Invasive Alien Species Colonisation Prevention:

Your guide to early detection and rapid response

Edited by

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Front cover: Grey squirrel © Paul Harry

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Foreword

It is a genuine pleasure to be invited to write the introduction to this excellent publication which describes exemplars of best practice in dealing with Invasive Alien Species (IAS). The wealth of practical experience and learning which is presented here - from the wide range of projects funded by the EU LIFE programme and the National Lottery Heritage Fund - is impressive and inspiring.

At the time of writing, there are more than 10,000 alien species present in Europe (EEA / EU Commission website), and the rate of new introductions has accelerated and is still increasing. IAS are organisms – animals, plants, fungi, bacteria or even viruses – that have dispersed to places outside their natural range where they cause problems. They typically have negative impacts on local biodiversity, the functioning of ecosystems and/or on the socio-economic wellbeing and health of people and local communities. At least 15 % of these IAS are known to have a negative ecological or economic impact. So, this guide is a timely and relevant contribution to helping with the many challenges that all European countries are facing.

In the majority of examples, human activities have provided the pathways and means by which these species have been deliberately or accidentally transported around the globe. What makes a species invasive in its new environment may be the result of complex processes and relationships and they are often poorly understood. Often a species may have moved without the natural predators or competitors with which it has evolved – and so can be 'released' from their constraining influence amongst the new species which have not come into contact previously. Irrespective of how they arrive and the reasons for their new found 'success', a large body of evidence shows that the consequences of IAS can be significant. These negative impacts include threatening the survival of some of Europe's rarest species either directly or through hybridisation. They can damage some of our most valuable and sensitive habitats and can have an economic impact across a range of industries including farming, forestry and fisheries. They can also take the form of new and serious diseases that affect human health or impact other species. Typically, the two main mechanisms by which IAS cause an impact is by outcompeting or predating on native species that have evolved without specific adaptations to cope with them. The populations of native species can be severely reduced or even driven to extinction. These shifts can have knock-on impacts on the functioning of natural and ecosystem

processes such as on soils and water systems, for example. The impacts of IAS may also be aggravated by the effects of climate change.

Biological invasions are among the top drivers of biodiversity loss and species extinctions across the world. Island populations around the world can be particularly vulnerable and one such example is that of the Eurasian red squirrel (*Sciurus vulgaris*) in the British Isles – a small archipelago to the west of the European mainland. In a classical example of an IAS outcompeting and displacing a native, the deliberate introduction of the American eastern grey squirrel (*Sciurus carolinensis*) in the 19th Century has led to the replacement of the native red squirrel across much of its former range: almost to the brink of extinction in Wales and England. The rate of displacement has been accelerated by several factors including through the transmission of a secondary alien species – squirrelpox virus. Grey squirrels, though largely unaffected, are carriers of the infection to which the red squirrel is highly vulnerable and populations are impacted by high levels of mortality.

This IAS impact is the subject of the EU LIFE and National Lottery Heritage Funded Red Squirrels United programme represented by several case studies in this guide. This highly successful programme was an innovative multi-partner collaboration between local community groups, NGOs, Universities and Government Agencies across Northern Ireland, Wales and England.

The strength of this collaboration is characteristic of all the EU LIFE and National Lottery Heritage Fund funded programmes described here. The links demonstrated in this book between the LIFE programmes is also hugely impressive. It provides a powerful demonstration of the impact of this EU funding programme across Europe and its effectiveness in bringing partners together in a shared cause and common purpose to deliver EU policy in member states. The European Union (EU) Regulation 1143/2014 on IAS aims to control or eradicate priority species, and to manage pathways to prevent the introduction and establishment of new IAS. The focus of the Principal Regulation aligns with an internationally agreed hierarchical approach to combatting IAS by:

- **prevention**: preventing species of concern from entering the EU, either intentionally or unintentionally
- **early detection and rapid eradication**: to prevent IAS from establishing

- **population control and containment/management**: some species are already well-established, and concerted management action is needed so that they do not spread any further and to minimise the harm they cause

Delivering these worthy objectives can be a daunting practical challenge. The projects described in this book are full of pragmatic and useful information about how to go about the task. The depth of experience and knowledge learned in the real world from these LIFE and National Lottery Heritage Fund programmes is an inspiration for all those communities, individuals and organisations who are faced with the real threat posed by IAS across Europe – and indeed the planet.

By working together in collaboration and partnership - with common goals and objectives, the collective LIFE experience is that we can often prevent, contain or at least manage the very worst impacts and consequences of invasive species. The message is that success is possible - and we do not necessarily have to accept as inevitable the damage that IAS can cause. These lessons, learned the hard way, are about being constantly alert to risks and threats. It's about an awareness and understanding of the list of species which may pose a threat and their *modus operandi*. Experience reinforces the need to react to new incursions with determination and speed. These exemplars show how much more can be achieved by pooling resources in partnership. They demonstrate the importance of being well prepared and organised to ensure effective coordination and communication in responding to IAS.

The key message that emerges from the following pages is the importance of engaging local communities in IAS programmes at all stages of the process. It is vital for the views of individuals and communities to be sought and heard from the very start of any programme. The understanding, support and involvement of local people is the critical ingredient for success. Any programme hoping to address the enormous challenges that IAS pose, needs to work in genuine partnership with and through those living with the consequences.

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Editors Acknowledgements

Red Squirrels United is primarily concerned with the eastern grey squirrel (*Sciurus carolinensis*) from an Invasive Alien Species (IAS) perspective, working to control populations in key native red squirrel (*Sciurus vulgaris*) areas across England, Northern Ireland and Wales. As we began to plot the development of this guide, we discussed how the impact and value would be much greater if we broadened it to include case studies from other LIFE and National Lottery Heritage Funded IAS mammal projects across the UK and Europe. In addition, we recognised the importance of collaboration, shared lesson learning and transferable approaches leading to a more balanced and informative guide which we hope users will find beneficial.

We express our sincere thanks to all the contributors and reviewers for their submissions, help and considerations and the whole Red Squirrels United project team who worked so hard to deliver the programme successfully. We would particularly like to acknowledge Ben Allen, Christina Allen, Jack Bamber, Craig Banks, Rebecca Brown, Rebecca Clews-Roberts, Rachel Cripps, Michael Dunn, David Everest, Caroline Finlay, Gillian French, Jennifer Fulton, Mike Green, Ryan Greenwood, Liz Halliwell, Paul Harry, Becky Hulme, Russell Layton, Mariella Marzano, Conor McKinney, Aileen Mill, Justine Montford, Simon O'Hare, Holly Peek, Gala Podgornick, Mike Pratt, Shanna Rice, Bonnie Sapsford, John-Francis Smyth, Michael Stinson, Ronald Surgenor, Cathleen Thomas, Stephen Trotter, Zelda van der Waal and Lizzie Wilberforce

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Nikki Robinson and **Craig Shuttleworth**

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About Red Squirrels United

Red Squirrels United (RSU) was a four year multi-partnership programme funded through EU LIFE and the National Lottery Heritage Fund running from 2016 – 2020. Many elements of RSU are described in the case-studies section but this short overview provides a brief summery of what the programme aimed to achieve.

RSU focussed on protecting remaining native red squirrel (*Sciurus vulgaris*) populations where they were under threat from non-native invasive grey squirrels (*Sciurus carolinensis*) in nine main areas across northern England, Northern Ireland and Wales (figure one).

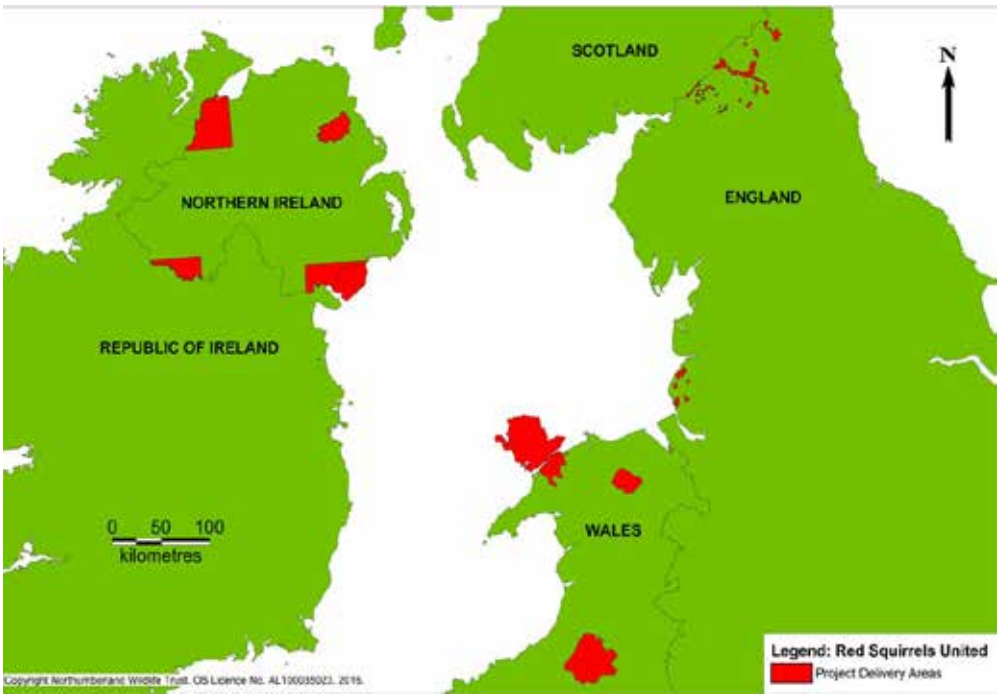

Figure 1: Map showing Red Squirrels United project delivery areas

Work to control grey squirrels and protect red squirrels has been going on for many years in the UK but RSU was the first programme to draw together some of these initiatives in a UK wide network. RSU aimed to:

- Tackle IAS colonisation prevention
- Develop early warning and rapid responses
- Maximise the impact of grey squirrel control and eradication approaches
- Aid the development of comprehensive IAS management frameworks

RSU also hosted a national programme of IAS and red squirrel conservation learning through annual Knowledge Fairs, community engagement and media campaigns. The project made a significant contribution to IAS management and maximised ongoing sustainability by increasing the impacts of red squirrel conservation in the UK.

Summary

This guide reflects the lessons learnt in European LIFE and National Lottery Heritage Fund invasive mammalian species projects from across Europe including the Red Squirrels United (RSU) project in the UK. Thirteen case studies are presented, and key elements are distilled in order to provide this early detection and rapid response best practice for the eastern grey squirrel (*Sciurus carolinensis*).

How can you tell a native red squirrel from a non-native grey squirrel?

It is critical that the public can differentiate between the eastern grey squirrel and the Eurasian red squirrel (*Sciurus vulgaris*). The grey squirrel is a highly invasive species which can occupy a wide range of mature woodland habitats including upland coniferous plantation, lowland deciduous forest, woodland scrub, suburban gardens and urban parkland. It can therefore potentially be found within any woodland suitable for the native red squirrel. This characteristic is just one of several challenges to be faced when trying to detect grey squirrel incursion.

It is also important to understand that although adult grey squirrels are larger (500-550g) than adult red squirrels (290-330g), subadult grey squirrels are often only slightly larger (350-450g) and thus using size alone to differentiate between the species is not reliable. In terms of coat colour variation, there can also be significant overlap between grey and red squirrels. This is especially true during the autumn and winter months when individuals of both species can have a mixture of red and grey hair. Unfortunately, this time period coincides with the peak period of dispersal activity.

Textbooks will often highlight the fact that grey squirrels generally lack ear tufts and if tufts are present, they are only a few millimetres in length, whereas red squirrels frequently have long tufts (two to four centimetres long). It is important to note that red squirrels may not have ear tufts following the spring coat moult. That said, when tufts are present and a clear unobstructed view of the head is possible, this feature is extremely useful in the autumn and winter months.

A final key feature is that grey squirrels almost always have a silver outer tail hair ‘halo’ or fringe. Again, an unobstructed view, in decent light will reveal this. It is true

that albino and melanistic (black) grey squirrels do not have this coat pattern, but these colour morphs are quite rare in grey squirrel populations living alongside or adjacent to remnant red squirrel populations. Red squirrels lack this pattern on the tail.

Recap:

- Grey squirrels can occupy any of the woodland habitats within which red squirrels are found
- Although red squirrels are often red and grey squirrels grey, the coat colours overlap and can be confusing
- If ear tufts are present then it is a red squirrel, if ear tufts are absent then it may be a grey *or* a red squirrel
- A silver outer fringe or halo on the tail is found only in grey squirrels. This is a good characteristic to look for

Grey squirrel early warning surveillance

The RSU project encompassed a range of approaches to the detection of grey squirrels across a wide variety of habitats from remote uplands to suburban gardens and coastal town parks.

The key lessons were:

- Community participation
  - It essential to empower local people with the skills and confidence to be able to:
    - Use monitoring equipment correctly
    - Accurately differentiate between red and grey squirrels
    - Know who to inform if a grey squirrel has been seen in an area vulnerable to invasion
    - Remove the animal themselves
    - Operate within a co-ordinated volunteer network
  - If volunteers participate in monitoring but do not wish to undertake grey squirrel control, then it is critical that an identified person trained in dispatch is available to provide rapid response to grey squirrel detection
  - Training workshops and/or shadowing can provide a valuable way in which to facilitate skill development

- Projects should seek to recruit local people who are actively feeding squirrels in gardens or local woodlands
- Volunteers are often collectively able to cover large numbers of monitoring areas; they often have good local knowledge and may be involved with other wildlife conservation projects that offer synergy. However, project managers must appreciate the limitations of volunteer-based mammal monitoring

These include:

  - People becoming ‘bored’ or ‘disillusioned’ if they are repeatedly asked to monitor areas where they find no evidence of target species
  - Variation in the quality and quantity of survey data/feedback being submitted
  - Variation in the amount of time individuals can provide and uneven geographical patterns of volunteer activity
- All RSU project partners ensured that they had core staff time dedicated to supporting volunteers and co-ordinating early warning and other approaches to grey squirrel detection

- Monitoring site selection & permissions
  - Landowner permission must be granted before any monitoring takes place
  - It is important that the locations of monitoring sites are not made widely known to minimise the risk of equipment being removed or damaged
  - The selection of locations used to proactively monitor for grey squirrel presence should be evidence based e.g. along riparian or other likely woodland corridors and dispersal routes leading into red squirrel habitats; within red squirrel habitat and surrounding buffer woodlands
  - Reactive monitoring following a report of a possible grey squirrel sighting should not only focus upon the location but include a wider surrounding area
  - Historical data can also be used to identify likely areas for grey squirrel detection, and sites selected should where possible take this into account

- Monitoring approaches
  - Motion-sensing wildlife cameras provide an invaluable method of detecting grey squirrel incursion. Cameras should be set up in accordance with manufacturer’s instructions. Typically, the camera is trained on a feeder, mesh cube containing whole hazel nuts or ground baited area containing

whole maize or sunflower seed. Deployment of camera density per hectare and spatial distribution pattern will depend on available resources

- In some coniferous habitats, camera trap monitoring has focussed on positioning cameras on ground feeding signs (e.g. stripped cones around stumps) and no bait is used
- Approaches are described in the Anglesey, Clocaenog, Formby, Kielder, Mourne mountains and the Mid-Wales case studies that follow this section
- In parallel with cameras, raising community awareness of the need to detect and report grey squirrels should also be considered. RSU project partners all achieved outreach through talks and stands at community events, social media platforms and 'report a sighting' website pages to encourage local reporting of grey squirrels
- Although not a primary monitoring technique, RSU occasionally used sticky pads fitted within plastic 'hair tubes' to detect squirrels. This means of catching hair can be labour intensive because the standard identification technique involves each hair shaft being viewed under magnification after it has been stained and cross sectioned. However, with a little practice it is often possible to identify hair from each of the two squirrel species by eye and without staining

Use of motion-sensing cameras

RSU relied heavily upon the use of motion sensing cameras as these allow remote monitoring of animals in gardens, woodlands and wild areas. Although there are a variety of models, they all have a Passive Infra-red (PIR) sensor which triggers the camera to record images and/or videos onto an internal Secure Digital (SD) card. The card can be retrieved from the camera, and the images viewed on a laptop or mobile phone via a suitable card reader. Camera locations were mapped using Apps such as Survey123™ or Google Maps™.

We found that where volunteer time was limited, it was best to set cameras to record images rather than video as the latter requires each individual video to be watched in its entirety in order to ensure that any animals were observed. In addition, selecting cameras with an integral viewing screen made it easier to check that a feeder was correctly positioned in the field of view when setting up a feeder. Where cameras did not have an integral viewing screen, a mobile phone set to 'selfie' mode was positioned in front of the camera and a photo taken to check the camera was positioned correctly.

Cameras are attached by a strap (and/or python security cable) to a tree trunk opposite a feeder or ground bait upon which they are trained. It is important that the distance between the camera and the food is sufficient to prevent 'glare' when the camera takes an image in dark conditions but not so great that an animal attends the feeder but does not trigger the PIR.

Squirrelpox virus (SQPV) risk

SQPV is carried by grey squirrels. Infected grey squirrels show no obvious clinical signs, however when the virus is picked up by red squirrels it produces pathogenic disease. It is highly infectious amongst red squirrels and therefore it is important that any potential cross-infection risk associated with the monitoring of grey squirrel incursion is minimised.

In order to reduce the risk of SQPV:

- Feeders should be thoroughly disinfected after use with a recommended anti-viral product made up to the correct strength such as Virkon™. For example, feeders placed in situ for a period of two weeks may be visited by multiple animals including both red and grey squirrels
- Although there is an inherent risk in attracting multiple animals to one feed source, a sensible trade off must allow enough time for different animals to visit feeders, without leaving feeders in situ for too long and thus increasing the risk of disease transmission
- Where we deemed the risk of cross-infection high, ground baiting using sunflower hearts is an option. The hearts are consumed without leaving a husk upon which saliva would be present as a source of potential viral contamination. Ground baiting spreads the food out so creates less of a focal point when compared with a wooden feeder

Rapid Reaction to grey squirrel sighting

RSU found a number of factors which affected both the scale and intensity of squirrel monitoring and the speed of response to grey squirrel detection:

- A smaller number of people than expected were recruited as volunteers in some areas
- Remote locations often made it challenging to undertake wide scale monitoring
- Both the above factors meant that despite detection of grey squirrels on trail cameras in multiple locations, it was sometimes extremely difficult to provide a response to every detection

- Limited manpower/resources meant that the focus had to be upon high invasion risk areas or key incursion corridors only
- Sometimes members of the public delayed reporting possible grey squirrel sightings in areas where the species was not thought to be present because they thought they must have been mistaken
- Cameras were sometimes left in situ for several weeks, and in some cases months for a variety of reasons (for example bad weather prevented volunteers accessing sites) meaning that results were not provided quickly enough
- Although many volunteers provided results quickly and efficiently, this was not always the case. There were occasions when results were not returned to project staff for several weeks, making rapid response impossible at sites where greys were later found to have been present
- Where monitoring opportunistically incorporated ongoing garden wildlife feeding (bird feeders/bird tables), there were incidents where people reported squirrel sightings on social media pages that were not associated with the project. In such circumstances there was sometimes a delay before third parties saw the post and contacted the project to make us aware
- Relying upon casual sightings or garden feeding meant that survey intensity was biased towards rural/suburban gardens and parkland. More remote areas were less visited

Key examples of Red Squirrels United project

RSU project partners adopted an evolving approach to grey squirrel detection, each creating a bespoke protocol which reflected local circumstances. From lowland coastal plain, offshore island to upland coniferous plantations.

In some areas, where red squirrel rangers were in situ, early warning system monitoring proved critical, providing regular valuable intelligence, helping to locate grey squirrels at an early stage. Volunteers were trained to deliver trail camera monitoring and provided data from surveys to project staff, who then responded by focusing control in the same areas, resulting in the removal of grey squirrels.

Volunteers recruited to help with trail camera monitoring also became involved with rapid response, providing grey squirrel control in response to results. This proved invaluable particularly in large and remote woodlands where it was not practical to deploy rangers to provide this response, particularly as grey squirrels

were often detected at multiple sites, geographically far apart.
In red-squirrel only areas, volunteers adopted a site-specific protocol where live capture traps were checked every two hours and operated a tag system to make absolutely sure that traps were closed at the end of the trapping session.

Grey squirrel control options

RSU used shooting and live capture trapping as the main methods of grey squirrel control. Where appropriate, in popular recreational woodlands, traps were concealed in wooden tree mounted boxes.

	+ve	-ve
Shooting	Selective method, so sympatric red squirrel not affected Useful for removing remaining trap shy animals from an area Useful if limited time available	Not permitted in state forests in England or Wales Must ensure blood contamination of ground is cleaned as much as possible Must ensure user expertise
Live capture trapping	Can release non targets Large number of traps can be placed in remote locations, leading to catch efficiency, often in areas where there is a perception that greys are not present (as they have not been seen)	Labour intensive in remote areas Volunteers not always willing to trap in large, state owned forests where they perceive a lack of effort from the landowner If method of dispatch is shooting must ensure trap and immediate area cleaned of any blood contamination Risk of animals caught in traps injuring themselves
Kill traps	Some people are not comfortable dispatching animals themselves, the kill traps make this easier for them. Meaning you may recruit more volunteers Saves time not having to check traps every 24 hours	Not suitable in red areas To some extent removes responsibility of the dispatch away from the trapper, and if it is not a clean kill welfare of the animal can be an issue

The Nordic Raccoon Dog Project

Invasive species common name (Latin name)

Raccoon dog (*Nyctereutes procyonoides*)

Native geography

China, north-east Indochina, Korea, eastern Siberia (Amur and Ussuri regions), Mongolia and Japan

Project name

The Nordic Raccoon Dog Project (LIFE09 NAT/SE/000344)

Project location or geographical area of conservation work

Sweden, Finland, Denmark, Norway

Lead organisation

Swedish Association for Hunting and Wildlife Management

Key partners

- Swedish Environmental Protection Agency, Swedish University of Agricultural Sciences, County administrative boards of Norrbotten, Västerbotten and Skåne, Swedish National Veterinary Institute
- Danish Nature Agency, Danish Environmental Protection Agency, Danish Hunters Association
- Finnish Wildlife Agency, Metsähallitus, Government of Åland
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Map of project land area and brief description

Figure 1: Project countries involved in the Nordic raccoon dog project (LIFE09 NAT/SE/000344)

Introduction and project background

The raccoon dog (*Nyctereutes procyonoides*) is a medium-size canid native to East-Asia that was introduced mainly to the European parts of the former Soviet Union in 1929-1955. Since then it has spread and established viable populations throughout eastern Europe, the Baltic countries, Poland, Germany and Finland, and it is now one of the most successful invasive alien carnivores in Europe.

Figure 2: An Asian raccoon dog
©Flickr Tanuki Head 010314 https://flic.kr/p/osww7T

The raccoon dog (figure 2) is threatening the biodiversity in Europe, mainly through predation on amphibians and ground nesting birds, and threatening animal and human health through the variety of pathogens it can carry. Around the millennium shift, the raccoon dog started to reproduce and establish populations in northern Sweden and mainland Denmark. A project was started in Sweden in 2008 to stop the species from establishing and spreading to southern Sweden and Norway (figure 1). It was quickly identified that to succeed it was necessary to engage neighbouring countries to minimise the immigration.

A successful EU LIFE funded project (LIFE09 NAT/SE/000344), involving Sweden, Denmark and Finland ran between 2010-2013 after which the national authorities took over the funding of the national projects. The partnership has continued after the LIFE-project in a co-operative Nordic project which Norway has also joined. The base for all national projects is paid staff (professional managers), but also involves hunters paid by the hour and voluntary hunters. The work in Sweden and Denmark, involves both detection and removal of animals to prevent population establishment in a new area and prevention of spread from an existing population. In Finland, the main task is to prevent spread over to Sweden and Norway and in Norway,

where there is no established population, detection and removal of small numbers of animals to prevent population establishment is the focus.

Key project goals

- Stop the raccoon dog from establishing in Sweden, Denmark and Norway
- In Finland close to the Swedish border, control the raccoon dog down to low density to minimise spread to Sweden and Norway
- In northern Sweden and mainland Denmark, where populations have established, the goal is to minimise and contain the population, prevent reproduction and further spread

Description of the project activity

The project generally aims to stop the raccoon dog from dispersing to and establishing across all of Sweden, Denmark and Norway. In northern Sweden and mainland Denmark (Jutland), the raccoon dog has already established reproducing populations; following immigration from northern Finland and Germany respectively. In Denmark, part of the raccoon dog population also originates from escaped farm animals.

The initial Swedish project realised at an early stage that co-operation with neighbouring countries was necessary to prevent the raccoon dog from immigrating in large numbers. The participation of Norway is a good example of proactive prevention. Although the country had only a few verified animals, they not only passively participate in the project, but also fund a large part of the work conducted in Finland to prevent raccoon dogs spreading into areas from which they would threaten Norway. This proactive strategy is far cheaper than waiting until they establish in the country before taking action.

Figure 3: Camera image detecting raccoon dogs ©Scoutguard

Detection of raccoon dogs is mainly done with the help of (1) camera traps (figure 3), (2) a citizen science observation system where the public reports possible raccoon dogs to the project and (3) with the help of Judas animals. The raccoon dog is a social species with the goal to find a partner and will start searching for a new partner as soon as they become alone. By sterilising captured animals, to avoid reproduction if lost, and releasing them with GPS-collars, these Judas animals locate and thus disclose wild animals that would otherwise have been difficult to find.

Professional hunters are the core of the project, they manage cameras, Judas animals and public sighting reports. Once a raccoon dog sighting has been professionally confirmed they use specialised dogs to capture the racoon dog to be used as Judas animal or cull the animal. Traps are also used. To cover the whole country, they have help from local hunters that have been educated by the project and are paid by the hour. These trained local hunters mainly manage cameras and traps, while the professional hunter takes care of the hunting and

culling. Many local hunters also voluntarily help the project by hunting and trapping raccoon dogs. Local hunters are individually less efficient than professionals, but they are more numerous. Each year before the hunting season starts, the project encourages the hunters through media to hunt and report raccoon dogs.

It is important to educate the public about the negative consequences of invasive alien species (IAS). The project educates hunters, students and other stakeholders on IAS. Information and project results are also disseminated intensively in hunting magazines, project website, Facebook™, and through general media such as newspapers, television and radio. By doing so, more people will report possible sightings, and the more they know about the species, the more accurate the observations will be.

Detecting and managing spread

Project scope	
Main ways of IAS spread	Dispersal from countries and areas with established populations
Method of detection used	Camera traps, citizen science observation system, Judas animals
Detection methods considered but not used (and why)	
Methods of removal/ control used	Professional hunters, hunting dogs, traps, local hunters
Removal methods considered but not used (and why)	Bounties are not used since it will put a value on the animals, and a risk that hunters might start protecting them. It is also easy to bring in dead animals from Finland to Sweden
Legislation in place to ensure high welfare standards	The project is approved by the Swedish Ethics Committee on Animal Research (Dnr A18-16)

Major difficulties faced

- Project funding is not secure, and this is an ongoing problem. A political shift might quickly withdraw the funding
- There were some initial difficulties with people trying to ‘undermine’ the project, but this has largely disappeared the more successful the project has become
- Unclear national legislation and varying understanding from national authorities have several times threatened the continuation of the project. This has largely improved since the new EU-regulation (1143/2014) was put into force

Major lessons learned

- Be innovative to find efficient methods
- Co-operate with applied research to improve methods as new data are produced, co-operate with neighboring countries, national agencies and projects for cost-efficient management
- Disseminate results and involve the public, citizen science can be very helpful Involve, educate and co-operate with local stakeholders such as hunters
- Monitor the population in some way, even though it may be difficult, otherwise you as well as your financiers will not know how you are doing and what requirements for improvements there may be

Success indicators of project

- Decreasing proportion of raccoon dogs in our monitoring systems
- Decreasing number of raccoon dogs culled per unit effort
- Decreasing number of validated raccoon dogs in the citizen science system

Success of project

Sweden, Finland, Norway shown in black
Denmark in green.

