable or increasing distribution was recorded in several areas.
- Community-led early warning and rapid response networks were established across all project areas.
- Increased community awareness and engagement.
- Novel and innovative approaches were deployed across the partnership.

Future project development

- Several RSU partners have secured or are pursuing further funding building on approaches and lessons learned through RSU.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★★★	★★★
Live traps	★★★	★★★
Kill traps	★	★
Pine Marten (as natural grey predator)	★	★★★
Immuno-contraception (oral bait delivered via hoppers)		★★★
Gene Drive (Selected inheritance manipulated so only male young are born)		★★★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★★★	★★★

★★★ High; ★★ Medium; ★ Low, blank = None.

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All resources published by RSU can be found at www.redsquirrelsunited.org

Diseases of Wildlife Scheme: red squirrel investigations

The Animal and Plant Health Agency

Geographical area of work

The Animal and Plant Health Agency Diseases of Wildlife Scheme *(APHADoWS)* covers England and Wales and undertakes red squirrel investigations in areas of Lancashire (Formby), northern England (Cumbria and Northumberland) and north Wales (Anglesey and Gwynedd). We also provide analytical support where requested to Scotland through the University of Edinburgh and Scottish Natural Heritage and to Northern Ireland through Ulster Wildlife and the Northern Ireland Environment Agency.

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www.gov.uk/apha

Twitter: @APHAgovuk
Facebook: @APHAgov
Youtube: www.youtube.apha

Key partners

- Defra
- GB Wildlife Diseases Surveillance Partnership
- Red Squirrels Trust Wales
- Lancashire Wildlife Trust
- Northumberland Wildlife Trust
- Cumbria Wildlife Trust
- Local red squirrel groups
- UK captive red squirrel breeding scheme
- International Zoo Veterinary Group

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	
Paid Contractors (7-12 months)	
Volunteers involved with Grey control	
Volunteers involved with squirrel monitoring	
Other Active Volunteers	
Other info here	All staff are members of the Animal and Plant Health Agency Veterinary and scientific staff at the various sites provide support as directed and would total around 10 to 12 people

Map of project land area

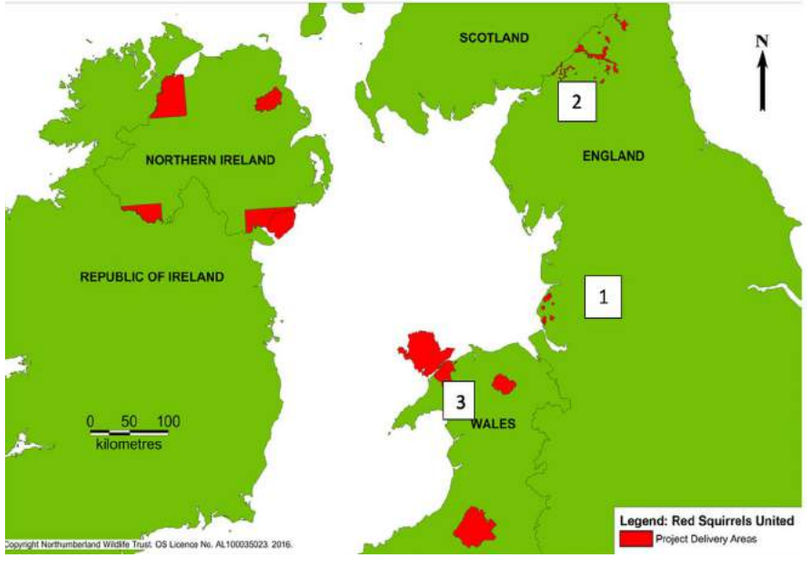

Figure 1. Areas of England and Wales covered by the *APHADoWS* and specifically mentioned in this chapter. © Northumberland Wildlife Trust)
1 Lancashire (Formby). **2** Northern England (Cumbria and Northumberland). **3** Wales (Anglesey and Gwynedd).

Introduction

The native Eurasian red squirrel (*Sciurus vulgaris*) and invasive North American Eastern grey squirrel (*Sciurus carolinensis*) are present throughout the UK areas covered by the *APHADoWS*. Coverage (Figure 1) encompasses both designated red squirrel strongholds such as seen in Cumbria (Whinfell Forest), Northumberland (Kielder Forest complex) and Lancashire (Formby coastal woodlands), but also the smaller fragmented woodland areas and remaining urban areas with remnant red squirrels, notably isolated small sites such as Grasmere in Cumbria. Anglesey and areas of north Wales have become a focal point of study in recent years due to red squirrel conservation translocation to the island and the subsequent mainland colonisation from 2009.

The landscapes we cover include both mixed deciduous type habitats, but due to the reduction in red squirrel geographical range, is often more coniferous-based, because such habitat offers less of a competitive advantage to the introduced species. Grey squirrel presence within the areas we work within has been a constant throughout the last 20 plus years that the *APHADoWS* has operated. Consequently, inter-specific infection transmission is responsible for the constant and variable numbers of Squirrelpox cases we diagnose.

The *APHADoWS* is an entirely Defra-funded scheme and service is provided by dedicated staff from the APHA, who undertake the investigation of wildlife disease incidents and the subsequent scientific analyses which supplements the veterinary input. This input is in response to animals submitted for examination to the scheme by members of the public, private veterinary surgeons, or volunteer-led conservation groups who have a common conservation interest.

Project aims

- The *APHADoWS* provides wildlife disease surveillance (wild mammal and bird species) in England and Wales for the Government, but, is unable to investigate all such incidents. Submissions are therefore triaged and responded to wherever possible, to provide a mechanism to investigate wildlife disease outbreaks in England and Wales. *DoWS Gateway* http://apha.defra.gov.uk/vet-gateway/surveillance/seg/wildlife.htm

- The *APHADoWS* responds where it is able in order to detect new or emerging disease threats posed to the wildlife species present.

- The *APHADoWS* only covers wildlife, whilst farmed and domestic livestock species, which have obvious importance to the national food chain are covered by other surveillance projects.

- Two key red squirrel diseases are monitored: Squirrelpox (SQPV) is a pathogenic disease caused when the infection is spread from grey squirrels to red squirrels; Adenovirus

(ADV) is an enteric infection that can cause mortality in red squirrels. The scheme is interested in other, less frequent diseases and causes of mortality in squirrels such as coccidiosis, lice (*Neohaematopinus* sp.), squirrel leprosy and rodent viral infections.

Description of the project

Deaths and suspected disease outbreaks are reported to APHA by private veterinary surgeons, reserve and project managers, members of the public or volunteer groups who monitor wildlife species. Information is triaged and where appropriate samples submitted to our regional Veterinary Investigation Centres and examined for the cause of death. These examinations are undertaken free of charge for accepted cases. A range of laboratory-based tests including bacteriological, fungal, parasitological, viral and histological analyses may be undertaken and results including cause of death recorded and released to the person, or organization submitting the sample. Information regarding the animals may then be released to provide help and further knowledge and understanding of the disease or cause of the mortalities.

With reference to the red squirrel, an interest in the discovery of Squirrelpox (Figure 2) in the native species was made. This continues to this day, as over the last few decades, this native species has faced extirpation through the disease and the part played in it by the grey squirrel, an immune carrier of the virus associated with the disease and by the competition it provides for both habitat and food resource.

Figure 2. Squirrelpox disease in a red squirrel.

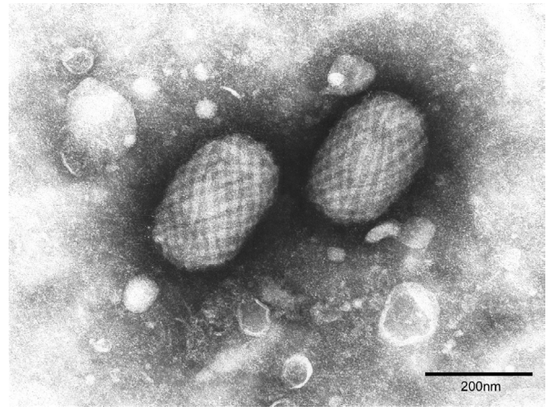

Figure 3. SQPV particles detected by TEM from the first case of Squirrelpox detected in a red squirrel from Norfolk in 1980. (© APHA Labs)

Historically, the first Squirrelpox case was detected in a red squirrel from Norfolk (Figure 3) in 1980 (Scott et al. 1981), by a predecessor organization of the APHA. The causative agent was originally described as a parapoxvirus, but is in fact a different virus, a chordopoxvirus, which resembles parapoxvirus, but is distinct from it. No further red squirrel cases were detected until the 1990s, when sporadic cases simultaneously appeared in Cumbria, Durham, Lancashire and Northumberland. Cases were also detected in Dorset and Suffolk, in red squirrels involved in trial releases and associated reinforcements undertaken at that time.

The analytical platforms used to detect both SQPV and ADV consist mainly of electron microscopy, to detect a viral particle presence of both agents, with SQPV from visible skin lesion material and from intestinal or faecal material for ADV. In addition, another assay, the polymerase chain reaction (PCR) is used mainly for ADV, where the virus may be present as an asymptomatic infection. This type of infection means the squirrel may contract the virus but, live happily with it and not show any outward sign of infection. This is particularly the case with the grey squirrel, where both SQPV and ADV are present as asymptomatic infections. No disease signs via surveillance and monitoring through post mortem and analytical testing have been detected in the grey squirrel caused by either of these two agents, bar a single case of pathogenic Squirrelpox detected in a single animal from England in 1994 (Duff et al. 1996).

ADV is also widespread geographically within the UK red squirrel population, the first detection in the species being in 1983, from an archived Anglesey road accident victim. The first large outbreak was recorded in a reinforcement exercise in Suffolk in 1997, with animals trans-located from the wild under licence from Cumbria. ADV cases have been detected across the UK since then and a study (Everest et al. 2018) recorded widespread ADV presence in captive animals (Figure 4), used for re-introductions and reinforcements. All known ADV and SQPV locations are shown in Figures 5 and 6.

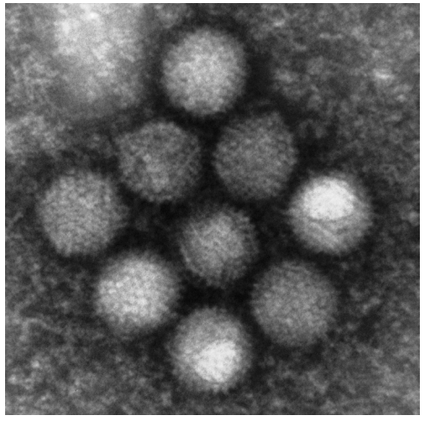

Figure 4. ADV particles detected in intestinal content from a captive red squirrel from England (Bar = 100nm).
(© APHA Labs)

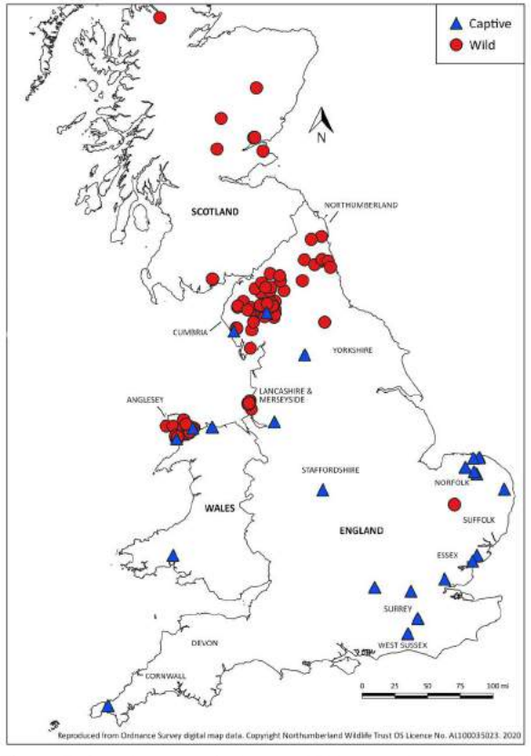

Figure 5. Case locations for known ADV cases detected in red squirrels to April 2020.
(© Northumberland Wildlife Trust)

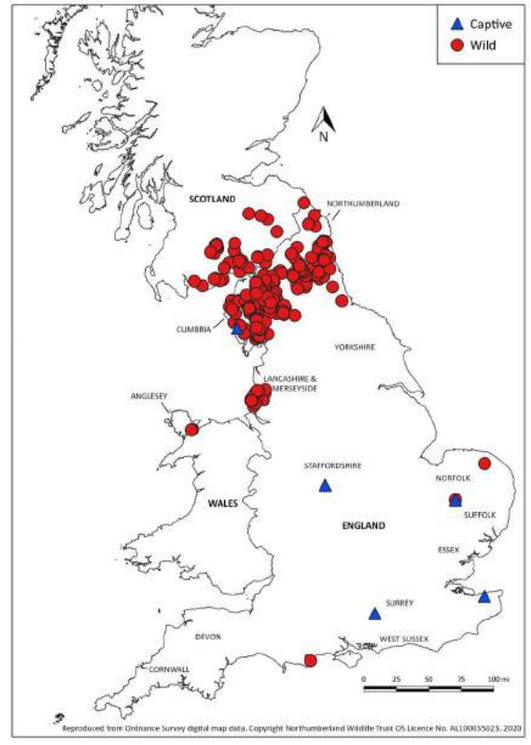

Figure 6. Case locations for known SQPV cases detected in red squirrels to April 2020.
(© Northumberland Wildlife Trust)

A further refinement to this analytical support network for the local red squirrel groups is a recently developed non-invasive assay platform using PCR and hair or whisker samples (Everest et al. 2019). This platform may use whiskers as a sample matrix from dead animals, where internal organs are not available for examination, such as with road deaths, animals found dead in nest boxes or several decayed animals, previously beyond use. In addition, hair may also be utilized from live animals, where welfare considerations preclude whisker use from live animals, using remote hair tubes or sticky pads on feeders. In this way, a general assessment of potential infection presence can be made using a population basis in a specific area at a given time. This may be represented as an environmental detection on the hair, which shows an infection presence which may be a possible danger to any red squirrel present. Also, the process can be used for grey squirrel surveillance and control.

Success indicators within the project

- The analysis of all submitted suspected SQPV and ADV samples wherever possible and the detection of outbreaks from new geographical locations. This is to assess changes in the epidemiology of SQPV disease, to examine the effects of conservation management programmes for both red squirrels and grey squirrels and to measure the geographical distribution of SQPV with time, in order to determine the prevalence of the disease.

- To provide suitable follow-up advice for each wildlife incident and ensure it is administered and that the appropriate responses are undertaken, such as in terms of bio-security information.

- The completion of all appropriate examination and analytical procedures and the identification of disease processes in order to discover and report the cause of death and all the associated findings relating to each case. The provision of grid reference locations for cases in any outbreak area will aid epidemiological investigations.

Major difficulties faced

- Resource availability for the various surveillance activities undertaken realistically precludes investigation into every wildlife incident, so appropriate choices need to be made and these follow set protocols. This could be true for SQPV analyses where numbers of samples are submitted from a single area location. If a current SQPV outbreak is ongoing, then it is less likely that additional samples will be examined. Priority would most likely be given to suspected SQPV cases from areas with no history of the disease and from areas which have not had a case confirmed for a long time.

- Changing priorities in terms of staff deployment with notifiable disease outbreaks will at times mean resources will need to be focused towards work of a higher national priority, such as with highly pathogenic avian influenza outbreaks or other notifiable and exotic diseases.

- Establishing clear pathways for knowledge dissemination regarding sample collection. This will enable the correct types of samples, or whole carcasses to be submitted to the correct APHA laboratory location to ensure a prompt examination wherever possible, with allied analytical testing.

Major lessons learned

- Funding needs to be available to ensure that the appropriate analytical support is provided for the needs of the clients to ensure answers are obtained.

- Any laboratory re-organisation or rationalisation may have a temporary adverse effect on ongoing surveillance activities. In cases such as this, laboratory resources, such as in terms of staff numbers must be sourced for use to ensure that all analyses are completed, and the results reported.

- Clear knowledge paths need to be developed to streamline appropriate sample collection and dispatch for analysis. This will help to ensure prompt delivery of appropriate samples and timely examination and reporting of analytical findings.

- Current resource constraints mean that there will be a likelihood for the need in some circumstances to prioritise and restrict analyses to the most appropriate incident locations in terms of gaining additional knowledge rather than continuing to focus on existing outbreaks. If funding is available from an outside source such as from the client or a support body, this will help to ensure that additional analytical provision can be provided.

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- All the submitted cases investigated can be categorised as positive or negative for SQPV or ADV by either electron microscopy or PCR analyses

- We ensure that the analytical testing procedures are both highly sensitive and validated and that the staff undertaking them are trained and experienced.

- A system is in place to ensure that there is a good understanding between the various agency laboratories and the people submitting the samples to ensure the animals are collected and stored correctly prior to submission and analysis at the appropriate laboratory location.

Future project development

- There is a need to ensure wherever possible that the available agency-based funding is enough to ensure the appropriate analyses are undertaken in all cases.
- Aid needs to be provided to local red squirrel groups to help source any additional funding streams that may be available in order to ensure that all the appropriate analyses may be undertaken on each sample wishing to be submitted for analysis.

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Comparative population genomics of red squirrels: Understanding diversity to support conservation management

The Royal (Dick) School of Veterinary Studies and the Roslin Institute, University of Edinburgh

Geographical area of work

Mainland Scotland, Isle of Arran, northern England and Formby (Merseyside)

Author and organisation contact details

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Key partners

- National Museum of Scotland (Dr. Andrew Kitchener)
- University of York (Dr. Phillip Cox)
- Forestry and Land Scotland (Kenny Kortland)

Resources

Typical Resource available	Number of people	Please add any additional information in this column
Paid Research Fellow	1	Dr. Melissa Marr, 0.5 FTE for 24 months, funded by the Daphne Jackson Trust
Principal Investigator	1	Dr. Rob Ogden, University of Edinburgh
Co-supervisors	2	Dr. Peter Lurz & Jeff Schoenebeck, University of Edinburgh
Collaborators	4	Dr Katie Beckmann, University of Edinburgh; Dr Andrew Kitchener, National Museum of Scotland; Dr. Phillip Cox, University of York; Kenny Kortland, Forestry and Land Scotland

Map of project land area

This project will contain Eurasian red squirrel samples *(Sciurus vulgaris)* from populations across mainland Scotland, the Isle of Arran, northern England and Formby (Merseyside). This wide study area covers a mosaic of habitat types with a variety of red squirrel management strategies. These include mainland and island habitats, regions with no grey squirrel presence, regions with mixed red and grey squirrel populations, forestry with no specific red squirrel management initiatives and those specifically managed to safeguard existing, and promote the expansion of, red squirrel populations. Where possible, squirrel samples that represent some of the nineteen Forestry and Land Scotland strongholds, Saving Scotland's red squirrels priority areas for red squirrels (PARC's) and the designated strongholds in northern England will be included.

Introduction

In 2020 the red squirrel genome was published by the Sanger Institute as part of the 25 Genomes project[i]. This opened the door for genome-wide research of wild red squirrels, which has the potential to be a powerful tool in the conservation of red squirrels in Britain. Populations in Britain have undergone severe declines and local extinctions that have been strongly associated with the invasive North American Eastern grey squirrel (*Sciurus carolinensis*). This species outcompetes Eurasian red squirrels for ecological resources and acts as a reservoir for Squirrelpox virus (SQPV), a disease that is lethal to red squirrels but from which grey squirrels are seemingly unaffected. In addition, loss and fragmentation of red squirrel habitat has been suggested as a contributing cause of declines and has been implicated in past near-extinction events in Ireland and Scotland, prior to the introduction of grey squirrels. These factors can cause several genetic problems for red squirrels. The combined effects of small population size, reduced gene flow between populations and diminished mating opportunities can lead to a decrease in genetic diversity across the genome. This can leave both individuals and whole populations vulnerable to the effects of sudden environmental change and the emergence of new pathogens. Overall, the risk of population extinction goes up.

The study area for this project covers a diverse landscape. Some woodland areas are well connected and contiguous, while others are isolated and fragmented. In addition, there are differing patterns of grey squirrel presence, with some areas completely free of this species, while others have well established grey squirrel populations that have been present for many decades and that act as a reservoir for SQPV. Therefore, there may be different genomic responses across red squirrel populations in response to variation in their environments.

Despite conservation concerns, surprisingly little genetic research has been carried out on red squirrels in Britain. Those studies that have been published have focused mainly on English and Welsh populations. They revealed regional differences in genetic diversity and the structure of local populations, set against a backdrop of extensive historic movement

and translocations of red squirrels. Recent studies of disease and skull morphology have revealed variation among red squirrel populations that indicate local adaptations. This project aims to build on these intriguing results by carrying out the first whole-genome sequencing of red squirrels in Britain. This will give us a much greater understanding of the species' genetic status and population trends over time and if the current range of strongholds and conservation areas capture the extant genetic diversity.

Project aims

- Establish how many populations exist across the study area.
- Determine how genetic diversity is distributed across the landscape.
- Quantify whether historic declines are associated with reductions in genetic diversity.
- Investigate genome-wide responses to grey squirrel exposure.
- Look for associations between phenotypic variation and genetic differentiation at functional areas of the genome.
- Assess the relationship between genetic diversity and disease resistance/susceptibility.
- Use our findings to inform forestry management and conservation strategies for red squirrels.

Description of the project

This project is part of an emergent collaboration of UK scientists and conservationists interested in the application of genetic management to red squirrel conservation. The study region covers a wide, heterogeneous, area, so that the genetic response of red squirrels to a variety of environmental stressors can be investigated. The key focus is on Scotland. Most red squirrels in Britain are now restricted to this region which holds an estimated 75% of the British population (*c.* 120 000 individuals) and acts as crucial sanctuary for the species within the UK.

To obtain DNA, samples will be sourced from a UK-wide biobank, part of the UK Biotechnology and Biological Sciences Research Council (BBSCR) CryoArks programme. Red squirrel DNA will be extracted from soft tissue samples sequenced at the Roslin Institute, University of Edinburgh. Next-generation sequencing technology will be used to sequence the genomes of around two hundred individual red squirrels. The short fragments of DNA sequences generated by the sequencer will be assembled into whole genomes by using the Sanger red squirrel genome as a reference guide. Variants called

Single Nucleotide Polymorphisms (SNPs), that are found throughout the genome, will form the basis of our dataset and provide the information we need to differentiate between populations, determine levels of genetic diversity and investigate the genetic basis of disease risk and phenotypic variation.

A suite of practical conservation measures are in place for red squirrels in Scotland and northern England and include: *i*) controlling the spread of greys through the border area, *ii*) imposing a 'red zone' to prevent greys from dispersing north of the river Tay, *iii*) developing red squirrel and strongholds areas and, *iv*) carrying out translocations to expand the red squirrel range and re-establish new populations. The current lack of genetic data risks the implementation of sub-optimal management strategies, limits adherence to national and international species management guidelines and potentially wastes scarce conservation resources. This study intends to work closely and engage with government and non-government organisations to provide genetic information on red squirrels. This will help to optimise conservation decisions and management strategies for this species into the future.

Future project development

- Genetic sequencing of UK captive-bred red squirrels is planned in order to assess their origins, levels of genetic diversity and utility in red squirrel conservation. Sample collection for this purpose has already begun and contributing organisations include the Wildwood Trust, Welsh Mountain Zoo, Lakeland Wildlife Oasis, Peak Wildlife Park and Belfast Zoological Gardens.

- Deep sequencing of a subsample of red squirrel genomes to perform in-depth analyses of demographic histories and changes in population size.

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Shooting grey squirrels for red squirrel conservation: LANTRA accredited course

Northern Red Squirrels

Geographical area of work

UK wide

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Key partners

- LANTRA™
- Purdoms Training
- Gardners Guns
- Northern Red Squirrels
- Red Squirrels Northern England (RSNE)
- Landowners
- Public

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	
Paid Contractors (7-12 months)	10 Lantra qualified
Volunteers involved with Grey control	62 Lantra qualified
Volunteers involved with squirrel monitoring	
Other Active Volunteers	

Introduction

Shooting is a well established method of grey squirrel (*Sciurus carolinensis*) management and is highly effective all year round (Figure 1), especially if combined with a thermal camera. Live capture trapping is another method and it is generally accepted as being highly effective 'seasonally' because an abundance of natural food reduces the interest that grey squirrels show in trap baits. Many red squirrel (*Sciurus vulgaris*) projects and local volunteer groups use shooting at fixed feeding stations as their best practice model and carry this out in a strategic and systematic way. Coordination and data recording are essential. Shooting in this way, particularly in areas where there are populations of red squirrels to protect, avoids this endangered species being 'unnecessarily' confined in live capture traps if and when they are caught as an unintentional by-catch.

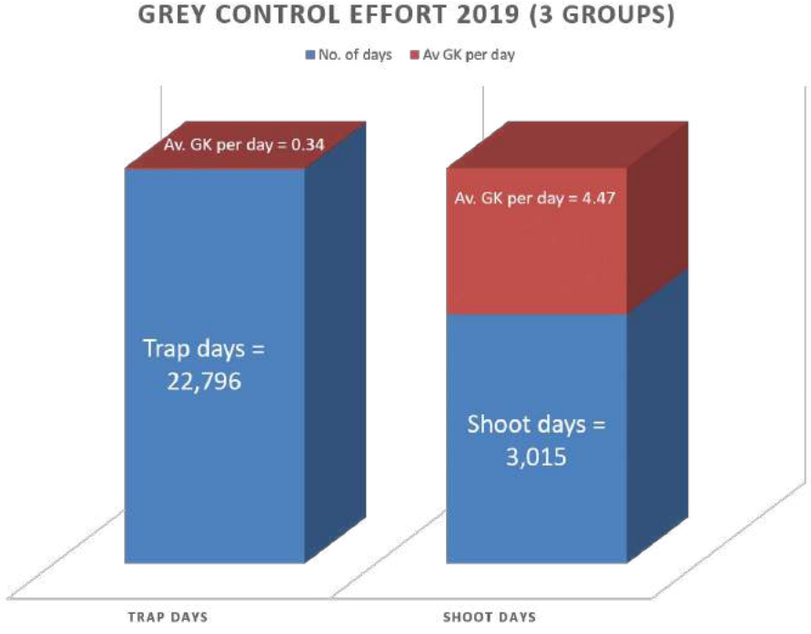

Figure 1. Cumulative grey squirrel kills (GK) by three local volunteer groups using two methods of control.

The LANTRA course 'Shooting Grey Squirrels for Red Squirrel Conservation' is the *only* registered accredited air rifle shooting course for grey squirrel management in the UK which gives landowners proof of competency on the part of the shooter. The course itself was developed at the request of the Woodland Trust (WT) with the specific aim of permitting 'targeted' shooting by those qualified to do so through successful completion of this accredited course. There were ten contributors involved in designing this unique course (in Sept 2018) with seven of these being rangers and volunteers consistently involved on the frontline of red squirrel conservation in Cumbria. The course is ongoing

and through regular internal reviews has further developed to ensure it is current and remains 'fit for purpose'.

Project aims

The course aims to help ensure that anyone shooting has shown a competency to effectively manage grey squirrels for red squirrel conservation. Specific objectives:

- Train 40 individuals to reach qualification standard.
- Increase support and landowners' confidence.
- Seek new land access for shooting of grey squirrels for red squirrel conservation.

Description of the project

Figure 2. LANTRA offers a unique course for grey squirrel control using air rifles.

The Lantra course 'Shooting Grey Squirrels for Red Squirrel Conservation' offers individuals the opportunity to gain, and thus provide, the evidence to demonstrate competency when seeking permission to enter private land in possession of an air rifle and to cull grey squirrels in order to conserve red squirrels. The course covers all aspects of best practice to show that an individual is competent to cull grey squirrels at fixed feeding stations using an air rifle of sub 12ft/lbs. There is a written examination, continuous assessment of student suitability and safe handling of air rifles and a practical range-based shooting test The course is delivered by two training providers - Northern Red Squirrels (NRS) & LANTRA;

- NRS is a widely recognised umbrella group for local volunteer red squirrel conservation groups. It was established in March 2008 to unite all independent voluntary groups and individuals who are working to help save red squirrels from extinction in the north of England and Wales. It is a 'network of voluntary action' that shares news, ideas and best practice and currently has 30 member groups across the two counties of Cumbria & Northumberland. One Welsh voluntary group has an honorary membership.

- LANTRA is a nationally recognised award and accreditation organisation; they have over 40 year's experience of developing quality training and qualifications.

- The individual course trainers have 65+ years collective experience in their fields. The course' delivery method is classroom and practical, costs are £90 per student (LANTRA fees) for the full day course which covers;

    - Red Squirrel Conservation/Grey Squirrel Management - delivered by Julie Bailey of NRS.

    - Air Rifle Safety, Law for both England & Scotland, Competency - delivered by Keith Snow (LANTRA Firearms Assessor/Instructor, Deer Management Qualification Assessor/Approved Witness, British Deer Society Instructor/Assessor)

The course is suitable for professional wildlife rangers and volunteers involved in culling grey squirrels to conserve red squirrels. Booking course attendance is initially via an expression of interest to the trainers followed by the issue/completion of a standardised booking form; permitted students are then advised if they have a secured place and following their payment are provided with the course brief and logistics.

Suitable persons - on attendance, all students must sign a declaration under Section 21 of the Firearms Act 1968 to declare that they are not a person prohibited by virtue of this Act. There is also other necessary paperwork to complete by the students prior to the course commencing. During the delivery phase of the course presentations; student participation is encouraged and welcomed. There are two assessments to complete on the day;

- Written assessment - students must attain a minimum pass rate of 24 out of 28 on the written examination.

- Practical assessment - students must fire five collective shots from their given firing point station of the shooting range and all five must hit and be within a one inch target set at 25 yards (Figures 3 & 4).

Figure 3. Participants shoot targets on a range.

Figure 4. Course participants must be able to accurately hit targets in areas that would deliver a clean kill.

Electronic course handouts and course feedback forms are provided following successful course completion.

The trainers are directly contactable and indeed encourage contact; to offer relevant advice to students and recommendations to groups and landowners.

Success indicators within the project

- Qualification standards are met.
- Supporting letters from landowners are obtained from certificate holders.
- Signed access documentation from landowners are obtained by certificate holders.

Major difficulties faced

- Lack of suitable LANTRA approved training centers to deliver the course more widely geographically (as requested by many volunteers nationally).

Major lessons learned

Applications are occasionally made by people unsuitable for course places.

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Seventy two people (so far) and are now certified as competent to use shooting at safe fixed feeding stations with a sub 12ft/lb air rifle as best practice in grey squirrel management for red squirrel conservation.
- Increasing support/confidence from landowners has been gained.
- New access to land (other than Forestry England) has been granted to LANTRA certified individuals.
- Grey squirrels continue to threaten red squirrel populations in Forestry England sites.

Future project development

- Continue to offer courses to suitable individuals.
- Work with partners to change the no shooting policy of Forestry England in line with most other landowners' acceptance of shooting where clear benefits to red squirrels are being demonstrated by suitable individuals.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★★★	★★★
Live capture traps		
Kill traps		
Pine Marten (as natural grey predator)		
Immuno-contraception (oral bait delivered via hoppers)		
Gene Drive (Selected inheritance manipulated so only male young are born)		
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

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Monitoring escaped captive bred red squirrels in the UK

Bangor University

Geographical area of work

Nationwide surveillance

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Key partners

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	0
Volunteers involved with squirrel monitoring	1
Other Active Volunteers	1

Introduction

Red squirrels have been documented escaping from enclosures erected as part of conservation translocations in both Belleek Forest Park, Republic of Ireland (Waters & Lawton 2011) and Newborough Forest, Wales (Shuttleworth et al. 2004). In Ireland, a fault in the enclosure design allowed squirrels to escape soon after confinement. These animals returned to the enclosure to feed and were captured within the vicinity at a later stage. In Wales, weaned juvenile red squirrels were able to move between partitioned sections of an enclosure via a small gap that an adult would be unable to fit through. They were able to access an area where a hatch had been opened to release unrelated adult squirrels. Unfortunately the juveniles had not yet been micro-chipped prior to their escape and hence it was unclear whether they were ever recaptured in the forest as wild born juveniles were also present.

In his wonderful monograph on red squirrels, the late David Stapleford recounts the unexpected discovery of an animal in a West Lynn (Norfolk) garden during the spring of 2000. Red squirrels had been locally extinct for many decades and David surmised that this individual may have arrived via European sea freight as there was a nearby port. However, we cannot discount the possibility that this was an escaped captive-bred animal.

Captive red squirrels are sometimes present in zoological collections and there are also examples of private ownership. Even where stringent biosecurity protocols are in place, with enclosures designed to minimise escape, occasionally individuals are lost from enclosures or indeed during transportation between enclosures. These animals may then travel into adjacent habitats and if encountered by local people, their presence is sometimes reported to wildlife conservation organisations and local media.

This scenario can create ‘recent’ local records of red squirrel presence in geography where the species actually became extinct many decades earlier. This can be unhelpful as it can create a sense amongst the public that a wild red squirrel population may be persisting locally especially in circumstances where the provenance of the animal is never established. Ascertaining from which captive collection an animal may have originated is however challenging because not all escapes are quickly noticed and there is little available data on distances that escaped animals may ultimately travel. There is also perhaps a natural assumption that an escape is unlikely to be the source of geographically distant sighting records.

Project aims

- We aim to compile records of escaped red squirrels, sighting location records, the ultimate fate of animals and associated photographic evidence. Where there was no evidence of an escape we would record the presence of an animal as a potential deliberate release or incidental transportation of a wild red squirrel (as grey squirrels have been accidentally transported within vehicles e.g. in engine bay).

- The information will help better understand the frequency of escapes and thus calibrate parallel reports of red squirrel sighting from regions where the species is extinct in the wild.

Description of the project

We started noting information on escapes during the writing of a 2014 publication examining Squirrelpox amongst captive red squirrels. During this research, we came across interesting records of viral exposure amongst captive animals including one 2004 instance of a recaptured escaped animal (Welsh Mountain Zoo) with antibodies to Squirrelpox present in the absence of any disease symptoms. There were various additional, but anecdotal, records of escapes including recaptures, but for most occurrences quantified data was typically lacking meaning that many records were of limited value.

Comprehensive data are particularly useful as they lend themselves to wider use. For example the recent planning application to construct an open roofed visitor walk through red squirrel enclosure at Dumfries House in south Scotland was weakened because the risk of animals escaping was difficult for the applicant to quantify. Additionally, information recorded in relation to red squirrel escape could be useful when authorities in Europe assess the risk of captive non-native exotic squirrel species escaping from collections in mainland Europe.

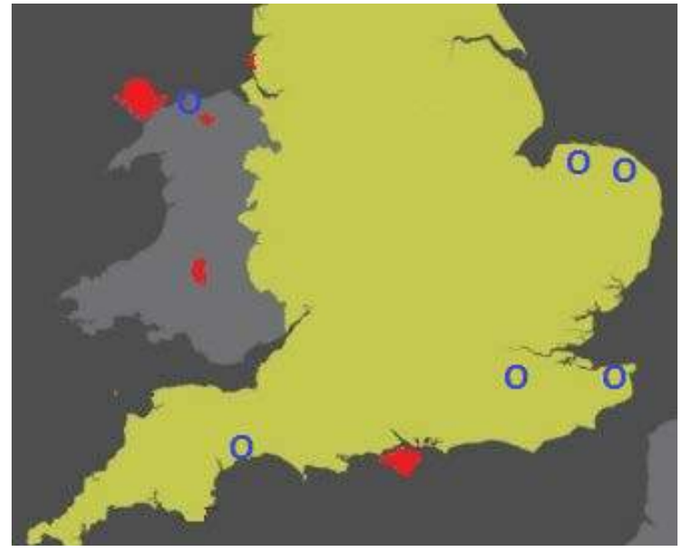

Figure 1. Locations of escaped captive red squirrels 2000-2020 shown in blue circle. Red shade shows existing wild populations.

We recorded six instances where red squirrels escaped from enclosures in geographies where the species was extinct in the wild and invasive grey squirrel populations were well established (Table 1, Figure 1). Animals were detected, and in several cases recaptured, at distances between 0 and 16 km from their original location. In four instances the animal was caught, including one where the animal was trapped and injured in an unsuitable trap design by a third party whilst the owning institution was undertaking professional trapping in the same area.

Table 1

[1]Early 2000s	Fakenham, Norfolk.	Female	Escaped from a roofed enclosure after the mesh wall was damaged in a storm. Remained in gardens near enclosure	Recaptured 1 day later	0 km
[1]Early 2000s	Sherington Park, Norfolk	Female	Escaped whilst being transported to a new breeding establishment 15km from original site	Recaptured 7 days later	2 km (Aylmerton Field Study Centre, Norfolk)
[2]2004	Welsh Mountain Zoo, Colwyn Bay	Female	Escaped from a roofed enclosure (no details)	Recaptured several weeks later	0 km
[3]18th August 2014	British Wildlife Centre, Lingfield, Surry	Unknown	Escaped from an open roofed visitor walkthrough enclosure (Figure 2)	Unknown fate	c. 1 km (near Blindley Heath on A22 road)
[4]9th Feb 2020	Wildwood Trust, Herne Bay, Kent	Unknown	Storm Ciara damaged an external door of an open roofed visitor walkthrough enclosure (Figure 3)	Located 3 days later and died in unauthorised trap (reported 18/2/20)	16 km (Maytree Gardens Centre in Dunkirk)
[5]3rd August 2014	Escot estate, Devon	Female named 'Thistle'	Escaped from an open roofed visitor walkthrough enclosure (Figure 4)	Unknown fate	2.2 km Cannan Way car park & Tip Hill in Ottery St Mary, Devon

1 Stapleford 2003; 2 Shuttleworth et al. 2014; 3 RSST unpublished data (2014); 4 Kent Online https://www.kentonline.co.uk; 5 East Devon News.

One of the escaped animals was observed having been caught by a domestic cat and was retrieved alive by a member of the public. In four of the remaining recorded escapes, a clear strategy was put in place after detection to recapture escaped animals. In one instance in Fakenham, the squirrel was observed in a neighbouring property and was enticed back into an enclosure by leaving a door open and placing food in bowls. Live

capture traps were deployed in three other cases and two of the animals were caught.

Figure 2. Red squirrel photographed near A22 Blindley Heath surrey in 2012.

Figure 3. Escaped red squirrel photographed at Maytree Garden Centre, Kent.

Figure 4 @EasteDevon Twitter feed March 3rd 2020.

Success indicators within the project

- Collating detailed records of escaped red squirrels.

Major difficulties faced

- Captive red squirrels are often housed in pairs, trios or small groups and therefore it is not always possible to quickly detect an escape.
- Open roofed public walk through enclosures housing red squirrels typically contain extensive tree canopy cover within which animals nest. This amplifies the challenge of monitoring numbers and detecting an escape.

Major lessons learned

- Despite the fact that red squirrels are locally extinct and people living there may therefore not be directly familiar with the species, some have been able to distinguish an escaped animal from resident grey squirrels and have reported their observations.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Given the paucity of published data on captive red squirrel escapes we are pleased to have collated a small but significant number of instances.

Future project development

- We will encourage the captive breeding fraternity to report escapes and describe the challenges faced and measures taken to detect and recover animals.

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Saving Scotland's Red Squirrels in north east Scotland: Restoring urban reds

Scottish Wildlife Trust

Geographical area of work

Aberdeen City and Aberdeenshire, Scotland.

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Key partners

Saving Scotland's Red Squirrels Partnership:

- Scottish Wildlife Trust
- Scottish Natural Heritage
- Scottish Forestry
- Scottish Land & Estates
- Red Squirrel Survival Trust
- RSPB Scotland

Additional partners in SSRS North East Scotland:

- Aberdeen City Council
- Aberdeenshire Council
- Aberdeen Western Peripheral Route Offset Mitigation Fund
- Forestry and Land Scotland

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	4 1 full-time Project Officer 2 full-time Grey Squirrel Officers 1 full-time Monitoring and Control Officer
Volunteers involved with Grey control	50. c. 50 at any given time, >315 participants since 2009
Volunteers involved with squirrel monitoring	45 Survey volunteers
Other info	1 Landowner on Forestry Grant Scheme Up to 10 on scheme in the past, but no longer eligible due to the success of grey squirrel removal

Map of project land area

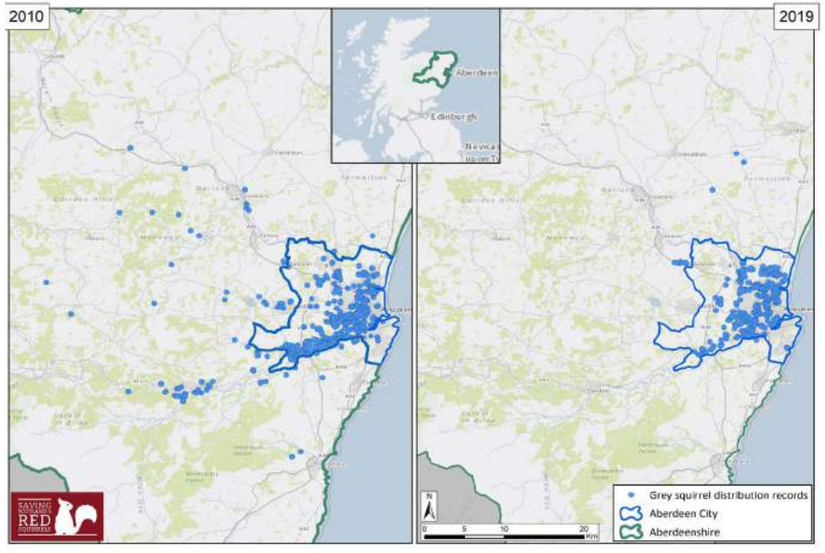

Figure 1. Maps of Aberdeenshire showing the change of grey squirrel distribution between 2010 and 2019, using distribution records from sightings, surveys and grey squirrel control. Even with the intensification of survey and monitoring in the region by 2019, the retraction in range is evident.

