



A Study of Hedgehogs in The Regent's Park

May and September 2015



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Working in
partnership with



Executive Summary

The hedgehogs in The Regent's Park are the only breeding population remaining in Central London. In 2014, with the assistance of more than 100 volunteers, detailed, systematic surveys of the hedgehogs were carried out over two intensive study periods, 19-31 May and 5-15 September; the results from these surveys can be found in Gurnell *et al.* (2015). In 2015, the survey work was continued over two further periods, 15–22 May and 4–11 September.

The principal survey method to determine population size and distribution was spotlighting; Primrose Hill, The Regent's University and Park Square Gardens were included in these surveys for the first time in 2015. As in 2014, in each survey period selected individuals were fitted with VHF radio tags/GPS tags to study movement, nest site locations, behaviour and habitat utilisation. In 2015, a new hedgehog marking system using numbered plastic sleeves glued onto spines was used and worked well. Furthermore, two FLIR thermal imaging cameras were trialled during spotlighting and radiotacking surveys and were found to be very effective in detecting hedgehogs up to 60 m away in open habitats and were very useful for behavioural observation.

In September 2015, footprint tunnels and camera traps were deployed in Leafyard Wood in the north of the park to try and understand why hedgehogs appeared to be absent from this seemingly favourable area.

Two additional studies were carried out in 2015 to get a better understanding of whether the population is isolated: a questionnaire survey of residents living in the vicinity of Regent's Park, and a genetic analysis of DNA extracted from samples of spines taken from individuals during the spotlighting surveys (undertaken by the Waterford Institute of Technology, Ireland).

As in 2014, the key to the success of the survey work in 2015 were the volunteers with 168 individuals helping on various activities in May (some on more than one activity), 161 in September and 26 on delivering the questionnaire survey forms. ZSL Veterinary Services again provided essential veterinary support and the Garden Wildlife Health Project also carried out post mortem examinations on hedgehog corpses found in the Park during 2015.

Thirty-three hedgehogs were captured in May 2015, which was similar to the numbers captured in May 2014 taking into account that the Zoo Car Park was not surveyed at that time. However, in contrast to 2014, numbers caught fell to 20 individuals in September 2015, approximately half the number seen in September 2014. Accounting for animals not captured, a crude estimate of population size in September 2014 would be 50 animals, and half this number in September 2015. The reasons for the fewer captures in September 2015 are not known, although there were nine deaths recorded during the summer of 2015 which would have had a considerable impact on this small population. Further, although breeding was confirmed in both summers, only three individuals captured in September 2015 were young, compared with 16 at the same time the previous year. This suggests that recruitment over the summer period in 2015 had been poor compared to 2014. However, a female with three nestlings was found in the Zoo grounds in September 2015, and so some late recruits may have been missed. Most animals were in good condition, and average body weights were good, suggesting the food availability for this small population was adequate.

As in 2014 some areas of the park were little used, particularly the northern end of the park including Leafyard Wood, parts of Cumberland Green and the sports pitches, although there was more activity on the sports pitches in September 2015 than during the previous surveys. No hedgehogs were found on Primrose Hill or in Park Square Gardens (September only). Again, three hot spots were identified: around the boating lake to the west, in Marylebone Green and Avenue Gardens, although relatively fewer animals were found here in September, and the Zoo car park. The hedgehogs in the Zoo car park

comprised ~25% of the total population in The Regent's Park in September 2014, May 2015 and September 2015 and can be considered as a local breeding population critically important to the main population in the park. There is clear evidence that hedgehogs move throughout the vegetated areas of the car park, which are sympathetically managed for hedgehogs by the ZSL Horticultural team, and they use all the habitats for nesting and foraging. There is also evidence that animals move to and from the main park across the intervening road. It is therefore likely that hedgehogs born with the grounds of the Zoo car park would disperse into the main population.

Between June and September 2015 there were 14 known mortalities, considerably more than 2014 when there were five known deaths; this increase in part may be due to better reporting as a result of increased public awareness about the hedgehog project. There are particular concerns about hedgehogs with leg injuries including six which died; these could have been caused by foxes and/or perhaps dogs. No road casualties were reported in 2014, but five were reported in 2015, all on the Outer Circle near the Zoo car park.

Nightly movement patterns of GPS/VHF tagged hedgehogs were similar to those found in 2014 and typical of hedgehog populations elsewhere. Over the four survey periods in 2014 and 2015, on average, male hedgehogs moved 892 m and females 821 m per night. One male in each of the two May survey periods, moved considerably farther than other animals (No.32 1897 m in May 2014; No.167 1934 m in May 2015). The overall mean 95% Minimum Convex Polygon range area for males, excluding the two wide ranging males, was 1.5 ha and for females 2.2 ha. Equivalent figures for 95% kernel ranges were 1.5 ha males and 2.0 ha females. Grassland, other than the sports pitches, was found to be particularly important as foraging habitat. Scrub, planted shrubberies and hedgerows were important as nesting sites.

Preliminary findings from the DNA analysis indicate a lack of genetic diversity within the population maybe as a result of past 'bottlenecking', isolation and/or a small founder population. Eight per cent of the 4,000 questionnaires sent to local residents were returned. There were no recent sightings of hedgehogs within 1 km of the park. Although our surveys did not find any hedgehogs on Primrose Hill one questionnaire return stated that they were present in 1999/2000 but thereafter disappeared. All in all, the evidence strongly suggests that the current population of hedgehogs in The Regent's Park is isolated.

The conclusion from the two years of surveys in The Regent's Park is that the hedgehog population is small, possibly declining and very vulnerable. We have recommended that further surveys be carried out in 2016 and beyond to continue to monitor population size. There should also be a readiness to carry out additional studies or implement measures that may help conserve this important population. This includes habitat management sympathetic to hedgehogs within The Regent's Park. A suite of recommendations were made in the 2014 report (Gurnell *et al.* 2015), and many of these are being implemented. In addition, a trial on whether hedgehog nest boxes would be useful was started in the autumn of 2015 and will continue throughout 2016.

The studies on hedgehogs at The Regent's Park during 2015 have attracted considerable attention in the media, including an item on Springwatch in May. The authors of the report have shared the study findings with peers at various scientific meetings reaching an audience of over 840. Seventeen land managers and 45 ground maintenance staff working in The Regent's Park received practical hedgehog conservation training. Awareness of hedgehog conservation amongst children and families was also raised through hedgehog themed Discovery Days at the Education Centre in Hyde Park and through the production of a popular hedgehog activity sheet which was available at the Regent's Park cafes.

The implications of the plan for the car park to be used as a lorry holding area submitted by HS2 are considered in this report and we conclude that it could pose a significant risk to the hedgehogs living in the Zoo car park and in The Regent's Park as a whole.

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1. Introduction

This study is a continuation of the work begun in 2014 in The Regent's Park to study the last known breeding population of hedgehogs in central London and to provide the data required to develop an evidence-based conservation strategy for this important but vulnerable population.

A full account of the work so far is given in *A Study of Hedgehogs in The Regent's Park, London: May and September 2014* (Gurnell *et al.* 2015) which also provides a review of the ecological requirements of hedgehogs, the status of hedgehogs in the UK and in The Regent's Park. In summary, there is strong evidence that hedgehogs are in serious decline in Britain (Hof, 2009; Wembridge, 2011; Macdonald & Burnham, 2011; PTES, 2013). New information (PTES, 2015) indicates a continuation of this decline with *Mammals on Roads* and *Breeding Bird Survey* data indicating mean annual losses of respectively 9.1% and 13.7% in rural populations between 2001 and 2014. Less robust data for urban populations are available but the *Garden Birdwatch* (2008-2014) anomalously shows an increase of 3.6% while the *Living with Mammals* survey (reported presence/absence reports mainly from gardens) has shown an overall decline of 30% in the reported presence of hedgehogs between 2003-2014 (Wembridge & Langton 2016) which equates to a mean annual loss of 2.5% that is more consistent with rural trends.

The 2014 study in The Regent's Park (Gurnell *et al.* 2015) established that spotlighting was an effective method for detecting hedgehogs with 27 individuals identified in May and 41 in September. Eleven of the 14 new adults found in September were from the ZSL car park; an area not searched in May. The hedgehogs found were generally in good condition with above average body weights. The presence of 5 youngsters in September confirmed that this was a breeding population. The combined use of VHF radio-tracking and GPS tags revealed the ranging behaviour and nest locations of a total of 16 hedgehogs. Ranging behaviour was generally consistent with other studies of European hedgehogs in terms of both nightly distance travelled (mean 798 m) and the area covered each night (mean 1.79 ha: 95% kernel estimation). These figures exclude one unusually wide-ranging male in May. Nest sites were mainly found in informal shrubberies (75% of nests), although some use of hedge bases and formal shrubberies was also recorded. Regarding foraging habitat, it was found that large areas of open grassland are avoided by hedgehogs but grassland within a fine-scale mosaic of formal and informal shrubberies, scrub and hedges is an important resource.

Gurnell *et al.* (2015) emphasised the vulnerability of such a small hedgehog population and advocated that 'risk to hedgehogs' should be an integral factor in evaluating any management procedures or changes of use. Measures to enhance habitat quality and reduce hazards for hedgehogs in the Park were recommended and that three hedgehog 'hotspots' should be particularly safeguarded i.e. Zone 1 the Avenue Gardens and Marylebone Green, Zone 2 the area around the ZSL car park, and Zone 5 Queen Mary's Gardens and the area around the Boating Lake.

A major success of the 2014 study was the Royal Parks Foundation's productive partnership with ZSL, The Royal Parks and other organisations. The project successfully engaged with the community, recruiting and training over 68 volunteer fieldworkers to help reveal a great deal of new information about this previously unstudied hedgehog population.

2. Aims of the 2015 project

The principal aims of the 2015 project build upon the conclusions and recommendations of the 2014 report (Section 8, Gurnell *et al.* 2015):

1. To continue spotlighting surveys to provide systematic counts of hedgehogs in both May and September 2015 (pre- and post-breeding) and to determine the distribution and population size of hedgehogs in the Park. Repeated annual surveys will be needed to monitor the population. Survey areas in 2015 should include areas not surveyed in 2014: Primrose Hill, The Regent's University and Park Square Gardens.
2. To study the genetic diversity and level of spatial isolation of The Regent's Park hedgehog population. Additional survey work will seek to establish the presence or absence of hedgehogs in nearby green spaces and whether or not there may be viable links to these areas, such as Primrose Hill.
3. To carry out more detailed behavioural observation of VHF radio-tracked hedgehogs to determine more precisely which habitats they use for foraging and nesting.
4. To trial the use of new field techniques including the use of thermal imaging cameras to detect and observe hedgehogs unobtrusively in the field and the use of a new identification marking system using numbered plastic sleeves attached to the spines.
5. To record sightings of foxes and other wildlife during nocturnal fieldwork.
6. To continue to work with ZSL to establish and record the causes of deaths and injuries of hedgehogs found in the park.
7. To gather knowledge from local residents and neighbours of the park using a questionnaire survey accompanied by an information leaflet inviting them to contribute information on local hedgehog sightings and other relevant information.
8. To raise awareness of hedgehog conservation using a variety of media. To produce information leaflet about the hedgehogs of The Regent's Park for the general public and develop educational materials and activities for young people. Also to disseminate the study outcomes to a wider audience, including ecology and land management professionals
9. To provide training for land management staff and volunteers. To support the managers of The Regent's Park in the implementation of habitat management recommendations (Appendix 14 and 15) to help conserve hedgehogs across the whole park; especially in the 'hotspots' identified.
10. To continue our successful work with our partners to engage volunteers, the local community and other stakeholders in the project in positive action to benefit the conservation of hedgehogs and other wildlife in the parks and urban environment.

3. A partnership project

The Regent's Park Hedgehog Research Project has been made possible thanks to a generous gift from The Meyer Family. This project has been a very successful partnership between the following organisations and individuals.

Royal Parks Foundation is the charity that helps to support London's eight Royal Parks. The charity reaches out to make the Parks part of more people's lives and raises funds for a wide variety of heritage, education, wellbeing and nature conservation programmes (registered charity 1097545). The charity delivers a wide ranging and accessible outdoor education programme at the Isis Education Centre in Hyde Park. The schools programme for primary and secondary schools is linked to the National Curriculum, and there is a year-round programme of informal activities for individuals and groups to join, from guided walks to hands-on sessions. The charity acted as the Hedgehog Research Project lead and provided the management and resources required to coordinate and deliver the fieldwork; recruit, train and manage the volunteers.

The Royal Parks welcome almost 78 million Londoners and tourists each year. The more than 2000 hectares of historic parkland provide opportunities for enjoyment, exploration and healthy living in the heart of London. London's eight Royal Parks are: Bushy Park, The Green Park, Greenwich Park, Hyde Park, Kensington Gardens, The Regent's Park and Primrose Hill, Richmond Park and St James's Park. The Regent's Park and Royal Parks Ecology Unit worked particularly closely on this project providing planning guidance and logistical support for the fieldwork periods.

The Zoological Society of London (ZSL), founded in 1826, is an international scientific, conservation and educational charity whose mission is to promote and achieve the worldwide conservation of animals and their habitats. Their mission is realised through their ground-breaking science, active conservation projects in more than 50 countries and two Zoos, ZSL London Zoo and ZSL Whipsnade Zoo. ZSL provided vital veterinary support during the two weeks of fieldwork in May and September. The Horticulture Manager also kindly provided guidance, volunteer support and access to the zoo grounds which enabled this 15 ha of Regent's Park to be included in the survey.

The Garden Wildlife Health (GWH) project (www.gardenwildlifehealth.org) is co-ordinated by ZSL's Institute of Zoology in partnership with the British Trust for Ornithology, Froglife and the Royal Society for the Protection of Birds. GWH conducts disease surveillance on free-living populations of garden bird, hedgehog, amphibian and reptile across Great Britain.

Dr Nigel Reeve, BSc, PhD, PGCE, MCIEEM. Dr Nigel Reeve studied zoology for his BSc and obtained his PhD by researching hedgehog ecology; both at Royal Holloway College, University of London. Having completed a PGCE at Garnett College (London), from 1982 to 2002 he taught and researched at Roehampton University and in 1994 published a monograph Hedgehogs in the Poyser Natural History series. From 2002 to 2013 he worked as Head of Ecology for The Royal Parks. Nigel Reeve has provided invaluable expert guidance in the planning, delivery, training, fieldwork and interpretation of the results of this hedgehog research project. He is a co-author of this report.

Professor John Gurnell, BSc, PhD. Emeritus Professor of Ecology, Queen Mary University of London. John Gurnell has carried out research on the ecology, behaviour, genetics, management and conservation of mammals, including methods of study, data analyses and modelling. He is especially interested in forest management, reintroductions and translocations as conservation tactics, modelling mammals in relation to management and disease, and the health and welfare of wild and captive animals. John Gurnell has provided invaluable expert guidance in the planning, delivery,

training, fieldwork and data analysis of this hedgehog research project. He is a co-author of this report.