Measure for		Confidence
Highly Successful	✘	High
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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

Sweden, Finland, Norway

- Support and adequate funding from national authorities
- Professional managers as a base, not solely relying on volunteers that often have other things to do when a raccoon dog needs to be culled
- Access to all land and derogations to hunt at all times using all methods are all necessary
- Close co-operation with applied research institutes, so that methods and tools used scientifically based

Denmark

The raccoon dog population has increased exponentially in Denmark in the last few years due to the reasons below. Nevertheless, it has to date been successfully confined to the mainland (Jutland). A continuously increasing population will however be difficult to contain in the long run.

- Limited access to private land
- Derogation to use necessary methods and tools are limited
- Not legal for local hunters to hunt at night
- Support from national authorities is in place, but there is limited funding

Future project development

- To manage more IAS within the same framework

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Quantified summary data

Date commencement: First Swedish project started in 2008. Life project ran between 2010-2013, thereafter and still ongoing Nordic co-operative project involving Sweden, Finland, Denmark and Norway

Resources: Monitoring; camera monitoring system, observation reports, data take at least one full-time person to manage

- Approximately 500 game cameras, 100 GPS collars, 300 traps
- Nine full-time employees in Sweden, 3.5 full-time employees in Denmark, one full-time employee in Finland, about 0.5 full-time employee in Norway. At least the same effort of voluntary hunters

Detail of cumulative area: The project works all over the countries

Costs: Total yearly costs for the management in the different countries are approximately; Sweden EUR 800,000, Norway EUR 110,000, Finland EUR 160,000 (with part funding from the Norwegian budget) and Denmark EUR 380,000

LIFE GESTIRE 2020: Northern raccoon management

Invasive species common name (Latin name)

Northern Raccoon (Procyon lotor)

Native geography

North and Central America

Project name

LIFE GESTIRE 2020

An innovative and experimental project for the conservation of biodiversity in Lo*mbardy (Italy),* co-financed by the European Commission

Project location or geographical area of conservation work

Parco Adda Nord (and neighbouring areas), Lombardy, Italy

Key partners

- Lombardy Region (Coordination), Parco Regionale Adda Nord (technical supervision) and Università degli Studi dell'Insubria, Environment Analysis and Management Unit – Guido Tosi Research Group (Scientific supervision)
- Regione Lombardia, Direzione Generale "Ambiente, Energia e Sviluppo sostenibile" Email: biodiversita@regione.lombardia.it and Parco Regionale Adda Nord Email: risorsenaturali@parcoaddanord.it

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Map of project land area and brief description

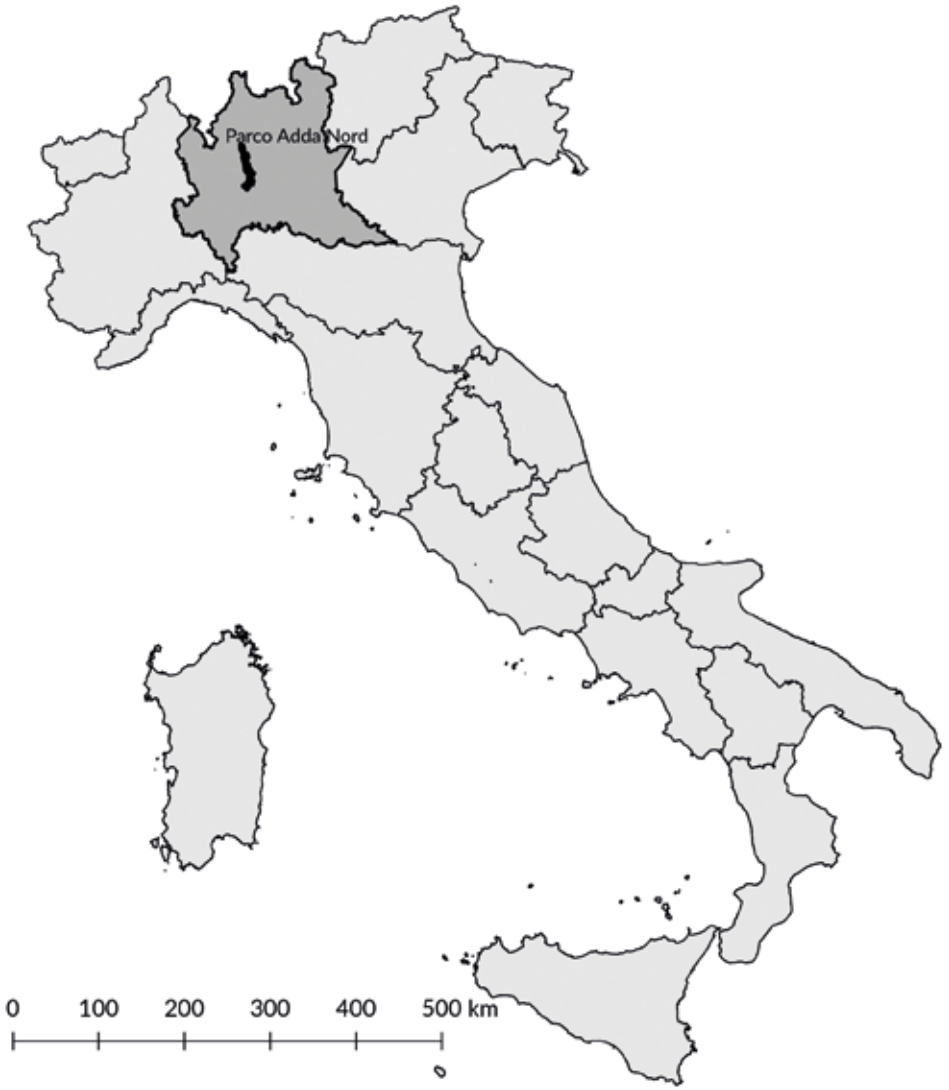

Figure 1a: Map of the general location of the Parco Adda Nord, in Region Lombardy, North Italy

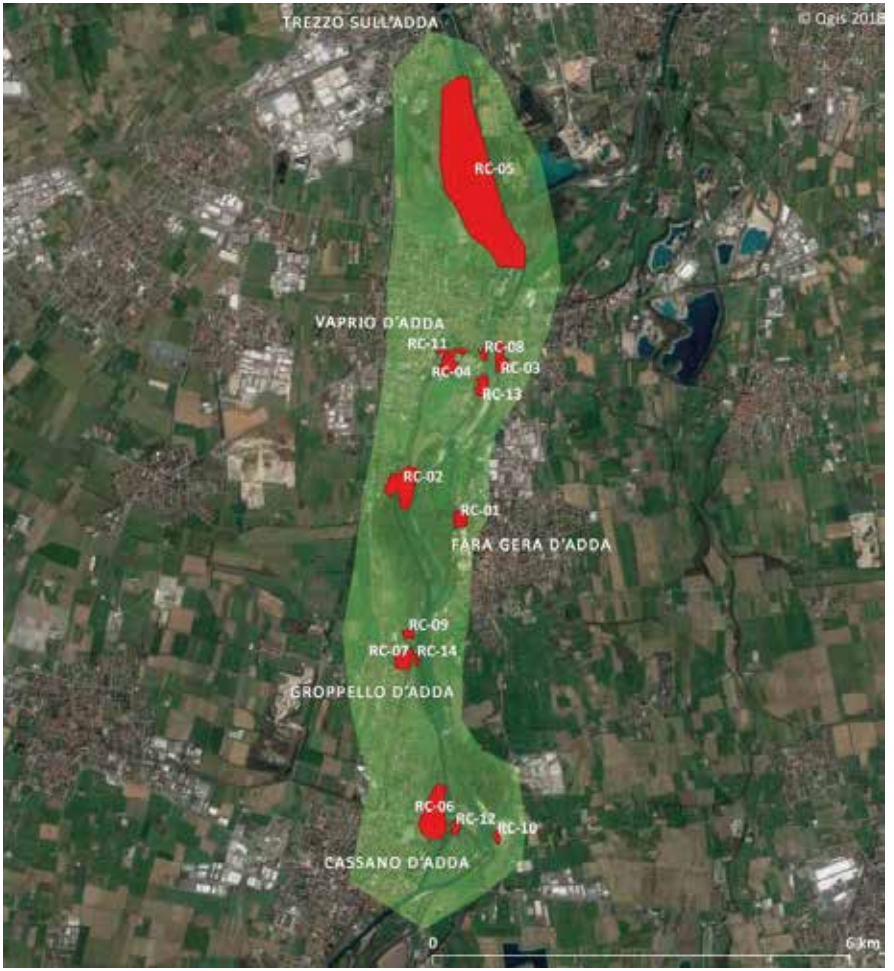

Figure 1b: Raccoon presence core areas in the Parco Adda Nord

Figure 1b shows the study area (in green) based on raccoon presence and the single trapping areas (in red) identified by an ID code (e.g. RC-01). Raccoons mainly occur along Adda river riparian and deciduous woodland corridors, in small parks and gardens. Woodland cover is dominated by oaks (*Quercus sp*.), hornbeam (*Carpinus betulus*), lime (*Tilia cordata*), black locust (*Robinia pseudoacacia*), willow (S*alix sp.*), alder (*Alnus sp.*). The river valley is further characterised by meadows and cropland and strongly urbanised areas with localised industrial sites and a dense road network. Human density is about 1000 inhabitants per square kilometre.

Introduction and project background

Originally a North and Central American species, the northern raccoon (*Procyon lotor)* belongs to the Mammalian order carnivora. Raccoons are predominantly nocturnal, omnivorous and habitat generalists and can be found in temperate or tropical forests, grassland areas and wetland, as well as urban and suburban areas.

The mating season is in February to early March. Gestation is about 63 days. Litter size at birth from two to five young. Young stay with or near their mother during the first winter and disperse the following spring with males moving over longer distances than females. As an invasive alien species (IAS), raccoons become predators and competitors of native species and can host transmissible pathogens such as the raccoon roundworm (*Baylisascaris procyonis*) which can be dangerous to humans. They are considered a pest in urban and agricultural areas. In Italy, the presence of *P. lotor* was first limited to a single population in Lombardy (earliest report 2003). However, some new reproductive nuclei have been recently found in Tuscany. This project concerns the population present in Lombardy, confined to the Adda Nord Park territory, covering approximately 120 Km^2. The geography includes urban and suburban areas and agricultural patches. The project will undertake a removal programme, carried out by one paid staff member. The aim is to prevent animals spreading from the existing population and to achieve the eradication of the northern raccoon from Lombardy. This is part of the EU co-funded "*LIFE GESTIRE 2020*" project and works within wildlife management laws.

Key project goals

- Raccoon removal from the current area occupied following introduction
- Veterinary examination and disease monitoring of culled animals
- Continuous monitoring after removal activities for at least three years
- Steps to prevent trade (both importation and sale)

Description of the project activity

Following the first reports (2003) and recent colonisation of northern raccoon in Lombardy, a programme started in 2016 to develop and apply methods to remove this alien species, according to recent laws on wildlife management.

We collated sightings from park staff, foresters, municipality workers, landowners, and volunteers to identify the likely distribution and hotspots of the species' occurrence. This was followed by scientific monitoring using 88 camera traps (figure 2) randomly distributed, starting from the sightings reported for the species in Adda Nord Regional Park. Once we had identified the total area of raccoon presence, the geography was divided into 14 trapping sites, where removal activities started in September 2016 and are currently in progress. Raccoons were trapped using ground-placed live capture traps (Tomahawk model 205 collapsible single door trap, and EGG TRAP™) (figure 3 & 4) that are left in pre-baiting for at least five days. We use different kinds of bait, generally dry cat-food along with something sweet, e.g. marshmallow, honey, cookies. The trapped raccoons are immediately euthanised by CO_2 gas, using a purpose build container into which the trap is placed thus avoiding handling of the animal (and ensuring operator safety).

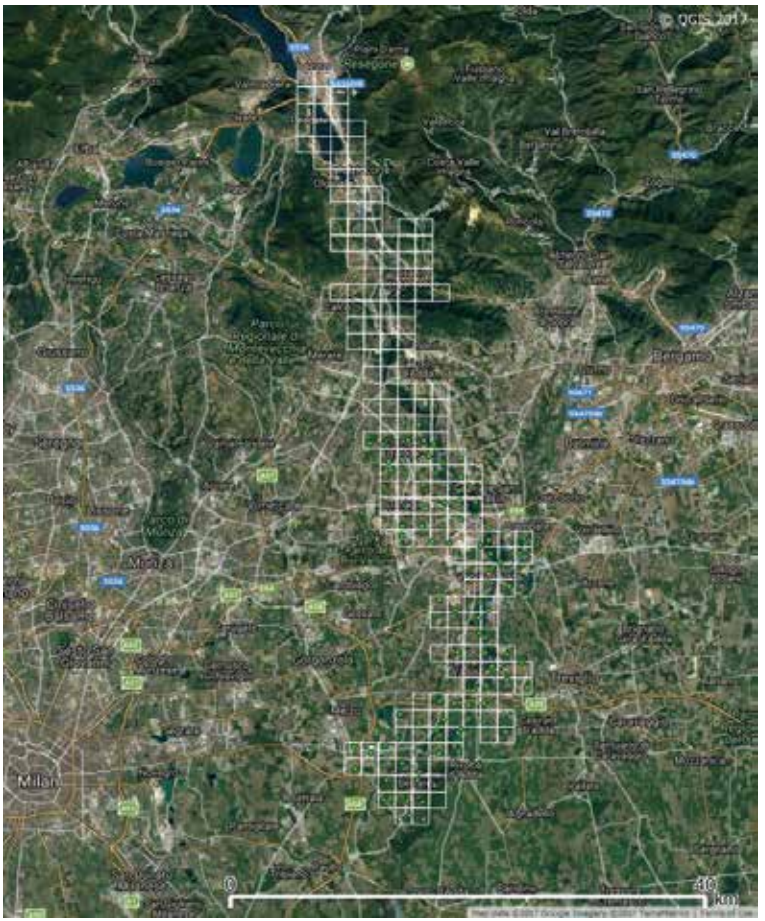

Figure 2: Camera trapping sites (green dots) during the first survey on raccoon distribution in Adda Nord Regional Park, Lombardy Region, north Italy
© QGIS 2017

Figure 3: Two raccoons trapped with Tomahawk live traps © Mattia Panzeri

Figure 4: Raccoon trapped with EGG TRAP™ © Mattia Panzeri

The carcasses were subsequently subjected to parasitological analysis at the University of Milan, Department of Veterinary Medicine (figure 5). Camera trapping (figure 6) is carried out also during the trapping activities, giving real-time information on presence, and will continue for three years after trapping has finished, both in the trapping area and the surrounding territories, to confirm the eradication of the species and prevent new colonisation due to undetected

propagule. To increase the investigation levels, we also identified different stakeholders located in the study area and in the surrounding territories. We primarily focused on farmers, food industries and waste management in order to create a network to promptly report any raccoons. We trained two trappers who worked full-time for six months. Due to animal rights groups opposition, we avoided wide dissemination of our plans and activities. However, the local population, particularly key stakeholders were informed about raccoon presence, through invasive species outreach activities promoted by Adda Nord Regional Park.

Figure 5: Measuring a culled raccoon © Mattia Panzeri

Figure 6: Raccoon caught on camera trap © Mattia Panzeri

- Finally, our research team is annually involved in University courses related to the management of alien species that give students the opportunity to get involved in the project field activities. Consequently, we could train two trappers who worked full-time in a six month internship during the second year of this project. This actively contributed to the achievement of the objectives we set, with the advantage of not using project raccoon control funds
- Starting on 1 January 2019, monitoring and trapping of raccoons will continue for another two years with the same procedures described above by one paid member of staff. In January, a meeting was held at the offices of the Adda Nord Regional Park with park staff and volunteer ecological guards (GEV) to present the results obtained so far and to illustrate the future work plan. Interested volunteer guards will be recruited to help with monitoring activities (camera trap checking, interviews with stakeholders, locals to check any raccoon sightings or damage potentially attributable to raccoons)

Detecting and managing spread

Project scope	Lombardy Raccoon population removal
Main ways of IAS spread	Human introduction followed by natural reproduction and spread
Method of detection used	Camera trapping, signs and tracks, stakeholders reporting and other local reports
Detection methods considered but not used (and why)	Wider 'citizen science' publicity to improve the records. This was not used in order to avoid opposition to species control by animal rights groups.
Methods of removal/ control used	Ground-placed live traps (Tomahawk and EGG TRAP™)
Removal methods considered but not used (and why)	Shooting. This was not used because it is still considered by the public as a cruel method
Legislation in place to ensure high welfare standards	Raccoon control was carried out in accordance to the indications in Leary et al. (2013) AVMA Guidelines for the Euthanasia of Animals: 2013 Edition. Approval and legal requirements according to the Italian Wildlife Protection and Hunting Law L.N. 157 from 1992

Major difficulties faced

- Insufficient funding: only one trapper was paid; major activities were only possible thanks to aid from university students doing thesis work. Meetings with Lombardy region are planned to try and increase funding and secure a long-term funding commitment
- Opposition from animal right groups: Avoid dissemination of our activities and identification of the trapping areas. Project partners are always available for further explanations and meetings with opponents/stakeholders
- Raccoon density was reduced to low levels after first two years of removal which caused a decrease in trapping success and required an increase in effort

Major lessons learned

- Early and timely action is important
- Multi-disciplinary approach (especially combined action of camera trapping and trapping methods) is essential
- Low profile during removal activities is important where animal rights may potentially disrupt project work
- Funds and long-term commitment needed from authorities responsible for implementation of the Regulation (EU) N° 1143/2014 of the European Parliament and of the Council on the prevention and management of the introduction and spread of invasive alien species

Success indicators of project

- Decrease in captures over time
- Lack of trapping juvenile/sub-adult individuals
- Total absence of records/captures in the following year

Success of project

		Confidence
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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

- Trend of strong decrease in raccoon captures over the two years of activities
- Total absence of reports/sightings by people after one year of removal activities
- Efficient trade ban in place, although not completely excluding risk of illegal trade or release of animals kept with pre-EU regulation permits

Future project development

- Increase the contribution of volunteers in raccoon monitoring to improve efficiency at low densities
- Organise monitoring activities (and if needed trapping) also in the surroundings of the current intervention area boundaries to verify that no raccoons occur outside the known range

References

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Quantified summary data

Date commencement: Activities started in September 2016
Surveillance effort in time and space: We covered an area of about 120 Km^2 using 88 camera traps, each one worked for 15 days 24/24H, without bait in order to evaluate the occupancy, for a total of 1,354 camera days. Integrating the data of this study with the previous reports and stakeholder survey, we focused on a central area of about 40 Km^2, where we activated 14 trapping sites. A total of 25 Tomahawk live capture traps and 20 EGG TRAP™ were used in 95 trap points with a monthly rotation system for a total of 740 trap-days from September 2016 to September 2018
Costs and funds available: The minimum costs of the interventions were about EUR 25,000 per year for three years (EUR 75,000), mainly used to pay one person in the field, including travel expenses and consumables. Field vehicle and the Tomahawk traps were already available from the scientific coordinator (Università degli Studi dell'Insubria). Contingency funds for 2019-2020 will be made available by Lombardy Region

Black rat on Tavolara island

Invasive species common name (Latin name)

Black rat (*Rattus rattus*).

Native geography

India and Southeast Asia

Project name

LIFE Puffinus Tavolara / Comune di Olbia
(LIFE12 NAT/IT/000416)

Project location or geographical area of conservation work

Tavolara and three smaller islets, Sardinia, Italy

Lead organisation

Comune di Olbia (Municipality of Olbia)

Key partners

- *Life Project:* LIFE12 NAT/IT/000416
- *Coordinating beneficiary:* Municipality of Olbia
- *Associated beneficiaries:* Tavolara - Punta Coda Cavallo Marine Protected Area and NEMO Srl
- *Other partners involved:* NGO Island Conservation; ISPRA (The Italian Institute for Environmental Protection and Research); Fo.Re.S.T.A.S.

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Map of project land area and brief description

Figure 1a: Sardinia showing the location of Tavolara.

Figure 1b: Tavolara island and three smaller islets.

Figure 2: Tavolara rises up 565m from the sea and contains the rare Yelkouan Shearwater © Archive MPA Tavolara - Punta Coda Cavallo

Tavolara, the main island in the Marine Protected Area, is a massive outcrop rising from the sea up to an elevation of 565 metres at Punta Cannone (figure 1a and 1b). About 6km in length, and 1.5km at its widest point, it towers over nearby islands. Indeed, it is a remnant of an enormous calcareous formation dating back to the Mesozoic, while the nearby landscape is dominated by older granite formations that have been smoothed out over time. The wild Tavolara, with its countless caves, cavities, and tunnels, both above ground and underwater, is home to range-restricted plants and a rich fauna.

Introduction and project background

The black rat (*Rattus rattus*) is by far the most widespread terrestrial mammal on the Mediterranean islands. It has been introduced in the region by man 2,000 years ago and its detrimental impact on nesting seabirds has been well documented. In Italy, black rats are present on about 75% of islands and on almost 100% of islands larger than 10 hectares in area.

The Tavolara archipelago is one of the most important areas for biodiversity conservation in the Mediterranean and it hosts numerous rare species, including some endemic ones. Tavolara is home to the world's largest colony of the Yelkouan shearwater (*Puffinus yelkouan*) classified as vulnerable (figure 2). This regional population amounts to about half of the entire world population. These birds were severely threatened by the presence of black rats, which eat their eggs and chicks, thus greatly reducing breeding success. Tavolara's shearwaters thus appeared to be destined to a gradual but constant decline that may ultimately have led to their extinction. The rat eradication project set out to safeguard this important population. During the eradication operation, all the staff involved were paid.

The control centered upon Tavolara island with work also occurring upon three small islets nearby.

Key project goals

- Protection of the world's largest population of Yelkouan shearwater from predation by the black rat
- Protection of other species such as the European storm petrel (*Hydrobates pelagicus melitensis*) which has the potential to breed and Scopoli's shearwater (*Calonectris diomedea*) which occasionally is found breeding on the islands. It was noted that these two species could remarkably enlarge their populations (especially the first) as a consequence of rat eradication
- Protection of other vertebrates of community interest probably preyed upon by rats such as European leaf-toed gecko (*Euleptes europaea)*, some land birds and other seabirds
- Increasing the natural complexity of island ecosystems through the eradication of the black rat

Figure 3: Aerial poison bait was distributed by specially designed hoppers
© Valentina Secchi

The effort to eradicate black rats from Tavolara took place from October to November 2017. Poisoned rat bait was dropped from a helicopter (figure 3) on two occasions, in accordance with standardised methodologies applied worldwide to eliminate rats from large, inaccessible islands such as Tavolara. In human inhabited low-lying areas of the island, two small standard rat poison dispensers

were used instead of aerial bait. The aerial poisoned bait (cereal-based pellets that disintegrate after the first rains) was scattered from a suspended bucket with a fan mechanism distributing the pellets within a radius of 80 metres. A GPS-guided system allowed bait distribution only when helicopter was flying along the approved digital flight plan. The operation was planned with the utmost care: possible negative effects were evaluated, and the measures to mitigate them were identified. The project was reviewed by some of the world's leading experts on the topic, thanks to a collaborative effort with the NGO Island Conservation, which also sent two experienced pilots to assist with the first bait distribution effort. The two distribution efforts were carried out in an optimal fashion, thanks to the experience of the pilots and the project team as a whole and to support from Fo.Re.S.T.A.S. operators (figure 4). No problems were observed in any native species or in the wider native island environment, nor were any adverse effects observed on fish and the marine environment. All necessary bio-security measures were enacted to reduce the risk of the rats making a comeback. Poisoned bait dispensers and traps were placed on Tavolara and on the boats that service the island, and awareness-raising activities were implemented targeting the authorities in charge of the tourist port and the military base.

Figure 4: Successful rat eradication was a team effort © Archive MPA Tavolara - Punta Coda Cavallo

Detecting and managing spread

Project scope	
Main ways of IAS spread	Accidental rat transportation and incursion by boats and natural swimming in the sea aided by island stepping-stones present in the area.
Method of detection used	Trapping sessions with live traps and snap traps; collection of signs and tracks
Detection methods considered but not used (and why)	We have not considered other methods
Removal methods of removal/ control used	Bait stations on the ground with rodenticide and aerial baiting with helicopter. Hand broadcast of bait where needed
Methods considered but not used (and why)	We have not considered other methods
Legislation in place to ensure high welfare standards	European regulation on the use of rodenticide – risk for non-target species.

Major difficulties faced

- Difficulty in obtaining the necessary permits for baiting distribution; lack of a proper legislation. After many meetings with Italian Ministry of Health we obtained permission to distribute baits notwithstanding current regulations on chemical rodenticide use
- Technical difficulties due to both the very rugged morphology of the island, probably at global level the steeper island where a rat eradication has been attempted, and the presence of settlements in the flat areas that imposed a ground-based baiting approach. We carefully planned aerial and terrestrial broadcast

Major lessons learned

- Establish contacts in advance with the authorities that issue permits
- Liaise with and inform the local community appropriately before the project submission
- To involve other international experts on different phases of the project

Success indicators of project

- Absence of black rat traces in all the bait stations placed on the ground for monitoring and biosecurity
- Absence of Yelkouan shearwater nest predation and consequent increase of breeding success

Success of project

Measure		Confidence
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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

- Two years after the intervention (November 2019) there are no traces of black rat presence, consequently we are confident that eradication has been successful.
- In 2018 and 2019, not a single Yelkouan shearwater nest was predated

Future project development

- Maintain island bio-security procedures to prevent the reinvasion of the black rat

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- Broome KG, Golding C, Brown KP et al. (2017) *Mouse eradication using aerial baiting: Current agreed best practice used in New Zealand* (Version 1.0). New Zealand Department of Conservation internal document DOC-3034281, Wellington, New Zealand
- Russell J, Towns D & Clout M (2008) Review of rat invasion biology. Implications for island biosecurity. *Science for Conservation 286*, New Zealand

Quantified summary data

- **Date commencement:** July 2013 – November 2018
- **Resources used:** 167 rat bait stations positioned on land; 17.7 tonnes of rat bait distributed throughout the island; about six hours of helicopter flight for the aerial distribution of rat bait; 258km of transects travelled
- **Cost & Contingency funds available**: The cost of the LIFE project was EUR 1,012,588. The cost of rodent eradication, including preliminary surveys, drafting of the eradication plan etc, was EUR 304,000

Preventing grey squirrel establishment on Anglesey

Invasive species common name (Latin name)
Grey squirrel (*Sciurus carolinensis*).