Introduction

Saving Scotland's Red Squirrels (SSRS) in north east Scotland focuses on removing a geographically isolated population of grey squirrels (*Sciurus carolinensis*) centred on the city of Aberdeen, where they were introduced in the 1970s. When SSRS began in 2009, grey squirrels had spread along the two river catchments of the Dee and the Don into rural Aberdeenshire. Left unmanaged they could threaten the healthy red squirrel populations of the Scottish Highlands.

Operating initially in Aberdeenshire and the rural outskirts of Aberdeen, the SSRS staff team aimed to eliminate grey squirrels from rural areas, pushing the outer limits of their range back towards the city. By the time Saving Scotland's Red Squirrels-Developing Community Action (SSRS-DCA) was launched in 2017, few grey squirrels could still be found across the wider countryside and red squirrels (*Sciurus vulgaris*) had begun to recover on the city outskirts. Now in the fourth of the five-year National Lottery Heritage funded SSRS-DCA national project, the focus is on progressively reducing the density and distribution of grey squirrels within urban Aberdeen with a view to eventual eradication.

In urban and suburban areas, SSRS-DCA operates a very successful trap-loan scheme in private gardens, highlighting the vital contribution made by Aberdeen's householders to the grey squirrel control effort. Crucial partnerships with Forestry and Land Scotland, and Aberdeen City Council have levered in significant funding contributions and facilitated access of grey squirrel control staff to the National Forest Estate, urban woodland and parks. A large volunteer force delivers annual spring feeder-box squirrel presence/absence surveys to inform conservation efforts.

Project Aims

- To strategically reduce the occupancy and density of grey squirrels in Aberdeenshire and Aberdeen City, aiming at the eventual eradication of grey squirrels from the entirety of north-east Scotland.
- To improve the efficiency and effectiveness of grey squirrel control activity through a three tier system of operational surveys.
- To enable red squirrels to recolonise their former range in rural Aberdeenshire and Aberdeen City.
- To continue to encourage public support for red squirrel conservation, the project and grey squirrel control.

Description of the project

SSRS-DCA in north east Scotland delivers part of a key element of the Scottish Strategy for Red Squirrel Conservation (2015), protecting Scotland's core red squirrel populations which are still naïve to grey squirrel competition, by working to contain or eliminate the isolated grey squirrel population that occurs in Aberdeen.

The SSRS North East team consists of two Grey Squirrel Control staff (GSOs), a Monitoring and Control Officer and a Conservation Officer, all employed by the Scottish Wildlife Trust (SWT). The project is managed by the SSRS Project Manager working to a SWT Project Board, under the guidance of the Saving Scotland's Red Squirrels Partnership.

As well as GSOs, grey squirrel control has been delivered by up to ten landowners under Rural Development/Forestry Grant funding schemes. As time has passed, the estates originally on the schemes reached the point when they were unable to detect any further grey squirrels and were able to cease their trapping. A third major element, delivering mainly urban grey squirrel control, is the army of householders who have looked after traps in their gardens, reporting any grey squirrels caught to the on-call SSRS dispatch team. Householder traps have been responsible for around half of all grey squirrel removals within the city.

An essential part of the success of the urban project has been the strong support of our work by Aberdeen City Council and Forestry and Land Scotland, including funding contributions and vital access permissions. This has included trapping in some public areas where high footfall required the development of inconspicuous trap-boxes, described by Willis (2015) in the previous Red Squirrel Conservation Practice (2015) publication.

Squirrel monitoring by SSRS north east is multi-levelled:

- A systematic spring survey, which began in 2011, runs at around 50 tetrads (2x2km sites), each with four feeder-boxes, for six weeks in March-April, and generates 12 hair-samples per tetrad e.g. Tipple and Tonkin 2019. This provides us with annual trends in squirrel distributions and occupancy.

- Much more detailed feeder-box surveys designed to identify any previously undetected grey squirrel colonies were started in 2014 (Figure 2). In rural areas, individual boxes were sited in patches of large-seeded broadleaf trees of ≥10 hectares, plus smaller woodland patches with the potential to act as movement corridors. In 2016, the scheme was extended to include city areas at a density of at least one box per 1km^2. A total of 170 survey sites provides confidence that no significant occupied grey squirrel habitat is omitted from our trapping effort.

Figure 2. Feeder boxes are used to collect hair samples for both distribution and reinvasion surveying.

- In 2018, SSRS began a new monitoring scheme for Aberdeenshire areas with low densities of grey squirrels. Feeder-box monitoring at static trap sites instigates trapping only when a grey squirrel was detected. This minimises the red squirrel catch and greatly increases the efficiency of grey squirrel control. Three cohorts of feeder-boxes are checked at three different intervals, depending on the results generated. Boxes where grey squirrels are detected are checked more frequently; following a period of no-detection, a box reverts to a lower checking frequency. Results suggest that nearly all the outlying small sub-populations have been removed.

- Within Aberdeen City the team uses feeder box surveys, camera traps and remote trap-monitors to determine the reinvasion time of grey squirrels into trapping areas following localised removal.

The latter two monitoring schemes are aimed at improving the efficiency of the trapping effort as grey squirrel densities decline, and it is hoped that they will also shed light on the dynamic and direction of reinvasion of the key remaining trapping locations.

With increasingly efficient targeting and productivity of the grey squirrel control effort delivered by SSRS staff, together with that delivered by landowners and householders, the population of grey squirrels has significantly declined in density and range (Figures 1 & 2). Red squirrels were quick to respond to vacated habitat in suburban areas and are increasingly seen in the city parks and gardens (Figure 3). Red squirrels are regularly seen along north Deeside, right into the city at Garthdee in the south of the city, and at Seaton Park and Bridge of Don and on the northern edge, in Hazlehead Park in the west of Aberdeen and Rubislaw Den running into the city centre.

Figure 3. Red squirrel visiting in a garden near Duthie Park in central Aberdeen in 2019 © Gina Ganzenmueller.

Success indicators within the project

- Continuing decline in grey squirrel occupancy and abundance as indicated by trapping and monitoring records.
- Increase in the occupancy of red squirrels as indicated by surveys and sightings records.
- Increased public engagement in conservation work as indicated by participation in the trap-loan scheme, numbers attending events and sightings records submitted.

Major difficulties faced

- Control work in public areas - difficulties in removing squirrels from very public areas. Even with the trap box design, it can be challenging to find suitable discreet locations for the trap box which can restrict the number of traps we use in places such as public parks.
- Access to critical sites - refusal of permission to trap in a few key patches of privately owned woodland or wooded garden can create a constant source of replenishment of grey squirrels for the surrounding land.
- Lack of scientific knowledge - a lack of prior published knowledge on urban grey squirrel population dynamics makes it more challenging to devise a strategic trapping campaign that takes into account grey squirrel hotspots and movement corridors when these might be different in nature in the urban environment to those understood in rural areas.

Major lessons learned

- Need for adaptive approach for low density populations - grey squirrel occupancy can be decreased with the use of a sustained and coordinated control programme, but eradication will require flexibility and adaptive management.
- Possibility for urban recovery - red squirrels can recover and recolonise their former range when grey squirrels are removed (or their densities reduced to low levels) even in urban areas provided habitat and connectivity is suitable.
- Importance of community engagement - public participation is an essential tool in the control of invasive non-native species. The huge volume of species distribution information the public contributes and the collaboration in controlling local populations of the non-native is invaluable.
- Need to account for differential reinvasion rates - some parts of Aberdeen's landscapes are more prone to rapid reinvasion by grey squirrels than others; developing a better understanding of this will be necessary for shortening the timescale for eradication.

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- The grey squirrel control approach is constantly being adapted towards increasing efficiency. In rural areas, since the implementation of constant monitoring at trap-sites in low-density grey squirrel areas combined with responsive trapping, trapping efficiency increased by 550% between 2017 to 2019.

- Aberdeen's isolated population of grey squirrels does not carry the Squirrelpox virus. Red squirrels therefore are only threatened by competition from grey squirrels.

- Red squirrel populations persisted near our areas of operation, allowing for recovery and recolonisation of trapped areas. Re-occupation by red squirrels of habitat where greys have been removed creates resistance to grey recolonisation when compared with unoccupied habitat (Porton et al. 2019).

- A partnership approach has enabled continuity of funding, national and local co-operation between a range of government agencies, NGOs, academics, local authorities and land managers and a momentum that sustains the work on the ground.

Highlighting how challenges identified in 2015 have been approached

- One of the difficulties identified in 2015 was in locating all breeding populations of grey squirrels. This has been addressed through setting up a new tier of intensive grey squirrel surveys covering virtually all potential grey squirrel habitat in Aberdeen and its rural hinterland, backed by intensification of public sightings recording.

- Persuading all relevant stakeholder organisations that we can achieve our aims of a sustained and continuing reduction in grey squirrel numbers over a significant time-scale has been addressed through our successes to date, such that the eventual aim of eradication no longer seems so far-fetched.

- A perceived difficulty was the problem of promoting grey squirrel control as a red squirrel conservation measure to a public who were unlikely to see grey squirrels lost from their gardens replaced by red squirrels. The rapid return of red squirrels first to suburban parks and then to more urban open spaces and garden feeders has helped to bring the majority of the public along with the project.

- The lack of published information on grey squirrel behaviour and population dynamics in urban areas is still an issue. Better information on squirrel movements, urban food sources and nesting habits, densities and breeding success would be useful in identifying key sites for focusing control measures and predicting the timescale for eradication.

Future project development

- The ultimate aim of SSRS in the north east is the complete elimination of Aberdeen's grey squirrels; however, it can be difficult to attain certainty that this has been achieved. SSRS aims to develop a scientifically validated robust minimum monitoring scheme to detect any resurgence or infiltration by remnant or invading grey squirrels. This will need to be combined with a rapid response control mechanism and is likely to involve trained grey squirrel control volunteers and, potentially, retained staffing to deliver immediate action.

- Part of the legacy plan for the project, is to develop a supported community action group to help oversee and deliver long-term population monitoring across the region, react to any residual grey squirrels detected and sustain red squirrel awareness and education for the area. This will help ensure that red squirrels are protected in the north east into the future, as infiltration of grey squirrels into Aberdeenshire from Angus to the south will remain a constant threat.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting		
Live traps	★★★	★★★
Kill traps		
Pine Marten (as natural grey predator)	★	★★
Immuno-contraception (oral bait delivered via hoppers)		★
Gene Drive (Selected inheritance manipulated so only male young are born)		
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★	

★★★ High; ★★ Medium; ★ Low, blank = None.

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II. Porton G et al. (2019). *Evaluation of the progress of Saving Scotland's Red Squirrels towards its region specific management aims, accounting for imperfect detection.* Report to People's Trust for Endangered Species.

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Saving Scotland's Red Squirrels in the Central Lowlands: Holding the Highland line

Scottish Wildlife Trust

Geographical area of work

Predominantly within Argyll, Loch Lomond and the Trossachs National Park, Stirlingshire (A&T) and Tayside (i.e. Perth and Kinross, and Angus). In addition, some monitoring activities are carried out in Fife and the central belt between Glasgow and Edinburgh, Scotland.

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Key partners

Saving Scotland's Red Squirrels Partnership:
- Scottish Wildlife Trust
- Scottish Natural Heritage
- Scottish Forestry
- Scottish Land & Estates
- Red Squirrel Survival Trust
- RSPB Scotland

Additional partners:
- Loch Lomond and the Trossachs National Park
- Forestry and Land Scotland

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	3 Seasonal Grey Squirrel Officers/contractors
Paid Contractors (7-12 months)	3 2 full-time Conservation Officers 1 full-time Grey Squirrel Officer
Volunteers involved with Grey control	75
Volunteers involved with squirrel monitoring	75
Other Active Volunteers	3 Outreach/office assistance
Other info	c.40 Landowners on Forestry Grant Scheme (75 landowners since the start of SSRS)

Note: Number of volunteers and landowners varies.

Map of project land area

Figure 1. Saving Scotland's Red Squirrels Central Lowlands project area with the 'Highland Line' control zone. Saving Scotland's Red Squirrels' Central Lowlands project area with the 'Highland Line' control zone depicted in Figure 1. This 10 kilometre-wide strip is where grey squirrel (*Sciurus carolinensis*) control is focused, with the main goal of protecting the red squirrel (*Sciurus vulgaris*) populations in the Highlands, Grampian, Argyll and northern parts of Stirling and Tayside from infiltration by grey squirrels and the Squirrelpox virus (SQPV). *© Scottish Wildlife Trust 2020; Contains OS data © Crown copyright and database rights 2020; Contains public sector information licensed under the Open Government Licence v3.0.*

Introduction

In Scotland red squirrel protection is based on strategic grey squirrel control in accordance with the Scottish Strategy for Red Squirrel Conservation (2015), which identifies key landscapes where control measures should be focused in order to provide the greatest benefit to Scotland's red squirrels. Now in the fourth year of the National Lottery Heritage funded Saving Scotland's Red Squirrels - Developing Community Action (SSRS-DCA) five-year project, SSRS in Scotland's Central Lowlands focuses on one of these landscapes, the Highland Line control zone.

The Highland Line control zone is a 10 kilometre-wide band of country running from Scotland's east coast north of Montrose through Kirriemuir, Crieff and Loch Lomond to the Firth of Clyde near Helensburgh. Here, grey squirrel control is aimed at containment of grey squirrels to the south of this coast-to-coast line in order to protect Scotland's core red squirrel populations to the north, where grey squirrels have never occurred. It complements work by SSRS in Aberdeenshire, which aims at eradication of an "island" population of grey squirrels centred on Aberdeen, threatening the same core red squirrel populations.

Grey squirrel control is delivered by SSRS staff, landowners and volunteers, reducing pressure from grey squirrels in the red/grey squirrel interface and minimising any future impact of SQPV arriving in the area. Pine martens (*Martes martes*) present across the Highland Line doubtless also contribute to the reduction in grey squirrels (Figure 2). Resident red squirrels have repopulated "controlled" areas despite the pressure of grey squirrels dispersing northwards from the uncontrolled populations living in Scotland's Central Belt to the south.

Figure 2. Pine Marten on feeder box © SSRS project camera trap

Project aims

- Defend the stronghold red squirrel populations in the Highlands, Grampian and Argyll, together with the northern (upland) stretches of Stirling and Perthshire, through sustained systematic control of grey squirrels along the Highland Line control zone to reduce occupancy and abundance.

- Support the region's landowners to carry out grey squirrel control on their land through the Forestry Grant Scheme, voluntarily or under the SSRS trap-loan scheme.

- Monitor SQPV prevalence in grey squirrel populations from the Glasgow-Edinburgh conurbations northwards and continue to track its progression towards the Highland Line.

- Build on existing public support for grey squirrel control in the region as a tool for red squirrel conservation, to create long-lasting control networks.

Description of the project

The Saving Scotland's Red Squirrels Central Lowlands team is staffed by two Conservation Officers (COs), covering Tayside and Stirling/the Trossachs respectively. They coordinate grey squirrel control work by Grey Squirrel Officers (GSOs), landowners and volunteers across the region and deliver support and training for grey squirrel control participants. They also organise and coordinate annual systematic spring surveys and carry out public engagement and local project activities to raise awareness of red squirrel threats and conservation, and to recruit new volunteers and landowners (Figures 3 & 4).

Figure 3. Engagement stand with Sandy Squirrel, A MacMaster & R Tammi. © Ann-Marie MacMaster

Figure 4. Tayside public engagement, featuring. E Castle-Smith & S Woodfin. © Ann-Marie MacMaster

GSOs carry out the essential grey squirrel control on the ground in the highest priority areas, particularly focussing on gaps in the landowner network and on urban areas. They recruit and train new volunteers and landowners and provide ongoing support to existing participants.

The regional team works closely with landowners and supports them to carry out grey squirrel control in three ways: funded control through the government Forestry Grant Scheme (FGS) which provides a five-year grant for an agreed number of traps to be operated 50 days per year; voluntary control carried out by estate staff; and facilitating access for volunteers or SSRS staff to carry out control on private land. Landowners include private individuals, Forestry and Land Scotland, private forestry companies and local authorities.

SSRS's standardised annual surveys, which started in 2011, determine species occupancy in about 85 tetrads (2x2km survey sites) across the red/grey squirrel interface area, using feeder boxes to collect hair samples. In some areas, camera traps have also been deployed where local pine martens, which take readily to squirrel feeders, leave quantities of hair which mask any squirrel hair in the sample. Camera traps at these locations can help determine squirrel presence that may otherwise have been missed. Results from the surveys are reported to the relational databases accessed by the project website, providing vital data to inform grey squirrel control activities.

Analysis of the survey data shows that the early years of the SSRS project effected the greatest decrease in grey squirrel occupancy, with a concomitant increase in red squirrel occupancy, which has since been maintained at a relatively steady situation (Tipple and

Tonkin, 2019). Recent occupancy modelling using the Central Lowlands survey data (Porton et al. 2019) has provided early warning of signs of grey squirrel recovery in some areas, requiring an intensification of control work in these places.

An important element of the SSRS Central Lowlands work is the monitoring scheme designed to track the spread of the SQPV from south to north. By 2013, SSRS had recognised that most grey squirrel populations to the south of Edinburgh and Glasgow hosted SQPV endemically. Testing of these populations for specific SQPV antibodies - hitherto a major element of the SSRS South Scotland project work - largely ceased. A new annual monitoring scheme collects blood samples from grey squirrels from around 30 10-kilometre squares across the landscape from the Glasgow-Edinburgh conurbations all the way north to the Highland Line. Blood samples are sent for SQPV ELISA antibody tests at the Moredun Research Institute. To date there has been no sustained incidence of SQPV in grey squirrels north of the Edinburgh and Glasgow northern limits, although there has been sporadic detection near Erskine and at Plean, south of Stirling.

Public engagement includes stalls at agricultural fairs, events and talks, often assisted by volunteers. Recent collaboration with the Loch Lomond and the Trossachs National Park has created a red squirrel conservation awareness-raising toolkit for schools and other young people. Another newly developed public engagement tool is the new SSRS-DCA website, launched in 2018. As well as the squirrel sightings reporting page, the website provides an online Community Hub. Here, individuals can create an account which allows them to review their own sightings, join private groups showing the results of surveys or other activities and access a record of their contributions to the project. A trapping portal enables people to report their trapping effort and captures online, providing staff vital access to a wide variety of project data from one source.

Success indicators within the project

- Sustained decrease or stable grey squirrel occupancy and abundance along the Highland Line shown through trapping returns, presence/absence surveys and sightings.

- Increased occupancy or stability of red squirrels in presence/absence surveys, sightings and in trapping returns in some areas.

- Increased and continued engagement of the public in red squirrel conservation work including volunteers and landowners contributing to grey squirrel control trapping, survey work, sightings and engaging with events.

Major difficulties faced

- Gaining land access - persuading relevant stakeholders of the need for grey squirrel control and achieving access to trap in some areas. This has been particularly difficult in areas of council owned public land where there may be high public footfall. Other areas of the SSRS project (Aberdeen) have shown that discreet control is possible in heavily used areas.

- Opposition to grey squirrel control - the promotion of grey squirrel control to the public living in certain key areas has sometimes proved problematic, particularly where people only see grey squirrels and are unlikely to see immediate recolonisation by red squirrels. This can generate a strong aversion to grey squirrel control by local residents and difficulty in removing critical populations of reinvading grey squirrels.

- Reluctance of some landowners to participate in the Forestry Grant Scheme - the current government FGS Grey Squirrel Control grant is 50% funded by the EU (until 31/12/20) which requires that forests receiving support are covered by approved management plans. Landowners therefore, need to produce either forest plans for larger forests/ woodlands, the production of which is funded under the grant scheme, or woodland management plans for smaller woodlands, which are not funded. In some cases, SSRS staff can assist with drawing up a simple woodland management plan, but where such smaller estates/farms do not currently carry out any woodland management, the input required often discourages them from applying for the grant, leaving significant gaps in the landscape-scale control network.

Major lessons learned

- Sustaining control efforts - occupancy and abundance of grey squirrels in key areas can be decreased successfully but control work will need to be sustained to ensure the populations do not rebound given constant influx of grey squirrels from the urban central belt.

- Red squirrel populations can be restored - red squirrels can recover to occupy former ranges if grey squirrels are reduced to a low level, and highlighting this recovery is a good tool for engaging the greater public and increasing understanding of the rationale behind project activities.

- Adapting monitoring techniques - an increase in pine martens in the Loch Lomond and the Trossachs National Park area has resulted in the need to use camera traps in conjunction with feeder box surveys in order to continue to record the presence/ absence of squirrels, because pine martens readily take to squirrel feeders, leaving enough fur on the sample pads to mask any squirrel hair or prevent it from sticking.

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Community involvement has been an important resource - without long-term volunteer and landowner (either with or without the grant scheme) assistance it is unlikely that the Highland Line could have been defended so successfully thus far. The Forestry Grant Scheme and its predecessors have facilitated commitment by land managers to long term grey squirrel management that would have been challenging to achieve otherwise.

- To date we have been fortunate that the SQPV has not spread northwards through grey squirrel populations as quickly as was predicted, allowing SSRS time to reduce local grey squirrel populations and set up control networks in advance of this additional threat to local red squirrel populations.

- The region is bordered to the north and west by strong populations of red squirrels in Grampian, northern parts of both Stirling and Perthshire, and Argyll, and which remain unaffected by grey squirrels, providing a ready source of red squirrel recolonisation to areas where grey squirrel densities have been reduced.

- Pine marten recovery appears to have contributed to the crash of some grey squirrel populations (e.g. in Strathyre), with red squirrel recovery following in its wake.

Future project development

- Defending the Highland Line and this form of targeted landscape-scale control will need to be sustained to ensure repopulation of grey squirrels from the Central Belt, Perthshire and Stirlingshire does not occur.

- Outreach to communities well to the south of the Highland Line where strong red squirrel populations still exist will be required to provide know-how for protection should SQPV arrive in the future.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★	★ ★
Live traps	★ ★ ★	★ ★ ★
Kill traps		
Pine Marten (as natural grey predator)	★ ★	★ ★ ★
Immuno-contraception (oral bait delivered via hoppers)		★
Gene Drive (Selected inheritance manipulated so only male young are born)		
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★ ★	

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

References

I. Porton G. *et al.* (2019). Evaluation of the progress of Saving Scotland's Red Squirrels towards its region-specific management aims, accounting for imperfect detection. Report to People's Trust for Endangered Species.

II. Tipple and Tonkin (2020) Evaluation of Spring 2019 Squirrel Surveys. A Report for Saving Scotland's Red Squirrels, a project under Scottish Wildlife Trust.

Saving Scotland's Red Squirrels in Southern Scotland: PARCs and people

Scottish Wildlife Trust

Geographical area of work

The Scottish Borders, Dumfries and Galloway, parts of South and East Ayrshire and South Lanarkshire.

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Facebook: www.facebook.com/SavingScotlandsRedSquirrels/

Key partners

Saving Scotland's Red Squirrels Partnership:

- Scottish Wildlife Trust
- Scottish Natural Heritage
- Scottish Forestry
- Scottish Land & Estates
- Red Squirrel Survival Trust
- RSPB Scotland

Additional partners in the Red Squirrels in South Scotland Advisory Board:

- Forestry and Land Scotland
- Red Squirrel Forum for South Scotland
- Red Squirrels North England
- Northern Red Squirrels (England)
- European Squirrel Initiative
- Southern Uplands Partnership
- Private forestry sector representatives

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	3 Seasonal Grey Squirrel Officers
Paid Contractors (7-12 months)	9 2 full-time Conservation Officers 2 full-time Community Engagement Officers 5 full-time Grey Squirrel Officers
Volunteers involved with Grey control	352
Volunteers involved with squirrel monitoring	96
Other Active Volunteers	101
Other info	59 Landowners on Forestry Grant Scheme

Note: Some volunteers carry out a variety of different roles, so the total number is less than the sum of the numbers in the categories above.

Map of project land area

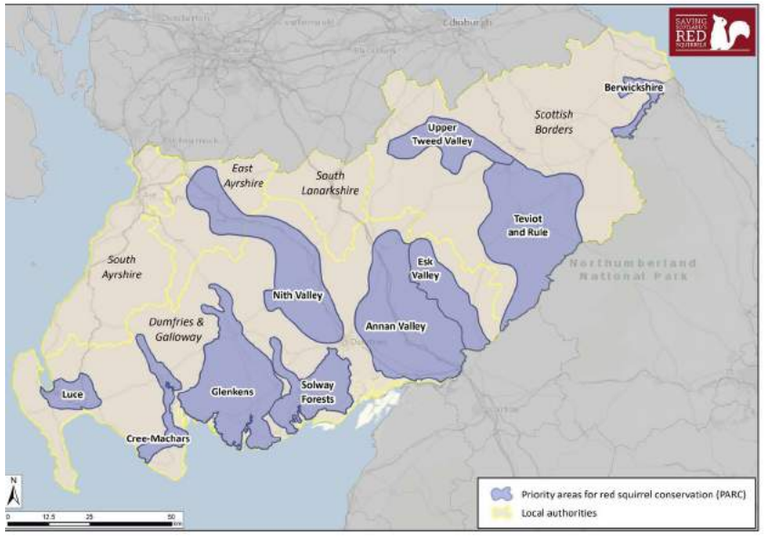

Figure 1. Priority Areas for Red Squirrel Conservation (PARCs) - © Scottish Wildlife Trust 2020; Contains OS data © Crown copyright and database rights 2020; Contains public sector information licensed under the Open Government Licence v3.0.

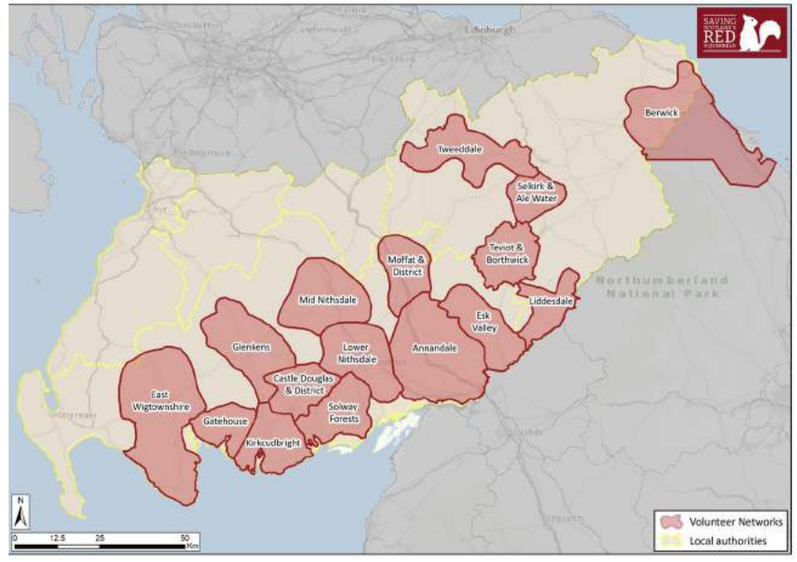

Figure 2. Red squirrel volunteer networks in South Scotland - © Scottish Wildlife Trust 2020; Contains OS data © Crown copyright and database rights 2020; Contains public sector information licensed under the Open Government Licence v3.0.

Introduction

Red squirrel (*Sciurus vulgaris*) conservation work has been ongoing in southern Scotland for over 25 years. Red squirrel range has been sustained across much of the region except for Berwickshire and the eastern half of Roxburghshire, where red squirrels are now rarely seen. Despite the presence of grey squirrels (*Sciurus carolinensis*) across much of the Scottish Borders except for the larger conifer forests, red squirrel populations are still thriving in Tweeddale and are present in the catchments of the Teviot, Borthwick and Ettrick Waters. In Dumfries and Galloway, red squirrels still thrive from the River Esk in the east to Stranraer in the west although under constant pressure from grey squirrels.

The red squirrel conservation project in southern Scotland is currently engaged in the fourth year of a five-year National Lottery-funded project, Saving Scotland's Red Squirrels - Developing Community Action (SSRS-DCA) running 2017-2022, which aims to galvanise and equip local communities to carry out essential red squirrel protection work.

SSRS-DCA in southern Scotland focuses on protecting red squirrels in selected Priority Areas for Red squirrel Conservation (PARCs), originally identified in 2014. In 2018, SSRS reviewed and added to the PARCs in the light of increasing threat of grey squirrel spread into previously grey squirrel-free regions of Dumfries and Galloway. The current PARCs provide enhanced protection of red squirrel populations from displacement by grey

squirrels (Figure 1). However, at the time of writing, the cessation of most grey squirrel control work during the 2020 Coronavirus (COVID-19) emergency is a worrying setback for red squirrel conservation here.

Project aims

- To protect red squirrel populations from replacement by grey squirrels and from disease for the long-term in carefully chosen priority landscapes (PARCs) in southern Scotland.

- To support networks of landowners in priority landscapes to trap grey squirrels on their land, either under funding contracts, or voluntarily, or with the assistance of local volunteers.

- To reduce the dependence of red squirrel conservation work in southern Scotland on high levels of SSRS staffing to carry out control work in the face of an ongoing grey squirrel threat.

- To train and equip local volunteer-led red squirrel networks to provide effective grey squirrel control, enabling them to take ownership of red squirrel conservation action across southern Scotland for decades to come.

Description of the project

SSRS-DCA in southern Scotland is part of a strategic approach to red squirrel protection by focussing grey squirrel control in the areas where it will achieve the greatest benefit for the region's native squirrel. A key aspect of SSRS-DCA in southern Scotland is to galvanise and enable local people to contribute significant conservation action to long-term red squirrel protection in their area and across the region.

SSRS South Scotland Conservation Officers (COs) have overall responsibility for coordinating grey squirrel control via Grey Squirrel Officers (GSOs), landowners and volunteers, while the Community Engagement Officers (CEOs) establish, train and support new and existing volunteer networks. As well as their own grey squirrel control work, the GSOs have a role in providing grey squirrel control training to volunteers.

Landowners are supported by SSRS staff to carry out grey squirrel control through various routes: funded control via the Forestry Grant Scheme (FGS), voluntarily using their own staff and by facilitating land access for SSRS staff and volunteers to carry out control. The SSRS Team assists with compiling the data required to support FGS applications and works with landowners to determine the optimum number and location of traps. The FGS and its predecessor schemes have facilitated commitment by land managers to long-term grey squirrel management that would have been challenging to achieve by other means.

Feeder-box monitoring has been carried out each spring in southern Scotland since 2013.

They are largely delivered by volunteers following standardised methodology, collecting over 1,200 hair samples from around 100 tetrads (2km square sites; Tipple and Tonkin, 2020). Comparison of the results across years provides a measure of change in squirrel distribution and occurrence over time. In 2019, the spring surveys logged the first recorded decrease in grey squirrel occurrence when compared with the previous spring, notably in Tweeddale, where pine martens (*Martes martes*) are established, and in areas into which the native predator is spreading out from Galloway Forest Park. Encouragingly, this decrease in grey records was accompanied by an increase in detection of red squirrels.

By April 2020 there were 16 volunteer red squirrel networks across southern Scotland (Figure 2), 12 of which were set up during the SSRS-DCA project. Each has been established in response both to urgent grey squirrel control needs in the PARCs (Figure 1) and to local enthusiasm to engage in voluntary red squirrel conservation. SSRS-DCA supports networks with essential start-up equipment for control, survey and public engagement, and an annual grant to sustain the network as it expands its activities. Volunteers joining a squirrel network can access SSRS's training and support, including shadowing of GSOs, squirrel survey training and in public engagement, fundraising and other activities.

The aim is for each network to coordinate its own volunteer grey squirrel controllers, in liaison with local landowners, within each network's remit area. This includes network trap-loan schemes, where residents are loaned traps and may be allocated an on-call volunteer dispatcher. Whilst volunteer networks are encouraged to respond to grey squirrel control needs in their neighbourhood, SSRS-DCA coordination ensures efforts are coherent across the wider landscape. Volunteer sightings reporting and survey data also help to inform the network's targeted grey squirrel control activities.

To provide a resource for the volunteer networks, not only during the SSRS-DCA project but also over the longer-term, the project has created an online Community Hub linking to a relational database holding the project's distribution and grey squirrel control data. Volunteers are supported to upload their own grey squirrel control, sightings and survey data to the Hub, join their local network and engage with the wider project. Networks are encouraged to use the Hub to facilitate the management of their own local red squirrel conservation efforts.

A critical contribution to the legacy strategy for the SSRS-DCA project has been the independent establishment of a volunteer-led Red Squirrel Forum for South Scotland. The Forum will help to drive coordination and consistency in volunteer activities across the region, reducing the network's reliance on the support of SSRS staff and creating the foundation for self-sufficiency in the future.

Success indicators within the project

- Reduction of range and abundance of grey squirrels in PARCs (quantified by grey squirrel control records, feeder-box surveys and sightings).
- Maintenance or increase in occupancy and range of red squirrels in PARCs (quantified by feeder-box surveys and sightings).
- Coverage of PARCs by volunteer network footprints, together with number of networks and average number of volunteers per network.

Major difficulties faced

Figure 3. Recruiting committed volunteers to carry out effective grey squirrel control and community engagement activities will vary depending on the remoteness of areas and the varied landscape topography, such as in the Tweed Valley – © Chris Fairgrieve.

- Challenges for landowners accessing funding schemes – landowners can be reluctant to take up the opportunity for funded grey squirrel control because of the time input required to access and administer the grant.
- Human population densities and landscape – landscapes can be remote, with low population densities and dissected by upland regions and by valley topography (Figure 3). The geography adds to the challenge of starting new red squirrel networks, engaging with people and achieving adequate coverage by volunteers.
- Gaps in the region's staffing – gaps in staffing have occurred for a variety of reasons, each setting back the forward momentum of the project.

Major lessons learned

- An initial underestimation of the Community Engagement Officer role - after the first year the project found that a single Community Engagement Officer could not adequately support self-sustaining red squirrel volunteer networks across the vast, dissected landscapes of southern Scotland, with its lack of direct travel routes, leading to growing slippage in meeting engagement targets. A decision was taken to divide the role into two new roles allocated to southeast and southwest Scotland, which has been found to provide a much more effective level of volunteer support.
- Staff roles evolve - during the current DCA phase, Grey Squirrel Officer roles have expanded to include extensive volunteer training via mentoring and shadowing as part of the network grey squirrel control schemes. They have also taken on some public engagement activities and administration duties with a view to ensuring a smooth handover of sites currently trapped by GSOs to volunteer controllers. The evolution of the role has required careful consideration, with adequate training and support to make sure staff are prepared to take on these differing responsibilities.
- Benefits of partner/stakeholder co-operation – in southern Scotland publicly-owned forestry includes significant amounts of grey squirrel habitat, particularly along forest edges where broadleaves and admixes of larch and pine are planted for amenity and landscaping value. Working with Forestry and Land Scotland (FLS) we were able to employ additional seasonal GSOs working under the SSRS umbrella to provide better coverage under a new funding agreement.

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	Medium
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Control work targeted to prioritised areas where it is coordinated and monitored in collaboration with a range of partners.

- Dedicated team of staff and volunteers, who are resilient, resourceful and creative in responding to setbacks and opportunities.

- Public recognition of the problems faced by red squirrels and the necessity for grey squirrel control measures has been greatly aided by the still widespread presence of red squirrels in the landscape and recognition of the threat as grey squirrels have moved in. There is still an acute sense of loss where red squirrels have only recently disappeared, and a passion for supporting work to restore them to local woodlands.

- Presence of large areas of upland conifer blocks where red squirrels can survive with very little competition from grey squirrels, providing source populations of red squirrels for lowland woodlands to be recolonised when cleared of grey squirrels.

Highlighting how challenges identified in 2015 have been approached

- Drawing on the lessons highlighted in the 2015 case study, SSRS changed focus away from squirrelpox virus (SQPV) containment to focusing effort on prioritised areas for red squirrel conservation in the presence of endemic SQPV in grey squirrels, enabling the project to side-step the difficulties of constantly chasing a disease front in favour of public empowerment to protect red squirrels locally.

- Challenges for landowners accessing funding schemes have continued over the past five years. The current Forestry Grant Scheme has a requirement for a Forest Plan or Forest Management Plan in order to access the grant. This can be a disincentive to landowner participation and can result in delays or discourage smaller estates/farms from applying, leaving significant gaps in the landscape-scale control network. The budget limitations have meant that it has not been possible to fund all requests for traps, creating reductions in the effectiveness of trapping on some key landholdings.

- The challenge of collecting easily analysable data has been greatly improved as project data systems are now managed through the newly-built online relational databases and SSRS Community Hub which has streamlined much of the project's data collection and analysis. The reluctance of a majority of volunteers to adopt the reporting facilities offered by the Community Hub has created an ongoing challenge, with Hub adjustments and greater training and engagement in progress to work towards addressing this issue.

- The current project has capitalised on the finding of huge enthusiasm among the public in southern Scotland for involvement in red squirrel conservation. This formed the foundation for the current five-year National Lottery Heritage Funded "Developing Community Action" phase of SSRS. The public response to the SSRS-DCA project has continued to exceed our expectations, leading to the formation of 12 new volunteer red squirrel protection networks since 2017.

Future project development

- Approaching the legacy phase of the project, SSRS plans to provide further training to volunteers over the next two years; allowing them to become more independent in record keeping (using the SSRS Community Hub), fundraising and volunteer recruitment.

- SSRS will assess what must continue to be provided by way of volunteer support and coordination for the period post-SSRS-DCA and seek funding to ensure required staffing and support structures are in place.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★ ★	★ ★
Live traps	★ ★ ★	★ ★ ★
Kill traps		
Pine marten (as natural grey squirrel predator)	★ ★	★ ★
Immuno-contraception (oral bait delivered via hoppers)		★
Gene Drive (Selected inheritance manipulated so only male young are born)		
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★	

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

References

I. Tipple N and Tonkin M (2020) Evaluation of Spring 2019 Squirrel Surveys. A Report for Saving Scotland's Red Squirrels: https://scottishsquirrels.org.uk/wp-content/uploads/2020/02/SSRS-SPRING-2019-SURVEYS.pdf

Red squirrels in South Scotland

Red Squirrel Forum for South Scotland

Geographical area of work

Local Authority Areas for the Borders and Dumfries & Galloway, South Scotland.

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Key partners

- Saving Scotland's Red Squirrels (SSRS: led by Scottish Wildlife Trust)
- Forestry and Land Scotland (FLS)

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	109 Trapping & shooting
Volunteers involved with squirrel monitoring	109 Includes some on SSRS Spring Survey
Other Active Volunteers	100 Admins, fundraisers, public awareness
Other info	Totals for 16 groups/ networks

Map of project land area

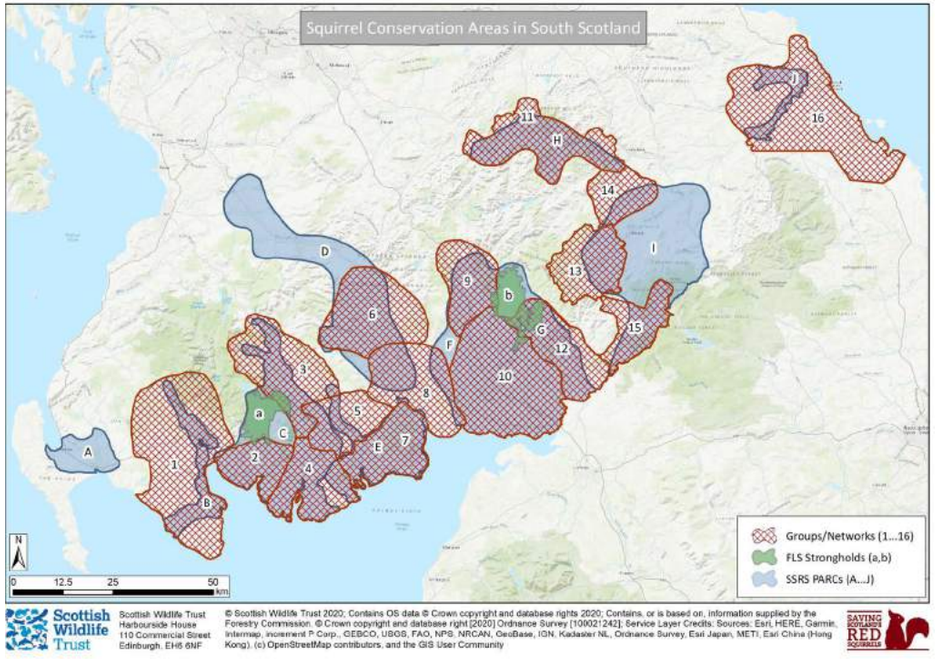

Figure 1. Map of red squirrel conservation areas in South Scotland.