The People's Trust for Endangered Species (PTES) is a UK conservation charity created in 1977 to ensure a future for endangered species throughout the world. Working to protect some of the most threatened wildlife species and habitats; it provides practical conservation support through research, grant-aid and educational programmes, including wildlife surveys, publications and public events. PTES coordinates an annual National Hedgehog Survey and an awareness campaign called Hedgehog Street aimed at ensuring the hedgehog remains a common and familiar part of British life. PTES provided expert guidance with regards to footprint tunnel work and footprint recognition.

The Central Royal Parks Wildlife Group brings together amateur and professional naturalists and ecologists who share an interest in the range of wildlife which survives within the Central Royal Parks, and promotes wildlife-friendly management alongside other priorities for the parks. The Group originally identified the need for a hedgehog survey in The Regent's Park and subsequently provided guidance and volunteer support in the field.

Untyped. All data for this project were collected and hosted on Cartographer (<http://cartographer.io>), a cloud-hosted service for crowd-sourcing environmental data. Cartographer allows environmental groups to collect data from volunteers and display it using custom maps and charts. The software has been developed by Untyped (<http://untyped.com>), who kindly provided the project with custom set up and support.

The volunteers. The fieldwork was supported by a team of more than 100 fantastic volunteers consisting of individuals with a wide range of backgrounds but sharing a keen interest in wildlife and conservation. A number of experienced volunteers acted as Volunteer Supervisors, leading small teams in the field during the fieldwork.

The Regent's Park Hedgehog Research Management Team was formed involving representatives from each organisation which met every two months or so to review progress and discuss plans.

4. Survey design

4.1 A science-led, community-based research project

This project was carried out under licence from Natural England; licence n° 2015-7158-SCI-SCI. As during 2014, five complementary survey methods were used to gather as much information as possible about the hedgehog population in The Regent's Park and reveal different levels of detail about their ecology and behaviour.

This approach involved a very resource-intensive programme of fieldwork which relied on the recruitment of a dedicated volunteer team.

The survey methods in 2015 included:

1. Footprint tunnels - placed only within Leafyard Wood in order to check for presence of hedgehogs in this area which proved difficult to survey using spotlighting.
2. Spotlighting - surveyors systematically searched for hedgehogs throughout the park for 2-3 hours after dusk on specific days to detect hedgehogs and hand capture, mark and release selected individuals. Some survey groups used a thermal imaging camera to improve searching efficiency.
3. GPS tracking - GPS packs were fitted to selected hedgehogs to get a broad picture of habitat use over a week.
4. Radio-tracking – VHF radio tags were also fitted to these selected hedgehogs and, using radio receivers and aerials, were located and followed over periods of 3-6 nights to assess foraging and feeding movements. Observations were normally aided with a thermal imaging camera.
5. Camera trapping – camera traps were set up in association with the footprint tunnels to record the presence and behaviour of hedgehogs, foxes or other animals.
6. Residents questionnaire – this consisted of a survey of residents surrounding Regent's Park asking for reports of hedgehog sightings within 1km of Regent's Park.

Recording forms for each survey method can be found in Appendix 2. Further details of the methods are presented below and an equipment list is included in Appendix 1.

4.2 Division of The Regent's Park into survey zones

Regent's Park covers over 160ha. In order to conduct a systematic search of the entire park, the project management team divided the park into eight zones based on the knowledge of the Park managers and wildlife officers.

Although excluded in 2014, Primrose Hill (Zone 8) was included in the survey areas in 2015 despite the lack of recent hedgehog sightings there. The availability of a thermal imaging camera to augment normal spotlighting improved the likelihood that presence/absence could be more conclusively established.

Areas of the park not managed by the Regent's Park team include Winfield House, Regent's University London, The Holme, Capel Manor College, Park Square Gardens and St John's Lodge. Access to the Regent's University was granted during 2015 and it was included within Zone 1a. Access to Park Square Gardens (Crown Estate) was also granted for spotlighting in September and included in Zone 1b. Access was permitted to Winfield House on Thursday 10 September and to the Open Air Theatre (OAT) if necessary for finding radio-tracked animals.

The Project Team was based at the Old Ironworks buildings, just on the Inner Circle in May, and the ATC training room in the Stockyard during September. These acted as 'Hedgehog Headquarters' and provided a safe place to meet, greet and train volunteers and for equipment to be stored.



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Figure 4.1 Aerial view of Regent's Park showing boundaries of the 8 survey zones and walk routes (dashed lines). Areas shaded yellow had limited access or no access (The Holme, St John's Lodge). OAT=Open Air Theatre.

4.3 Survey timings

As in 2014, two intensive periods of fieldwork took place, in May and September:

- 15 – 22 May 2015 - after the hedgehogs had woken up from hibernation and become sexually active.
- 4 – 11 September 2015 - after breeding and prior to hibernation when both sexes were still active. Any young would be from this year and litters would not be disturbed in their nests.

A Hedgehog Questionnaire was also delivered to residents living around Regent's Park in July 2015.

4.4 Volunteer involvement

A team of volunteers were recruited to carry out the five survey methods. These volunteers worked alongside the project team supervisors to complete all required activities on each survey day and record the data captured.

The volunteers were key to the fieldwork's success and together with the project supervisors worked a total of 1,660 hours (207 8-hour days) over the May, July and September survey periods (Table 4.1).

Table 4.1 Volunteer and supervisor hours worked on the hedgehog survey in May, July and September 2015. NB: Some volunteers and supervisors worked across multiple activities.

Month	Activity	Number of volunteers per activity	Volunteer hours in the field	Number of supervisors per activity	Supervisor hours in the field
May	Spotlighting	63	283.5	22	99
	Day nests	15	22.5	9	13.5
	Morning radio-tracking	21	45	6	13.5
	Evening radio-tracking	47	164.5	13	45.5
	Night radio-tracking	22	66	6	18
	Sub total	168	581.5	56	189.5
July	Questionnaire delivery	26	65	2	10
	Sub total	26	65	2	10
September	Spotlighting	60	300	18	90
	Day nests	22	44	11	22
	Morning radio-tracking	18	49.5	7	19.25
	Evening radio-tracking	40	140	15	52.5
	Night radio-tracking	18	58.5	8	26
	Footprint tunnels + camera traps	3	6	3	6
	Sub total	161	598	62	215.75
2015 TOTAL		355	1244.5	120	415.25

4.4.1 Volunteer recruitment, management and retention

In order to capture peoples' imaginations and to motivate the team, the volunteers were referred to as 'Hedgehog Heroes'. A volunteer recruitment pack was produced and shared by email to previous volunteers, groups known to the Foundation and other recommended contacts. Interested volunteers then submitted application forms by email to the Royal Parks Foundation Volunteer Manager who liaised with them closely throughout the project.

Volunteers were recruited from a number of sources – 102 in May, 26 in July and 82 in September (Table 4.2).

Table 4.2 Recruitment sources of the individual 2015 volunteers in May, July and September 2015
NB. Fewer volunteers were needed for the September survey as we limited the number of volunteers needed for the evening radio-tracking sessions.

Recruitment Source	May-15	Jul-15	Sep-15
Repeat volunteers	41	17	52
ZSL	23	0	15
PTES / Hedgehog Street	15	0	3
Friends or family	14	3	2
RPF	7	0	0
The Royal Parks	2	0	0
Springwatch	0	6	6
Land Manager training	0	0	3
CRPWG	0	0	1
TOTAL	102	26	82

The Royal Parks Foundation Volunteer Manager kept in close contact with the volunteers throughout the project. Volunteers

- received regular email updates
- had the opportunity to attend a training workshop
- were involved in a real life scientific research project
- had the opportunity to handle a hedgehog
- were provided with refreshments during the survey nights
- were invited to thank you drinks in May and October
- received a thank you hedgehog pin badge at the end of the project
- were supplied with reference letters where requested
- were given the opportunity to buy a specially-designed range of 'Hedgehog Hero' clothing

The feedback from the volunteers was excellent and the project fostered a real sense of community and willingness to stay involved in other wildlife research projects in the Parks.

"I just wanted to say thank you for the experience. I really enjoyed taking part and I thought your organisation of so many volunteers and shifts was amazing! I will be interested to hear all the results and would love to be involved again." – Katy, Hedgehog Hero 2015

“I wanted to thank you too. It's great to be part of this initiative and also be able to learn new skills. The surveys were very well organised and at all times I knew what I was doing and why. Happy to help out in September.” – Steph, Hedgehog Hero 2015

4.4.2 Volunteer training

In order to promote best practice in the field, to ensure that the hedgehogs' welfare was a priority at all times and foster a good team spirit, two volunteer training sessions were held in The Regent's Park led by the project team and our scientific advisors.

The aims of these sessions were to:

- Brief the volunteers on the research programme as a whole
- Update on 2014 survey results
- Introduce the core project team and partners
- Demonstrate the techniques and field equipment available and allow time for practice
- Outline the welfare facilities available and run through the risk assessment
- Say thank you to all the volunteers
- Build a sense of common purpose and team spirit

Two training session options were offered to the volunteers ahead of the May survey. As there were so many repeat volunteers in September, only one session needed to be held. The May training sessions were at the Old Ironworks Buildings in Regent's Park on the following dates:

Saturday 25 April: 10:00 – 13:00

Wednesday 6 May: 18:00 – 21:00

The September training session was held in a Capel Manor College classroom on:

Wednesday 19 August: 18:00 – 21:00

A comprehensive volunteer survey guide was produced for each survey period (Appendix 3).

The main contents of this pack were:

- | | |
|-------------------------------|-------------------------|
| 1. Project Summary | 10. Volunteer kit list |
| 2. About hedgehogs | 11. Risk assessment |
| 3. Survey activities overview | 12. Hedgehog HQ |
| 4. Key dates | 13. Emergency Procedure |
| 5. Survey Zone Maps | 14. Travel |
| 6. How to handle a hedgehog | 15. Key Contact Details |
| 7. Hedgehog marking system | 16. Project Partners |
| 8. Hedgehog first aid | 17. How-to-guides |
| 9. Data Management | |

These survey guides were distributed to the volunteers at the training sessions as part of their volunteer 'pack' along with a lanyard with key contact information, Regent's Park out of hours access map, risk assessment and how-to-guides. When volunteers arrived at the training session they were also asked to sign a medical release form and a photograph and film footage release form.

Feedback from the volunteers about the training days was excellent:

May:

"Depth of knowledge that the team has about the subject being delivered very effectively with humour, as well as 'sound science' principles", "Friendly and clear explanations and good introduction to the survey", "Very interesting and informative, thanks!", "What did you like best about the workshop? Pictures and stuffed animals courting!", "I feel really ready for my activities"

September:

"Interactive and friendly, great content covered", "Great workshop and super excited for September!!", "All information and presentations were great", "Really great to meet other people and see the impact of the activity"



Figure 4.1 John Gurnell teaching the volunteers how to use the radio-tracking equipment



Figure 4.2 Half of the May Hedgehog Heroes!



Figure 4.4 The May Hedgehog Heroes in training



Figure 4.3 The September Hedgehog Heroes in training

4.4.3 Supervisor training

Given the 2015 plan to carry out all night field work sessions, the number of trained supervisors needed to cover the shifts and lead groups of volunteers had to be increased. To do this, a number of 2014 volunteers who had shown good field work skills were invited to receive additional supervisor training for the 2015 sessions. All those who were asked accepted the invitation.

One training session was held for all supervisors, the aim of this session was to:

- Brief the supervisors on the research programme as a whole
- Update on 2014 survey results
- Introduce the core project team and partners
- Demonstrate the techniques and field equipment available in detail
- Carry out practical field work practice, e.g. use of thermal imaging camera, sexing and weighing a hedgehog etc.
- Run through the proformas to be completed for each activity
- Outline the welfare facilities and the supervisors role to ensure volunteer safety
- Build a sense of common purpose and team spirit

This supervisor training was held in the ATC training room, The Stockyard, Regent's Park on **Wednesday 22 April: 18:00 – 21:30**



Figure 4.4 Supervisors in desk training

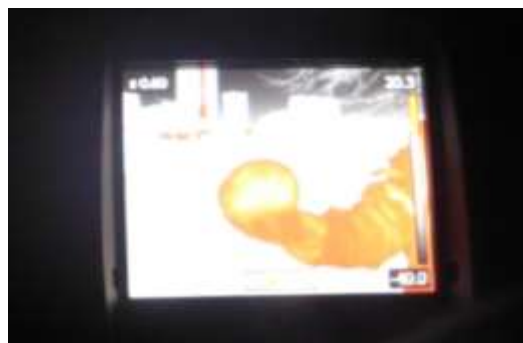


Figure 4.5 Supervisors tested the thermal imaging cameras in the field

4.5 Personnel Health and Safety

Volunteers' and supervisors' health and safety was of paramount importance to the programme and a risk assessment was produced by the Royal Parks Foundation, signed off by the Park Manager and distributed to everyone involved within their volunteer pack (Appendix 4) at the training sessions. A number of measures were put in place to reduce the main risks involved:

1. Volunteers would always work in a minimum group size of two so they were never alone in the Park.
2. A project supervisor from the core team was always on site in Regent's Park when volunteers were there.
3. Hi-vis jackets were provided to volunteers so they could be easily seen in the Park
4. At night time, individual LED torches were provided to each volunteer for use when walking around the Park.
5. Personal lanyards, which had a card with the projects key contact information including the Regent's Park Duty Sergeant and the emergency procedure, were given to each volunteer.
6. Gloves and goggles were provided for handling hedgehogs.
7. Hand sanitiser was provided for after handling hedgehogs.
8. All equipment was checked regularly, well maintained & any broken equipment disposed of.
9. When night time and morning shifts started or ended after the last tube, volunteers who didn't have access to their own transport were provided with a taxi ride home.
10. Spare warm clothing was kept at Hedgehog HQ.
11. A separate risk assessment and FAQs were produced for delivery of the local residents questionnaires.

The Parks police were informed of the survey dates so they knew volunteers would be on site after the Park had closed. An emergency procedure was also put in place and outlined in the volunteer briefing pack.

4.6 Veterinary support

The Veterinary Services team at ZSL, as key partners to the project, were again on standby during both periods of fieldwork in May and September 2015.

A veterinary surgeon or veterinary nurse accompanied the volunteers in the field on the two spotlighting nights during the fieldwork week in case any hedgehogs were found to be visibly unwell or injured. These animals would be taken to the ZSL hospital where all necessary care would be provided.

On the other survey nights, and in fact throughout the whole year, if anyone were to come across an injured hedgehog, it was agreed that it would be taken to the ZSL hospital.

