

NATIONAL PARKS AND WILDLIFE SERVICE



ALL-IRELAND SQUIRREL AND PINE MARTEN SURVEY 2019



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An Roinn Cultúir,
Oidhreacht agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

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Front cover, small photographs from top row:

Limestone pavement, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Garden Tiger** *Arctia caja*, Brian Nelson; **Fulmar** *Fulmarus glacialis*, David Tierney; **Common Newt** *Lissotriton vulgaris*, Brian Nelson; **Scots Pine** *Pinus sylvestris*, Jenni Roche; **Raised bog pool**, Derrinea Bog, Co. Roscommon, Fernando Fernandez Valverde; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

Red Squirrel *Sciurus vulgaris*, Michael Ryan



All-Ireland Squirrel and Pine Marten Survey 2019

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Executive Summary

In 2019, a survey was conducted across the island of Ireland on the distribution and status of three mammal species, the native Red Squirrel *Sciurus vulgaris* and Pine Marten *Martes martes*, and the invasive Grey Squirrel *Sciurus carolinensis*. The Grey Squirrel was introduced to Ireland just over 100 years ago, and has since spread to cover most of the eastern half of the island. The Grey Squirrel competes with the Red Squirrel for resources, and carries a disease that is fatal to the native species. As a result, the spread of Grey Squirrel had been mirrored by a retraction in Red Squirrel range and a reduction in numbers.

The distributions of the two squirrel species have been observed through a series of surveys running since the middle of the 20th century. In recent surveys however, it became apparent that in some parts of Ireland there had been a change in the fortunes of the two species. In surveys conducted in 2007 and 2012 it was evident that the Grey Squirrel had disappeared from parts of the midlands of Ireland. This disappearance was linked in subsequent studies to the re-emergence of the Pine Marten, a native carnivore of Ireland. The Pine Marten had previously almost disappeared but has made a considerable recovery after becoming protected under Irish and EU legislation. High densities of Pine Marten were found in the midlands of Ireland, in the areas where Grey Squirrel had disappeared. Meanwhile, Red Squirrel has made a recovery in some of these areas and seemed capable of co-habiting woodlands with the native carnivore.

The current survey sought to update the distribution maps for the three species in recognition of the rapidly changing situation. The survey team was a collaborative effort between academics and NGO officers from both Republic of Ireland and Northern Ireland, and used the online recording facilities offered by the National Biodiversity Data Centre (RoI) and Centre for Environmental Data and Recording (NI). The survey was publicised using print, broadcasting and social media, with the public invited to contribute sightings as part of a citizen science effort.

Three thousand four hundred and seven records were received during the course of the survey, a large increase on the number received in previous surveys. Grey Squirrel records however had decreased in number, and the range covered by the species had dropped considerably, with 37.8% fewer hectads (10 km x 10 km squares) occupied than in 2012. The distribution gap in the midlands now stretches across nine counties, with Grey Squirrel having functionally disappeared from Co. Fermanagh, Co. Monaghan and parts of Co. Meath and Co. Kildare since the 2012 survey. Red Squirrel sightings have increased considerably, and it has returned to parts of the midlands from which it had disappeared. The number of sightings of Pine Marten, previously considered an elusive animal, was very high, with signs that its core range has expanded from the west and midlands to include parts of Northern Ireland and Co. Wicklow. Again, there is evidence of the negative correlation between the Grey Squirrel and Pine Marten, and it is in the areas where the Pine Marten has increased most significantly that this squirrel has disappeared. The Grey Squirrel continues to thrive in some areas, in particular in urban regions around Belfast and Dublin. There was some evidence of further Grey Squirrel spread into the southwest of the island.

The survey was very successful and underlined the benefits of citizen science and using the collective knowledge of an informed and enthusiastic public. The collaborative nature of the study, bringing together colleagues from institutions across both parts of the island, was very productive. The status of the two native species is very good, with very important populations in their strongholds in the west and midlands of Ireland. However, recommendations are made to ensure that this remains the case, with further monitoring required to allow early intervention if conservation at a local or national level is required.

Acknowledgements

The authors would like to thank our colleagues in our respective institutions National University of Ireland, Galway, Vincent Wildlife Trust and Ulster Wildlife for facilitating and supporting this survey. Special thanks to Dariusz Nowak, Eoin MacLoughlin and Kate McAney. We really appreciated the support and help from the two data centres, the National Biodiversity Data Centre (RoI) and Centre for Environmental Data and Recording (NI), especially Liam Lysaght and Barry O'Neill. Thanks to landowners for access to woodland, in particular Coillte and NPWS. This project received a lot of publicity and we appreciate the assistance from various radio, TV and print media journalists, presenters and producers. As a Citizen Science project we received contributions from literally thousands of individuals, and their effort and enthusiasm were vital to the success of the survey. In particular, the members of the squirrel groups in Northern Ireland who conducted various non-invasive surveys, made a huge contribution to the work. Finally, this survey was helped greatly by Conor McKinney, who helped initiate and launch the work. This project was partially funded by the National Parks and Wildlife Service.

1 Introduction

1.1 Squirrels and Pine Marten in Ireland

There are two species of squirrels found in Ireland, the Eurasian Red Squirrel *Sciurus vulgaris* and the Eastern Grey Squirrel *Sciurus carolinensis*, an introduced North American species.

The Red Squirrel has one of the largest natural ranges of any squirrel, occurring across Europe and Asia from Ireland to Japan (Gurnell, 1987). Red Squirrel was reported in Ireland in the 7th century by the Irish writer Augustine (Barrington, 1880), and may have existed on the island even before the last Ice Age (Finnegan *et al.*, 2008). The current population of Red Squirrel is mostly derived from reintroductions in the 19th century following the catastrophic deforestation of the 16th and 17th centuries (Barrington, 1880). Red Squirrel requires forested habitat in order to survive and can be found in coniferous, deciduous and mixed woodlands. The population densities fluctuate annually, mainly due to seed availability, with the autumnal seed crop influencing winter survival, and success and longevity of the following spring's breeding season. Although Red Squirrel can feed on a variety of foods, it is the tree seeds that make up the majority of its diet. It is for this reason that a mix of trees, rather than a single seed source in a monoculture wood, provides a better habitat for Red Squirrels. Population densities rarely exceed 1.5 squirrels per hectare (Andren & Lemnell, 1992; Gurnell, 1983; Lurz *et al.*, 2005). The Red Squirrel is protected in the Republic of Ireland under the Wildlife Act (1976) and Wildlife (Amendment) Act (2000), and also in Northern Ireland under the Wildlife (N.I.) Order of 1985.

Eastern Grey Squirrel (hereafter just referred to as Grey Squirrel) has a natural range across much of eastern North America, however, they have been introduced to a number of other countries, including Ireland, Britain, South Africa and Italy (Gurnell, 1987). Grey Squirrel was introduced into woodland surrounding Castle Forbes in Co. Longford in 1911 (Watt, 1923), and this one recorded introduction is thought to have given rise to the current population. The Grey Squirrel is an invasive species, causing damage to trees by stripping bark (Lawton, 2003) and having an impact on the Red Squirrel through disease-mediated competition. The Grey Squirrel competes indirectly with Red Squirrel for food resources and also carries a virus that causes lethal squirrel pox in the native squirrel populations (McInnes *et al.*, 2012). Although it feeds on similar resources, the Grey Squirrel has a more varied diet, and therefore is able to avoid the population fluctuations seen in the Red Squirrel, by utilizing other food sources when the seed crop is low in a given year. It is a larger squirrel, weighing approximately twice as much as the Red Squirrel, and has larger fat reserves, allowing individuals to survive lean winter periods more easily. When Grey Squirrel is present, Red Squirrel has a lower level of juvenile recruitment into the population (Wauters *et al.*, 2000). Grey Squirrel is usually found in deciduous forests in its native range, but also inhabits mixed woodlands and parks in Ireland (Lawton *et al.*, 2015).

A series of studies, investigating the impact of Pine Marten on squirrels (Sheehy *et al.*, 2014, Sheehy & Lawton, 2014, Flaherty & Lawton, 2019, Sheehy *et al.*, 2018, Twining *et al.*, 2020), has shown that the native carnivore is intrinsically linked to the fortune of both squirrel species in Ireland. The Pine Marten is a tree-climbing carnivore and its presence is very strongly negatively correlated with that of the Grey Squirrel. Pine Marten feeds on a variety of foods including meat, fruit and seeds and is found in rural woodlands. The species was previously quite rare in Ireland, with a restricted distribution, but protection under the Irish Wildlife Acts of 1976 and 2000, and the EU Habitats Directive has resulted in an increase in range and abundance of the species across the island.

1.2 Previous squirrel and Pine Marten surveys

There have been a number of surveys of squirrels, dating back to before the introduction of the Grey Squirrel (Table 1). Barrington (1880) reported on the introduction of Red Squirrel through the preceding century, in the belief that it had not been present previously, and included contemporary records of Red Squirrel at the time. The origin of Grey Squirrel and its presence is noted by Middleton (1932) and Moffat (1938), but it is not until later reports by the National Parks and Wildlife Service (1968 and 1973) and by Crichton (1974) and Ní Lamhna (1979) that maps of the distribution of the two squirrel species were compiled. These maps were based on the knowledge of individuals working in the forestry industry and personnel working for the Wildlife Service. This current survey is one of a series that began with work conducted by O'Teangana *et al.* (2000), who mapped the Red and Grey Squirrel distributions having merged datasets gathered in the Republic of Ireland (Reilly, 1997) and Northern Ireland (O'Teangana, 1999). At that time, Grey Squirrel had spread from the point of introduction in Co. Longford to cover much of the eastern half of Ireland. It had reached the east coast, and was pushing southwards into Co. Wicklow and Co. Wexford. It inhabited all counties of Northern Ireland, although had just arrived at the borders of Co. Antrim. The western edge of Grey Squirrel distribution was limited by the River Shannon. The Red Squirrel was still widespread throughout the island, but quite rare, and in certain midlands counties where the Grey Squirrel had longest been established, it had disappeared.

A follow-up all-Ireland survey was conducted in 2007 between researchers in NUI Galway, and members of the CRISIS (Combined Research and Inventory of Squirrels in Irish Silviculture) squirrel project (Carey *et al.*, 2007). This survey (Figure 1) again highlighted the continued spread of the Grey Squirrel throughout the eastern half of the island, with advances into Co. Waterford, Co. Cork, Co. Limerick and Co. Antrim. The Red Squirrel at the time was still found across the island of Ireland, but the gap in its distribution in the midlands had persisted, and possibly increased in size. For the first time, in the 2007 survey respondents were asked to include details of Pine Marten sightings as well, following anecdotal reports of the loss of Grey Squirrel at a local level, in conjunction with the return of the native squirrel species. The distribution maps showed the Grey Squirrel had seemingly disappeared from small areas of Co. Cavan, Co. Laois and Co. Offaly where the Grey Squirrels was expected to be doing well. This suggestion became the focus of subsequent research, with a follow up survey conducted in 2012 (Lawton *et al.*, 2015), when three regional surveys overlapped (Sheehy & Lawton, 2014; Goldstein *et al.*, 2014; Flaherty & Lawton, 2019).

The 2012 survey showed the reversal of the previous trend of a spreading, invasive alien species, with the midlands gap in Grey Squirrel distribution having extended to cover an area of approximately six counties (Figure 2). The Red Squirrel was commonly reported, and seemed to have made a partial recovery in the midlands region. In some parts of the island, such as Donegal and in the south-west, the Grey Squirrel had continued to expand its range in keeping with its previous trajectory. The Pine Marten was reported throughout the island, with a very dense population in the midlands and western region, as also reported by O'Mahoney *et al.* (2012). The Pine Marten had made a substantial recovery having become protected under the 1976 Irish Wildlife Act and following the banning of strychnine in 1992. Analyses of the distributions of the three species found the Grey Squirrel and Pine Marten to be strongly negatively correlated to one another (Sheehy & Lawton, 2014), with the Red Squirrel being positively associated with the Pine Marten, probably as a result of the loss of their competitor. Subsequent work in Scotland (Sheehy *et al.*, 2018) and modelling of environmental data in regions where Grey Squirrel is common compared to regions where it is rare (Flaherty & Lawton, 2019) have added further evidence to the impact the Pine Marten has on Grey Squirrel persistence in an area, and suggest that the effect may be caused by a predator naivety on behalf of the Grey Squirrel (Sheehy *et al.*, 2018, Twining *et al.*, 2020).