Native geography
Eastern United States (USA) / Canada

Project name
Red Squirrels United
(LIFE14 NAT/UK/000467)

Project location or geographical area of conservation work
The island of Anglesey, north Wales, United Kingdom

Lead organisation
Red Squirrels Trust Wales

Key partners
- The Wildlife Trusts
- Bangor University
- Zoological Society of Wales
- Animal and Plant Health Agency
- Natural Resources Wales (NRW)
- Bangor City Council
- Isle of Anglesey County Council AONB staff
- National Trust

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Map of project land area and brief description

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 UK and the Republic of Ireland. Woodland cover on Anglesey is 3-4% and this includes 1,000 hectares of mixed coniferous plantation. The majority of the landscape is agricultural grazing land. Although grey squirrels were once common, the species was eradicated in 2013. The island currently contains the largest population of red squirrels (*Sciurus vulgaris*) in Wales.

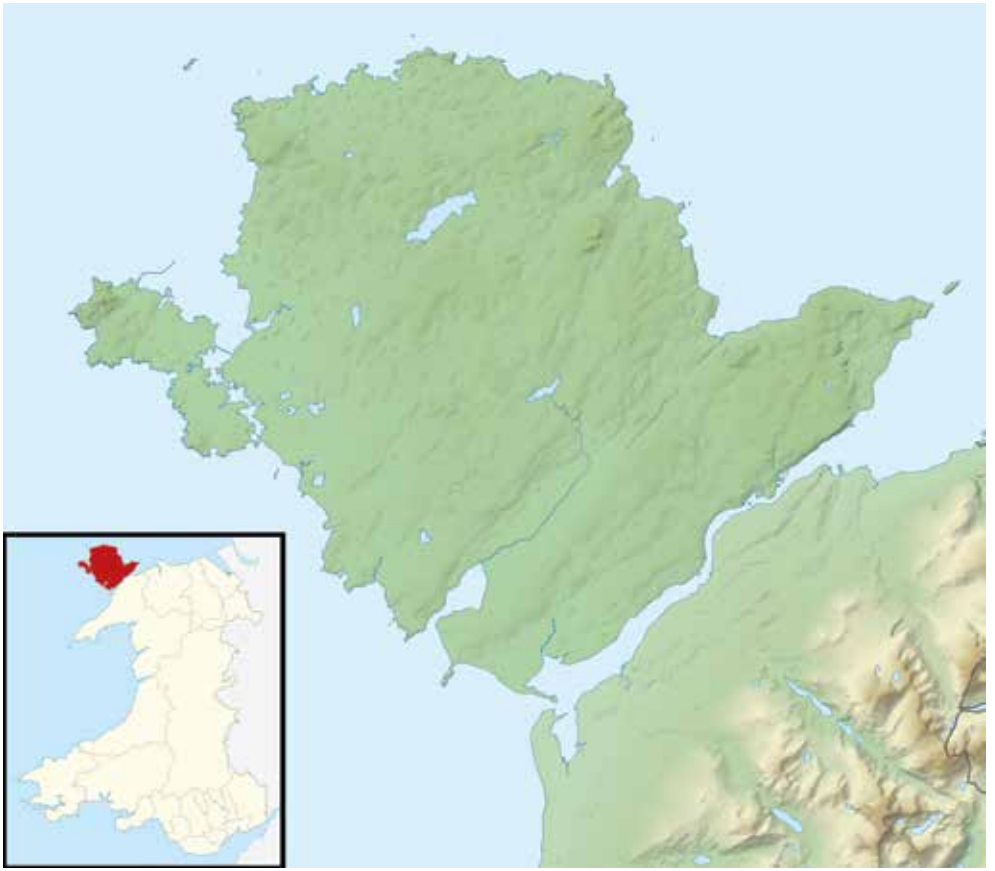

Figure 1: The island of Anglesey with insert showing the islands' location in Wales

Introduction and project background

The grey squirrel is native to eastern North America and was first introduced to the UK in 1876. The species is a serious pest in hardwood timber stands because it strips bark from a wide range of tree species. Grey squirrels out-compete native red squirrels for resources and carry squirrelpox virus (SQPV) which produces fatal and epidemic disease in red squirrel populations.

Grey squirrels were first recorded on Anglesey in the mid 1960s. In the subsequent three decades they colonised all the suitable woodland habitats which caused the red squirrel population to decline to approximately 40 adults. Co-ordinated grey squirrel control started on the island in 1998 with eradication achieved in 2013. However, in the autumn of 2015, incursion was detected resulting in three grey squirrels being live capture trapped at locations approximately 10km apart (figure 2). A fourth grey squirrel was reportedly shot by a member of the public in early 2016.

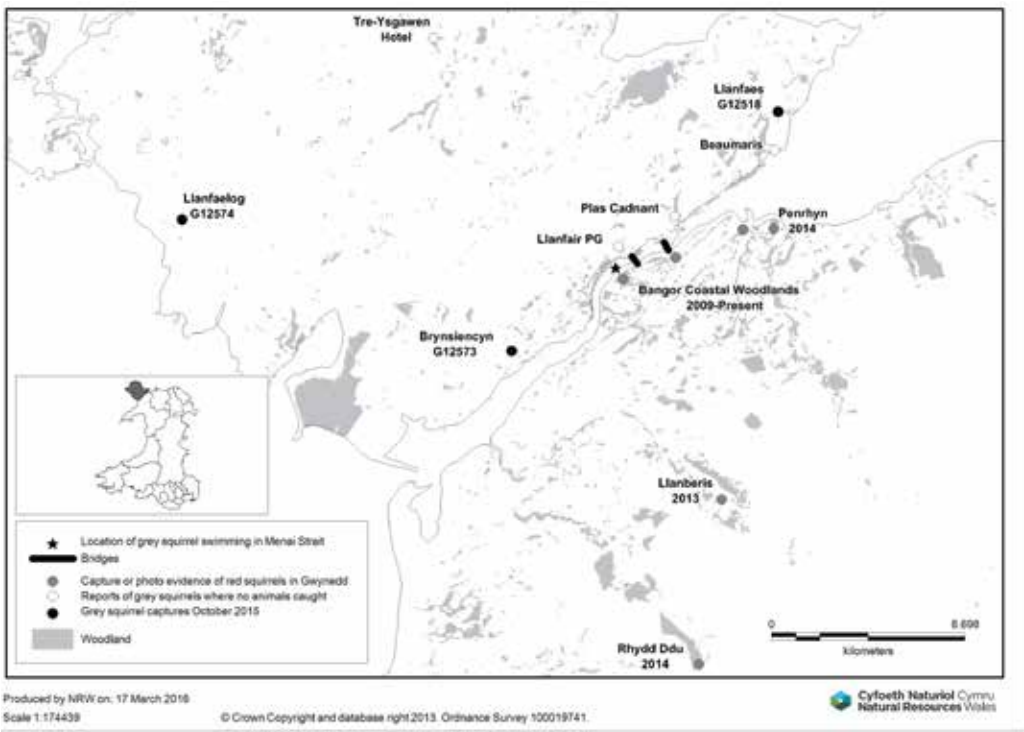

Figure 2: Detection of grey squirrels on Anglesey in 2015

In 2016, the Red Squirrels United (RSU) project started, with the aim of developing an effective early warning system to prevent grey squirrels re-establishing on the island and to minimise the risk of inter-specific pathogenic viral infection. The approach was to empower local people with the ability to differentiate grey squirrels from native red squirrels, to be aware of the characteristic signs of SQPV in red squirrels and to have the confidence to report sightings to the project. In addition, a co-ordinated network of garden and forest feeding stations was established across the island to create a proactive surveillance network.

The RSU project is an adaptive demonstration project with a key objective of producing best practice that has transferability to other invasive species management projects. The project benefitted from publication of earlier lessons learned during the historical 2016 grey squirrel incursion in Shuttleworth et al. (2016) and that book chapter should be read in conjunction with this case study.

Key project goals

- To identify all potential grey squirrel incursion pathways
- To empower local communities with the skills and confidence to differentiate invasive grey squirrels from native red squirrels
- To rapidly detect grey squirrel presence on the island of Anglesey
- To efficiently remove animals which are sighted on the island

Description of the project activity

Figure 3: Grey squirrels were caught on Anglesey in the autumn of 2015 following sighting reports received from the general public © Pixabay

The island eradication was a population removal to a sea boundary across which vehicle traffic traverses either using the Holyhead ferry port to Ireland or the two bridges to the Welsh mainland. Grey squirrels have since demonstrated an ability to reinvade Anglesey, underlining the importance of sustained monitoring vigilance (figure 3). The RSU project recognised that establishing a long-term proactive squirrel detection programme using large numbers of wildlife cameras was, in the light of resource restrictions, not a sustainable option in the long-term. Building upon the public popularity of red squirrels, it was recognised that local people were already establishing feeding stations so they could watch the animals in gardens and woodlands. Documenting this naturally evolving network offered the seamless opportunity to create an early warning system to detect grey squirrel incursion and also evidence any squirrelpox disease in red squirrels.

RSU provided free squirrel supplemental feeding hoppers and encouraged the local community to send in details of the location of their hoppers, the types of food being provided and both a telephone and email contact. The aim was to have 200+ locations logged by 2019 and in parallel to provide people with information on the ecology of red squirrels, the threat posed by grey squirrels and what physical characteristics can be used to tell the two species apart. In 2018 we published a free online colour e-book entitled *'Red squirrels in my garden: guidance and tips to help encourage and conserve local populations'* (Shuttleworth & Halliwell 2018) (figure 4a & 4b) which contained information, illustrations and diagrams. The guidebook availability and repeated requests for the wider public to report grey squirrel sightings were shared on social media platforms. In the autumn of 2017, SQPV was detected in mainland red squirrels close to the bridges to the island (Everest et al 2017) and the island network proved invaluable in demonstrating an absence from the Anglesey red squirrel population. Potential cases of island infection were reported but follow up histological surveillance indicated these were bacterial infections.

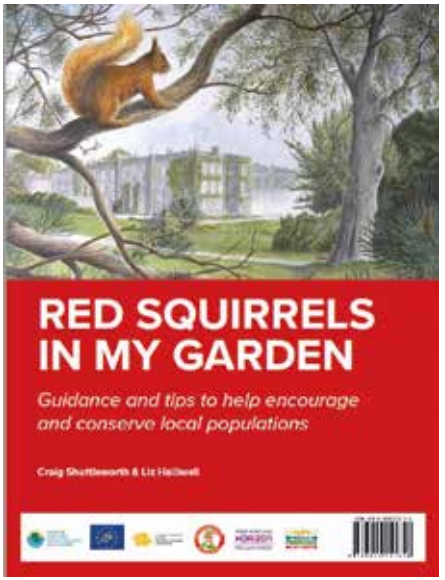

Figure 4a: A free book was produced to educate people about squirrel ecology and the difference between species
Figure 4b: The book contained detailed life history information

In parallel to the community based early warning network, wildlife cameras were rotated between locations in woodlands close to Holyhead ferry port/freight hub and near to the road bridges linking Anglesey and the mainland. The camera recorded images were checked every two weeks. In 2017, two of the grey squirrel sightings reported from the island by the public resulted in the project successfully removing the animals using live capture cage trapping. One animal was caught near Holyhead Port and this highlighted the potential invasion pathway represented by road traffic stowaways. The second animal was on the southern coast adjacent to the mainland which contains a large grey squirrel population. It is possible that this animal swam the narrow sea strait.

Grey squirrels were able to naturally colonise Anglesey in the mid 1960s almost certainly either by swimming from the mainland or running over one of the two bridges. Mainland populations are controlled near the coast to try and limit the probability of such natural dispersal to the island. The RSU project also focused on better understanding the risk of stowaways on heavy goods vehicles, train freight, or in domestic vehicles and what practical contingency could be put in place to deal with this.

In December 2016 a grey squirrel was hit by a car in the mainland village of Llanberis and unbeknown to the driver the impact had pushed the animal unharmed through the plastic front grill and it was stuck by the radiator in the engine compartment (figure 5). The resulting press reporting included reference to an officer from a national animal welfare organisation, the Royal Society for the Prevention of Cruelty to Animals (RSPCA), attending along with a local mechanic. They freed the squirrel from the engine bay compartment but were unable to prevent it from escaping back into the wild. Discussions with the RSPCA & North Wales Police led to agreement for a protocol should such a situation ever arise on the island.

Working with the Natural Resources Wales (NRW), the Welsh statutory nature conservation authority an island early detection and removal protocol was developed within a wider red squirrel island conservation plan. Ongoing public education and community outreach (working with school children & community groups) maintained and reinforced the message that grey squirrels on Anglesey must be reported and removed quickly.

Figure 5: A grey squirrel accidentally trapped inside a motor vehicle in north Wales © Moduron Maethlu Motors LTD

Detecting and managing spread

Project scope	
Main ways of IAS spread	**Natural dispersal:** Traversing over the sea strait using the lower rail deck on the Britannia Bridge. Swimming the Menai Strait **Human mediated dispersal:** Stowaway in road and rail freight vehicles (including ferry traffic). Deliberate translocation of animals by people carrying them in vehicles
Method of detection used	Community awareness of grey squirrels as an invasive species and the parallel network of early warning feeding stations combined with regular camera trapping near incursion points. Localised use of wildlife cameras at diffuse ground baited locations elsewhere
Detection methods considered but not used (and why)	Comprehensive geographical coverage using wildlife camera monitoring (logistics and budget constraints but also evidence that the use of cameras alone may fail to detect grey squirrel presence)
Methods of removal/control used	Live capture trapping with shooting as an alternative. Trapping included a live capture trap loan scheme where volunteers set and monitored the trap, but a third party dispatched any target species caught
Removal methods considered but not used (and why)	Kill traps could not be used on Anglesey
Legislation in place to ensure high welfare standards	Captured grey squirrels are protected under the Animal Welfare Act 2006 which safeguards welfare during confinement The Wild Mammals (Protection) Act 1996 Wildlife and Countryside Act 1981

Major difficulties faced

- The grey squirrel is listed as 'Species of Union Concern' within the EU Regulation (EU) No 1143/2014 on the Prevention and Management of the Introduction and Spread of Invasive Alien Species. However, although Anglesey is the only county in Wales without grey squirrels, the Governments response to the EU Directive, a Grey Squirrel Management Action Plan for Wales, makes no tangible financial commitment to help maintain Anglesey as grey squirrel free
- Cases of public misidentification of red squirrels as being grey squirrels remains an ongoing problem. We have also noted several instances where partially crushed carcasses of species such as hedgehog and rabbit on roads are also reported as grey squirrels. We are continuing to provide online resources to illustrate differences between the species
- As observed in 2015, there is sometimes a delay between a sighting being made and it being reported. In addition, we have had one instance where a grey squirrel photograph was posted online and alleged to have been taken on Anglesey when subsequent investigation revealed this had been a hoax
- Pathogenic skin infections such as exudative *Staphylococcal dermatitis* and *Dermatophilus congolensis* have been observed in island red squirrels and these are easily confused with SQPV signs. The infections are challenging to differentiate from photographs and, where a body is available, there are inevitable delays waiting for histology reports

Major lessons learned

- Many local people wrongly believe that grey squirrels cannot cross the Menai Strait and that Anglesey is a safe haven for red squirrels. It is therefore essential to keep refreshing the message on social media and other news platforms that there is a need for constant vigilance regarding the threat of island reinvasion by grey squirrels
- A network of woodland and garden feeding stations monitored by the public is resource efficient, but likely to produce a geographically patchy surveillance network. Thus, there remains a need for project resource to undertake surveillance elsewhere to achieve comprehensive landscape coverage
- Reports of grey squirrels on Anglesey were sometimes initially posted on general wildlife sighting or local community social media group pages/accounts. It was important therefore that project social media had a wide membership to increase the likelihood that some were also active on other pages
- Without public awareness of the threat posed by grey squirrels the project would not have detected and then removed the two grey squirrels in 2017

Success indicators of project

- Create a network of 200+ garden/woodland squirrel feeding stations managed and monitored by members of the public
- Produce online e-book guidance to provide people with information about native red and invasive grey squirrel ecology and how to differentiate the two species
- Rapidly remove detected grey squirrels to prevent population res-establishment and pathogenic disease in sympatric red squirrel populations
- Collate all relevant information to gain a better understanding of both the possible incursion routes and their probability (figure 6)

Figure 6: A grey squirrel swimming in north Wales © Steve Ransome

Success of project

Measure		Confidence
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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 network of 200+ garden/woodland feeding stations were catalogued by autumn of 2018. A parallel database contained details of habitat, type of foods being provided and contact details for each location. This meant that we could group email the network with information about emerging pathogenic infection threats and any suspected sightings of grey squirrels
- In the spring of 2018, we published a 120 page bilingual (English/Welsh) guide on red squirrel and invasive grey squirrel ecology. This was available as a free e-book download
- We received video evidence of a grey squirrel near the port of Holyhead in February 2018 (SH 2695 8139) but were unable to locate the animal. The subsequent fate of this animal remains unclear and it may still be at large
- An attempt to eradicate grey squirrels in 90km^2 on the Gwynedd mainland was not successful and we were unable to prevent grey squirrel incursions into mainland woodlands in close proximity to the bridges

Future project development

- We are working with Ulster Wildlife and regional ferry companies to raise the probability of detecting stowaway grey squirrels concealed within traffic during sea-ferry crossings
- We established a network of 30 pine marten (*Martes martes*) boxes in the mainland areas adjacent to the island, initiated a co-ordinated captive breeding programme and in 2019 will release animals as a potential biological control for grey squirrels (figure 7)
- We have helped develop a new non-invasive method of determining viral infection status in mammals using hair (Shuttleworth et al 2019). We hope that further technical evolution may allow SQPV to be monitored simply by collecting hair at feeders using sticky pads

Figure 7: Pine martens will be released into the mainland area in 2019 after the presence of one animal was discovered in 2018 © Paul Harry

References

- Everest DJ, Floyd T, Donnacie B et al. (2017) Confirmation of Squirrelpox in Welsh red squirrel. *Veterinary Record 181*, 514-515
- Shuttleworth CM, Everest DJ, Halliwell EC et al. (2019) Detecting viral infection in red squirrels. *Veterinary Record 184*: 507
- Shuttleworth CM & Halliwell EC (2018) *Red squirrels in my garden: Guidance and tips to help encourage and conserve local populations*. 120pp. ESI. ISBN 978-0-9547576-5-6
- Shuttleworth CM, Halliwell EC & Robertson P (2016) Identifying incursion pathways, early detection responses and management actions to prevent grey squirrel range expansion: an island case study in Wales. In Shuttleworth CM, Lurz PWW & Gurnell J (eds) *The Grey Squirrel: Ecology & Management of an Invasive Species in Europe*. ESI. ISBN 978-0-954757-62-5

Quantified summary data

Date commencement: The project started in autumn 2016 to December 2019.
Surveillance effort in time and space: 220 record garden monitoring stations established on Anglesey
Resource: Over 400 traps provided, 25 wildlife cameras, 30 pine marten boxes and 150 wooden feeders
Labour resource: 50 mainland volunteer trappers recruited, trained and monitoring 120 live capture traps. 20 camera trap monitoring volunteers trained. 100+ island residents involved in red and grey squirrel monitoring. The Red Squirrels United project provided funds for one full time education officer
Detail of cumulative area over which these are applied: All 3,000 hectares of woodland across the 720km^2 island of Anglesey & Holy Island landscapes covered and around 1,500 hectares on the mainland (via trapping)
Cost & Contingency funds available: Project costs for camera traps and staff time £40K per annum. This does not include the parallel grey squirrel eradication work

LIFE U-SAVEREDS project

Invasive species common name (Latin name)
Eastern grey squirrel (*Sciurus carolinensis*)

Native geography
Eastern United States (USA) / Canada

Project name
LIFE U-SAVEREDS
(LIFE13 BIO/IT/000204)

Project location or geographical area of conservation work
Perugia, Umbria, Italy

Lead organisation
ISPRA, Institute for Environmental Protection and Research, Italy

Key partners
- Experimental Zooprophylactic Institute of Umbria and Marche Regions
- ISPRA, Institute for Environmental Protection and Research
- Lazio Regional Agency, Directorate for Environment and Natural Systems
- Legambiente Umbria, local environmental association
- OIKOS Institute s.r.l
- Perugia Municipality
- Umbria Regional Agency

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Map of project land area and brief description

Figure 1a: Location of the Project area in Italy (black dot); regions neighbouring Umbria and considered for the implementation of the Early Warning and Rapid Response System are in grey.

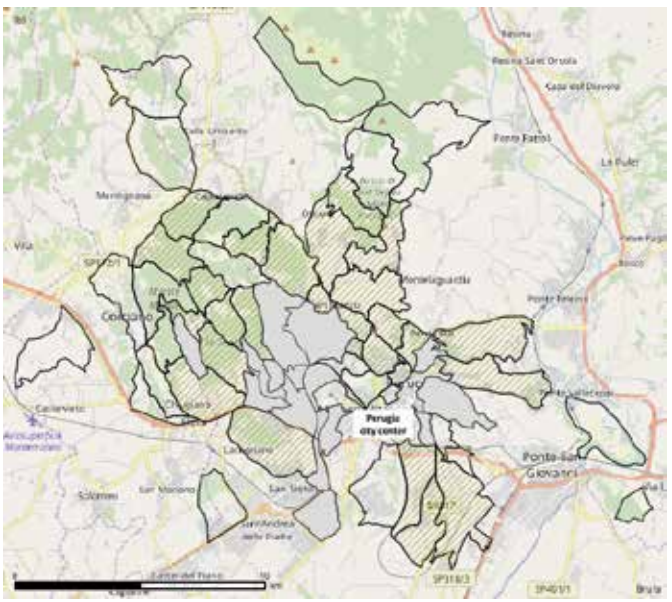

Figure 1b: Detailed map of the Perugia area, divided into several Management Units (MUs), as defined to facilitate the implementation of field activities. MUs of established grey squirrel presence at the beginning of the project are in grey; dashed MUs correspond to MUs that were monitored in 2015 and/or 2017 and 2018 to verify the presence/spread of the grey squirrels.

Introduction and project background

The eastern grey squirrel (*Sciurus carolinensis*) is an arboreal mammal, native to the eastern United States and adjacent southern eastern Canada. It is found mainly in deciduous and mixed forests, but it also thrives in city parks and floodplains. In its invasive range, it can damage trees by debarking, and in Europe, it causes the local extinction of the native red squirrel (*Sciurus vulgaris*) through resource competition and the spread of squirrelpox infection.

The grey squirrel was accidentally introduced in the city of Perugia (Umbria, Italy) in the early 2000s, and since then has spread to a range of approximately 50 km^2. Management activities started in 2016 and in 2018, following the removal of 1,070 animals, the invasive alien species (IAS) range was reduced to an area of approximately 3 km^2.

Despite the difficulties encountered in involving resident citizens, the removal of the animals occurred both in the Perugia urban and suburban areas and in nearby woodlands. The project mainly involved paid staff and a few students as volunteers and aimed at local eradication and prevention of spread of the IAS to the Apennines forested areas of central Italy.

Key project goals

- Local eradication or at least removal of 80% of grey squirrels from the Perugia area
- Prevention of spread from the Perugia area to nearby woodlands
- Prevention of introduction and establishment of the grey squirrel in other areas in central Italy

Description of the project activity

The LIFE U-SAVEREDS Project 'Management of grey squirrel in Umbria: conservation of red squirrel and preventing loss of biodiversity in the Apennines' is a LIFE+ project, funded by the European Commission to protect the Eurasian red squirrel from the threat posed by the introduction and expansion of the introduced grey squirrel. As in the British Islands and the north of Italy (especially in Piedmont), the early-2000s introduction of the grey squirrel in Umbria, central Italy, negatively affected local red squirrel populations. The grey squirrel presence represented a severe threat to forest biodiversity in central Italy because, considering the geographic and ecological characteristics of Umbria, the risk of an expansion of the population outside the regional borders was very high (figure 1a and 1b).

The LIFE U-SAVEREDS started in October 2014, and it pursued objectives both at the regional and national scale.

At the regional level, the primary goals were:

- The local eradication or at least the removal of 80% of grey squirrels
- The prevention of the grey squirrel spread to nearby woodland areas

The prevention of spread was fundamental since the woodlands near Perugia represent an ecological corridor towards the forested areas of the Apennines.

To achieve these goals, we adopted the following methodologies:

- Direct observation of the animals from vantage points (figure 2), camera-trapping (figure 3), hair-tubes and collection of occasional reports were carried out to detect the grey squirrels and define the alien species range

Figure 2: An observer gathering data on red and grey squirrel presence in the Perugia area © Giuseppe De Socio

Figure 3: A camera trap used to detect squirrels in the expansion area © Daniele Paoloni

- Removal through live capture and euthanasia (or surgical sterilisation and subsequent release in urban parks, for a limited number of individuals), performed to attempt the local eradication and avoid the expansion of the population to nearby areas; for live captures, we used Tomahawk live capture traps (mod. 202.5, 48x15x15 cm)

Live capture trapping (figure 4) was carried out by paid staff, but landowners and citizens were also involved as in the Perugia area the grey squirrel thrives in urban parks and small private properties within the suburban areas (private gardens and orchards). Landowners were asked to grant access to their properties for the positioning of traps and to notify the project technical staff in case of capture of grey squirrels or other non-target species. Some students also helped in the management activities, and they undertook surveys both to detect squirrels and to estimate their range and abundance.

Figure 4: Tomahawk live trap © Daniele Paoloni

We also implemented an information and communication campaign, through the following actions:

- Five annual press conferences
- Participation in television broadcasts
- Organisation of public meetings and field excursions with citizens
- Direct contact with landowners through letters, door-to-door campaigns, and phone calls
- Promotion of a photographic contest
- Organisation of a roundtable with animal-welfare groups

We also initiated educational activities, involving local schools of the Perugia municipality (figure 5) and nearby areas.

Figure 5: Environmental education activities - involvement of schoolchildren in the Arbor Day 2017, during which hazelnut planting activities were started in different areas of Perugia to improve habitat conditions for the red squirrel © LIFE U-SAVEREDS/Legambiente Umbria Archive

At the national scale, the project aimed to:

- Setting up an Early Warning and Rapid Response System (EWSRR) to remove any new squirrel foci in central Italy
- Creating an Alien Squirrel Emergency Team (ASET), a group of experts supporting local agencies for management of established alien squirrel population in other Italian regions

To set up the EWSRR, we drafted a booklet and distributed it to a network of wildlife technicians working in the project area and neighbouring regions. The booklet summarised the main risks associated with IAS squirrel introductions in central Italy, and it provided guidelines on the detection methods to use in case of IAS squirrel reports, to confirm the species presence. The ASET also produced guidelines for the removal activities that should be implemented in the case of confirmed reports.

At the regional scale, we started the management activities in 2016, and in 2018 the IAS range was reduced to an area of about 3 km^2. The risk of spread now

seems limited. Nevertheless, for the After-LIFE period (2019-2023), we plan to continue with the removal of the residual animals and the information campaign. At the national level, we activated the EWSRR and no new non-native squirrel population established in central Italy during the project implementation. However, we will maintain both the early warning network and the ASET to face the risk related to potential new introductions in Italy.