A set of broad principles about how to handle the injured hedgehogs were agreed between the partners.

1. The welfare of the animals was paramount at all times.
2. The preferred option was always to treat an animal's injuries where possible and release it back into the Park.
3. If an animal could be treated but not released back into the Park due to the nature of its injuries, and it was felt that if it could have some quality of life in a captive setting, then intervention was the agreed option. E.g. operating on or amputating a hind leg. Contingency funds for treating these animals were set aside.
4. If an animal's injuries were so bad that it could not be treated, then it would be euthanased.

A very experienced hedgehog carer, Sue Kidger, kindly agreed to care for and rehabilitate any hedgehogs that would need long term or specialist care at a dedicated hedgehog unit in her own home.

Any hedgehogs found dead or euthanased from The Regent's Park were submitted to the Garden Wildlife Health (GWH) project based at ZSL's Institute of Zoology. GWH vets conducted a detailed post-mortem examination on the animal, where possible, established a cause of death and also recorded significant underlying conditions. A full tissue archive was retained from each case for further studies as required (Appendix 10).

4.7 Data management

Data were collected by hand in the field using template recording forms for each survey method (Appendix 2). All the data were then inputted into Cartographer by the scientific advisors. For reasons of consistency, the volunteers were not involved with any data entry.

Volunteers were encouraged to take photographs of the hedgehogs to aid with identification, and in particular any distinctive features. Photographs of nest locations and general fieldwork activity were also taken. The volunteers then uploaded all the photographs onto Dropbox – an online service that allows the sharing of files, photos and videos. Details of how to use Dropbox were sent to all volunteers before the started.

4.7.1 Cartographer

The Cartographer software is a field data management system for environmental groups. A bespoke Cartographer web application was created in 2014 capable of collecting, storing, processing and displaying all the data from the hedgehog project.

Although this software worked well for the project in 2014, a number of updates were made early in 2015 to fine tune the system. This included changes to the classification of habitat types and the recapture status of individuals.

4.8 Data analyses

The position of study zones and location of hedgehogs as determined by direct search (spotlighting), Radio-tracking and GPS tracking have been presented on Google Earth maps. Survey data recorded on Cartographer have been analysed with Excel, Xlstat and Minitab software. Movement, home range size and habitat analysis have been carried out using Ranges 9 (Anatrak Ltd.). Two measures of home range size have been used here for direct comparison with the literature, 100% and 95% (i.e. excluding 5% of the outermost locations) simple minimum convex polygons (MCP) and 95% probabilistic kernel methods (e.g. Worton, 1989; Wauters et al., 2007). The MCP method measures the home range area as that bounded by the smallest convex polygon that contains all locations. Kernel methods assume that an individual uses space as described by a bivariate probability density function, called the utilisation distribution (a three dimensional probability map with the vertical axis representing which parts of the home range are used most frequently). The area bounded by the 95% isopleth (contour) gives the 95% probability of finding (locating) the animal within that area (Figure 4.4). Home range areas have been presented in hectares. Body weight, distance and home range data were normally distributed and have been analysed using Analysis of Variance.

5. Survey Methods

5.1 Spotlighting

Spotlighting consisted of systematic nocturnal searches (using designated routes) within seven selected zones of the park and within ZSL (Figure 4.1) to locate hedgehogs with the aid of bright torches (LED Lenser P7.2, brightness up to 320 Lumens). Searching also involved listening for the rustles in undergrowth, or the noises made during courtship or fighting. As hedgehogs ‘freeze’ when they hear the sounds of a potential predator approaching, fieldworkers were instructed to minimise conversation, walk quietly on grass or bound surfaces where possible and wear rustle-free clothing. Two spotlighting groups had the use of a FLIR E60 thermal imaging camera (see below).

On the two main Friday survey nights in May and September. Teams of 4-5 volunteers plus one supervisor were sent to each zone and given a set route to walk around. The volunteer tasks involved:

- Searching for the hedgehogs
- Recording the data captured for any hedgehog found on a proforma
- Assisting the supervisor with sexing, weighing, checking and marking the hedgehog
- Taking photographs of the group or hedgehogs found

The protocol was for groups to spread out but to follow the route at a steady slow rate, pausing briefly every 20 metres or so to listen for sounds. Walking closely to the edges of hedges or borders allowed the searchers to listen for sounds in the undergrowth whilst also scanning the torch across open grassland where hedgehogs were easy to spot. Location records from spotlight searches will inevitably be biased towards open habitats. Experienced searchers will also find hedgehogs in undergrowth but will be less effective where there is background noise such as that from wind or traffic or when walking on noisy surfaces.

Spotlighting is a simple, effective and low disturbance way to locate hedgehogs for identification marking, gathering biometric data and attaching VHF or GPS tags. Data were recorded on the Spotlighting Proforma (Appendix 2a).

In 2014, identification marking was carried out using a system of marking the spines with colour combinations of 5-10mm lengths of coloured plastic (polyolefin) electrical sleeving glued over 5 individual spines in each of one or more areas of the dorsal pelage. For the marking scheme see Appendix 3 of the 2014 report. The plastic sleeving was filled with superglue and fitted over the spine leaving the sharp tip protruding; so the spine remained fully functional (Figure 5.1). Such marks last longer and are more visible than paint but are not permanent and will eventually moult away. However, as spines can have a life of up to 18months (Reeve, 1994) it was judged that marks would certainly last for the duration of each sampling period and likely that at least one colour marker per patch would remain for the period of slightly over 3 months between the end of May and early September. In May and September 2015 there were recaptures of marked animals, demonstrating the durability of this marking system; although not all were individually identifiable.

In 2015, in order to increase the reliability with which individuals could be identified, hedgehogs were marked using a similar system but we used yellow plastic sleeves (1.6mm internal diameter polyolefin sleeving) bearing pre-printed numbers¹. This is an adaptation of a method (using hand-drawn numbers) first used by Wroot (1984). To ensure durability to the printed number, prior to field use, we sprayed the sleeving with a fixative (Perfix Colourless Fixative; Daler-Rowney Ltd). Five duplicate sleeves, each bearing the animal’s identification number, were glued to spines on the crown of the head. This system made individual identification simpler and, with fewer sleeves to be fixed to the

hedgehog, it also reduced handling time. Using this system, an animal would remain identifiable even if only one marked spine remained in the pelage.

Using individual identification marks allowed population size to be estimated as well as persistence in the population between the first and second survey periods.



Figure 5.1 Hedgehog 13 Marked in 2014, a subadult male (600g) found on 5/09/2014 with coloured plastic markers glued on to spines in positions A (crown of head) and C (right shoulder).



Figure 5.2 Hedgehog 152 Marked in 2015 with five yellow numbered plastic markers glued only to spines on the crown of the head.

¹ Printasleeve Ltd Higher Street, West Chinnock, Crewkerne, Somerset, TA18 7QA. 1.6mm internal diameter Polyolefin sleeving.

5.2 Footprint tunnels

No footprint tunnels were placed in the Park in May 2015 as the method did not prove successful in the 2014 survey despite much volunteer effort in both May and September.

However, in September 2015, seven tunnels were carefully positioned in Leafyard Wood in the north west of the park. This is an area which had been very difficult to survey using spotlighting and where hedgehog catches had been very low. It was hoped that the footprint tunnels and camera traps may help detect presence or absence of hedgehogs in this site.

The tunnels were positioned following linear features where possible and in areas where natural paths could occur. Each tunnel was numbered and pegs were used to secure the tunnel to the ground. The minimum distance between tunnels was 15 m. The dried hedgehog food, Spike's Dinner was used as bait, rather than the hot dog sausages used in 2014. The tunnels were in situ for five nights, from Sunday 6 September until Friday 11 September and the paper and bait was changed on Tuesday 8 September with a footprint tunnel proforma completed for each tunnel (Appendix 2c) by two volunteers.

5.3 Camera traps

A camera trap was placed 2-3 m up on a nearby tree pointing to each of the seven footprint tunnels in Leafyard Wood and the memory card changed at the same time as the 'tracks' paper and bait. The cameras used in this survey were the same as in 2014, Bushnell HD Trophy Cameras. They were triggered by movement and on activation set to record videos for 20 seconds, day or night, recording form in Appendix 2d.



5.4 GPS and VHF radio tracking

The GPS tags used were I-gotU travel trackers (A41JF, Maplin, U.K.) modified by Mark Ferryman as described by Stevenson *et al.* (2013) The modified tags weighed approximately 18g and were 42mm x 24mm x 10mm. Once retrieved from the animals the accumulated location data were downloaded from the GPS tags.

In 2015, rather than using a separately-attached VHF radio tag (Biotrack TW5 weighing 13g) we used smaller radio tags (Titley LT5-357, 173MHz, weight 3g: Titley Scientific; UK Distributor, Coppull, Lancashire, England) attached with expoy resin to the GPS packs (see 5.5 below) to make a combined package weighing up to 22g (see Figure 5.9). 'Piggy-backing' the VHF tag minimised the total area required for tag attachment to only the base of the GPS tag and, if the GPS tag should detach, it could be retrieved using the VHF signal.



Figure 5.9 The GPS tag with the smaller Titley LT5-357 VHF transmitter attached. The combined package weighed 22g and was 65mm long (excluding 14cm flexible trailing whip aerial). During field use, waterproof tape covered the operating button in the centre of the GPS tag.

The GPS tag/VHF transmitter packages were glued to the mid-dorsal of a hedgehog by using clippers to cut short an area of spines – leaving them about a third of their original length – in a patch

corresponding to the size of the GPS tag. A fast-setting epoxy adhesive (Araldite 90 seconds) was then applied to the base and sides of the tag which was positioned onto the cut patch and held for at least 90 seconds until firmly bonded as shown in Figure 5.10. At the end of the study the tag was removed by trimming away the spines to which it was glued.

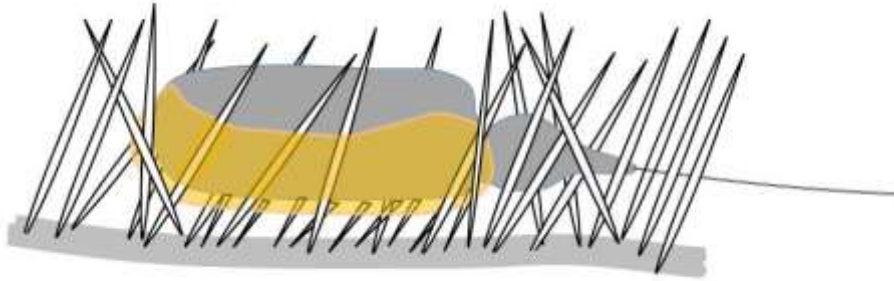


Figure 5.10 Diagram showing, in side view, how the GPS/VHF transmitter tag was glued to the mid-dorsal spines of a hedgehog. The yellow represents the epoxy resin binding the GPS tag to the cut spines under the tag and to intact spines on the sides.

Animals were relocated using either a Sika, TRX or Mariner receiver with a handheld 3-element Yagi aerial. Radio-tracking was used to relocate hedgehogs as required and to retrieve GPS tags from which the accumulated location data could be downloaded, to precisely locate nest sites (Recording form in Appendix 2e) and for behavioural observation of selected animals (Recording form in Appendix 2b). Radio-tracking is the only method that allows individuals to be regularly monitored and their nest sites, foraging areas and interactions with conspecifics to be observed. In 2015 observation of hedgehog activity was assisted with the use of a FLIR E60 thermal imaging camera.

Volunteer support for radio-tracking comprised of 6-9 volunteers available each night plus two supervisors. Depending on the focus for the night and the location of the hedgehogs being followed, the volunteers and supervisors would search for the animals. Once a hedgehog was found, two volunteers were left with the hedgehog to record its behaviour as the rest of the group moved on to find the next hedgehog. If the hedgehogs to be tracked were in different areas of the Park, the volunteers would be split into two groups, each with a supervisor. Again, if a hedgehog was found, two volunteers would remain with the hedgehog whilst the others moved on to find the next hedgehog.

Whilst members of the group were locating the radio signals, the other volunteer members would take the opportunity to carry on spotlighting to look for new, unmarked hedgehogs.



Figure 5.10 A hedgehog with GPS/VHF transmitter tag glued to the dorsal spines.

5.5 GPS tags

In 2014, a static test of the accuracy of GPS tags carried out in Hyde Park found them to be accurate to ± 10 m with bearings or headings being random. A further static test of GPS tags was carried out in The Regent's Park in February 2015 to assess fix error when the tags were close to walls, metal railings, tree trunks or under dense vegetation, typical of situations where hedgehogs might be found in The Park. Here the fix error was judged to be ± 17 m or larger and bearings were not necessarily random (Appendix 6).

Six animals were fitted with GPS tags for seven nights in May 2015 and 10 animals tagged for seven nights in September 2015.

5.6 Thermal imaging

Thermal imaging cameras were used both to detect hedgehogs during spotlighting and to observe behaviour in the field. The model used was a FLIR E60 (supplied by Beechwood Equipment), which had a 4 hour battery life; the battery was easily replaced with a spare in the field to give 8 hours of continuous use. The set-up configuration of the E60 that was used is detailed in Appendix 5.

The 'Above Alarm' mode allowed precise ($\pm 0.1^{\circ}\text{C}$) adjustment of the temperature threshold above which an object would be displayed in red against a grey background. This allowed the user to compensate for changes in ambient temperature, ensuring good discrimination between a hedgehog and the background. During behavioural observations no additional light was required to observe the behaviour of the hedgehog, reducing a potential source of disturbance. The E60 allowed video (MPEG4) or still (JPEG) images (resolution 320 x 240 pixels) to be recorded to a standard SD card as required. The 'Above Alarm' mode was the best mode for detection at a distance. Under field conditions in amenity grass (up to about 10cm tall) hedgehogs could reliably be detected at distances up to 60m, further in very short grass or less far when the hedgehog was partially obscured by vegetation. The 'Above Alarm' mode was also generally good for behavioural observation – especially when the animal was partially obscured by vegetation. During behavioural observation at less than 10m, the 'Rainbow high contrast' mode was sometimes useful to display more detail of the hedgehog or its surroundings when in complex environments.



Figure 5.11 The FLIR E60 in field use with display set in 'Alarm mode' for behavioural observations during 30minute sampling periods. .



Figure 5.12 Image captured from the FLIR E60 in May 2015 with display in 'Alarm Mode' and the detection temperature threshold set at 13.7°C (a few degrees above the ambient at the time) so that warmer objects show red against a grey background. This hedgehog is clearly visible at an estimated 40 metres.