Table 1 Previous Irish squirrel and Pine Marten distribution surveys (updated from Carey *et al.*, 2007) Species are abbreviated to RS (Red Squirrel), GS Grey Squirrel and PM (Pine Marten).

Author	Species	Scope	Region	Parties surveyed
Barrington (1880)	RS	Introductions Distribution Status	All Ireland	Voluntary observers
Middleton (1932)	GS	Distribution Status	UK, ROI	Voluntary observers
Moffat (1938)	RS, GS	Distribution Status Data amalgamation	ROI	Voluntary observers
NPWS (1968)	RS, GS	Distribution	ROI	Forestry, Wildlife personnel
NPWS (1973)	RS, GS	Distribution	ROI	Forestry, Wildlife personnel
Crichton (1974)	RS, GS	Distribution	ROI, NI	Forestry, Wildlife personnel
Ní Lamhna (1979)	RS, GS	Distribution Data amalgamation	ROI, NI	Forestry, Wildlife personnel Biologists Voluntary observers
Hannan (1986)	RS, GS	Forestry damage	ROI	Forest Officers
UWT (1993)	RS, GS	Distribution Habitat preference	NI	Forest Officers
Gettinby (1994)	RS, GS	Distribution Habitat preference	NI	Selected woodlands surveyed
Reilly (1997)	RS, GS	Distribution Habitat preference	ROI	Forestry, Wildlife personnel Voluntary observers
O'Teangana (1999)	RS, GS	Distribution Habitat preference	NI	All sites over 15 ha surveyed
O'Teangana <i>et al.</i> , (2000)	RS, GS	Distribution Data amalgamation	ROI, NI	Forestry, Wildlife personnel Voluntary observers NI sites over 15 ha surveyed
Lawton, Rochford (2000)	RS, GS	Distribution	Wicklow	Selected sites surveyed Voluntary observers
O'Neill, Montgomery (2003)	RS, GS	Distribution	NI	Selected sites surveyed
Poole (2007)	RS, GS	Distribution Habitat preference	Western ROI	Selected sites surveyed Voluntary observers
Carey <i>et al.</i> (2007)	RS, GS, PM	Distribution Data amalgamation	ROI, NI	Forestry, Wildlife personnel Voluntary observers Selected sites surveyed
O'Mahony <i>et al.</i> , (2012)	PM	Distribution	ROI, NI	Historical data Selected sites surveyed
Sheehy, Lawton (2014)	RS, GS, PM	Distribution	Midlands ROI	Forestry, Wildlife personnel Voluntary observers Selected sites surveyed
Goldstein <i>et al.</i> (2014)	RS, GS, PM	Distribution	South and Southwest ROI	Forestry, Wildlife personnel Voluntary observers Selected sites surveyed
Lawton <i>et al.</i> (2015)	RS, GS, PM	Distribution	ROI and NI	Forestry, Wildlife personnel Voluntary observers Selected sites surveyed
Flaherty, Lawton (2019)	RS, GS, PM	Distribution	West and Shannon region ROI	Forestry, Wildlife personnel Voluntary observers Selected sites surveyed

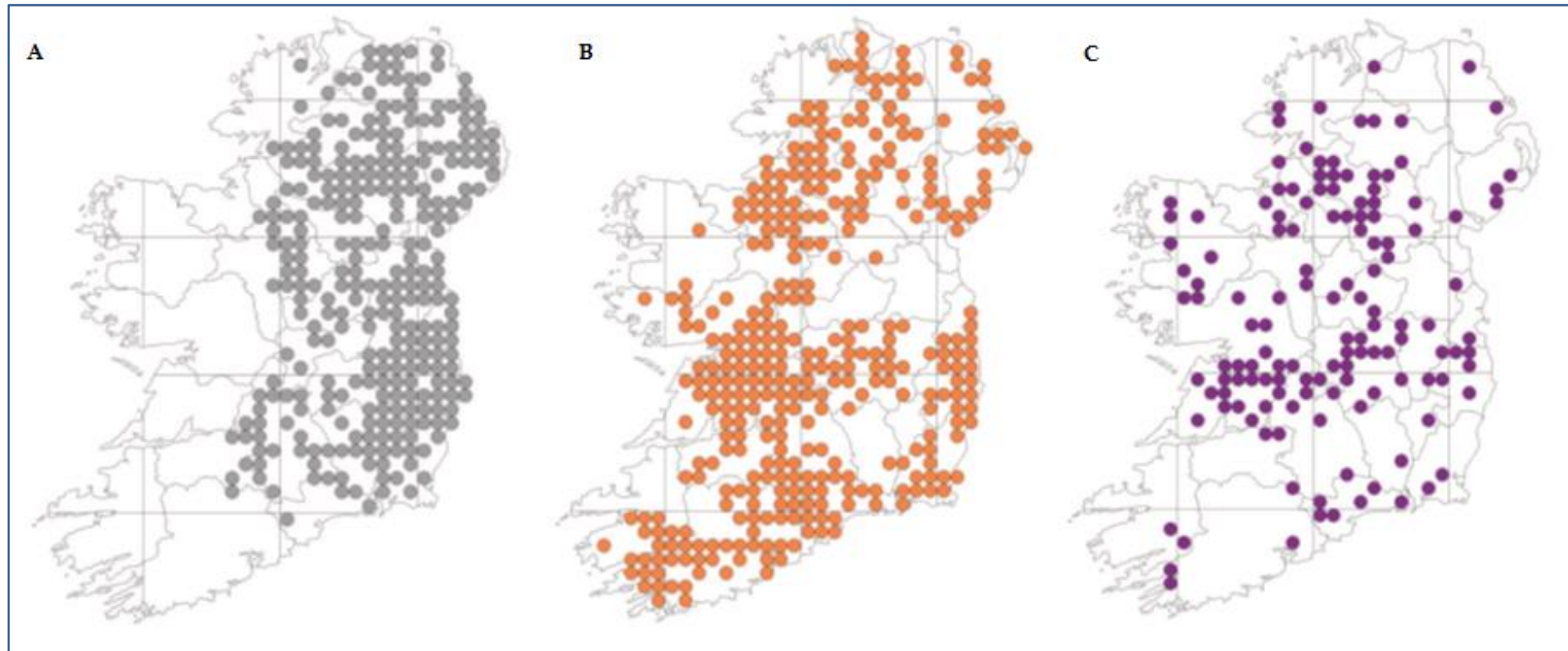


Figure 1 Distribution in Ireland of (A) Grey Squirrel (B) Red Squirrel and (C) Pine Marten as reported in 2007 Irish Squirrel Survey (Carey *et al.*, 2007).

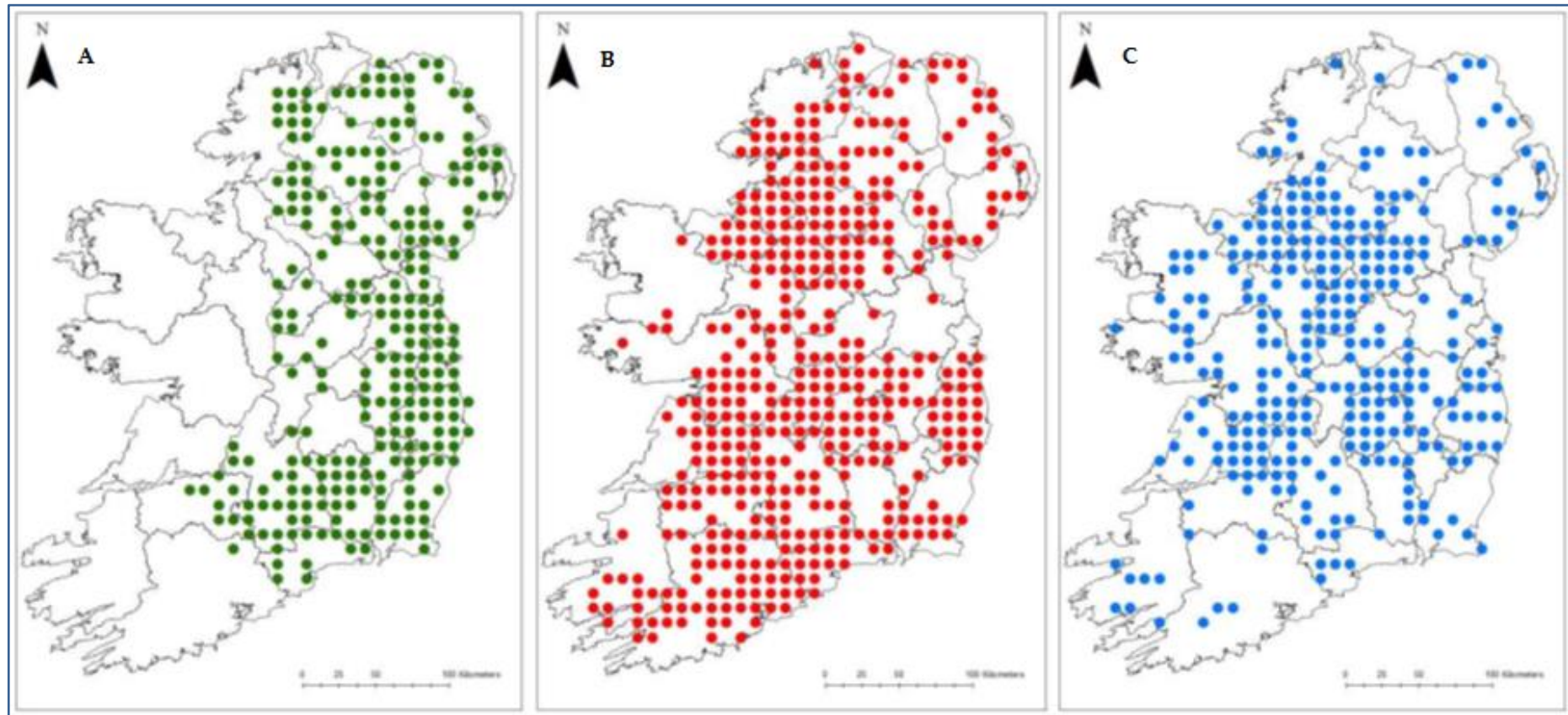


Figure 2 Distribution in Ireland of (A) Grey Squirrel (B) Red Squirrel and (C) Pine Marten as reported in 2012 Irish Squirrel Survey (Lawton *et al.*, 2015).

1.3 Previous squirrel and Pine Marten surveys

A recommendation of the 2012 survey (Lawton *et al.*, 2015) was that a further distribution survey should be conducted before or during 2022, however it was noted that further regional studies may be required sooner, due to the changing picture at the frontiers of Grey Squirrel spread, and also in recognition of the emerging demise of the Grey Squirrel in the midlands. During the 2018 International Squirrel Colloquium, which took place in Galway, Ireland, a group of Irish squirrel biologists, conservationists and other stakeholders decided to carry out a new all-Island survey covering both jurisdictions in the following calendar year, in recognition of the likelihood of further distribution changes emerging from various contributors to the colloquium. Representatives from various institutions joined together to carry out and report on the survey: National University of Ireland Galway (NUIG), Ulster Wildlife (UW) and Vincent Wildlife Trust (VWT) conducted the work. Online support and record compilation was conducted using the interactive websites of the National Biodiversity Data Centre (RoI) (NBDC) and Centre for Environmental Data and Recording (NI) (CEDaR). Funding was provided by the National Parks and Wildlife Service (NPWS), which is a section of the Department of Culture, Heritage and the Gaeltacht (RoI).