Detecting and managing spread

Project scope	Grey squirrel removal from the Perugia area Prevention of spread from the Perugia area to neighbouring woodlands Prevention of introduction and establishment of the grey squirrel in other areas in central Italy
Main ways of spread	Natural spread from an existing population Release in new areas
Method of detection used	Camera-trapping, direct observations, monitoring of foraging stations
Detection methods considered but not used (and why)	Hair-tubes were used only in the early stages of the project, but the technique requires the microscopic examination of hairs, and it was considered time-consuming and more difficult to implement in our specific context with respected to the other, adopted techniques. Also, the staff of the local management agencies was more willing to collect data from camera traps than to control and collect hair samples from the tubes
Methods of removal/control used	Live trapping and subsequent euthanasia by carbon dioxide inhalation
Removal methods considered but not used (and why)	Shooting was considered but not applied in this project, because of national regulation and guidelines that recommend live capture trapping and subsequent euthanasia as the primary method for the grey squirrel removal. Moreover, it was felt that shooting could lead to opposition of citizens and stakeholder groups
Legislation in place to ensure high welfare standards	Council Regulation (EC) no. 1099/09 was considered for the euthanasia of the animals

Major difficulties faced

- Initially there was limited reporting of grey squirrels by the general public. The project tackled this by developing information campaigns on the importance of grey squirrel removal to protect the red squirrel and on impacts of IAS
- We encountered a lack of co-operation of citizens in grey squirrel management and in particular, difficulties accessing private land in order to remove animals. The project organised meetings and established direct contact with citizens to improve this
- Opposition from local animal rights groups was encountered. This occasionally resulted in damage to project equipment. The project facilitated meetings with groups and took steps to prevent the removal and damage of the traps

Major lessons learned

- Need to educate the community about the importance of nature protection, aiming to create an emotional connection between native species and people
- Promote meetings between local agencies and those managing grey squirrels to prevent potential spread or new introduction. This allows an early warning and rapid response network to be implemented more easily and can enhance existing steps to detect grey squirrels. It is particularly important to provide local agencies with clear and easily implementable guidelines
- Adopt technical measures to prevent the removal and damage of the traps and develop alternative plans in advance, to make sure that any opposition to the project does not cause management activities to be suspended
- Appropriate design of removal strategies to circumvent the difficulty of entering small private properties, e.g. through the use of feeding stations to attract the animals into adjacent areas where they can be controlled

Success indicators of project

- Participation of both citizens and project staff undertaking grey squirrel control in informative meetings
- Feedback received from local communities and experts on patterns of grey squirrel presence and evidence of increased public knowledge on the grey squirrel issue (e.g. measured through questionnaires)
- Activation of monitoring/removal campaigns following first detection and confirmation of the actual presence of IAS squirrels
- Reduction in the risk of spread from the Perugia area to nearby woodlands and neighbouring regions

Success of project

Measure		Confidence
Highly Successful		
Successful	✘	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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

- Following the organisation of informative meetings with technicians and experts at the regional and supra-regional scale, we obtained positive results of inbound/outbound questionnaires, and according to opinion polls, local communities acquired a basic knowledge on alien species and the grey squirrel issue in particular. Nevertheless, difficulties remained in involving a large number of citizens in data collection, because the information campaign targeted specific but small groups of people
- Most of the confirmed grey squirrel presence reports resulted in the activation of monitoring and eventually removal attempts, with active and effective collaboration between the project staff and the technicians of other local agencies
- The analysis of the grey squirrel distribution and abundance in the Perugia area allowed us to conclude that project activities reduced the risk of geographical expansion and also that no new alien squirrel populations established in central Italy

Future project development

- Technical activities (monitoring and removal at a local scale and nationally, in the case of grey squirrel being found in new areas) will continue with the same methodologies adopted during the LIFE Project. For the 2019-2023 period, we developed an After-LIFE Conservation Plan that identifies the priority areas of action
- Communication activities will also continue at both spatial scales. An After-LIFE Communication Plan details the six actions (press releases, networking, environmental education, public meetings, notice board and website maintenance) that we will carry out in the future (see http://usavereds.eu/it_IT/materiali-del-progetto/, English version available)

References

- LIFE U-SAVEREDS Early Warning System and Rapid Response booklet (http://usavereds.eu/it_IT/materiali-del-progetto/, in Italian only)
- LIFE U-SAVEREDS After-LIFE Communication Plan (http://usavereds.eu/it_IT/materiali-del-progetto/)
- Gurnell J, Lurz PWW, McDonald R, Pepper H (2009) *Practical techniques for surveying and monitoring squirrels*. Forestry Commission Practice Note, 12 pp
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Quantified summary data

Date commencement: 01/10/2014

Surveillance effort in time and space: at the regional scale, we performed a first survey in 2015 (May to December). We distinguished a central area, where the grey squirrel population was well established (13.5 km^2) and where we estimated local densities through direct observation of the animals, and a peripheral/expansion area (26.4 km^2), where direct observations, camera-trapping and hair-tubes were used to detect squirrels. In 2017 and 2018, we repeated the survey including additional areas (total 60.6 km^2, 47.1 km^2 in the peripheral area), adopting the following techniques: direct observations, camera-trapping, monitoring of artificial foraging points

At the national scale, monitoring was activated through the EWSRR network and surveys were performed opportunistically, on the basis of the species reports.
Resources used: Four binoculars, two GPS, two telemeters, two compasses, 46 camera-traps and 150 Tomahawk live capture traps (mod. 202.5, 48x15x15 cm)

Labour resource (effort in the expansion area only, regional scale):

- **in 2015:** 20 hair-tube stations, 398 observation points and 69 transects, 75 camera-trapping stations
- **in 2017-2018:** 493 observation points, approx. 100 camera trapping stations and 30 artificial foraging points

Cumulative area: 47.1 km^2 (regional survey to verify the grey squirrel spread from the Perugia core area); 72,363 km^2 (cumulative area of the regions neighbouring Umbria, for the EWSRR)
Costs and funds available: the total budget for the monitoring activities performed in 2015 and in 2017-2018 was EUR 74,545 and EUR 48,131, respectively. It includes personnel, travel, equipment and consumables costs. The setting up of the EWSRR had a budget of EUR 29,883

Grey squirrel eradication in the Mourne Mountains

Invasive species common name (Latin name)
Eastern grey squirrel (*Sciurus carolinensis*)

Native geography
Eastern United States (USA) / Canada

Project name
Red Squirrels United
(LIFE14 NAT/UK/000467)

Project location or geographical area of conservation work
The Mournes, County Down, Northern Ireland (United Kingdom)

Lead organisation
Ulster Wildlife

Key partners

- Animal and Plant Health Agency
- Bangor University
- Belfast Zoo
- National Trust
- Newcastle University
- Newry, Mourne and Down District Council
- Northern Ireland Environment Agency
- Northern Ireland Squirrel Forum
- Mourne Heritage Trust
- The Wildlife Trusts

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Project website: www.ulsterwildlife.org/redsquirrels
& www.redsquirrelsunited.org.uk/

Map of project land area and brief description

Figure 1: Map of the Mournes & Buffer Area

The isolated Mournes plain is situated on the east coast of Ireland in county Down, Northern Ireland (NI). It is bordered on one side by the Irish Sea and on the other side by the Mourne Mountain range. The main entry points into the Mournes for dispersing grey squirrels (*Sciurus carolinensis*) are through Newcastle and Newry/Warrenpoint/Rostrevor. Occasionally grey squirrels have been detected coming over the Mourne Mountains, including Slieve Donard (the highest peak in the Mournes) although this is less common.

Introduction and project background

The eastern grey squirrel is native to eastern USA / Canada. The species was originally introduced to Ireland in 1911 in County Longford. Since then they have spread throughout large parts of the island except to a few areas, particularly in the west.

It is a diurnal species with activity peaking during the early morning and during the late afternoon in the summer months. The species is highly associated with

deciduous woodland habitat but will also occupy coniferous stands although typically at a lower population density. Unlike red squirrels (*Sciurus vulgaris*), grey squirrels tend to spend the majority (c 60%) of their time on the ground. Grey squirrels are a known forestry pest because they cause bark stripping damage to a variety of tree species. It is estimated that the cost to forestry is around GBP 10 million/year in Britain and EUR 4.5 million in Ireland. The species causes the regional extinction of native red squirrels through resource competition and the spread of squirrelpox disease.

The Mournes plain is a key red squirrel stronghold in Northern Ireland. Small pockets of volunteers had been working to prevent established grey squirrels displacing red squirrels in this area for many years. However, it was recognised that there was a need for a project to better co-ordinate organised efforts to remove grey squirrels from the Mournes plain and prevent subsequent reinvasion from occurring.

Figure 2: Shimna Valley in the Mourne Mountains

As part of Red Squirrels United, a three-year project was undertaken in the period 2016-2019. The work in the Mournes plain sought to eradicate the residual grey squirrel population. It also aimed to detect and remove small numbers of grey squirrels dispersing in, in order to prevent re-colonisation of the area. Paid staff carried out an eradication effort, while volunteers were trained, equipped and empowered as part of the project to work alongside paid staff. The project also offered a financial grant scheme to local volunteer networks carrying out grey squirrel control.

Key project goals

- Eradicate grey squirrels from the Mournes plain by control and monitoring within forestry blocks and work with NGOs and the local council to clear other habitat such as parkland, nature reserves and small woodlands
- Work with landowners to detect and control grey squirrels using hedgerow or other linkage habitats that provide corridors for grey squirrels to use to spread between woodland sites
- Undertake grey squirrel control within a buffer zone around the Mournes plain of sufficient depth to prevent incursion into the Mournes plain
- Set up monitoring stations on the two main entry points into the Mournes plain. Use volunteers to help monitor, trap and remove grey squirrels at strategic sites throughout the project area
- Educate the public so that they are aware of the importance of reporting sightings of red and grey squirrels

Description of the project activity

The aim of the project was the eradication of grey squirrels from the Mournes area. This included control within a buffer zone around the Mournes plain so that grey squirrel dispersal could be intercepted before animals reached there. Alongside this, Ulster Wildlife ran a public education programme. This allowed staff to train and equip volunteers to monitor and help with grey squirrel capture and dispatch.

In addition to public reports, grey squirrels were detected via strategic camera trap placement in conjunction with wooden feeders from which hair samples could be collected. Live capture traps were used to trap grey squirrels and dispatch methods included cranial dispatch, the use of an air pistol to shoot grey squirrels in the trap or most frequently the use of a Kania 2000 tree trap fixed to the exterior of a live capture trap (figure 3) containing a grey squirrel. In the latter case, the live capture trap door could be opened, and the squirrel would then move into the Kania trap fixed to the outside, triggering the mechanism which would then dispatch the animal.

Figure 3: Kania 2000 trap fitted to a live capture trap. If a grey squirrel is caught in a live capture trap, a Kania can be fitted and secured on the outside of the door. If the door is opened, the animal will move into the Kania triggering the spring mechanism which dispatches it
© Ulster Wildlife

Grey squirrels were also shot with an air rifle at certain sites. All dispatched grey squirrels were dissected, and tissue samples sent to the Animal and Plant Health Agency for analysis on adenovirus or squirrelpox virus as part of a research programme.

Paid staff in conjunction with trained volunteers carried out both monitoring of sites and grey squirrel control. The area covered is incredibly large, so volunteers were vital in the delivery of the project. Landowners gave permission to allow Ulster Wildlife to work on their land, which was crucial especially in strategic locations such as grey squirrel corridors or areas near red squirrel hotspots. They also helped by monitoring and reporting sightings. Working with stakeholders allowed us to develop important partnerships and working relationships to further the project. This also facilitated the sharing of best practice.

Project staff also carried out education work in schools (primary, secondary and special schools) as well as tertiary education organisations. They engaged with the public when attending events, orgainsing training sessions, talks, red squirrel walks and feeder building sessions.

Figure 4: Local people were involved in the manufacture of feeders used to attract grey squirrels so they could be detected using wildlife cameras © Ulster Wildlife

These events helped give the local public a sense of ownership over their local project as they learned about the need for the project, what the objectives were and how they would be achieved. Education and community outreach reduced the likelihood of opposition to the control of grey squirrels.

Working with schools allowed us to get the message out to people at a young age and reach more people as the children will bring the message home with them. We encouraged the public to report squirrel sightings which helped the project target control more efficiently to remove remaining animals.

The most important area of the education work undertaken was training volunteers. These may be volunteers new to the field or existing volunteers that we could upskill to take on more responsibility within the project. Training courses include a LANTRA accredited Grey Squirrel Control workshop, camera trap training and data mapping training. Training volunteers also ensured there is a network to continue the grey squirrel control efforts post project.

Detecting and managing spread

Project scope	
Main ways of spread	Grey squirrels have been found to mainly use wooded river corridors and hedgerows to spread through the landscape. In the Mournes, they also use stone walls as dispersal routes
Method of detection used	Strategic monitoring at feeders via camera traps Sightings reported by volunteers and members of the public
Detection methods considered but not used (and why)	Visual line transects were not used because of the effort required and the risk of observer error in differentiating between red and grey squirrels
Methods of removal/control used	Live traps are used in conjunction with cranial dispatch, shooting via air pistol and dispatch via the Kania 2000. Shooting with an air rifle is also used in certain sites
Removal methods considered but not used (and why)	
Legislation in place to ensure high welfare standards	Wildlife of Animals (NI) Act 2011 The Wildlife (NI) Order 1985 Wildlife & Natural Environment Act (NI) 2011

Major difficulties faced

- Getting permission to work on certain land holdings e.g. Council owned woodland
- Restricted resources: Limited equipment e.g. traps and cameras, for both paid staff and to loan to volunteers. This was exacerbated when most cameras were diverted to volunteers during the national presence absence survey for red squirrels, grey squirrels and pine marten
- By definition, the eradication to a boundary meant that although the grey squirrels may be completely eradicated there is an ongoing need to prevent reinvasion

Major lessons learned

- A network of good volunteers is crucial as they form a valuable part of the team and extend the reach and efficacy of control efforts
- Not to underestimate the natural corridors squirrels will use to move between sites
- Not to underestimate small patches of woodland/scrub habitat that grey squirrels will inhabit
- Education is crucial when it comes to eradication. The public are less likely to oppose control if they are well educated on the how and why of eradication

Success indicators of project

- By end of year three, the Mournes Plain and surrounding buffer zone will have been successfully cleared of grey squirrels
- Extension of the eradication and buffer zones
- To have trained and equipped volunteers in place to continue working after year three

Success of project

Measure		Confidence
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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 original eradication zone and buffer zone were extended after years one and two as it took less time to clear the initial targeted area than expected
- The target of 'Grey Squirrel Management' volunteer training (LANTRA) courses delivered was exceeded before end of Year two. Ulster Wildlife had a target of delivering 12 LANTRA courses across the project area in three years. At the time of writing 20 courses have been delivered
- Education is reaching people. We were able to set up a new red squirrel community group in Rostrevor, a key red squirrel area. This group is interested in red squirrel monitoring and conservation but more importantly are interested in carrying out grey squirrel control in the area to protect the local population. We are also assisting in setting up a Biodiversity Group in Castlewellan. The group will incorporate red squirrel conservation into their work to safeguard the important red squirrel population in this woodland

Future project development

- Expanding the project area to include the nearby town of Newry, which is densely populated with grey squirrels and which acts as a source population for reinvasion of the Mournes buffer area
- Use of the Kania 2000 tree trap as a tool for dispatch has been successful. Paid staff and volunteers used the trap and it has enabled more volunteers to carry out dispatch as before many were not happy to undertake cranial dispatch but will happily use a Kania

References

- Shuttleworth CM, Lurz PWW & Gurnell J (2016) *The grey squirrel: ecology and management of an invasive species in Europe.* European Squirrel Initiative, 532 pp
- Finlay S (2017) *Squirrel and pine marten survey 2017*. Red Squirrels United, Ulster Wildlife unpublished report

Quantified summary data

Date commencement: The Red Squirrels United project began in September 2016.

Surveillance effort in time and space: In the first 26 months the cumulative landscape area included in the Mournes Plain and buffer zone was 1,948 km^2 see attached map). The total area of sites covered including private landowners, forestry, other NGOs and landowners is 8,343.61 hectares. We are securing new permissions on a weekly basis and are currently in talks with Newry, Mourne and Down District Council to acquire permissions for their lands within the area.

Labour resource: During this time there was one full-time paid staff member working in this area whose focus was grey squirrel control and one part time staff member who undertook community engagement with the assistance of on average five volunteers

Resources use: They have had on average 30 cameras and 50 live traps at their disposal

Grey squirrel management in the upland coniferous forest of Clocaenog

Invasive species common name (Latin name)
Grey squirrel (*Sciurus carolinensis*).

Native geography
Eastern United States (USA) / Canada

Project name
Clocaenog Forest red squirrel project
Red Squirrels United
(HG-14-10510)

Project location or geographical area of conservation work
Clocaenog Forest, Denbighshire/Conwy, Wales

Lead organisation
Natural Resources Wales (NRW)

Key partners
- Red Squirrels Trust Wales (RSTW)
- Clocaenog Red Squirrels Trust (CRST)
- British Association for Shooting and Conservation (BASC)
- Local landowners
- Bangor University
- The Wildlife Trusts

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Map of project land area and brief description

Figure 1: Map showing Clocaenog Forest (pale green) and insert showing the forest location in north Wales.

Clocaenog Forest covers an area of 5,500 hectares, just under half of which is managed using Low Impact Silvicultural Systems (LISS) relying on the gradual and successive thinning of crops to produce a more structurally diverse forest. The forest is managed by Natural Resources Wales (NRW) as part of the Welsh Government Woodland Estate. It is a typical upland forest, dominated by Sitka spruce (*Picea sitchensis*), but with patches of Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*). The latter are the favoured tree species food source for red squirrels. Clocaenog is managed to deliver multi-purpose benefits, and various techniques have been adopted to proactively target biodiversity conservation.

Introduction and project background

Grey squirrels have been present in northeast Wales, and Clocaenog Forest, for over 30 years. Red squirrels (*Sciurus vulgaris*) are a conservation priority for the forest, being one of just three priority areas for the species in Wales (Halliwell et al 2015). The presence of grey squirrels represents a threat to the red squirrel population as a result of competition for food and infection spread. The northern and western forest edges are bounded by open moorland which provides minimal opportunities for grey squirrel incursion, but the wooded valleys bordering Clocaenog Forest on the northeast and southeast boundaries provide corridors for grey squirrel movement and contain resident populations.

Control of grey squirrels within the forest is co-ordinated by NRW using contractors. More recently, the Red Squirrels United (RSU) project (National Lottery Heritage Funding) has been supporting volunteer trapping with training courses and a live capture trap-loan scheme through Red Squirrels Trust Wales. Volunteers are now regularly trapping within Clocaenog and the 10km buffer zone to limit incursion into the forest. Occasional grey squirrels are detected via the 50+ trail cameras situated throughout the forest (to monitor for red squirrels as well as detect grey squirrels). Immediate live capture trapping commences following the first grey squirrel sighting.

The British Association of Shooting & Conservation (BASC) Greenshoots project (grant-aided by NRW 2015 - 2018) has also encouraged control by its members in surrounding woodlands and estates.

Figure 2: Red squirrel caught on camera at a feeder © RSU Volunteer

Key project goals

- Early detection of grey squirrels within the forest including where a parallel red squirrel population reinforcement is being undertaken
- Efficient removal of detected grey squirrels from within Clocaenog Forest
- Prevention of grey squirrel recolonisation
- Awareness raising of red squirrel conservation action within local community

Description of the project activity

The management plan for Clocaenog Forest sets out the measures necessary to conserve the small population of red squirrels that still occurs there. These measures have included live capture trapping and hair tube surveys (undertaken by ecological contractors) as well as research to provide improved understanding of red and grey squirrel ecology and the status of the red squirrel population. See Halliwell et al. (2016).

An extensive live capture trapping survey in 2011/12 funded by NRW concluded that the red squirrel population was in severe decline (Shuttleworth & Donoyou 2012) and a reinforcement may be necessary (Shuttleworth & Hayward 2015). The decision to include Clocaenog Forest in the multi-partner Red Squirrels United project was therefore timely.

RSU funded a Red Squirrel Ranger (three-year post; part-time) who supported the formation of a local taskforce of volunteers dedicated to seeing red squirrels thrive once more in Clocaenog Forest. A series of training days covering squirrel ecology and monitoring, forest management and grey squirrel control were well attended. Volunteers were trained to use the agreed RSU control methods i.e. live capture trapping and cranial dispatch. Volunteer participants, some of whom who had never previously considered grey squirrels as a problem, willingly began grey squirrel control once they knew that without this intervention the reds would become extinct locally.

Given the size of the forest, volunteers were organised into smaller geographic groups that focussed on the corridors that grey squirrels were known to use to enter the forest. These were primarily across the north, east and south and included both private and NRW-owned land. Local volunteers were happy to approach landowners to ask for permission to trap grey squirrels with access never having been refused.

As the RSU project progressed, volunteers were able to adapt trapping methods based on evidence gained during initial attempts. The use of trail cameras became a very helpful resource for detection purposes. Over 50 cameras aimed at feeder boxes were installed primarily to detect red squirrels in the wider forest, but also to identify the presence of grey squirrels. These were monitored by volunteers twice per week in the main red squirrel areas and every six weeks elsewhere. Should grey squirrels be detected, live capture trapping commenced immediately.

Figure 3: The project trialled the use of hazel nuts with mesh cubes as a way of attracting squirrels and getting images on adjacent camera traps © RSU Volunteer

In some areas, mesh cubes baited with whole hazelnuts were used together with trail cameras to detect grey squirrels. The diameter of the mesh prevented food from being accessed and therefore didn't provide a food source for the grey squirrels. Where red squirrels were detected, the cubes were replaced with feeder boxes.

As well as detecting grey squirrels, volunteers also found images and videos of possibly three pine martens (*Martes martes*) from within the forest over a period of two years and images of deer (muntjac, *Muntiacus reevesi* and roe, *Capreolus capreolus*), fox (*Vulpes vulpes*), hare (*Lepus europaeus*), badger (*Meles meles*), polecat (*Mustela putorius*) and various bird species.

Despite the best efforts from all involved, the red squirrel population remained critically low, so a reinforcement programme became the main focus in 2017. The reinforcement was led by NRW, with volunteer involvement crucial to its success.

NRW staff and volunteers have worked alongside each other, with NRW also supporting the control programme, providing technical advice and managing control contracts. The majority of resources needed for grey squirrel control (traps and bait) were purchased by NRW as part of their contribution to this joint effort and NRW provided a building for the volunteers to store equipment.

The Red Squirrel Ranger also carried out a school outreach programme where Key Stage 2 pupils learned the differences between red and grey squirrels and made a drey. Further awareness raising comprised talks to groups (e.g. Wildlife Trusts, Rotary, Women's Institute); information stands at local shows; guided walks and collaboration with other red squirrel groups. University and College-age students have also benefitted from educational sessions.

The newly formed local red squirrel group, Clocaenog Red Squirrels Trust (CRST) are now gaining momentum with an aim to continue the conservation work.

In summary, this is an exceptional example of partnership working between government and non-government organisations and highlights the vital contribution that volunteers make to conservation success as well as a dedicated resource in the form of a ranger-type post.

Detecting and managing spread

Project scope	
Main ways of IAS spread	Dispersal from surrounding resident populations
Method of detection used	Camera traps on squirrel feeder boxes and mesh bait cubes, and sightings
Detection methods considered but not used (and why)	Hair tubes were used previously for detecting red and grey squirrels, but time and training is needed to accurately identify red vs grey hair. Camera traps are a more effective method now that they are affordable
Methods of removal/control used	Live capture trapping and cranial dispatch
Removal methods considered but not used (and why)	Kill traps are not possible due to risk of capture of red squirrels and other non-target species. Shooting is not possible within the forest due to health and safety issues around public access within the forest
Legislation in place to ensure high welfare standards	The Wild Mammals (Protection) Act 1996 makes it an offence to inflict unnecessary suffering of any wild mammal. All trappers are trained to ensure compliance with high welfare standards Animal Welfare Act 2006 Wildlife and Countryside Act 1981

Major difficulties faced

- Limited resources affected delivery effectiveness – the Red Squirrel Ranger was a part time role, whereas a full time post could have achieved more; some funding is available for contractor management of grey squirrels but there is also a reliance on volunteers. Ongoing funding is needed for the ranger role to provide support for the volunteers to maintain enthusiasm and interest
- Difficulties in capturing animals detected – high effort is sometimes needed to capture a single animal. A more efficient trapping method is needed and is being evolved
- Data gathering from volunteers – some are happy and able to supply what is needed (time sheets and grey control record forms) but others do not submit forms even following frequent requests and offers of getting the information in other ways (e.g. via email if they don’t want to fill in the form)

Major lessons learned

- There is a need for rapid response following detection of grey squirrels. Hair tubes were a previously used detection method, but analysis of samples was slow leading to significant delay between detection and trapping. Availability of more affordable camera traps has improved surveillance
- Ongoing grey squirrel control required. Volunteers are in no doubt that grey control will be an ongoing task. The new red squirrel group hope to gather enough funds to employ professional controllers periodically
- Ongoing volunteer recruitment and support is essential

Success indicators of project

- Establish a squirrel monitoring programme with forest-wide monitoring to determine red squirrel distribution, with minimum of five people involved per year
- Undertake grey squirrel trapping training courses to upskill volunteers to undertake control effectively and humanely; minimum of two courses per year and minimum of five attendees per event
- Establish a grey squirrel live capture trap loan scheme so that volunteers are engaged in the programme to remove grey squirrels and support recovery of red squirrel population; reduction in grey squirrel numbers in Clocaenog Forest and buffer zone with a minimum of five people engaged in the scheme per year

Success of project

Measure		Confidence
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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 RSU project has been highly successful in meeting all targets for monitoring, trapping and volunteer training
- Although a red squirrel population is still present in Clocaenog forest, numbers are low. The population reinforcement may need to be extended
- Ongoing grey squirrel reinvasion will continue to present a threat, and this is amplified because of low red squirrel abundance
- Recent engagement of local people in the project has helped to significantly raise the profile of the need to manage the grey squirrel population to safeguard the red squirrels
- Training and mentorship to volunteers from Red Squirrels Trust Wales & Bangor University was invaluable

Future project development

- Fundraising to provide ongoing funds for CRST to support red squirrel conservation work, including grey squirrel management

References

- Halliwell EC, Shuttleworth CM, Wilberforce EM et al. (2015) Striving for success: an evaluation of local action to conserve red squirrels (*Sciurus vulgaris*) in Wales. In: Shuttleworth CM, Lurz PWW, Hayward M (eds) *Red Squirrels: Ecology, Conservation & Management in Europe*, 175-192. European Squirrel Initiative
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- Shuttleworth CM & Hayward M (2015) *Future red squirrel conservation in Clocaenog Forest Contract P21018-0026*. Report to Natural Resources Wales

Quantified summary data

Date commencement: Red squirrel conservation, including grey squirrel management has been ongoing since 1994. The Red Squirrels United project started in 2016 and ended December 2019

Surveillance effort in time and space: 2004-2015 – live trapping covering 10-100 locations across the forest once per year; 2016-2019 – trail cameras run year-round over 1800 hectare total area

Resources: 2004-2015 – 20 live capture traps per site; 2016-2019 – 60 camera traps followed up with live trapping

Labour resource (Effort): 2016-2019 – 2206 volunteer hours plus employed contractor six weeks per year

Detail of cumulative area over which these are applied: 2004-2015 – different locations across the 5,500 ha forest. 2016-2019 cameras covering total area of approx. 1800 hectares

Cost & Contingency funds available: Red Squirrel Ranger part time role, co-ordination and training - £20K per year; contractor £8K per year; consumables £1.2K per year; cameras, traps and consumables £2.5K

Preventing grey squirrel spread in northwest Italy

Invasive species common name (Latin name)

Grey squirrel (*Sciurus carolinensis*).