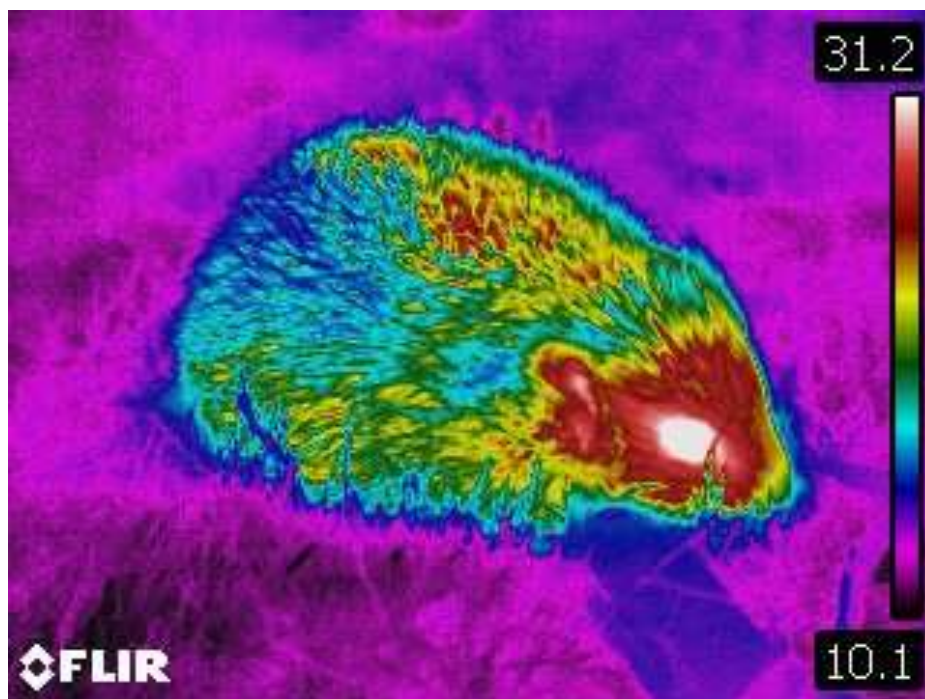


Figure 5.13 Image captured from the FLIR E60 in May 2015 of a hedgehog at close quarters with display in 'Rainbow high contrast' mode. This clearly shows the warm face and eye of the hedgehog (over 30°C), the cooler body and grass at about 10°C.

5.7 Residents questionnaire

One of the 2015 survey aims was to determine if The Regent's Park hedgehog population was isolated. To help answer this, a local resident's questionnaire was designed and delivered to neighbours of the park.

Both a printed questionnaire for distribution to homes surrounding Regent's Park and an online questionnaire to be sent to Royal Parks Foundation email subscribers who have particular interest in Regent's Park were created. The questions in both questionnaires were exactly the same.

The aims of the questionnaire were to:

- Determine if local residents had ever seen a hedgehog, dead or alive:
 - In Regent's Park
 - On Primrose Hill
 - In their garden
 - Anywhere within 1km of Regent's Park
- Discover if they knew of any hedgehogs released into Regent's Park
- Gather contact information for any interesting hedgehog sightings
- Raise awareness of hedgehog conservation with local residents

5.7.1 Questionnaire pack

4,000 questionnaire packs were printed for distribution and the online questionnaire was sent to over 700 subscribers. The printed questionnaire pack included:

- Introductory letter
- Questionnaire response form (Appendix 7a)
- Royal Mail SAE to return the completed questionnaire
- 2014 Hedgehog Programme information leaflet

The outer envelope was designed carefully to attract people's attention. A drawing of a hedgehog and the Royal Parks Foundation, The Royal Parks and ZSL's logos were used to distinguish it from other 'junk' mail the householder might receive.

The 4,000 packs were made up by hand with the help of Royal Parks Foundation staff.

5.7.2 Questionnaire distribution

Printed questionnaires:

Using Royal Mail postcode data, the roads surrounding Regent's Park were split up into manageable delivery areas. These areas were defined based on the length of road, number of households and other physical features. 26 areas, each with between 60 - 300 households, were created and were each targeted separately for delivery.



Figure 5.14 Example map given to volunteers, the roads they needed to target were written in the white box and highlighted by hand on the print out.

Volunteers helped to distribute the 4,000 questionnaire packs. On Thursday 30 July, 20 volunteers met in the Regent's Park office and were each given approximately 150 questionnaires to distribute in one of the 26 areas, some volunteers worked in pairs to target the bigger areas.

Some volunteers couldn't attend on the 30th so were posted their pack of questionnaires and a map of a target area to deliver in.

To ensure all volunteers were safe and confident whilst delivering, a risk assessment and FAQ document (Appendix 7b) were produced and distributed to all. Volunteers were asked to sign a copy of the risk assessment before their delivery.

Online:

The email to Regent's Park subscribers was sent out to 710 people with an open rate of 43% and click through rate of 4%. For both types of questionnaire, a deadline of Sunday 6 September 2015 was given for all responses to be returned.

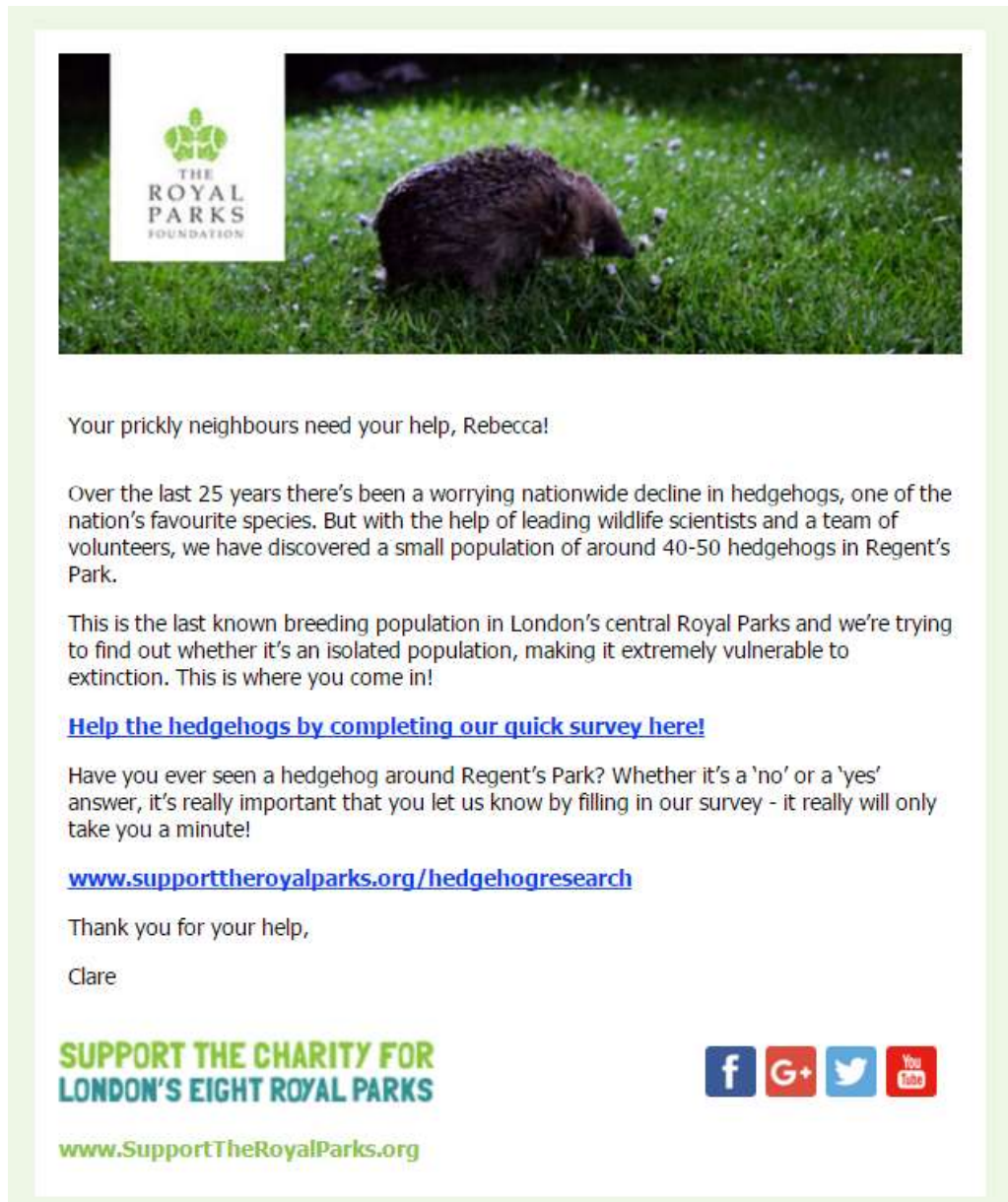


Figure 5.15 Email to Regent's Park subscribers asking them to complete the hedgehog survey

5.8 Land manager and gardener training

Land managers and gardeners are two groups where a raised awareness of hedgehogs could be particularly effective in improving conditions for hedgehogs in the park. They are responsible for developing and implementing plans and practices that could reduce potential hazards and increase suitable habitat for foraging and nesting. It is also important that gardeners understand the need to take appropriate action, including reporting, when injured or dead hedgehogs are found or when nests are accidentally disturbed.

16 July 2015 – Land managers training

Good attendance with 17 managers, supervisors / team leaders / regular volunteers from nine organisations working on The Regent's Park estate

- The Landscape Group
- The Royal Parks
- US Embassy – Winfield House
- The Conservation Volunteers
- The Holme
- Sustain – Regent's Park Allotment
- Crown Estate Paving Commission (CEPC)
- Open Air Theatre
- Regent's Park Volunteers

The Land Managers course has been produced by the People's Trust for Endangered Species in partnership with the British Hedgehog Preservation Society and developed with hedgehog experts Dr Pat Morris & Dr Nigel Reeve.

Nigel Reeve delivered the course at the Regent's Park offices. The course content included:

Talk 1	Hedgehog Ecology and behaviour – an overview of basic biology, ecology, behaviour, disease and rehabilitation
Talk 2	Threats to hedgehogs and the law – urban and rural threats; UK conservation status and decline; UK legislation; the latest survey methods
Outdoor session	Guided walk around Regent's Park
Talk 3	Land management for hedgehogs – practicalities of remediating threats and encouraging hedgehogs

This course has been designed for those involved in the management of public greenspace or private amenity land, consultants, landscape architects and developers. Hedgehogs are also frequently overlooked in ecological impact assessments. Small management changes can dramatically improve areas of land for this UK BAP species, potentially reversing its decline and enriching biodiversity more broadly. The delivery of this course to land managers and gardeners in The Regent's Park involved an identification of issues affecting hedgehogs in the park and inviting participants to consider how the management of the Park could be changed to benefit hedgehogs in the light of the conclusions of the 2014 hedgehog study (Gurnell *et al.* 2015).



Figure 5.16 Land managers walking route in Regent's Park



Figure 5.17 Nigel Reeve and the land managers by the Regent's Park allotment site

19 August 2015 – Hedgehog Ecology and Management for Practitioners

Nigel Reeve and John Gurnell also delivered two shortened training courses, tailored for the Regent's Park grounds maintenance teams.

In total, 45 people attended from four organisations, including CEPC, ZSL, The Landscape Group and Regent's University.

The format was slightly different:

- Introduction to hedgehogs + why under threat
- A study of hedgehogs in The Regent's Park
- Habitats and hazards
- Guided Walk in Regent's Park
- Questions

The feedback from all three training sessions was excellent.



Figure 5.18 Nigel Reeve discussing grassland management with the grounds maintenance teams

6. Results

6.1 Hedgehog numbers

Peak numbers of individuals captured occurred in September 2014 (Figure 6.1; full details of individuals captured according to survey zone are shown in Appendix 8a - Table A.8.1). Accounting for the number of individuals not captured, this is believed to equate to a total population of ~50 animals. Numbers would be expected to be higher in the autumn following summer breeding, but the lowest number of captures was obtained in September 2015, when approximately half the number of animals were captured compared with September 2014. Spring numbers in 2014 and 2015 were similar, if the fact that the Zoo car park was not surveyed in May 2014 is taken into account¹.

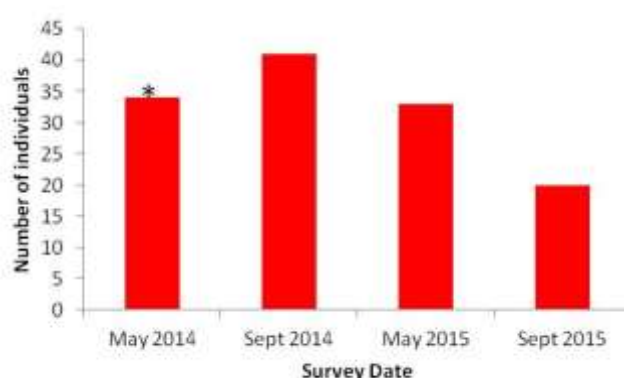


Figure 6.1 Numbers of individuals captured. * - Zoo car park not surveyed, so the total of 27 adjusted upwards by adding the mean proportion of animals captured in the zoo car park from the other three survey dates (0.26).

Over the four survey periods, individual body weights varied considerably and on average females, tended to be slightly heavier than males except in September 2014 (Figure 6.2.) Adult body weights ranged from 740 g to 1310 g (Table 6.1) with an overall mean of 922 g ($N = 90$, $SD = 176.0$ g). It is possible that adult females in any of the survey periods may have been pregnant, which will have affected their body weight. However, there was no significant adult body weight sex-survey period interaction ($F_{3,82} = 1.55$, $P = 0.21$) or significant sex main effect ($F_{1,82} = 1.25$, $P = 0.267$), but there was a significant survey main effect ($F_{3,82} = 10.47$, $P < 0.001$). This is attributable to adult hedgehogs being significantly lighter in May 2015 than at other survey times (Table 6.1).

More adult females than adult males were captured in each of the four survey periods, although the bias towards females was greater in the September than the May survey periods (Table 6.1).

¹ Based on the surveys carried out in September 2014, May and September 2015, on average, 26% of all the individuals captured in The Regent's Park were from the Zoo car park. If we assume a similar proportion occurred in May 2014, this would equate to 34 individuals, similar to the number of individuals captured in May 2015.