This survey aimed to determine the current (2019) distribution of both squirrel species and the Pine Marten on the island of Ireland, using non-invasive monitoring techniques and reports from the general public. The resulting data is presented as a series of maps showing individual sightings, hectads (10 km x 10 km squares) where the animals are detected, and heat maps showing the relative densities of the species. The increase or decrease of each species since the previous survey is calculated using the hectads occupied.

2 Methods

This survey was conducted using citizen science, following the Principles of Citizen Science, as set out by the European Citizen Science Association (ECSA) (<https://ecsa.citizen-science.net/documents>). The methods of contacting the public and gathering the information has developed since the earlier surveys, with much of the publicity gained through social media as well as traditional media routes. In the 1997 survey, responses from the public were gathered on paper record forms only (O'Teangana *et al.*, 2000). In 2007 responses were also collected over the phone (Carey *et al.*, 2007) and a website questionnaire was included in 2012 (Lawton *et al.*, 2015). In the current survey, most of the responses were gathered online, using the wildlife recording platforms provided by CEDaR in Northern Ireland and the NBDC in the Republic of Ireland (CEDaR: <https://www2.habitas.org.uk/records/uw-squirrel-monitoring>; and NBDC <http://www.biodiversityireland.ie/record-biodiversity/surveys/all-ireland-squirrel-and-pine-marten-survey>). Additional records received on an *ad hoc* basis by the survey team were added to the online databases on behalf of the member of the public concerned.

2.1 Survey Questionnaire and Circulation

The online questionnaires followed the standard form used by the two national record centres. They asked respondents for contact details (name and email address), along with information on where the animal was seen (county and name of forest or townland) and an Ordnance Survey reference. The spatial reference was automatically generated on the websites using clickable maps (Figure 3). The questionnaires also asked for information on the observation: which animal had been observed, the observation type (a drop down menu including options such as live sighting or road kill) and abundance. There were also options for respondents to add a picture of the sighting, and a comment box for further information. Both sites also offered information about the survey (Figure 4), and to help identify the species concerned (Figure 5).

A press release was issued in early March 2019, and received considerable coverage in several local and national newspapers, together with radio and TV interviews (Table 2). Dedicated social media pages were set up on Facebook and Twitter (both @squirrelsurvey) (Figure 6), which were used initially to publicise the survey, and then to update the public on the survey and early results as per the ECSA principles. As the project progressed, social media page updates focused on specific counties, with an explanation regarding changes since the previous surveys.

Additional records were sought and gained through dedicated searches in regions of the island. These served to fill in gaps or confirm absences where few records had been received, particularly in more remote areas. They also allowed for the validation of records in areas of particular interest, for example at the distribution frontiers for each species or where a species had seemingly disappeared from an area previously noted as part of their range. Flyers and posters advertising the survey were distributed in areas of particular interest (Figure 7). Primary woodland in a region was visited and local residents interviewed. Records were also gained through the use of non-invasive monitoring devices such as hair tubes (Goldstein *et al.*, 2014) and trail cameras (*e.g.* Sheehy *et al.*, 2018).

In Northern Ireland, a network of Red Squirrel Community Groups has been set up over the last 20 years under the auspices of the Northern Ireland Squirrel Forum, an initiative of the Department of Agriculture, Environment and Rural Affairs. Each community group (Figure 8) was asked to carry out a series of non-invasive investigations in woods within their own catchment area. Trail cameras and squirrel feeders were distributed to each group. They were asked to place the equipment in forests for seven to 14 days, following specific instructions. The trail cameras were directed at the squirrel feeders, which were secured to trees and baited with sunflower seeds. Volunteers were also supplied with a disinfectant (Virkon) to clean the feeders between uses.

Sample details

Recorder name

The name of the recorder

Recorder email

someone@somewhere.com

Record date

2019-02-01

County

Select county

Location name

Townland or nearest village

Spatial reference

S123456 or 51.12345,-9.12345

Click on map to generate spatial reference.

Observation details

Species name

Eastern Grey Squirrel (Sciurus carolinensis)
Eurasian Red Squirrel (Sciurus vulgaris)
Pine Marten (Martes martes)

Species picture

Browse... No file selected.

Observation type

Observation type

Abundance

Abundance

Additional information

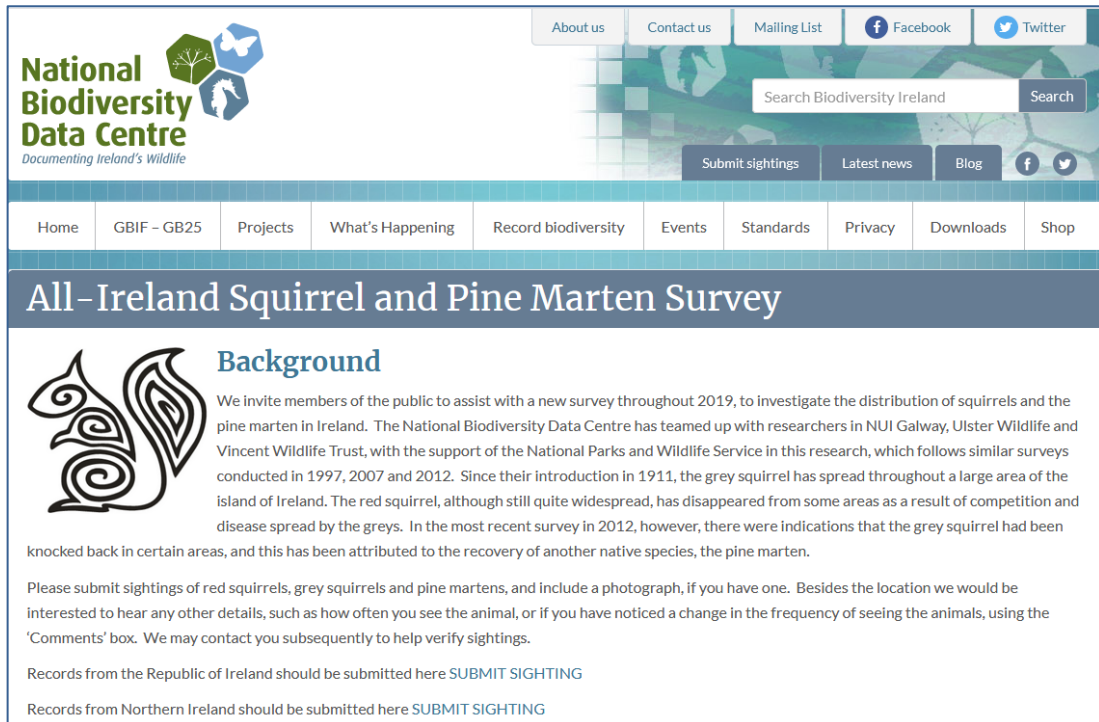
Additional information

Click map for grid reference

Map of Ireland showing county boundaries and major cities. The map includes a legend with options: Terrain, Satellite, OSI, and Counties. The map is powered by Esri and OpenStreetMap.

Figure 3 Screenshot of All-Ireland Squirrel and Pine Marten Survey 2019 survey form on the NBDC website.

A



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All-Ireland Squirrel and Pine Marten Survey

Background

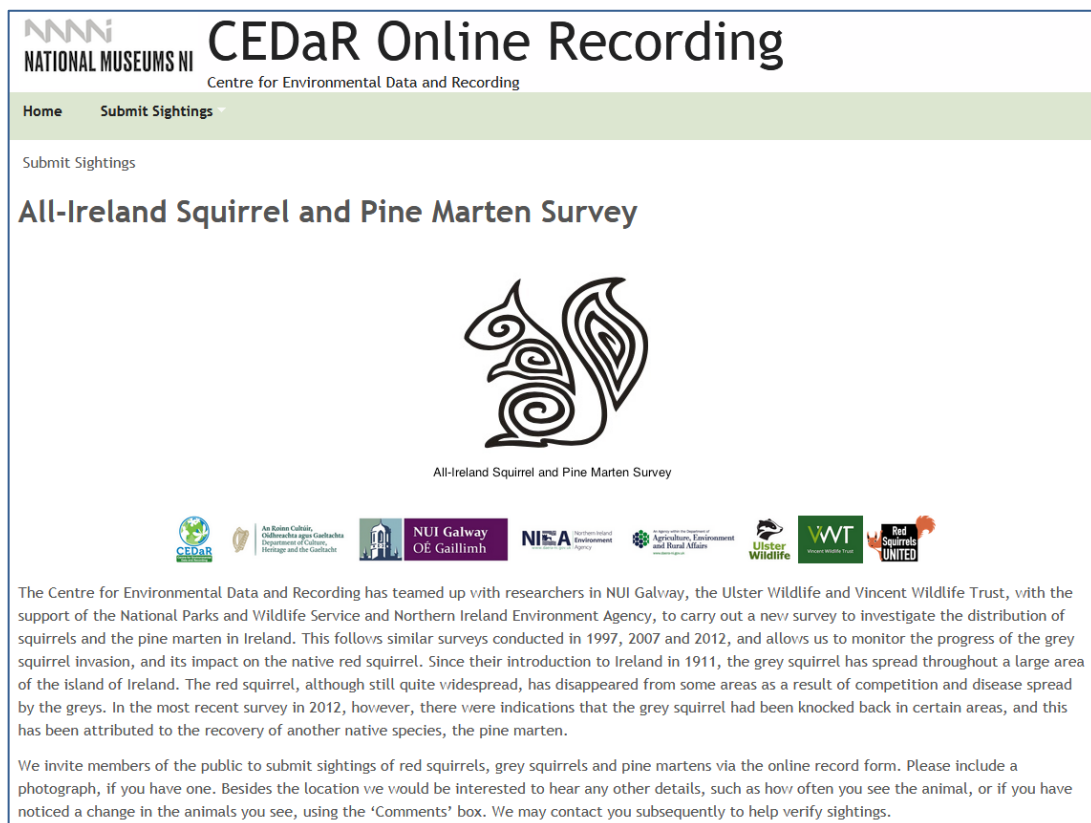
We invite members of the public to assist with a new survey throughout 2019, to investigate the distribution of squirrels and the pine marten in Ireland. The National Biodiversity Data Centre has teamed up with researchers in NUI Galway, Ulster Wildlife and Vincent Wildlife Trust, with the support of the National Parks and Wildlife Service in this research, which follows similar surveys conducted in 1997, 2007 and 2012. Since their introduction in 1911, the grey squirrel has spread throughout a large area of the island of Ireland. The red squirrel, although still quite widespread, has disappeared from some areas as a result of competition and disease spread by the greys. In the most recent survey in 2012, however, there were indications that the grey squirrel had been knocked back in certain areas, and this has been attributed to the recovery of another native species, the pine marten.

Please submit sightings of red squirrels, grey squirrels and pine martens, and include a photograph, if you have one. Besides the location we would be interested to hear any other details, such as how often you see the animal, or if you have noticed a change in the frequency of seeing the animals, using the 'Comments' box. We may contact you subsequently to help verify sightings.

Records from the Republic of Ireland should be submitted here [SUBMIT SIGHTING](#)

Records from Northern Ireland should be submitted here [SUBMIT SIGHTING](#)


B



NATIONAL MUSEUMS NI **CEDaR Online Recording**
Centre for Environmental Data and Recording

Home | Submit Sightings

All-Ireland Squirrel and Pine Marten Survey



All-Ireland Squirrel and Pine Marten Survey

CEDaR | **An Roinn Cultúir, Oideachais agus Gaeilteachas** | **NUI Galway** | **NIEA** | **Department of Agriculture, Environment and Rural Affairs** | **Ulster Wildlife** | **WT** | **Red Squirrels UNITED**

The Centre for Environmental Data and Recording has teamed up with researchers in NUI Galway, the Ulster Wildlife and Vincent Wildlife Trust, with the support of the National Parks and Wildlife Service and Northern Ireland Environment Agency, to carry out a new survey to investigate the distribution of squirrels and the pine marten in Ireland. This follows similar surveys conducted in 1997, 2007 and 2012, and allows us to monitor the progress of the grey squirrel invasion, and its impact on the native red squirrel. Since their introduction to Ireland in 1911, the grey squirrel has spread throughout a large area of the island of Ireland. The red squirrel, although still quite widespread, has disappeared from some areas as a result of competition and disease spread by the greys. In the most recent survey in 2012, however, there were indications that the grey squirrel had been knocked back in certain areas, and this has been attributed to the recovery of another native species, the pine marten.