Key:

Squirrel Groups/Networks: 1, East Wigtownshire; 2, Gatehouse; 3, Glenkens; 4, Kirkcudbright; 5, Castle Douglas & District; 6, Mid Nithsdale; 7, Solway Forests; 8, Lower Nithsdale; 9, Moffat & District; 10, Annandale; 11, Tweeddale; 12, Esk Valley; 13,Teviot & Borthwick; 14, Selkirk & Ale Water; 15, Liddesdale; 16, Berwick.

Red Squirrel Strongholds (Forestry & Land Scotland); a, Fleet Basin; b, Eskdalemuir
Priority Areas for Red Squirrel Conservation (PARCs, SSRS): A, Luce; B, Cree-Machars; C, Glenkens; D, Nith Valley; E, Solways Forests; F, Annan Valley; G, Esk Valley; H, Upper Tweed Valley; I, Teviot & Rule; J, Berwickshire

(Map prepared by Nicole Tipple, SSRS)

Introduction

Early 20th century introductions of grey squirrels (*Sciurus carolinensis*) into the central lowlands of Scotland did not bring Squirrelpox virus (SQPV) into the country as introductions into England had. However, by 2008, grey squirrels seropositive for SQPV were detected at multiple locations close to the border with England almost certainly as the result of northward grey squirrel dispersal. By 2014, SQPV had crossed several watersheds to reach the central lowlands, adding to the level of competitive threat faced by red squirrels (*Sciurus vulgaris*) throughout south Scotland. Grey squirrels have now largely replaced red squirrels in some areas (e.g. upper Tweed, Berwickshire), continue to infiltrate generally, and have also occupied woodland areas not recently known to have held red squirrels.

Pine martens (*Martes martes*) are also increasingly evident: there was a small reintroduction by the then Forestry Commission into Galloway Forest Park in 1981, and it is thought that recent releases of rescued and rehabilitated individuals have seeded a separate population in the Borders. Saving Scotland's Red Squirrels (SSRS) revised and increased the number of Priority Areas for Red Squirrel Conservation (PARCs) to 10 in 2019, covering all or part of the major river catchments in south Scotland. In 2010, Forest Enterprise Scotland (now Forestry & Land Scotland) demarcated two Red Squirrel Strongholds in Dumfries & Galloway, with which two of the PARCs overlap.

The Red Squirrel Forum for south Scotland is an umbrella body for all volunteer Squirrel Groups/Networks (SG/Ns) in the region. It's prime functions are to (1) facilitate mutual self-help amongst all SG/Ns, (2) represent the role of the volunteer sector at regional, national and UK-wide levels and (3) promote the work of its SG/Ns through its website, the media, workshops and meetings.

Project aims

- The overall goal is to promote the long-term conservation of red squirrel populations in south Scotland through concerted and sustainable volunteer action.
- The Forum works in partnership with the current SSRS project (2017-22) and represents all its constituent SG/Ns.
- Its focus is on areas adopted by its current 16 SG/Ns, which deliberately overlap with the 10 PARCs demarcated by SSRS.
- Objectives, with much variation across SG/Ns, variously include: preventing further spread of grey squirrels; reactive protection of red squirrels following SQPV outbreaks; natural re-establishment of red squirrels following localised reduction of grey squirrels and awareness-raising in the general public.

Description of the project

Figure 2. Publicity leaflets for the Teviot and Borthwick valleys, Scottish Borders (© Nigel Sargent)

Figure 3. Donations are offered in exchange for free used ice cream boxes at Cream o' Galloway, Gatehouse of Fleet (© Peter Garson).

Figure 4. Sandy the squirrel at Glenkens Show, New Galloway (© the late Brian Fishwick).

Figure 5. No explanation required! (© Peter Garson).

The Forum was brought into existence in 2018 as the regional volunteer partner in south Scotland for the current SSRS project, which is subtitled 'Developing Community Action'. The Forum is designed to be the permanent umbrella body for its constituent SG/Ns and all their volunteers. It is run by a Board comprised of representatives of the SG/Ns, which are also affiliated to SSRS. The Forum has no funds but has the potential to apply for grants through one of its SG/Ns (some are registered charities).

SSRS has a prime role in the formation and support of new SG/Ns, including equipment provision and training. Individual SG/Ns oversee their own local activities for surveys, grey squirrel control, awareness-raising and fund-raising (although annual maintenance support is currently available from SSRS) (Figures 2,3,4 & 5). The majority of volunteer effort in surveying and grey squirrel control is focused on private land. Surveys and grey squirrel control by trapping within the National Forest Estate (managed by Forestry and Land Scotland) can be permitted for specified locations and time periods via an arrangement between SSRS and FLS. Private wooded landholdings may obtain Forestry Grant Scheme support from Scottish Forestry for grey squirrel control: volunteers are sometimes invited by landowners to help with these grant-aided initiatives.

The Forum organises an Annual Meeting to bring together its volunteers with those representing the border counties in England (via its sister volunteer forum, Northern Red Squirrels [NRS]), staff from ongoing funded projects (SSRS, Red Squirrels Northern England [RSNE]), professionals with related responsibilities (FLS, UK Squirrel Accord [UKSA]) and scientific expertise (e.g. specialists on squirrel diseases, pine marten biology and contraception research). It assists individual SG/Ns in running training workshops (e. g. survey techniques in 2019 c/o Solway Forests Red Squirrel Network). It is also overseeing a mutual self-help scheme amongst all SG/Ns. Those with substantial experience with any component of a comprehensive portfolio of activities (e.g. grey control, fundraising, working with schools; 19 activities in all) are asked to offer advice and training to other SG/Ns which are asking for help in developing their capacity in new directions. Information on all needs and capabilities is captured in a chart including all SG/Ns and activities. This is posted on the Forum website, along with SG/N contact details, in addition to a comprehensive collection of advisory documents and list of links to UK squirrel-related websites.

Success indicators within the project

- Holding two Board meetings per year.
- Holding an Annual Meeting for all SG/Ns and other volunteers, also attended by staff from SSRS and FLS, and representatives for northern England (RSNE, NRS) and UK (UKSA).
- Setting up the 'Offers and Needs' chart to facilitate mutual self-help amongst all SG/Ns.

Major difficulties faced

- Persuading well-established SG/Ns to be ambitious in expanding their range of activities, including the attraction of volunteers with novel skills and experience.
- Encouraging newer SG/Ns to seek help from others in developing their activities and skills.
- Networking with volunteers not currently linked to SG/Ns, such as those involved with the SSRS Spring Survey or Trap Loan schemes (GDPR is an impediment).

Major lessons learned

- Keep it simple! The Forum operates on the basis of a one-page Terms of Reference document and has no bank account. Every SG/N has a seat on the Board.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- The formation of the Forum was encouraged by SSRS, which currently provides funding to support its events.
- It was set up on the basis of advice from key players in both Red Squirrels Trust Wales and NRS, the neighbouring volunteer forum in the north of England.

Future project development

- To better facilitate the exchange of knowledge, experience and skills amongst all SG/Ns, as the SSRS project and the support it provides is scheduled to reduce from early 2022.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★★★	★★★
Live traps	★★★	★★★
Kill traps		★★
Pine Marten (as natural grey predator)	★★	★★★
Immuno-contraception (oral bait delivered via hoppers)		★★★
Gene Drive (Selected inheritance manipulated so only male young are born)		??
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

Timber harvesting protocol in red squirrel areas

The European Squirrel Initiative

Geographical area of work

The Blackwood Estate, Auldgirth, Dumfries & Galloway, Scotland

Author and organisation contact details

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European Squirrel Initiative

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Key partners

- Mid-Wales Red Squirrel Project
- University of British Columbia (Wildlife Department)

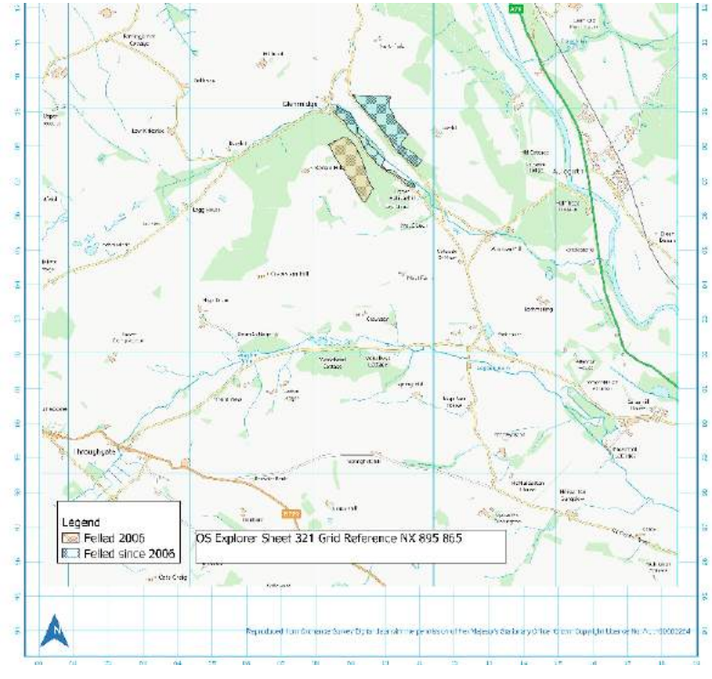

Figure 1. Landscape area showing woodland and two clear-felled areas.

The project area is a typical Scottish lowland river valley (Glen Midge, Auldgirth, Dumfriesshire). The woodland is owned and managed by a mixed enterprise private estate. The valley is steep sided but internal access is poor. The valley bottom is highly suitable for conifer production and adjacent open land provides winter grass for livestock. Sheep graze the hill tops and valley bottoms. The wooded valley grew 70% Sitka spruce (*Picea sitchensis*), 15% Lodgepole pine (*Pinus contorta*). 5% beech (*Fagus sylvatica*) and 10 % poplar (*Populus* spp.). Timber harvesting has always been dictated by the local timber prices. The first area felled left only a small area of very poor Lodgepole pine and a strip of beech to the north. The rest of the area to the west of the main block was young conifer, not suitable for sustaining red squirrels (*Sciurus vulgaris*). The second area of felling was of the only remaining stand that was suitable for sustaining red squirrels.

Introduction

Red squirrel distribution in the British Isles has largely been stable except at the interface with grey squirrels (*Sciurus carolinensis*). When sympatric with the introduced species and culling occurs, red squirrels increase in number and populations expand, as they have done on Anglesey and in parts of Ireland.

Populations fluctuate in size in relation to food availability and population census assessments must attempt to account for cone mast/production years. If forest managers do not do this then how are we able to form meaningful local, regional and national conservation strategies? Habitat structure and tree seed productivity are important when considering likely red squirrel carrying capacity in the light of proposed forestry operations.

Red squirrels are protected by the Wildlife & Countryside Act (1981). It is an offence to damage, destroy or obstruct access to any structure or place which a red squirrel uses for shelter or protection (a drey). In 2019, Forestry Commission Scotland (FCS) were granted a licence by Scottish Natural Heritage (SNH) to continue timber harvesting in all areas where there are red squirrels across Scotland. The licence indicated that in each year, less than two percent of the plantation habitat on the National Forest Estate is clear felled, and nearly two thirds of this is Sitka spruce, which supports the lowest density of red squirrels. Timber operations tend to be small relative to the population ecology of red squirrels and their large home ranges in conifer forests (e.g. 11 to 14 hectares per individual in spruce). Overall, clear felling in all of Scotland is roughly estimated to displace between 1000 and 2000 red squirrels each year, depending on food availability and thus the population density at the time.

Forest operations inevitably remove squirrel habitat and may impact local populations. Animals affected by clear felling may disperse into adjacent crops, and although FCS have no records of adult red squirrels being killed directly by forest operations there are challenges in monitoring this. Harvesting of timber can, however, be improved with better thought. There are clear examples from around the world of where this has happened and what the issues are that conservationists are up against.

Year	Number of Red Squirrels	Where	Reference
18th Century	'to the point of extinction'	Scotland	Harvie-Brown, Fraser-Darling Monica Shorten
1890	'Becoming extremely abundant throughout the British Isles'		Monica Shorten and in White's Natural History of Selborne
1990s /2000	400 – 600+	Jersey	Louise Magris This has increased due to supplement feeding
2017	160,000	75% of these are in Scotland	'Atlas of Mammals of Aberdeen & the Cairngorms 2017'
2017	140,000	IRELAND	Ulster Wildlife
2018	121,000 – 160,000 Approx 30,000	UK England	Wildlife Trusts website People Trust for Endangered Species website
2018	55,000	Scotland (FC land only)	SNH / FC recent document
2018	1,000	Wales	Halliwell et al. (2015)

Project aims

- **To ensure better site planning.** The direction in which the felling (if clear felling is to be undertaken) is to take, should be considered. Is it driving the red squirrels towards other mature trees and refuge? Are connecting tree corridors being left? Are there any rope or net bridge crossing provided?

- **Better timing of harvesting operations.** Where possible, don't harvest when young red squirrels are in the dreys. There is a need for accurate identification and buffer zones around dreys with arboreal escape routes.

- **Better use of harvesting pattern.** This can be done on many sites but not all, by adopting the 'Fraser-Darling' technique i.e. harvest and working outwards from inside the forest stand.

Description of the project

Much emphasis is placed on the control of grey squirrels in order to help red squirrels. It is the major part of the picture at the 'Interface' between red and grey squirrels (Figure 2). This is vital but is only a small part of the bigger management picture.

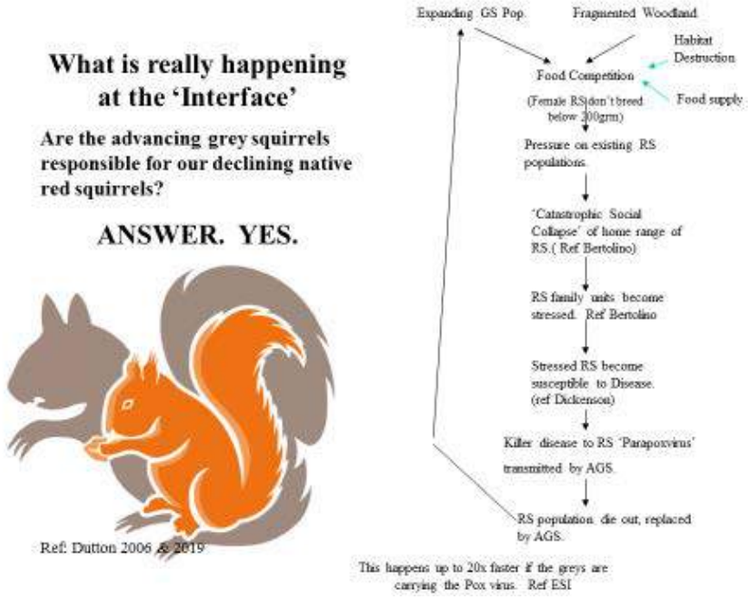

Figure 2. Grey squirrel / red squirrel interactions.

We should remember that the majority of red squirrels in Great Britain are not immediately threatened by grey squirrels. However, they are potentially affected by timber harvesting This can have a huge impact on local populations and where there are a few large landowners operating, a change in the 'land managers' policy or a dramatic increase in timber prices, can, does and will, have a huge negative effect on the local red squirrel population, as has been seen in parts of Dumfries and Galloway, also in Aberdeen-shire in the past couple of years. This point is highlighted in Figure 2 with arrows in green, and it also effects winter food availability. Both factors, habitat and resource availability effect the survival of the local red squirrel population.

To minimise 'habitat destruction' and thus potential declines of this highly protect species, a clear long-term plan is required where red squirrels are present, to identify suitable habitat for squirrels to move into if clear fell harvesting is to take place. If clear fell harvesting is the preferred silvicultural method of harvesting (instead of group felling of strip felling or CCF etc), then careful consideration must be given to the time of year when harvesting and how the harvesting is to be done, i.e. which compass direction operations move towards.

The case in Glenmidge (Figure 3) demonstrated the catastrophic effect that a poor harvesting plan has on a local population. The first clear fell area was felled going away from other trees and in June, simply because 'that was where the gate into the wood was', I was told by the owner of the estate. Forestry Commission 'Thinning Licences' do not have to go out to public consultation, only if there is clear felling. Therefore, records of red squirrels can be unrecorded and not feature or 'show-up' when the licence is being issued as was the case on Anglesey in 2019, particularly if the records are collected by people other than recognised groups, like SNH or Natural England.

When harvesting, larger groups of trees around dreys must be left, not just individual trees and these groups must have 'escape routes'. These trees can be harvested later on if required. How many times do you see on a large clear fell site with not one tree left standing or a group; it happens all too often, if you don't believe me, please visit any harvesting area in Scotland today and the vast majority will be a large cleared area.

When harvesting crops, Fraser-Darling taught farmers in the west Highlands to cut hay from the centre of the field outwards in order to save the corncrake (*Crex crex*), as it would run (not fly) through the grass and would not break cover, people thought he was mad, but he was not. A similar style of tree harvesting could be achieved today as most harvesting is done with large processing machines, rather than motor manual operators and ALWAYS harvest the crop toward other suitable crops.

The picture below is of the eastern side of Glenmidge after the more recent clear fell. Note not a single drey tree was left in an area known for red squirrels.

Figure 3. Glen Midge, June 2019 following clear felling operations. This is a well known red squirrel area, note the lack of drey trees being left. This hillside was pure spruce with a mature spruce and Poplar crop in the valley bottom. All trees now gone and no red squirrels. Habitat destroyed.

Major difficulties faced

- Obtaining meaningful change in the timber Industry e.g. Australia and Finland where timber harvesting has decimated the population of the Siberian flying squirrel (*Pteromys volans*) in the Aspen forests and the Koala bear (*Phascolarctos cinereus*).

- in the blue Gum forests (*Eucalyptus* spp.) in Australia. The industry is too powerful and can over 'trump' conservationists every time and it does NOT need to be like this.

- Below is a clump of trees left with a Koala in them but with NO arboreal escape route. These are Gum trees but they could as easily be Sitka Spruce.

Figure 4. An example of poor forest management practice.

- Better funding for wildlife and regulatory inspectors to enforce harvesting licences is required, with teeth to fine firms that break the law.

- A willingness to listen, learn and understand about the issues and to try to improve the situation, rather than the standard 'this is my territory or country, please don't tell us what to do' by the authorities!

Major lessons learned

- Poor planning and timing of the harvesting operation can have an unnecessary negative impact upon red squirrels.

- An absence of longer-term planning of crop management is sometimes apparent, answering the question, 'if we fell that, what will happen to the population of whatever species' needs to be universally considered.

- SNH and FCS in recent years have developed regulatory timber licensing which seeks to ensure a balance between timber production and wildlife conservation. There are examples such as Glen Midge valley where red squirrel populations locally decline because of local harvesting. SNH and the FCS need to be willing to listen and understand what is being said and suggested to learn lessons from this.

- There needs to be a much better processing of timber harvesting licencees involving ALL those who have an interest or knowledge without it taking additional time.

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Timber merchants do not want to incur ANY extra costs to harvesting whether actual of perceived and will fight hard not to increase labour on harvesting operations.

- There is a basic failure to engage by all Regulators in looking at the issues and asking 'how can we improve what we are doing' to conserve and restore our native fauna and flora. Only information or research will be used that has been commission by the said Regulators, rather than using ALL information that is available.

Future project development

- I would like to work with any organisation on a Landscape Trial over say five years, where perhaps two sites close to each other could be managed; one site conventionally and the second site using the my 'Fraser-Darling's style of harvesting.

- I would like to work with any National Timber harvesting bodies to improve the Harvesting licencing systems.

References

I. Dutton C (2016) *The grey squirrel management handbook*. ESI

II. Shuttleworth (2018) https://theconversation.com/rare-woodland-wildlife-at-risk-because-of-50-year-old-tree-felling-rules-107535. The Conversation

Red squirrel reintroduction project

Trees for Life

Geographical area of work

Scottish Highlands

Author and organisation contact details

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Website: treesforlife.org.uk/red-squirrel-reintroduction-project/

Facebook: treesforlifeuk
YouTube: Dundreggan

Key partners

- Scottish Natural Heritage (licensing authority)
- Forestry and Land Scotland, Darnaway Estate, Cawdor Estate (trapping sites)
- Ben Shieldaig Estate, Kinloch Woodlands SCIO, Coulin Estate, National Trust Scotland, Reraig Estate, Attadale Estate, Lochletter Estate, Woodland Trust Scotland, Ardtornish Estate (release sites)
- University of Edinburgh (genetic testing of hair samples)
- Inverness Men's Shed (nest box construction)
- Schools throughout the project area

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	1.5 One full-time and one half- time member of staff
Volunteers involved with Grey control	0
Volunteers involved with squirrel monitoring	20 Reporting sightings & feeding sign
Other Active Volunteers	35 Translocation assistants & supplementary

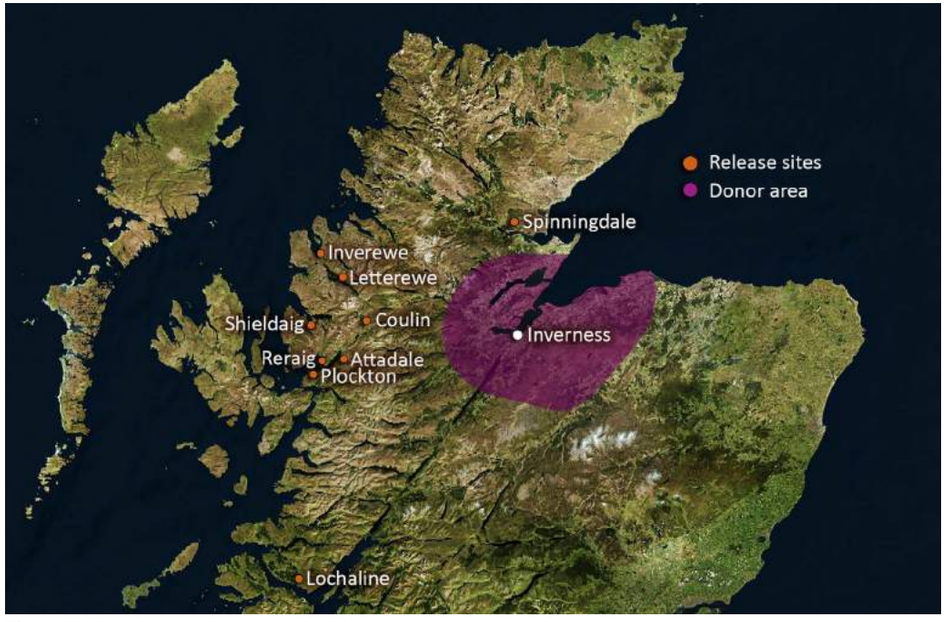

Figure 1. Map of project land area. Red Squirrel Reintroduction Project Area.

Introduction

Red squirrels (*Sciurus vulgaris*) were once present across most of the Scottish Highlands. However, prior to any recent translocations, red squirrels were missing entirely from the northwest. Many of the last sightings were in the 1970s and it is likely that their decline was due to the widespread deforestation that occurred during and after the wars, as well as persecution from the Highland Squirrel Club which killed circa 103,000 reds between 1903 and 1946.

Since the loss of red squirrels from the northwest there has been large-scale re-afforestation and there is now an abundance of suitable habitat there. However, as it is separated from current red squirrel range by large expanses of open landscapes, it is unlikely to be re-colonised naturally. Critically, there are no grey squirrels (*Sciurus carolinensis*) in the Highlands, so translocating red squirrels to suitable forests in the northwest provides an opportunity to create a series of new populations that can expand without threat of competition or disease from grey squirrels.

There are locations across the central Highlands that are classed as red squirrel strongholds. The project does not directly work in any of them but operates close to the Black Isle stronghold just west of Inverness and Daviot Loch Moy to the south. Pine martens *(Martes martes)* exist in healthy numbers across the project area.

The project is run by one paid member of staff with assistance during the translocation seasons from several volunteers. We also have a member of staff who works 50% time on community engagement. Funding is primarily from charitable trusts.

Project aims

- Reintroduction of red squirrels to the northwest Scottish Highlands.

Description of the project

The aim of the project is to reintroduce wild-caught red squirrels to suitable sites in the northwest Scottish Highlands, restoring them to their former range and creating new populations that are free from the threat of grey squirrels. In the long-term, this has the potential to make a significant increase to both the numbers and range of red squirrels in the UK.

There are four key aspects to the project:

1) Release sites

Release sites must meet criteria that have been agreed with NatureScot as part of a project licence. These are based around historical presence of red squirrels, habitat size, quality and connectivity, landowner agreement, consultation with neighbouring landowners and local communities, and long-term management of the woodland.

Once a site has been confirmed as suitable, a meeting is held with the local community to give people an opportunity to ask questions or raise concerns and to offer them the opportunity to volunteer on the project.

Between 20 and 30 red squirrels are released at each site, depending on the degree of connectivity to other woodland.

2) Donor sites

The project works only with wild red squirrels and these are trapped (under licence) from both woodlands and residential gardens within approximately a 40-mile radius of Inverness. This area is free from Squirrelpox and to ensure that there is no negative-long-term impact on donor populations we do not trap at densities of more than two squirrels per 200 ha per year.

Woodland sites are pre-baited for up to a month before trapping and a team of volunteer assistants is employed to help with this. Forestry and Land Scotland is a key partner as

we trap widely across their land, as well as on other local estates. Residential gardens are sourced by visiting houses that border woodland.

3) Translocation

Figure 2. Red squirrel in a trap.

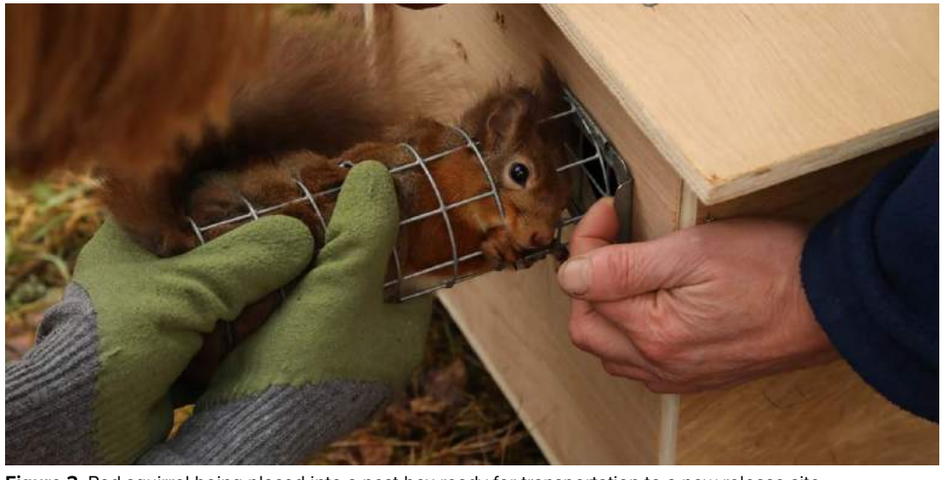

Figure 3. Red squirrel being placed into a nest box ready for transportation to a new release site.

Translocations are carried out in February-March and October-November, to ensure that we do not trap females with dependent young. Traps are set at first light and checked hourly (Figures 2 & 3). All red squirrels are given a health inspection to ensure that they do not have any diseases or injuries that would make them unfit for translocation. These checks take place in the field and include collecting hair samples for genetic analysis. The red squirrels are then placed into nest boxes lined with hay and provisioned with nuts and a slice of apple and transported to the release site. Once there the boxes are secured to trees and some moss is placed in the exit hole. The red squirrels leave the boxes at first light the next morning, when there are no people around.

We provide supplementary food for up to six months after release to help the red squirrels settle in to their new habitat. This is carried out either by local volunteers or by, e.g. estate staff at the release sites.

4) Monitoring

Annual monitoring is carried out for five years after release. This is in the form of presence-absence surveys across the available woodland area, in addition to the compilation of sightings and breeding reports.

We have carried out nine translocations so far, to Shieldaig, Coulin, Plockton, Reraig, Inverewe, Letterewe, Attadale, Spinningdale and Lochaline. All have been successful, and the populations are breeding and expanding throughout the available habitat. Of particular interest are the long-distance movements that we have recorded from red squirrels at a number of release sites – distances of up to 19 km and over some areas of open ground.

The project has been running since 2016 and has been funded in two stages. The initial three years was through the National Lottery Heritage and the current phase is funded by several smaller grants and trusts including the People's Trust for Endangered Species and the European Outdoor Conservation Association (Figure 4).

Figure 4. Community engagement - stall at Belladrum festival. -®Trees for Life

Stage 1 (2016-2019) was run by one full-time member of staff. We found that there was a huge opportunity to engage positively with local communities and so for Stage 2 we are employing a second member of staff at 50% time to work with schools and other groups around the release sites. The project is highly dependent on volunteer assistance; several assistants are employed to help with each translocation (mainly pre-baiting and trapping) and to carry out supplementary feeding at release sites.

Success indicators within the project

Figure 5. Volunteer releasing a red squirrel from nest box. -®Lynda Simpson

- Red squirrels are successfully translocated to the release site with no injuries or deaths (Figure 5).
- Our short-term indicator is that red squirrels are still present at the site one year after release, that there is evidence of breeding and that the population is feeding on natural foods.
- Our long-term indicator is that red squirrels are still present at the site five years after release and the population is expanding throughout the available habitat.

Major difficulties faced

- Funding phase two of the project was challenging. We would like to carry out a third phase when this phase finishes but anticipate funding to be even harder to secure.

Major lessons learned

- Trapping from gardens is much less resource intensive than trapping red squirrels in larger woodlands.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- All nine translocations (180 red squirrels) have been completed with no injuries to or loss of red squirrels other than one that was subsequently found to have had pneumonia.
- All seven translocated populations are still present one year after release (a year has not yet passed at the other two release sites). There is widespread evidence of natural feeding and successful breeding and expansion throughout the available habitat.
- Five years has not yet elapsed since any of our translocations, hence a ‘Highly Successful’ assessment cannot be made. We anticipate that the criteria for this will be met at all sites and that we will, in time, be able to define it as ‘Highly Successful’.

Current and future importance of contemporary and future methods of grey squirrel control.

There are currently no grey squirrels in the Highlands. Trees for Life participated in Emma Sheehy's research on pine martens, red squirrels and grey squirrels, and believe pine martens could be a key potential natural control for grey squirrels which should be researched further.

References

I. Sheehy E, Sutherland C, O'Reilly C & Lambin X (2018) The enemy of my enemy is my friend: native pine marten recovery reverses the decline of the red squirrel by suppressing grey squirrel populations. *Proceedings of Riyal Society B.* doi.org/10.1098/rspb.2017.2603.

Brampton and District Red Squirrel conservation

Brampton and District Red Squirrel Group (B&DRSG)

Geographical area of work

North Cumbria/southwest Northumberland, England

Author and organisation contact details

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Facebook: @BramptonDistrictRedSquirrelGroup

Key partners

- Northern Red Squirrels
- National Trust
- Woodlands.co.uk
- RSPB
- Woodland Trust
- Parish Councils
- Private and individual landowners, and members of the public

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	40 More shooters than trappers
Volunteers involved with squirrel monitoring	6
Other Active Volunteers	31 Members of the public who currently monitor traps in their gardens/on their land
Other info	150 Members of B&DRSG

Map of project land area

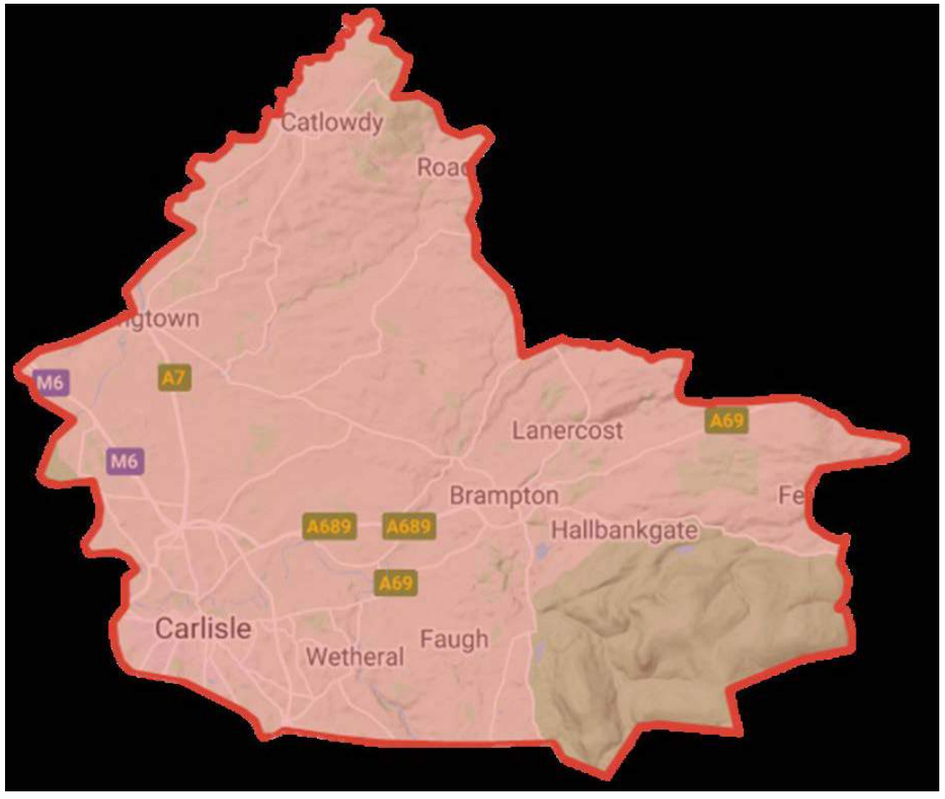

Figure 1. B&DRSG Areas of Operation Map.

Brampton and District Red Squirrel Group (B&DRSG) operates in an area from the fringes of Kershope Forest in the north spreading west along the England/Scotland border to just south of Carlisle. The geographical area then moves east to Lambley in Northumberland and then northwest back up to Kershope.

Introduction

Historically, red squirrels (*Sciurus vulgaris*) were in abundance in the Brampton area of north Cumbria. A news report in the summer of 2007 highlighted a decline in local red squirrel numbers, a fact coinciding with the local invasion of grey squirrels (*Sciurus carolinensis*) to this part of the county. This news prompted the launch of the B&DRSG in September of that year.

With increasing volunteer support, coordination and local knowledge, the group were able to identify and target significant grey squirrel populations threatening the local red squirrels. The group expanded into neighbouring and surrounding land areas in the summer of 2010 and expanded further in January 2020.

The group holds registered charity status as ‘Brampton & District Red Squirrel Group’, is a volunteer-based community red squirrel group and for 12+ years has contributed immensely to the red squirrel conservation movement in the north of England.

Project aims

The group’s project seeks to manage grey squirrels in order to consolidate and expand the regional red squirrel population.

Specific objectives:

- To maintain a community-based contribution to the wider integrated conservation of red squirrels in northern England.
- To raise awareness of the plight of the red squirrel through community events and educational activities.

Description of the project

The project has secured access and landowner permission and delivers direct and practical red squirrel conservation by managing grey squirrel populations across key target areas. The woodlands covered within this project are a range of broadleaved, coniferous and mixed deciduous habitats.

We systematically trap (live trapping) and shoot grey squirrels that currently threaten our existing red squirrel population. The retention of red squirrels in the project area contributes towards the wider regional conservation of red squirrels in adjoining areas within the landscape of the two counties of Cumbria and Northumberland, in the north of England. We have many other resources to aid our work including trail cameras for monitoring sites and thermal imaging cameras which have proven to be an invaluable resource in detecting grey squirrels which can then be culled.

All of our group’s work is carried out by volunteers. We have approximately 40 regular operatives involved in conventional grey squirrel management and with a flurry of new operatives coming on board, particularly in 2019, we now have more shooting than trapping. The group membership currently sits at 150.

Volunteer work encompasses administration, fundraising, the provision of talks, project representation at shows and events, management of the group’s activities, record coordination, charity collection box monitoring, merchandise sales and media representation.

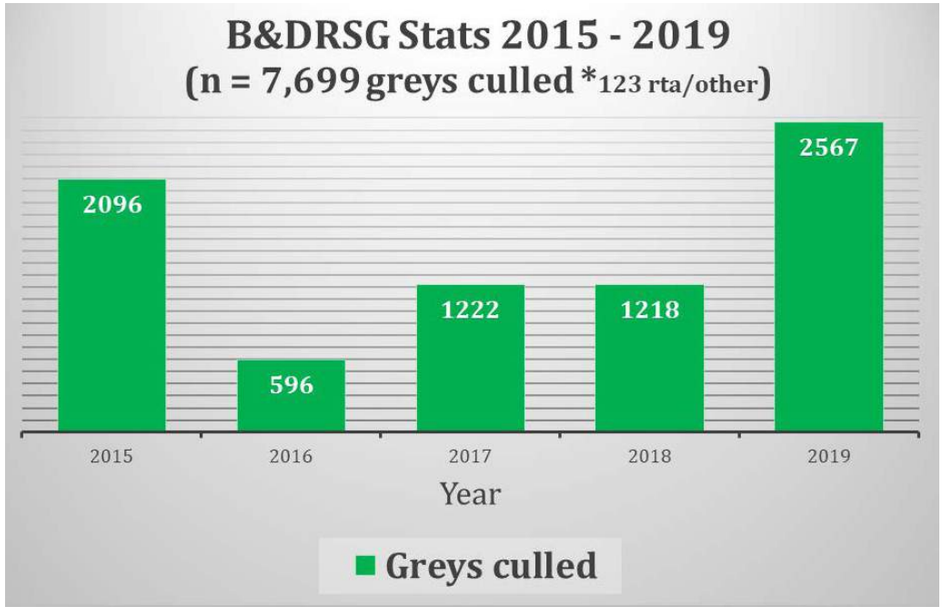

Figure 2. B&DRSG Grey squirrel cull statistics 2015-2019.

Our operatives have successfully removed 7,699 grey squirrels (Jan 2015 through Dec 2019) (Figure 2) since the last publication study five years ago and red squirrels have returned to many areas following grey squirrel management. However, grey squirrels continue to move in from all directions so we must provide continuity of grey squirrel management work to ensure the benefits to red squirrels are maintained.

Our management programmes focus upon restricting grey squirrel invasion from the incursion corridors of both the Gelt and Eden rivers. Work is ongoing and we will continue to facilitate grey squirrel removal and complete our standardised records which provides us with invaluable data.

Success indicators within the project

- Secure and maintain woodland sites as grey squirrel-free as long as possible in order to allow the return of red squirrels to such habitats.

Major difficulties faced

- The prevalence of grey squirrels in some urban areas can be problematic and without access or management, leaves opportunities for grey squirrels to breed and spread out, with the risk of displacing red squirrels.
- Grey squirrel management in areas where the public have access is often difficult. Traps and monitoring cameras are occasionally damaged and/or stolen, and grey squirrels have been released from traps.
- A lack of support from a large ‘Trust’ landowner that won’t allow shooting as an effective method of grey squirrel management is disappointing.
- Lack of funding to pay for actual “boots in woods” (Figure 3).
- Outdated government policies hinder efficient landscape-scale conservation efforts.
- Forestry operation practices, such as clear-felling red squirrel habitat during the breeding season demoralises volunteers.

Major lessons learned

- Red squirrels have returned to several woodland areas following intensive and sustained grey squirrel management.
- Population monitoring using feeding stations and other sighting records obtained, and the use of thermal imaging cameras (Figure 4), are all invaluable components of the project.

Figure 3. B&DRSG Volunteer using thermal imaging equipment.

Figure 4. B&DRSG 'Boots in Woods' work.

- Grey squirrels continue to move into woodland sites previously controlled and repeated management is therefore always necessary.

- The same, if not more effort, has to be applied to remove that one remaining grey squirrel that was missed during management relative to the initial removal of many resident animals!

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Red squirrel distribution has been maintained and many local populations have recovered following grey squirrel management.

- Increasing support, coordination, local knowledge and the use of technology are key to the ongoing success of this project.

Future project development

- The B&DRSG are keen to further develop our proven success where woodlands have been repopulated with red squirrels (following grey squirrel management) following an absence of many years.