Native geography

Eastern United States (USA) / Canada

Project name

LIFE09 NAT/IT/00095 EC-SQUARE

Project location or geographical area of conservation work

Northwest Italy: Regions Lombardy, Piedmont and Liguria

Lead organisation

Regione Lombardia (regional authority)

Key partners

- Regione Piemonte
- Regione Liguria
- Università dell'insubria
- Università di Torino
- Università di Genova
- Istituto Oikos

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Map of project land area and brief description

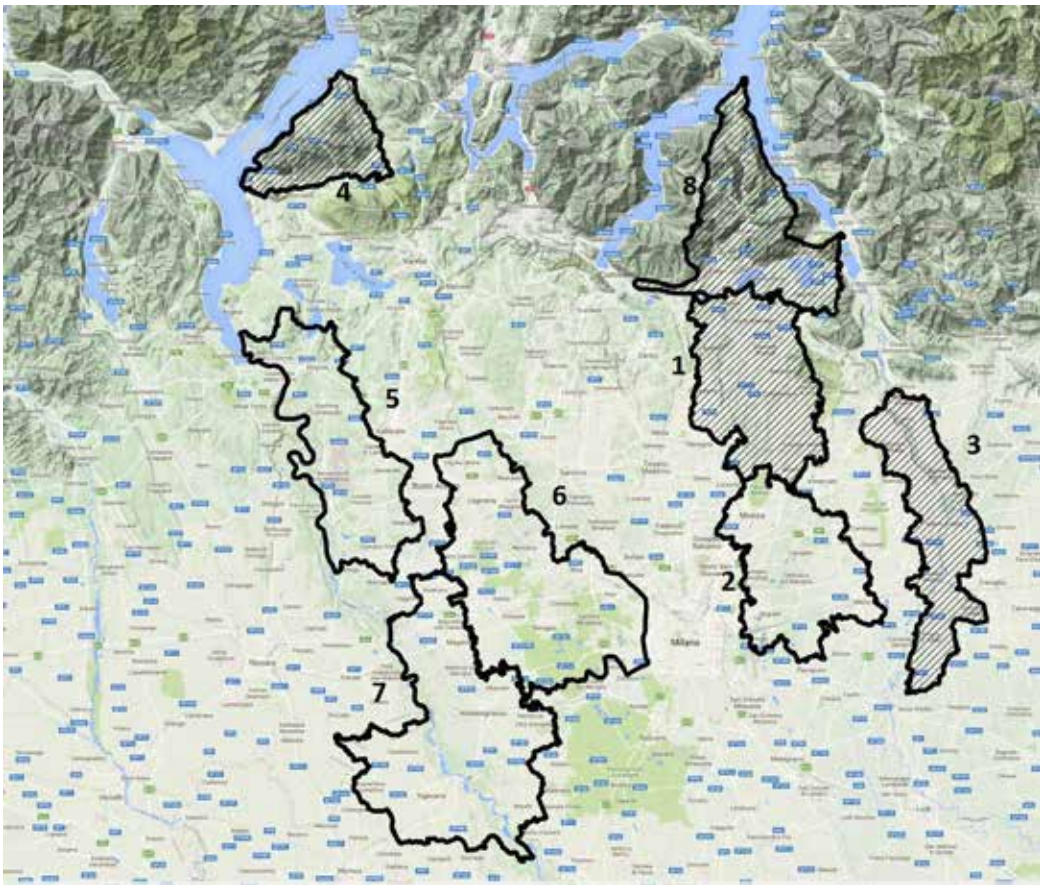

Figure 1: Macro-areas (black line) with the presence of grey squirrels or other introduced squirrel species in Lombardy. The area selected for management in the EC-SQUARE LIFE Project are dashed in black. Macro-areas are 1: Lambro settentrionale, 2: Lambro meridionale, 3: Adda, 4: Alto Varesotto, 5: Ticino settentrionale, 6: Alto Milanese, 7: Ticino meridionale, 8: Triangolo Lariano. In area 4, another non native invasive squirrel, Pallas's squirrel (*Callosciurus erythraeus*) is also present.

Introduction and project background

The Eastern grey squirrel (*Sciurus carolinensis*) is an arboreal mammal, native to the eastern United States and south-east Canada. It can live in deciduous and mixed forests, agricultural landscapes and urban or suburban green areas. In Europe it has been introduced in Great Britain, Ireland and Italy. In these countries it causes the local extinction of the native Eurasian red squirrel (*Sciurus vulgaris*) through resource and disease-mediated competition. In Great Britain, the species produces severe damage to forests and tree plantations through debarking of a variety of tree species.

Figure 2: Grey squirrel near a feeding station © Andrea Balduzzi

In Italy, the grey squirrel was introduced first into Piedmont (1948), subsequently into Liguria (1966) and then into many places in Lombardy (figure 2). The aim of the EC-SQUARE project was to develop methods to control and eradicate grey squirrels in different socio-ecological contexts. This was integrated with societal assessments to investigate the public perceptions of the general problems posed by invasive alien species (IAS) especially in the case of grey squirrel. Specific control methods linked to local public perception and opinion of the alien species have been developed (e.g. surgical sterilisation in one urban area) and made available to policy makers at different administrative levels.

EC-SQUARE was the first project in Italy to tackle the management of an abundant and widely distributed IAS in a multi-disciplinary, organised way. Actions initiated during the LIFE project resulted in the near complete eradication of grey squirrels in Liguria at Genoa Nervi and in at least two areas in Lombardy and Piedmont. Moreover, intensive control continued after the LIFE project; this will secure the persistence of red squirrel populations in the areas encompassed by the project.

Key project goals

- Eradication of the grey squirrel population in the city of Genoa and in areas in Piedmont and Lombardy
- Prevention of spread from neighbouring areas into any sites cleared of grey squirrels (in Piedmont and Lombardy)
- Prevention of introduction and establishment of the grey squirrel in other areas in northern Italy

Description of the project activity

The main objective of the project was the conservation of the native red squirrel and forest ecosystems, through actions to prevent a further expansion of the grey squirrel. The presence of grey squirrels in Italy is a major threat for the long-term survival of red squirrels in Italy and in the rest of Europe. Inter-specific competition for food resources causes extinction of the native species in areas colonised by the alien congener (so-called replacement competition).

Project actions have been carried out in three regions: Piedmont, Liguria and Lombardy, where large and numerous populations of grey squirrels occurred. The LIFE EC-SQUARE started in 2010 and ended in 2015.

The direct environmental benefits include:

- The removal of non-native squirrels from about 3,000 hectares of forested areas and the recolonisation of these areas by red squirrels
- The almost complete eradication of the grey squirrel population at Genoa Nervi and in neighbouring areas (trapping of the last animals is underway in the post-LIFE)
- The implementation of activities aimed at eradicating non-native squirrels in four macro areas (out of eight in total) in Lombardy; one a few kilometres from Switzerland

- In Piedmont, activities began to control the largest Italian grey squirrel population; a small sub-population of grey squirrels has been eradicated in the largest lowland forest of the region, a habitat of great importance to preserve lowland forest biodiversity and for red squirrels. At Genoa Nervi the project conducted the first eradication of an alien species through capture and surgical sterilization of the animals. The project is characterized by a strong innovation compared to more traditional methods of eradication. All the actions were conducted through the coordination of personnel working for the project, from the regions and universities, provincial and parks staff, gamekeepers and groups of volunteers involved in squirrel monitoring

The project carried out an opinion poll on public perception on the threats posed by grey squirrel and possible management actions. The results revealed that citizens had a very limited knowledge about the two squirrel species (native reds and invasive greys) and about the negative impacts caused by the introduced species. They also had little knowledge about the phenomena and the general problems associated with IAS (figure 3). Therefore, a communication action plan (CAP) and an information campaign was implemented, in order to change the attitude of the public and stakeholders on the control of the grey squirrel and raise awareness on the importance of the red squirrel in forest ecosystems.

Figure 3: Informing the community about the impacts of non-native squirrels was an important part of the project © EC Square

Figure 4: The project worked with many schools © EC Square

Environmental education (figure 3) had the aims of improving knowledge in primary and secondary school children, the general public and stakeholders on the role of the red squirrel in forest ecosystems and the impacts produced by the grey squirrel; in particular, the activities with pupils (figure 4) have the aim to reach through them to their families, thereby expanding the effectiveness of outreach. This activity involved the preparation of an educational kit including an interactive game 'What happened to Mr. Red'. In the school year 2012/2013, 131 classes have been involved in environmental education activities, including a contest between classes. Additional activities with the involvement of other classes were held in the two following years. The action also provided for the production of prototypes (six in Lombardy, four in Piedmont and two in Liguria): innovative structures designed to facilitate the observation of red squirrels in nature and therefore aimed to increase the public's perception of direct contact with squirrels and other animals.

Detecting and managing spread

Project scope	Eradication or control of grey squirrel populations in Piedmont, Lombardy, Liguria regions Prevention of spread from neighbouring areas after removal Prevention of introduction and establishment of the grey squirrel in other areas in Italy
Main ways of IAS spread	Natural spread from neighbouring populations Release of animals in new areas
Method of detection used	Hair-tubes, camera-trapping (figure 5), direct observations, monitoring of foraging stations
Detection methods considered but not used (and why)	
Methods of removal/control used	Live capture trapping and subsequent euthanasia by carbon dioxide inhalation Live capture trapping of urban grey squirrels, their surgical sterilisation and release in another urban area
Removal methods considered but not used (and why)	Shooting was considered but not applied with the grey squirrel because national guidelines recommend live capture trapping and subsequent euthanasia. Moreover, shooting could raise the opposition of citizens and stakeholder groups
Legislation in place to ensure high welfare standards	AVMA Guidelines for the Euthanasia of Animals Council Regulation (EC) no. 1099/09

Figure 5: Camera traps were used to monitor native red squirrel and detect grey squirrels © S Bertolino

Major difficulties faced

- Opposition from local animal rights groups, with appeals to regional and council courts, media campaigns, mail bombing (mass duplicate emails to one email address), local demonstrations in a co-ordinated - communication campaign
- Problems were encountered during trapping activities such as vandalism and intimidation of staff involved in the actions
- Poor citizens' collaboration in gathering data on the presence of the grey squirrel
- Difficulties of access to private areas for animal removal resulted in the organisation of meetings and establishing direct contacts with owners
- Change of political leadership

Major lessons learned

- Need to educate people about the importance of nature protection, aiming to create an emotional connection between native species and local people
- Promote meetings with local agencies and technicians working in the areas of potential spread or new introduction: thus, an early warning and rapid response network can be implemented more easily enhancing the network of existing detectors and providing them clear and easily implementable guidelines
- Adopt technical measures to prevent the removal and damage of the traps and develop alternative plans in advance, to make sure that any opposition to the project does not lead to a suspension of the management activities
- Appropriate design of removal strategies to circumvent the difficulty of entering small private properties, e.g., through use of feeding stations to attract the animals out and to locations where they can be caught

Success indicators of project

Figure 6: Red squirrel abundance increased following removal of grey squirrels © S Bertolino

Figure 7: Providing information to the public included the development of a 'squirrel observatory' © S Bertolino

- Decline in grey squirrel abundance locally and a parallel increase in red squirrel abundance (figure 6)
- Participation of citizens in informative meetings, use of project web site and Facebook pages (figure 7)
- The trend in the number of media article positive or negative to the project

Success of project

		Confidence
Highly Successful		
Successful		
Partially Successful	✘	High
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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

- Distribution of the grey squirrel in the project area and population densities proving to be much higher than estimated during the planning of the project
- Opposition from animal rights groups and other groups of citizens
- Reduced political support in some areas
- Difficulties in involving local authorities
- Low trapping effort and limited numbers of trapping staff

Future project development

- Trapping and monitoring is continuing in Lombardy with the same methodologies adopted during the LIFE Project following recommendations in the After-LIFE Plan
- Trapping and monitoring is continuing in the city of Genoa searching for the last animals there
- Public outreach and communication activities will also continue in Lombardy

References

Most of the documents produced by the project are available here; some are in English others only in Italian: http://www.rossoscoiattolo.eu/documenti

Quantified summary data

Date commencement: 01/09/2010
Surveillance effort in time and space: 36 sites monitored in Lombardy, direct observations, camera-trapping and hair-tubes; a large population (2,000 km^2) monitored in Piedmont; urban areas monitored in Liguria
Resources used: about 400 Tomahawk live capture traps; 30-40 camera-traps, three cars, hundreds of hair-tubes; a veterinary clinic
Cumulative area: about 700 square Km
Costs and funds available: the total budget for the preliminary monitoring activities was 67,000 EUR; for subsequent monitoring and control 726,000 EUR. It includes personnel, travel, equipment and consumables costs

Preventing grey squirrel spread in an urban landscape

Invasive species common name (Latin name)

Grey squirrel (*Sciurus carolinensis*).

Native geography

Eastern United States (USA) / Canada

Project name

Red Squirrels United
(LIFE14 NAT/UK/000467)

Project location or geographical area of conservation work

North Merseyside and West Lancashire, England

Lead organisation

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

Key partners

- National Trust
- Natural England
- Sefton Council
- Forestry Commission England
- Ministry of Defence
- Mersey Forest
- Red Alert volunteer group
- The Wildlife Trusts

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Map of project land area and brief description

The north Merseyside and west Lancashire Stronghold (figure 2) is a 197km^2 area encompassing around 400 hectares of contiguous (mainly coniferous) woodland surrounded by a 5-15km wide buffer zone. Woodland coverage in the buffer zone is patchy and fragmented; there are approximately 140 woodlands between 0.5 and 20 hectares in size. These woodlands comprise around 40 different ownerships and have numerous uses, including pheasant shooting, amenity woodlands, parkland and farmland woodlots.

The Stronghold is heavily populated and there are three large towns on the west coast (Crosby, Southport and Formby). Southport is the largest town with a population of approximately 90,000.

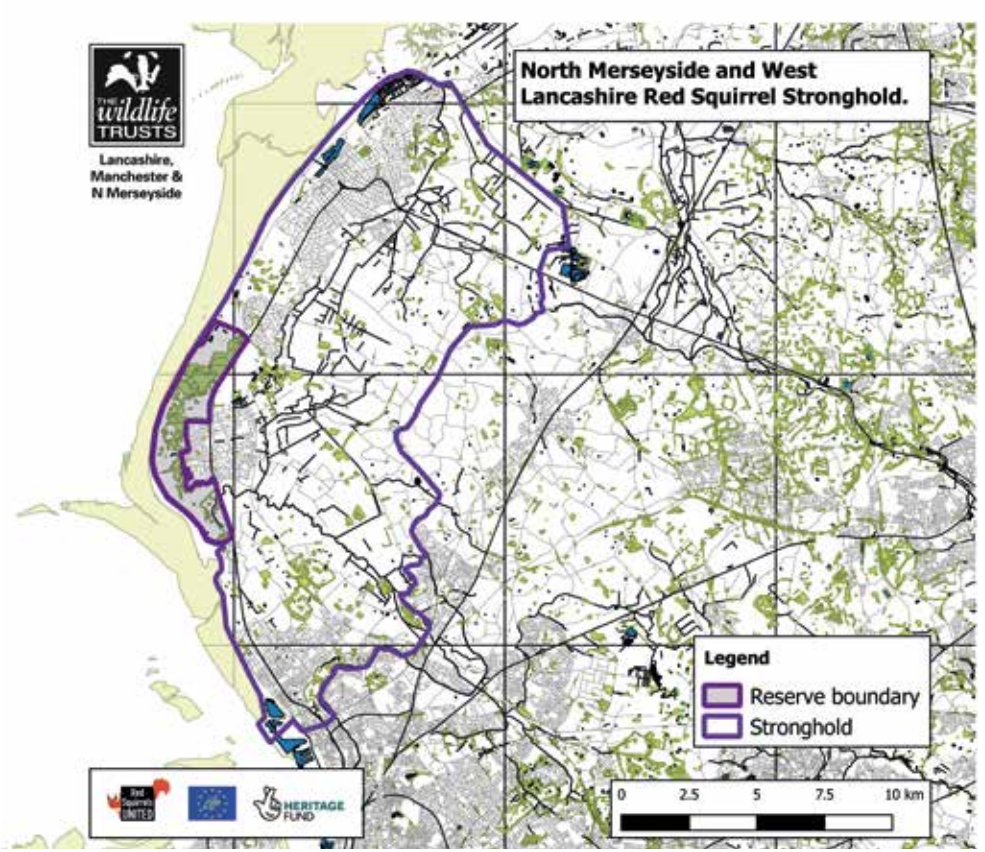

Figure 1: Merseyside red squirrel Stronghold area

Introduction and project background

Grey squirrels were introduced to the UK from North America in the late 19th century. The first grey squirrels weren't recorded in Lancashire until the late 1940s. They had firmly established in the north of the county by the late 1980s and continued to disperse and spread across the landscape. There was a sighting of a grey squirrel on top of Pendle Hill (557m above sea level) in 2008 and one was seen swimming across Anglezarke Reservoir in 2005.

The 400ha area of contiguous coastal woodlands holds a stable population of red squirrels and is largely grey squirrel free. Grey squirrels are present in the fragmented, isolated woodlands throughout the surrounding landscape. The parks and gardens of the urban areas, particularly Southport hold large breeding populations of grey squirrels. These two contrasting rural and suburban landscapes provide different challenges in terms of grey squirrel control.

The aim of the RSU project was to prevent incursion of grey squirrels into the coastal stronghold woodlands and limit or reduce the population in the surrounding buffer zone. Lancashire Wildlife Trust employed two members of paid staff through the RSU project – a Community Engagement Officer to raise awareness of the project and a Ranger to undertake grey squirrel control throughout the woodlands. A volunteer group has been active in the area since 1997 running a live capture trap loan scheme in the towns, in particular Formby. Community awareness and the trap loan scheme are an effective way of detecting and removing grey squirrels in urban areas before they reach the coastal woodlands and the aim is to expand this scheme further across Southport and Crosby.

Key project goals

- Increase public awareness and encourage reporting of grey squirrel sightings to Lancashire Wildlife Trust to aid in early detection of grey squirrels
- Rapid removal of grey squirrels through the reactive urban trap loan scheme
- Proactive grey squirrel control through live capture trapping and shooting in woodlands

Description of the project activity

The aim of this project was to keep the coastal red squirrel stronghold woodlands grey squirrel free and also limit and ultimately reduce populations in the surrounding landscape, allowing the red squirrel population to expand.

Grey squirrel control is co-ordinated by Lancashire Wildlife Trust who are the main point of contact for the reporting of all red and grey squirrel sightings. Grey squirrels are detected by a variety of methods:

- Trapping by the Red Squirrel Ranger
- Feeder stations monitored by volunteer shooters
- Public sightings
- A bi-annual monitoring programme
- Trail camera surveys

Proactive grey squirrel control in the woodlands is largely carried out by the Red Squirrel Ranger. The Ranger focuses on four areas of woodlands identified through previous work as holding large, breeding populations of grey squirrels. Three of these areas are complexes of connected woodlands in Little Crosby, Scarisbrick and Southport. The fourth is very close to the coastal reserve woodlands and was identified by Lurz et al. (2007) as an important incursion route into the stronghold. The Red Squirrel Ranger controls grey squirrels mainly by live capture trapping, but where appropriate will shoot as well, for example, where land use means traps cannot be left in situ. There are also a small number of volunteers carrying out regular grey squirrel control by shooting.

Grey squirrel sightings reported by members of the public are recorded centrally by Lancashire Wildlife Trust. The local volunteer group run an urban live capture trap loan scheme to trap grey squirrels reported in residential gardens. Volunteers arrange delivery of traps to householders along with a guideline sheet and list of volunteers who are able to collect and dispatch the grey squirrel once caught. At present, members of the public wishing to participate in the scheme are put in touch with the local volunteer through Lancashire Wildlife Trust, but the aim is for this scheme to be fully volunteer led in the future. Landscape scale grey squirrel control can only be achieved through tackling both urban and rural woodland populations at the same time.

Lancashire Wildlife Trust co-ordinate a standardised bi-annual monitoring programme undertaken every March and October. Volunteers undertake walks along 30 visual transects (27 within the stronghold and three at Knowsley and Rufford). There are an additional four sites monitored with trail cameras (figure 2) and feeders. The bi-annual monitoring programme has been running since 2002 and provides long term data on changes in grey squirrel distribution. This is also supported by additional surveys undertaken by volunteers year round at sites not covered by the monitoring programme. This helps to inform the grey control strategy.

Figure 2: Monitoring often used wildlife cameras
© Lancashire Wildlife Trust

There are over 40 different landowners within the stronghold as well as tenants who own the shooting rights in some woodlands. Over the last decade, Lancashire Wildlife Trust have built good relationships with the majority of these. With the exception of two, all landowners grant access to project staff and volunteers. One owner will not grant access at all and the other will grant access for surveys but not for grey squirrel control.

Although landowners and tenants grant access to land for grey squirrel control there are very few who take responsibility for any grey squirrel control themselves. Some gamekeepers do undertake grey squirrel control, but this is limited due to other responsibilities. For grey squirrel control to be sustainable we need

landowners to contribute resources to grey control, whether this is financial or 'in kind' e.g. man hours.

The Community Engagement Officer promotes the project and encourages people to report sightings and/or volunteer through events (figure 3) and training workshops. The Community Engagement Officer also works with local primary and secondary schools where possible. This can vary from a talk to a specific interest group to a workshop for a whole class. The Community Engagement Officer has previously worked in partnership with Sefton Council to run workshops on red squirrel conservation for primary schools within the area.

Figure 3: The project organised regular community outreach events
© Chris Vere

Detecting and managing spread

Project scope	
Main ways of IAS spread	This is a very adaptable species which can disperse through different landscapes and habitats including towns and farmland
Method of detection used	Visual transects, hair tubes, trail cameras, public sightings, trapping in woodlands, shooting at feeders
Detection methods considered but not used (and why)	Forward Looking Infra-Red Cameras (FLIR) – expensive for the amount of use. Main method of control is live capture trapping or shooting from feeders. Free shooting is only supplementary and very limited
Methods of removal/control used	Trapping in woodlands and gardens. Shooting from feeders and some free shooting
Removal methods considered but not used (and why)	Kill traps not appropriate for use in red squirrel areas
Legislation in place to ensure high welfare standards	Captured grey squirrels are protected under the Animal Welfare Act 2006 which safeguards welfare during confinement The Wild Mammals (Protection) Act 1996 Wildlife and Countryside Act 1981

Major difficulties faced

- A minimum level of continuous funding is required to allow ongoing and effective grey squirrel control
- To carry out grey squirrel control in urban areas co-operation is needed from a large proportion of the community as well as resources to dispatch trapped grey squirrels. It remains unclear as to whether use of the Kania 2000 trap could encourage more volunteers to carry out grey squirrel dispatch
- Landowners are reluctant to take responsibility for grey squirrel control. Those that do undertake grey squirrel control often do not have the resources to maintain it at the required intensity

Major lessons learned

- Environmental factors can impact on success and allocation of resources, e.g. good tree seed crops leading to increase in grey squirrels; the management of disease outbreak in red squirrels taking up resources
- The effort needed to get 'buy-in' from local community can vary greatly. In circumstances where there is a handful of dedicated and motivated people a project can gain momentum and be successful
- A combination of paid staff and volunteer effort for grey control is essential. Volunteers are reluctant to undertake trapping of grey squirrels in woodlands. This could be due to the geography of this area. Paid staff are needed to undertake this aspect of the project
- Scientific research can greatly assist on the ground conservation efforts by providing additional data and a different perspective, whether it is an undergraduate dissertation or a PhD research project. It also motivates staff and volunteers by providing feedback and measurable outcomes on the effort they put in

Success indicators of project

- Reduction in grey squirrel abundance
- Increase in red squirrel distribution
- Public attendance at events and training workshops on grey squirrel control

Success of project

		Confidence
Highly Successful		
Successful		
Partially Successful	✘	high
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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 participation in trap loan scheme has varied greatly between areas
- Difficult to get volunteers who are prepared to carry out grey squirrel dispatch for the trap loan scheme
- Increase in grey squirrel numbers has meant more resources were needed to achieve targeted levels of population reduction
- Increase in number of dead red squirrels and confirmed cases of squirrelpox disease has taken away resources from proactive grey squirrel control and community engagement

Future project development

In the final year of the project we are hoping to employ at least one contractor for approximately six months to assist the Red Squirrel Ranger with grey squirrel control.

References

- Lurz P, Gurnell J & Rushton S (2007) *Assessing the risk of encroachment of grey squirrels into red squirrel forest reserves.* Report prepared for Forestry Commission England
- Chantrey J, Dale T, Read JM. et al. (2014) European red squirrel population dynamics driven by squirrelpox at a gray squirrel invasion interface. *Ecology and Evolution 4*: 3788-3799

Grey squirrel detection and early warning system in Northern England

Invasive species common name (Latin name)
Grey squirrel (*Sciurus carolinensis*)

Native geography
Eastern United States (USA) / Canada

Project name
Red Squirrels Northern England (RSNE)
Red Squirrels United
(LIFE14 NAT/UK/000467)

Project location or geographical area of conservation work
The project is involved with efforts to conserve red squirrels before in the seven counties across northern England where wild-living red squirrels (*Sciurus vulgaris*) occur. This case study looks at squirrel management in and around Kielder Forest red squirrel reserve, which spans the counties of Cumbria and Northumberland, and lies adjacent to contiguous forest north of the border in south Scotland

Lead organisation
Northumberland Wildlife Trust (NWT)

Key partners
- Forestry Commission England
- Natural England
- Cumbria Wildlife Trust
- The Wildlife Trust of Lancashire, Manchester and North Merseyside (Lancashire Wildlife Trust)
- Red Squirrel Survival Trust
- Northern Red Squirrels
- The Wildlife Trusts

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Map of project land area and brief description

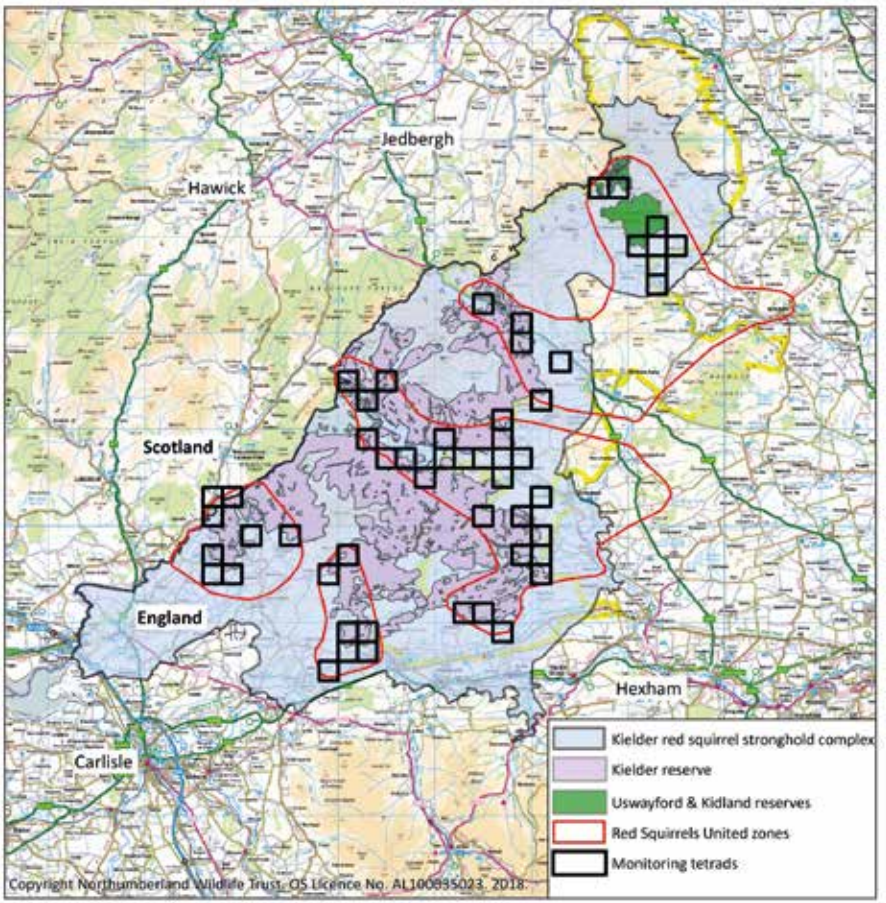

Figure 1: Kielder, Kidland and Uswayford Forests in Northern England, collectively known as the Kielder red squirrel stronghold complex. The map also shows the surrounding buffer zone to this complex of reserves, four distinct zones identified for priority work under the Red Squirrels United programme, and 52 tetrads where early warning system monitoring occurs.