We invite members of the public to submit sightings of red squirrels, grey squirrels and pine martens via the online record form. Please include a photograph, if you have one. Besides the location we would be interested to hear any other details, such as how often you see the animal, or if you have noticed a change in the animals you see, using the 'Comments' box. We may contact you subsequently to help verify sightings.

Figure 4 Screenshots of All-Ireland Squirrel and Pine Marten survey pages on (A) National Biodiversity Data Centre (RoI) and (B) Centre for Environmental Data and Recording (NI) (CEDaR) websites.

Guide to species identification

Red Squirrel *Sciurus vulgaris*


Native species

Weight: 240-350g


Length: 180-240mm

Fur Colour: Red-brown, chestnut or grey-brown fur, with a white belly. Tail can vary in colour, and can be dark, red or blonde. They often have prominent ear tufts, which are most obvious during the winter months.

Comments: Red squirrels are relatively shy and elusive, and are most frequently seen up in the canopy of trees.



Red Squirrel (Photographer: Joe Kiley)



Red Squirrel (Photographer: Robbie Reynolds)

Grey squirrel *Sciurus carolinensis*


Non-native species

Weight: 450-720g


Length: 240-280mm

Fur Colour: Grey fur, occasionally chestnut coloured on the back and haunches, particularly in the summer. Tail is grey, with a white fringe to the hair. No ear tufts

Comments: Grey squirrels are bolder than red squirrels, and so tend to be more conspicuous. They spend more of their time on the woodland floor.



Grey Squirrel (Photographer: Gillian Day)



Grey Squirrel (Photographer: Gillian Day)

Pine marten *Martes martes*


Native species

Weight: 1.5-2.1kg


Length: 410-520mm

Fur Colour: Dark brown fur, with a large cream or yellow coloured throat patch.

Comments: They are typically nocturnal, and very good climbers. They could be confused with other mustelid carnivores, such as the American mink, but pine marten are larger and have prominent rounded ears. Mink have darker fur, and are more frequently found close to water.



Pine Marten (Photographer: Roland Surgenor)



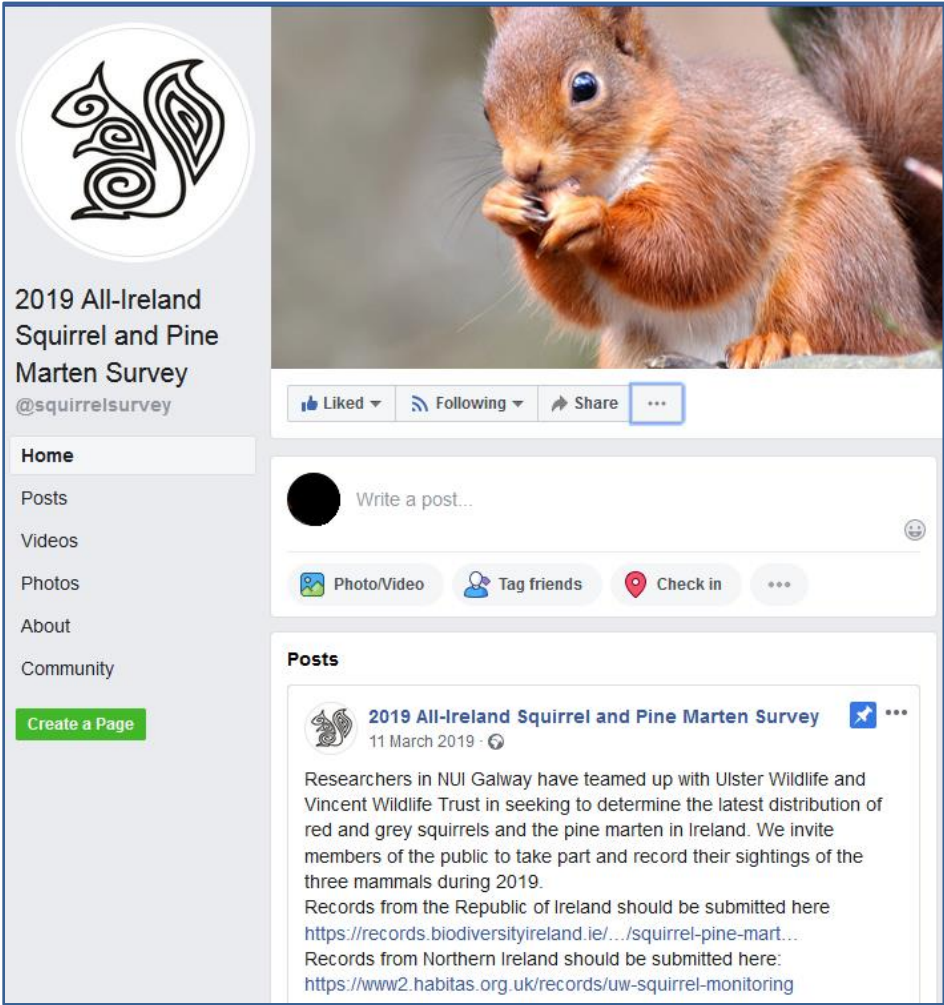
Pine Marten (Photographer: Roland Surgenor)

Figure 5 Screenshot of information provided on NBDC and CEDaR websites on each of the three target species.

Table 2 Publicity generated via the media for the All-Ireland Squirrel and Pine Marten Survey in 2019.

Media Source	Date	Media type
RTE.ie	11/03/2019	Online
Irish Times	11/03/2019	Print
Galway Daily	11/03/2019	Online
Shannonside Radio	11/03/2019	Radio
Irish Independent	12/03/2019	Print
The Green News	12/03/2019	Online
The Irish World Newspaper	12/03/2019	Online
Leitrim Observer	12/03/2019	Print
RTE Radio 1	12/03/2019	Radio
Flirt FM	12/03/2019	Radio
Midlands 103 FM	12/03/2019	Radio
LMFM Radio	12/03/2019	Radio
Kilkenny Today	12/03/2019	Print
Farming Life	13/03/2019	Print
Galway Bay FM	13/03/2019	Radio
Northern Sound	13/03/2019	Radio
Connemara FM	14/03/2019	Radio
Radio Kerry	14/03/2019	Radio
Radio Ulster	14/03/2019	Radio
Today with Maura and Daithi, RTE One	19/03/2019	TV
The Times	19/03/2019 & 17/04/2019	Print
Spirit Radio	23/03/2019	Radio
Belfast Telegraph	25/03/2019	Print
The Irish News	29/03/2019	Print
Belfast Live	29/03/2019	Online
UTV News	March 2019	TV

A



B

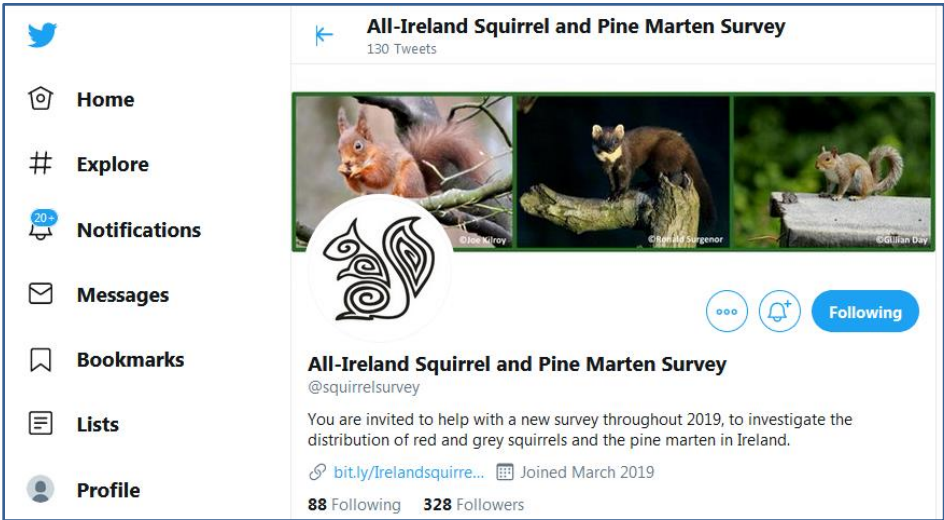


Figure 6 Screenshot of (A) Facebook and (B) Twitter social media pages for the All-Ireland Squirrel and Pine Marten Survey 2019.



2019 All-Ireland Squirrel and Pine Marten Survey

Have you seen Squirrels or Pine Martens in your area?

We are conducting a new distribution survey of red squirrels, grey squirrels and pine martens! If you have seen any of these animals in 2019, we invite you to record your sighting on the National Biodiversity Data Centre website: www.biodiversityireland.ie

For more information, please go to our Facebook or Twitter pages where you can contact us:

Facebook: 2019 All-Ireland Squirrel and Pine Marten Survey Twitter: @squirrelsurvey



Photographer: Joe Kilroy

Red Squirrel

- Length: 180-240 mm / Weight: 220-430 g
- Distinct red coat and prominent ear tufts
- Shy, spend most of their time in the trees
- Native to Ireland



Photographer: Gillian Day

Grey Squirrel

- Length: 240-285 mm / Weight: 400-720 g
- Ears have no tufts, they are more like mouse ears
- Bolder and spends more time on the ground
- Invasive species; introduced in 1911



Ulster Wildlife



Photographer: Roland Surgenor

Pine Marten

- Length: 60 cm / Weight: 1-2.2 kg
- Dark brown fur with a pale patch on throat
- Long bushy tail
- Mostly nocturnal, but can be active during summer days
- Native to Ireland

2019 All-Ireland Squirrel and Pine Marten Survey

Zoology, Ryan Institute, NUI Galway.





VWT
Vincent Wildlife Trust

Figure 7 Poster/flyer designed to promote the survey.

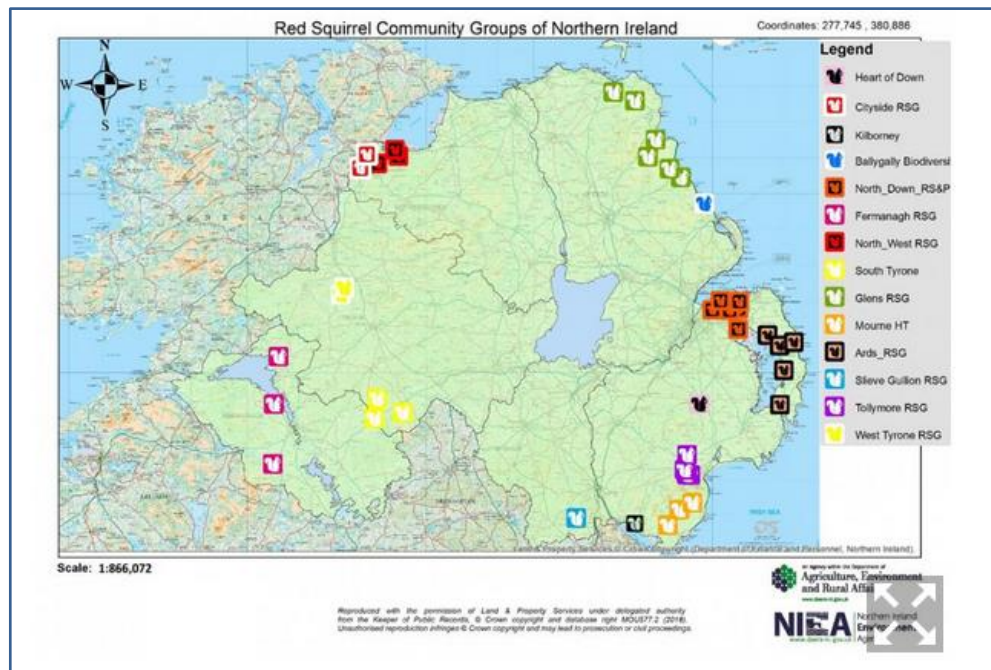


Figure 8 Red Squirrel Community Groups of the Northern Ireland Squirrel Forum (source: <https://www.daera-ni.gov.uk/articles/red-squirrel-groups-northern-ireland>).