- We will seek additional funding to provide continuity of grey squirrel management work where clear benefits to red squirrels will be demonstrated.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in <u>developing</u> this aspect of grey squirrel management in your project area
Shooting	★★★	★★★
Live traps	★★★	★★★
Kill traps		
Pine Marten (as natural grey predator)		
Immuno-contraception (oral bait delivered via hoppers)		
Gene Drive (Selected inheritance manipulated so only male young are born)		★★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

Grasmere red squirrels

Grasmere Red Squirrel Group

Geographical area of work

South Lakes District & Lake District National Park, Cumbria, England

Author and organisation contact details

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Key partners

- National Trust
- Red Squirrels Northern England (RSNE)

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	
Paid Contractors (7-12 months)	1 Part time
Volunteers involved with Grey control	4
Volunteers involved with squirrel monitoring	1
Other Active Volunteers	Householders report greys and are willing to have traps in gardens Many (50) house-holders have had traps in the past

Map of project area

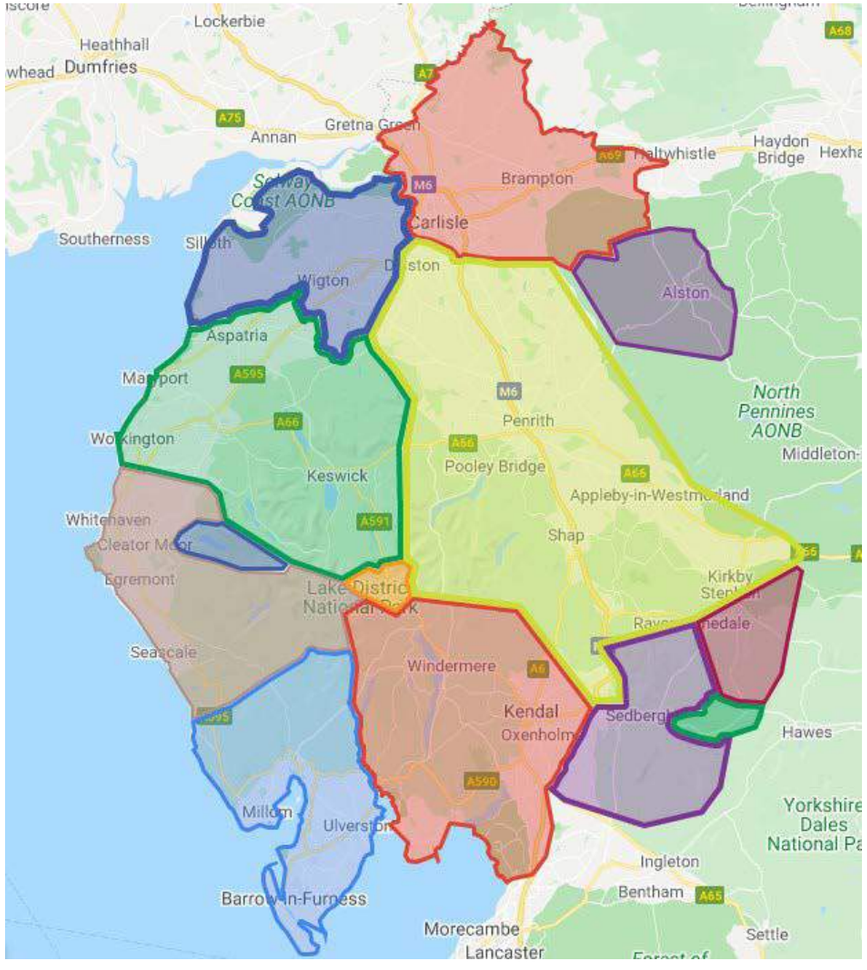

Figure 1. The location of Grasmere Red Squirrel Group within a network of English voluntary groups is shown in orange.

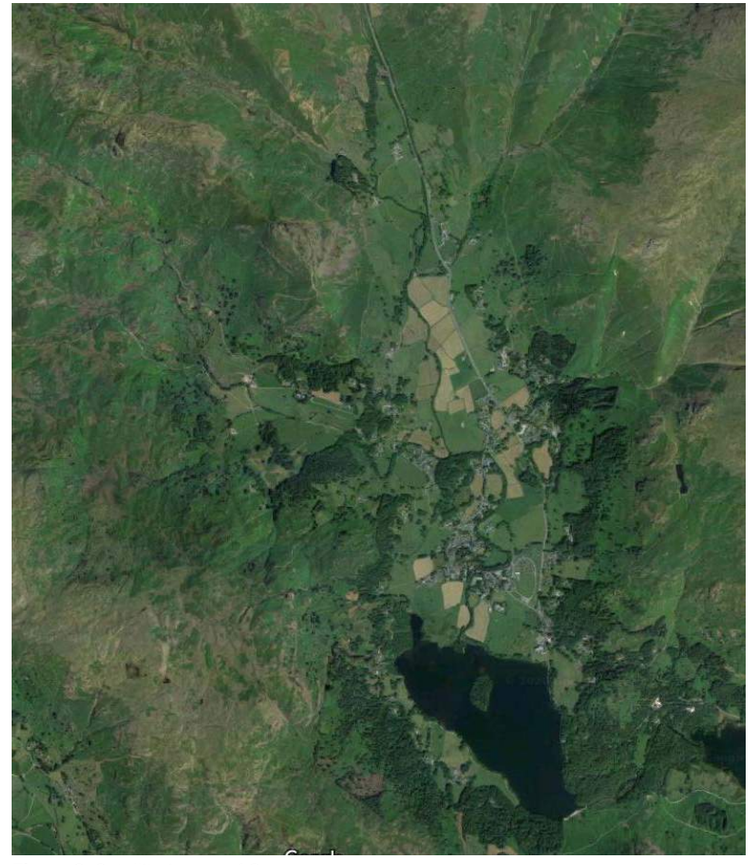

Figure 2. Satellite image of Grasmere.

The area is 36 km^2 (14 sq miles) (Figures 1 & 2) with a total of 200 hectares of woodland. The National Trust is the largest owner of woodland. The Lake District National Park is selling its woodlands and now just one remains in their ownership. The rest of the woodland habitats are in private ownership. There are several Larch (*Larix* spp.) and Conifer plantations but the majority is broadleaf predominantly Oak (*Quercus* spp.) and Beech (*Fagus sylvatica*) with a number of small estates around Victorian houses containing tall mature specimen pines (*Pinus* spp.) and other conifers. The woodland forms a fairly narrow ribbon on both sides of the valley (Figure 2).

There are approximately 700 residents and over 42% of the dwellings are second homes or holiday lets. Most of the year numbers of people are swelled by day visitors, and holiday-makers staying in hotels, guest houses and self-catered accommodation. Apart from the central village and several clusters, dwellings are spread out around the valley.

Introduction

The English Lake District has always had red squirrels (*Sciurus vulgaris*). Grey squirrels (*Sciurus carolinensis*) arrived in the 1970s and numbers increased in the 80s and 90s with literally 100s resident by the year 2000. The red squirrel population almost suffered a local extinction in 2002 with a massive outbreak of Squirrelpox virus. The only reason that the red squirrels survived was the dedicated work of a few individuals who controlled grey squirrels. The red squirrels were forced to the outer peripheral edges of the woodlands.

The Grasmere RSG was formed early in 2006 and we now have a good population of red squirrels. There are no pine martens (*Martes martes*) in the area.

Four kilometres to the north is the edge of the Thirlmere Red Squirrel Reserve/Stronghold though there is infrequent grey squirrel control there. The area of the original buffer zone associated with the Reserve was extended southwards to include all of Grasmere and hence was eligible for England Woodland Grant Scheme EWGS (and Woodland Improvement Grants, WIG) grants. This funding historically provided the bulk of the Grasmere groups' funding, however most of these grant schemes were terminated in 2015. No landowner has applied for the replacement funding, a Stewardship scheme, for which the administration is far too burdensome for owners of small woodlands.

To the east and west are ridges of mountains reaching an altitude of 400-760 metres; at the northern end the vale splits into several valleys all ending at least at 230 metres. This forms a natural boundary on three sides, well above the tree line (only very occasionally have grey squirrels been seen on the fells and the road to the north). To the south-east and south-west, where the grey squirrels come from, the valley continues to Rydal and the adjacent valley of Great Langdale.

The Grasmere group is run by volunteers and since 2012 pays for one part-time ranger who shoots grey squirrels.

Project aims

- Protection of red squirrels from Squirrelpox virus
- Maintaining/expanding the red squirrel population.
- Preventing grey squirrels reaching the Thirlmere Stronghold from the south.

Description of the project

With the formation of the Grasmere Red Squirrel Group in early 2006 we were able to coordinate effort and record statistics which have been very valuable for identifying trends

and developing strategy. In 2009, we decided to remove all the grey squirrels in the area starting in the north and working southwards. With the large population of grey squirrels trapping was very effective. The red squirrel population increased, and they had second litters in 2010.

From 2009 to 2012 the bulk of the control work was carried out by three people though over 20 people have helped with dispatching grey squirrels, and more than 50 households have helped with monitoring traps. We built a network of over 100 people who contributed by monitoring garden feeders and walking local woodlands. The work has been a real community effort, carried out entirely by people living in the village, at least until 2017 as our current ranger lives in an adjacent valley.

We deployed mainly 'Beck' feeder/traps (designed in Cumbria) which catch only grey squirrels based on weight, allowing red squirrels to access the food and escape should they set off the trap. They have many advantages over live capture cage traps but cost much more and unfortunately are no longer in production. We also put holes in live capture cage traps to allow red squirrels to escape and mounted them off the ground in wooden sleeves to prevent interference from badgers (*Meles meles*).

Our methods changed when the area became red squirrel only. Grey squirrels are extremely wary of traps when they enter a red squirrel only area. We have obtained landowners' permission to both trap & shoot. Free shooting is now the most effective method as there are very few grey squirrels. The proportion of grey squirrels culled by free-shooting has increased from 30% in 2010 to 97% in 2019. Currently, our Ranger (contractor) together with a volunteer expert shooter carry out the vast majority of grey squirrel control. The shooters use thermal spotting scopes and these are a great benefit.

From 2010 we have concentrated on the 'frontier' areas which are the main incursion routes for immigrating greys travelling from Rydal and Skelwith Bridge/Elterwater from our South. We have placed Beck feeder/traps at established locations on the incursion routes and from 2014 we monitored activity with trail cameras that send emails with a photo in near real time. So far, we have received over 134,000 emails and are currently using six of these cameras.

We have a grey squirrel sightings hotline and communicate daily via email and texts. Our aim is to remove newly arriving grey squirrels as quickly as possible in order to minimise the chances of Squirrelpox transmission to the red squirrels. We carry out supplementary feeding of red squirrels, deploy road signs, produce a newsletter for the community and carry out monitoring for RSNE. We give talks on red conservation to the local primary school, local groups, the public at Allan Bank National Trust property as well as helping to train countryside leadership trainees. Our work has enabled the National Trust property of Allan Bank in Grasmere to gain a national reputation for being an excellent location for the public to see red squirrels and they heavily promote this aspect, as do the local hotels.

We carry out red squirrel population surveys in our area and keep detailed statistics on red and grey squirrels. We analyse the data to establish trends, etc. and change our strategy when appropriate.

Our initial funding in 2008 was from the Friends of Grasmere charity to buy Beck traps. Our area is part of the buffer zone of the Thirlmere Stronghold and was eligible for EWGS/ WIG grants which provided the bulk of our funding from 2009, however most of these were terminated in 2015 before their contractual date. Since then the National Trust has been our biggest funder and this has been supplemented by local charities, traders, one hotel and individuals.

Red squirrel numbers have recovered following population crashes caused by major outbreaks of Squirrelpox in 2002 and 2003. The ratio of red to grey squirrels has changed dramatically from approximately 1:20 in 2004 to generally red squirrel only in present day. We still get Squirrelpox outbreaks in some years and are just recovering from one now (spring 2020). The first suspected Squirrelpox death carcass is sent to the Animal and Plant Health Agency (APHA) to undertake disease testing. We have also had clusters of red squirrels dying from other diseases which, sometimes, APHA cannot identify.

All the effort has paid off with a good population of red squirrels which has expanded outside our area to the south. The overall density of red squirrels in the Grasmere woodlands is now approximately 0.3 per hectare, with some woodlands supporting more than 0.6 per hectare. Many of the red squirrels in Grasmere have two litters a year and this started in 2010 after grey squirrels were removed in 2009.

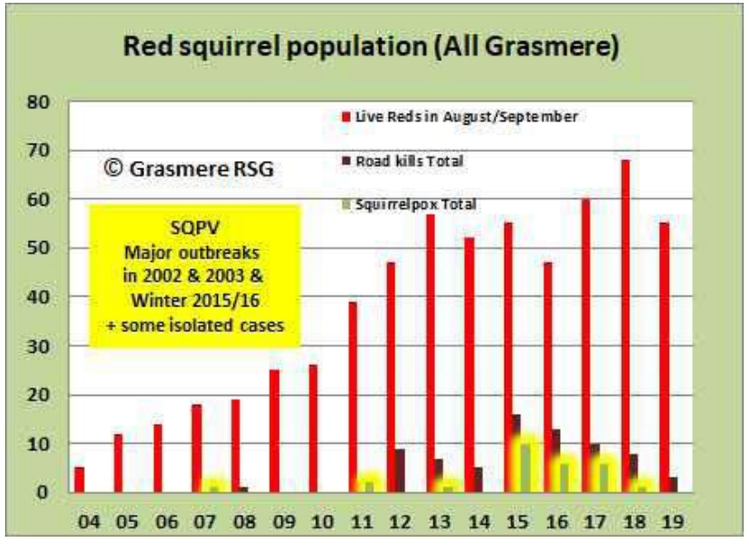

Figure 3. Numbers of red squirrels, road traffic deaths and outbreaks of Squrrelpox virus.

Figure 3 shows the estimated population of red squirrels in Grasmere, the number of

roadkills and deaths due to Squirrelpox between 2004 and 2019. Unfortunately, since the 2019 population data was collected, we have had a recent confirmed outbreak of Squirrelpox which has reduced the number to about 50 animals.

Success indicators within the project

- Maintaining/increasing the size of the red squirrel population.
- Evidence of breeding female red squirrels producing second annual litters.
- Elimination of each detected grey squirrel within 24 hours or less from the time of a sighting report or emailed photo from a camera trap.

Major difficulties faced

- Continual entry of grey squirrels to our area.
- Ongoing funding has been hard to obtain.

Major lessons learned

- Once an area has been cleared of grey squirrels, regular monitoring, rapid response and shooting is the most effective way to keep it grey squirrel free. Obtaining permission to shoot is critical. Greys squirrels are extremely wary of traps when they enter a red squirrel only area.
- Squirrelpox outbreaks do occur, but so long as red squirrels survive in adjacent areas they will repopulate. In different parts of Grasmere, repopulation took two years after an outbreak in 2002; nine months in 2003. Occasionally, a recognisable red squirrel survived an outbreak whilst known to have been continuously present in the area during an outbreak. Rapid intervention reduces the scale and duration of Squirrelpox. This includes humane dispatch of sick animals, to prevent them infecting the rest of the population, and testing for the virus. An outbreak in one part of Grasmere does not seem to spread to other parts of Grasmere although the 2020 outbreak is a sad reminder that a single infected grey squirrel can wipe out a whole area of red squirrels. It's red or grey squirrels, you can't have both!
- We only use live capture traps with holes to allow red squirrels to escape and these are mounted on trees to prevent disturbance from badgers.
- We maintain our 'red only' area by using a great deal of effort and at considerable cost.

Our area is very small - to do the same for a much larger area would be almost impossible to resource. We believe that community led groups are the best way to tackle areas like ours. Large forests without local communities obviously need a different approach.

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Dedication both of volunteers and our ranger, working together to keep Grasmere a grey squirrel free zone.
- Eliminating grey squirrels as soon as they enter the area to minimise the chance of them breeding in the area and also of passing on Squirrelpox infection to the red squirrels.
- Use of technology to provide close to real time monitoring of key incursion routes for grey squirrels via camera traps; use of thermal scopes for shooting.
- Communicating the plight of the red squirrels and our conservation work to local people and the public encouraging them to get involved in their own areas.

Highlighting how challenges identified in 2015 have been approached

- The grey squirrels just keep on coming to Grasmere!!
- Withdrawal of the EWGS/WIG grants; we have had to find alternative funding.
- A woodland ownership changed hands and the new owner terminated permission for grey control.
- A woodland was felled because of *Phytophthora ramorum* infection which causes the disease sudden oak death.
- Dependence on a very small number of individuals to coordinate and continue with the work – this is an ongoing problem!

Future project development

- Continue to work as we have to maintain Grasmere as a grey squirrel free zone and helping with grey squirrel control and population monitoring in adjacent areas

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in <u>developing</u> this aspect of grey squirrel management in your project area
Shooting	★★★	★★★
Live capture traps	★	★
Kill traps		
Pine Marten (as natural grey predator)		
Immuno-contraception (oral bait delivered via hoppers)		★★
Gene Drive (Selected inheritance manipulated so only male young are born)		★★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

Wight Squirrel Project

The Isle of Wight (IOW) Red Squirrel Trust

Geographical area of work

Isle of Wight

Author and organisation contact details

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Key partners

None directly but we do liaise with:

- Forestry Commission England
- Hampshire and Isle of Wight Wildlife Trust
- Isle of Wight Council through the Isle of Wight Red Squirrel Forum and as necessary if a project requires their input.

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	1 Part time
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	0
Volunteers involved with squirrel monitoring	14
Other Active Volunteers	17
Other info	5 Trustees

Map of project land area

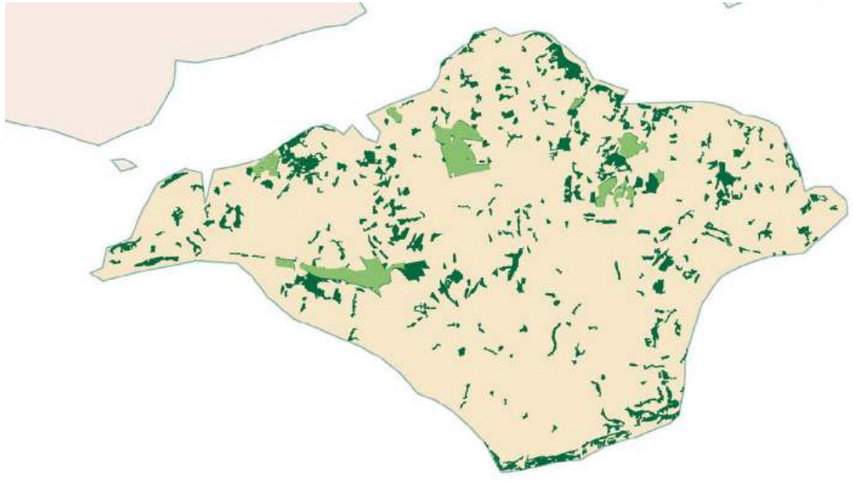

Figure 1. Woodland distribution across the Isle of Wight.

The Forestry Commission map shows the small fragmented nature of woodland on the Isle of Wight. What it does not show are the corridor links which, thanks to the historical JIGSAW tree planting project, are pretty good now. A recent survey shows red squirrels (*Sciurus vulgaris*) can move from east to west and north to south on the island via woodland corridors, although not in a direct and straight line. The survey also highlighted areas where further planting would enhance connectivity.

The distribution map for 2019 shows where the general public reported seeing red squirrels. It does not include the data for bi-annual woodland monitoring or surveys. The pattern of distribution reflects urban space, gardens, plus public paths and woodland. Squirrels do make their way into towns, usually following trees through the gardens. There are areas of arable land where there are few, or no, trees and therefore sightings are recorded very rarely (or not at all).

Introduction

The Isle of Wight is grey squirrel (*Sciurus carolinensis*) free thanks to the Solent acting as a barrier. However, very occasionally a grey squirrel is found on the Island so we actively monitor for both species. There are no pine martens (*Martes martes*) on the Isle of Wight. The Isle of Wight is seen as a national stronghold for red squirrel although the island is not heavily wooded and woodlands are generally small and linked via hedgerows. The squirrels are welcomed in gardens and there are very few places where supplementary feeding isn't available. Even in woods with organised shoots, the red squirrels help

themselves to food put out for the pheasants – with the gamekeepers blessing.

Wight Squirrel Project is run by volunteers and focuses on monitoring, research and welfare.

The IOW Red Squirrel Trust educates the public about red squirrels, their habitat and the animals they share it with. One person is paid part-time to carry out admin and there are five trustees.

Project aim

- Keep the Isle of Wight grey squirrel free.
- Keep up to date with non-invasive monitoring techniques.
- Extend and update education programme.
- Purchase woodland as a base for the charity to operate from.

Description of the project

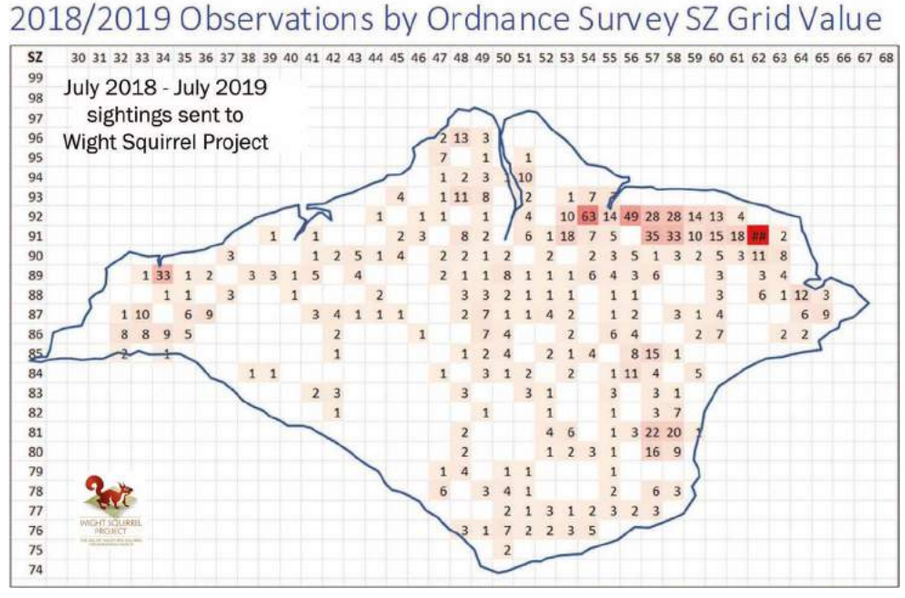

Figure 2. Red squirrel data collected by the project.

The Isle of Wight is a stronghold for red squirrels (Figure 2) although the occasional dead grey squirrel is found. The bodies have obviously been planted (one was still frozen!) in the hope of causing a panic and gaining publicity. The project is not willing to oblige and hence the bodies have all been removed without press coverage. Contingency plans are in place to deal with grey squirrels and all reports are investigated, with follow up action if deemed necessary. So far, it has been a case of misidentification.

Woodlands are small and fragmented, often with busy roads running through them and housing built into or adjacent to woodland. Where development has encroached into woodland there is garden feeding but also perils such as cats, rat poison, Fenn traps IV (kill traps) and waterbutts (within which animals can drown), plus infection if feeders are not cleaned. Road traffic deaths are common when squirrel numbers are good but, as expected, drop when numbers are poor. Road traffic mortality data are used as part of our monitoring programme. From the monitoring viewpoint, people are willing to talk about their visiting squirrels.

Woodland management varies and squirrels are in lower numbers in neglected woods or where other objectives (usually commercial, such as tourism) are a priority. Encouragingly, the JIGSAW project (a tree planting project) has greatly enhanced connectivity between woods and a recent study by Helen Butler showed that the squirrels have corridors moving east to west and north to south.

Figure 3. Project logos.

Wight Squirrel Project (Figure 3) is affiliated to The Conservation Volunteers and is run by volunteers. Monitoring using various but well tested non-invasive techniques is the main focus. Information is used in planning applications, where there may be problems with tree felling and also welfare issues. In spite of repeated publicity, rat poison and Fenn traps are still used, both horrendous deaths for the squirrels. Helen is trying to get the law tightened re using these techniques where red squirrels are present.

Post mortem examinations, totaling nearly 800 cases, give another very informative dataset. Squirrel ears are kept for use in DNA and disease studies both of which have proved very interesting. For example, only one case of leprosy was found in a batch of 93 and that animal was asymptomatic. With the remaining DNA, two genetic studies were carried out. The second study was commissioned and funded by Wight Squirrel Project and carried out by Bournemouth University. Results were not as expected as so far with over 100 animals tested from all parts of the island, no European haplotypes (bloodlines) have been found.

Sick and injured red squirrels are taken in for treatment but often they are too near death to treat successfully. Those who recover are always released to the area they came from. Details of treatment for each animal is documented and lessons learned are due to be written up and shared.

The Isle of Wight Red Squirrel Trust is run by trustees. We had a shop in Ryde High Street from May 2015 to December 2019 but competition for volunteers where there are so many charity shops is fierce and we could not recruit enough reliable volunteers to keep it open for long enough to make it viable. We now pay an administrator who works from home. This is backed up by an improved website. We still want to purchase a small woodland.

Figure 4. Road traffic signs to reduce red squirrel deaths on the road.

Thanks to graphic designer Kate Northover, we have classy new logos and eye catching road signs. The road signs have been very popular, on and off the Isle of Wight (Figure 4). They can only be placed on private property but are still more successful than the official signs. Sadly some have been stolen, as were some of the official signs.

Funding is from (generally) private supporters, fund-raising, legacies and sometimes grants.

Success indicators within the project

- No grey squirrels have established on the island.
- Genetic studies funded by Wight Squirrel Project.
- Loyalty of volunteers and Isle of Wight general public support.

Major difficulties faced

- Lack of funding.
- Lack of government support as we are seen as a ‘safe’ area without grey squirrels.
- Over development on a small island.

Major lessons learned

- Not to be over optimistic and rely on other people

.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- The Isle of Wight remains still ‘grey free’
- A better understanding of the origin of the red squirrels is now held.
- Volunteer recruitment of professional statistician so write up of data is moving forward faster.
- Failure to secure a piece of woodland we wanted to buy and closing the shop.

Future project development

- Both charities are upgrading websites.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	N/A	If greys get here ★ ★ ★
Live capture traps	N/A	If greys get here ★ ★ ★
Kill traps	N/A	★
Pine Marten (as natural grey predator)	N/A	★ ★
Immuno-contraception (oral bait delivered via hoppers)	N/A	If greys get here ★ ★ ★
Gene Drive (Selected inheritance manipulated so only male young are born)	N/A	If greys get here ★ ★ ★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	N/A	If greys get here ★ ★ ★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

References

I. Simpson et al. Causes of mortality and pathological lesions observed post-mortem in red squirrels (*Sciurus vulgaris*) in Great Britain. *BMC Veterinary Research* 9:229

II. Hardouin et al. (2019) Conservation of genetic uniqueness in remaining populations of red squirrels (*Sciurus vulgaris L.)* in the South of England

III. Simpson et al. (2013) Association of a lukM-positive clone of Staphylococcus aureus with fatal exudative dermatitis in red squirrels (*Sciurus vulgaris*). Veterinary Microbiology 162: 987-991.

IV. JIGSAW tree planting https://www.forestresearch.gov.uk/research/visualisation-tools-for-public-participation-in-managing-landscape-change-visulands/visulands-isle-of-wight/

Solway red squirrel conservation project

Solway Red Squirrel Group (SRSG)

Geographical area of work

The Solway Plain, North Cumbria, England

Author and organisation contact details

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Key partners

- Red Squirrels Northern England (RSNE)
- Northern Red Squirrels (NRS)
- Penrith & District Red Squirrel Group (P&DRSG)
- Cumbria Wildlife Trust.
- Natural England.
- Solway Wetlands Partnership.
- Landowners and members of the public.

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	None
Paid Contractors (7-12 months)	None
Volunteers involved with Grey control	13
Volunteers involved with squirrel monitoring	14
Other Active Volunteers	6

Map of project land area

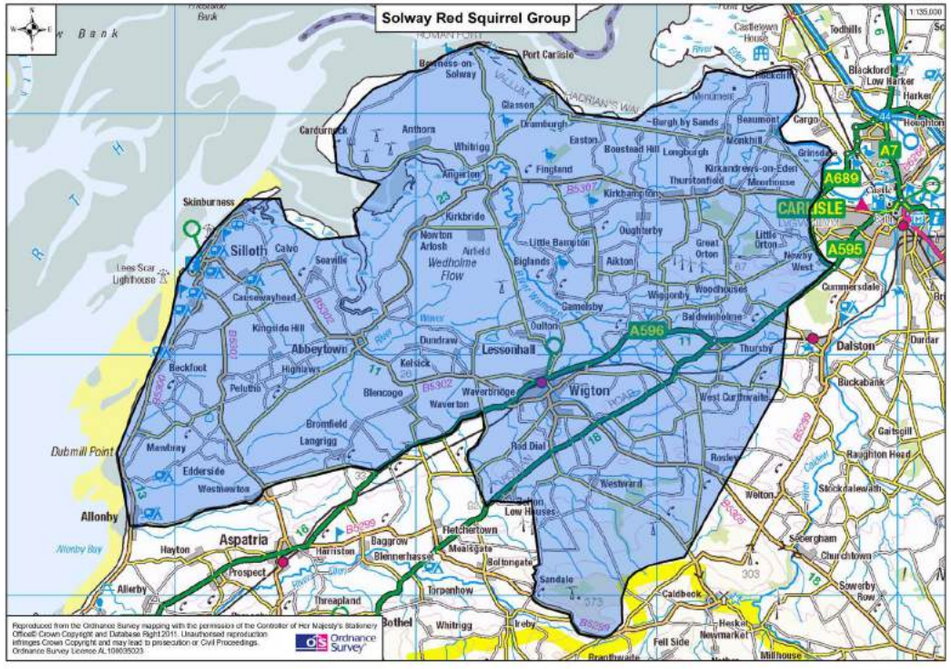

Figure 1. SRSG project area

The Solway Red Squirrel Group (SRSG) covers an area of approximately 195 square miles (Figure 1). The Solway estuary forms the boundary on the north and west. The Solway Area of Outstanding Natural Beauty (AONB) extends along the coastline and inland and comprises large areas of salt marsh and raised mire. Natural England, Cumbria Wildlife Trust and the RSPB manage reserves in this area. To the south the land rises towards the northern fells of the Lake District and has the largest area of woodland, over 240 acres, which is a made up of managed forestry and mixed woodland which are privately owned. The central area is intensively farmed, however there are small patches of mixed woodland throughout with five areas of woodland over twenty acres, one of which is managed by Natural England, the others are largely privately owned. The city of Carlisle is on the north eastern boundary.

Introduction

Until 12 years ago, red squirrels (*Sciurus vulgaris*) were often seen throughout the area, particularly in the south and east. Their numbers declined rapidly as more grey squirrels (*Sciurus carolinensis*) arrived. Over the last 18 months there have been signs of a slow red squirrel recovery with more sightings reported. Grey squirrels are still widespread but are

much less abundant. The work of the group is done entirely by volunteers. In 2014 and 2017 we received a grant from the Solway Wetlands Project. Initially, we received some donations from parish councils, but all recent fundraising has been by volunteers. There are no pine martens, designated squirrel reserves or strongholds in the area.

Project aims

- To control and eliminate grey squirrels through year-round control on a zero tolerance basis.
- To encourage red squirrels to recolonise from existing and adjacent populations.
- To recruit more volunteers to the cause in whatever capacity - control, monitoring, fundraising etc.
- To raise public awareness of the threats posed by grey squirrels.

Description of the project

The SRSG was formed in 2012 with the help of Red Squirrels Northern England (RSNE), Penrith & District Red Squirrel Group (P&DRSG) and Brampton & District Red Squirrel Group. The trigger was a member of the public bemoaning the fact that she no longer had red squirrels visiting her garden regularly and how much she missed their antics. Our aim is to bring red squirrels back into peoples' gardens and the wider countryside for the enjoyment of all.

Grey squirrel control is carried out entirely by volunteers. We have found that effective control is only possible when it is carried out throughout all 12 months of the year using two legal methods - trapping and shooting. Trapping alone achieves seasonal success, and when combined with roaming thermal guided shooting, achieves greater efficiencies at the times of year when feeder-based trapping and shooting is not as effective because of high abundance of natural foods. Data demonstrates that of the total number of grey squirrels culled, 60% were shot and 40% trapped.

The use of monitoring cameras is vital particularly in areas where both red and grey squirrels are present. Shooting is the best option for control in these areas as red squirrels are then not stressed by being caught in traps at a time when they may be pregnant or have young. Shooting is also much more time efficient as traps need to be visited every couple of hours to check for red squirrel or other by-catch presence.

Progress over the last five years has been steady and permissions to shoot and trap have increased greatly since new volunteers have joined the group. Grey squirrel numbers

culled have increased, but it's firmly believed that this is down to being better resourced on the ground with greater familiarity with the terrain and its hotspots. We are fortunate that our northern and western boundaries are protected by the sea so no grey incursions can occur from there; it is only on our southern and eastern boundaries that we need to be vigilant.

Red squirrel sightings have increased, but the only area where there are regular sightings lies alongside our southeastern boundary which borders the P&DRSG where sustained grey squirrel control has been carried out over a number of years and as a result there is a good red presence. It is primarily from this area that natural red squirrel recolonisation will occur.

From local sources we know that there is a small red squirrel presence on our southwestern boundary, but no other information is available regarding either red or grey squirrel presence in this area. In 2019 we had a few scattered red squirrel sightings on the outskirts of our core red squirrel area in the southeast which would indicate red squirrels are venturing further afield (Figure 2).

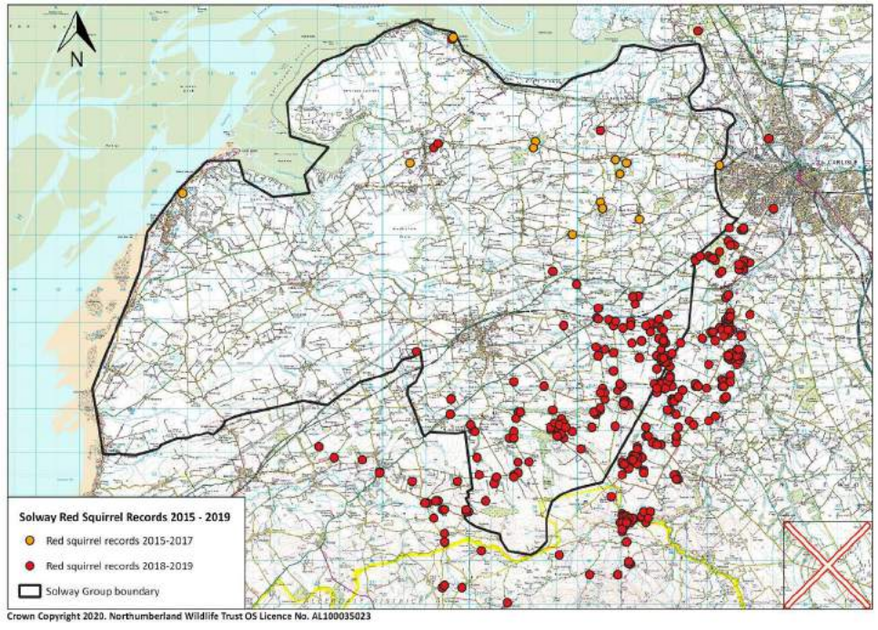

Figure 2. Red squirrels sightings recorded by the group.

The map of red squirrel sightings shows scattered sightings to the north, west and centre of our area but we think these are probably the last remnants of the old population rather than recolonisations as they are all one-off sightings, and all but two occurred before 2018 (shown in yellow). Also, they are nowhere near existing populations of red squirrels.

We would like to recruit more volunteers particularly to help with publicity, raising awareness and fundraising as well as for grey squirrel control. This is particularly important in the west of our area where we have very little knowledge of squirrel numbers and localities. We do give presentations about red squirrel conservation to interested groups but at present we do no work with schools.

Success indicators within the project

- Increased co-operation from landowners resulting in greater geographical coverage of grey squirrel control.
- Red squirrels returning to areas where they have not been seen for years. This increases local community awareness of red/grey squirrel management.

Major difficulties faced

- A trapping-only policy in certain areas makes efficient year-round control very difficult because shooting cannot occur at times when cage trapping is inefficient.
- As red squirrels are only present in a small area, it will take many years for natural recolonisation to occur.
- A lack of resources for publicity and raising awareness.

Major lessons learned

- For grey squirrel control to be effective it needs to be carried out all year round.
- Repeat control and monitoring is necessary to check for any further grey squirrel incursions.
- The use of monitoring cameras and thermal imaging is invaluable.
- With sustained grey squirrel control, red squirrel numbers will increase in those areas where they are still present.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

Success

- The increased use of monitoring cameras and thermal imaging.
- More permissions granted for grey squirrel control means a larger area can be covered.
- Existing red squirrel populations being sustained and an increase in red squirrel sightings recorded.

Failure

- Where permission is for trapping only and no shooting allowed, there is no effective year-round control.

Highlighting how challenges identified in 2015 have been approached

Major difficulties faced

- The continued persistence of grey squirrels in the area.

Major lessons learned

- Sustained year-round control is vital to reduce grey squirrel numbers.
- With the recruitment of more volunteers, more permissions obtained and more sustained control, grey numbers are now decreasing.

Future project development

- Steps taken to ensure group sustainability are a priority.
- Consolidation and expansion of grey control effort is important if we are to maintain red squirrel recovery.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in <u>developing</u> this aspect of grey squirrel management in your project area
Shooting	★★★	
Live traps	★★	
Kill traps		
Pine Marten (as natural grey predator)		
Immuno-contraception (oral bait delivered via hoppers)		
Gene Drive (Selected inheritance manipulated so only male young are born)		★★★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

Red squirrels in Newcastle

Friends of Havannah/ Save Newcastle Wildlife

Geographical area of work

Newcastle upon Tyne, Tyne and Wear

Author and organisation contact details

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Facebook: www.facebook.com/savenewcastlewildlife
www.facebook.com/friendsofhavannah

Key partners

- Newcastle City Council
- Urban Green Newcastle
- North East Red Squirrels
- Animal and Plant Health Agency

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	n/a
Paid Contractors (7-12 months)	n/a
Volunteers involved with Grey control	4
Volunteers involved with squirrel monitoring	3
Other Active Volunteers	10

Map of project land area

Figure 1. Map of Havannah.

Introduction

Havannah and Three Hills Nature Reserve is one of three locations in Newcastle City that was said to support red squirrels (*Sciurus vulgaris*) historically. The first modern recording of a red squirrel sighting in Havannah was during 1998 and there was thought to be a population of approximately 10-12 individuals resident there until late 2019, when a mass mortality occurred. There has been no definitive evidence of red squirrel activity since Spring 2020 and trail cameras have recorded the presence of grey squirrels in the reserve. Grey squirrels (*Sciurus carolinensis*) are present in surrounding woodlands, east and west of the reserve at Gosforth Park Nature Reserve and Woolsington Woods. No pine martens (*Martes martes*) are present in the reserve or in the surrounding area. The woodland is relatively isolated and fragmented and is slowly being hemmed in by residential development. North East Red Squirrels provided funding for feed in feeding stations. All those involved are unpaid volunteers, with the exception of one ranger.

Project aims

- Raising public awareness of the red squirrel population within Havannah.
- Preserving the resident red squirrel population.
- Eradication of grey squirrels to prevent spread of disease to the native red squirrel.

Description of the project

Havannah and Three Hills Nature Reserve was thought to support the last breeding population of red squirrels in Newcastle. The reserve is located on the urban fringe of Newcastle upon Tyne, approximately five miles north west of the city centre. The reserve comprises 45 hectares of woodland, wetland, heathland and grassland. The site was managed by Newcastle City Council until up until spring 2020 and is now managed by Urban Green Newcastle. The surrounding area has been overdeveloped in recent years, with multiple housing developments bringing increased recreational pressures to wildlife in and around the reserve as a result of human disturbance and domestic pets.

Some of the earliest red squirrel sightings date back to 1998. Several surveys, including visual surveys, drey counts, feeding sign transects have been carried out in the past few years by volunteers, ecology consultants and North East Red Squirrels. Results suggested a population of 10-12 individuals, located in woodland in both the Havannah and Three Hills areas. Volunteers from the Friends of Havannah Group provided supplementary feed from 2014, with the support of Red Squirrels Northern England, Ponteland Red Squirrels and latterly North East Red Squirrels. The feeders are filled and cleaned on a regular basis by volunteers. They were removed when grey squirrels were sighted. Grey squirrel sightings in the reserve were reported to Save Newcastle Wildlife/North East Red Squirrels were forwarded to trappers. Save Newcastle Wildlife has been campaigning for better protection for the reserve since 2015, in particular to maintain a buffer zone around the site to preserve the red squirrel population.

In Autumn 2017, fencing was erected around the main feeding areas, with funds given to Newcastle City Council as mitigation for the impact of a recent housing development on the reserve. In Spring 2018, Newcastle City Council granted permission for up to 500 houses, 30 metres to the north of the reserve. £30,000 was secured for red squirrel conservation from Bellway and Miller Homes, following Save Newcastle Wildlife's campaign against the development, which the group believed would compromise wildlife in and around the reserve. A red squirrel management strategy was subsequently commissioned by the developers. In October 2017, a red squirrel carcass was located in the reserve by the Springvale Factory and sent to the Animal and Plant Health Agency (APHA). The sample was found to be a juvenile in poor bodily condition with the cause of death as pneumonia. No indication of Squirrelpox virus or adenovirus was present.