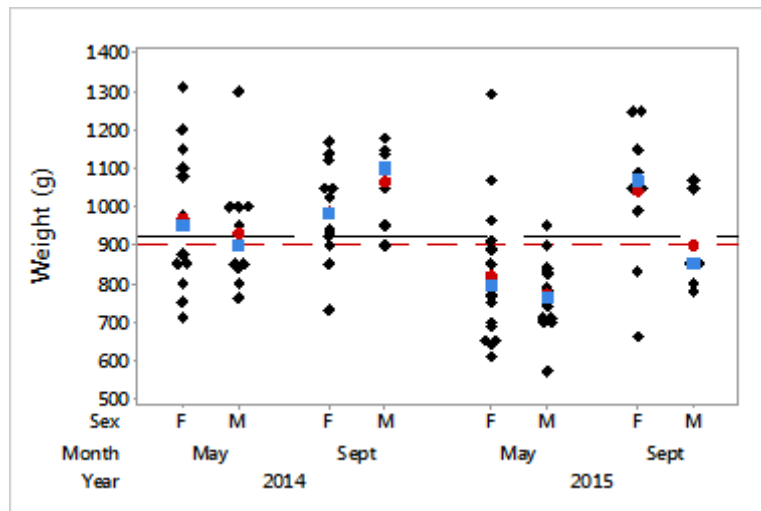


Figure 6.2 Individual body weights of adult hedgehogs. Red circles = median values, blue squares = mean values. Broad dash line = overall mean, narrow dash line = overall median. F = female, M = male

Table 6.1 Mean body weights for adult male and female hedgehogs captured in each survey and sex ratios. SD = standard deviation.

Year	Month	Sex	N	Mean (g)	SD (g)	Sex ratio M:F
2014	May	Female	13	970	185.5	0.85
		Male	11	932	148.2	
	Sept	Female	12	986	129.9	0.58
		Male	7	1067	106.4	
2015	May	Female	16	822	182.6	0.88
		Male	14	771	96.1	
	Sept	Female	11	1043	172.2	0.55
		Male	6	900	127.1	

Thirty-nine per cent of the hedgehogs captured in September 2014 were juveniles or subadults and 20% in September 2015 (Appendix 8a - Table A.8.1). In addition, three young in a nest were found in the eastern part of the Zoo grounds (adjacent to the anteater enclosure) in September 2015. Thus the hedgehogs within the park bred in the summers of both years.

Hedgehogs were individually marked with coloured markers in 2014 (five markers of each of two colours placed on two different parts of the body), and five numbered markers in 2015 (on the head area of the body), and many markers were lost from individuals between survey periods. Some individuals may have lost all markers, but this could not be determined. For these reasons, it was not possible to accurately estimate the proportion of animals that persisted in the population between survey periods. However, minimum persistence estimates have been calculated. In 2014, the minimum persistence of male and female hedgehogs from May to September, a period of approximately four months, was 38% and 69% respectively in 2014 and 36% and 50% in 2015 (Figure 6.3). Thus, females appeared to persist better over the summer period in each year than males. However, there was little difference in the persistence of males (44%) and females (45%) from September 2014 to May 2015, a period of approximately eight months (Figure 6.3).

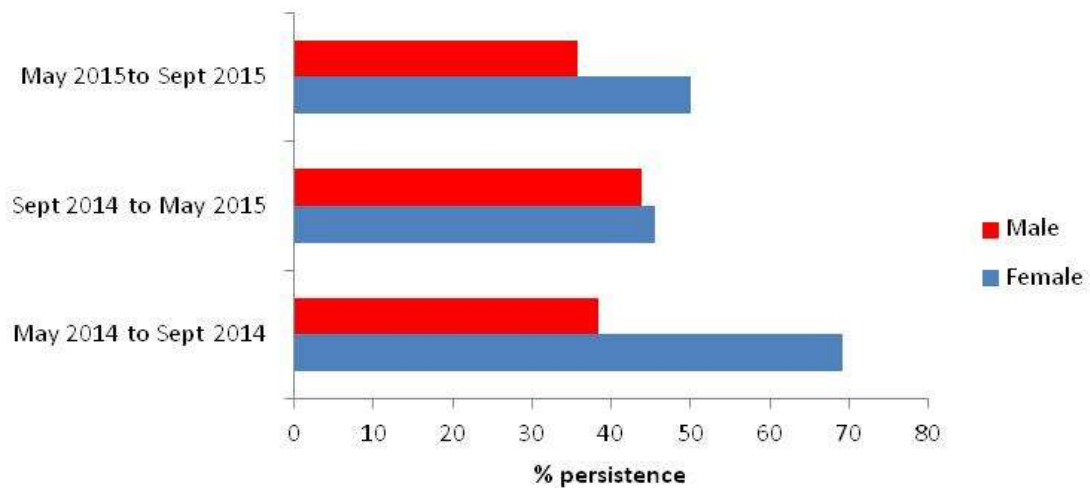


Figure 6.3 The minimum percentage persistence of animals from one survey period to the next.(termed persistence because it is not known whether animals survived but were not recaptured; termed minimum because some hedgehog may have lost all their marks between survey periods and thus not recognised as recaptures).

6.2. Time of capture

The main spotlighting surveys were carried out between 20.00 hours and 01.00 hours on two consecutive Fridays during each survey period. On these occasions, most animals were captured between 21.00 hours and midnight (Figure 6.4). However, hedgehogs were opportunistically captured and if necessary marked during the intervening nights through to 06.00 hours when animals were being radio- tracked, especially in September 2014 and May and September 2015. This accounts for the right-hand tail to the distributions of time of capture (Figure 6.4).

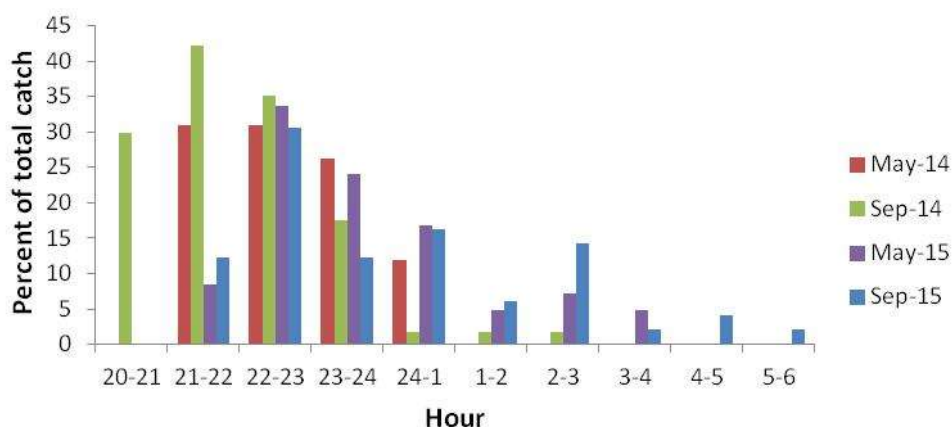


Figure 6.4 Time of capture of hedgehogs for each survey period.

Between 85% and 93% of individual hedgehogs had been captured by the second Friday spotlighting night; thus, few new, unmarked individuals were captured at the end of each survey period (Figure 6.5).

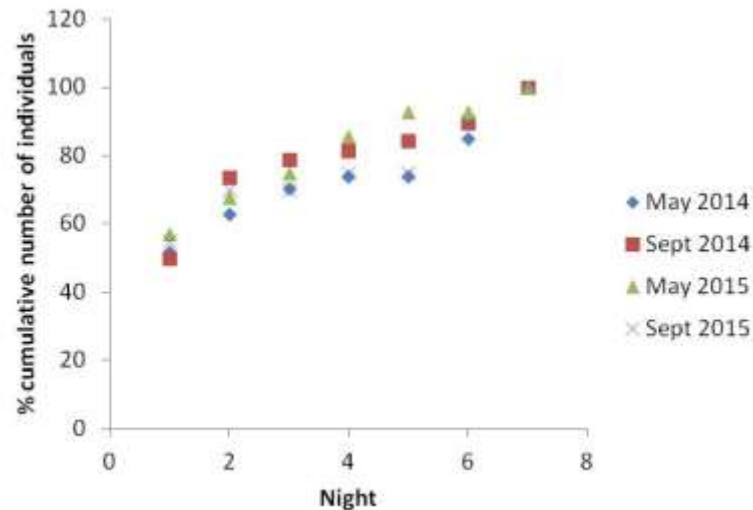
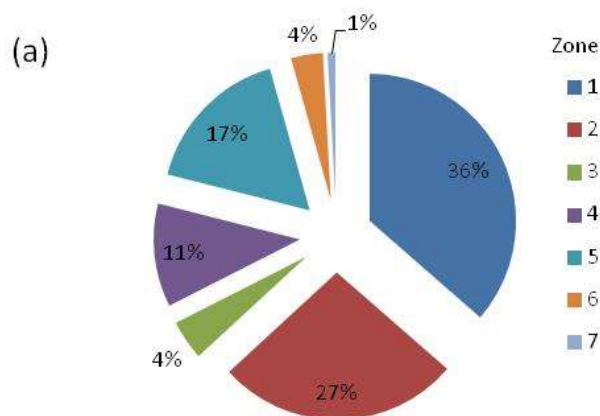


Figure 6.5 Percent cumulative number of new individuals captured during each survey week.

6.3. Distribution of captures

No hedgehogs were captured on Primrose Hill (Zone 8; 2015 only) and very few animals were captured in the grounds to the Zoo (Zone 7) and Zones 3 (Sports pitches) and 6 (east of the Winter Gardens) (Figure 6.6a) at any time. In contrast, most captures occurred in Zones 1 (Avenue Gardens/ Marylebone Green), Zone 2 (principally the Zoo car park) and Zones 4 and 5 (around the Boating Lake and Wetland areas); these were considered to be three hedgehog hotspots (Figure 6.6b; Figure 6.7). There was a similar relative distribution of captures in each survey period with the exception that some hedgehogs were captured on the sports fields in September 2015 (Figure 6.7). In September 2015 fewer individuals (3 or 15% of all individuals) were captured in Zone 1 which was a 'hotspot' with 10 or 30% of all individuals found there in May 2015.



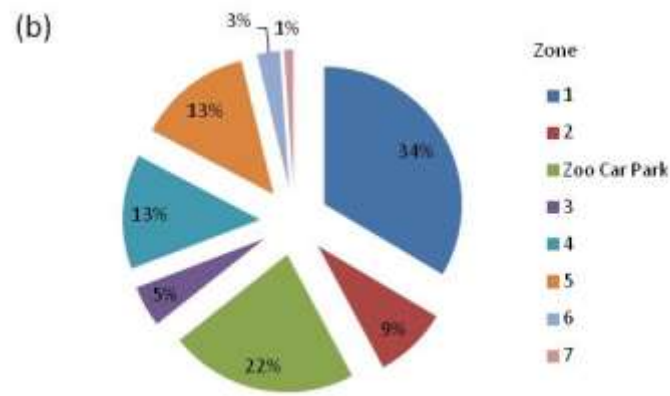


Figure 6.6 Percentage of all captures in each zone. (a) All four survey periods, (b) September 2014, May 2015, September 2015 survey periods when the Zoo car park was included in the surveys.



Figure 6.7 Locations of hedgehog captures within Regent's Park. Red - May 2014, Yellow - September 2014, Orange - May 2015, Blue - September 2015. Note: The Zoo car park (top right) was not surveyed in May 2014.

The Zoo car park was not surveyed in May 2014, but overall there was a similar relative distribution of captures in each survey period with the exception that some hedgehogs were captured on the sports fields in September 2015 and proportionally fewer were captured in Zone 1 at this time (Figure 6.7).

6.4. Radio-tracking

Between 6 and 11 hedgehogs were fitted with radio-tags and GPS tags during each survey period and, although where possible animals were tagged in as many representative parts of the park as possible, the results on the distribution of nest sites, behaviour and movement will be related to the particular areas that the tagged animals inhabited. For example, no hedgehogs were tagged in the Zoo car park in May 2014 and September 2015, and so there are no results for this part of The Regent's Park for these periods.

6.4.1. Nest sites

Day nests were found throughout the park (Figure 6.8). During the week long survey periods, 50% of hedgehogs radio-tracked were found to use more than one day nest, with a maximum of four nests (Figure 6.9). Forty six per cent of 60 nests were found in scrub habitats, 22% in planted shrubberies and 12% in hedgerows (Figure 6.10). See Appendix 11 for photographs of the nesting sites.

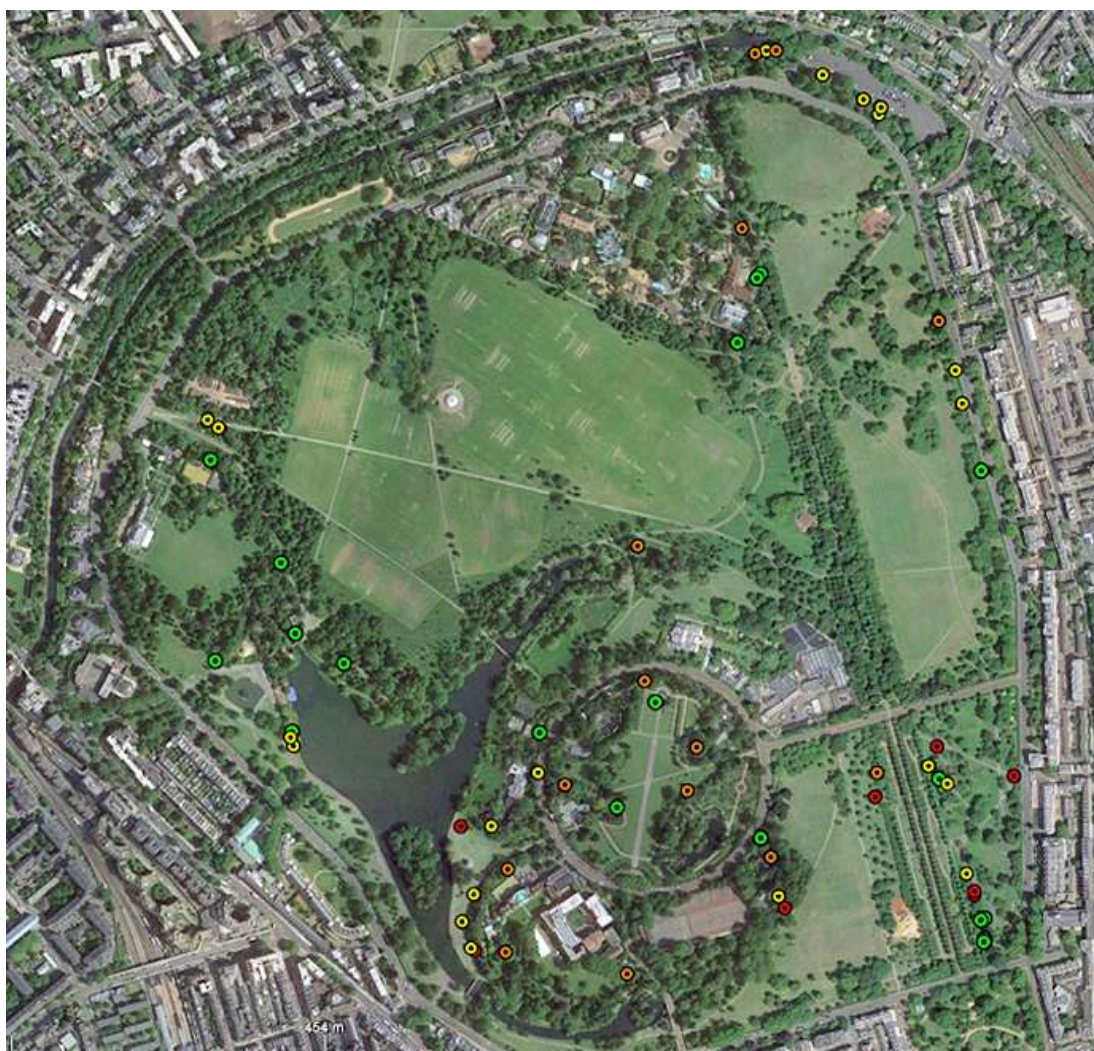


Figure 6.8 Nest sites of radio-tracked hedgehogs.