2.2 Compilation of Results

Reports received were accepted if they fulfilled certain criteria. When a photograph was included with the record, or when the record was submitted by a professional (*e.g.* a forester, wildlife ranger or ecologist) they were automatically accepted. Sightings deemed reliable due to the authoritative information that accompanied the report were also accepted, along with records in areas where other sightings of the same animal were also recorded. Sightings that were in unusual locations with no corroborating evidence were rejected, unless a positive follow up survey or additional report were received of the animal in question.

Records from NBDC and CEDaR, and the Northern Ireland squirrel group records via Ulster Wildlife were combined to one Excel spreadsheet, with data points from NBDC and Ulster Wildlife converted from the Irish Grid Reference system to WGS84 using the online batch converter at <http://ww2.scenic-tours.co.uk/serve.php?t=WoNlbJvoVlhuJL5405objaa8jVO8atNuwZV>. Distribution maps were generated by QGIS.

3 Results

The number of accepted records received in each county, province and in total for each of the three species under investigation are presented in Table 3. A comparison of records received by province for each species with those received in 2012 is given in Table 4. For reference, counties and provinces of Ireland are shown in Figure 9. Maps showing the overall coverage of the survey, using locations of all records received and hectads from which records were returned are given in Figures 10 and 11.

The location of each record, the hectads occupied and a heat map (based on number of records per hectad) are shown for Red Squirrel (Figure 12), Grey Squirrel (Figure 13) and Pine Marten (Figure 14).

The overall coverage of the survey was very high, with records received from all counties of Ireland. Areas where no records were returned were characterised by low human population density and low forest cover. Coverage was higher than in previous surveys, particularly in Northern Ireland. The total number of records received was 3,407 and increase of 19.5% compared to 2012 (2,851). There was a highly significant difference in the proportions of records of the three target species between the survey carried out in 2012 and the current survey in 2019 across all of Ireland (X^2 (df = 3) = 37.919, $p < 0.0001$), and in Munster (X^2 (df = 3) = 30.018, $p < 0.0001$) and Leinster (X^2 (df = 3) = 57.299, $p < 0.0001$). The difference in the proportion of records of the three species in Ulster between 2012 and 2019 was not significant (X^2 (df = 3) = 5.946, $p > 0.05$). It was not possible to test the difference in Connacht due to the absence of Grey Squirrel.

Grey Squirrel was recorded in 22 counties, down from 26 counties in 2012, with only one validated record received from a further four counties. The gap in its distribution in the midlands, estimated to cover a previously occupied area of approximately six counties in 2012, now covers an area of approximately nine counties. Grey Squirrel has functionally disappeared from Co. Fermanagh, Co. Monaghan, west of Co. Meath and west Co. Kildare. Comparing the hectads occupied between 2012 (270 hectads occupied) and 2019 (168 hectads) shows a 37.8% decrease in range in the Grey Squirrel in Ireland in seven years. By comparison the number of hectads occupied by Red Squirrels in 2019 was 465, compared to 445 in 2012 (an increase of 4.5%). Although Grey Squirrels have disappeared from much of the range in which they have longest been established, there was a continued spread into the southwest of the country, with new areas of both Co. Cork and Co. Kerry recording Grey Squirrel for the first time. It should be noted however that with Grey Squirrel disappearing from parts of Co. Limerick and Co. Tipperary, that these individuals at the front of the invasion are not backed up by the usual following wave of Grey Squirrel. Grey Squirrel sightings were still common along the east coast, with high densities recorded in the urban sprawls of Dublin and Belfast. A detailed description of current Grey Squirrel range, and changes since the previous surveys, is given in the discussion.

Red Squirrel was recorded in every county, showing it is still widespread throughout Ireland. The number of records increased in many areas, particularly in Ulster and Leinster. The most marked increases in Red Squirrel sightings were in Co. Westmeath, Co. Offaly and Co. Laois, the areas from which the Grey Squirrel has disappeared from longest, showing there is a lag period between the introduced species disappearing and the native one returning. The midlands gap in Red Squirrel distribution recorded in previous surveys has retracted, however it is still rare in much of Co. Meath, Co. Louth and Co. Dublin. Red Squirrel was still absent from western parts of counties along the Atlantic coast where woodland is rare and connectivity is poor.

Pine Marten numbers increased dramatically in both Ulster and Leinster. Its core area appears to have expanded once again, with high numbers of records in Co. Meath, Co. Kildare, Co. Carlow, Co. Wicklow, south Co. Kilkenny and Co. Wexford in Leinster and in Co. Antrim, Co. Down and Co. Fermanagh in Ulster. This expansion of the core area of Pine Marten overlaps with the contraction in range of Grey Squirrel. Pine Marten was recorded in 400 hectads, compared to 299 in 2012, an increase of 33.8%.

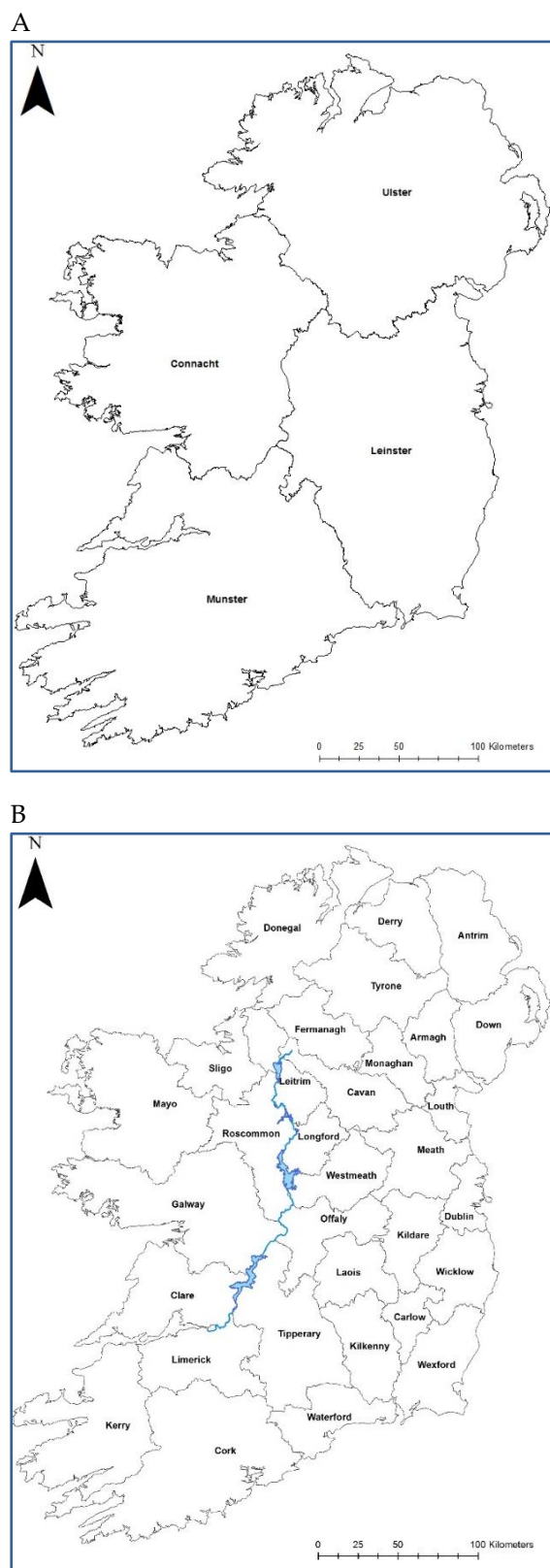


Figure 9 (A) Provinces and (B) Counties of Ireland, including the River Shannon.

Table 3 Survey returns, with number of records of Red Squirrel, Grey Squirrel and Pine Marten, received in 2019, per county, province and in total in Ireland.

County	No. of Records	Red Squirrel	Grey Squirrel	Pine Marten
Antrim	241	131	75	35
Armagh	49	9	27	13
Cavan	89	55	1	33
Derry	53	14	33	6
Donegal	136	85	34	17
Down	251	86	118	47
Fermanagh	100	60	0	40
Monaghan	26	14	1	11
Tyrone	63	22	18	23
Ulster subtotal	1008	476	307	225
Carlow	71	10	23	38
Dublin	259	47	202	10
Kildare	108	34	32	42
Kilkenny	65	34	9	22
Laois	95	60	0	35
Longford	34	17	0	17
Louth	27	12	9	6
Meath	43	4	15	24
Offaly	103	67	1	35
Westmeath	64	31	0	33
Wexford	69	27	21	21
Wicklow	275	174	62	39
Leinster subtotal	1213	517	374	322
Galway	156	108	0	48
Leitrim	138	75	0	63
Mayo	61	22	0	39
Roscommon	95	49	0	46
Sligo	58	29	0	29
Connacht subtotal	508	283	0	225
Clare	164	104	0	60
Cork	225	211	6	8
Kerry	63	46	1	16
Limerick	42	32	4	6
Tipperary	120	68	15	37
Waterford	64	47	10	7
Munster subtotal	678	508	36	134
Total	3407	1784	717	906

Table 4 Number of records of Red Squirrel, Grey Squirrel and Pine Marten received in 2019 by province compared with returns for 2012 (Lawton *et al.*, 2015).

	2012	2019
Ulster		
Red Squirrel	324	476
Grey Squirrel	204	307
Pine Marten	111	225
Leinster		
Red Squirrel	349	517
Grey Squirrel	465	374
Pine Marten	190	322
Connacht		
Red Squirrel	329	283
Grey Squirrel	2	0
Pine Marten	197	225
Munster		
Red Squirrel	463	508
Grey Squirrel	96	36
Pine Marten	121	134
Total		
Red Squirrel	1465	1784
Grey Squirrel	767	717
Pine Marten	619	906

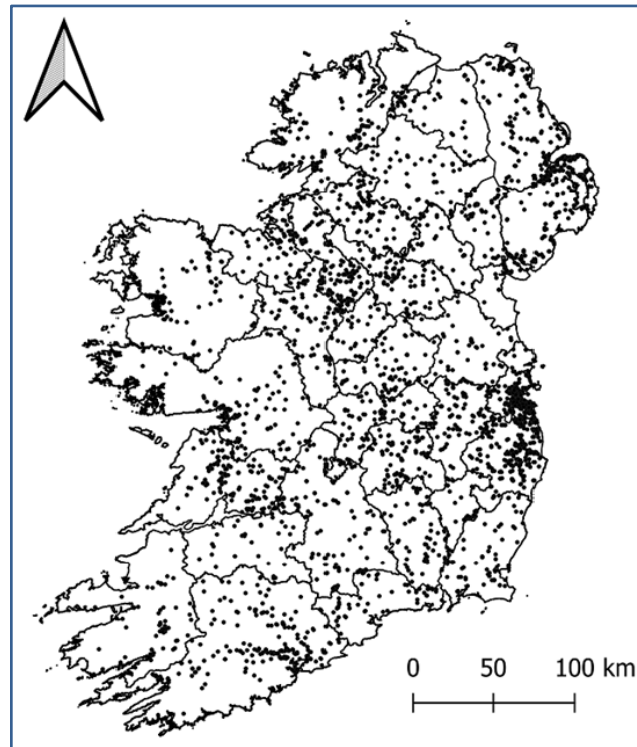


Figure 10 Locations of each record received as part of the 2019 All-Ireland Squirrel and Pine Marten survey (N = 3407).