In 2019, the population suffered a mass mortality, with the first reported death on 30 September 2019. Numerous deaths were subsequently reported by members of the public and supplementary feeding ceased. A total of four specimens were located and retrieved by Save Newcastle Wildlife and sent to APHA for testing under the Diseases of Wildlife Scheme:

- The first sample, an immature male, was found to have died as a result of anaemia caused by heavy lice infestation by *Neohaematopinus sciuri*.
- An adult female was found to be in poor bodily condition with only a small amount of food in the stomach. It had a fractured right humerus and gross signs of pneumonia.
- Trauma was the cause of death in two of the squirrels sent for testing, while three were affected by lice.
- One female adult body showed clear evidence of predator/scavenger animal/bird trauma, some, not all, of which occurred at the time of death. This animal had been in reasonable condition, with no evidence of lice.
- Following polymerase chain reaction (PCR) tests, adenovirus was found to be present in a number of samples. However, this did not seem to affect the individuals, with the absence of pathology suggesting some ability to cope with to the virus.
- Two adult samples tested positive for Squirrelpox virus. All samples sent to the APHA showed signs of stress and had been affected by a range of diseases.

Supplementary feeding resumed in January 2020 with the installation of one feeder with a trail camera to monitor feeder activity. No grey squirrels were recorded at the feeder and another feeder was put up in February. Video footage suggested a remnant population of at least three red squirrel individuals until early spring 2020. It is worth noting that the previous population estimates of 6-10 individuals were likely to be conservative, given that at least nine deaths occurred between September and November 2019 and the mass mortality did result in a population extirpation.

It is unclear whether reds will be able to successfully recolonise the reserve, however, road deaths suggest that individuals have been attempting to return. As residential development comes closer to the reserve, gardens with bird feeders will likely attract grey squirrels closer to the reserve and further increase human disturbance.

Figure 2. Red squirrels within the Havannah reserve.

Figure 3. Red squirrels have declined recently due to Squirrelpox outbreaks and other causes of mortality.

Success indictors within the project

- Retaining the red squirrel population within the reserve.
- Recruiting active volunteers to help support the ongoing conservation work.
- Raising public awareness of the plight of the native red squirrel.

Major difficulties faced

- Lack of support from the local authority, who recognise red squirrel as a priority species but do not do enough to conserve the species.
- Reluctance by authorities to maintain a habitat buffer zone around the reserve,
- Lack of funding to carry out projects i.e tagging, tracking of red squirrels.

Major lessons learned

- Local residents are crucial to preserving the red squirrel population as they become active volunteers reporting red and grey squirrel sightings.
- There appears to be a general lack of regard for conserving biodiversity where planning development is concerned.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- A lack of cooperation from housing developers and council officers during planning application processes.

Future project development

- We will continue to raise awareness amongst local residents on the need to report grey squirrel sightings.
- We are liaising with the local authority to install red squirrel road warning signs.
- The future of this red squirrel population is uncertain.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	Not permitted but would be useful	★ ★ ★
Live capture traps	★ ★ ★	★ ★ ★
Kill traps		
Pine Marten (as natural grey predator)		
Immuno-contraception (oral bait delivered via hoppers)		★ ★
Gene Drive (Selected inheritance manipulated so only male young are born)		
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		★ ★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

References

I. Bosch S & Lurz PWW (2015) The Eurasian Red Squirrel *Sciurus vulgaris*.

Red Squirrels Northern England (RSNE)

Red Squirrels Northern England

Geographical area of work

Northern England

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Key partners

- Northumberland Wildlife Trust
- Cumbria Wildlife Trust
- Forestry Commission
- Forestry England
- Natural England
- Red Squirrel Survival Trust
- UK Squirrel Accord

Resources

Typical Resource available	Number of people
Full-time staff	2 Project Manager; Data and Monitoring Officer
Part-time staff	1 Northumberland Project Officer
Full-time Rangers	3 South Lakes, Central Lakes & Harwood Forest area in Northumberland
Paid Contractors (1-6 months)	7 Cumbria: Longtown, Kershope and Spadeadam areas Northumberland: Kielder Village to Bellingham to south of Wark; South of Rothbury and Druridge Bay areas
Paid Contractors/ Groups (7-12 months)	3 Northumberland: Bellingham, Wooler and Kyloe forest areas
Volunteers involved with squirrel mo-ni-toring (with RSNE)	150+ Annual Monitoring Programme in northern England and supplementary surveys in Kielder and Grasmere to Grizedale Project
Support from Wildlife Trust Partner-ships	Marketing, Finance & Admin support (e.g. website, Friends of Red Squirrel membership, Red Report newsletters etc.)

Map of project land area (area of main collaboration)

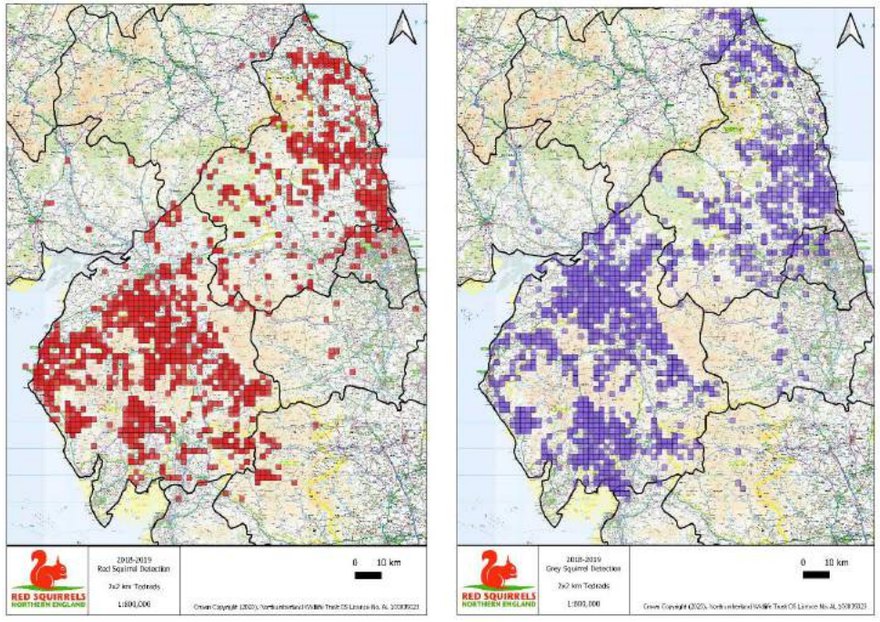

Figure 1. The area of RSNE's main collaboration - Maps illustrate all 2018-2019 red squirrel & overlapping grey squirrel range (data from community groups, landowners and RSNE effort and public sightings) across the north of England.

Introduction

Red Squirrels Northern England (RSNE) is the lead organisation striving to conserve red squirrels (*Sciurus vulgaris*), collaborating across seven counties, where wild red squirrel populations still exist, including: Cumbria*, Northumberland*, Tyne & Wear, County Durham, North Yorkshire, Lancashire & Merseyside (* main areas of direct delivery as of 2020). The project has been active since 2011 and builds on three decades of conservation activity, involving local communities and many other partners. RSNE's formation was a direct response to a series of Government agency reviews of red squirrel conservation from 2008 to 2011, which pointed to an urgent need for annual squirrel range monitoring, unified recording and compilation of grey squirrel (*Sciurus carolinensis*) management and to develop a co-ordinated and joined up approach to red squirrel conservation.

RSNE strive to protect red squirrels in the following ways:

- Helping people understand why red squirrels are under threat and why action is needed;

- Working with communities and volunteer red squirrel groups to encourage local support, involvement and conservation action;
- Monitoring woodlands to better understand where red squirrels live so we can take appropriate action to conserve them;
- Facilitating the management of grey squirrels in areas where red squirrels are found in order to allow them the space they need to thrive;
- Developing and nurturing partnerships to ensure there is a joined-up approach to this work;
- Assisting land managers to access government grants to deliver environmental benefits (including red squirrels).

Project aims

Objective 1:	Maintain 2012 red squirrel geographical range and extend it where possible	→ by encouraging/developing networks of grey squirrel management and red and grey squirrel monitoring and surveillance
Objective 2:	Empower local community-led conservation	→ by sharing best practice with and supporting community groups and landowners
Objective 3:	Collaboration with multiple partners	→ sharing knowledge and developing new approaches/ strategies to conserve red squirrels

Description of the project

RSNE is now entering its 10th year of the project. It is managed by Northumberland Wildlife Trust, in collaboration with Cumbria and Lancashire Wildlife Trusts, Forestry England (FE) and Forestry Commission (FC), Natural England and Red Squirrel Survival Trust. A Project Management Group meets twice a year with partner representation. Wider input is also given by a Project Advisory Group that meets twice a year. Partners work alongside local communities and hundreds of passionate volunteers, with a core aim to secure the future of this most cherished native British mammal.

In 2005, 17 large conifer forests in northern England were designated as Red Squirrel Reserves (RSR) to help provide a focus for red squirrel conservation. Each RSR is surrounded by a 5km buffer zone. Together these make up the "strongholds". RSNE commenced fieldwork in 2012 and focused on targeted grey control in and around RSR, in order to create space for reds to thrive without competitive pressure. Government funding

was made available via the English Woodland Grant Scheme (EWGS) to landowners, specifically in these areas. Since 2015, and the launch of Countryside Stewardship Woodland Improvement Grants (CSWIG) through the new Rural Development Programme for England, funding has been made available for landowners and managers throughout red squirrel range, recognizing red squirrels as a priority species both inside and outside of these strongholds.

RSNE's Annual Squirrel Monitoring Programme, which was established in 2012, has been a key component of the project. Through standardised monitoring, 300 locations are surveyed each year, during a three-month period in the spring (from 1st March to 31st May), across known red squirrel range in northern England. Volunteer involvement for this venture has been crucial. The aim of the programme is to build a long-term dataset that will evidence changes in red and grey squirrel range over time to help demonstrate the impact of the collective conservation effort.

Collaborating with the Northern Red Squirrels (http://www.northernredsquirrels.org.uk/) volunteer community (comprising of 30+ community groups) has been invaluable. Our aim has been to support and empower these local community groups to deliver red squirrel conservation activities, which has been shown to amount to more than 80% of the total conservation effort in the region. RSNE support is provided through, for example, delivering targeted community talks to recruit new volunteers; delivering best practice trapping and survey training workshops; facilitating access permission where needed; supplying and/or loaning out equipment; making groups aware of funding opportunities and supporting applications; collating regional data and providing bespoke analytical maps.

Assisting landowners to access government grants (i.e. CSWIG) has been instrumental in supporting RSNE ranger grey squirrel control and monitoring on the ground. This entailed writing bespoke red squirrel conservation strategies; supporting the development of wider woodland management plans; completing the grant application process on behalf of landowners and in some cases also doing the grant claims and evidence submissions.

Our work has been funded through a variety of channels, including: RSNE's Friends of Red Squirrels members, private donations, landowners' CSWIGs, FE and FC, United Utilities, Scottish Woodlands, Tilhill and Edwin Thompson Forestry, the National Trust, Woodland Trust, Lake District Foundation, Red Squirrels United and others. Ensuring the project is financially sustainable in the long-term is a continual challenge, especially in the current pandemic climate.

We strive to keep our partners, volunteers and wider stakeholders informed via our quarterly electronic RSNE newsletter, the Red Report, and more regularly via updates on RSNE's social media accounts via Facebook and Twitter. A biannual printed update is also sent out to our Friends of Red Squirrel membership.

Success indicators within the project

- Through collaborating with private landowners and utilising the support of CSWIGs, RSNE has been able to deliver effective grey squirrel control in specific areas - this has enabled the bulk of our direct delivery.

- Other collaborations that enabled/funded conservation delivery include direct support from: FC/ FE; National Trust; Woodland Trust; Ray Wind Funds; RSNE Friends of Red Squirrel membership and various other donations. This wider support was critical in maintaining the project's viability during the last (2019/20) financial year.

- The collation of over 110,000 records of conservation effort data and red and grey distribution data is a testimony to the collective effort. This evidenced the following (recorded) annual grey cull numbers across the region (as mapped in Figure. 1):

2015	21,663
2016	11,747
2017	15,560
2018	16,853
2019	22,199

- Without the contribution of over 170 volunteers, involved in the delivery of surveys, analysis of results, and arranging access or delivering survey equipment, the annual monitoring programme would not have been possible – in 2019, 86% of surveys were carried out by volunteers and 14% by RSNE staff.

- Through the collective efforts of local groups and land-mangers, combined with the support and co-ordination of RSNE, we have maintained red squirrel range (see Fig. 1) and evidenced - by coordinating and reporting on the annual spring monitoring programme - the stabilization of red squirrel distribution across the north of England (Fig. 2). There are likely to be some localised gains and losses due to environmental factors (e.g. good autumn seed crops and mild winters). When compared with the historic national decline of red range, it is undeniable that something has halted this trend in the project area, yet it also demonstrates that the battle against grey squirrel incursion requires sustained effort into the future, at least until the development of alternative solutions (e.g. fertility control and/or gene editing research, both currently advancing).

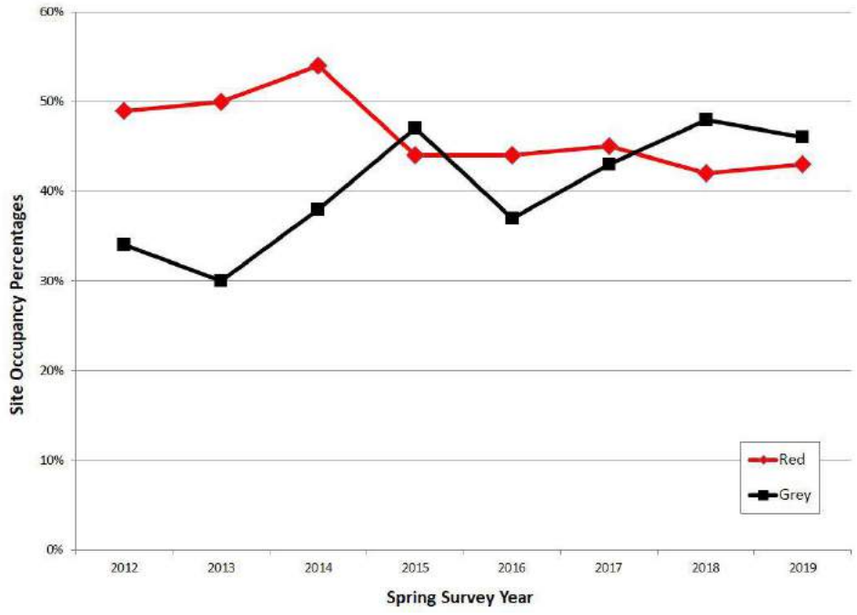

Figure 2. Red and grey squirrel site occupancy for all spring surveys 2012-2019. Site occupancy is shown as a percentage of the total number of surveys completed each year.

Major difficulties faced

- With the end of the EWGS, which included a specific grant to support red squirrel conservation in targeted strongholds, the project had to adapt to the new, broader environmental grant scheme with Countryside Stewardship. The application process proved to be more complex and time-consuming, with a single annual application window and the requirement to have an agreed Woodland Management Plan before becoming eligible for support. This reduced the level of support directly available for red squirrel conservation. RSNE have however adapted to the new opportunity and have supported the production of Woodland Management Plans, assisted in the registration of woodland areas with the Rural Payments Agency and helped in the development of appropriate Deer Management Plans, following advice and guidance from the Deer Initiative.

- The annual spring monitoring programme is a sizeable challenge and takes a significant amount of time and resource (both from staff and volunteers) to deliver in terms of securing the survey data and analysing the results. Without access to some unrestricted funds (i.e. funds not committed to direct delivery of grey squirrel control) it would not be possible to delivery this critically important activity. The 2020 monitoring programme overlapped the pandemic lock-down, thus giving an opportunity to review the future survey methodology and seek funding for 2021's programme.

- The majority of groups and landowners share conservation data with RSNE, which provides a strategic overview of squirrel distribution and conservation effort. This is vital for morale through demonstrating our positive collective impact. The data is also key to influence resource allocation and government policy development. However, not all groups share data with the project, with the consequence that there are gaps in our understanding of distribution patterns in some areas. In order to stimulate future collaboration and data sharing, we will endeavor to assist groups to collect and collate data (by offering a mobile app support) and to use our expertise in QGIS (mapping software) to support groups with data analysis.

- A key challenge has been the ability to support the wide range of local groups with limited project capacity. Volunteers are central to the success of red squirrel conservation effort across northern England and I'm very grateful for the opportunity to work with such a passionate and enthusiastic community. It however is critical that we develop systems and approaches which are flexible enough to cope with local variation, but, is consistent enough to enable robust analysis at a strategic scale. We hope to consult with volunteers and address challenges through our next phase – 'Return of the Reds' (see below).

Major lessons learned

- The RSNE survey methodology has its limitations, as does any survey of this extent. Could it be better? Perhaps. Hence, we will look at redesigning the approach and endeavor to revalidate the placement and number of tetrads, increase the observation window (from two to four weeks) and also double the observation points within each tetrad to two.

- Investing in the local volunteer communities: by providing training opportunities, supporting public engagement events, supplying equipment where funding allows etc. are vital components in strengthening local community groups, which in turn helps build the collective conservation effort.

- Cultivating trust and rapport with landowners and local community groups, by committing to and delivering (realistic) commitments, over a long time period, is essential for success.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct. * Based on an objective assessment.

Reason(s) for success/failure

- Three of the 17 Red Squirrel Reserves (Dipton/Dukeshouse, Healey/Kellas, Slaley/Dukesfield) are situated in the Slaley Red Squirrel Stronghold, right on the grey squirrel frontline. At the start of RSNE project, with the support of the five-year EWGS, intense grey squirrel control was enabled. In years four and five, signs of a rebounding red squirrel population became evident in its centre. However, with the end of the EWGS and the slow uptake of the new scheme (CSWIG) intensive grey squirrel control was significantly reduced. This potential loss of conservation benefit is a risk associated with changing levels of support, however it was also always recognised that Slaley was a more difficult stronghold to defend, given the pressure of the surrounding grey squirrel populations and it being comprised of a connected patchwork of mixed forests (broadleaved and conifers). It is thus inherently difficult to defend and therefore requires significant and sustained effort to maintain any red squirrel population. This will require commitment, engagement and support for the landowners and managers in this area. It may be that complementary grey squirrel control measures, such as fertility control (that is in development by Defra/APHA) could be of significant help here in the future.

- In comparison to Slaley, the Red Squirrel Stronghold of North Yorkshire (Greenfield, Widdale and Garsdale reserves), even though on the grey frontline, is more defendable due to its geography and composition of fewer forest blocks. Here red squirrels have held their ground, though only thanks to the sustained control effort by landowners and the support of the Yorkshire Dales National Park.

- Being quick to digest new Government environmental grant schemes enabled RSNE to facilitate landowner access to the CSWIGs early on. This enabled the gradual development of a portfolio of grant contracts that fund and support grey squirrel control and red squirrel monitoring.

- Linked to the above point, the time-consuming application process for CSWIG grants, combined with RSNE's one project officer being part-time, only allowed for a couple of CS applications per year. Thus, limited project staff/resource time hampered the task of potentially enabling more landowners to access grants.

- The database of over 110,000 records, accrued since the inception of RSNE, has helped to demonstrate that we are collectively making a positive difference to red squirrel distribution stability. It has especially highlighted the significant contribution of the volunteer community. This has motivated volunteers; demonstrated to sponsors that it is worth supporting red squirrels and, perhaps not many realise it has also been instrumental in steering Government policy development (e.g. the inclusion of red squirrels in strategy and environmental grants outside of strongholds) and will continue to do so going forward.

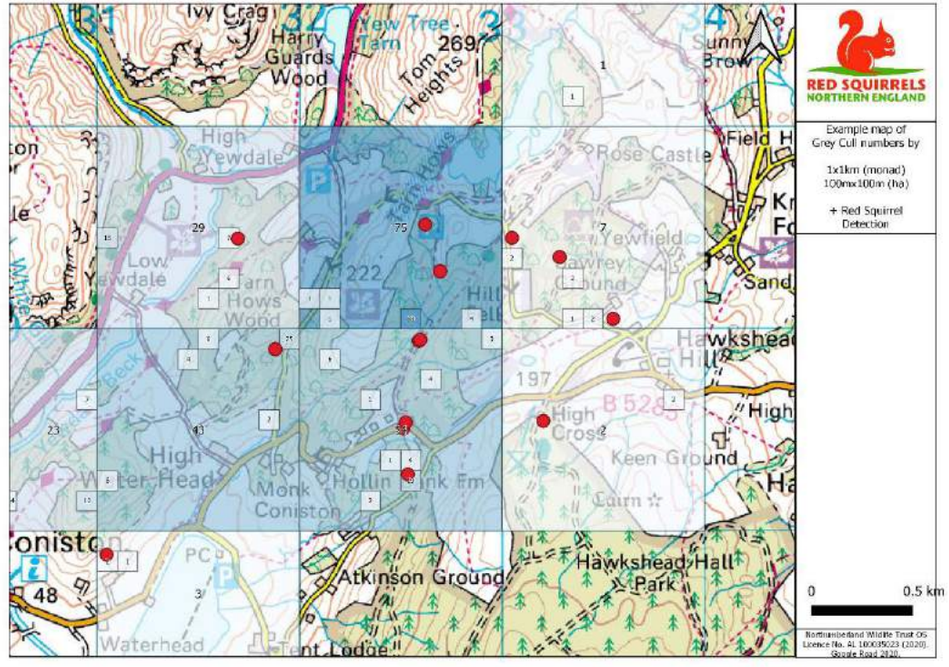

Figure 3. - Illustrating grey squirrel control in a particular woodland area, by grouping culls by monads and hectares, can inform conservation decisions and demonstrate effort.

Future project development

- RSNE is currently (2020) collaborating with the UK Squirrel Accord and its partners to support the development of a revised Red Squirrel Action Plan for England.

- We are (as from June 2020) testing a free mobile app, utilising a system developed by Imperial College, London, for collecting conservation activity data in the field. Initial testing feedback from rangers and volunteers/groups is promising. Together with an interactive online portal the system should improve data accuracy, data collection efficiency and help streamline data collation.

- In 2019/20 a partnership between three Wildlife Trusts (Northumberland, Cumbria and Lancashire) and the Animal and Plant Health Agency developed a new five-year 'Return of the Reds' project proposal (+12 month development phase at its start), which is hoped to be submitted to the funder in spring 2021 (following a year delay due to the pandemic):

  – Return of the Reds will deliver a bold vision to change the future of red squirrel conservation and to engage local communities and visitors in nature's recovery in our region. It will continue to support volunteers to manage grey squirrels throughout northern England as well as embracing emerging opportunities to change the future of red squirrels through fertility control (contraceptive) and natural control by predators (pine martens).

  – There is no other opportunity to realise the potential of these new mechanisms for red squirrel conservation and without properly testing and understanding their impact in our region and with our communities, they will not be effective.

  – Alongside an innovative and specialist ecological programme, significant investment in the engagement of new audiences will raise the profile of red squirrels, provide opportunities for >100,000 people to engage with and experience this iconic species and secure sustainability of conservation approaches.

  – The premise of this project is that more of the same is not enough for the red squirrel which is both ecologically and culturally significant. Change is needed and can only be achieved through an ambitious approach based on emerging science, which responds to and engages both local communities and the wider public.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★ ★	★ ★ ★
Live capture traps	★ ★ ★	★ ★ ★
Kill traps	N/A	N/A
Pine Marten (as natural grey predator)	★	★ ★
Immuno-contraception (oral bait delivered via hoppers)		★ ★ ★
Gene Drive (Selected inheritance manipulated so only male young are born)		interested
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★	★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

References

I. www.rsne.org.uk. (n.d.). *Squirrel Monitoring Programme | Red Squirrels Northern England*. [online] Available at: https://www.rsne.org.uk/squirrel-monitoring-programme [Accessed 25 Jun. 2020].

Red squirrel conservation in Lancashire & North Merseyside

The Wildlife Trust for Lancashire, Manchester and North Merseyside (Lancashire Wildlife Trust)

Geographical area of work

Lancashire and North Merseyside, England

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Key partners

- Red Alert (Lancashire and Merseyside)
- National Trust
- Natural England
- Sefton Council
- Forestry Commission
- Knowsley Safari Park and Estate
- Red Squirrels Northern England
- Red Squirrels United (project ended 2020)
- Nottingham Trent University (PhD research project)
- 30+ local landowners

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	1 Employed by LWT
Volunteers involved with Grey control	10-15 Many volunteers undertake multiple roles. Total active volunteers = 35-40
Volunteers involved with squirrel moni-toring	25-30 Hosted by LWT
Fundraising and events	8-12
Student placements	1-2 per year
Red Squirrel Officer (FTE)	1 Employed by LWT

Map of project land area

Figure 1. Map of the project area.

The project is based in and around the North Merseyside and West Lancashire Red Squirrel Stronghold (Figure 1). This stronghold covers an area of 197km^2 and comprises a 400 hectare (ha) area of reserve woodlands on the coast around Formby and Ainsdale, surrounded by a buffer zone. This buffer zone stretches inland into west Lancashire and is comprised mostly of agricultural farmland, interspersed with small, sparsely connected, privately owned woodlands which range from 0.5 ha to 20 ha in size.

The area is heavily populated with large urban areas in the north, south and on the eastern boundary of the stronghold. These residential areas, parks and gardens provide habitat for both red (*Sciurus vulgaris*) and grey squirrels (*Sciurus carolinensis*) and challenges for grey squirrel control.

Introduction

This project is centred in and around the North Merseyside and West Lancashire Red Squirrel Stronghold which was designated in 2002. Red squirrels are widespread throughout the stronghold area, although the population is most concentrated in the coastal reserve woodlands in Formby and Ainsdale, which are maintained as grey squirrel-free habitats. Grey squirrels are also widespread throughout the remaining stronghold, but particularly in the urban areas.

The red squirrel population has suffered two major outbreaks of Squirrelpox in the last 15 years. The first began in 2007 and the population declined by 80% but recovered quickly by 2011. The second began in 2018 and the impact is still to be fully evaluated.

Lancashire Wildlife Trust (LWT) have been co-ordinating red squirrel conservation in the area since 1993 and since 2009 have had paid staff who undertake grey squirrel control. Additional staff have also been employed sporadically, through different funded projects to undertake community engagement work. Funding has been secured historically through English Woodland Grant Schemes, Landfill Tax and most recently through EU LIFE and The National Lottery Heritage Fund in the form of the Red Squirrels United (RSU) project.

Volunteers assist with a bi-annual monitoring programme, grey squirrel control and local fundraising efforts. In 2018 the Red Alert group re-formed and became constituted and now take a more active role in leading on events, education and fundraising.

Project Aims

- Prevent incursion of grey squirrels into the coastal reserve woodlands, maintaining these as grey squirrel-free habitats; thus, reducing the risk of Squirrelpox outbreaks.

- Control grey squirrels throughout the stronghold to reduce the risk of Squirrelpox outbreaks and the effects of competition, consequently allowing the red squirrel

population to increase in size and range.

- To raise awareness among landowners and the public and encourage them to become involved in red squirrel conservation and grey squirrel control.

Description of the project

The project consists of three main strands: grey squirrel control, standardised monitoring and community engagement.

Through the RSU project, Lancashire Wildlife Trust were able to employ a full-time Red Squirrel Ranger (RSR) and Community Engagement Officer (CEO). The RSR carried out grey squirrel control, focussing on priority areas identified through previous work and research projects. This strategy has so far proved successful in minimising dispersal and reinvasion of grey squirrels into key red squirrel areas. The main method of grey squirrel control is live-capture trapping supplemented with shooting. The RSR also co-ordinated volunteer grey squirrel control effort in woodlands which is mainly shooting.

The CEO organised local events and school visits to publicise the project, training workshops, co-ordinated the standardised bi-annual monitoring programme and supported the Red Alert volunteer group.

Figure 2. Volunteer putting up trail camera and feeder as part of the standardized bi-annual monitoring programme. (© Rachel Cripps)

In 2018, the Red Alert volunteer group became a constituted group, with the aim of taking a more active role in leading certain aspects of the project to coincide with the end of the RSU project. In its first year the group gained a membership of 30+ (Figure 2). A majority of members take on active roles, including grey squirrel control, events and education, fundraising and standardised monitoring. The group have successfully run several events and have taken on this role from the CEO (Figure 3). There is also a desire within the group to develop education activities and relationships with schools as well as take on the co-ordination of the urban trap-loan scheme. This is currently largely delivered by volunteers but LWT are still a central point of contact for the scheme.

Figure 3. LWT and Red Alert meeting with local MP Bill Esterson to discuss red squirrel conservation in Formby. (© LWT).

Post RSU, the LWT employs a Red Squirrel Officer to co-ordinate conservation activities, support the Red Alert group and secure funding, as well as an RSR to continue with grey squirrel control. This is currently on a part-time basis due to funding constraints, but full-time grey squirrel control is needed to sustain the project.

The LWT record and collate public sightings of red and grey squirrels throughout the stronghold, and in partnership with Red Alert, run an urban trap-loan scheme in the towns and urban areas. This scheme allows members of the public who have grey squirrels visiting their gardens on a regular basis to loan and monitor a trap and then call a volunteer to dispatch any grey squirrels caught. This trap-loan scheme is primarily co-ordinated by a core group of volunteers and is an area of the project that continues to be expanded.

A bi-annual monitoring programme has been an integral part of the project since 2002. There are currently approximately 30 volunteers undertaking visual transects, hair tube surveys and monitoring trail cameras. This monitoring programme follows trends in both red and grey squirrel populations and has been invaluable in tracking the decline and subsequent recovery of the red squirrel population following the Squirrelpox outbreak in 2008 and again in 2019.

Figure 4. One of the red squirrels radio collared by Kat Fingland in Formby during her PhD research. (© Steve Hollingsworth)

Research is a key part of the work in Merseyside. The LWTt and Red Alert are currently working with Kathryn Fingland at Nottingham Trent University who is conducting a PhD research project on how red squirrels utilise the urban environment (Figure 4). The research is helping to answer some key questions concerning management of red squirrels within the stronghold including the demographic, size and genetic diversity of the population and the monitoring and identification of disease within the population.

In 2018, the LWT began investigating novel ways of detecting deceased red squirrels during a squirrelpox outbreak. This led to the Red Squirrel Officer working with Kryus Ltd, a dog training company with over 40 years experience in various fields of detection, from

explosives to conservation. Kryus trained Max, the red squirrel detection dog and the Red Squirrel Officer as a detection dog handler (Figure 5). They have successfully been working as a team throughout the most recent Squirrelpox outbreak to locate red squirrels that have died from Squirrelpox. The advantages a detection dog brings include being able to locate carcasses for testing to confirm Squirrelpox, removing infected carcasses from the environment and being able to detect an outbreak in low density or remote populations where sick individuals may not be visible.

Figure 5. LWT and Kryus Ltd with Max, the red squirrel detection dog. (© Rachel Cripps)

Success indicators

- No new cases of Squirrelpox in the reserve woodlands.
- Maintain or increase red squirrel distribution throughout the stronghold and wider landscape.
- Increase the number of households involved in the urban trap-loan scheme.

Major difficulties faced

- Finding sources of funding remains one of the biggest difficulties the project faces. Funding opportunities are becoming more limited, particularly those that will fund grey squirrel control. Projects often need to be designed around the funder rather than focussing on conservation impact.

- Changes in woodland ownership bring about changes to permissions for access and grey squirrel control, making landscape-scale grey squirrel control a challenge.

- During the final year of the RSU project, the LWT received significant attention from an animal rights group who protested at a number of events. Support for red squirrel conservation in the area is still strong but this is something that needs to be considered when planning future events and with any future expansion of the project.

Major lessons learned

- Benefits of sharing knowledge, communicating with other red squirrel projects and groups.

- Level of control required to make an impact on the grey squirrel population and benefit red squirrels.

- Level of publicity required to engage the public in the urban trap-loan scheme.

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Highlighting how challenges identified in 2015 have been approached

(1)

- **Finding sources of funding and keeping continuity between funding pots** – In 2016 the LWT received three years of funding through the RSU project and are hoping to embark upon another large partnership project to follow on from this success. The benefits of these projects include the duration of funding (often 3-5 years) but they take time and resources to develop and report on. Plugging the gap between projects is still a major difficulty.

- **Access to woodlands has proved difficult in certain areas** – Landowners change and with them, permissions, so this is an ongoing issue. We have gained access to some new woodlands but lost access to woodlands we have previously had access to. Grey squirrel control remains a controversial topic.

- **Volunteer base has become stagnant and recruiting new volunteers is quite challenging** The volunteer network has been rejuvenated through RSU and the employment of a CEO, who has been able to focus on recruiting new volunteers, student placements and has also supported the Red Alert group in becoming a constituted group.

(2)

- **Need to promote the project more and run more community events** – This was overcome by the employment of a CEO through the RSU project and subsequently the rejuvenation of the Red Alert group who are continuing with community engagement work. It will take ongoing effort to maintain the profile of the project.

- **Project vulnerable if any of the core group of volunteers leave** – The project is more resilient since the rejuvenation of the Red Alert group, but the success of the group is still dependent to some extent on a small number of people.

Future project development

- Continue to build upon the successes of the RSU project, including maintaining the partnerships developed and supporting the Red Alert group in delivering conservation activities.

- The results of the PhD project at Nottingham Trent University and the production of an urban management plan should provide a valuable insight into the conservation of the red squirrel population in Formby which we hope to implement in the future.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★ ★ ★	★ ★
Live traps	★ ★ ★	★ ★ ★
Kill traps		
Pine Marten (as natural grey predator)		★
Immuno-contraception (oral bait delivered via hoppers)		★ ★ ★
Gene Drive (Selected inheritance manipulated so only male young are born)		★ ★ ★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★	★ ★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

References

I. Lurz P, Gurnell J, Rushton S (2007) *Assessing the risk of encroachment of grey squirrels into red squirrel forest reserves.* Forestry Commission.

II. Chantrey J, Dale T, Read JM, White S, Whitfield F, Jones D, McInnes CJ & Begon M (2014) European red squirrel population dynamics driven by squirrelpox at a gray squirrel invasion interface. *Ecology and Evolution* 419: 3788-3799

III. Chantrey J, Dale T, Jones D, Begon M & Fenton A (2019) The drivers of squirrelpox dynamics in its grey squirrel reservoir host. *Epidemics* 28: 100352

Penrith and District Red Squirrel Project

Penrith & District Red Squirrel Group (P&DRSG)

Geographical area of work

Eden District in Cumbria, England covering 650 square miles.

Author and organisation contact details

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Key partners

- Northern Red Squirrels (NRS)
- Red Squirrels North England (RSNE)
- Cumbria Wildlife Trust
- Lake District National Park
- Eden District Council and Parish Councils
- National Trust
- United Utilities
- RSPB
- Center Parcs
- Oglesby Charitable Trust
- Corporate and Individual Sponsors
- Members
- Private landowners

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	5 Rangers +1 Administrator 2 further Rangers funded externally
Volunteers involved with Grey control	25
Volunteers involved with squirrel monitoring	10 Many involved in fund raising, organizing local events and acting as eyes and ears for rangers etc
Other Active Volunteers	50+
Other info	580 Members of P&DRSG

Map of project land area

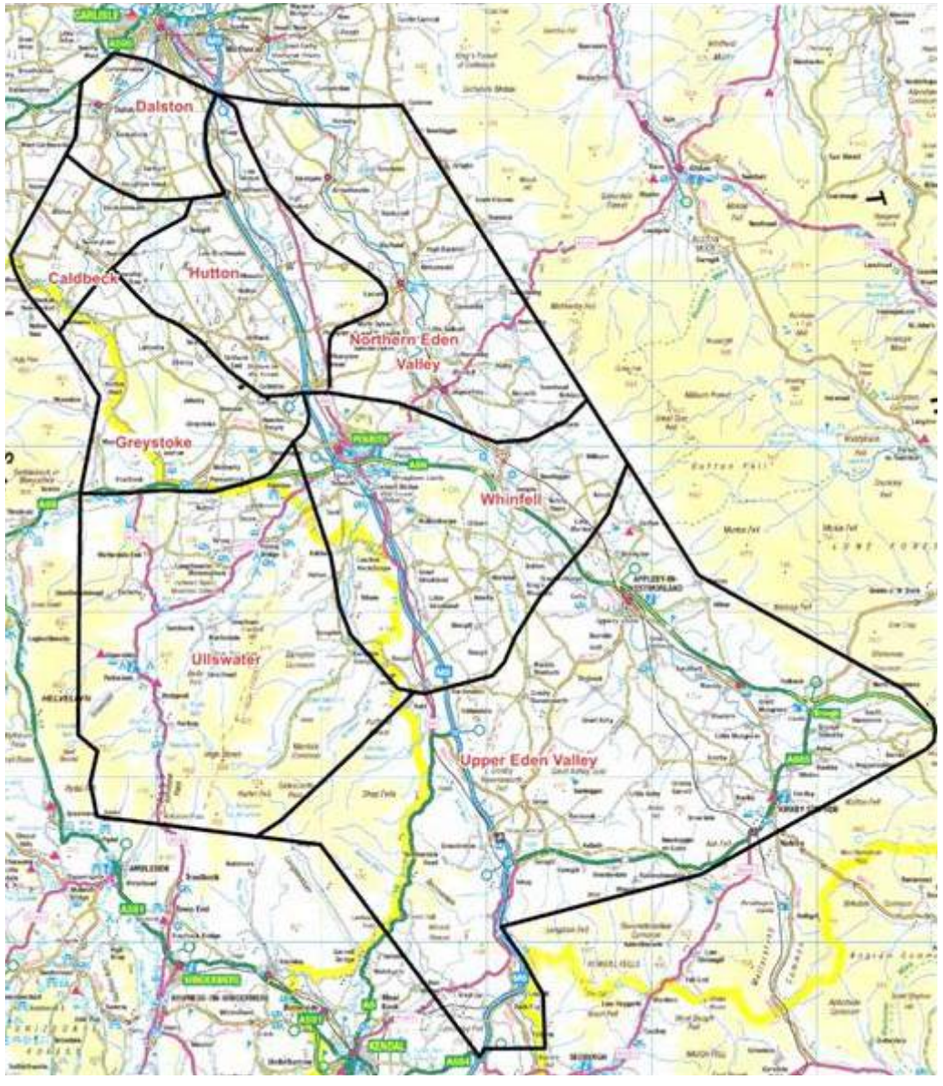

Figure 1 P&DRSG areas of operation.

Penrith & District Red Squirrel Group (P&DRSG) cover an area of approximately 650 square miles incorporating the north and upper River Eden valleys, the area around Ullswater and Haweswater and takes in two of the original designated red squirrel reserves at Whinfell and Greystoke Forests. This includes a mixture of steep wooded terrain, commercial and private amenity forestry and mixed farmland with hedges and a lot of connectivity for squirrel movement. Some pheasant (*Phasianus colchicus*) shooting interests limit grey squirrel (*Sciurus carolinensis*) control during the season and a ban on shooting in Forestry England woodland is a huge issue. Urban areas are increasingly a worry too in terms of lack of grey squirrel control, allowing these areas to act as reservoirs from which grey squirrels disperse into the surrounding countryside.

Introduction

P&DRSG was started about 30 years ago with the first significant incursions of grey squirrels spreading from the south into a key red squirrel (*Sciurus vulgaris*) area. Grey squirrels are now well established virtually all around the boundaries of the group area so there is invasion from all sides (although the Pennines to the east less so). It is only an increase in group activity and especially in paid contractors, supported by volunteers that is maintaining red squirrel numbers and keeping grey squirrel numbers under control. Consequently, the stronghold/buffer zones of Whinfell and Greystoke no longer are geographically relevant, and our control system has now been changed from defending these areas and into a landscape coverage. This approach is much more effective.

There are, no pine marten (*Martes martes*) recorded in the P&DRSG area. As a conservation group we and particularly the private landowners on whom we rely for access, are opposed to the reintroduction of this predator but we accept a natural landscape colonisation.

Woodland grant aid is still important as a funding source but has dropped substantially since the end of Woodland Improvement Grants and the introduction of new schemes.

Project aims

- Maintain and expand red squirrel population distribution within the P&DRSG area by promoting grey squirrel control.
- Implementing grey squirrel control as effectively and as widespread as possible; encouraging the use of thermal imaging as an efficient means of detection.
- Supporting evolving grey squirrel control methods.

Description of the project

P&DRSG has evolved over the last 30 years or so. It differs from a lot of other groups in that our strategy is to use paid contractors to control grey squirrels assisted by volunteers. We recruit volunteers to promote our work and help our fundraising over the 650 square miles in which we operate. The aim is to provide landscape grey squirrel control cover of the entire geographical area rather than the limited to the original concept of strongholds and buffer zones. Our experience shows that short-term contracts do not work – control has to be kept in place throughout the year (Figures 2 & 3).