Red - May 2014, Yellow - September 2014, Orange - May 2015, Green - September 2015. No hedgehogs were radio-tracked in the Zoo car park in May 2014 and September 2015.

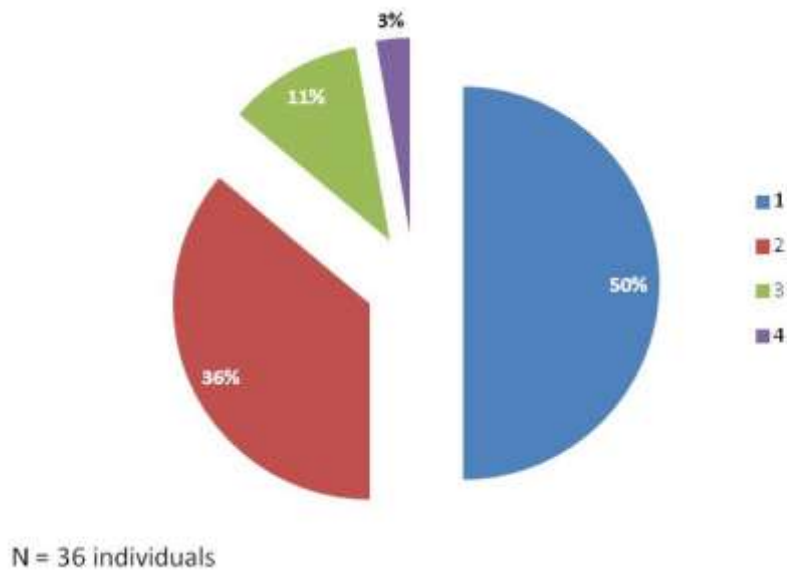


Figure 6.9 Number of nests used by individual hedgehogs during the survey weeks (all surveys combined). N = 36 hedgehogs.

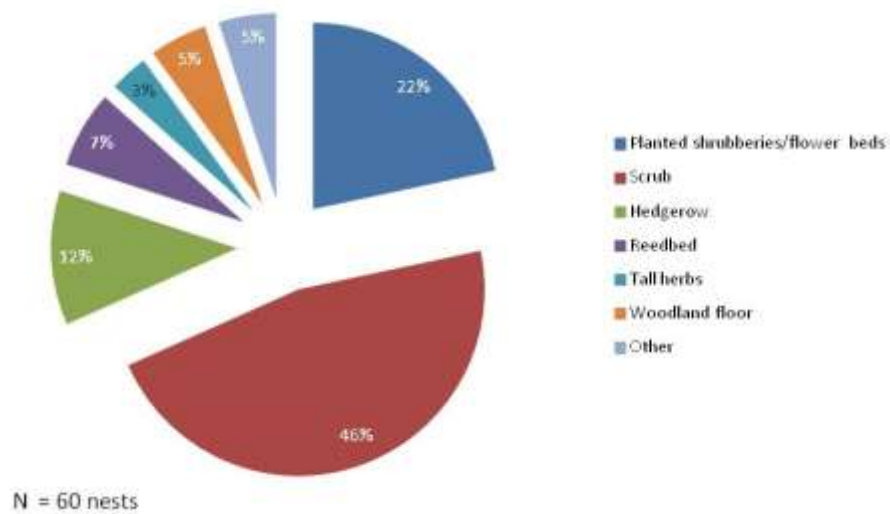


Figure 6.10 Habitat in which day nests were found (all surveys combined). N = 60 nests.

6.4.2. Behaviour

Where possible radio-tagged hedgehogs were observed through a thermal imaging camera for approximately 30 minutes on one or more nights during the survey periods and their behaviour recorded every two minutes (Figure 6.11).

On 52% of occasions hedgehogs were observed foraging, they were stationary on 21% of occasions and moving slowly on 16% of occasions (Figure 6.12). In all, 407 observations from 33 individuals of foraging behaviour were made. Favoured foraging habitats were long and short grass (64% of observations), planted shrubberies (19%), scrub (6%) and hedgerows (6%) (Figure 6.13).



Figure 6.11 Locations of 407 foraging records during half-hour observations of 33 radio-tracked individuals. Red - May 2014, Yellow - September 2014, Orange - May 2015, Green - September 2015. No hedgehogs were radio-tracked in the Zoo car park in May 2014 and September 2015.

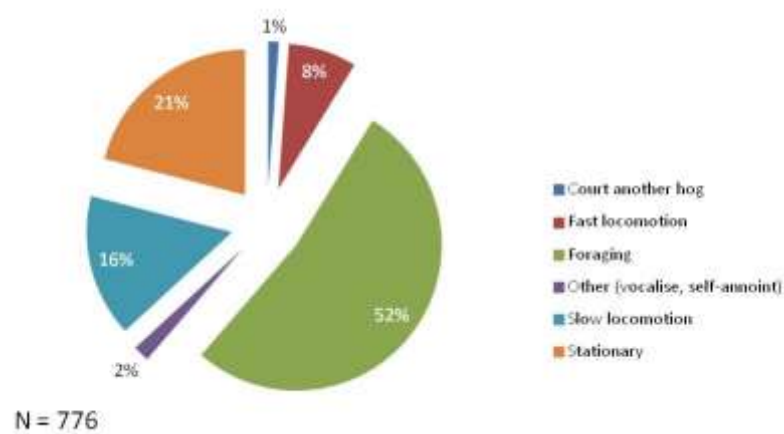


Figure 6.12 Behaviour recorded while radio-tracking hedgehogs - all surveys combined. N = 776 behaviours.

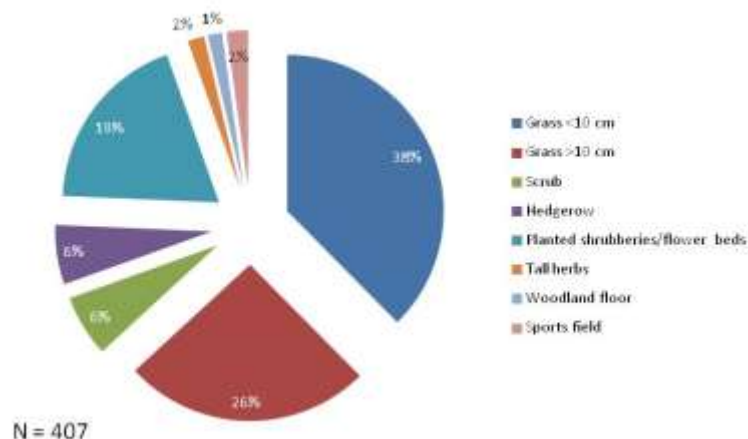


Figure 6.13 Habitat of hedgehogs when observed foraging.
N = 407 observations.

6.5 GPS tracking

Details of movement and home range for each hedgehog GPS tracked in each survey period are shown in Appendix 8b -Table A.8.2.

6.5.1 Night time distance moved

Over the four survey periods, on average, male hedgehogs moved 892 m and females 821 m (Figure 6.14). One male in each of the two May survey periods, moved considerably farther than other animals (No.32 1897 m in May 2014; No.167 1934 m in May 2015). Using mean distance moved as a general measure of movement for each hedgehog, there was no sex-survey period interaction (Anova $F_{3,26} = 2.46$, $P=0.09$), sex main effect ($F_{1,26} = 0.14$, $P=0.72$), or survey period main effect ($F_{3,26} = 0.22$, $P=0.89$) in the nightly distances moved by hedgehogs. Leaving out the two wide ranging males did not make any difference to these findings.

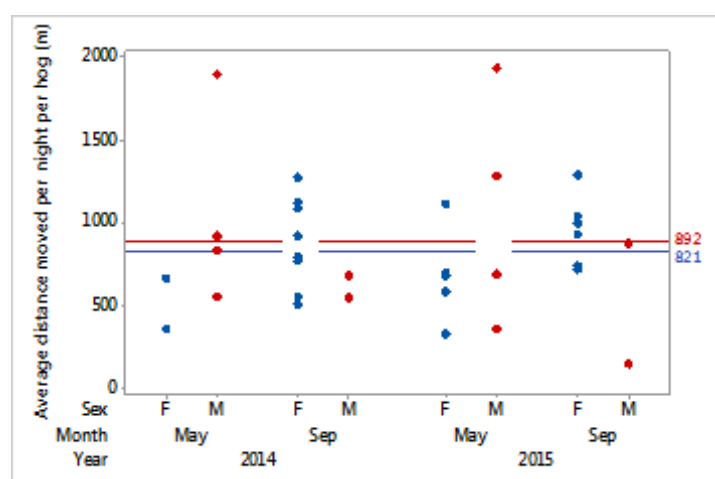


Figure 6.14 Average distance moved (m) each night by each hedgehog
red = male, blue = female. Horizontal lines = mean female and male distances
(males do not include the two high values)

6.5.2 Night time home ranges

Ninety-five per cent Minimum Convex Polygon (MCP) and kernel ranges for each hedgehog GPS tracked in each survey period, based on all locations, are shown in Figure 6.17, and 95% kernel ranges for all individuals and all nights tracked are shown in Figure 6.18. Examples of 95% kernel night ranges for selected individuals from May and September 2015 are shown in Figure 6.19; examples of ranges for 2014 are presented in Gurnell *et al.* (2015). Figure 6.19 demonstrates that individuals frequently used slightly different areas each night and they frequently had more than one centre of activity.

Average 95% MCP and kernel range areas across all survey periods were similar (males, MCP 1.5 ha, kernel 1.5 ha, excluding one wide ranging male in May 2014 and one in May 2015; females MCP 2.2 ha and kernel 2.0 ha) (Figures 6.15 and 6.16).

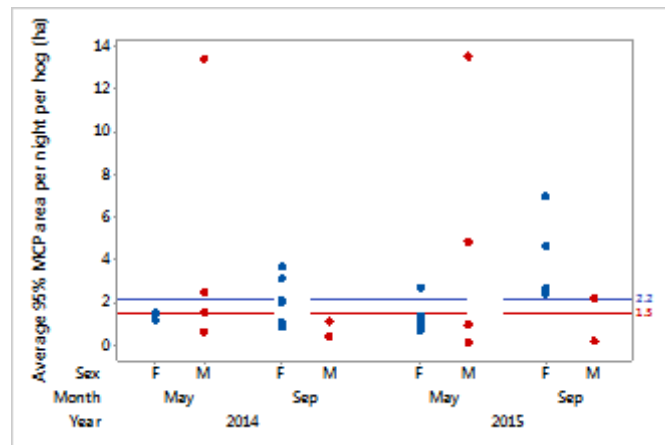


Figure 6.15 Average 95% MCP (ha) per night for each hedgehog; red = male, blue = female. Horizontal lines = mean female and male ranges (males do not include the two high values: No.32 13.4 ha in May 2014; No.167 13.5 ha in May 2015).

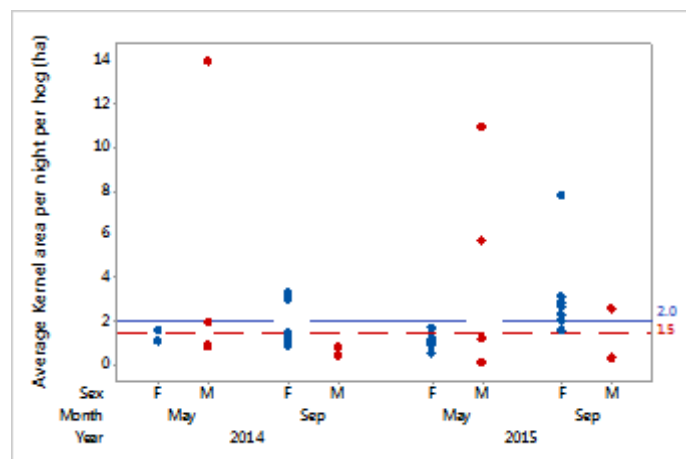


Figure 6.16 Average 95% Kernel range area (ha) per night for each hedgehog; red = male, blue = female. Horizontal lines = mean female and male ranges (males do not include the two high values: No.32 16.7 ha in May 2014; No.167 13.7 ha in May 2015).