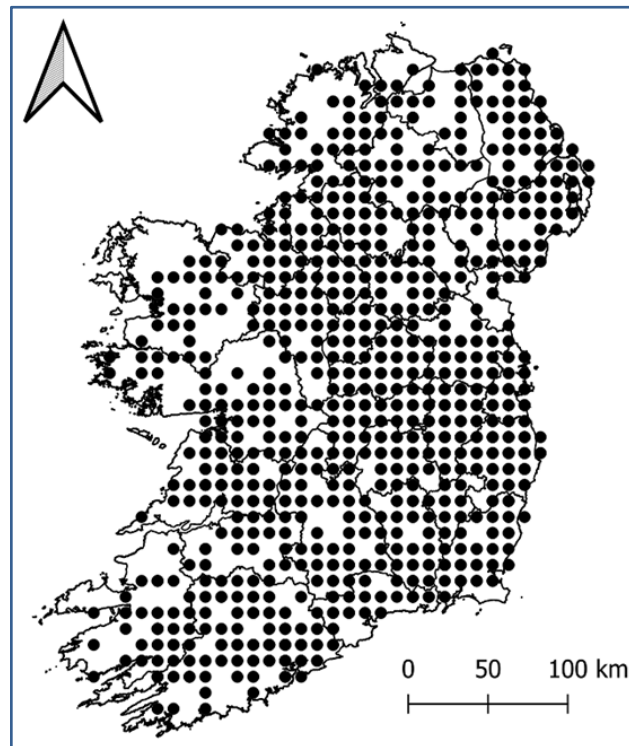


Figure 11 Hectads (10 km x 10 km squares) from which records were received during the 2019 All-Ireland Squirrel and Pine Marten survey.

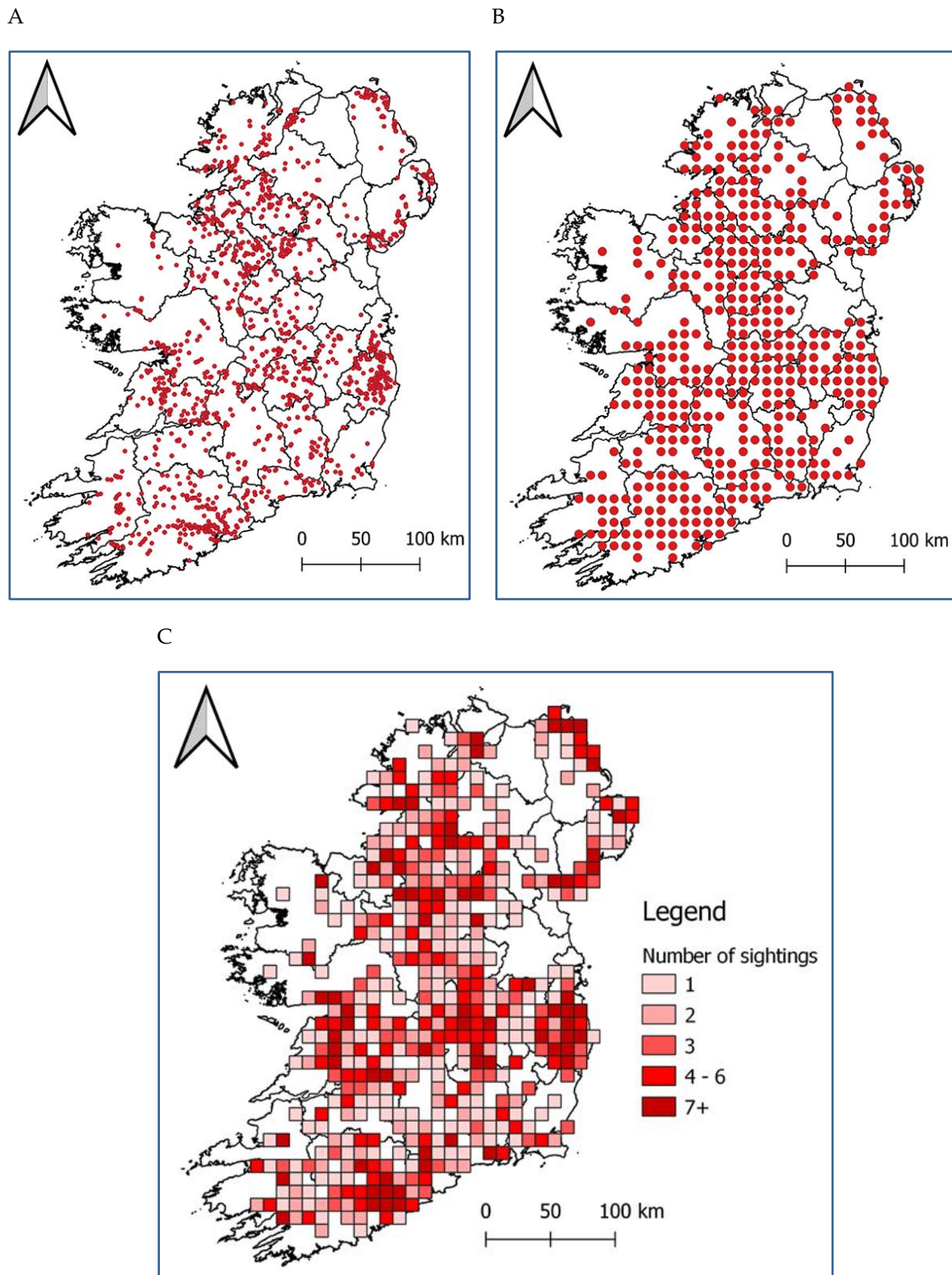


Figure 12 Results for Red Squirrel in the 2019 All-Ireland Squirrel and Pine Marten survey showing, (A) locations of Red Squirrel records (N = 1784) received; (B) hectads (10 km x 10 km squares) in which Red Squirrel was recorded; and (C) heatmap showing relative density of Red Squirrel in occupied hectads.

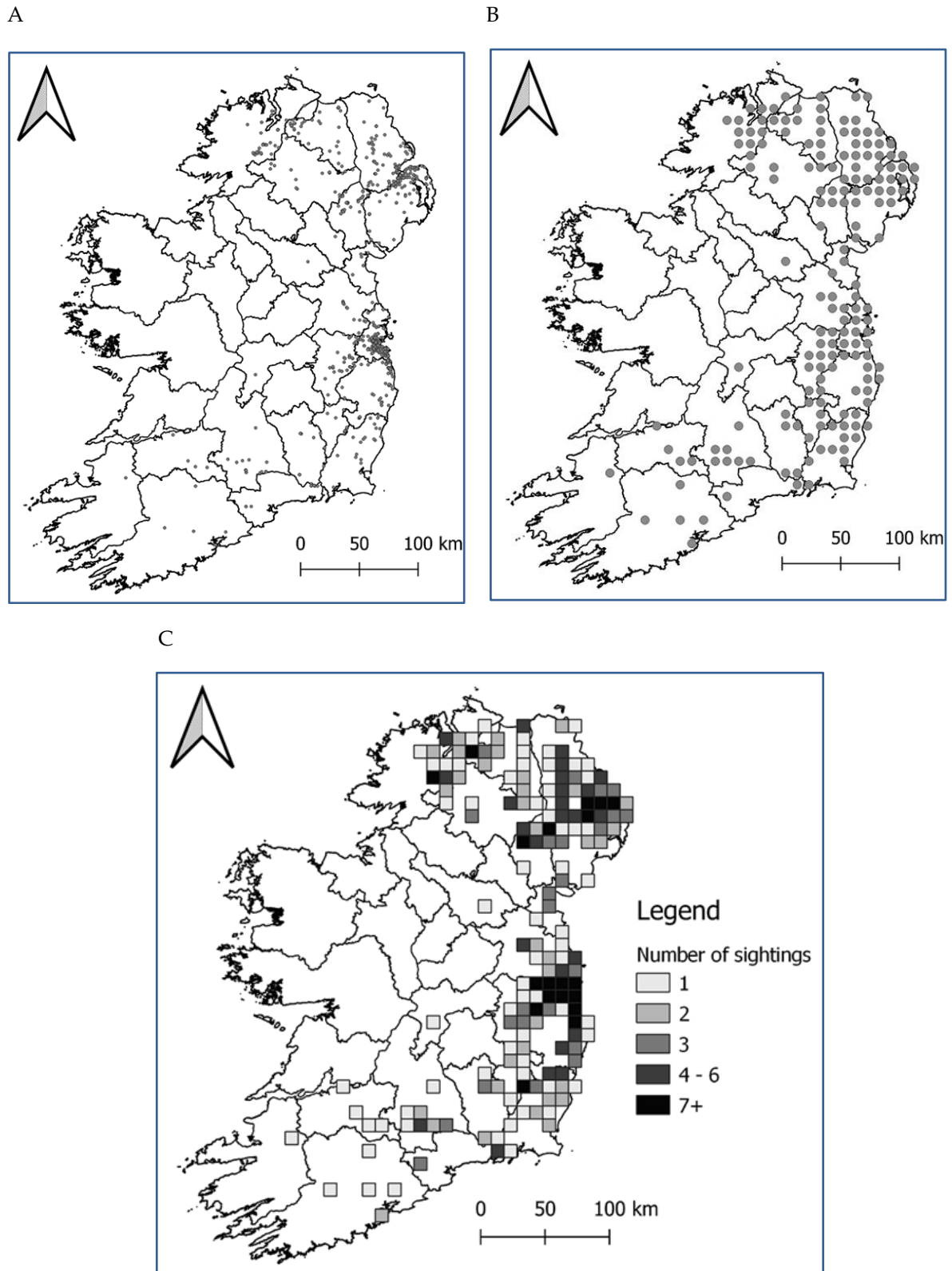


Figure 13 Results for Grey Squirrel in the 2019 All-Ireland Squirrel and Pine Marten survey showing, (A) locations of Grey Squirrel records (N = 717) received; (B) hectads (10 km x 10 km squares) in which Grey Squirrel was recorded; and, (C) heatmap showing relative density of Grey Squirrel in occupied hectads.