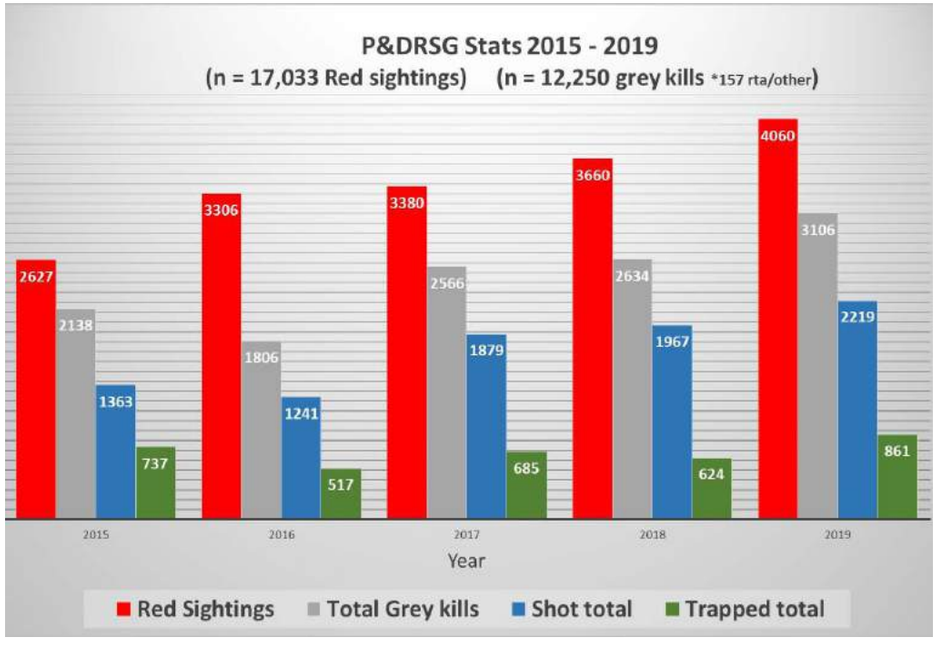

Figure 2. P&DRSG Grey squirrel control and red squirrel sighting data

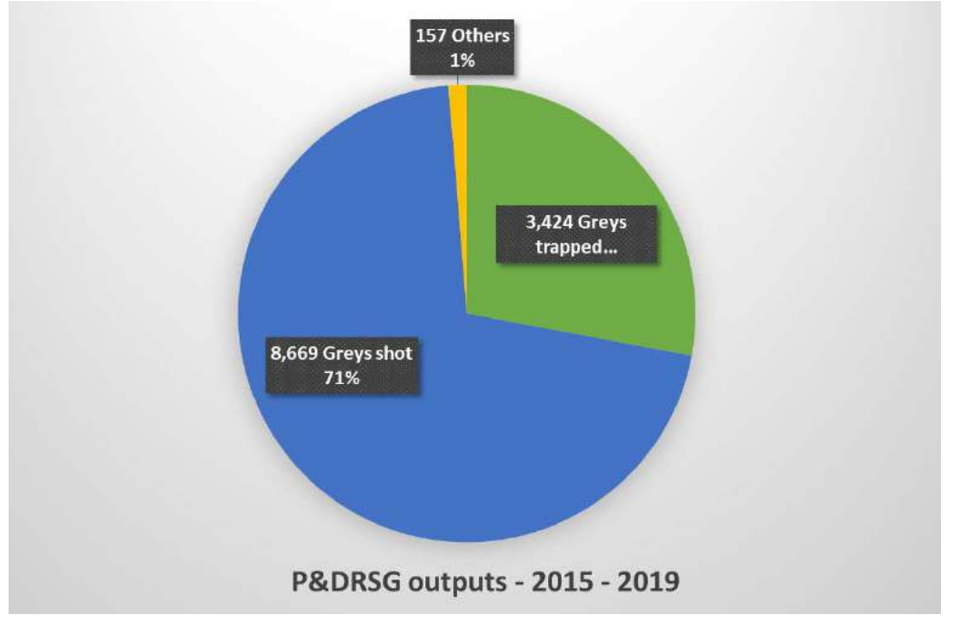

Figure 3. Grey squirrels shot and trapped.

The contractors are called Red Squirrel Rangers, they carry identification and very visible notices on their vehicles to help publicise the work being undertaken. The area covered shown in the Figure 1 is divided into seven sub-areas with a ranger operating in each area. We currently have seven rangers – three full-time and two part-time, funded by the group, one more directly employed by Center Parcs and the other part-time funded by the Red Squirrels Northern England project. All put in many more hours than they invoice for and show an unparalleled dedication to red squirrel conservation.

Fundraising to meet the cost of this ranger service plus a contract to cover an administrator for the group is the key activity of the Trustees and other volunteers. In 2006, P&DRSG became a charity and this has had a small benefit in terms of fundraising.

Methods of grey squirrel control have also changed, particularly in the use of trail cameras in conjunction with feeders. Thermal imaging has revolutionised grey squirrel control and made it a lot more cost effective. This has resulted in the % of shooting rising relative to trapping, and once again highlights the major problem of Forestry England woodland policy, particularly on shooting. Live cage trapping has its place but is far more labour intensive, with all traps visited at least twice in every 24 hours being the ideal.

We support the investigation and research into other methods of grey squirrel control but recognise that our work in an area where red squirrels are still numerous is key and that

delivery of alternatives is still a long way off. Finding a sustainable way of keeping the group going is becoming very difficult. This now includes rangers and volunteers making squirrel feeders which are sold by a variety of means and have become an important income stream.

Squirrelpox has increasingly dented our efforts, which is disappointing. There is growing recognition that red squirrel feeders must be withdrawn during a disease outbreak in order to limit viral cross-infection.

Promotion of our work using the website, social media and illustrated talks is ongoing. Trustee, ranger and supporter meetings take place every six weeks, which keeps the groups' activity on everyone's agenda. We are also finding innovative ways of raising money which has been very important in addition to our 580 members and sponsorship (Figure 4).

Figure 4. Raising public awareness is a key element in P&DRSG efforts.

Success indicators within the project

Major difficulties faced

- Difficulty of maintaining funding streams and attracting new funding.
- Continued refusal of Forestry England to allow shooting - this is a **MAJOR** Problem.

Major lessons learned

- Use of trail cameras, feeding stations and monitoring key to grey squirrel control with very much increased use of thermal imaging and shooting.
- Necessity of regular/repeat grey squirrel control.
- Squirrelpox outbreaks are more widespread and withdrawal of feeders by public in areas of outbreak is essential.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- The group covers a very large area with challenging geography and ground conditions. Given the scale of the landscape covered, the outcome is not the same across the whole area and varies from very successful to a struggle to maintain the status quo. More resources needed.

Highlighting how challenges identified in 2015 have been approached

Grey squirrel control - Providing grey squirrel control has become increasingly difficult due to funding constraints, reduction in grant funding and Government support particularly where there are still red squirrel populations at risk.

Shooting restrictions - Forestry England (and others) refusal to allow shooting as part of grey squirrel control remains a handicap. Additionally, a lack of grey squirrel control in urban areas allowing grey squirrels to breed and spread.

Forestry management - A large increase in forestry felling and thinning has reduced red squirrel habitat.

Thermal imaging - Thermal imagers are now supplied to all rangers and have made control a great deal more effective and efficient. This is allied to use of trail cameras which have become a very important tool. There has been a large reduction in reliance on trapping as a result.

Future project development

- Increased funding to enable expansion of the Ranger team is essential.

- This needs to be supplemented by increased participation of volunteers taking advantage of further development of technology and kit in controlling grey squirrels.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★★★	★★★
Live traps	★★★	★★★
Kill traps		
Pine Marten (as natural grey predator)		
Immuno-contraception (oral bait delivered via hoppers)		★
Gene Drive (Selected inheritance manipulated so only male young are born)		★★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

East Anglian Red Squirrel Group – Captive breeding programme

Pensthorpe Conservation Trust

Geographical area of work

Norfolk, Eastern England

Author and organisation contact details

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Key partners

- Countryside Restoration Trust (CRT)
- Pensthorpe Conservation Trust (PCT)
- Animal and Plant Health Agency (APHA)

Our dedicated group currently consists of six members, located across Norfolk:

- Pensthorpe Conservation Trust (PCT)
- Kelling Heath Holiday Park
- Pettitts Animal Adventure Park
  Mayfields (Countryside Restoration Trust)
  Weybourne Forest Lodges
  Whitwell Hall

Resources

Each member of the East Anglian Red Squirrel Group (EARSG) is responsible for the costs of upkeep and husbandry requirements of their red squirrels (*Sciurus vulgaris*). Project time is volunteered by all members and at least two other interested people. This would also include Pensthorpe Conservation Trust (PCT) staff and volunteers who assist at some of the other sites.

Geographical area

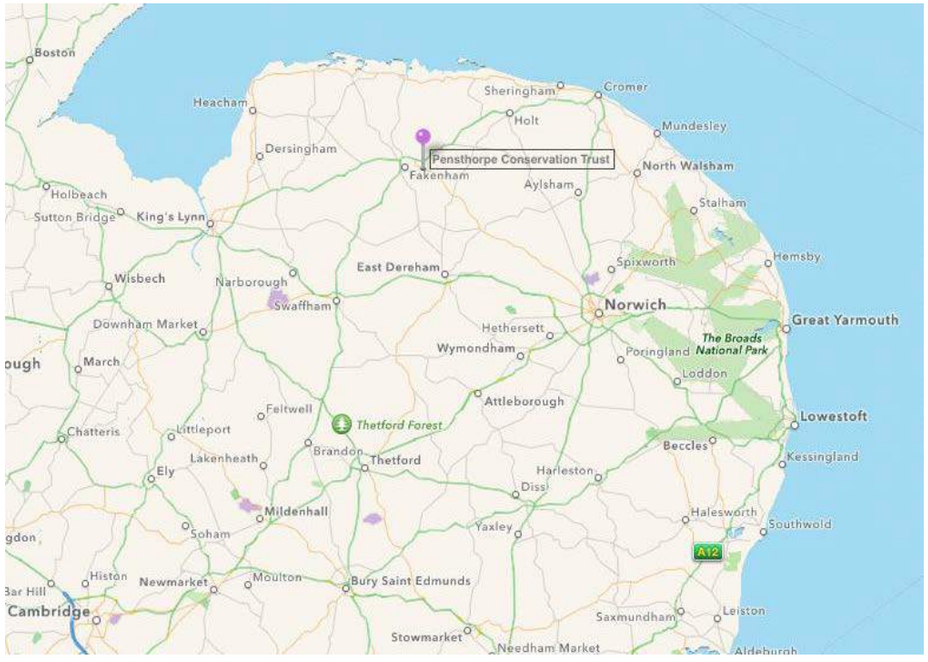

Figure 1. Location of the Pensthorpe Trust.

Introduction

The EARSG was formed by the late David Stapleford, with the help of Kevin Hart in 1998. Before this, David Stapleford had a long-term interest with British mammals and particularly red squirrels. He was pioneering in the captive breeding of red squirrels in his back garden for many years, providing squirrels for the National Red Squirrel Captive Breeding Programme.

In his book 'An affair with red squirrels' he highlights the history of red squirrel decline in Norfolk as indicated in the annual mammal reports of the Norfolk and Norwich Naturalists Society.

It was reported that in 1963 red squirrels were one of the most widespread of our mammals with the Thetford Forest population estimated at several thousand, grey squirrels (*Sciurus carolinensis*) were noted at several locations on Norfolk boundaries. By 1988 there were no red squirrels outside of Thetford and the population in the forest was scarce and scattered, these were the last reported sightings by the society.

There are no suitable sites in Norfolk for any reintroduction project due to the strong grey squirrel population. However, the group members are committed to supporting any viable translocation projects nationally and have provided animals for the successful red squirrel reintroduction to Anglesey. More recently EARSG provided red squirrels for a population reinforcement project at Clocaenog Forest, in north Wales.

The red squirrels in the EARSG breeding programme belong collectively to group members. The PCT has been elected by the group to co-ordinate squirrel movements and manage the project.

Project aims

The EARSG's aims are:

- To educate the public about the red squirrel and its conservation status in Great Britain.
- To be part of a national breeding programme that provides red squirrels for release into the wild through appropriate International Union for Conservation of Nature (IUCN) screened translocation projects.
- To develop and improve best practice for holding and breeding red squirrels in captivity.

Description of the project

Some of the EARSG member sites are open to the general public, others are private individuals and others education establishments. This gives a wide-ranging accessibility to reach a number of different sectors of the community to highlight red squirrel conservation.

Individual group members are responsible for the husbandry and upkeep of the red squirrels and any young produced, until such a time as they need to be transferred to Pensthorpe for holding, transferring to other group members, distribution to release projects or transfer to other captive breeding programmes.

The collective working of the group is a vital key to the success of the breeding programme. At least one breeding pair of red squirrels is usually held at each member location; currently there are six members that have one, two or three enclosures. The group meets annually to discuss objectives and husbandry.

The PCT has three enclosures and quarantine facilities (Figure 2). Outside cages connected to and behind each enclosure allow space to accommodate a number of squirrels when necessary. These facilities enable PCT to hold two breeding pairs as well as act as coordinator for the group to ensure a good management of genetic variability and to take care of squirrels for other members when required. Overhead runs connect all three

enclosures. This means that where required, red squirrel access to different enclosures can be allowed as necessary. This gives more freedom to move kittens away from their parents, minimising the need for handling.

Figure 2. Pensthorpe red squirrel enclosures

Husbandry

One of our objectives is to develop and improve best practice for holding and breeding red squirrels in captivity (Figure 3). Captive squirrels need a specialised diet: for example pregnant females chew antler provided for extra calcium, and favour cucumber when lactating. Sweetcorn cobs provide a good source of vitamin K. We provide the red squirrels with a variety of fresh foods as well as nuts and seeds. A varied diet is a key part to their health and breeding success.

Figure 3. Captive red squirrels receive a rich and varied diet.

The kittens

Studbook names are given to the kittens every year, with each year corresponding to a letter of the alphabet. Kittens of 2011 were named with an A; 2012 with B; 2013 with C and so on. This helps in both engaging the public, as well as monitoring the age and identity of the squirrel pairs.

For example, we have a pair called Flint and Hazel; the male, Flint was born in 2016 and the female, Hazel in 2017. The second pairs names, Hock and Iris, tells us that Hock will be three years old in 2020 and Iris has her first season as an adult. All kittens born in 2020 will have studbook names beginning with the letter J.

We minimise handling of kittens (Figure 4), but will move the spring litter before the female produces her summer litter to avoid competition. Care is also taken when introducing squirrels, making sure there are plenty of boxes and different feeding stations to avoid competition.

The captive red squirrels offer great opportunities for public engagement, photography and press coverage. Good management of genetics is essential to keep a viable captive population.

Figure 4. Red squirrel kittens.

Education and information

Group members have different sectors of the public visiting their squirrel enclosures and all offer some educational information in the form of interpretation about red squirrels and the issues they face. At Pensthorpe we hold daily red squirrel talks during the school holidays and write regular updates for the visitors and members. Whitwell Hall and Themelthorpe focus on education in countryside matters and they allow access to develop education packages for school groups and colleges specifically related to squirrels. Themethorpe has recently built a squirrel enclosure on the side of their education hide, allowing visitors to experience a unique view of the red squirrels in the canopy.

Release

The best result for a captive breeding programme is to release animals back into suitable habitat. We have been pleased to supply squirrels for the Anglesey release project over several years; and more recently Clocaenog Forest, in north Wales. We are keen to continue to support and supply squirrels to viable reinforcements or reintroductions.

Success indicators within the project

- Successful breeding and rearing of healthy kittens.
- Transferring red squirrels to suitable reintroduction projects.
- Raising awareness of the conservation of the red squirrel
- Improving communications and coordination between squirrel breeders nationally

Major difficulties faced

- Limited number of translocation projects because of a lack of suitable areas, a lack of funding and/or willingness to undertake a release programme. The process required for any reintroduction is long, expensive and difficult. This leaves us with the issue of justifying captive breeding as well as placement of young red squirrels.
- There is a public perception that the red squirrel is a zoo species, not a native one, with a general misunderstanding of the problems facing red squirrels in the wild. It has been a long time since free-living red squirrels were seen in Norfolk.
- Stereotypical behaviour is a difficult issue to alleviate, even while improving enclosure enrichment. It receives a negative response from the public, making red squirrels a difficult species to keep on public display to help raise visitor awareness.
- Variable availability of dedicated resources, we are under-resourced with no fundraising. Squirrels are expensive and challenging to keep well and in recent years, we have lost two members of the group due to this.

Major lessons learned

- There is a lot of interest in red squirrel reintroduction, however in reality there are very few suitable sites that address IUCN translocation requirements. Grey squirrel trapping is not considered a viable or cost effective way forward, and particularly in an area where no red squirrels remain and the grey squirrel population is large and well established.
- During times when re-populating or boosting a wild population becomes a less viable objective, EARSG focuses on providing public learning opportunities and research.
- Stress to red squirrels caused by handling and moving animals is a major consideration for their captive management.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Success in captive breeding and successful weaning of young.
- Providing red squirrels for reintroductions and reinforcement projects.
- Proven breeding in the wild of released red squirrels at release sites.
- Increasing public awareness of the red squirrel and conservation activities, including continuous press coverage at local and national levels.
- Without translocation possibilities, the management of the captive red squirrel breeding programme does not have the most favoured outcome.

Future project development

- Increasing the profile of captive breeding as an important element for national red squirrel conservation.
- Collaboration with other zoological organisations to form a National Red Squirrel Focus Group

References

I. Stapleford D (2003) An Affair with Red Squirrels. The Larks Press, Dereham, England.

II. Shuttleworth CM, Everest DJ, McInnes CJ, Greenwood A, Jackson NL, Rushton S, Kenward RE (2014) Inter-specific viral infections: Can the management of captive red squirrel collections help inform scientific research? *Hystrix, Italian Journal of Mammalogy* doi:10.4404/hystrix-25.1-10126

III. An Affair with Red Squirrels – David Stapleford 2002

Save our squirrels

Save our Squirrels Berwick Group

Geographical area of work

North Northumberland and southern Berwickshire

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Key partners

- Red Squirrels Northern England (led by the Northumberland Wildlife Trust)
- Saving Scotland's Red Squirrels (led by the Scottish Wildlife Trust)
- Forestry England (WIGs)
- Wooler Red Squirrel Group
- Northern Red Squirrels
- Red Squirrels Forum for South Scotland
- Private and individual landowners

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	19
Volunteers involved with squirrel monitoring	33 Many volunteers undertake both control & monitoring
Other Active Volunteers	3 Raising awareness/ fundraising

Map of project land area

Figure 1. shows the working area of the Save our Squirrels Berwick Group and the Saving Scotland's Red Squirrels Berwickshire Priority Area (blue) and the Forestry England's Kyloe Red Squirrel Reserve and Stronghold (red).

Introduction

The project area lies between Bamburgh and Belford in the south and Coldstream, Duns and Eyemouth in the north. Towards the north of the area is the valley of the River Tweed, to the west the River Till and the eastern boundary is the North Sea. Much of the area consists of large country estates. The landform consists of gently rolling mixed farmland with numerous mixed (broadleaf and conifer) and coniferous woodlands.

Prior to 2000, red squirrels (*Sciurus vulgaris*) were present in many woods throughout the area. However following the first sighting of a grey squirrel (*Sciurus carolinensis)* in the Tweed valley in the early 1990s numbers of red squirrels have decreased as the grey squirrel presence increased. It is felt that these grey squirrels originated both from Scotland, and from the west of England following the rivers Teviot and Tweed into this area.

There are two designated red squirrel conservation landscape areas in the Group's working area: in Northumberland the designated Kyloe Red Squirrel Reserve (Figures 2 & 3) and Stronghold and in Scotland the Saving Scotlands Red Squirrels (SSRS) Berwickshire Priority Area.

Figure 2. Red squirrels are a key part of the forest within the Kyloe red squirrel stronghold area.

Figure 3. Camera traps are used to monitor the Kyloe population.

The pine marten (*Martes martes*) was considered to be extinct in the area, however there was confirmed evidence of one in Kidland forest in 2010. In recent years there have been increasing sightings of pine martens in Berwickshire and north Northumberland, with animals appearing to be spreading naturally through the Borders and into Northumberland. It is hoped that numbers will naturally increase.

The Save our Squirrels Berwick Group was formed in 2006 and is made up of enthusiastic volunteers with no paid staff. The majority of the Group's funding comes from Forest England's Woodland Improvement Grants.

Project aims

- The project seeks to safeguard, maintain and expand the current red squirrel population.
- To control the spread and numbers of grey squirrels.
- The eradication of grey squirrels is highly desirable where feasible.
- To raise awareness of the plight of the red squirrel through community events and educational activities.

Description of the project

In 2006 two members of a local wildlife group were asked by Peter Lurz to assist with undertaking a survey of red squirrels in the Kyloe Red Squirrel Reserve. It soon became apparent that with grey squirrels moving into the area, the red squirrels in north Northumberland and Berwickshire would become extinct if action was not taken. Save our Squirrels Berwick Group was formed to protect this population.

The group delivers practical red squirrel conservation by monitoring the population and controlling grey squirrels along main incursion routes and surrounding woodlands. From its inception, we realised that just conserving an 'island' of red squirrels would fail as it would simply be overwhelmed by incoming grey squirrels from surrounding areas. Landscape wide conservation would be needed to have any chance of conserving local red squirrels. However, of course, all you do is protect a larger island, and our current working area is 650 square kilometres.

We have always worked on both sides of the Scottish/English border, as squirrels do not recognise the border and so why should we. Currently there is no adjacent red conservation work being undertaken either in Berwickshire or the Borders or to the south of our Group. We work closely with the Wooler Group who are working to our south west and we also work closely with local landowners. In order to engage landowners and gamekeepers, separate raising awareness days were organised for both parties with talks, discussions and practical sessions which have proved very successful.

All our work is carried out by volunteers. We have approximately 19 regular volunteers involved in grey squirrel control and 33 undertaking monitoring, with some volunteers doing both activities. Some members are active in raising awareness and fundraising through talks, displays at shows and events (Figure 4 & 5), merchandise sales and media representation. North Northumberland and Berwickshire are very sparsely populated areas so the Group will never attract large numbers of volunteers. The working methodology we have evolved is to make maximum use of volunteers valuable time.

Figure 4. Community outreach is a key part of the groups work.

Figure 5. Display material helps local people understand the threats faced by red squirrels.

Along the main incursion routes in the river valleys of the Tweed and Till we live trap and shoot grey squirrels that currently threaten our existing red population. Away from these incursion routes, where there are small numbers of grey squirrels, and especially where we have populations of red squirrels, we undertake regular monitoring using feeders and hair tubes collecting hair samples. We also make extensive use of trail cameras both at the feeders and at baited sites throughout the woodland. All monitoring equipment is disinfected to minimise transmission of Squirrelpox virus.

Monitoring allows the group to keep a check on red squirrel numbers, provides early evidence of grey squirrel incursion and also has the effect of baiting them into a location, holding them there until we can conduct trapping activity. This targeted trapping makes the best use of our controller's time.

During 2019, our grey squirrel controllers successfully removed 938 grey squirrels from 123 separate woodlands. Red squirrels have returned to many areas following grey squirrel control, however grey squirrels continue to move in again, and are regularly reported so we must provide vigilance and continuity of grey squirrel control work to ensure the benefits to red squirrels are maintained.

Since 2012 the group has implemented a standardised recording of their work, allowing for associated monthly records which provide us with invaluable data for organising future control. From 2012, 4,468 grey squirrels have been removed from our working area.

Since the Group's early days we have always worked closely with the various versions of SSRS and RSNE. Both very different organisations bringing their own strengths and weaknesses and different approaches to volunteer groups. For several years now, RSNE has been encouraging and assisting landowners in the Kyloe Reserve and within the Stronghold to apply for the Forestry England Woodland Improvement Grants. Several of these landowners have been granted WIGs and these are being managed by RSNE. The Group is contracted by RSNE to undertake this conservation work in these landholdings and this forms a large part of the funding needed to keep the Group operating.

The Save our Squirrels Berwick Groups work is ongoing and we will continue to facilitate grey squirrel removal throughout this area to conserve, safeguard, maintain and expand the current red squirrel population.

Success indicators within the project

- Monitoring to show evidence of sustainable populations of red squirrels in woodland within our area.
- Monitoring showing red squirrels repopulating woodland that previously contained grey squirrels.
- A continued reduction in grey squirrel numbers in our woodland area.

Major difficulties faced

- Working in an area with a very small population makes it difficult to recruit enough volunteers (especially controllers) to cover the number of woods required for landscape wide conservation efforts.
- The area we cover extends on both sides of the English/Scottish border. This entails working with both RSNE and SSRS. The two organisations have very different approaches to red conservation and red squirrel volunteer groups. Squirrels do not recognise the border and neither should we.
- In some areas too much bureaucracy from the Wildlife Trusts has hindered rather than helped volunteer groups working. Volunteers need to spend their valuable time on practical conservation work not completing paperwork.

Major lessons learned

- Monitoring using feeder boxes, sightings records and the use of trail cameras are all essential components of this project.
- Following the removal of grey squirrels by sustained control, red squirrels will return to woodland areas extending their range. Once grey squirrel control has started, repeated control is necessary as grey squirrels will recolonise the area from surrounding woodlands.
- Groups need a secure financial income allowing their volunteers to spend their valuable time on practical conservation work in local woods.
- Volunteer groups need to have the support of local landowners and to be able to work in collaboration with them.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Red squirrel distribution has been maintained and many local populations have recovered following grey squirrel control. If the group had not been formed, and volunteers not worked extensively for the conservation of our local red squirrels, they would have become very rare/extinct in this area by now.

- Trapping/shooting on their own will not eradicate grey squirrels from our woodlands but will probably always be part of the red conservation programme (Figure 6). We must work hard to retain a sustainable population of reds in our woods until either or both the Immuno-contraception and Gene Drive come on line as active control methods.

- Although pine martens appear to be recolonising this area there must be uncertainty as to how quickly their numbers will increase to a level that will impact on grey squirrel abundance.

- There are never enough volunteers.

Figure 6. When a grey is detected at a feeder trapping starts so it can be removed.

Future project development

- Intensive targeted control in priority woodland to encourage red squirrel spread and recolonisation.

- An increase in shooting alongside continued live trapping for grey squirrel control and the use of FLIR thermal imagers for monitoring and control.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★	★ ★
Live capture traps	★ ★ ★	★ ★ ★
Kill traps		
Pine Marten (as natural grey predator)	★	★
Immuno-contraception (oral bait delivered via hoppers)		★ ★ ★
Gene Drive (Selected inheritance manipulated so only male young are born)		★ ★ ★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★	★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

Northeast red squirrels

Northeast Red Squirrels

Geographical area of work

North East England, chiefly south Northumberland

Author and organisation contact details

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Key partners

- Friends of Havannah
- Landowners
- Ministry of Defence
- Natural History Society of Northumbria
- National Trust
- Newcastle City Council
- Northumberland County Council
- North Tyneside Council
- Red Squirrel Groups
- Urban Green
- Woodland Trust

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	2
Paid Contractors (7-12 months)	1
Volunteers involved with Grey control	20
Volunteers involved with squirrel monitoring	20
Other Active Volunteers	10

Map of project land area

The Northeast Red Squirrels (NeRS) group works within an area bordered by the north bank of the river Tyne to about 15 kilometres north of that geographical feature (Figure 1). The eastern boundary is the North Sea and the western boundary is the river North Tyne. Some grey squirrel (*Sciurus carolinensis*) work is done on the south bank of the Tyne to form a buffer area.

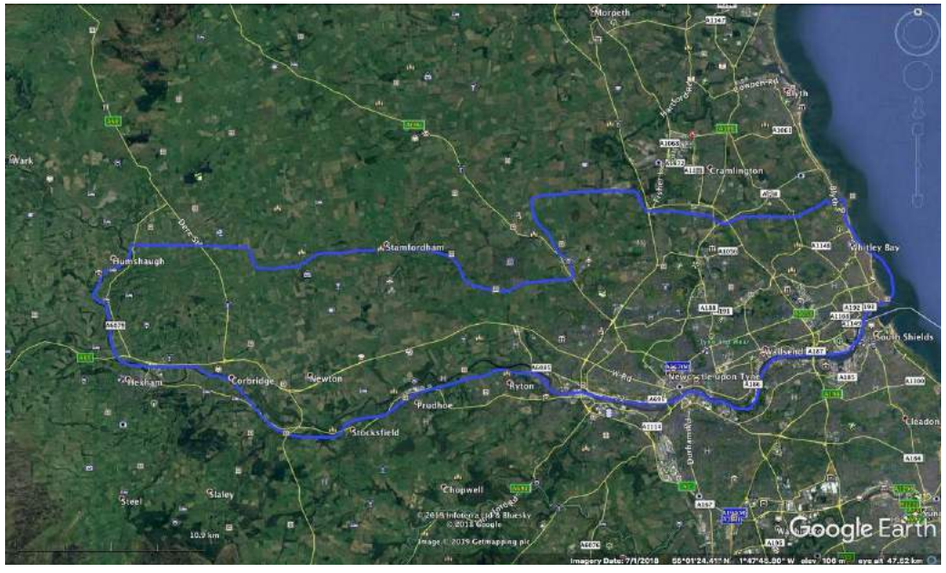

Figure 1. Map of the NeRS project area shown by a blue boundary.

Introduction

Grey squirrels arrived in south Northumberland about twenty years ago. Red squirrel (*Sciurus vulgaris*) conservation groups formed soon afterwards and have managed to maintain red squirrel breeding colonies in several places. Two colonies are close to the Tyneside conurbation: Ponteland to the northwest of the city and Havannah Nature Reserve at the northern edge of the city of Newcastle. The Havannah animals may be the only red squirrels within an English city. Adjacent important red squirrel populations are nearby at Wallington Hall, owned by the National Trust and within the East Cramlington Nature Reserve.

The Newcastle area is urban along the Tyne in the east before becoming more rural for the remainder with farmland and mixed woodland. City parks are important in the urban area.

There are no recent pine martens records for this area and the species has been absent for some decades.

NeRS was formed as a charity to raise funds and help volunteers maintain and expand the red squirrel population. Equipment and feed is supplied to volunteers. About 50% of funds is used to pay for part time rangers. Data is maintained and submitted to the Red Squirrels Northern England (RSNE) project.

Project aims

- Retention of the remaining red squirrel colonies.
- Facilitating the spread of red squirrels so the species occupies historical areas.
- Removal of grey squirrels.
- Monitoring of both red and grey squirrel populations.

Description of the project

NeRS is run by trustees who have been successful in applying for conservation grants e.g. the Post Code Lottery and Heritage Lottery Funds. Other fund raising has generated income from individual donations and small amounts have been raised from local sources.

Figure 2. Live trapping is the main approach to grey squirrel management. Any captured red squirrels are released immediately.

The conservation and management of red squirrels at Havannah Nature Reserve has been carried out through the parallel Friends of Havannah group. The chief activity of NERS is grey squirrel control. This is done chiefly by live trapping (Figure 2). Initially, trapping targeted the densely populated grey squirrel areas of Newcastle and then subsequently expanded to encompass woodlands in more rural areas. Good co-operation has been obtained form many landowners, although pheasant shooting estates have not allowed access. Local volunteers have been recruited and use has been made of part-time paid rangers, especially to cover the more remote project areas. Funds are used for purchase of equipment including squirrel feeders, traps and trail cameras. Travel costs are reimbursed for non-local travel. Feeders are used after a woodland has been cleared of grey squirrels and then monitoring is started with return trapping conducted if a grey squirrel is detected. Very few of the landowners in our area permit shooting. Rigorous protocols are enforced so that the conduct of volunteers and contractors is professional and the NeRS group maintains a good local reputation. To date no significant problems have occurred even in popular public parks.

Figure 3. NeRS work closely with the Ministry of Defence at Albermarle Barracks.

Education and community involvement is an important part of NeRS work. A major success was with the Ministry of Defence at Albermarle Barracks (Figure 3). The camp has an extensive area of woodland where grey squirrels have been culled and red squirrels are now seen once again on the site. The soldiers on camp have taken on the role of “adopt a wooders”.

Cost effectiveness of the work has been assessed. In dense urban areas and areas of high grey squirrel abundance the cost per cull is low. In rural areas and in “repeat areas” the cost per cull is higher as grey abundance is generally low. Overall the cost per grey removed is about £11. Significant numbers of grey squirrels have been removed; over 3,500 in the two years to end of February 2020. In the calendar year 2019 about 2,500 grey squirrels were removed. It is tempting to chase an increase in total cull numbers by going south of the river Tyne where large populations exist. However, we have restricted trapping work south of the river to a buffer zone along the south bank.

A constant question we ask is - “ where do the greys come from?. “ Answer - “ who knows - Durham?”

Success indicators within the project

- Retention of red squirrel colonies.
- Breeding of red squirrels within the project area which does not contain any of the forests designated as red squirrel strongholds.
- Maintaining a low abundance of grey squirrels.

Major difficulties faced

- Lack of co-operation from shooting estates.
- Long term funding is always a worry.
- Slow progress gaining access to North Tyneside Council land.

Major lessons learned

Figure 4. Community outreach is important as a means of spreading the word about red squirrel conservation but also fundraising.

- Funding continuity is crucial.
- Communication with all partners is crucial including outreach to local communities (Figure 4).
- Teamwork and liaison are important to avoid waste of resources.

Project success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Comprehensive grey squirrel culling is undertaken.
- Use of ‘adopt a wooders’ for reporting of sightings and grey squirrel control following detection of animals.
- Control work is successfully undertaken by paid contractors.
- Grey squirrel cull data is shared with RSNE.

Future project development

- Make the project boundaries secure to facilitate further red squirrel recolonisation.
- Cull extensively south of the Tyne or grey contraceptive are essential to reduce dispersal pressure into the NeRS area.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★	★
Live traps	★ ★ ★	★ ★ ★
Kill traps	★	★
Pine Marten (as natural grey predator)		★ ★
Immuno-contraception (oral bait delivered via hoppers)		★ ★ ★
Gene Drive (Selected inheritance manipulated so only male young are born)		★ ★ ★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

References

I. Dutton C (2016) The grey squirrel management handbook. ESI.

II. Dutton C (2004) The red squirrel - addressing the wrong. ESI

Investigating the effect of widespread clear felling on grey squirrels

Squirrel Action Greenhead Gilsland

Geographical area of work

South Tyne Valley, Northumberland

Author and organisation contact details

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Key partners

- Red Squirrels Northern England (RSNE)
- The National Trust
- Featherstone Estate

Map of project land area

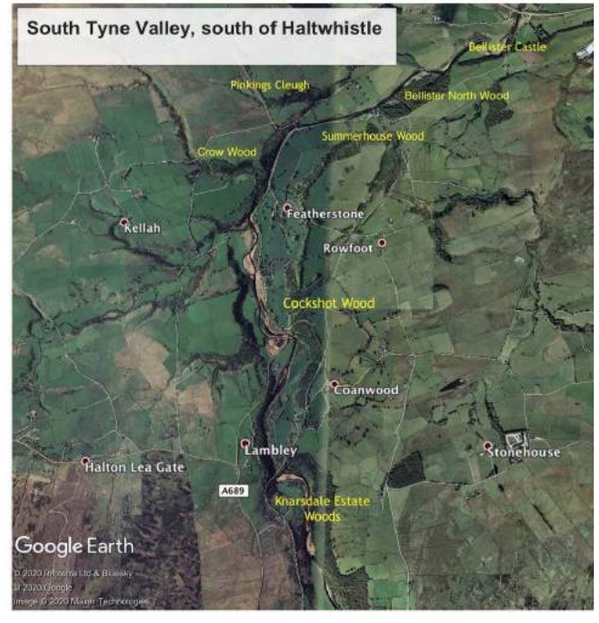

Figure 1. South Tyne valley south of Haltwhistle, Northumberland.

The Featherstone estate consists of tenant livestock farms. The valley sides have been planted with commercial conifers. There are some deciduous areas, with rhododendron understory. There is a syndicate pheasant (*Phasianus colchicus*) shoot with rearing pens in Summerhouse Woods and Cockshot Wood. There are pheasant feeders in all others. Most grey squirrel traps were set in pens, or near feeders, as these attract grey squirrels (*Sciurus carolinensis*) over red squirrels (*Sciurus vulgaris*).

The Bellister Estate is owned by the National Trust. Bellister North Wood is deciduous, and runs along the east bank of the South Tyne from Parkburnfoot to Bellister Castle. Broomhouse Wood was ~50% spruce (*Picea spp.),* most of which was felled in 2017, leaving birch, hazel and relict mature oaks (*Quercus spp*.).

To the south lies the Knarsdale Estate, which is managed for grouse (*Lagopus lagopus*) and pheasant. The gamekeepers will shoot grey squirrels on sight, but trapping by squirrel volunteers is not permitted.

Introduction

Squirrel Action Greenhead Gilsland (SAGG) was formed in 2007, when grey squirrels started to travel east up the river Irthing corridor, affecting the resident red squirrel population. As the volunteer base grew, the group was able to expand east to the Haltwhistle area and the South Tyne. The Featherstone and Bellister estates lie along the South Tyne. Access for trapping to the Featherstone Estate was granted in 2013, and Bellister (National Trust) in 2015. Prior to this, although members of the Featherstone syndicate shot grey squirrels, there was no systematic control. There is a resident grey squirrel population, and a remnant red squirrel population survives. Red squirrels rarely visit pheasant pens or feeders, and are more frequently seen in late summer each year after the grey squirrels have been trapped out. Trapping season is from March/April, depending on weather, to July, after which there is so much natural food grey squirrels will not enter traps. The trapping year 2019 was atypical with clear felling of large conifer plantations on Knarsdale Estate (immediately to the south of Featherstone) in late winter 2018/early spring 2019, and of plantations on Featherstone in late spring and early summer 2019. The general impression at the time was that in 2019 there seemed to be more grey squirrels trapped in absolute terms, and that a higher proportion of females showed no sign of pregnancy or lactation. This paper examines trapping data from 2018 and 2019. The data for 2018, when there was no clear-felling, showed that approximately 67% of adult female grey squirrels trapped showed signs of pregnancy or recent lactation. This figure is consistent with the literature (71%). In 2019, with widespread felling, numbers caught were increased (thought to be migration from felled areas) and 30% of adult females showed signs of pregnancy or recent lactation.

Project aims

- The eradication of grey squirrels from the South Tyne Valley is highly desirable.
- In practice the project seeks a reduction in local grey numbers to permit survival of a relict population of red squirrels.
- A secondary aim is to prevent the population of grey squirrels from growing and expanding north over the Roman Wall to the southern boundary of Kielder Forest.

Description of the project

Live capture traps were set using the standard methodology with a pre-bait, and twice-daily inspection and cull of captured grey squirrels. Trapping ended after several clear days of no grey squirrel captures. Traps were mounted on tree trunks above ground level to avoid interference from badgers (*Meles meles*). Traps were modified with a plywood floor (to retain bait), a canvas roof (to protect trapped animals from rain) and two wires dividing the opening to prevent pheasants entering. Whole maize was used as bait. Non-target species were released. Trapped greys were dispatched by the sack method. The size of each grey squirrel was noted and was particularly useful when distinguishing between juveniles and adults. Ventral surface was examined externally to determine sex. Juveniles were sexed by assessing ano-genital distance. For adult males, the presence/absence of descended testes in the scrotal sac was noted. For adult females, the teats were examined. Females with tiny pink teats are considered non-parus i.e. they have not lactated and have not had a litter. Lactating females have long dark teats often with swollen bare skin around them (*personal observation* and consistent with Edwards et al. cited in Hayssen 2016). It is usually possible to express a drop of milk from the teats of a lactating female immediately after dispatch. Females that had bred either in a previous year or much earlier in the season also show the longer darkened teats, but the fur has regrown around them and it is not possible to express milk. Females that were not lactating were gently palpated. The animal was held in the palm of the hand ventral surface uppermost, and the abdomen palpated with both thumbs. Embryos can be felt as near-spherical bodies (larger than the kidneys) within the otherwise soft abdomen. This gave an indication of at least mid-to late pregnancy. For the purposes of this paper, females described in the raw data as non-pregnant but which appeared to have been lactating recently were included in the pregnant/lactating category (see Table). Data were recorded in a field notebook. For Featherstone woods, each month a summary was emailed to the red squirrel group data coordinator, to be collated and sent to RSNE with the rest of the group's data. Data from National Trust (NT) woods were sent to the local NT office, and sent to RSNE.

Trap-nights were defined as the number of traps used multiplied by the number of nights that the traps were set and provided a measure of control effort

Woodland grid references were taken from OS map Explorer OL 43 (ISBN 0-319-23472-X).

Figure 2. Crow Wood Featherstone before felling (N Leeming 2019).

The contiguous Knarsdale plantations (Hagg Wood, Low Asholme and Oakeyside Wood) (Figure 3) to the south of Featherstone were felled in early spring 2019. Pinkings Cleugh to the north was felled in May/June 2019, Crow Woods were part felled in July 2019 (Figure 2), as trapping was taking place, and parts of Summerhouse Wood were felled in August 2019.