Introduction and project background

The North American eastern grey squirrel is now well established and widespread across much of the UK and some areas of northern Italy following a number of deliberate introductions since the 1870s. A study in 2010 commissioned by Defra estimated that grey squirrels cost the British economy £14m per year, principally through damage to timber crops caused by bark stripping of trees. Grey squirrel range expansion is also linked to the decline of native red squirrels through a combination of competitive pressure and the spread of infection such as squirrelpox virus (SQPV).

In the north of England, grey squirrels began to colonise counties containing red squirrels in the late 1980s and early 1990s. As a reaction to the threat posed to native red squirrels, the Wildlife Trusts in Northumberland and Cumbria established conservation programmes (e.g. Red Alert) whilst community groups began to form to protect their local red squirrel populations.

Despite growing control efforts, grey squirrels continued to expand their range. This triggered a Government policy change in 2005 aimed at targeting resources in and around 17 large coniferous forests, habitats where grey squirrels do not have such a competitive edge over red squirrels when compared with deciduous forest. The largest of these reserves, Kielder Forest, spans the counties of Cumbria and Northumberland, providing a habitat for up to 50% of the English red squirrel population. This managed coniferous plantation forms part of a network of three reserves along with Kidland and Uswayford in Northumberland; collectively referred to as the 'Kielder stronghold complex'. The importance of these woodlands for reds squirrels has been underlined by the historic absence of invasive grey squirrels from all three woodland landscapes.

Key project goals

- Establish an early warning system in 52 sites around the fringes of the three 'grey squirrel-free' woodlands of Kielder, Kidland and Uswayford to provide ongoing monitoring of red squirrel and detection of grey squirrel incursion
- Ensure proactive grey squirrel control is undertaken along key dispersal/ invasion pathways leading into the Kielder stronghold complex woodlands
- Increase volunteer participation in this project so the work can be maintained at community level
- Systematically record all data collected within the early warning system

monitoring and associated grey squirrel management to inform subsequent data modelling

Description of the project activity

The RSNE project, managed by Northumberland Wildlife Trust, has been undertaking squirrel range monitoring and grey squirrel management around Kielder, Uswayford and Kidland forests since 2012. This approach was underpinned by guidance from Lurz et al. (2007) who provided a landscape assessment identifying the most likely incursion routes for grey squirrels to move into red squirrel reserves.

Project effort to protect Kielder, Kidland and Uswayford, in partnership with the Forestry Commission who own over 90% of these three reserves, has been bolstered by community groups, providing grass-roots participation in four nearby areas: The Irthing Gorge, the North Tyne, and in Coquetdale and north Cumbria.

In 2015, it was decided that the Kielder stronghold complex forests would be the focus of effort for the Red Squirrels United (RSU) project, as they were amongst the only remaining grey squirrel-free forest in England and therefore presented an opportunity to explore new methods of invasive alien species (IAS) colonisation prevention. Work managed by RSU project partner, NWT, would focus on establishing an ‘early warning system’ to detect grey squirrels as they arrived around the fringes of the reserves. Rangers would then respond, working in partnership with local community groups, to maintain the reserves’ status as ‘grey free’.

Parts of Kielder, Kidland and Uswayford forests are extremely remote, with low human population densities. Although historically there had been some local interest and community participation in red squirrel conservation in these areas, this was minimal in context of the scale of the forests. It was hoped that the establishment of a regular monitoring programme would incentivise local people to get involved and provide critical intelligence that would inform management decisions: for example, helping to identify grey squirrel arrival, influencing decisions on spatial deployment of rangers.

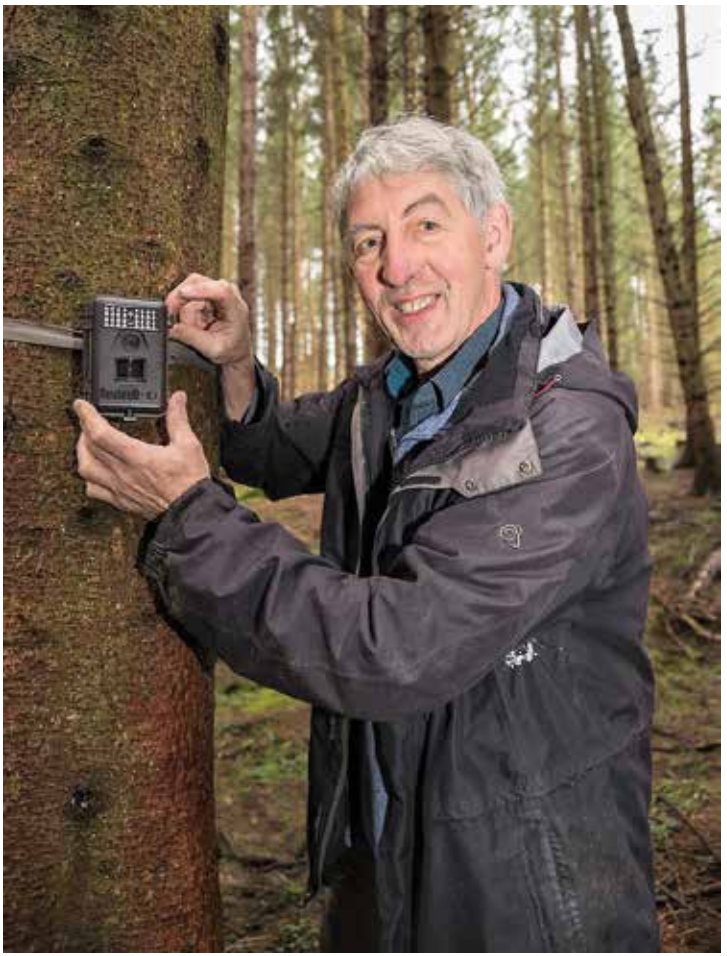

Figure 2: John Hartshorne a volunteer setting up a camera trap as part of the monitoring of the Kielder stronghold complex
© Steve & Ann Toon

NWT oversees the annual squirrel range monitoring programme in 300 sites across red squirrel range in northern England. The primary method used is trail camera surveillance (figure 2), with cameras set up to detect squirrel visits to baited feeders over a 15 day period. Hair samples are also taken as a back-up method; these are obtained from sticky pads placed on the underside of feeder lids. The feeder is baited, and the camera is set to record whenever activated by movement at intervals of 30 seconds.

Thirty sites are surveyed annually around the three forests using these methods annually. A further 22 sites were also identified during the development phase for the project, making a total of 52 sites that would form the early warning system.

Site selection was made using a number of criteria, including suitability of habitat to increase the likelihood of detection of squirrels: Areas of mixed or broadleaved woodland, or mature stands of conifer were selected in preference, based on field knowledge gathered over the previous five years, and also using Forestry Commission data on felling coupes. This helped eliminate areas of younger forest, pure Sitka spruce (*Picea sitchensis*) stands, or areas identified for felling in the next five years. Also critical to site selection was the ease of access.

For frequency of monitoring, it was decided that quarterly would be a good temporal scale, striking a realistic balance between practical achievability with the resources available, and gathering enough intelligence to prevent IAS establishment. All 52 surveys would be completed within a window of one month in January, April, July and September.

Volunteers were recruited to help deliver the early warning system, making use of existing volunteers from the three local squirrel conservation groups. Other volunteers were engaged through existing projects, for example the Ratty project, a water vole conservation project managed by NWT, where a team of volunteers were already in place to check mink rafts around Kielder. These volunteers attended training sessions to upskill them in use of trail cameras. Initially a high number of surveys were carried out by staff, but with a view to engaging and training up new volunteers as the project progressed.

Management of grey squirrels in the surrounding landscape, within the four identified zones was carried out by full time red squirrel rangers, employed through the project to proactively trap or shoot on private land. Much of the intelligence used to direct this work stemmed from historical control work carried out by the RSNE project, which in turn was informed by earlier modelling work. Further proactive grey squirrel management was delivered by the local community red squirrel groups.

Detecting and managing spread

Project scope	
Main ways of IAS spread	Woodland corridors, principally using prime habitat (broadleaved or mixed woodland as preference)
Method of detection used	Trail camera monitoring at baited feeding stations plus hair sampling at 52 sites around main forest fringes, sited in prime squirrel habitat
Detection methods considered but not used (and why)	
Methods of removal/control used	Trapping (live capture cage traps) or shooting (air rifle use at feeders, or shotgun method supplemented by thermal imaging cameras) (shooting in Non-FC woodlands only)
Removal methods considered but not used (and why)	
Legislation in place to ensure high welfare standards	Animal Welfare Act 2006 The Wild Mammals (Protection) Act 1996 Wildlife & Countryside Act 1981

Major difficulties faced

- Community involvement: although there are several active community groups and volunteers, this is not proportionate to the scale of the three forests (>40,000 hectares). Providing incentives to established groups (grants, trap loans etc) is helping to improve their capacity, as is using a collaborative approach to funding new volunteers and running local talks in conjunction with local volunteers
- The community groups are primarily active in the surrounding landscape around the fringes of the forests and volunteers are often unwilling to divert their own resources to protecting red squirrels on Forestry Commission estate. Although they recognise the significance of forests for red squirrels, there is a reluctance to provide support to conservation in Forestry Commission owned forests. This is partly a resourcing issue (economy of scale) and partly a feeling that there should be more red squirrel conservation effort applied by the landowner
- The trapping only policy (on Forestry Commission estate) remains a bone of contention because many volunteers prefer to shoot grey squirrels or do not have the resources to undertake live capture trapping. We have found

that providing joint training days in conjunction with Forestry Commission is positive and can motivate volunteers (figure 3). However, the no-shooting policy is unlikely to change in the near future

Figure 3: Joint Red Squirrels United and Forestry Commission England grey squirrel control trap training event © Heinz Traut

- The early warning system monitoring has proved extremely successful in detecting grey squirrels in a high percentage of sites within each monitoring round; so much so that providing a ‘rapid response’ has proved impossible, with little resources, over such a large area. Although we have increased the number of volunteers participating in the delivery of the early warning system monitoring to over 90%, few of these volunteers are able or willing to respond to grey squirrel detection. The key is to establish which volunteers are willing to carry out grey squirrel control if needed, and to provide training in this as well as in monitoring techniques

Major lessons learned

- The project would have benefitted from more local engagement work in the early stages, both at development and during the first months of fieldwork. It is integral that local communities feel that their opinions are valued, and that their needs are recognised and form part of local strategy. Although human population densities are extremely low around the Kielder complex, there are still a number of dedicated local volunteers whose enthusiasm could have been better harnessed from the beginning. This might have led to greater levels of community participation and belief in the direction in which the project was travelling
- Converting early warning into a rapid response proved challenging. The project was perhaps not well prepared enough to deal with multiple grey squirrel occurrences during monitoring. The early warning system has been extremely effective in detecting grey squirrels, but not all of those actively involved in survey delivery were prepared or adequately trained to provide rapid response grey squirrel control. Wherever possible, volunteers should be geared up to deliver both monitoring and grey squirrel control. Expecting staff to respond to grey squirrel detection on camera when they are covering vast areas of wooded landscape (and may at any given time be proactively involved elsewhere) is not practical or efficient. In an ideal world, rangers and local project volunteers should work collaboratively to provide this rapid response, although as this project has proved, this is not always possible due to landscape, scale and human population density

Success indicators of project

- Early warning system will identify squirrel occupancy at 52 sites surrounding the fringes of Kielder, Uswayford and Kidland forests every three months
- Establish community vigilance in all current gaps in control pathways leading into the three grey-free woodlands
- Increase community participation in the early warning system monitoring from 37% to 75%

Success of project

Measure		Confidence
Highly Successful		
Successful		
Partially Successful	✘	high
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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: early warning monitoring system delivered each quarter in approximately 50 sites, providing regular intelligence on IAS arrival
- Success: increase in community participation in early warning system from 37% (October 2016) to 96% (July 2019)
- Failure: in providing rapid response to grey squirrel detection across the project due to geographical scale and lack of manpower to provide response in areas of sparse human population
- Failure: with the lack of resourcing to provide rapid response, IAS (grey squirrel) remained present in multiple locations, around the fringes of ‘grey-free’ forests

Future project development

- Allocate time and resourcing to staff to provide rapid response: in reality this means ensuring Ranger time is blocked out for a four week period following each monitoring window, and that increased mileage to cover this work is budgeted for
- Two volunteers involved with early warning system monitoring are now trained in live capture trapping and dispatch techniques to ensure volunteer participation in rapid response to monitoring results
- Provision of financial incentives to local squirrel groups: this was not in place at the start of the project, but by providing ongoing support to volunteers we are providing greater motivation, encouraging them to collaborate more closely

References

- Lurz P, Gurnell J & Rushton S (2007) *Assessing the risk of encroachment of grey squirrels into red squirrel forest reserves*. Forestry Commission Report.
- Shuttleworth CM, Lurz PWW & Gurnell J (2016) *The grey squirrel: ecology & management of an invasive species in Europe*. pp532. ESI.

Quantified summary data

Date commencement: October 2016 to July 2019

Surveillance effort in time and space: Early warning system monitoring programme covered 52 sites four times annually = approximately 200 surveys per year. Total surveys 595 (@ eight hours per survey = 4,760 hours). The total number of volunteer delivered surveys was 416 (@ eight hours per survey = 3,328 hours). In kind cost: volunteer surveys (skilled labour) @ £150 per day: 416 days = £62,400 (figure four and five)

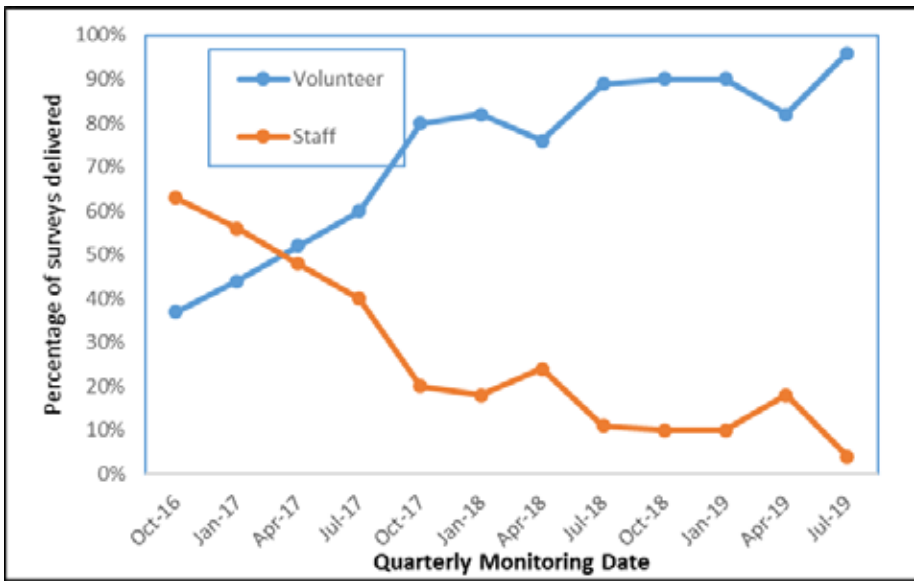

Figure 4 shows percentage of early warning system surveys delivered over a three year period by NWT staff and volunteers, showing the increase in community participation over time (37% to 96%)

Grey squirrel management: (project staff only, not volunteers)

Period	No. of staff	Total accumulative staff months	No. of contractors	Total accumulative contractor months	No. of live trap days	No of live shoot days	Total cost
2016	3	19	3	7	4013	142	£36,200
2017	3	25	1	2	5066	293	£44,050
2018	2	24	0	0	2141	474	£42,996
2019	3	14	0		2108	121	£22,930

*partial data: to August 2019 only

Figure 5: Total grey squirrels culled (shot and trapped): project staff only 2016: 374, 2017: 451, 2018: 311 & 2019: 368 (partial data to Aug 2019 only)

The Mid-Wales Red Squirrel Project

Invasive species common name (Latin name)
Grey squirrel (*Sciurus carolinensis*).

Native geography
Eastern United States (USA) / Canada

Project name
The Mid-Wales Red Squirrel Project (MWRS Project)
Red Squirrels United (HG-14-10510)

Project location or geographical area of conservation work

- The Mid-Wales Red Squirrel Focal Site (MWRSFS)
- The Tywi Forest and surrounding conifer plantation forests, covering areas of the three counties, Ceredigion, Carmarthenshire and Powys

Lead organisation

Wildlife Trust of South and West Wales (WTSWW)

Key partners

- WTSWW
- Natural Resources Wales (NRW)
- Carmarthenshire County Council
- Ceredigion County Council
- The Vincent Wildlife Trust
- The British Association for Shooting and Conservation (BASC)
- The National Trust
- Private Forestry Companies, including Selectfor, Tilhill, Pryor & Rickett Silviculture and Scottish Woodlands
- The Wildlife Trusts

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Map of project land area and brief description

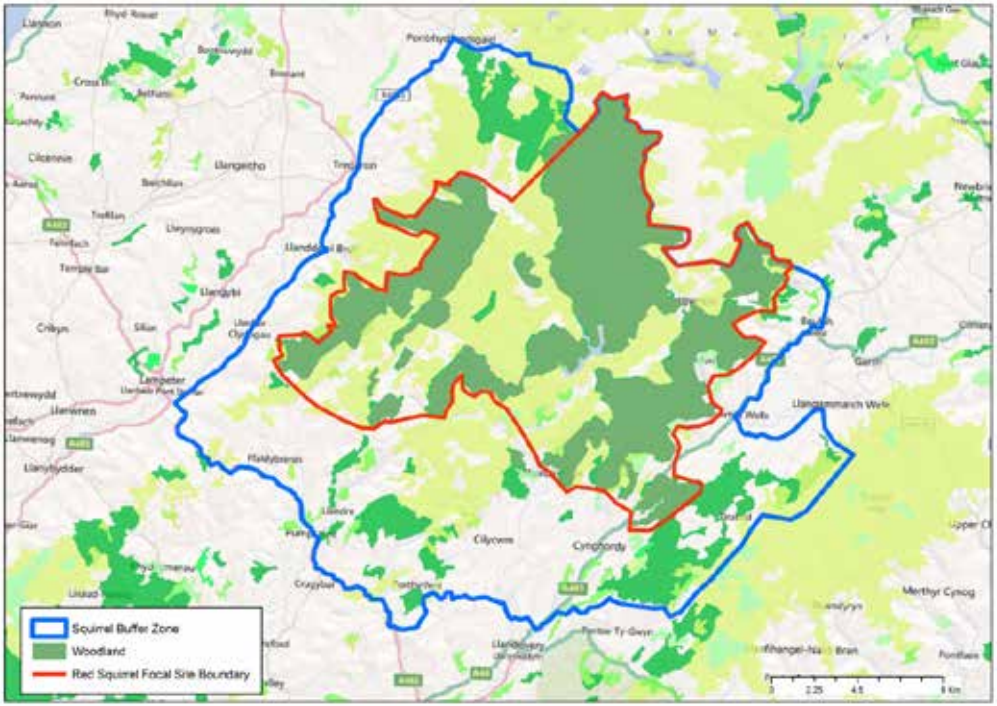

Figure 1: The Mid-Wales Red Squirrel Focal Site (MWRSFS)

The Mid-Wales Red Squirrel Focal Site includes the upper Tywi Catchment, including the Tywi Forest and surrounding plantation forests.

Introduction and project background

The first recorded sighting of a grey squirrel in mid-Wales was in 1958 in Rhandirmwyn. Grey squirrels have replaced red squirrel (*Sciurus vulgaris*) populations throughout much of the UK, however, in Mid-Wales, the population of red squirrels has survived at a low density. This is mainly due to the nature of the non-native forestry plantations in the focal site. The Sitka spruce (*Picea sitchensis*) dominated plantations provide poor squirrel habitat, but the larger grey squirrel finds it more challenging to find sufficient sustenance within the focal site than red squirrels. Therefore, the habitat within the focal site is particularly unattractive to grey squirrels, which works to keep the population at a low level.

The project is working with forest managers to improve the habitat for red squirrels whilst not attracting grey squirrels. Grey squirrel control is essential in the focal site buffer area to keep the population at a low density and to prevent colonisation of the core of the focal site. The project runs a live capture trap loan scheme for landowners within the focal site and buffer areas. The trap loan scheme is overseen by staff members and operated by volunteer co-ordinators who are trained in grey squirrel control techniques. Volunteers are given appropriate training, guidance, free equipment loan and bait provision either from their local volunteer co-ordinator, or from a staff member. In addition, BASC operate a live capture trap loan scheme in a wider area around the focal site and buffer areas.

Key project goals

- To keep the grey squirrel population in the buffer of the Focal Site at as low level as possible in order to prevent colonisation of the core of the Focal Site
- To keep the core of the focal site free of grey squirrels
- To work with forest managers to ensure that there is sufficient feeding habitat for red squirrels in the core of the focal site whilst not encouraging grey squirrels
- To maintain a close working relationship with the Vincent Wildlife Trust (VWT) as they work to restore a viable population of pine martens *(Martes martes)* in the focal site and buffer

Description of the project activity

The project is volunteer based and aims to expand and protect the unique population of red squirrels in mid-Wales by engaging with a variety of stakeholders, including forest managers and local people. Our main objectives are:

- To improve the habitat in the focal site for red squirrels
- To reduce the population of grey squirrels in the focal site and buffer
- To increase public awareness and understanding of the value and the needs of red squirrels in mid-Wales

Red squirrels have been able to persist in the forests of mid-Wales due to forest composition making the area relatively unsuitable for grey squirrels. In order to safeguard the red squirrel population in the focal site, a balance needs to be maintained between ensuring sufficient feeding habitat for red squirrels without encouraging grey squirrels. Patches of good feeding habitat (key areas) are needed within a wider matrix of lower quality habitat. Forest connectivity needs to be maintained between key areas throughout the felling cycles to enable movement of red squirrels between patches of feeding habitat.

The project is working with forest managers to improve the habitat within the focal site for red squirrels. In 2017, WTSWW coordinated the creation of a five-year Management Plan for the focal site on behalf of the project partnership. The Plan entitled '*Optimising Habitat Management for Red Squirrels*' is a collaboration with several private forestry companies and NRW. Whilst acknowledging that forest managers have other, sometimes conflicting, management objectives, the partnership works to ensure that recommendations are followed by as many forestry managers as possible and that the Tywi Forest has red squirrel conservation as one of its major objectives for future forest management.

Grey squirrel control is essential in the buffer area to keep the population at a low density and to prevent colonisation of the core of the focal site. The project runs a live capture trap loan scheme for landowners within the focal site and buffer area. The trap loan scheme was set up in 2014 to give local people free access to trapping equipment, bait, training and support for grey squirrel control. The scheme operates via a network of 'hubs' overseen by staff members and headed by volunteers, who co-ordinate trapping activity in their local areas. Local community networks of trappers present a sustainable model of grey squirrel control and complement the trapping carried out by contractors funded through Welsh Government (WG) grant schemes.

Figure 2: Local volunteer monitor feeding stations with camera traps to detect grey squirrel presence © MWRSP

Grey squirrel presence in the core of the focal site is also detected by volunteer-managed camera traps, installed as part of red squirrel surveys (figure two). When a grey squirrel is detected, to prevent the possibility of spread of disease if both species of squirrel use the same feeder, the volunteer removes the food source. If possible, this is followed by grey squirrel control using live trapping and cranial dispatch, carried out either by the volunteer or by the Grey Squirrel Control Officer. The site manager is informed of the presence of grey squirrels on their site and encouraged to implement a grey squirrel control regime.

An essential component of the project is public engagement. To increase awareness of red squirrel presence and conservation needs, the project has a presence at local agricultural shows and events. The project has also installed red squirrel information boards at key locations in the focal site; there is a project website and Facebook™ page and red squirrel information leaflets.

Outreach work with schools also helps to improve public awareness. School activities are a key method of engaging with local families in rural areas. Through woodland-based activities and games, children find out about the value of red squirrels and the need for conservation measures.

Once volunteers are involved in the project it is important to keep them engaged in project activity and to encourage them to do so by appreciating their efforts. Volunteer events are organised, such as ‘squirrel-chewed cone hunts’ (figure 3) and social gatherings where volunteers can network and exchange ideas about red squirrel conservation. These events are key in providing an overview of project activity for volunteers, making them aware of other’s efforts that compliment their own. The project also has a quarterly newsletter which helps to keep volunteers informed and maintains their interest.