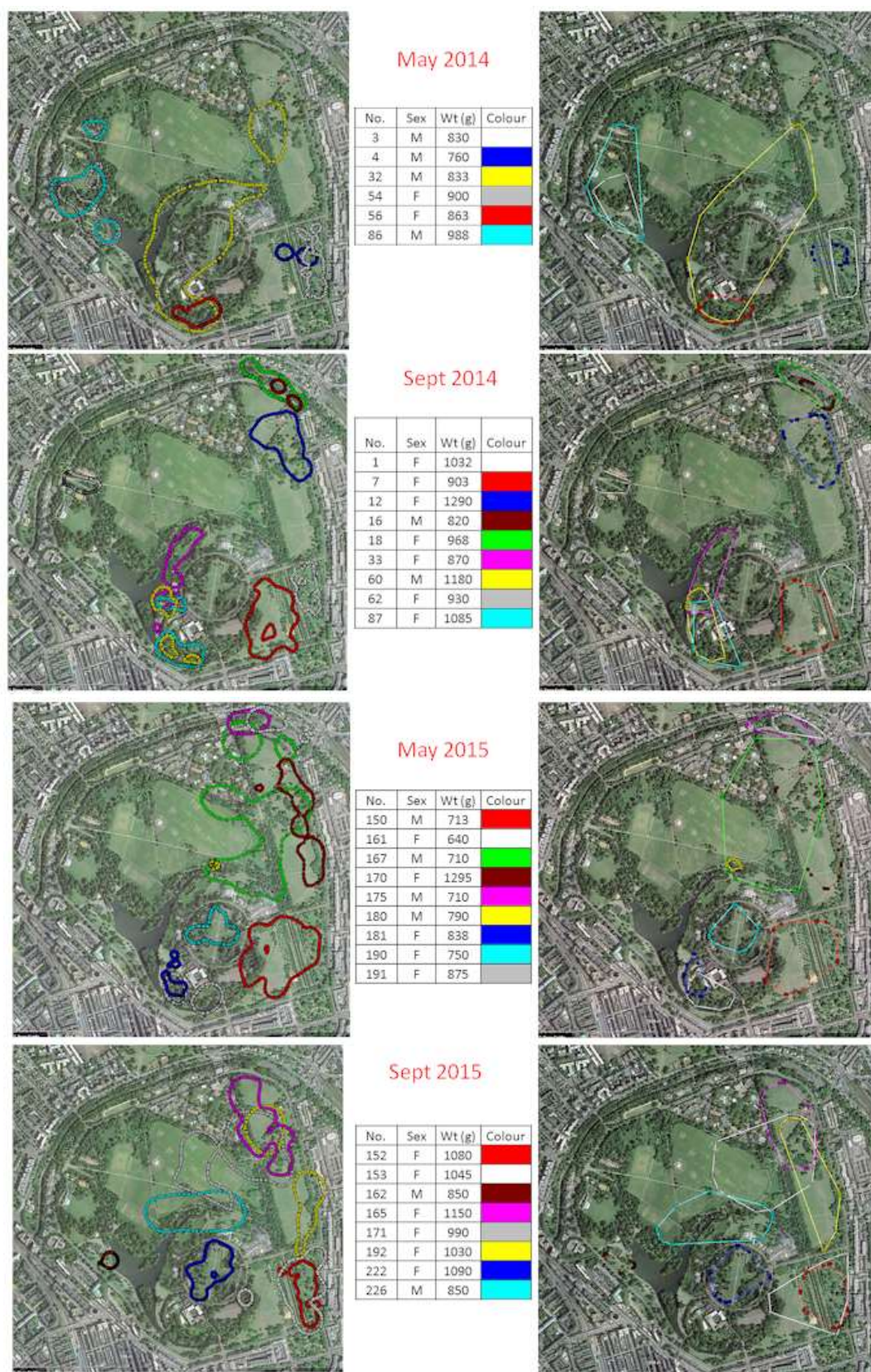


Figure 6.17 95% kernel (left) and 95% Minimum Convex Polygons (right) for all locations for each hedgehog GPS tracked in each survey period.



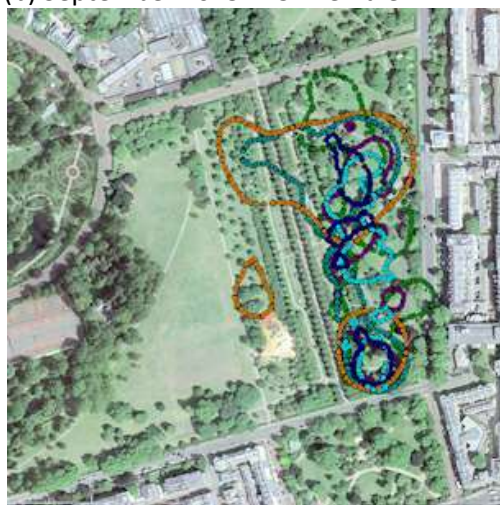
Figure 6.18 95% kernel ranges for each night for each animal GPS tracked for all four surveys combined. Number of ranges = 180; number of individuals = 36.

There were no significant differences in sex-survey period interaction, sex main effects, or survey period main effect in either MCP or kernel range areas (MCP, sex-survey period $F_{3,26}=1.54$, $P=0.23$, sex $F_{1,26}=0.47$, $P=0.50$, survey period $F_{3,26}=0.48$, $P=0.70$; kernel, sex-survey period $F_{3,26}=1.38$, $P=0.27$, sex $F_{1,26}=0.60$, $P=0.71$, survey period $F_{3,26}=0.46$, $P=0.71$). Leaving out the two wide ranging males did not make any difference to these findings.

(a) May 2015 #150 Male



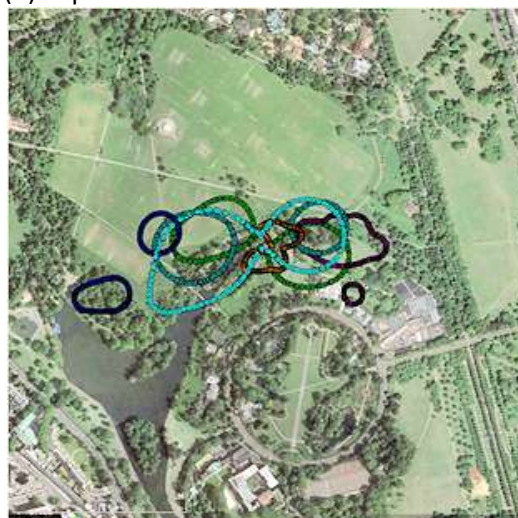
(b) September 2015 #152 Female



(c) May 2015 #167 Male



(d) September 2015 #226 Male



(e) May 2015 #190 Female



(f) September 2015 #222 Female

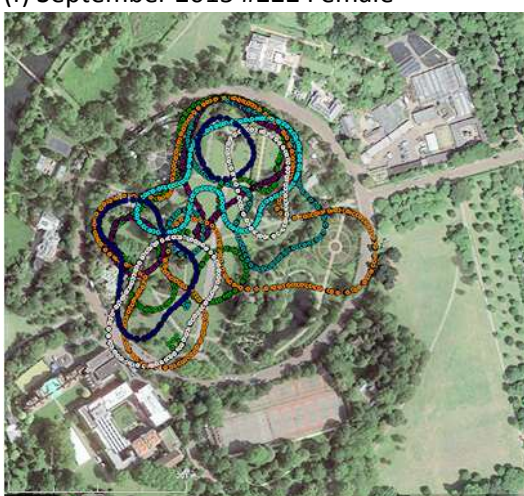


Figure 6.19 Examples of 95% kernel ranges in May and September 2015.
Each colour represents a different night.

6.5.3 Habitat utilisation

The analysis of the GPS data of the habitats used by hedgehogs during the night when they were active clearly showed that they preferred amenity grassland, other than the sports pitches (Figure 6.20). However, pooling data from all hedgehogs can be misleading because habitat use depends on the habitat available within the home ranges of the animals, and this will depend on where in the park they lived. To take account of the different proportions of each habitat type within the 95% MCP range areas of each hedgehog, Jacob's habitat selection indices for point fixes for each individual are presented in Table 6.2. Values of the Jacob index range from -1.0, avoidance, to +1.0, strong preference. Overall, grassland, hedgerows and roughland were preferred, which supports the observations on foraging habitats from the radio-tracking studies on behaviour. Bare artificial habitats were least preferred.

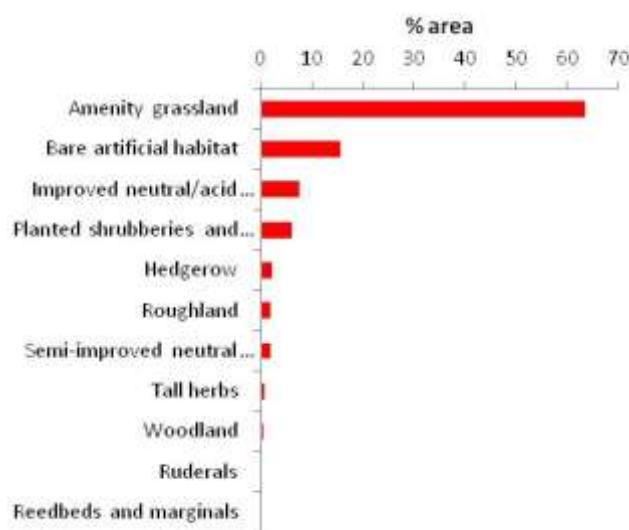


Figure 6.20 Mean percentage of habitat locations, each with a 5m circle radius, that fall within different habitat types for GPS-tracked hedgehog ranges - all surveys combined (No. ranges =180, No. locations = 5,980). Habitats within the Park that were not surveyed are not included.

Table 6.2 Ranking of habitat types according to Jacob's indices.
Pos = Jacobs Indices $>+0.1$, Neg = Jacob's Indices <-0.1 , Diff = Pos-Neg.

Rank	Habitat	Pos	Neg	Diff
1	Amenity grassland	100	56	44
2	Improved neutral/acid grassland	59	38	21
3	Hedgerow	38	27	11
4	Roughland	17	11	6
5	Woodland	1	0	1
6	Ruderals	2	2	0
7	Reedbeds and marginals	6	8	-2
8	Semi-improved neutral grassland	17	21	-4
9	Tall herbs	10	16	-6
10	Planted shrubberies and flower beds	27	48	-21
11	Bare artificial habitat	51	117	-66

6.5.4 Hotspot area - the Zoo Car Park

Finding that a breeding local group of hedgehogs resided in the Zoo car park has been of particular interest. Hedgehogs were surveyed in the Zoo car park in September 2014, and May and September 2015, but not May 2014. A list of hedgehog captures is shown in Appendix 9 - Table A.9.3 and Figure A.9.1. Hedgehogs were captured throughout all the vegetated areas of the car park. Over the three survey periods, hedgehogs captured in the Zoo car park comprised 26% of all the individuals captured throughout The Regent's Park and 22% of all captures. Young animals captured in the Zoo car park show that it was a breeding sub-population (Appendix 9 - Table A.9.3).

Two animals were fitted with GPS/VHF tags in September 2014 and two in May 2015. The location of day nest sites are shown in Figure A.9.2 and showed that these particular animals nested in the vegetation to the west and south of the car park. Some of the tagged animals were followed on a few occasions to observe their behaviour. Records of where they foraged are presented in Figure A.9.3 showing activity to the east as well as the west and south of the car park. Nightly home range boundaries for the four tagged animals are shown in Figure A.6.4, again clearly showing the animals did not necessarily use the same areas every night, they had more than one centre of activity and individual ranges overlapped. However, over the period of the surveys, they tended to range over the whole of the car park. However, the hedgehogs rarely crossed the tarmac areas of the car park (data not shown).

6.5.5 Injuries and deaths

A number of illnesses and injuries were recorded during the studies, none during the September surveys themselves, but some during the May surveys and at other times during 2015, which may be partly related to increasing awareness of hedgehogs in The Regent's Park. The ZSL vets treated all injured or sick animals; some were released back into the population, others euthanased on welfare grounds. Some animals showed signs of old injuries, e.g. to their hind legs, but had recovered. Known hedgehog deaths during the study are shown in Table 6.3. Two main areas of concern are leg injuries and road deaths. No road kills were found in 2014, but three occurred during the summer of 2015 and one in the autumn. All these road kills occurred on the stretch of road outside the main Zoo car park entrance. This shows that hedgehogs do move between the Zoo car park and the main part of The Regent's Park.

Table 6.3 Hedgehog deaths known to occur during the period of the study in 2014-2015.

Year	Period	Minimum population size	Leg injuries	Road-kill	Other causes	Total deaths
2014	May survey	27+	3	0	2	5
	Sept survey	41	0	0	0	0
2015	May survey	33	2	0	2	4
	Summer	-	3	3	2	8
	Sept survey	20	0	0	0	0
	Autumn	-	0	1	1	2
Total			8	4	7	19

Post-mortem examinations supported by microbiology, parasitology and histopathology were conducted by the Garden Wildlife Health Project team and these can be seen in Appendix 10.

6.5.6 Footprint tunnels

No hedgehogs were detected in the footprint tunnels or the nearby camera traps placed in Leafyard Wood during the survey period in September 2015.

6.5.7 Foxes

Foxes were regularly seen when working in the park during the night, especially in the western and southern areas (Figure 6.21). It is not possible to say how many individuals live in the park from these data.



Figure 6.21 Locations fox sightings in 2015. Red - May, Yellow - September

Foxes were also detected on all seven camera traps placed in Leafyard Wood on all nights in September 2015 indicating a high degree of activity in this area of the park where at least one fox den was believed to be present.

6.5.8 Questionnaire results

Four thousand questionnaires were delivered to homes surrounding the park and there were 321 returns (73 online and 248 postal); a response rate of 8% (Figure 6.21). There were no confirmed recent sightings of hedgehogs on Primrose Hill or within 1 km of The Regent's Park. Seven people reported historical sightings in their gardens near to the Park, and one person reported seeing hedgehogs regularly on Primrose Hill during the evening until ~1999/2000. Six dead hedgehog sightings were reported, mostly on the Outer Circle, one in 2011 and five in 2015 which is consistent with our road casualty records for 2015.



Figure 6.21 Location of questionnaire responses close to The Regent's Park

7 Discussion

7.1 Study methods

As in 2014, the key to success of the project in 2015 was the skilled assistance provided by large numbers of volunteers, many of whom had contributed to the 2014 surveys and had become adept at working with hedgehogs. Spotlighting was found to be an effective way of detecting hedgehogs with few new unmarked individuals being captured by the end of each survey period. However, the use of two thermal imaging cameras (one allocated to the Primrose Hill team) provided an extra level of confidence that animals were not being missed in open habitats. The FLIR E60 allowed reliable detection at distances up to 60 metres in open short grassland and permitted behavioural observation without the use of a torch; minimising disturbance. Thermal imaging requires a clear 'line of sight' and cannot 'see through' vegetation or objects. However a hedgehog moving through light vegetation cover, could often be glimpsed through gaps in the cover as it moved, allowing observations to take place. This success was in contrast to the negative results reported by Haigh *et al.* (2012) using a Testo 880 device in arable (wheat ~30cm), garden and pasture in which the detection distance was less than one metre. New, lower-cost devices are becoming available and may be useful in future monitoring e.g. the Seek thermal camera attachment for smart phones with a 206 x 156 resolution sensor, with the extended range model available at around £260, or the stand-alone Seek Thermal Reveal Handheld Thermal Imager at around £330.

The use of numbered plastic sleeving for individual identification was also effective with animals marked in May being easily identifiable in September. If the numbers remain legible in May 2016 we will continue to use this simple and effective marking method.

We used the same modified I-gotU travel trackers (A41JF, Maplin, U.K.) modified by Mark Ferryman as described by Stevenson *et al.* (2013). An accuracy of ± 10 m was found for tags in the open. During 2015, further tests were carried on the accuracy of the GPS units when close to objects or under dense vegetation. As expected the location error of tags in these positions was larger, in the order of ± 17 m or more. The use of Titley LT5-357 VHF tags (weight 3g) instead of the heavier Biotrack TW5 tags (weight 13g) allowed us to mount the VHF tag on to the GPS tag, saving both package weight and allowing a single attachment point. However, the range of the smaller tag was significantly less and we experienced a number of VHF tag failures in the field – in May we lost 2 and in September 3 of 10 tags used. Some failed prior to field use. Only one tag that failed in the field was recovered by chance and that was clearly damaged (a severed aerial).