Trapping took place from April to July in 2018 and from March to July in 2019. Other volunteers from the Featherstone syndicate shoot in other woods, and report their numbers, but they only record number and sex, and are not considered here.

As noted above, the general impression at the time was that in 2019 there seemed to be more grey squirrels trapped in absolute terms, and that a higher proportion of females showed no sign of pregnancy or lactation, compared to earlier years. Retrospective examination of notebooks confirms this suspicion. In 2018, the percentage of adult females showing signs of pregnancy or lactation at cull was 67%. This is consistent with the value of 71% in the literature (Thompson 1978, cited in Hayssen 2016). In 2019, the situation was reversed, with only 30% of adult females showing signs of pregnancy or lactation at cull.

In previous years, the has author trapped on Featherstone, Bellister, in the Haltwhistle area and on parts of the Blenkinsopp Estate immediately south of the Roman Wall. Trapping starts in woodlands with pheasant pens, as these typically yield the most squirrels, and moves to other woodlands after several days during which no squirrels have been caught. In 2019, it was decided to concentrate on Featherstone, where it was anticipated that the Knarsdale felling to the south, and the planned felling in Featherstone itself, would lead to grey squirrels flooding the surrounding area. This accounts to some extent for the difference in trapping effort between the two years (trap-nights 2018, 122; for 2019, 310). Trapping duration was prolonged because there were more squirrels to catch. In absolute numbers over twice as many grey squirrels were caught in 2019 (108) than in 2018 (41), but the overall female: male ratio (including juveniles) was similar in the two years (19:22 vs 52:57), almost 1:1, with a slight bias towards males.

Year	Adult Female			Adult Male		Trap Nights
	NP	P/L	% P/L	Imm	TD	
2018	6	12	66.7	2	20	122
2019 numbers corrected for effort*	12	5		2	18	
2019	30	13	30.2	4	47	310

NP: Not pregnant
P/L: Pregnant, Lactating or likely recent lactation
Imm: Near adult, but testes not visible in scrotal sac
TD: Adult, testes descended into scrotal sac
*2019 numbers multiplied by 122/310 i.e. 0.39, as whole numbers

Woodland	Grid Reference	Date	Female Grey Squirrel			Male Grey Squirrel			Trap nights	Red squirrels
			Juv	NP	P/L	Juv	Imm	TD		
Featherstone Castle	NY674609	April-18	0	2	1	0	0	0	10	0
NT Bellister/ ParkburnFoot	NY684620	April-18	0	1	1	0	0	0	5	0
Featherstone Pond	NY679603	April-18	0	0	2	0	0	1	5	0
Featherstone Crow Woods	NY673615	May-18	0	2	2	0	0	8	24	0
NT Bellister/ ParkburnFoot	NY684620	May-18	0	0	1	0	0	2	6	0
Featherstone Summerhouse	NY678608	June-18	1	0	3	0	2	8	24	2
NT Broomhouse Wood	NY696623	June-18	0	0	0	0	0	0	12	0
NT Bellister/ ParkburnFoot	NY684620	June-18	0	1	1	0	0	1	6	0
Featherstone Castle	NY674609	July-18	0	0	0	0	0	0	12	0
NT Bellister/ ParkburnFoot	NY684620	July-18	0	0	1	0	0	0	18	0
Total			**1**	**6**	**12**	**0**	**2**	**20**	**122**	**2**

Woodland	Grid Reference	Date	Female Grey Squirrel			Male Grey Squirrel			Trap nights	Red squirrels
			Juv	NP	P/L	Juv	Imm	TD		
Featherstone Summerhouse	NY678608	March-19	0	10	2	0	4	17	68	0
Featherstone Cockshot Wood	NY676599	April-19	1	6	1	0	0	11	60	0
Featherstone Summerhouse	NY678608	April-19	0	3	0	0	0	0	12	0
NT Bellister/ ParkburnFoot	NY684620	May-19	0	2	1	1	0	0	6	0
NT Broomhouse Wood	NY696623	May-19	2	0	2	0	0	2	6	0
NT Bellister Bank/Castle	NY698628	May-19	0	0	0	0	0	2	6	0
NT Bellister/ ParkburnFoot	NY684620	June-19	0	1	0	2	0	1	21	0
NT Broomhouse Wood	NY696623	June-19	0	2	2	1	0	1	30	0
NT Bellister Bank/Castle	NY698628	June-19	2	3	1	2	0	4	45	0
Coanwood (garden)	NY677589	June-19	1	1	1	0	0	2	6	1
Featherstone Crow Woods	NY673615	July-19	2	2	3	0	0	7	50	5
Total			**8**	**30**	**13**	**6**	**4**	**47**	**310**	**6**

Key
Juv: Juvenile - this year's young
NP: Not pregnant
P/L: Pregnant, Lactating or likely recent lactation
Imm: Near adult, but testes not visible in scrotal sac
TD: Adult, testes descended into scrotal sac
NT National Trust

Figure 4. Clear felled area of Crow Wood showing trees with dreys left standing (© N Leeming July 2019).

More red squirrels were caught in 2019 (6) compared to 2018 (2). Most of the 2019 red squirrels were in Crow woods, and they were all caught as the conifers in that wood were being felled. The operator of the tree harvester (a Finn) was sympathetic to red squirrels and had left the trees with dreys standing (Figure 4). No red squirrels were seen in the clear felled areas after felling ceased. Interestingly, in previous years, red squirrels have been seen (by members of the shoot and the public) in several of these woods after trapping campaigns had removed the resident grey squirrels. The data support the initial observation in the field, i.e. pregnancy rates were lower in 2019.

Other conclusions are conjecture: that grey squirrels fleeing from felled plantations take up residence in the nearest piece of suitable habitat but do not breed that year. It is interesting (but probably coincidental) that the absolute numbers of breeding females in the two years was almost the same (12 vs.13). It might be interesting to go back through the data to see how many pregnant/lactating females were culled from these woods in previous years, as an indication of the carrying capacity of the area, prior to felling.

It appears that the red squirrels survive as a small remnant population where grey squirrels are numerous. The grey squirrels certainly feed on grain left for pheasants, as well as

natural food. It is said that red squirrels avoid pine martens by 'going high', where the martens cannot. It is possible that these red squirrels use the same mechanism to avoid conflict with grey squirrels.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★★★	★★
Live traps	★★★	★★
Kill traps		
Pine Marten (as natural grey predator)		★★★
Immuno-contraception (oral bait delivered via hoppers)		★★★
Gene Drive (Selected inheritance manipulated so only male young are born)		★★★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

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Collaborative red squirrel conservation in West Cumbria

West Lakes Squirrel Initiative (WLSI) and Copeland Red Squirrel Group (CRSG)

Geographical area of work

West Cumbria, Cumbria, UK

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Both groups engage with the public through the 'West Lakes Red Squirrels' Facebook group

Key partners

We have the backing and support of a consortium of private and public landowners, principally through allowing access to their land holdings, as well as, in the case of some of the larger landowners, sponsorship of the work undertaken on their land. Certain of our landowner supporters have asked for discretion and no publicity in our dealing with them. We have therefore not named individual organisations.

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	15 Also undertaking monitoring
Volunteers involved with squirrel monitoring	10 Not carrying out grey squirrel control
Other Active Volunteers	2 Fundraising, communication and data logging

Map of project land area

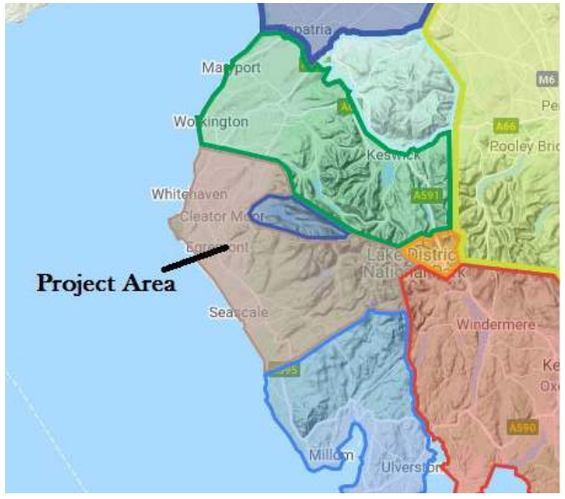

Figure 1. Map of project area.

The area covered by the two organisations covers a large part of the Western Lake District and the coastal fringe of Cumbria, from Waberthwaite in the south to Maryport in the north. The Buttermere Valley is the eastern extent of the group's working area. The geography we cover contains varying landscapes and environments, including a large part of the Lake District National Park. Land ownership varies widely and includes large corporate landowners, councils, trusts, farmers and privately-owned gardens and woodland.

Introduction

Although the geographical area within which we work has not historically been designated as a red squirrel (*Sciurus vulgaris*) stronghold, west Cumbria has always had an extant population of red squirrels with few, if any, grey squirrels (*Sciurus carolinensis*) seen until around 20 years ago. Upon reaching the area, grey squirrels spread rapidly and are now present across most of the study area. Red squirrels are also present in most areas, including within the major urban centres, but competition pressures from grey squirrels and the threat of Squirrelpox disease can have a significant local effect on red squirrel numbers if not dealt with quickly and efficiently.

The two groups work across an area that is geographically diverse, covering the Lakeland valleys of Eskdale, Wasdale and Buttermere through to the urban centers of Egremont, Whitehaven, Cleator Moor etc. The two groups are volunteer-led, working with some of the larger local landowners who are supportive of our work. In some instances, this includes financial support to our work, although much of our funding comes from public fundraising. In general, the local populace is supportive of the work the two groups do,

and both groups take care to ensure their reputation is maintained through careful vetting of volunteers and ensuring high standards of conduct in our work. This policy has helped to ensure a good working relationship and a high level of trust with those landowners who allow us to work on their land.

Project Aims

- Eradication of grey squirrels from the landholdings within which the group are active.
- Conserving and expanding existing red squirrel populations.
- Preventing the further spread of grey squirrels through the area.
- Increase public awareness of the plight of red squirrels in the area.

Description of the project

The Western Lakes Squirrel Initiative (WLSI) was set up in 2013 to engage in grey squirrel control through an area of West Cumbria, covering an area extending from Waberthwaite in the south, through to Broughton Moor in the north. The initiative was established as a limited company to enable it to work on corporate landholdings, where public liability insurance was a requirement of several organisations. At this time, due to the ill-health of the current coordinator, Copeland Red Squirrel Group (CRSG) was in a moribund state, so WLSI incorporated this group, with the aim of resurrecting it more fully in the future as resources allowed.

Given the company structure of the WLSI it was possible to establish access to several extensive landholdings through formal contractual arrangements. However, it should be noted that this access did not come about solely due to our corporate structure, but, was also facilitated by the professional reputation that the initiative had established.

Figure 2. Red squirrel and typical WLSI feeder.

As a volunteer-led organisation, working in an area with both red and grey squirrels, it was determined at an early stage that culling of grey squirrels by shooting with air rifles was the most effective control method available to the initiative. This is done through the establishment of fixed feeding stations to attract squirrels (Figure 2). Where appropriate, we utilise trail camera survey data to detect grey squirrels. A shooting position is established at 25 yards distance from each feeder. This distance is the same for all feeders to ensure a consistency in the shooting set-up. Whilst live trapping is used in specific instances, given the need to regularly check traps throughout the day (the initiative's policy is to not to set traps unless they can be checked a minimum of three times in a 24 hour period) this is typically too labour intensive for a group where the majority of members are in full-time work and the woodlands tend to be remote from main roads and population centres.

The reliance on shooting as the initiative's principal control method means that strict vetting of prospective volunteers is considered essential. A period of several weeks of mentoring and observation by experienced volunteers is required before new volunteers are permitted to venture out solo, and it is also a requirement of all volunteers that they fill and monitor feeders during the week, with shooting generally taking place at weekends. It is this culture of professionalism that has helped to establish the initiative's reputation, which in turn has led large risk averse organisations to allow the initiative access to their land.

As the WLSI's reputation has grown over the years, leading to more and more requests for support in grey control, the workload for the WLSI coordinators was becoming overwhelming. With an increase in volunteer numbers in the Copeland area, in 2019 the CRSG was re-established as a standalone group to try and alleviate some of this administration and coordination pressure. It is planned that the WLSI and CRSG will continue to work closely together, sharing a common pool of volunteers and supporting one another with resources as required. The intention is that CRSG will act as a more conventional volunteer group, as opposed to the company structure of WLSI, focusing on grey squirrel control and red squirrel conservation on private landowner permissions, with the WLSI focusing more on corporate landowner contracts. Since the re-establishment of the CRSG, both parties have ensured that stakeholders are aware of the ongoing collaboration.

Historically a significant amount of the WLSI funding has come from corporate sponsorship, a funding route source that will be less significant for CRSG. Collecting tins have been used for several years to supplement the WLSI income, and it is envisioned that this will be a key source of funding for CRSG, but with more and more of a move away from cash payment collecting tin income is falling. This will require some creative thinking to come up with new sources of funding. Ideas currently being explored include feeder sponsorship, guided photography trips and crowd funding via local print and social media. Complementary to this is a recognition of the importance of building a positive and strong web-presence through social media. Most volunteers' principal focus is supporting red squirrels through 'boots on the ground' work, but we need to ensure that we do not neglect keeping the general public informed about the good work we are doing.

Success indicators within the project

Figure 3. Red squirrel sighting locations in west Cumbria during 2019.

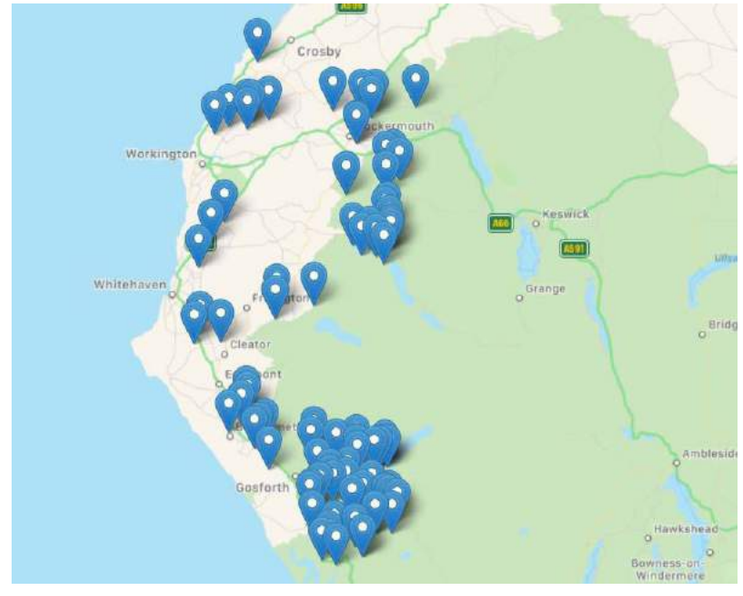

Figure 4. [WLSI Img3] Grey squirrel cull locations in west Cumbria during 2019.

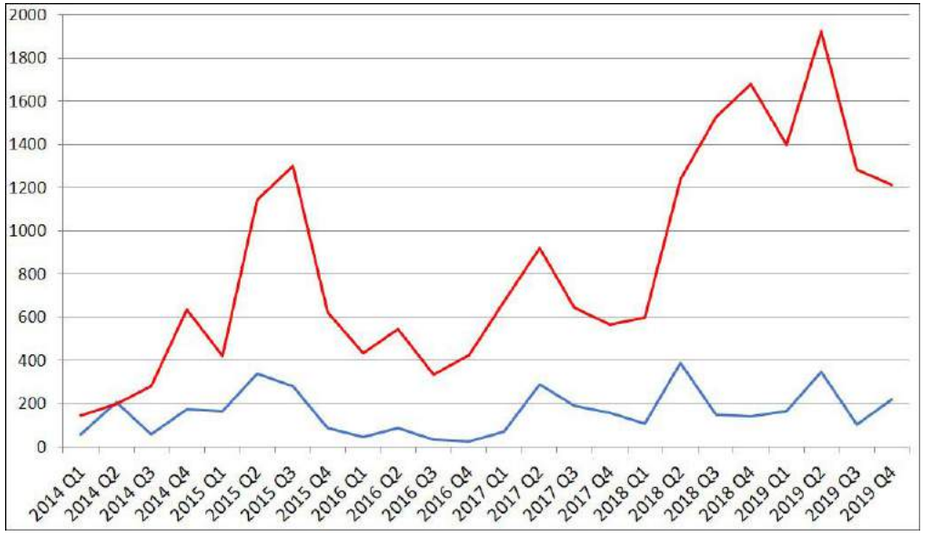

Figure 5. Red squirrel sightings (red line) & grey squirrel cull records (blue Line) by quarter over six years.

- Ensuring that the red squirrel population thrives by monitoring and tracking the number of red squirrel sightings year by year (Figure 3 & 5).
- Expanding the range of red squirrels in west Cumbria (Figure 3).
- Reducing grey squirrel abundance and distribution (Figure 4 & 5).
- Maintaining community outreach so that the local population and visitors are motivated to support red squirrel conservation.

Major difficulties faced

- Resistance to grey squirrel culling by certain landowners, allowing pockets of grey squirrels to remain in red squirrel areas.
- A lack of support from Forestry England and The Woodland Trust, both being UK Squirrel Accord signatories and major local landowners with both red and grey squirrels seemingly being left to their own devices in their woodlands.
- Not being able to establish land ownership of woodland with known grey squirrel populations, preventing the possibility of negotiating access.

Major lessons learned

- Prioritisation of resources is important – effort should focus on areas where red and grey squirrels are mixing. Total numbers of grey squirrels culled is not the only metric of success!
- There is limited value to establishing permissions and monitoring points if there is no resource to maintain them.
- Building a reputation as credible and trustworthy organisations is key to building public and landowner trust and helping gain land access.
- A questioning attitude to prospective volunteer motivations is important – are they in it for the right reasons, or just looking for shooting opportunities?

Project Su ss

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	Medium
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Whilst reducing in some areas, red squirrel populations locally are stable or increasing relative to when the initiative's work started.
- Whilst grey squirrel numbers are still significant in the area, where able to access areas to control them, numbers can quickly be reduced.
- Following grey squirrel control, red squirrels have been returning to areas where they haven't been seen for a number of years.
- Red squirrel populations appear resilient, with Squirrelpox outbreaks not resulting in long-term or widespread population declines.

Future project development

- Given the limited volunteer resource, more judicious deployment of monitoring/control points will be a key future action.

- Given the general move away from cash to electronic payments, and a consequent reduction in collection tin income, alternative methods of fundraising are being investigated.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★ ★ ★	★ ★ ★
Live traps	★ ★	★ ★
Kill traps		
Pine Marten (as natural grey predator)		★
Immuno-contraception (oral bait delivered via hoppers)		★
Gene Drive (Selected inheritance manipulated so only male young are born)		★ ★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★	★ ★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

References

I. Armstrong, P (2015) *Red squirrel conservation in West Cumbria*. In: Shuttleworth CM, Lurz PWW & Halliwell EC (Eds) Shared Experience of red squirrel conservation practice. pp. 137-143. ESI.

The Wildwood Trust: Breeding and conserving red squirrels in Britain

Wildwood Trust & Wildwood Escot

Geographical area of work

Wildwood Trust, Herne Common, Kent
Wildwood Escot, Ottery St. Mary, Devon

Author and organisation contact details

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Key partners

- The British and Irish Association of Zoos and Aquariums (BIAZA)
- Native Species Working Group
- Natural Resources Wales
- Red Squirrel Trust Wales
- Clocaenog Red Squirrel Trust
- UK Squirrel Accord (UKSA)

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	0
Volunteers involved with squirrel monitoring	0
Other Active Volunteers	0
Other info	5 Paid squirrel keepers across the two sites Employed full time by the Charity

Map of project land area

Figure 1. Location of Wildwood Trust in Kent.

Introduction

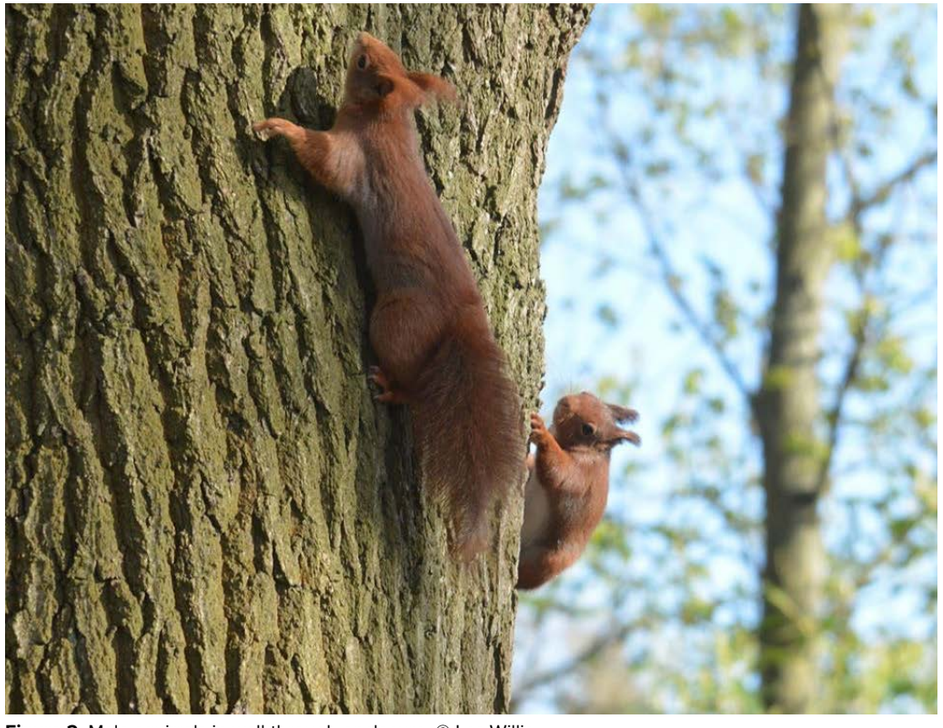

Figure 2. Male squirrels in walkthrough enclosure. © Les Willis.

Wildwood Trust became a registered charity in 2001. It is a discovery wildlife park in Kent, educating visitors about British native species. The red squirrel (*Sciurus vulgaris*) has featured prominently in the Trust's aims to promote and, where appropriate, restore native species to former habitats in Britain (Figure 2). In 2015, Wildwood secured the sister park Escot Ltd in Devon. This institute also has an important input into captive breeding and public education of red squirrel conservation in the southwest. Wildwood Trust Kent has provided captive-bred squirrels for reintroductions in Wales since 2005. Both Wildwood Kent and Wildwood Escot display squirrels to the public, in walkthrough enclosures which inspire the public to see these animals in natural surroundings and raise the profile of species conservation. We have knowledgeable and experienced red squirrel keepers and our conservation officers are involved in research work exploring the impact pine martens (*Martes martes*) may have on grey squirrel numbers and the associated success of the return of red squirrel populations to the British landscape. Under the management of the British and Irish Association of Zoos and Aquaria (BIAZA), Wildwood Trust is coordinating the Red Squirrel Focus Group. This was initiated in March 2020 to bring together nationally, red squirrel captive breeders and ensure that the highest standards of husbandry, disease management, and genetic recording are achieved. This will ensure that the captive population will be fit for survival in all appropriate release programmes. In 2019 Wildwood Trust hosted the first BIAZA accredited workshop for red squirrel husbandry for captive breeders.

Project aims

- To ensure the highest standards of captive husbandry, and disease control is applied across the national breeders of red squirrels to optimize success in appropriate conservation translocation programmes.
- To assist in research which facilitates the success of red squirrel reintroductions and other translocations.
- To engage and educate with the public to the possibility of the return of red squirrels to British natural habitats where it is currently extinct.

Description of the project

Wildwood Trust Kent and Wildwood Escot captive breeding facilities currently consist of three pairs of squirrels across the two sites. The sites have the opportunity to breed squirrels for future conservation translocation projects. Red squirrels are housed as pairs and can either have one or two litters per year. The offspring are either sent to reintroduction or population reinforcement projects in the UK or are distributed to other Zoological collections and private breeders as part of National studbook. These squirrels and their offspring are kept in enclosed breeding facilities to ensure the identification and therefore the genetic bloodlines of squirrels in the breeding programme are recorded and monitored.

We are constantly monitoring and improving both our husbandry skills and knowledge and have contributed lessons learned to a 'Captive Red Squirrel Management: National Recommendations and Guidance' document. Wildwood Trust Kent has a proven track record of assisting with release projects in Wales. First with the Anglesey Island project (2005 to 2016), and recently with the reinforcement of a small population at Clocaenog Forest, northeast Wales (2017 to present). A total of 30 squirrels have been sent for release during this period.

Figure 3. Wildwood Trust Kent – Squirrel Walkthrough.

In 2011 a three-quarter acre walkthrough 'red squirrel' enclosure was built at the Escot site. This has proved to be very popular with the public. The enclosure houses a single sex group of squirrels which is habituated to the public. This exhibit facilitates close contact and good opportunities for education and photography. In 2019, Wildwood Trust in Kent also opened a one-acre walkthrough facility for public viewing (Figure 3). Again, the protocol is to house a single sex group of red squirrels, and no breeding takes place within the enclosures. These walkthroughs immerse the public in a red squirrel experience, which educates and raises the profile of our native squirrel. The incidence of stereotypical behaviour in captive red squirrels, which can be prevalent in breeding enclosure, would appear to decline in this type of exhibit.

In September 2019 the first BIAZA accredited workshop for 'Red Squirrel Husbandry' was was organised and hosted by Wildwood Trust. There was good attendance with 35 attendees from 16 institutions. Presentations were given on:

- Monitoring the captive red squirrel population in the UK
- Implications of adenovirus infection
- Captive husbandry management at Wildwood Trust
- A history of squirrel reintroductions in Wales
- An introduction to the BIAZA Conservation Translocation Policy.

Practical sessions were also given on a variety of topics including, building commensal rodent-proof squirrel feeders for captive red squirrel enclosures; encouragement of natural drey construction in captive red squirrels; the use of motion sensor camera traps to monitor squirrel behaviour in captivity and a general discussion on the incidence of stereotypical behaviour amongst captive squirrels.

In order to strengthen and improve information across the country's collective captive breeding group, Wildwood is co-ordinating a focus group under the guidance of BIAZA and the Native Species Working Group. The BIAZA Red Squirrel Focus Group has several objectives, the first being to identify and collate all holders and breeders of red squirrels in the UK. It is hoped that in time a database of all the captive breeders in the UK will be identified and approached to join the group. This national breeding group would then be able to opt into a voluntary protocol for red squirrel captive breeding, public enclosures and release programmes in the UK as discussed by the UK Squirrel Accord (UKSA). The outcome of this group is to develop and provide best practise guidance in the management and breeding of red squirrels, which will maximise the success of reintroductions through appropriate projects.

By encouraging and supporting these new collaborative initiatives, it is hoped that the national captive population of red squirrel will be an important component in future reintroductions or reinforcements projects.

Success indicators within the project

- Success in captive breeding of red squirrels.
- Ability to provide red squirrels for translocation projects which have been screened against IUCN (2013) guidelines.
- Contribute information on captive red squirrel husbandry to improve national best practice.

Major difficulties faced

- The UK studbook for captive red squirrels does not contain detailed genetic data. There is a suspicion that genetic variability would benefit from new bloodlines being introduced.
- Public perception of red squirrels in the wild is often low. The long absence of red squirrels from local areas has allowed grey squirrels to replace red squirrels in the public's affections.
- A cohesive approach to infection surveillance in captive red squirrel populations was limited until adenovirus screening was introduced.

Major lessons learned

- The need for good grey squirrel control within woodland sites where walkthrough red squirrel enclosures are present. This is essential to reduce the probability of disease transmission from grey to red squirrels.
- The need to maintain good national records on captive red squirrels and the development of the best standards of care in captivity that can be applied to all institutes that hold red squirrels.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Success in captive breeding of red squirrels.
- Donating 30 squirrels over 15 years to translocation projects
- More research is required on the factors that create successful captive management and breeding of squirrels; particularly relating to factors affecting infant mortality rates (Figure 4).

Figure 4. Kittens at Wildwood Escot, Devon.

Future project development

- Wildwood Trust assisted in coordinating a national captive red squirrel breeding group. This included developing a written best practice with organisations within the UKSA.

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III. IUCN/SSC (2013). Guidelines for reintroductions and other conservation translocations. Version 1.0, Gland, Switzerland, IUCN Species Survival Commission.

Red squirrel conservation in the Greenfield Red Squirrel Refuge

Yorkshire Dales National Park Authority

Geographical area of work

Greenfield plantation, Langstrothdale, Yorkshire Dales National Park (YDNP), England.

Author and organisation contact details

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Key partners

- Tilhill Forestry
- Forestry Commission (FC)
- Yorkshire Dales National Park Authority (YDNPA)

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	
Paid Contractors (7-12 months)	1 A full-time conservation officer is funded through an EWGS grant. The role includes grey squirrel control
Volunteers involved with Grey control	
Volunteers involved with squirrel monitoring	
Other Active Volunteers	
Other Info	Monitoring work undertaken by YDNPA staff

Map of project land area

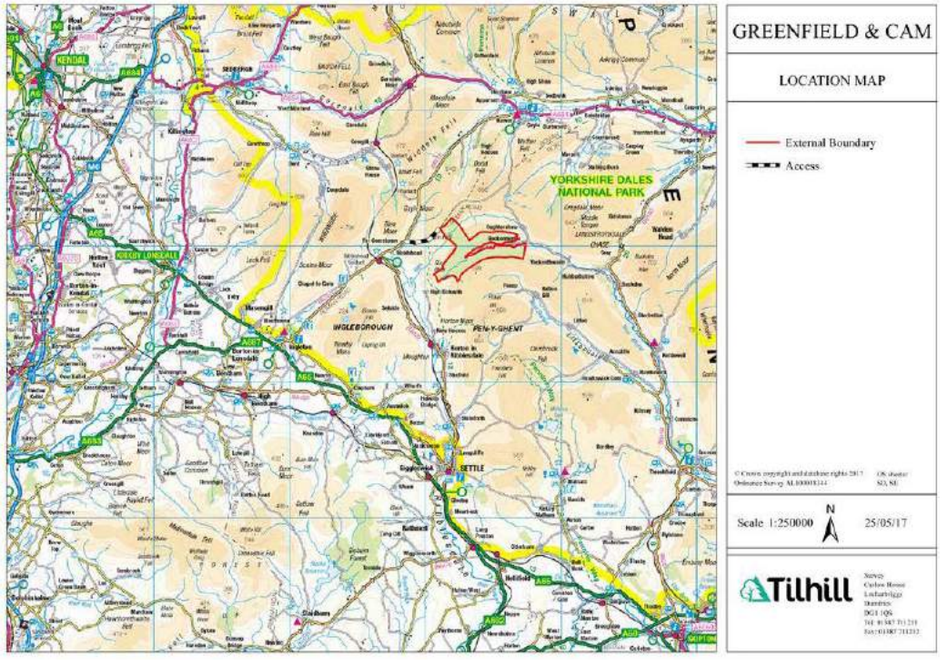

Figure 1. Map of the project area.

The woodland was planted between 1968 and 1979 and was initially managed as two separate units under different ownership known as Cam and Greenfield respectively. In 2014, Cam woodland was purchased by the owner of Greenfield and together the areas have subsequently been managed under a single long-term forest design plan. Greenfield covers an area of 1054 ha and was predominately Sitka spruce (*Picea sitchensis*, 71.4% of the woodland area), Norway spruce (*Picea abies*, 1.4%), Japanese larch (*Larix kaempferi* 3.4%), lodgepole pine (*Pinus contorta*, 8.0%), mixed broadleaves (2.9%) and open ground (12.9%). Cam woodland covers 220 hectares and although definitive details are not available, was predominately planted with Sitka spruce and lodgepole pine. The plantation is currently approximately half way through the first harvesting rotation of the commercial conifer crop element. Harvesting commenced in 2009 and the revised management plan allows for the harvesting up to 2033.

Introduction

Following unconfirmed reports of red squirrels (*Sciurus vulgaris*) in 2004, a small-scale live trapping project was undertaken within the plantation. Red squirrels were caught on seven separate occasions and in some instances recaptures of the same animal were suspected. Two grey squirrels were also caught. All captures were from within a single trapping area and there was no evidence of any squirrels in other areas that were trapped within the plantation. The discovery of red squirrels meant that there were no historical data on population size or distribution. Neither Greenfield or Cam woodlands were included within the 17 large conifer forests designated as Red Squirrel Reserves in northern England. The North of England Red Squirrel Conservation Strategy published in 2005 did include part of Cam woodland within a geographical buffer area surrounding the adjacent Red Squirrel Reserve of Widdale.

Additional data collected by the Yorkshire Dales National Park Authority (YDNPA) confirmed the presence of red squirrels throughout the woodland. With the large area of suitable isolated habitat, and the linear river corridors leading to the plantation offering limited incursion routes for grey squirrels, the YDNPA proposed that the whole of Greenfield and Cam were designated as a Red Squirrel Reserve with an adjacent buffer area surrounding it. This information was presented to the North of England Red Squirrel Steering Group who endorsed the decision to designate Greenfield as a Red Squirrel Reserve in December 2008.

This enabled funding from an England Woodland Grant Scheme (EWGS) woodland management grant from the Forestry Commission (FC) to contribute towards the cost of a full-time conservation officer to undertake grey squirrel control in and around the reserve.

To date, camera trap surveys have found no evidence of pine martens within the woodland areas.

Project aims

- Maintain a sustainable population of red squirrels in Greenfield by delivering the current Red Squirrel Reserve strategy.

- Eradicate grey squirrels from the reserve area and limit incursion.

Description of the project

The objective has been to implement the Red Squirrel Reserve strategy in Greenfield. In 2009 a grey squirrel trapping programme began. This was undertaken by a full-time conservation officer employed by Tilhill. Initially the trapping effort was undertaken across a wide area of the Greenfield plantation but, due to the different ownership none occurred in Cam woodland. Trapping results were assessed to determine the areas where squirrels were most likely to be found and from these data a systematic control programme was designed.

The original aim of control was to reduce the number of grey squirrels within woodland compartments, eradicating them so that the emphasis of the trapping could then move to the edge of the buffer area to prevent further incursion from further down Wharfedale, where broadleaved woodland areas were thought to support relative high numbers of grey squirrels. As the number of grey squirrels in Greenfield decreased, some trapping was also undertaken outside Greenfield, in Widdale along the most likely primary grey squirrel incursion route to the north and, at as site just outside the plantation boundary to the south. In addition to the trapping funded by EWGS & Countryside Stewardship (CS), ecological consultants carried out some trapping at several different sites in the eastern incursion corridor in Upper Wensleydale between 2016 and March 2019.

Recent comprehensive grey squirrel control trapping effort within the plantation has only resulted in the capture of red squirrels. In order to prevent such non-target captures, from the beginning of 2019 the use of trail cameras to detect grey squirrels before deploying live- traps began. Camera traps were erected at trapping sites for three to four weeks and the captured images monitored on a weekly basis. If only red squirrels were recorded, then the cameras were moved to another location. When grey squirrels were detected, trapping was undertaken for two weeks after a grey squirrel capture until no further captures were made. This method was undertaken as part of a rolling programme of monitoring and was carried out at over 50 different sites within the woodland.

Greenfield is a large isolated site with ongoing active forestry operations and a carefully coordinated deer management programme. Trying to implement a volunteer programme of grey squirrel control would therefore be problematic and would require considerable coordination even if volunteers were available. The FC funding enables Tilhill to employ a conservation officer who has an excellent working knowledge of the area, is fully aware of the timings and location of forestry operations and is part of the deer management programme. This is crucial in delivering a coordinated control programme in a working forest. YDNPA staff have worked closely with the conservation officer to assist with long-term monitoring work.

One of the issues is that many of the woodlands within the key grey squirrel incursion corridor in Widdale are small, often under different ownership, and are sites where grey squirrels are thought to be at low density. Implementing grey squirrel control is therefore

difficult. The presence of a conservation officer who has been able to react to grey squirrel reports received has meant that grey squirrels have been removed from several of these sites. This co-ordinated approach has played a crucial role in helping to prevent populations of grey squirrels from becoming established within the buffer area.

The conservation officer has also provided specialist advice, dissemination of best practice and mentoring to enable several landowners wanting to carry out small-scale grey squirrel control in the buffer area. In addition, drey surveys have been undertaken in Greenfield prior to felling works so that protected red squirrel nest sites are retained.

The grey squirrel control at Greenfield makes a key contribution to the other red squirrel conservation initiatives being undertaken in the adjacent complex of Garsdale, Mallerstang and Widdale Red Squirrel Reserve and buffer areas. It also compliments the long-standing work of the Penrith, Garsdale, Sedbergh, Mallerstang and Wensleydale red squirrel groups who have been undertaking a range of conservation measures in the wider area for many years.

As Greenfield is not suitable for educational or school visits, the Snaizeholme Red Squirrel Viewpoint in the adjacent area of Widdale is still promoted and regularly used.

Success indicators within the project

- To have a sustainable population of red squirrels by eradicating grey squirrels from the reserve and preventing further incursion of grey squirrels, primarily from the eastern part of the buffer zone in Upper Wharfedale.

Major difficulties faced

- Multiple land ownership in the buffer areas means that extending grey squirrel control into these areas requires a considerable amount of time and extensive liaison.

Major lessons learned

- One of the main reasons for the success of work has been getting the right people in place to carry out the grey squirrel control. It has been fortunate that the two conservation officers who have been appointed have been extremely dedicated, efficient and professional in carrying out their work. The importance of getting ‘the right person’ should not be underestimated.

- Long-term monitoring work has complimented the grey squirrel control operations and played an important role in determining the effectiveness of the project.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Funding to enable grey squirrel control to be undertaken.
- The results of long-term monitoring undertaken in conjunction with trapping results show the decline in grey squirrel numbers and distribution, with an associated increase in red squirrel distribution (see Figure 2)

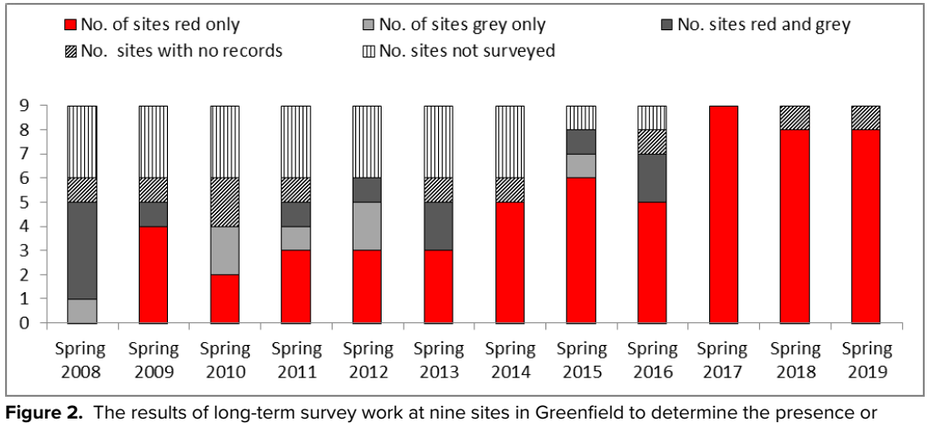

Figure 2. The results of long-term survey work at nine sites in Greenfield to determine the presence or absence of red and grey squirrels.

Highlighting how challenges identified in 2015 have been approached

- In the wider area, further work is still required to try and bring together the work of statutory bodies and other organisations, especially where opinions differ on expectations and management issues.
- In the wider area, the relatively small size (range between 35 hectares and 95 hectares) of conifer woodlands in the YDNP are a constraint that needs to be worked around when managing them for red squirrels.
- Managing the long-term availability of cone bearing trees within a commercial conifer is difficult, especially in relatively small woodlands but can be achieved if positive conservation measures are implemented by the landowner.

Future project development

- Establish trap lines within the buffer area to prevent grey squirrel incursion into the reserve area.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in <u>developing</u> this aspect of grey squirrel management in your project area
Shooting	N/A	★
Live traps	★ ★ ★	★ ★ ★
Kill traps		
Pine Marten (as natural grey predator)		★ ★
Immuno-contraception (oral bait delivered via hoppers)		★ ★ ★
Gene Drive (Selected inheritance manipulated so only male young are born)		★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★ ★ ★	★ ★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

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Magical mammals: Red squirrels in north-west Wales

Red Squirrels Trust Wales

Geographical area of work

The Isle of Anglesey and the Arfon District of mainland Gwynedd.

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Key partners

- Bangor University
- Zoological Society of Wales
- Animal Plant Health Agency (APHA)
- Natural Resources Wales (NRW)
- Bangor City Council
- Isle of Anglesey County Council AONB staff
- National Trust Wales
- Menter Fachwen
- The Wildlife Trusts

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	2 During the period 2017-2019 there were 2 contractors. This reduced to 1 in 2020
Paid Contractors (7-12 months)	3 During the period 2016-2019 there were 3 contractors. This reduced to 0 in 2020.
Volunteers involved with Grey control	45
Volunteers involved with squirrel monitoring	6 + 200 Six volunteers monitoring camera traps in Gwynedd and 200 monitoring gardens and woodlands on Anglesey Directors of RSTW
Other Active Volunteers	8

Map of project land area

Figure 1. Map of Anglesey and northern Gwynedd.