Figure 3: Volunteers searching for evidence of squirrel feeding signs
© MWRSP volunteer

Detecting and managing spread

Project scope	
Main ways of IAS spread	Via broadleaved riparian corridors, particularly in the east and south-west of the focal site
Method of detection used	Buffer area: trap loan scheme member (volunteer) detection focal site core: appearance of grey squirrels on camera traps
Detection methods considered but not used (and why)	Trap alarms. Not reliable in the area due to poor range and quality of mobile phone networks
Methods of removal/control used	Live capture trapping and cranial dispatch
Removal methods considered but not used (and why)	Shooting. WTSWW does not have in-house experience or the necessary insurance cover for shooting activities
Legislation in place to ensure high welfare standards	Animal Welfare Act 2006 The Wild Mammals (Protection) Act 1996 Wildlife & Countryside Act 1981

Major difficulties faced

- **Lack of funding:** A full-time grey squirrel control ranger position is required to control grey squirrels in the focal site buffer and to combat grey squirrel incursion into the core area. The project only had five staff days a week in total. Additional funding is currently being sought
- **Lack of support from WG & NRW**: Despite the creation of a Grey Squirrel Control Action Plan, the WG has failed to commit adequate resources to the control of grey squirrels. Landowner grey squirrel control through Glastir schemes is often difficult to access and does not provide the landowner with adequate equipment, support or monitoring. The MWRSP regularly notifies NRW of grey squirrel presence in WG forests in the MWRSFS. However, NRW do not act on this information; grey squirrel control is only undertaken annually in one to three sites in the MWRSFS, historically with very poor results. MWRSP has actively encouraged both WG and NRW to undertake further grey squirrel control in the woodlands that they manage. In 2019 the project coordinated volunteer camera trapping efforts with the annual NRW grey squirrel control contract; resulting in much improved capture rates
- **Lack of volunteers who are willing to dispatch trapped grey squirrels:** Due to a low human population in the focal site and buffer, as well as the 'hands-on' nature of live capture trapping, cranial dispatch and the time commitment required, there is a limit to the number of landowners within the project area who are willing to participate in the trap loan scheme

Major lessons learned

- **Trap loan scheme member support:** To sustain maximum participation levels, trap loan scheme members need to be supported in their local area by well informed and enthusiastic staff and/or volunteers
- **Trap loan scheme member enthusiasm:** To retain members and to keep them enthused, trapping volunteers need to be reminded of how their efforts are contributing to wider red squirrel conservation. This becomes increasingly important as the local population of grey squirrels and the number of squirrels trapped declines. Trapper enthusiasm can be bolstered by one-to-one engagement, regular newsletters, talks, press releases in local papers etc

Success indicators of project

- Grey squirrel control in place across a significant area of the MWRSFS, with focus on the buffer zone in particular
- At least eight active volunteer groups and at least 50 volunteers actively controlling grey squirrels
- Long term trend of decline in numbers of grey squirrels caught (as a ratio to effort expended)

Success of project

Measure		Confidence
Highly Successful		
Successful	✘	Medium
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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

- There are currently over 100 trap loan scheme members actively engaged in the project
- A reliance on volunteers to undertake grey squirrel control can result in unpredictable levels of participation dependent on issues which are out of the control of the project such as volunteers moving away from the area, sickness or other commitments leading to lack of availability
- Due to the large scale of the project area, the inaccessibility of some of the large forestry plantations and the lack of staff resources, it is not always possible to trap and dispatch grey squirrels when they are detected

Future project development

- A focus on three forest sites in each of the three habitat networks in the project area. This will help to hone our knowledge of red squirrel population dynamics, habitat suitability as well as potential entry routes for grey squirrels

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Quantified summary data

Date commencement: Project began in May 2014, with the trap loan scheme commencing in October 2014

Surveillance effort in time and space: 115 active trap loan scheme members and six active volunteer co-ordinators. Trap loan scheme members are all trapping on land within or less than than a mile outside of the boundary of the focal site and buffer area

Resource e.g. number of camera traps, live capture traps: 360 live capture traps. 230 with trap loan scheme members and co-ordinators and 130 available for future trap loan scheme members and for large scale trapping exercises. 28 trail cameras are currently installed in the focal site as part of red squirrel surveys; camera traps also detect grey squirrels

Labour resource (Effort): Over the four years July 2015 to June 2019, volunteers have spent 6,172 hours undertaking grey squirrel control activities, an average of 1,543 hours a year

Detail of cumulative area over which these are applied: Trap loan scheme members are active within the focal site buffer area, with some members extending trapping activities into the focal site core and others active up to one mile outside the boundary of the buffer area. This area is approximately 250 square miles

Cost & Contingency funds available: £34,000

Pallas's squirrel eradication in the Netherlands

Invasive species common name (Latin name)
Pallas's squirrel / red-bellied squirrel (*Callosciurus erythraeus*)

Native geography
Southern China and mainland southeast Asia

Project name
Eradication of Pallas squirrel in Weert, the Netherlands

Project location or geographical area of conservation work
Municipality Weert, Province of Limburg, the Netherlands

Lead organisation
Dutch Mammal Society (Zoogdiervereniging)

Key partners

- The project was financed by the Dutch Food and Safety Authority (nVWA) and the province of Limburg, with practical help of the municipalities of Weert and Leudal
- Natuurmonumenten (An NGO, landowner, nature organization with many nature reserves in the area)
- Regional Hunting Groups

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Map of project land area and brief description

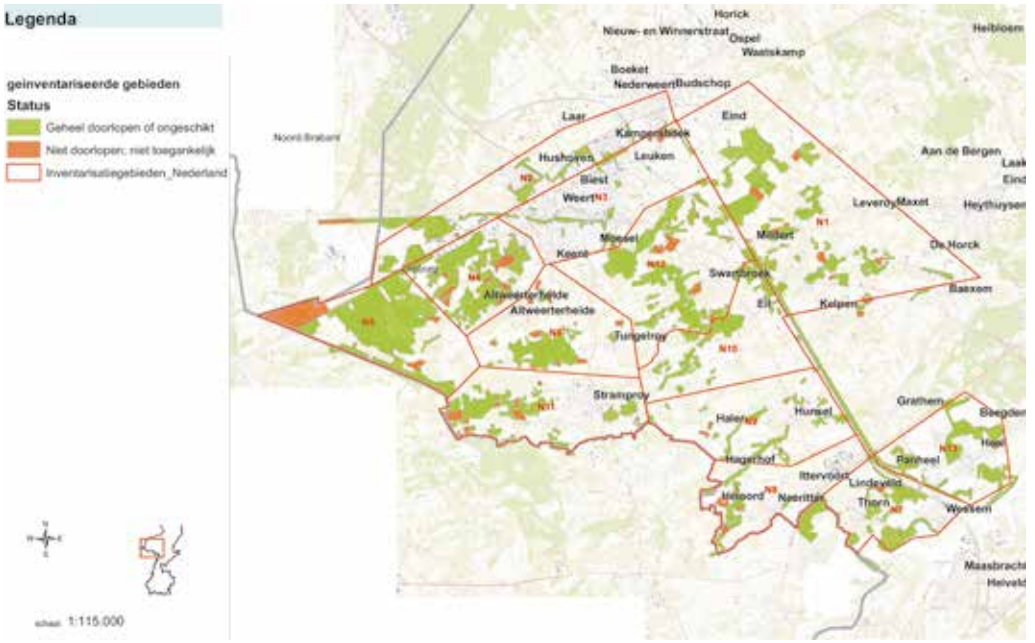

Figure 1: Overview of the eradication area around Weert

The area around Weert (figure 1) can be described as rural. It is a landscape dominated by agriculture, small streams and associated wetland habitats. Green indicates woods which were checked for signs (question marks) of Pallas's squirrels. Areas which had suitable habitat, but which were impossible to visit are indicated in red.

Introduction and project background

Pallas's squirrel (*Callosciurus erythraeus)* is a highly adaptive and opportunistic species with a very diverse diet (figure 2). New populations can establish after the escape of only a few individuals. Damage caused by this species is most frequently tree bark-stripping (figure 3), but citizens of the Municipality of Weert also recorded damage to houses and the exclusion of native red squirrels *(Sciurus vulgaris).*

Figure 2: Pallas's squirrel © Ard van Roij

Figure 3: Bark stripping damage caused by Pallas's squirrel © Vilmar Dijkstra

In 2008 the presence of the Pallas's squirrel was first detected near Weert. As the Pallas's squirrel is highly invasive, the province of Limburg and the Food and Safety Authority decided to start an eradication programme with a professional staff and paid field workers. Three years after discovery of this population, an eradication programme was started. The goal was complete removal of the existing population and to prevent a further spread of the population in the Netherlands and adjacent Belgium. All citizens in the area were informed and asked to report sightings of this exotic species. The help of citizens was crucial for the success of the eradication campaign as many squirrels were trapped in

private gardens. The promise that trapped squirrels would be sterilized and put in captivity instead of being killed was very important for support and collaboration of the local community.

This programme resulted in the complete removal of the population by 2015. After the eradication campaign stopped, area-wide surveillance was undertaken several times to detect presence of the species. No signs of Pallas's squirrels were found. The conclusion is that the species was successfully eradicated.

Key project goals

- Total removal of the local population
- Repeated post eradication surveillance to ensure that no residual population remained

Description of the project activity

The eradication campaign in Weert, the Netherlands, started with a public communication campaign. All inhabitants in the area received a flyer explaining the negative impact of Pallas's squirrel on native red squirrels and showing damage to houses and trees. Informing citizens in the area was essential, as an important part of the squirrel population was living in gardens and backyards. Some people were also actively feeding the squirrels.

The campaign was successful, and trapping went well without major problems, although some live capture traps were stolen, disabled or destroyed. In instances of local people refusing to allow traps in their garden, other nearby locations were selected to trap resident squirrels. Securing permission to enter and look for Pallas's squirrels in small pieces of woodland in the countryside was more difficult. In particular, hunters were not always co-operative when permission to enter their private property was requested. The last trapped squirrel (October 2015) was found just outside such a private piece of land, highlighting the importance of gaining access to all or at least as much private properties as possible. As this represents a prerequisite for success, for future eradication campaigns, legally enforced access to land by professional personnel would be beneficial.

Communication is crucial and it is also important to repeat and continue the same public message during a longer period. It turned out that, for many people, only part of the project message was remembered, in particular information on how

to distinguish a Pallas's squirrel from a dark coloured European red squirrel. Distributing leaflets on identification and reporting of Pallas's squirrel was an essential part of this eradication project. A communication strategy should be commonplace in eradications of non-native squirrel species because the general public may often like these animals and may need to be convinced these species can have detrimental effect on native squirrels in the future, even if such negative effects are not visible yet.

Figure 4: Pallas's squirrel in live capture trap © Rene Janssen

The live capture trapping effort was concentrated in the winter and spring months with a large number of traps deployed to increase the chance of trapping Pallas's squirrels (figure 4). In summer, traps were removed and only placed at the request of citizens or after reliable confirmation of squirrel presence was obtained. This intensive trapping campaign was continued during the winter months of 2011-2012 with over 300 live capture traps deployed. In the next winter of 2012-2013, the trapping scheme was repeated. All trapped individuals were brought to a specialised animal rehabilitation centre where squirrels were sterilised and afterwards housed in captive Zoological collections.

Detecting and managing spread

Project scope	
Main ways of IAS spread	Initially a few individuals had escaped from a local animal trader and in the years thereafter the species colonised the Weert region
Method of detection used	Mainly by looking for fresh signs of bark stripping, complemented with sightings reported by people living in the area
Detection methods considered but not used (and why)	Sound detection. In Japan sound detection is used in detecting Pallas's squirrels. A few tests were done, but in practice the value of this approach was not explored as most of the population was already trapped at that time
Methods of removal/control used	Live capture trapping with wire-mesh cages
Removal methods considered but not used (and why)	Shooting was not allowed and was considered too dangerous in the suburban public areas
Legislation in place to ensure high welfare standards	Animals Act 2019 (Wet Dieren). This prescribes that all trapped animals have to be treated according to certain welfare standards (good housing conditions, no suffering, etc.)

Major difficulties faced

- A major difficulty was in securing access to all private groves and small patches of woodland. We observed that hunters were especially reluctant to give permission to enter their properties, although most of them supported the eradication campaign
- Another problem was theft or damage of traps, which occasionally happened
- Detecting the last individuals was challenging, which is of course inevitable

Major lessons learned

- A communication strategy should be commonplace in eradications of exotic squirrels, because the general public highly appreciates (exotic) squirrel species and often has to be convinced these species can have detrimental effect on native squirrels in the future even if these negative effects are not visible yet

- Communication has to be repeated as long as the project is running and all notifications have to be answered. The memory of the community is short
- A large number of active traps are needed, as sometime only one or two out of 10 traps were effective in catching squirrels. It is however impossible to predict which trap will be effective
- Include as many stakeholders as possible, including stakeholders with an opposite point of view

Success indicators of project

- The indicator of success of the eradication programme was that no Pallas's squirrels could be detected in the area anymore *(figure 5)*. There would be no sightings and no fresh signs of bark stripping damage

Figure 5: October 2015 and the last Pallas's squirrel trapped in Weert
© Rene Janssen

Success of project

Measure		Confidence
Highly Successful	✘	High
Successful		
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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 achieved all the measures required to demonstrate successful eradication of the population

References

- Adriaens, T, Baert, K, Breyne et al. (2015) Successful eradication of a suburban Pallas's squirrel Callosciurus erythraeus (Pallas 1779) (Rodentia, Sciuridae) population in Flanders (northern Belgium). *Biological invasions* 17: 2517-2526. https://doi.org/10.1007/s10530-015-0898-z
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Quantified summary data

Date commencement: The project started in 2008 and officially ended in 2014
Surveillance effort in time and space: In 2009 a first inventory was made to detect presence of the species in the area. Trapping started in October 2011 and lasted until November 2013, with a last isolated trapping session in October 2015
Resources used: More the 300 live capture traps were used during peak months, with trapping effort concentrated in December till May (winter and spring).
Labour resource: The total costs summed up to ca. EUR 330,000
Detail of cumulative area over which these are applied: In total the area was ca. 50km2
Cost & Contingency funds available: Not necessary, as the population has been removed. If necessary, a new campaign can be started

Pallas's squirrel eradication in Belgium

Invasive species common name (Latin name)
Pallas's squirrel / red-bellied squirrel (*Callosciurus erythraeus*)

Native geography
Southern China and mainland Southeast Asia

Project name
Eradication of Pallas's squirrel from Dadizele, West Flanders (Belgium)

Project location or geographical area of conservation work
Province of West Flanders, municipality of Dadizele (Moorslede), Belgium

Lead organisation
Research Institute for Nature and Forest (INBO)

Key partners

- Agency for Nature and Forest (ANB)
- Municipality of Moorslede
- Site owner Mariënstede vzw
- Part of this work was performed and co-funded within the framework of the EU co-funded Interreg 2Seas project RINSE (Reducing the Impact of Non-Native Species in Europe) (www.rinse-europe.eu) (2012–2014), which sought to improve awareness of the threats posed by invasive species, and the methods to address them

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Map of project land area and brief description

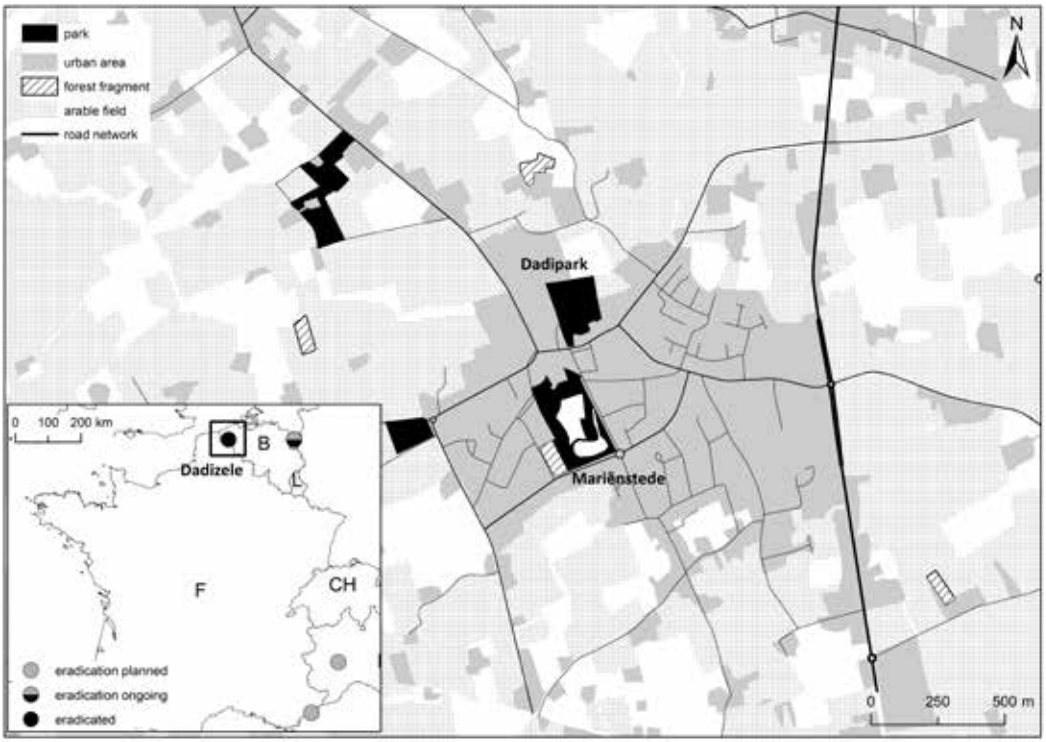

Figure 1: Pallas's squirrel eradication project area

Pallas's squirrel was successfully eradicated from Dadizele and currently the species is no longer established in the wild in Belgium.

Introduction and project background

Pallas's squirrel is a species of tree squirrel native to Asia. Like the North American eastern grey squirrel (*Sciurus carolinensis*), Pallas's squirrel can reach very high densities and outcompete native red squirrels (*Sciurus vulgaris*). The species is a known carrier of several macroparasites but their impact on native species is unknown. Tree bark stripping by this species can be severe and it causes damage in forests, parks and tree plantations. It is also notorious for gnawing cables and electrical wiring.

This invasive alien species (IAS) is established in Japan, Argentina, France and Italy, where most populations are under active control. It was historically established in Flanders and the Netherlands but was successfully eradicated.

The aim of the Dadizele project was to eradicate an established, but isolated population that probably originated from escaped individuals from an abandoned funfair park or a nearby pet shop. Outside the Park, the squirrels had very little habitat available to them, as the landscape matrix consists of arable land with very few trees. The work involved the removal of several animals present in the area using live capture trapping and wildlife cameras for surveillance. The project was run using existing capacity and resources.

The successful eradication of the Dadizele population meant that Pallas's squirrel (figure two) is currently no longer established in the wild in Belgium. Animals historically on the Belgian side in the border region with the Netherlands (Limburg), were also eradicated during the Weert eradication campaign described elsewhere in this volume.

Key project goals

- To prevent further damage to the park
- To prevent animals from colonising a larger area and to prevent any future associated damage costs
- Rapid eradication was considered the best option to achieve these goals

Description of the project activity

In 2005, bark stripping and cable gnawing were observed in a suburban park in west Flanders (northern Belgium). The damage was linked to the occurrence of Pallas's squirrels. The population most probably originated either from animals which escaped from an abandoned zoo in the nearby amusement park and/or from a nearby pet shop. To avoid further damage to ornamental trees in the park, the park manager decided to start trapping the squirrels.

Figure 2: Pallas's squirrel *(Callosciurus erythraeus)* © Andrew Hardacre Flickr 051217

Simple wire mesh live capture traps were placed near the trunks of large trees and baited with peanuts, walnuts or hazelnuts. Traps were checked daily in order to minimise the period of confinement for both target and non-target (bycatch) species. A total of 46 squirrels were caught and removed from the site during the first three months. This was an unexpectedly high number and with continued trapping the number increased from 100 in 2006 to 130 individuals by spring 2007. It was soon acknowledged that the problem had been underestimated and further action was no longer affordable for the local manager alone. Thus, regional authorities became involved. Considering potential damage, exotic status and invasive behaviour, authorities quickly agreed on action. Prior to the actions, political support was sought through a written statement of the High Council for Nature Conservation, an advisory body to the Minister of the Environment. A local contact point was set up at the municipality for communication to citizens.

By the end of spring 2008, an additional 78 were caught. After a period of 18 months without further sightings, squirrels were again reported in the park. Digital wildlife cameras were installed to detect any remaining squirrels. In successive years, the number of animals removed increased to 248 in total, and by 2011,

the last known animal was removed. Although the control started relatively quickly and the extent of the invasion was limited, the campaign still took over five years and required an investment of over €200,000 including 18 months of post-eradication surveying.

Detecting and managing spread

Project scope	
Main ways of IAS spread	Some Pallas's squirrel roadkill was reported 5km from the park, but presumably the limited natural spread recorded was because of the insular landscape context
Method of detection used	Visual searches for animals and nests Wildlife cameras including Reconyx models Bait points and baited nest boxes Liaison and interviews with local stakeholders
Detection methods considered but not used (and why)	
Methods of removal/control used	Live capture trapping with pre-baiting using simple mesh wire traps
Removal methods considered but not used (and why)	Shooting was not considered an option in the park, which was heavily used for recreation by villagers, also, this method would meet legal and practical restrictions.
Legislation in place to ensure high welfare standards	Law of 14 August 1986 on the protection and welfare of animals.

Major difficulties faced

- Initial misidentification of Pallas's squirrels as Chinese rock squirrel (*Sciurotamias davidianus*) slowed down the response
- Acquiring political support
- Lack of co-ordination, unclear mandates of different actors
- Committing sufficient human resources for trapping and keeping a constant trapping effort
- Initial lack of experience

Major lessons learned

- Eradication requires sufficient resources and ongoing monitoring
- Eradication required repeated intensive live capture trapping campaigns with intermittent periods of apparent zero-occurrence of squirrels
- A scientific approach to follow-up progress of the actions is important

Success indicators of project

- The indicator of success of the eradication programme was that no squirrels could be detected in the area anymore. There would be no sightings and no fresh signs of damage

Success of project

Measure		Confidence
Highly Successful		
Successful	X	High
Partially Successful		
Failure		

High confidence means that the assessor feels they have approximately 80% chance of the given score 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 achieved all the measures required to demonstrate successful eradication of the population e.g. no prospects of recolonisation after eradication
- Response was timely as squirrel densities were low at the onset of the project (about 3 animals per hectare)
- Actions were supported by both the site manager and the local authority who communicated about them to the local community

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- Adriaens T, Baert K, Breyne P et al. (2015) Successful eradication of a suburban Pallas's squirrel *Callosciurus erythraeus* (Pallas 1779) (Rodentia, Sciuridae) population in Flanders (northern Belgium). *Biological Invasions* 17: 2517-2526
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Quantified summary data

Date commencement: The project started in 2005 and ended in 2011.

Surveillance effort in time and space: Continuous surveillance effort with traps placed when squirrels were detected and an additional 18 months of post-eradication surveying

Resources used: The trapping scheme consisted of five trapping periods with a varied number of traps deploying a minimum of 19 and a maximum of 44 (i.e. 4–9 traps per hectare). In total two, three trapper years (number of man-years of full-time trapper effort), efforts were concentrated in winter and spring. Materials and transport costs amounted to ca €50,000

Labour resource: The total costs summed up to ca. EUR 160,000

Detail of cumulative area over which these are applied: In total the area was ca. 2.7km2

Cost & Contingency funds available: Not necessary, as the population has been removed. If necessary, a new campaign can be started

A practical guide to early surveillance and monitoring

Nikki Robinson, David Everest, Paul Harry, Craig Shuttleworth

Introduction

Understanding the distribution of a species in a landscape through time is an important part of effective wildlife management (Tosh 2016). This means that some type of population survey is needed. Wildlife monitoring is done not only to assess the distribution of common species or the conservation status of endangered species (Buckley & Beebee, 2004), but is also used to monitor pest species (Edwards et al. 2004).

As part of its early warning surveillance, Red Squirrels United (RSU) deployed a range of approaches and monitoring techniques across all its project areas in northern England, Wales and Northern Ireland.

These included:

- Visual transects
- Hair tubes
- Motion sensing cameras
- Garden feeder networks
- Public sightings

Any of these methods can be deployed during surveillance and together provide a suite of approaches to choose from. Motion sensing cameras were widely used across RSU project areas and we have focused on this method in this practical guide.

Use of motion-sensing cameras

The introduction of motion-sensing cameras (camera traps) in the 1990s has led to their widespread use in monitoring the distribution (e.g. Pettorelli et al. 2010) and abundance (e.g. Manzo et al. 2012) of mammal populations. As product availability has increased and prices decreased, motion-sensing cameras have become an increasingly popular and cost-effective way to monitor red and grey

squirrel distributions (Tosh 2016). Cameras were heavily utilised to assess red (*Sciurus vulgaris*) and grey (*Sciurus carolinensis*) squirrel distributions in all RSU project areas.

Image data recorded by camera traps provides information which can be used to inform local grey squirrel control strategies, highlight potential health issues in red squirrel populations such as squirrelpox virus (SQPV) or opportunistically reveal the presence of other rare species which may be present in the area such as pine marten (*Martes martes*). Camera monitoring can also be useful in more remote areas which have a low human population and is seen to be less resource intensive as one person can monitor multiple cameras.

Differentiating between red and grey squirrels

It is crucial that the public can differentiate between red (figure 1) and grey squirrels (figure 2), particularly in or near areas inhabited by both species. On the face of it, identifying the differences between a red squirrel and a grey squirrel should be relatively straightforward. Grey squirrels are larger (500-550g) than red squirrels (290-330g) and red squirrels have ear tufts (two-four centimetres long) which grey squirrels do not.

Figure 1. A red squirrel (*Sciurous vulgaris*) with ear tufts © Paul Harry

Figure 2: A grey squirrel (*Sciurous carolinensis*) displaying the classic ‘halo’ around the tail © Paul Harry

However, it isn’t always that straightforward. Size alone isn’t always a reliable indicator particularly as sub-adult grey squirrels can be a similar size to adult red squirrels. Also, if viewing a species in isolation, size is often quite difficult to gauge. Typically, in publications, the selected images of red and grey squirrels used to illustrate the two species will show very ‘red’, red squirrels with large ear tufts and very ‘grey’ grey squirrels. However, there can be considerable variation in coat colour within both species, with very ‘red’ grey squirrels (figure three) and very ‘grey’ red squirrels (figure four) sometimes present, particularly during the autumn and winter months when both species can have a mixture of red and grey hair. When ear tufts are present, these are certainly one useful feature for identification during autumn and winter months. It is important to note though that following the spring coat moult, red squirrels may lack ear tufts.

Figure 3: This is a grey squirrel with very ‘red’ colouring. The giveaway is the ‘halo’ around the tail which red squirrels never have but it could easily be mistaken for a red squirrel © Sheila Ivison

Figure 4: A red squirrel with ‘grey’ coat coloration. This squirrel has ear tufts but on a wet day when they are less obvious could be confused for a grey squirrel © Pixabay

Grey squirrels will nearly always have a 'halo' or fringe of silvery fur running around the outside of their tail which red squirrels never have. Albino or melanistic (black) squirrels do not display the halo but are not typically found in areas where grey squirrels are sympatric with, or next to red squirrel populations. Therefore, the 'halo' is a very useful characteristic to look for when identifying the species.

Monitoring for health

As well as detecting grey squirrel incursions, camera monitoring can also be used to provide a general visual indicator of the health of resident red squirrel populations.

In the UK and Ireland, squirrelpox disease is carried by grey squirrels who act as an immune reservoir for SQPV and thus harbour it as a sub-clinical infection, whilst showing no outward clinical signs of infection. However, when transmitted to red squirrels, squirrelpox produces pathogenic disease, which is invariably fatal, with death occurring one to two weeks after infection with the virus. The transmission pathways for squirrelpox from grey squirrels to red squirrels or from red squirrels to red squirrels are not yet fully understood. However, research has shown that red squirrel populations in close proximity to grey squirrels carrying SQPV can decline up to 25 times faster than red squirrels in close proximity to grey squirrels who are not infected (Rushton et al. 2006). It is expected, therefore, that as the grey squirrel continues to expand its range, contact rates between the two species will rise, increasing the likelihood of squirrelpox spreading to remaining red squirrel populations (Collins et al. 2014).

Red squirrels with squirrelpox display facial lesions and scabs (figure 5) predominantly around the eyes and mouth although these can also appear on other parts of the body, including the paws. However, there are several other diseases that can present similar visual signs to squirrelpox such as Dermatophilosis and Fatal Exudative Dermatitis (FED). These can also cause mortality among red squirrels but are far less common that squirrelpox - only two cases of Dermatophilosis (*Dermatophilus congolensis*) have been recorded in squirrels (Holmes et al. 2019) and the disease to date does not appear to have spread to the remaining red squirrel population.