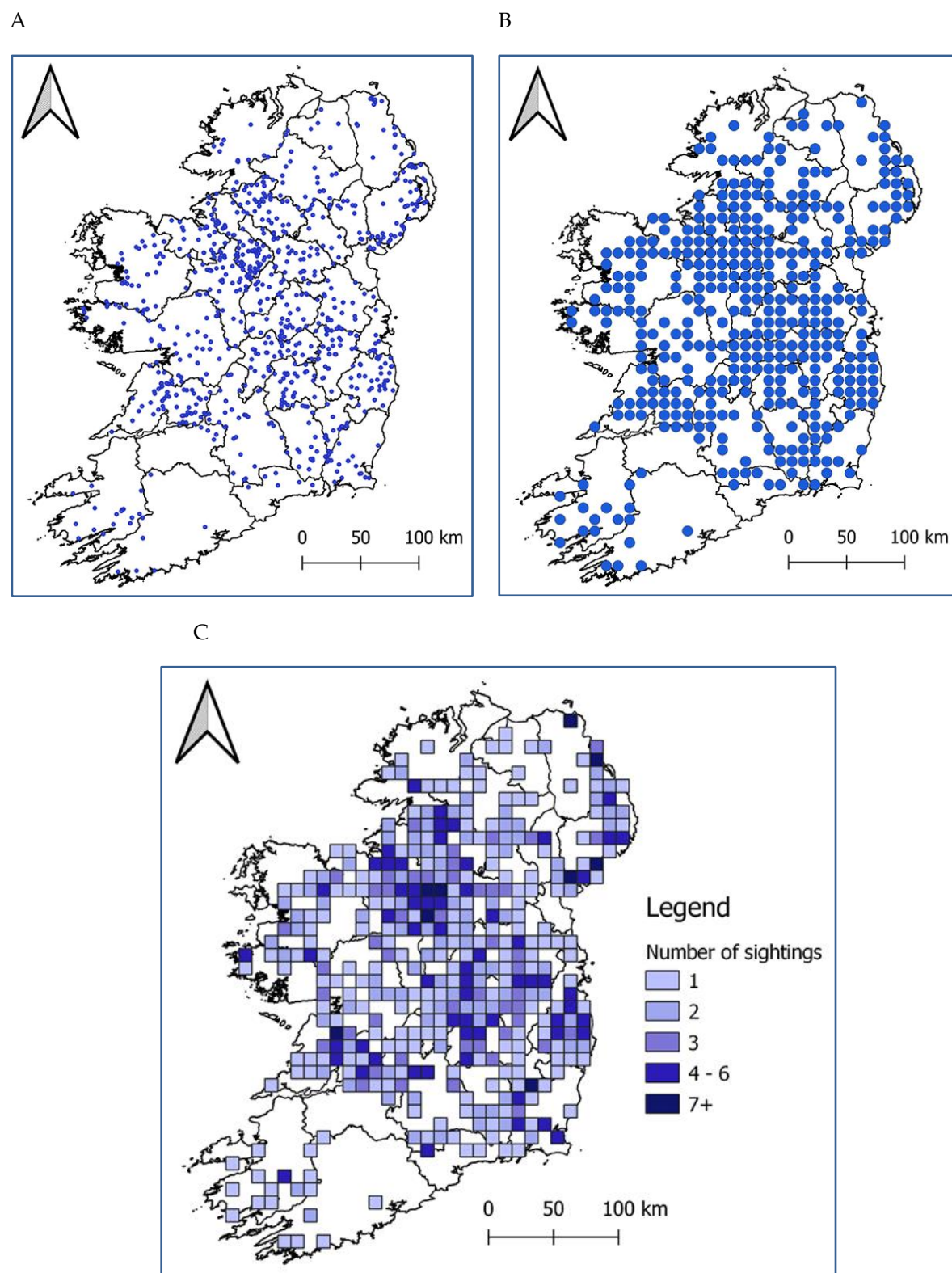


Figure 14 Results for Pine Marten in the 2019 All-Ireland Squirrel and Pine Marten survey showing, (A) locations of Pine Marten records (N = 906) received; (B) hectads (10 km x 10 km squares) in which Pine Marten was recorded; and, (C) heatmap showing relative density of Pine Marten in occupied hectads.

4 Discussion

The number of valid records received during the course of this survey ($N = 3407$) was high in comparison to the numbers received in 2012 ($N = 2851$). The targeted effort in encouraging members of the public to act as citizen scientists and share their sightings and experiences of the three animal species was very successful. The use of social media allowed members of the survey team to discuss the project directly with interested individuals, and keep the public updated as the survey continued, in keeping with the ECSA Principles of Citizen Science. Media coverage was excellent, especially through interviews on local radio stations, which allowed the survey team to highlight the historic distribution and trends of the three species in the broadcast locality. The survey coverage was particularly strong in Northern Ireland compared to previous surveys, thanks to the collaborative, multi-partner, and trans-regional nature of the survey team. Using the online portals of CEDaR as well as NBDC helped in this regard also, as well as accessing Northern Irish media stations. The use of citizen science to determine the distribution of Irish squirrels is much more cost-effective than traditional field surveys (Goldstein *et al.*, 2014). The use of citizen science must include some form of validation process, but there still remains the possibility of some erroneous data points being included. This drawback is offset however by the large and robust dataset that is gained (Tulloch *et al.*, 2013). The use of trail cameras and hair tubes in validation exercises and the photo upload option on the online record system, gives us a strong and reliable set of distribution maps. The increase in reach of the current survey makes it difficult to compare numbers of records and range of the species with previous surveys. However, the decrease on both metrics for Grey Squirrel is stark, when compared to the relative increases in the two native species.

Overall, the declining trend in the range of Grey Squirrel in the midlands of Ireland, first noted in 2007 (Carey *et al.*, 2007) and again in 2012 (Lawton *et al.*, 2015), has continued. The extent of loss of Grey Squirrel range, as shown by the decrease in hectads where they were noted to be present, is profound and surprising in such a relatively short period of time. This loss in Grey Squirrel numbers and range has been correlated to the increase in Pine Marten numbers in the midlands (Sheehy & Lawton, 2014). Subsequent studies have linked this to a predator naïve reaction on behalf of the Grey Squirrel, which does not show the same caution as a Red Squirrel in the presence of Pine Marten (Sheehy *et al.*, 2018, Twining *et al.*, 2020). Although the Grey Squirrel has continued to spread, particularly into the southwest (appearing in Co. Kerry for the first time), this is not accompanied by an invasive wave, as experienced in the invasion of the eastern half of Ireland during the 20th century. Grey Squirrel sightings remain very high in the large urban areas of Dublin and Belfast. It should be acknowledged here that squirrels are easier to see in urban parks, and the number of people living in these areas means they are more likely to be recorded. However, it is clear that Grey Squirrel are still particularly numerous in these habitats, in particular when compared to the other two species which generally prefer rural and less populated woodlands.

The outlook for the two native species is very good, with both showing signs of increasing numbers and recovery in areas from which they had previously been extirpated. The Red Squirrel is found in all counties of Ireland and is generally dependent only on the presence of mature woodland habitat. It had previously disappeared from a large area in the midlands of Ireland (Carey *et al.*, 2007), but it has made a partial recovery, with that gap now contained to parts of Co. Meath, Co. Louth and Co. Dublin. There appears to be a lag in the return of the Red Squirrel following the disappearance of the introduced squirrel, with it now having returned to regions where Grey Squirrel had disappeared in 2012. It is expected that the Red Squirrel should therefore make a further recovery in Co. Meath over the next few years. The Irish population of Red Squirrel has recently been assessed as Least Concern (Marnell *et al.*, 2019), an improvement on the previous assessment of Near Threatened in 2009 (Marnell *et al.*, 2009). This improved status was based on the results of the 2012 survey (Lawton *et al.*, 2015) and the emerging results of the current survey. Conservation work carried out in Northern Ireland, as part of the ongoing work of the Northern Ireland Squirrel Forum, and the network of local Red Squirrel community groups, and also through translocation projects in Co. Galway, Co. Mayo and Co. Dublin has helped to maintain and enhance the distribution of Red Squirrel in Ireland.

Pine Marten has had a very mixed recent history in Ireland, having almost disappeared completely in the mid 20th century as a result of persecution and habitat loss. Only small clusters of animals remained, predominantly in the west of Ireland, before their protection under the Wildlife Act of 1976. Its recovery since becoming strictly protected has been slow, but the increase in forest cover has also helped and it is now widespread throughout the island of Ireland and was recorded in every county. The decline in range of Grey Squirrel was linked to a core area for Pine Marten covering Connacht and part of the midlands, and it now appears that this core area has expanded to include all of the midlands, plus the southeast from Co. Wicklow down to north Co. Waterford. The Pine Marten is a relatively elusive and predominantly nocturnal species. Nonetheless, this core area has been associated with high densities of Pine Marten (Sheehy & Lawton, 2014), which may help to explain how frequently it was recorded here. Pine Marten is once again coming under pressure as it causes problems for keepers of game birds and chickens, and can also den in attics of domestic dwellings. Vincent Wildlife Trust, in association with the National Parks and Wildlife Service, is providing advice and information to people affected through a dedicated website www.pinemarten.ie, in an effort to mitigate the problems without resorting to controlling the animal directly.

4.1 Ulster

There was a large increase in the number of records received for Ulster between the 2012 survey (639 records) and the current survey (1008 records). As a result the number of records for all three animals increased. This is due to the collaborative nature of the work between researchers on both sides of the Irish border. The Grey Squirrel population has undergone a noticeable northward contraction, and has disappeared from counties Cavan, Monaghan and Fermanagh, areas in which it was previously common. There is a clear delineation between Red Squirrel and Grey Squirrel in Ulster, with Grey Squirrel being the dominant squirrel species across the north in Co. Derry, Co. Antrim and northern parts of Co. Down, Co. Donegal and Co. Tyrone. Red Squirrel is the more common squirrel in other parts of Ulster, in particular Co. Fermanagh, south Co. Down, Co. Cavan and Co. Monaghan. There are signs that Red Squirrel has disappeared at a local level in some parts of north Co. Derry and the Inishowen peninsula, and these parts may be suitable as the focus of future conservation work in the north by the local squirrel conservation groups. The presence of Grey Squirrels in the wider Foyle catchment extending into west Co. Tyrone and east Co. Donegal is concerning, with the species present within less than 25 km of the western seaboard; these areas could be the target of future cross-jurisdictional conservation activity.

In 2012 there was a northeast-southwest divide across Co. Fermanagh between the two species, separated by Upper and Lower Lough Erne, but by 2019 the Grey Squirrel had retreated from all parts of the county and has been replaced by the Red Squirrel. The Pine Marten distribution across Ulster is very similar to that of the Red Squirrel, and again shows a strong negative correlation with that of the Grey Squirrel. There is a strong population of Red Squirrel in north Co. Antrim, where the Grey Squirrel is anomalously less common, and this could be related to the conservation work conducted in the region by the Glens Red Squirrel Group (Figure 8). Grey Squirrel density in the greater Belfast area is very high, with many records from Northern Ireland centred on the city.

4.2 Leinster

The province of Leinster, in which the Grey Squirrel was introduced and has historically thrived (Barrington 1880; O'Teangana *et al.*, 2000) is now the site of a large reduction in Grey Squirrel distribution and abundance. The contraction of the Grey Squirrel distribution in the midlands has continued and accelerated since the 2012 survey. Grey Squirrel records in Leinster decreased overall from 465 (2012 survey) to 374 (2019 survey), however if records from Co. Dublin are excluded, the decrease is even more stark (from 315 to 172 records). No records of the previously invasive species were received from Co. Laois, Co. Longford or Co. Westmeath, and only one was received from Co.

Offaly, meaning the species is functionally absent from much of the province. Numbers in other counties (such as Co. Kilkenny and Co. Meath) are significantly reduced as well. Co. Meath was previously the focus of a study into Grey Squirrel damage (Lawton 2003) and control programmes (Lawton 1999), and during the 1990s had a very large number of Grey Squirrel, with regular control having very little impact on the population. Details were gathered of Grey Squirrel culled in one estate, Mountainstown House, during the 1990s (Figure 16). The number of squirrels removed varied considerably year on year, but ranged from 20 animals in 1990 to 95 in 1996 (Lawton 1999). On visiting the estate during the current survey, survey members were informed that Grey Squirrel had not been seen on the estate since 2014, with the numbers noticeably declining since 2004 (Atalanta Pollock, pers. comm.).

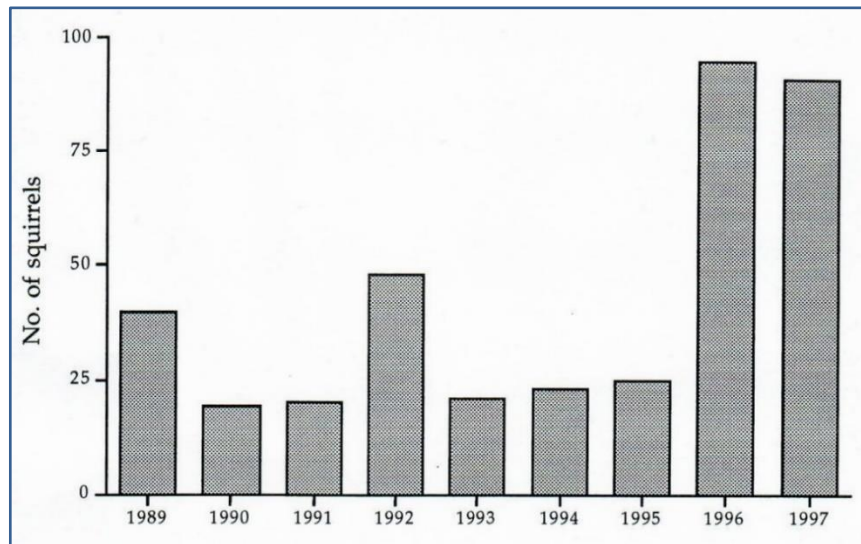


Figure 16 Number of Grey Squirrel killed annually in Mountainstown House woods, Co. Meath (75 ha), using identical removal effort each year (from Lawton, 1999).