The 720km^2 island of Anglesey (Welsh: Ynys Môn) is situated off the north coast of Wales and is separated from the adjacent mainland by the narrow Menai Strait. There are two bridges providing road and rail links to the mainland and the port of Holyhead is a key hub for trade between the United Kingdom and the Republic of Ireland. Woodland cover on Anglesey is 3-4% and this includes 1000 hectares of mixed coniferous plantation, whilst the majority of the landscape is agricultural grazing land. Although grey squirrels (*Sciurus carolinensis*) were once common, the species was eradicated in 2013. The island currently contains the largest population of red squirrels (*Sciurus vulgaris*) in Wales.

Opposite the island is the mainland district of Arfon in the county of Gwynedd. Although the coastal Arfon woodlands contain small numbers of red squirrels, the species is absent from all but a handful of sites further inland. The City of Bangor contains 20% woodland cover and is surrounded by a patchwork of agricultural fields amongst extensive woodland habitats bordered to the south by the Carneddau mountains. Hardwood tree species reflect the acid soils with sessile oak, birch, hazel, alder and willow common across the landscape. However, in many areas the woodland species composition reflects historical estate planting and/or less acid soils and here beech, ash, sweet chestnut and lime are present.

Introduction

Red squirrel conservation has been taking place in this part of Wales since 1997 and resulted in the successful eradication of grey squirrels from Anglesey in 2013. Since then, six grey squirrels have been detected and removed from the island via a volunteer squirrel monitoring network and volunteers also conduct some mainland grey squirrel control. In the period 2016-2019 this mainland effort was supported by contractors paid for through the national Red Squirrels United project.

A single pine marten (*Martes martes*) was present in the mainland woodlands in both 2018 and 2019. A pine marten release project will take place in 2020 with the aim of establishing the predator across Gwynedd as a natural means of suppressing the grey squirrel population and captive-bred animals have been sourced for this project.

Disease surveillance amongst red and grey squirrel populations is a key element in the conservation work. Here volunteers routinely collect the bodies of dead red squirrels and pass them on for post mortem and histological studies. This surveillance has revealed an absence of hantavirus and lymphocytic choriomeningitis virus (LCMV) in red squirrels whilst leprosy and adenovirus infections were present. Dermatophilosis infection was also found in two red squirrels. Squirrelpox was not detected on Anglesey but a small mainland outbreak was confirmed in 2017.

Red Squirrels Trust Wales, Natural Resources Wales and the Clocaenog Red Squirrel Trust are currently developing a new five-year project to conserve red squirrels and pine marten across north Wales.

Project aims

- Maintain Anglesey free from grey squirrels to prevent inter-species competition and protect the resident red squirrels from being exposed to Squirrelpox virus.
- Source captive-bred pine martens for reintroduction to northern Gwynedd.
- Undertake comprehensive screening for viral infections and disease amongst both red and grey squirrel populations.
- Expand the network of volunteers undertaking grey squirrel control and monitoring red squirrel populations. Volunteers are trained with relevant skills, knowledge and information.

Description of the project

The project controlled the Arfon (Gwynedd) grey squirrel population in order to reduce contact with mainland red squirrels and limit the probability of grey squirrels dispersing

onto Anglesey. In the period 2016 to 2019, paid contractors removed 7,415 grey squirrels and volunteers an additional 462 animals. Although the grey squirrel population was depressed, continual immigration into the area meant that there was a constant presence of the species.

An established co-ordinated community based early detection network on Anglesey led to the identification and removal of two grey squirrels in 2017. Working with Holyhead Port authority to risk assess the accidental transportation of grey squirrels, a reactive contingency plan was produced to deal with any grey squirrel detection at the Port and all Port staff were given a book on the identification of red and grey squirrels to assist this.

The threat posed by grey squirrels to red squirrels meant that monitoring the health of wild red squirrels was a key priority. The project therefore screened dead red squirrels for a range of infections:

Adenovirus & Squirrelpox virus

Landscape scale viral surveillance revealed a significant cluster of red squirrel mortality associated with pathogenic adenovirus in 2017 (Everest et al. 2017) and again in 2020. Squirrelpox virus was also detected amongst mainland red squirrels in 2017 and the isolated outbreak died out without causing local red squirrel extinction. Dermatophilosis, a severe skin disease, was confirmed in two Anglesey red squirrels that had initially been suspected as Squirrelpox cases.

Hantavirus

Screening of kidney samples taken from 21 red squirrel carcasses recovered in the period 2016/17 were negative for hantavirus (using a pan-hantavirus nested RT-PCR test). Whilst the test (Klempa et al. 2006, EID 12:5) had not been validated for screening red squirrel specimens, it is a widely adopted published approach with proven success at detecting a wide range of known and novel hantaviruses in a range of diverse host animal species.

Lymphocytic choriomeningitis Virus (LCMV)

Kidney samples were collected from the same 21 animals and tested (using a Pan-Arenavirus RT-PCR assay directed against the L-gene and following the methodology as published in Vieth et al. 2007). No amplified LCMV genetic material was detected in any of the screened red squirrel tissue.

Leprosy

Samples collected from 121 frozen red squirrel carcases collected between 1983 and 2018 in north-west Wales were tested for leprosy using established genetic techniques. Studies identified *Mycobacterium leprae* DNA in two animals.

Grey squirrel infection

Few grey squirrels sampled and tested were found to have signs of pathogenic infections. However, in 2019 two cases were investigated. An animal trapped on 21st February 2019 near the village of Cwm y Glo in Gwynedd was found to have internal parasites in the abdominal cavity (Figure 2). Investigations by APHA [case 26-M0313-02-19] revealed that the white sections comprised the larval form of a cestode (tapeworm) parasite.

Figure 2. - Cestode (tapeworm) parasite inside grey squirrel abdominal cavity. © Paul Holmes Animal Plant Health Agency.

In July 2019 a contractor trapped a grey squirrel with chronic skin disease (Figure 3). The carcass was sent to APHA [case 26-M0058-07-19] for gross post mortem and histology. The results suggested fungal infection by a Candida species.

Figure 3. Candida infection of grey squirrel. © Paul Holmes Animal Plant Health Agency**.**

Future project evolution

In 2018 it became apparent that the project needed to evolve grey squirrel control away from a live-capture trapping based approach because it was difficult to maintain grey squirrel populations at a low level without significant financial resources. Research findings from Ireland had revealed strong evidence that pine martens were associated with grey squirrel declines. Consequently, RSTW investigated the feasibility of a pine marten release project in Gwynedd using captive-bred animals. The proposal was screened against International World Conservation Union (IUCN) guidelines and a wide community consultation took place. In 2020 the first four captive-bred pine martens will be released with VHF radio-transmitters fitted so that their movements can be documented. Monitoring will be carried out by volunteers including collection of scat and the use of remote passive-infra red triggered wildlife cameras. Volunteers currently monitor cameras in key mainland areas where red squirrels persist in order to detect grey squirrels and any visual signs of pathogenic disease in the red squirrels.

Outdated forestry Laws

In 2018 forest clear-felling near Bodafon on Anglesey was discovered during peak red squirrel breeding season when dependent young were in the nests. Subsequently, it became apparent that although a tree felling licence was in place, the licencing authorities were unable to include 'enforceable wildlife conditions' because the 1967 Forestry Act did not allow this in England or Wales. A public campaign and UK Government petition was met with a refusal by Forestry Commission and DEFRA to make legislative changes in England at this time. However, in Wales, the national statutory forestry and nature conservation body NRW supported change and Welsh Government acknowledged the weakness in the current timber harvesting legislation. We are hopeful that there will be legislative change in Wales to protect forest wildlife.

Success indicators within the project

- Successful prevention of Squirrelpox outbreaks taking place on the island of Anglesey in the period to 2019.
- Successful horizon scanning for Hantavirus and LCMV infections in the period 2015-2019.
- Preparations for the future release and establishment of captive-bred pine martens in Gwynedd have been successful.

Figure 4. Male captive bred pine marten in a release enclosure in northern Gwynedd.

Major difficulties faced

- A small number of grey squirrels continue to disperse onto Anglesey.
- Recruitment and retention of volunteers willing to cull grey squirrels remains a significant challenge. A majority of local people are controlling grey squirrels in their gardens or within woodlands near to home. This makes it difficult to ensure control is targeted to key woodlands and invasion corridors.
- The small number of captive adult female pine martens means that numbers of young available for release projects are extremely limited; even if a large proportion of the females produce litters.

Major lessons learned

- A small volunteer based organisation like RSTW can confidently undertake thorough IUCN screening of a pine marten translocation proposal despite the level of technical assessment required.
- Pathogenic viral infections can be detected and managed effectively through citizen science and co-ordination via social media. However, this needs the detection and collection of red squirrel carcasses along with sufficient financial resources to cover both post mortem and associated histological screening costs.

- It is worth undertaking post mortem of grey squirrels that show signs of disease or infection as the findings can illuminate additional threats to sympatric red squirrel populations.

- A reliance solely upon live-trapping control of grey squirrels is unlikely to result in sustained declines in the absence of significant financial resources. Consequently, pine martens will be reintroduced to provide a complementary natural predation of grey squirrels with the aim of establishing the predator at a density which is sufficient to make their impact significant.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- We were unable to eradicate grey squirrels from the Arfon district during the Red Squirrels United project and this has meant a continual risk of the mainland red squirrel population coming into contact with these grey squirrels.

- A Squirrelpox virus outbreak was recorded in mainland red squirrels in 2017 and although this was contained the ongoing threat posed remains a constant risk.

- The acquisition of captive-bred pine marten was challenging although four were obtained in the autumn of 2019.

- Significant public outreach resulted in higher levels of awareness of the threat grey squirrels pose to red squirrels across the Arfon district.

Highlighting how challenges identified in 2015 have been approached

In 2015 we reported on the 'Painting the Town Red' project which preceded 'Magical Mammals':

- **Fundraising limitations** - We were subsequently able to secure significant four-year long project funding through the EU LIFE and National Lottery Heritage Funded Red Squirrels United project partnership.

- **Limited core volunteers** - There remains a relatively small group of 20 people who carry out project management, grey squirrel control and monitoring activities.

- **Continual grey squirrel dispersal into mainland woodlands adjacent to Anglesey** - Although we greatly reduced grey squirrel numbers, we were unable to maintain these habitats as completely grey squirrel free (Figure 5).

- **Limiting grey squirrel dispersal** - In 2019 we developed a protocol for the Holyhead Port authority to use in order to reduce the likelihood of grey squirrels being accidently transported by vehicles using the ferry service to/from Ireland.

Figure 5. - Squirrel confrontation. © Heather Blakeslee Nov 2014 https://flic.kr/p/eiWJVx

Future project development

- Predictive spatial modeling will be undertaken to understand red squirrel, grey squirrel and pine marten dispersal and settlement patterns within the woodland landscape in Gwynedd. This will help us understand potential interactions between species and how to monitor them.

- Increasing the number and demographic range of people volunteering and to develop participation opportunities to maximise the health and well-being benefits of engaging with red squirrel conservation.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★	★★
Live capture traps	★★★	★★★
Kill traps		
Pine Marten (as natural grey predator)	★	★★★
Immuno-contraception (oral bait delivered via hoppers)		★★
Gene Drive (Selected inheritance manipulated so only male young are born)		★★★
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

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Clocaenog red squirrel recovery

Clocaenog Red Squirrel Trust (CRST)

Geographical area of work

Clocaenog Forest, Nr Ruthin,
Denbighshire, north Wales

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Key partners

- Natural Resources Wales (NRW)
- Red Squirrel Trust Wales
- Welsh in Business
- Wales Squirrel Forum
- Innogy Renewables UK Limited
- Brenig Wind Ltd Community Benefit Fund
- Llysfasi College
- Dŵr Cymru (Welsh Water)

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	Grey squirrel control contractors are employed periodically by NRW
Paid Contractors (7-12 months)	
Volunteers involved with Grey control	8
Volunteers involved with squirrel monitoring	16
Other Active Volunteers	2/3 CRST also benefit from the help given by members who provide support with necessary Welsh translations of written materials and information

Map of project land area

Clocaenog Forest (near Ruthin) is a large upland commercial conifer plantation in northeast Wales (5500 hectare) located on the Denbighshire and Conwy county boundary. The forest is managed by Natural Resources Wales (NRW) on behalf of the Welsh Government. The plantation comprises a mix of conifer species including larch (*Larix spp*.), Norway (*Picea abies*) and Sitka Spruce (*Picea sitchensis*) (69%), and pine (*Pinus spp*.). There is also a small amount of mixed broadleaved trees.

The forest sits between 300 and 500m above sea level and is surrounded by moorland and farmland to the north and west making it somewhat of an island. This is thought to be the saving factor of the red squirrel (*Sciurus vulgaris*) as the geography has acted as a partial barrier to grey squirrel (*Sciurus carolinensis*) dispersal.

Clocaenog Forest is one of seven areas across Wales which have been identified by the Welsh Assembly Government for wind farm development and expansion.

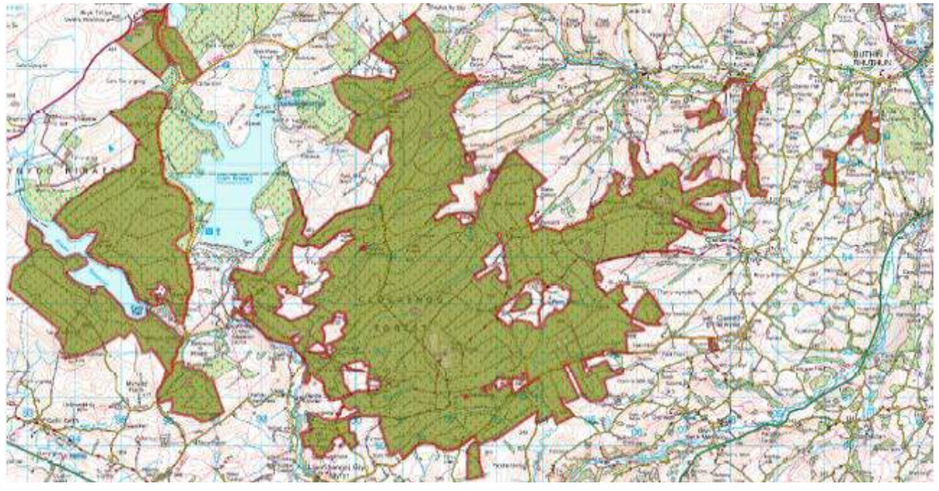

Figure 1. Clocaenog Forest (map kindly supplied by NRW).

Introduction

Mainly planted in the 1930s, it wasn't until the early 1950s that red squirrels (*Sciurus vulgaris*) started making use of the food items (buds, shoots and seed) that the maturing trees started to offer. In the late 1990s there were up to 400 animals present and were considered Wales' largest population until the subsequent success on Anglesey. This former stronghold for red squirrels is no more, the current population figure is now estimated to be less than 50.

Historically, the dominance of sitka spruce has made the forest less attractive to grey squirrels as the small size of seed produced by this coniferous tree species meant that it is harder for grey, relative to red squirrels, to gain enough energy from this food alone. However, over the last twenty years, grey squirrel incursions into the forest have become more frequent and widespread requiring a greater emphasis on monitoring and control. There have been verified sightings of pine marten (*Martes martes*) but there does not appear to be a resident population, (the last confirmed sighting was in April 2019).

Clocaenog Red Squirrel Trust (CRST) was formed in 2019 by a group of conservation enthusiasts who were already involved in the protection of red squirrels in Clocaenog Forest. Group members were already volunteering through the Red Squirrels United (RSU) project which ran for four years, (up to spring 2020). Other time-limited conservation activities had also taken place prior to the RSU project starting. Notably, Mammals in a Sustainable Environment (MISE) which was a European funded project.

CRST is now a fully constituted voluntary group and registered charity, the group is fully support by NRW.

Project aims

CRST aims to:

- Help conserve and protect the small remnant red squirrel population.
- Raise awareness of the threats red squirrels face. This is done through community partnerships, engagement and activities.
- Continue with grey squirrel monitoring/control within and around the forest (including a buffer zone).
- Increase the population of red squirrels by using a reinforcement translocation programme following International Union for Conservation of Nature (IUCN, 2013) guidelines.

Description of the project

Following on from the RSU project achievements, CRST aim to continue and build on the successful conservation work.

Several red squirrel population reinforcement phases have already been completed (2017-19). Eighteen captive-bred animals donated from various accredited-breeders around the country and four translocated animals from a wind thrown wood on Anglesey were brought

to Clocaenog Forest between 2017 and 2019. Volunteers along with staff from NRW built four enclosures at key locations in the forest. These suitable habitat areas were selected because there had been recent red squirrel records recorded there. Captive squirrels were held in enclosures for a quarantine period during which volunteers carried out daily health and welfare checks. The release programme was deemed successful as breeding has occurred. There was some mortality recorded along the way, including adenovirus disease, predation and road traffic incidents.

In addition to the mortality mentioned above, at least one pine marten had been present in the forest for a time. The animal had been identified as being from the Mid-Wales pine marten reinforcement project managed by The Vincent Wildlife Trust (VWT). The animal had appeared in several locations around mid/north-Wales but it was later found dead many miles from Clocaenog (in England). However, the phase two reinforcement programme (2018/19) did become a little more challenging to manage as there was a re-appearance and increased presence of other pine marten/s, (not sure if it was just one animal).

Trail camera footage showed pine marten doggedly exploring several enclosures and disturbing captive red squirrels. Consequently, releasing the animals into the forest during this period was out of the question. One of the hypotheses for the renewed pine marten presence was that they again may have made their way to the forest from the Mid-Wales release programme. VWT became involved in trying to help identify if the animal/s had indeed originated from mid-Wales, (through bib pattern identification). Many weeks were spent trying to achieve identification. Eventually, one pine marten was trapped by VWT (under license) and relocated to help reduce the risks of newly released red squirrels being predated. The identity of the pine marten was not established.

Further close monitoring of enclosures took place to ensure there were no more pine marten sightings. Once it had been established that pine martens were no longer visiting the enclosures, the captive red squirrels were released. Obviously, the red squirrels were held in enclosures for longer than planned but the timing of their release was hopefully in sync with lower risks of pine marten predation.

Figure 2. Newly released red squirrel with radio collar (© Jon Young).

Figure 3. Radio tracking training for volunteers (© Holly Peek).

All released animals had been previously microchipped and some were fitted with temporary radio collars, (under license) (Figure 2). A combination of professional conservationists/ ecologists and volunteers (after training) were able to track the whereabouts of several released animals (Figure 3). The purpose of this activity was two-fold: firstly, to monitor their health and welfare and secondly, to determine the range of the newly introduced squirrels and learn about which parts of the forest they preferred to use. Some of this work was supported by The People's Trust for Endangered Species

Following the programme of radio -tracking, all red squirrels with collars were re-trapped and their collars removed. Monitoring then focused upon data collected from the micro-chips within released animals. CRST found that there were some specifically designed and adapted radio-frequency identification (RFID) readers available and that these could be incorporated into feeder boxes. Over a six-month period, nine RFID were purchased and placed throughout the forest where remote trail camera data had shown red squirrel presence. CRST were only able to do this because money for equipment was gratefully donated from Cofnod, Denbighshire Council and NRW. We were not disappointed with the results as numerous RFID started to record chip reader information from various animals (Figure 4). Coupled with pictures from trail cameras, newly introduced animals were tracked and monitored to see how they were doing.

Figure 4. Red squirrel using an RFID reader feeder box (© CRST - June 2019)

However, the use of these RFID readers was not without challenges. Using this technology in a Welsh upland forest tested the robustness and reliability of the kit. Extracting raw data from the readers was also a challenge at times, as well as interpreting the information provided. As the use of these readers continued, adaptations and modifications were made based on the growing knowledge and experience of CRST volunteers. Feedback to the manufacture has been ongoing in terms trying to improve the technology's overall performance and reliability.

Currently, CRST is trialing the latest RFID model following some further modifications. The new reader has improved waterproofing and can now also weigh any animal that sits on the feeder box platform. This will be valuable and additional information as we continue to gather crucial data regarding the health and welfare of red squirrels.

CRST has over 80 cameras placed around the forest. Depending on the volume of photographic records cameras take, helps determine how often the units are checked by volunteers. For example, some blocks of cameras are checked every week because animals are very active. Other blocks are checked every six to eight weeks because there is little or no activity.

As camera checks are undertaken this will also determine how we use valuable (and limited) volunteer resources for grey squirrel control. To support this work, NRW commissioned a professional forest-wide survey (including grey squirrel control). This is an important piece of work as it includes significant parts of the forest that now feature a newly built wind farm. Regular conservation activity in this part of the forest has yet to begin. The results from the survey will help CRST identify further areas of the forest that need ongoing monitoring once full and regular access is allowed.

Of course, all the above is dependent on finance and how well as a group we do with our fundraising efforts! With this in mind CRST is working in partnership with Red Squirrels Trust Wales to gain future funding from the National Lottery Heritage Fund (NLHF). Currently, the 'Magical Mammals' project has successfully moved to the NLHF one-year development phase of the application.

Success indicators within the project

Figure 5. Young red squirrels getting used to the forest (© CRST - Feb 2019).

- Sustained and verifiable increases in red squirrel population numbers (i.e. year-on-year breeding successes) that supports growth in the numbers and lowers extinction risks associated with small populations (Figure 5).

- Wider appreciation and understanding from local communities of the benefit to everyone of protecting and preserving local wildlife.

- Increased involvement from a wider range of people in conservation volunteering.

Major difficulties faced

- Recruiting and retaining more volunteers from the local community and further afield.

- Not being able to monitor a significant part of the forest for well over a year because of a wind-farm development.

- There is still a relatively small population of red squirrels, hence risk factors remain high because of such low numbers.

- Presence of pine marten in the forest and particularly animals disturbing captive red squirrels in enclosures.

- Use of monitoring technology such as the radio-frequency identification (RFID) readers and the challenges already identified with using this equipment.

Major lessons learned

- Without a professional and dedicated ranger role (as present during the RSU project), direct conservation leadership and coordination is diminished. Success/failure is now largely based on levels of volunteer input.

- Stop, start approaches to conservation, any written plans (from any agency/organisation) are meaningless without sustained funding/support or identified and accessible resources.

- Even with a small increase in population size, significant risk factors remain that continually threaten red squirrel survival rates.

- There are competing priorities for forest managers, this sometimes means commercial development over heritage conservation.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- Several small areas of the forest are now known to have well-established red squirrels.

- Red squirrel breeding has occurred and continues in the forest. However, it is not really known if the overall population has increased or declined.

- Grey squirrel presence in red squirrel areas continues, typically in low numbers, but grey squirrel control is a challenge following detection given the distances that animals can cover. Trapping is very labour-intensive and this can prove challenging.

- The likely sustainability of the current volunteer input (without successful recruitment of new volunteers) and the difficulty in knowing/judging what a sustainable population of red squirrels in Clocaenog Forest should be.

Future project development

- Current discussions are underway about undertaking a further reinforcement programme using captive-bred animals or CRST starting its own in-house red squirrel breeding programme.

- Gain further funding to help sustain red squirrel conservation over the short to medium term (funding aim is for a five-year duration project)

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting		
Live traps	★ ★ ★	★ ★ ★
Kill traps		
Pine Marten (as natural grey predator)		★ ★
Immuno-contraception (oral bait delivered via hoppers)		★ ★
Gene Drive (Selected inheritance manipulated so only male young are born)		
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

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Red squirrel conservation in North West

North West Red Squirrel Group

Geographical area of work

Derry City and Strabane District Council Area, NW of Northern Ireland

Author and organisation contact details

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Key partners

- Ulster Wildlife
- Woodland Trust

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	
Paid Contractors (7-12 months)	
Volunteers involved with Grey control	12
Volunteers involved with squirrel monitoring	14
Other Active Volunteers	10

Map of project land area

Figure 1. Derry City and Strabane council area.

Introduction

Red squirrels (*Sciurus vulgaris*) have been present throughout the region, however the encroachment and expansion of the grey squirrel (*Sciurus carolinensis*) population has threatened the local populations. In some cases, grey squirrel colonisation has resulted in the loss of red squirrels in certain woodlands.

Figure 2. Volunteers helping at an information day.

The majority of our volunteer work (Figure 2) is based in the Derry City Council area as this is where most of our volunteers are based. The River Foyle divides the city of Derry/ Londonderry into the western 'Cityside' area and the eastern 'Waterside' area. Red and grey squirrels are found on both sides of the river, with the red squirrel populations mainly found in the Cityside and the grey squirrel populations mainly found in the Waterside area. It is believed that the River Foyle has somewhat restricted the western movement of the grey squirrel, but has not completely stopped them from colonising the Cityside area.

Pine marten (*Martes martes*) are not a significant feature in our area, however in the last few years we have surveyed them in three different areas. We hope that with further monitoring that the local pine marten population will increase.

The work of the group is all down to our dedicated group of volunteers in helping to protect our red squirrels and controlling the grey squirrel population. While the establishment of the group was initiated by the City Council, they have taken a step back in their involvement with the group and it is now independent and self-sustaining.

Project aims

- Maintain current red squirrel populations via supplementary feeding and monitoring with trail cameras.
- Eradication of grey squirrel populations, particularly in areas with both red and grey squirrels are present together.
- Prevent grey squirrel spread by controlling populations that may be the source of dispersal into red squirrel areas.

Description of the project

Our conservation work begins by finding out where the red and grey squirrels are found. To do this we set up feeders to attract any squirrels that may be in the area. We set up a trail camera opposite the feeder to photographically record anything that triggers the camera (Figure 3). The footage from the camera is checked after about two weeks. If there are red squirrels present, we continue the feeders in place. If grey squirrels are present, we want to begin a trapping routine as soon as possible. We prefer to prioritise monitoring surveillance in locations where both red and grey squirrels are found, so we will start controlling the grey squirrels in these interface areas.

Figure 3. An example of the photographs recorded on trail cameras.

Volunteer roles include maintaining and cleaning the feeders and cameras that we have set up. When it comes to controlling grey squirrels, volunteers will bait and check traps on a regular basis of at least twice a day. If a grey squirrel is in a trap, a volunteer who has been trained and is comfortable to do so, will dispatch the grey squirrel (often using a Kania spring-trap).

Other volunteer roles include offering their time to represent the group at fundraising and information events. These events are a good way for us to recruit more volunteers and to make contact with landowners that have reported squirrels on their property. Landowners that cooperate with our conservation work allow our volunteers access to enter their property. If they have red squirrels we will set up a feeder plus a camera, and will provide food to help maintain and boost the existing population. If there are grey squirrels on the property, the landowner will set traps and check them regularly. If a grey squirrel enters the trap, they will contact the group and a volunteer will come and dispatch the grey squirrel.

We also get involved with schools and local youth groups. If asked, our volunteers will visit schools and deliver presentations on red squirrels and the conservation work the group does. We have also held events for youth groups. Typically we allow the youth groups to build their own squirrel feeder. We will help them set up the feeder along with a camera in a woodland or forest. We will leave the equipment up for a few weeks and will show them the results we get.

Some fundraising activities we have hosted during our information include puzzle games, raffles and arts and crafts. We have also found that hosting pub quizzes are a good way to generate funds for the group.

We have found that social media posts can generate interest and support for grey squirrel control. We would typically ask people if they have grey squirrels on their property and if they want us to take care of the problem. Very often there is a positive response to this and helps further our grey squirrel control efforts. Similarly, it is a good way for people to contact us with any red squirrel sightings they have.

While we work in a range of areas throughout the Derry and Strabane council area, our main area of work is at Muff Glen Forest, Eglinton. Here, we have created a ‘Red Squirrel Safari’ walk. This is to encourage people to get out into a local woodland and to also give them the opportunity to see red squirrels. We created and erected information boards and leaflets through a grant application at the two entrances of the forest for the public to enjoy.

Success indicators within the project

- We are more aware and have greater knowledge of the squirrel populations in our area of work. Using trail cameras and feeders to understand where our red and grey squirrel populations are.

- We have greatly increased our grey squirrel control effort, particularly since 2017. This has been achieved by recruiting more people who shoot and also training more volunteers to use a modified Kania spring trap to dispatch grey squirrels caught in live-capture traps.

- We have cooperated with more landowners. We have permission to control grey squirrels and feed red squirrels that may be present on their property.

Major difficulties faced

- People and/or domestic dogs interfering with traps. Members of the public releasing grey squirrels from traps and damaging/stealing traps and cameras.

- Lack of government/council support, particularly with grey squirrel control. The council has restricted our ability to control grey squirrels in certain geographical areas.

Major lessons learned

Figure 4. The project information board at Muff Glen Forest.

- Once people are more aware and informed about threats to red squirrels, they appear to be more receptive to the grey squirrel control work we do (Figure 4).

- Cooperation with land owners is vital. This allows us to have access to areas we previously could not enter, whether that is for monitoring red squirrels or controlling grey squirrels.

- Getting people who shoot involved in grey squirrel control greatly helps with control efforts. Recruiting more individuals who shoot has allowed us to cover more areas to control grey squirrels. This in turn has resulted in an increase in the numbers of grey squirrels we are controlling per year.

- Using modified Kania traps and having volunteers trained to use this piece of equipment has allowed the group to greatly increase its grey squirrel control efforts.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- More intensive grey squirrel control across wider woodland areas.

- Increased monitoring of squirrel populations.

- Initiated pine marten surveys.

- Put in place direct communication with more landowners to gain permission to undertake red squirrel conservation work on their property.

Highlighting how challenges identified in 2015 have been approached

- Lack of volunteers for grey squirrel control. A number of LANTRA™ (https://www.lantra.co.uk/our-courses) grey squirrel control training courses were subsequently held for volunteers. LANTRA™ courses helped in understanding the legal issues associated with grey squirrel control.

- More people who shoot became involved in grey squirrel control and were recruited. Through grant awards, more equipment was bought to help in grey squirrel control (live traps, modified Kania traps).

- Through events and Facebook™, people often ask us for help in controlling grey squirrels on their property.

Future project development

- Recruiting and maintaining a greater number of volunteers.

- Sourcing grants to help purchase equipment and support functioning of the group's activities.

Current and future importance of contemporary and future methods of grey squirrel control.

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	★★★	★★★
Live traps	★★★	★★★
Kill traps		
Pine Marten (as natural grey predator)		★★
Immuno-contraception (oral bait delivered via hoppers)		★★
Gene Drive (Selected inheritance manipulated so only male young are born)		
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).		

★★★ High; ★★ Medium; ★ Low, blank = None.

Tollymore Red Squirrels

Tollymore Red Squirrel Group

Geographical area of work

Tollymore Forest Park, Newcastle,
Co. Down Northern Ireland

Author and organisation contact details

Tollymore Red Squirrel Group
c/o Woodside Cottage
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Email: tollymorersg@googlemail.com
Website: www.tollymoredsquirrelgroup.com

Key partners

- Department of Agriculture, Environment & Rural Affairs (DAERA-NI) – Forest Service
- Northern Ireland Environment Agency (NIEA)
- Northern Ireland Squirrel Forum
- Newry, Mourne and Down District Council

Resources

Typical Resource available	Number of people
Paid Contractors (1-6 months)	0
Paid Contractors (7-12 months)	0
Volunteers involved with Grey control	0 Forest Service NI, Wildlife Officer
Volunteers involved with squirrel monitoring	10
Other Active Volunteers	10

Map of project land area

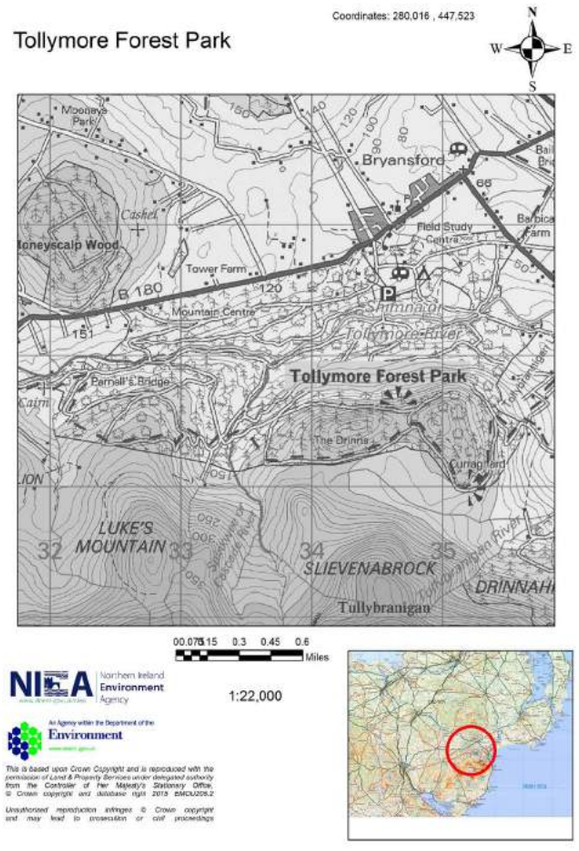

Figure 1. Map of Tollymore Forest Park.

Covering an area of almost 630 hectares at the foot of the Mourne Mountains, Tollymore Forest Park (Figure 1) has panoramic views of the surrounding mountains and the sea at Newcastle. It is open to the public all year.

From Belfast, take the A24 south to Clough Village, then join the A2 Newcastle Road. Just past Dundrum, the forest park is signposted to the right.

From Newcastle, follow the signposted route from the Central Promenade towards Bryansford Village. After about two miles the forest park is signposted on the left.

Introduction

Tollymore Red Squirrel Group (TSRG) works in partnership with DAERA – Forest Service Northern Ireland (NI) in the conservation of our native red squirrel (*Sciurus vulgaris*) within Tollymore Forest Park and adjoining areas. The group was formed in 2004 by volunteers and Forest Service (FS) staff, who were concerned about the decline in the native red squirrel population and the increase in grey squirrels (*Sciurus carolinensis*). A concerted effort was made by FS Wildlife Officers and FS staff to cull grey squirrels and the volunteers set up a supplementary feeding programme to boost the diminishing red squirrel population. At that time, there may have been only 12 red squirrels remaining in the park.

In 2008, after four years of culling and supplementary feeding, a non-scientific survey estimated that the red squirrel population had grown by 75%.

The group was aware that disease can be associated with supplementary feeding and consequently use the steel “McComb Red Squirrel Feeder” (Figure 2) which excludes grey squirrels and is disinfected with the recommended anti-viral disinfectant Anigene™ every seven to ten days.

Figure 2. Tollymore red squirrel near a ‘McComb feeder’.

A historical Squirrelpox disease outbreak in 2011 was estimated to have reduced the forest red squirrel population by 85% and in 2016, the Squirrelpox virus (SQPV) returned to Tollymore Forest Park. Over the next few years, occasional cases were also reported close to Donard Forest, Clonahullion Wood and Tipperary Wood.

Tollymore Forest Park has had a good pine marten population for many years and is also home to many other wildlife species.

Project aims

- To safeguard the native red squirrel population within Tollymore Forest for future generations.
- To report any grey squirrel sightings to the Forest Service Wildlife Officer so that control operations can take place to help reduce the risk of SQPV.
- To highlight the plight of our native red squirrel, educate the public about the dangers from the grey squirrel presence and give the local community a sense of ownership and pride in these iconic woodland creatures.
- To continue to work with Forest Service and other agencies to put red squirrel- friendly tree planting schemes into operation to replace felled and diseased trees and to limit habitat loss.

Description of the project

TRSG working in partnership with Forest Service NI, base all their red squirrel conservation work in local forests under the control of Forest Service NI and have a license to operate within these forests. We have great support from DAERA – and the Environment Agency, the Northern Ireland Squirrel Forum, local newspapers/media, the local people and other red squirrel groups.

The group is very small and obtained charitable status in 2011, it does not have any premises or employees and its expenditure is largely made up of insurance costs, educational materials and feeder maintenance. We are fortunate that we get small subsidies and bursaries from local support organisations and have local fund-raising events.

Figure 3. Red squirrel photographed within Tollymore Forest.

Figure 4. Winter in Tollymore Forest (photo Kit Adams).

From 2004 our remit was to safeguard the local red squirrel population (Figure 3 & 4) and over the last 16 years we have had many successes and some major setbacks to contend with, including the unenviable title in March 2011 of being the first forest in Ireland to have a recorded case of the Squirrelpox disease.

As a group, we have adapted as circumstances around us have changed. Prior to 2011 the group had always been aware of the SQPV and hygiene/disease related issues associated with supplementary feeding of red squirrels in the presence of even a handful of grey squirrels. Consequently, over the years we developed "The McComb Feeder" which we had hoped would eliminate or reduce the risk of infection. Since the 2011 outbreak of SQPV, hygiene and monitoring has been a main priority. The number of supplementary feeders within the park was reduced from nine to four and no feeders were located on the boundary with Bryansford village, where it was felt the risk from grey squirrels in private gardens could not be controlled. Any reported sightings of grey squirrels within the park are passed to volunteers who bait areas for the Forest Service Wildlife Officers to then trap. We rarely have grey squirrel reports/sightings in the park now and any that occur are usually near to the village.

Volunteers check and take down the supplementary feeders every seven to 10 days (allowing for seasonal variations). The feeders are cleaned and soaked in an antiviral disinfectant as per instructions and relocated in the same vicinity. The feeders are removed when natural food is plentiful in the forest.

The group has recently been involved in a citizen science project coordinated by Queens University, Belfast to survey for pine martens (*Martes martes*), who are believed to contribute to the decline of the grey squirrels in some areas. The annual 'Red Squirrel Day' is still our biggest yearly event, though we still continue with our walks, group/school/club visits throughout the year.

Success indicators within the project

- Increased sightings of red squirrels in Tollymore Forest Park and beyond.
- Grey squirrel sightings remaining only occasional in Tollymore Forest Park.
- Community pride and commitment in helping to preserve our local red squirrel population for future generations.

Major difficulties faced

- Negative and public opposition towards grey squirrel control.
- Recruiting volunteers who are willing to become part of the committee and take on administrative and practical roles.

Major lessons learned

- Red squirrel conservation has moved forward and larger organisations with more time and resources available to them have afforded our groups' volunteers the opportunity to concentrate their time and effort on their local projects.
- We appreciate that all volunteer time is precious and that it must be used wisely in projects. It is important that a project fulfills every volunteer's expectation of being a useful group member so they enjoy being part of red squirrel conservation.

Project Success

Success or Failure		Confidence (indicate Low, medium or High)
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given selected score (Failure, partially successful, successful or highly successful) being correct. Medium confidence is defined as 51-79% chance of the assessor score being correct and Low confidence only 50% chance of being correct.

Reason(s) for success/failure

- We have a very active team of dedicated volunteers who commit a tremendous amount of time and energy to red squirrel conservation.
- In 2004, grey squirrels dominated within Tollymore Forest – they are now rarely seen within the park because of the diligence of the volunteers and their use of motion cameras, the reporting of the public and Forest Service staff of sightings and the work of the Forest Service Wildlife Officers. Thanks to them the red squirrels now have a haven and stronghold.
- The group has a very good working relationship with Forest Service and receives great support from all their staff.
- TRSG has great support from the local community.

Highlighting how challenges identified in 2015 have been approached

- **SQPV** - reducing the number of feeders has produced a smaller, healthier population of squirrels which can be sustained by the local habitat.
- **SQPV** - supplementary feeder hygiene has always been important, as it is the one of the main areas of possible infection, the group uses steel hoppers which are cleaned & disinfected every seven to 10 days.

Future project development

- To continue to engage with the local community and highlight red squirrel conservation, through Red Squirrel Day, walks, bi-annual diary in the local paper and school and club visits etc.
- To help Rebecca Synnott from Waterford Institute of Technology collect hair samples from red squirrels from Tollymore Park and the surrounding area. Rebecca will collect samples from red squirrels all over Northern Ireland and extract genetic information from these samples with the aim to provide information on the heritage of the different squirrel populations throughout Northern Ireland. Using this DNA, she can also look at the levels of inbreeding and the presence of disease within these populations.

Current and future importance of contemporary and future methods of grey squirrel control

Approaches	Importance in your project currently	Future importance in developing this aspect of grey squirrel management in your project area
Shooting	Forest Service Grey squirrel control	Forest Service Grey squirrel control
Live traps	n/a	n/a
Kill traps	n/a	n/a
Pine Marten (as natural grey predator)	★	★
Immuno-contraception (oral bait delivered via hoppers)		
Gene Drive (Selected inheritance manipulated so only male young are born)		
Habitat management (reducing availability of tree seed crops favoured by grey squirrels).	★ ★ ★	★ ★ ★

★ ★ ★ High; ★ ★ Medium; ★ Low, blank = None.

References

I. Red Squirrel Conservation Handbook (2010) *Tollymore Red Squirrel Group*, Mourne Heritage Trust, Forest Service (DARDNI)