Figure 5: Squirrelpox virus displaying classic facial lesions © APHA

The visual signs for FED typically include scabs around or over the nose, on the lips and digits, alopecia and lesions in the coat (figure 6). Laboratory tests show that numerous colonies of bacteria can also sometimes be present, especially in the exudate – the fluid that oozes out from scabs and lesions. These colonies of typically staphylococcus bacteria, particularly a type called *Staphylococcus aureus,* may be considered the principle cause of death in such cases but may also be contributory factors to other causes of death (Simpson et al. 2010). *Staphylococcus aureus* can be transmitted from people to squirrels so maintaining biosecurity and wearing gloves is essential to prevent the spread of infection.

Figure 6: Fatal Exudative Dermatitis © APHA

Dermatophilosis has gross visual similarities to squirrelpox with raised firm skin lesions over the face, nose and forehead which may be visible (figure 7). The eyelids can also be swollen and pale with some hair loss and necrotic (dead) tissue present.

Figure 7: Dermatophilosis © APHA

There are further diseases such as adenovirus, a gastro-intestinal virus carried sub-clinically (without causing obvious harm) by grey squirrels and although also carried sub-clinically, it may become fatal to red squirrels in some circumstances, such as animals which are stressed. It is usually spread by faeces, but presents with no external signs, beyond diarrhoea on occasions. This sign, however, may have several potential causes so it is not a definitive indicator of the infection. This disease is an emerging threat to red squirrel populations (Everest et al. 2014).

What all these diseases have in common is that they can only be determined with confidence by laboratory testing. It is therefore important that any carcasses recovered from the environment are submitted for analysis and confirmation of the cause of mortality. Differentiating between the causes of skin lesions in red squirrels is important from a conservation perspective as detection and confirmation of squirrelpox disease requires resource intensive management actions to control grey squirrels and increased biosecurity measures to mitigate the spread of infection among red squirrels.

Dead animals can be difficult to detect as they are often concealed in undergrowth and can be hard to spot even in a relatively open woodland. The role of dogs in

wildlife conservation management is becoming increasingly popular and through RSU, a detection dog has been used successfully in Lancashire to sniff out dead red squirrels (figure 8). Depending on the terrain, dogs can search an area up to the size of a football pitch in less than an hour (figure 9) and possess more than 220 million olfactory receptors in their nose (Correa 2011). Humans only have five million olfactory receptors meaning dogs can search an area far more quickly and efficiently than a person enabling carcasses to be removed quickly from the environment. This prevents diseases such as SQPV from continuing to shed viral particles which they can do for several weeks after death.

Figure 8: Detection dog Max indicating on red squirrel scent. Dogs possess more than 220 million olfactory receptors in their nose © Paul Harry

Figure 9: Dogs can search an area up to the size of a football pitch in under an hour © Holly Peek

Duration of camera monitoring

Camera monitoring can take place for several reasons such as monitoring for presence or absence of red and grey squirrels during annual/bi-annual surveys, assessing squirrel activity at feeders and as part of an early warning system to detect grey squirrel incursion. The selected duration of surveillance can vary depending on the monitoring purpose. For example, if the camera trap is part of an early warning system, cameras may remain in situ for a considerable length of time, sometimes permanently. If used for annual or bi-annual population survey monitoring, cameras may be in place for shorter periods of time, typically between two weeks and 30 days duration. Cameras should not be left unchecked beyond 30 days duration as batteries may expire, memory cards may be full or sightings of species which need responding to quickly (rapid response) may be missed.

Camera equipment

Camera traps in general use a Passive Infra-Red (PIR) sensor to detect movement. When movement is detected passing across the sensor, the camera will activate and either take a photograph(s) or a video depending on how the camera has been setup. The sensitivity of the sensor is setup during the manufacturing process and cannot be amended on the majority of camera traps available to consumers.

Standard camera traps take colour photographs during the day and black and white images at night. At night the cameras use an infra-red flash to illuminate the subject matter. This infra-red flash comes in two variants typically Visible and Low Glow. Some animals such as badgers and foxes can be very cautious and sometimes react to the Visible LEDs. Camera traps are normally powered by AA batteries. Lithium Batteries offer the best performance but can be expensive. Rechargeable NiMh batteries can also be used but the batteries will need to be replaced with freshly charged ones at regular intervals. Always check the manual that comes with the camera for recommended battery types for the model purchased.

There are many different makes and models of camera and they vary in price range. Which one you purchase will depend on the task and the quality of results required. As with all technical purchases it is normally sensible to buy the best you can afford with the features you want and seek out suppliers who are willing to offer discounts for bulk purchases. Unfortunately, different camera trap

manufactures make cameras with different features and capabilities, so finding one that fits all scenarios can be awkward.

Some cameras have a scheduling option that allows users to set an active time and an inactive time. For example, some cameras can be scheduled to only work between set times. At all other times the camera will remain inactive and will not operate. This option can be appealing for those who only want to record wildlife at set times of the day or night. Not all cameras have this option, so check if this is available prior to purchasing if this is a facility that is important to you.

Be aware of manufacturers who boast high megapixel resolution images. Some manufactures will advertise an image resolution of 32 megapixel images when in reality this figure is much lower and the advertised resolution is achieved by upscaling or digitally blown up using internal software within the camera. The image quality may therefore not be as high as expected.

Trigger time is also very important when choosing a camera and is especially important when using the camera to take still images. Chose a camera that triggers within 0.15 – 0.4 seconds. When using video mode this is not quite as important.

Camera mounting

Most camera traps come supplied with a webbing type strap that allows for the camera to be mounted to fence posts (figure 10) or trees. In most cases and particularly when the camera is being used for monitoring a squirrel feeder, this method is generally sufficient. However, there are times when the camera position needs to be manipulated, for example when it is installed on a tree that isn't straight up and down and the camera has to be pointed at a different angle. If this angle is not too severe, a piece of wood (figure 11) can be positioned in such a way as to wedge the camera into the required position. It is important to note that if this method is used with some of the less expensive brands of camera and if the webbing strap is tightened too tightly, then the plastic body of the camera door can be warped by a small amount, which can allow water ingress in bad weather.

Figure 10: Camera fastened to post with webbing strap © Paul Harry

Figure 11: Camera fastened to tree with webbing strap and wooden wedge © Paul Harry

Tripod mount

Tripods can come in useful when you want to place a temporary camera (figure 12). Most camera traps have a tripod mount screw thread at their base which allows them to be easily mounted on a tripod. Tripods have the advantage of allowing the operator to point the camera in exactly the correct position and at the correct angle (figure 13). This makes them ideal for monitoring red squirrels or other wildlife in your garden. Their disadvantage is that they can be easily moved, and light tripods can be blown over in high winds.

Figure 12: Tripods are useful for temporary placement but can be easily moved or blown over © Paul Harry

Figure 13: Tripod with camera mounted © Paul Harry

Ultrapod

Ultrapods are reasonably low cost, hard wearing plastic tripods (figure 14) that have an added advantage over a standard tripod. They can be strapped onto trees, branches (horizontal and vertical) or fence posts as well as being used as a free-standing small tripod. The camera is attached using its tripod mount onto the Ultrapod's ball head (figure 15). This ball head can be used to accurately manipulate the position of the camera to point in the correct direction.

Figure 14: Ultrapod strapped to a tree © Paul Harry
Figure 15: Ultrapod with camera mounted © Paul Harry

Baseplate

Mounted in a similar way to an Ultrapod, a baseplate can also be used to provide an accurate way of siting cameras. When used with a ball head, they can provide a very sturdy way of mounting the camera to a variety of surfaces. Plates can be strapped, screwed or nailed to suitable surfaces (horizontal or vertical) (figure 16) and the ball head can be used to accurately manipulate the position of the camera to point in the correct direction.

Figure 16: Baseplate attached to tree with camera mounted © Paul Harry

Ground Spike

Another method of locating a camera trap is by using a Ground Spike (figure 17). These simple but effective mounts can be used to mount all sorts of cameras and accessories. The spike is pushed into the ground and a camera can be attached, either with a small ball head or directly onto the thread at the top of the spike. These are particularly useful in open areas where there is nothing to strap a camera onto.

Figure 17: Ground spike with camera mounted © Paul Harry

Advantages of the above

Flexible mounting options

- Easy to install
- More accurate positioning of camera

Disadvantages

- Additional cost

Considerations prior to siting a camera

Prior to siting a camera, the monitoring purpose should be identified, and location suitability assessed taking into consideration the following:

- Known or potential grey squirrel incursion points
- Suitability of habitat
- Evidence of target species
- Accessibility
- Terrain
- Health and safety

It is imperative that written permission is secured from the landowner prior to any cameras being installed in a location. If you are carrying out monitoring on behalf of an organisation or community group, you should carry a letter of consent issued by the organisation enabling you to access the area in question.

Assess the suitability of habitat for the species in question and search for evidence such as feeding signs or food caches that may indicate squirrels are already present in the area. The time of year may affect results depending on the availability of natural food sources, whether the species is going through a dispersal period (spring and autumn), weather patterns etc and these factors should be given due consideration.

Evaluate the terrain and accessibility (figure 18). Think - can you access the area relatively easily or are there hazards such as fallen trees (figure 19) and uneven terrain to contend with? Think about travel distances, the number of cameras to be monitored and the frequency for checking – can you return to an area to check

all cameras on a weekly basis for example? Consider health and safety issues such as hazards at the site, lone working and communication in areas with poor mobile phone signal and conduct a risk assessment.

Figure 18: Evaluate terrain and potential hazards. Here there are unmade roads, steep slopes and a watercourse to be aware of © Paul Harry

Figure 19: Look out for hazards such as fallen trees and uneven terrain © Paul Harry

Once the location has been selected, the camera is generally attached to a tree (although as outlined in camera equipment, setups can vary) and either pointed at a feeder, ground bait or signs of feeding activity on the ground; in the case of squirrels this could be chewed cones for example.

Before attaching the camera, ensure that there is a clear line of sight to either the feeder, ground bait, cones etc and that the camera lens/sensor is not obscured by foliage or low hanging branches. Small branches and twigs that may move up and down in front of the camera and falsely trigger the sensor should be removed.

Cameras placed in an area with public access or close to a public footpath should be concealed in the tree (figures 20 and 21) or camouflaged (figures 22 and 23) to reduce the risk of theft or damage.

Figure 20: It is often a good idea to conceal camera traps. Can you see it? © Paul Harry

Figure 21: Arrow showing location of camera trap © Paul Harry

Figure 22: This camera has been camouflaged using moss © Paul Harry

Figure 23: Arrow showing camouflaged camera © Paul Harry

Cameras may also be secured with a padlock or Python security cable (figure 24) for additional security.

Figure 24: A python security cable can be used for additional security © Paul Harry

Installing cameras

Cameras come with their own setup instructions which vary dependant on the make or model but as a standard procedure, ensure the batteries are charged and inserted correctly; the SD card is inserted, and formatted in the camera and has sufficient capacity; Verify that the correct date and time are displayed before installing the camera in its location.

To aid in recording the results from your camera, each camera should be assigned a unique name. This name can be assigned to each camera during the setup process. This name along with the OS grid reference of its position will give people analysing the data the information needed to log the results accurately. Types of data that may need recording are location, camera id, image title, date, time, and species. This can be captured on a spreadsheet or form.

As discussed in the camera equipment section, there are multiple methods for camera installation and which setup is used will be dependant, on purpose, budget etc.

If installing a camera on a tree, select a sturdy tree that is unlikely to move in the wind and secure the camera to the tree using a webbing strap. Any loose ends of strap should be secured to prevent them flapping and triggering the camera sensor.

Feeder and camera installation equipment

Before installing a feeder and camera it is worth conducting an inventory to make sure all the required tools are present and correct. A comprehensive equipment list for camera and feeder installation is listed below (figure 25). Not all of this equipment may be necessary all of the time, but this provides a useful reference and lists all the tools that are required to cover most installations or eventualities.

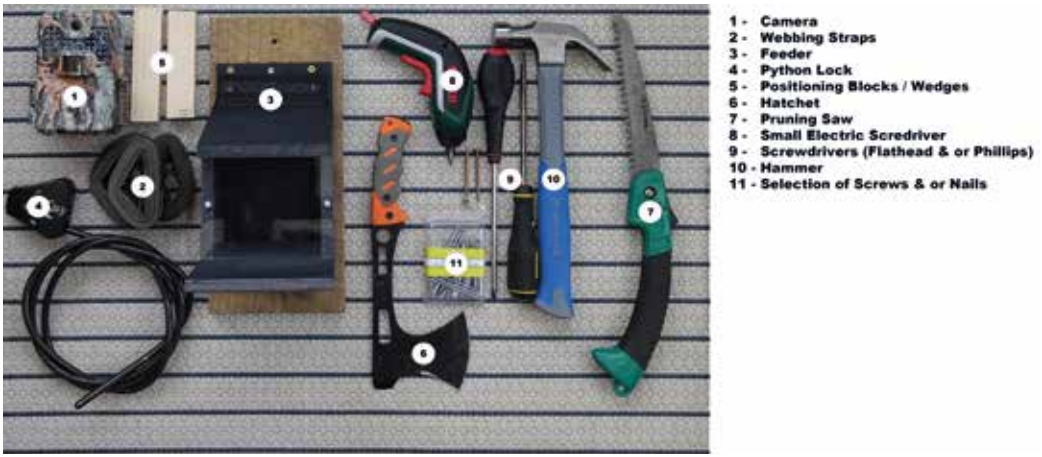

Figure 25: Conduct an inventory to check you have all the necessary tools for feeder and camera installation © Paul Harry

If using ground cameras or you require a more advanced camera setup, the items captured below (figure 26) could also be useful.

Figure 26: A more advanced camera equipment setup © Paul Harry

Cameras pointed at feeders

If pointing the camera towards a feeder, select two trees approximately five to seven metres apart that provide a good field of view (figure 29). If the feeder is too far from the camera (figure 27), the sensor may not trigger, images are likely to be poor quality and species identification could be challenging. If the camera is too close (figure 28), the field of view is restricted which may result in fewer and/ or partial images of the species.

Different cameras have slightly different specifications and it is always advisable to test for the ideal focusing distance of your camera(s) before installing them in the woods for the first time.

Figure 27: How not to do it! This camera has been installed too far away from the feeder and the sensor may not trigger or produce poor quality images © Paul Harry

Figure 28: How not to do it! This camera has been positioned too close to the feeder resulting in a partial image © Red Squirrels Trust Wales

Figure 29: Just right! The optimum distance from camera to feeder © Paul Harry

Ensure the camera is north facing and the feeder is attached to the south facing side of the tree to prevent sunlight from obscuring images. Install the feeder first at a height of approximately 1.5 metres from the ground and secure it to the tree using webbing straps (figures 30 and 31).

Figure 30: Install the feeder approximately 1.5 metres from the ground © Paul Harry

Figure 31: Secure the feeder using webbing straps or cable ties © Paul Harry

The feeder can also be securely screwed (figure 32) or nailed to the tree (figure 33).

Figure 32: Feeder screwed to tree © Paul Harry

Figure 33: Feeder nailed to tree © Paul Harry

Then secure the camera to a tree facing the feeder. If the camera has an integral viewing screen, use this to check the camera is correctly pointed towards the feeder. If the camera does not have this screen, a mobile phone set to 'selfie' mode can be positioned over the lens of the camera and a photo taken to check the camera is positioned correctly. Baseplate camera mounts with a ballhead, and Ultrapods can be used to help with correct positioning as can wooden wedges (figure 34) or bits of branch inserted securely between the tree and the camera. These are particularly useful if the camera is pointed towards ground bait or feeding signs on the ground.

Figure 34: Wooden wedges or bits of branch can be inserted between the tree and the camera to improve focus © Paul Harry

Food in feeder

There are many types of squirrel feeder commercially available but typically these are made of wood or plastic with a flip top lid, a shelf at the front and a removable perspex 'window'. This type of feeder can easily be installed, removed, cleaned and disinfected. Feeder hygiene is extremely important and further information on this is contained in the biosecurity section.

Fill the squirrel feeder with the chosen choice of bait. Typically, this is a mix of whole maize and sunflower seeds, but peanuts and hazelnuts can also be used (figure 35). If the camera monitoring is part of an ongoing survey it is important to ensure the same food mix is used across the camera and feeder network to ensure consistency.

Figure 35: A variety of food can be added to the feeder including whole maize, sunflower seeds, peanuts and hazelnuts © Paul Harry

Small amounts of food can be placed upon the ‘shelf’ in front of the feeder or scattered on the ground to spread the scent and attract animals to the food source. If using peanuts, two peanuts can be used to prop the lid of the feeder open slightly allowing the scent to disperse.

Ground baiting and ground camera monitoring

Where the risk of spreading infection between animals or species is deemed to be medium or high, food scattered on the ground can be used for monitoring instead of a feeder. Sunflower seeds or whole maize can be scattered on the ground (figure 36) creating less of a focal point when compared to a feeder. To potentially reduce cross-infection risk further, seeds or nuts without a shell or husk can also be used such as sunflower hearts. These are consumed without leaving a husk upon which saliva would be present as a potential source of viral contamination. The camera can be installed and pointed towards the food source.

Figure 36: Food can be scattered on the ground if not using a feeder
© Paul Harry

Another camera method used is a ‘ground monitoring’ approach. This technique can be used to further reduce the opportunity for cross-infection and reduces the likelihood of other species being attracted to the area by artificial food sources. Prior to siting a camera, search for signs of squirrel feeding activity such as nut shells or chewed cones which can often be found at the base of a tree. Squirrels will split shells cleanly in half along the join (figure 37) whilst mice will chew a small hole in the top of the shell. Squirrels will also extract the seeds from cones leaving a ‘feathered’ appearance on the discarded cone (figure 38). Mice will nibble it right down to the core leaving just the stem of the cone.

Figure 37: Squirrels will split nuts such as acorns or hazel cleanly in half
© Paul Harry
Figure 38: Squirrel chewed cones have a ‘feathered’ appearance © Paul Harry

Once signs of squirrel activity in the area have been identified, install the camera and point it towards the area in question.

Challenges of identifying red or grey squirrels on camera images

In the section on differentiating between red and grey squirrels, we highlighted the main identifying features of red and grey squirrels. However, images retrieved from camera traps present additional challenges. The image may be blurred, taken in poor light, poor weather conditions or the species partially concealed and/or difficult to pick out from the background.

A useful tip for animals difficult to pick out is to click through the images very quickly as it is easier for the eye to register change. When a change is observed, the image can be scrutinised more closely. If we look at the two images below the change is quite apparent in as much as there is a red squirrel on the first image though it is very difficult to spot (figure 39) as shown by the arrow. In the second image it has moved (figure 40) and although still difficult to see there is a clear difference between the first and second image.

Figure 39: The squirrel is virtually invisible against the tree trunk © MWRSP

Figure 40: Now you see it! The red squirrel is near the base of the tree in the foreground but could easily be overlooked © MWRSP

Even when an animal has been spotted on the image it can still be challenging to identify if it is obscured by poor light and shadow.

The animal captured in this image (figure 41) has bright light behind it but is partially obscured by the darkness of the tree canopy and presented at an awkward angle. The size and lack of ear tufts (the image was taken in December when most red squirrels would have ear tufts) identify this as a grey squirrel but the light passing over the tail means the classic 'halo' is not readily discernible.

Figure 41: The light is behind this grey squirrel and the darkness of the canopy makes it difficult to clearly identify the species © MWRSP

Blurred and black and white images present further challenges.

There is an animal on top of the feeder in this image (figure 42), but it is barely visible and virtually impossible to identify due to the light and clarity issues.

Figure 42: The animal on top of the feeder is virtually impossible to identify © Paul Harry

The squirrel in this black and white image (figure 43) is located just above the base of the tree in the foreground. The squirrel appears slightly blurred and it is very difficult to observe if ear tufts are present or if there is a halo around the tail making it very difficult to identify if it is a red or grey squirrel.

Figure 43: Red or grey squirrel? © MWRSP

Although the image here is in colour and relatively clear (figure 44), the squirrel appears to be moving at speed and is very blurred. It is virtually impossible to tell if ear tufts are present, but the absence of a halo identifies this as a red squirrel despite the apparent grey coat colouration.

Figure 44: The squirrel in this image is very blurred but the absence of a halo around the tail identifies it as a red squirrel © Paul Harry

Sometimes the use of photo enhancement technology can help to improve image clarity and thus identification. By using a programme such as Photoshop and loading the image, the area of the image we are interested in can be selected and manipulated to potentially provide a clearer idea of the type of animal captured on the camera.

There is a red squirrel in this image (figure 45), but it is very difficult to identify. The squirrel is extremely hard to spot as it is almost completely shadowed by the tree and it is even harder to identify which species it is.

Figure 45: It is hard to spot let alone identify the species of squirrel in this image © MWRSP

The image was loaded into photoshop and manipulated slightly to try and improve the clarity (figure 46). The image is still not completely clear but by improving the lighting, it is possible to identify the animal as a red squirrel.

Figure 46: By manipulating the image in photoshop and improving the lighting and clarity it is possible to identify this animal as a red squirrel © MWRSP

Biosecurity

During any monitoring process, effective biosecurity protocols are crucial to prevent the spread of disease and infection.

Vehicle

Prior to entering any monitoring site, vehicle wheels should be treated with an appropriate disinfectant such as Virkon™ S and this should be re-applied whenever moving to new locations. It is essential that the disinfectant is made up to the correct strength as per manufacturer's instructions otherwise it may be ineffective.

Personal

Always ensure that clothing and footwear are clean and free from mud before entering the monitoring site and spray footwear and clothing (where possible) with an appropriate disinfectant. This should be repeated whenever moving to a new location.

Be aware that many disinfectants are skin irritants and can cause severe damage to eyes or if ingested. If disinfectant comes into contact with skin or eyes, rinse and flush immediately with plenty of water. If ingested, drink water but do not induce vomiting and seek medical advice. Eye protection (safety glasses) and gloves should be worn when applying disinfectant to minimise the risk of contact.

Good hygiene is crucial in the woodland and you should always carry anti-bacterial handwash and wipes. Plastic surgical gloves should be worn whenever possible and these should be replaced with a new pair at every location visited. Always wear suitable clothing and sturdy footwear or wellington boots when visiting the monitoring site. Long sleeves and long trousers (preferably tucked into socks) are recommended to protect against ticks and insect bites. Ticks can carry Lyme disease which is transmitted to people when they are bitten by an infected tick. When exiting the woodland brush off all clothing and when home check skin thoroughly for signs of ticks. If a tick has attached itself to your skin, remove immediately using a proper tick remover. DO NOT try and remove the tick with your fingers as it may expel bodily contents into your body or leave the head behind which can cause infection. Other diseases to be aware of include Leptospirosis which is spread by rodents and generally transmitted through

animal urine. Whilst protecting human health is vital, so is minimising the risk of transmitting infection to red squirrels. The bacteria *Staphylococcus aureus* is found naturally in humans, but the bacteria can be transmitted to red squirrels (Simpson et al. 2010) where it is potentially fatal. Hence regular hand washing and wearing gloves is vital to protect person and squirrel.

Feeders

Feeders should be thoroughly cleaned and disinfected prior to installing. If using Virkon™ S, a minimum of 10 minutes should be left between disinfecting the feeder and filling it with food allowing the product to work affectively and any residue to evaporate. If the disinfectant is likely to be in prolonged contact with any metal parts, these should be rinsed with clean, fresh water. Once the feeder is installed, it should be filled with the identified food source and regularly emptied (figure 47), cleaned (figure 48) and disinfected (figure 49).

Figure 47: Uneaten food should regularly be emptied from feeders © Paul Harry

Figure 48: It is important to regularly clean and rinse feeders removing traces of old food © Paul Harry

Figure 49: It is vital to disinfect feeders regularly © Paul Harry

Regularly emptying and disinfecting the feeder mitigates infection spread and food should never be left in the feeder long enough for it to go mouldy (figure 50 and 51). If there is a build-up of food under the feeder (figure 52), spread this out across the ground and reduce the amount of food put in the feeder itself to prevent waste and mitigate the spread of infection.

Figure 50: Food should never be left long enough in a feeder to go mouldy
© Paul Harry

Figure 51: Any mouldy food must be removed and the feeder thoroughly cleaned and disinfected prior to filling with fresh food
© Paul Harry

Figure 52: A build-up of food under a feeder may go mouldy and can increase infection risk
© Paul Harry

Food removed from feeders should either remain in the woodland and be scattered across the floor or removed from the woodland completely. If removing food from the woodland for example due to mould, always ensure this is collected in a sealed container or bag and disposed of. Never re-use uneaten food either in the same or separate woodland.

Managing risk

Woodlands can be dangerous places with several hazards to be aware of. The terrain can be uneven and slippery and may contain severe gradients. Dense vegetation (figure 53), low hanging branches and poor weather conditions present additional hazards (figure 54) and in commercial forestry sites, forestry operations may take place using heavy machinery.

Figure 53: Dense vegetation can be tricky to navigate
© Paul Harry

Figure 54: Poor weather conditions present additional hazards © Paul Harry

All organisations and community groups should have health and safety protocols and risk management procedures in place. Ensure that you are aware of these prior to entering a monitoring site and follow them at all times. Whilst organisations and community groups should hold relevant statutory insurances including public liability, individuals are unlikely to be covered for personal injury or loss/damage to personal property and equipment. Check what insurance you are covered by (particularly if you are a volunteer) and consider taking out your own policy for personal injury etc. Declare any existing medical conditions where relevant to the host organisation or community group so that they are aware of any issues that may arise.

Always carry a first aid kit, mobile phone, torch, a whistle, a map, drinking water and snacks. Where appropriate use sunscreen and insect repellent. Monitoring can often be carried out alone and organisations should also have a lone working policy in place. Ensure you are aware of what this policy is and follow it. When lone working ensure your organisation and a nominated ‘buddy’ (designated point person of contact) know exactly where you are going, your intended route and what time you expect to return. Let them know when you have arrived home safely. If working on a site where commercial forestry operations are taking place (figure 55) ensure you wear a hi-vis vest/jacket, read and follow any warning notices and maintain a safe distance from forestry machinery.

Figure 55: Be aware of any forestry operations that may be taking place
© Paul Harry

In poor weather, woodlands can become very dangerous places indeed. Before travelling to a site, check the weather forecast for signs of inclement weather and postpone your visit if extreme weather is predicted. Do not work in the woodland in high winds (over 40mph) or when there is snow on the ground. High winds can cause trees and branches to fall and debris to become airborne. Forestry roads can become treacherous in snowy or icy conditions (figure 56) and may be impassable due to fallen trees (figure 57). Be aware of the potential for flooding or landslips in periods of heavy rainfall and how this may affect the terrain.

Figure 56: Forestry roads can become treacherous in snowy or icy conditions
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Figure 57: Fallen trees can block roads © Paul Harry

Emergencies

Despite all precautions, accidents can still happen. If you have mobile phone signal call the emergency services and give them your precise location. In remote locations in the middle of a woodland this can be difficult, but you can provide them with a grid reference or download a location finding application such as What3Words™ which will give your precise location. Even in areas with no mobile phone reception you should still be able to call the emergency services but if this is not possible use the international distress signal of six whistle blasts, torch flashes or shouts leaving a one minute pause before repeating.

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