In addition to the reduction of Grey Squirrel in the midlands, the distribution gap in Co. Wicklow, which was noted in 2012, has expanded and a new gap has appeared in Co. Wexford. In Co. Wicklow, Grey Squirrel sightings are mostly limited to the coastline, with a few isolated inland sightings in the southeast of the county and around the borders. The Grey Squirrel continues to thrive however in Co. Dublin. Grey Squirrel is noted for its ability to live in urban woods and parkland (Parker & Nilon, 2008) and these habitats are unlikely to be invaded by Pine Marten.

The continued recovery of the Pine Marten in Leinster provides further evidence of the negative correlation between it and Grey Squirrel. The number of records of Pine Marten from Leinster increased dramatically since the previous survey. This may in part be due to an increase in public awareness and recognition of the animal, but clearly indicates a strong abundance particularly in the expanding core area.

Red Squirrel continues to return to areas of Leinster from which it had been extirpated by the Grey Squirrel. The number of records increased in every county apart from Co. Wexford, with the number of sightings in Co. Wicklow, Co. Offaly, Co. Laois, Co. Kilkenny, Co. Westmeath, Co. Longford and Co. Carlow increasing by at least 58% each. The recolonisation of Co. Westmeath, a county in which Red Squirrel was only present in patches previously, is indicative of the ability of the species to recover the ground lost to the Grey Squirrel. The Red Squirrel can survive alongside the Pine Marten as reported previously (Sheehy & Lawton, 2014). The Red Squirrel remains absent from parts of the province, in particular parts of Co. Meath, Co. Louth and Co. Dublin, areas where the Grey Squirrel persists, or has only recently disappeared. At present neither species is found in large parts of Co. Meath.

4.3 Connacht

Connacht has long been the focus of interest in the fortunes of Red Squirrel given its generally Grey Squirrel-free status and the strong populations that have been typical of the previous surveys. The River Shannon had been seen as the barrier preventing incursion of greys into the west, however more recent studies have shown that the available habitat and the core populations of Pine Marten have combined with the river barrier to keep the Grey Squirrel out (Flaherty & Lawton, 2019). In previous surveys occasional individuals of Grey Squirrel were recorded west of the Shannon, but crucially none of these had become established populations. In the current survey, there were no validated records of Greys Squirrel in the west. In fact, there were only two records of Grey Squirrel within 20 km of the east bank of the river, suggesting that the possibility of the Grey Squirrel spreading into the west is even more remote than previously. Flaherty (2016) modelled potential Grey Squirrel spread into the west and highlighted a series of 47 woodland sites in the counties either side of the Shannon that should be used for future monitoring of potential Grey Squirrel spread or establishment in the area. Although the Grey Squirrel persists in one of these sites in each of Co. Cavan and Co. Offaly, and in some sites in south Co. Tipperary, it is not recorded in any of the sites close to the Shannon.

Red Squirrel sightings in general were consistent with records in 2012, except for a substantial drop in Co. Sligo. A similar drop was seen in records of Pine Marten in Co. Sligo, and may reflect poorer regional participation in the current survey than previously. Like the other counties in the region, Grey Squirrel was not recorded. There is an indication that the Red Squirrel range has expanded into an area in north-western Co. Roscommon, an area in which there were no Grey Squirrel in 2012 (Lawton *et al.*, 2015). Red Squirrel was recorded both by sightings and in follow up non-invasive monitoring at the sites of previous Red Squirrel translocations in Derryclare, Co. Galway and Ballina, Co. Mayo (Poole & Lawton, 2009; Waters & Lawton, 2011). These populations have continued to survive 14 and 12 years, respectively, after the initial introduction of animals to the forests. There are also indications in Co. Mayo that Red Squirrel has spread from the point of reintroduction; this is part of the focus of a current ongoing study.

The status of the Pine Marten also remains relatively unchanged since 2012. More records were received of the Pine Marten in Co. Galway, Co. Mayo and Co. Roscommon, but the number of sightings dropped in Co. Sligo as mentioned above. Once again its distribution overlaps considerably with that of the Red Squirrel, and the Pine Marten does not appear to have any negative impact on the native squirrel.

4.4 Munster

The number of Grey Squirrel sightings in the current survey decreased considerably from 2012, with previously strong populations in Co. Limerick, Co. Tipperary and Co. Waterford now seemingly much reduced. In particular Grey Squirrel has disappeared from north Co. Limerick and the centre of Co. Tipperary. Incongruously it appears to have spread further into Co. Cork and was recorded in Co. Kerry for the first time. This appears to be a continuation of its spread as an invasive species. However, previous spread was characterised by individuals being recorded through citizen science, with a 'wave' of populations becoming established behind the advancing frontier (Goldstein *et al.*, 2014). In the current survey, individual records ahead of the previous known distributions are not backed up by nearby established populations. It should be noted however that these new sightings are well beyond where the predicted frontier was expected to be in models conducted by Goldstein *et al.* (2016). It is important that this situation is monitored in the coming years to determine if the expansion becomes established or represents occasional migrants only.

This trend of southwestern expansion of the Grey Squirrel range may threaten the historical stronghold for Red Squirrel that has existed in Munster. There also remains the threat that the Grey Squirrel could spread to the previously uninvaded west of Ireland by crossing the Shannon near Limerick. However, the presence of high Pine Marten densities in Co. Clare, indicated by a large number of sightings in 2019

and as observed in previous studies, may prevent the establishment of a Grey Squirrel population across the Shannon (O'Mahony *et al.*, 2012; Flaherty & Lawton, 2019). In previous surveys, occasional Grey Squirrel sightings were recorded to the west of the Shannon, without the species becoming established in the region. No Grey Squirrel were recorded in 2019 in Co. Clare, or any other part of the west (see above). The possibility of Grey Squirrel spreading into the Red Squirrel stronghold to the west is remote, but vigilance and continuous monitoring are required.

Pine Marten distribution and number of records are very similar to that of 2012, with strongholds remaining in the northeast of the province. It remains especially common in Co. Clare, which represents part of the core range of the native predator (O'Mahony *et al.*, 2012). The scattered sightings in Co. Limerick, Co. Kerry and Co. Cork indicate it is present here at a lower density than in its core area. This low density may be insufficient to prevent the continued Grey Squirrel southwestern spread, as the negative correlation between the two species has generally been seen in areas with a high Pine Marten density (Sheehy & Lawton, 2014).

The Red Squirrel status in Munster remains relatively unchanged since 2012. The species continues to be common and widespread throughout most of the province, apart from areas with limited suitable habitat such as the Co. Kerry peninsulas and the southwest of Co. Clare. Two hundred and eleven records of Red Squirrel were received from Co. Cork, the highest on the island, and a 47.6% increase on 2012. It was very commonly seen, particularly in woods around Cork city.

5 Conclusions

The recorded contraction in Grey Squirrel range noted in the 2012 survey has accelerated with Grey Squirrels disappearing from up to 38% of hectads they were previously recorded in. It is no longer present over much of the longest established range, and is now concentrated along the east coast, southeast and the north of Northern Ireland. Large numbers of Grey Squirrel records were received from the urban and suburban areas of Dublin and Belfast, and so in these parts at least that it is expected to persist in Ireland. The Grey Squirrel is still present in parts of Co. Donegal where it was noted to have expanded in 2012, but has not spread further. In the southwest, occasional sightings were received much further advanced than expected based on previous records. Nonetheless, the lack of a strong population behind this advancing front suggests that the spread of Grey Squirrel may not be as invasive as experienced in other parts of the island.

Red Squirrel is found in every county, and the number of records has continued to increase since the previous surveys in 2007 and 2012. The west of Ireland remains a stronghold of the species, however there are several other counties where it is very commonly seen. It was most commonly recorded in Co. Cork and Co. Wicklow, which was previously considered an area where Red Squirrel was under threat, maintains a very substantial Red Squirrel population. It has started to reappear in areas from which it has been absent for a long period of time, however it is still absent from parts of Co. Meath and Co. Louth, although the trend suggests that it may recolonise these areas naturally as well.

Pine Marten continues to return following its previous decline across the island, and is now found in every county, having been recorded on six occasions in Co. Derry, where it were considered absent in 2012. The core range of the Pine Marten, which has been correlated to the demise of the Grey Squirrel, has expanded and now stretches through the west, the midlands, the southeast of Ireland and parts of Northern Ireland. This suggests that the Grey Squirrel may start to further decline in these areas in the coming years.

6 Recommendations

This survey was very effective in gaining verifiable records from members of the public across both jurisdictions on the island of Ireland. Using citizen science to gather records and also, in Northern Ireland and Donegal, to conduct non-invasive monitoring ensured very good coverage across the island. Records were received from most hectads in Ireland where substantial woodland cover is available. It is recommended that future surveys of these species or other wildlife should follow this methodology. The work brought together academic research groups and NGOs, bringing several areas of expertise and potential public reach to the project. Working with the database centres of NBDC and CEDaR allowed the project team to use well-established and reliable online recording systems, as well as accessing the knowledgeable and enthusiastic members of the public already recording wildlife regularly on the two websites. By sticking to the Principles of Citizen Science laid out by the European Citizen Science Association we ensured that all members of the project team worked to the same ethos, and that the members of the public who contributed to the study were kept informed of its progress. This commitment will continue into the dissemination of the project findings, after the production of this report. Social media pages, which were an excellent means of keeping the survey live and providing feedback, will be maintained for some months after the project has finished. Following the 2012 survey, the project database was forwarded to NBDC for permanent storage and access by the public, and the same principle continues to this study, with the data already in possession of the two data centres. Media coverage was very good, with boosts from television and radio appearances by project team members both sides of the Irish border. The use of local radio stations in particular allowed focused messages to be delivered depending on the region in question.

The Red Squirrel groups that make up the Northern Ireland Red Squirrel Forum are a valuable community resource, where dedicated and interested members of the public can take part in active conservation programmes. Recently a new group was started in Co. Donegal and it is recommended that this network of local groups is rolled out across Ireland. Each group can take ownership of monitoring and conservation in their local area, providing site by site mitigation as required or recommended by the NPWS, and acting as an early warning system if Grey Squirrel was to arrive or Red Squirrel disappear. The sites highlighted by Flaherty (2016) and also the outputs of work conducted by Flaherty & Lawton (2019) and Goldstein *et al.* (2016) should be monitored to see if changes occur and if they follow predicted outcomes.

The revised status of the three species determined by this survey, and the change in the risk category of the Red Squirrel in the latest Red Data list provide a source of relief for those interested in the protection of Ireland's native animals (Marnell *et al.*, 2019). However, there is a concern that this could lead to a perception that no further work is required on these animals. The situation remains dynamic and it may still be necessary to instigate some management measures aimed at controlling Grey Squirrel incursions, or to conserve Red Squirrel or Pine Marten. This requires further monitoring and potential intervention at a local or regional level.

Pine Marten continues to thrive in Ireland, but are the source of some controversy as they can cause problems for gamekeepers, farmers and home owners. The positive aspects of the return of this native species, still under threat in other areas of its historic global range, should be highlighted along with the benefits for the Red Squirrel. The information resource www.pinemarten.ie, jointly produced by VWT and NPWS should be promoted where possible, to ensure the public can access best practice information on protecting their interests.

In 2008, an All-Ireland Red Squirrel Species Action Plan was co-authored by the National Parks and Wildlife Service in the Republic of Ireland and the Environment and Heritage Service in Northern Ireland (NPWS & EHS, 2008). This document contained several conservation actions and recommendations to protect the native squirrel species. Many of these were never acted upon in the changing financial climate after the Action Plan was published. It is recommended that this document be revisited and updated given the changes that have occurred since.

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