7.2 Hedgehog numbers, mortality

The catch of 33 hedgehogs in May 2015 was comparable to that in May 2014 after adjustment for the fact that the ZSL car park was not surveyed in the earlier period. However, the catch in September 2015 was only 20 individuals; half that found in September 2014. This low count may be anomalous but could be a consequence of the 14 known 'deaths' (7 males, 5 females and 2 of unknown sex) between June-November 2015, including one severe leg injury taken into permanent captivity. Six had traumatic leg injuries consistent with predator attacks, one more was witnessed being predated by a fox, one had a severe facial injury of unknown cause, four were killed on the Outer Circle near the ZSL car park as a result of road traffic collision injuries, one was suspected to have drowned and one had pneumonia. Reporting of casualties may be greater than previously as a result of the increased understanding amongst staff that all hedgehogs should be reported.

The extent to which domestic dogs may pose a hazard to hedgehogs remains unknown. Dogs are not normally present in the park after dark (unlike Primrose Hill) and therefore are not a significant hazard for active animals. However, the disturbance or injury of hedgehogs in their daytime and breeding

nests by dogs, when off the lead and allowed to rummage through the undergrowth, is a potential problem for hedgehogs. Hof and Bright (2009) found that although no statistically significant relationship existed in urban areas, there was a negative impact of dogs on the presence of hedgehogs in countryside areas, where the prevalence of dogs was higher in their study. This might suggest that high levels of dog activity in some areas of the park, where dogs are let off the lead and allowed to enter the undergrowth, could be a problem for hedgehogs during the day in addition to the risk from foxes at night.

As in 2014, most animals were in good body condition although in May 2015 both male and female mean weights were respectively 17% and 15% less than in May 2014.

Further counts in 2016 will be required to understand whether recruitment can match such losses. Four young weighing 420g – 660g were found in September 2015. Three of these were found in the Zoo car park and one in Zone 4, on the lawns behind St John's Lodge.

The persistence of individuals between each field survey period shows that females persist in the marked population better than males. This is not surprising as the wide ranging behaviour of males during the breeding season may result in a greater exposure to hazards such as accidental death, road kill and predator attack (Reeve, 1994).

7.3 Genetics and isolation

Preliminary data from an analysis of microsatellite DNA from 42 samples using six loci show a lack of genetic diversity in the population. The number of alleles at a given locus is in general low (2 to 6) in the Regent's Park samples compared to other studies but also just one allele dominates five of the six loci (EEU3, EEU3, EEU5, EEU6, EEU37) and two alleles between them dominate locus EEU1. The mean expected heterozygosity (HE) was 0.239, and the mean observed heterozygosity (HO) was 0.218. These preliminary data support the idea that the population has a restricted gene pool, possibly as a result of past 'bottlenecking', the effects of isolation and/or a small founder population. (Full report in Appendix 13)

7.4 Nightly movement

In 2015, the findings from the studies on movement using the GPS data were consistent with those in 2014 and the results have been combined. As in 2014, one male during May in 2015 was found to move over a large area which has been attributed to mate finding behaviour. Excluding these males, on average male hedgehogs moved 892 m each night and females slightly less at 821 m. Both the estimate of home range area produced similar results: the 95% kernel range area and the 95% minimum convex polygon area for males was 1.5 ha; for females, the figures were 2.0 and 2.2 ha respectively. As reported previously (Gurnell *et al.* 2015), these movement metrics are consistent with other studies on European hedgehogs, such as those reviewed by Reeve (1994).

7.5 Nest sites

The GPS data are not accurate enough to locate nest sites and nests were found directly by using the radio-tracking equipment to find the tagged hedgehogs during the day. Over all four surveys, 60 nests of 36 individuals were located. Half of the hedgehogs were found to use more than one nest site during the week, with a maximum of four for one animal that lived in Queen Mary's Gardens. Most nests were found in scrub habitats (46%) followed by planted shrubberies (22%) and hedgerows (12%) demonstrating the importance of these habitats for hedgehogs in the park.

7.6 Behaviour observations

More detailed observations during half hour focal animal periods (776 observations) showed foraging as the dominant behaviour with 52% of observations with fast (8%) and slow (16%) locomotion together accounting for 24% of observations. 21% of observations were stationary. This is consistent with previous studies. Habitat use during foraging dominated by short (38%) and longer grass (26%) together accounting for 64% of observations. Planted shrubberies/flower beds accounted for 19% of foraging observations and hedgerow (6%) and scrub (6%) together accounted for 12%. However, biases both in available habitat and ease of observation in open grassland.

7.7 Distribution and habitat use

No hedgehogs were found on Primrose Hill in 2015 although it was searched twice in May and twice in September 2015. Fieldworkers observed high levels of disturbance by the public after dark for dog walking and socialising. From the Residents Survey one respondent reported the former presence of hedgehogs prior to around 2002 but there have been no recent reported sightings. It should also be noted that no hedgehogs were found in Park Square Gardens.

Most captures were in three 'hotspots' i.e. Zone 1 (Avenue Gardens/ Marylebone Green) although relatively fewer hedgehogs were found here in September 2015 compared with previous surveys, Zone 2 (principally the Zoo car park) and Zones 4 and 5 (around the Boating Lake and Wetland areas). It is not clear why these areas are particularly favoured although they exhibit some fine-scale complexity in their landscape and could be linked to food and nest site availability.

Such landscape effects were shown by Hof & Bright (2010) who concluded that grassy field margins in arable landscapes increased the abundance of carabids and earthworms to the potential benefit of predators of macro-invertebrates such as the hedgehog. However, gastropods were negatively affected by the presence of a grassy field margin, possibly as a result of predation by the abundant carabids in these fields.

The Zoo car park became the focus of attention towards the end of 2015 with respect to HS2 (High Speed 2 is the planned new railway linking London Euston with the Midlands and the North West) wishing to use a large part of the Zoo car park as a lorry holding area for a period of 16 years while the construction work at Euston Station is carried out. The hedgehogs in the Zoo car park comprised ~25% of the total population in The Regent's Park in September 2014, May 2015 and September 2015 and is considered a local breeding population critically important to the main population in The Regent's Park. Our studies show that hedgehogs move throughout the vegetated areas of the car park, which are sympathetically managed for hedgehogs by the ZSL Horticultural team, and they use all the habitats for nesting and foraging. Road casualties on the Outer Circle outside the Zoo car park provide evidence that animals move to and from the main park across the intervening road. It is therefore likely that hedgehogs born with the grounds of the Zoo car park would disperse into the main population. As stated in the 2014 report (Gurnell *et al.* 2015), hotspot areas within The Regent's Park need to be safeguarded. The plans submitted by HS2 for the change of use of the zoo car park involve both the loss and fragmentation of green space around the car park as well as higher levels of disturbance; especially during construction. Such changes could pose a significant risk to the viability of hedgehogs living in the car park area and, as this is a hotspot area, could impact on The Regent's Park hedgehog population as a whole.

However, as in 2014, there were areas within the park where few hedgehogs were found, even though they 'appeared' to be suitable habitat. These areas included the Zoo grounds, the sports pitches, to the north of the park, including Leafyard Wood, and to the south of Cumberland Green. It is interesting to note that for the first time some hedgehogs ventured onto the sports pitches in September 2015, but the reasons for this are unclear. September 2015 also saw some hedgehog

activity inside the eastern part of the zoo grounds which may be explained by hedgehog access holes having been cut in the wire mesh boundary fence prior to the survey. It is not easy to provide an explanation as to why more hedgehogs were not regularly found in these areas but it could be related to predator pressure, even though foxes were regularly sighted throughout the western and southern part of the park. It is believed that there at least one (and probably more) fox dens was present in Leafyard Wood and foxes were consistently seen on the camera traps set up in the Wood in September 2015. Hof *et al.* (2012) provided evidence that in arable landscapes, space use and edge-refuging in particular, is driven by the presence or absence of predators rather than food availability, which was not significantly different between the respective distances to edge cover. In arable fields, hedgehogs were found 42 ± 2.8 m from edge cover in the absence of badgers, compared to only 4 ± 1.1 m from edge cover (hedgerows, woodland) in their presence. They proposed that the conservation of hedgehogs in areas with abundant predators would be benefitted by increasing the complexity of habitat. More refuges may be created by establishing more and denser hedgerows in rural areas, dense shrubbery and undergrowth in urban areas, and by increasing the connectivity between suitable habitats.

Across both years the habitat suitability analysis of the GPS data clearly showed the importance of long and short amenity grass (other than the sports pitches) to the hedgehogs. Hedgerows and roughland (scrub) were also preferred whereas bare, artificial habitat was understandably avoided.

7.8 Questionnaire survey

The 8% response rate from the questionnaire survey was considered good and the lack of any reports of hedgehogs being seen within 1 km of the park reinforced the idea that the population is currently isolated. One reliable report that hedgehogs were frequently seen on Primrose Hill until 1999/2000 is interesting. It suggests that hedgehogs were more widespread at that time, but something must have happened to cause their disappearance shortly after this date.

8. Public awareness

In May 2015, the Royal Parks Foundation Education Centre ran two hedgehog themed family Discovery Days, attended by 330 children and 200 adults. Children were able to test the radio-tracking equipment and thermal imaging cameras, as well as learning about the secret life of hedgehogs.



In May 2015, 4,000 hedgehog awareness leaflet summarising the results of the 2014 survey and highlighting how people could help were printed and distributed to our volunteers, park offices, partners as well as being included with the resident questionnaire mailing in June (Appendix 16d).

How can you help support the hedgehogs in Regent's Park?

- Do not allow your dogs to rummage in the undergrowth – they may disrupt hedgehog nesting sites.
- Please take all your litter home with you – polystyrene cups, plastic beer can lids, elastic bands and other litter can all be harmful to hedgehogs.
- Take care when driving or cycling at dusk on park roads – we discovered our hedgehogs often cross over the roads!
- If you see an injured hedgehog in the Park in the daytime, call the Park Office on 0300 061 2300.
- Become a Hedgehog Hero and support their conservation by adopting a hedgehog (virtual of course!).

For more information visit SupportTheRoyalParks.org

HEDGEHOG FACT FILE:



Habits: Hedgehogs are nocturnal and spend the day sleeping in nests under bushes or back shrubs. They hibernate throughout the winter.

Spines: Although babies are born with only 100 or so pale spines, the adults have between 2,000 - 7,000 dark brown spines.

Diet: Hedgehogs eat worms, beetles, earwigs, slugs, spiders, caterpillars and millipedes.

Size: Adults measure around 20cm long.

Lifespan: Average 2 - 3 years but can live as long as 10 years.

Breeding: Hedgehogs are usually solitary, only pairing up to mate. 4-5 young hoglets are born generally in spring after a one month gestation period.



Did you know that hedgehogs still live in The Regent's Park?

There has been a worrying nationwide decline in hedgehog numbers in the last 25 years. The Regent's Park is now the only central London Royal Park with a breeding population.

In the first hedgehog survey of its kind in the Park, intensive fieldwork in 2014 confirmed the presence of a hedgehog population, but it is very vulnerable and needs your help.

With thanks to:
The Royal Family
People's Trust for Endangered Species
Central Royal Parks Wildlife Group
Landscape

The Royal Parks Foundation
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Working in partnership with:

THE ROYAL PARKS ZSL

The study also attracted a lot of media attention. Michaela Strachan and a BBC Springwatch film crew helped us find the first hedgehog of 2015. This was aired on Monday 1 June 2015 and viewed by over 2.5 million people.



On 3 June, Clare Bowen, Henry Johnson from PTES and Julia Clarke, Head of Ecology at the Royal Parks, gave live interviews on BBC Breakfast News with Nigel Reeve giving a live interview on BBC London Radio. A pre-recorded interview with London Live and ITN News was also aired.

The story then featured in The Times, Daily Mail, Guardian, Evening Standard, local papers and many online sites including WIRED, Yahoo News and London 24. See press release and further news coverage in Appendix 16a and 16b.



The Royal Parks Foundation ran a social media and email campaign (to 58,000 supporters) alongside Springwatch. There was a high level of interaction on twitter, with over 100 retweets and increased traffic (over 130 unique views of the main hedgehog pages) to the Royal Parks Foundation website. Hedgehog carer Sue Kidger brought her captive hedgehog Alfie to Regent's Park for the filming. Alfie was an instant hit nationwide.



Nigel Reeve, John Gurnell and Clare Bowen presented the results of the study at a number of conferences throughout 2015 including:

- Day of the Hedgehog
- PTES hedgehog meeting
- Help for Hedgehogs Conference Mammal Group meeting
- CIEEM audience
- BES audience
- Ricoh audience
- Friends of Regent's Park
- Surrey Mammal Group

In July 2015, 4,000 hedgehog activity sheets were created and distributed to three cafés in Regent's Park and Hyde Park. These were given out with crayons to children to keep them entertained, but also educate them about hedgehogs (Appendix 16c).

9. Conclusions and recommendations

9.1 The data obtained from field work carried out in May and September in 2014 and 2015 show that this is a small and very vulnerable population of hedgehogs; the last breeding population remaining in Central London. A particularly low count of individuals and a scarcity of young in September 2015 suggest that the population may be in sharp decline; a situation that requires urgent further action and study in 2016.

9.2 The project in 2015 built on the organisation and management carried out in 2014 and again was very successful with a large number of volunteers contributing to this success. Many returning volunteers were becoming very proficient in surveying and handling hedgehogs.

9.3 The survey methods and field techniques worked well; in particular spotlighting to assess numbers and distribution and the combination of GPS and VHF tracking to understand movement dynamics and habitat preferences for both feeding and nesting. The improved identification marking system and additional use of thermal imaging to assist spotlighting and behavioural observations were also very successful.

9.4 Nightly movement patterns of GPS/VHF tagged hedgehogs were similar to those found in 2014 and typical of hedgehog populations elsewhere. Over the four survey periods in 2014 and 2015, on average, male hedgehogs moved 892 m and females 821 m per night.

9.5 The 'hotspots' of hedgehog activity identified during 2014 were less well defined in 2015. Nevertheless, key areas for hedgehogs remained: 1) around the boating lake to the west, 2) in Marylebone Green and Avenue Gardens, although relatively fewer animals were found here in September, and 3) the Zoo car park. The hedgehogs in the Zoo car park comprised ~25% of the total population in The Regent's Park in September 2014, May 2015 and September 2015 and can be considered as a critically important breeding, local population to the main population in the park. There is clear evidence that hedgehogs move throughout the vegetated areas of the car park, which are sympathetically managed for hedgehogs by the ZSL Horticultural team, and they use all the habitats for nesting and foraging. There is also evidence that animals move to and from the main park across the intervening road. It is therefore likely that hedgehogs born with the grounds of the Zoo car park would disperse into the main population.

9.6 Between June and September 2015 there were 14 known mortalities, considerably more than 2014 when there were five known deaths; this increase in part may be due to better reporting as a result of increased public awareness about the hedgehog project. There are particular concerns about hedgehogs with leg injuries including six which died or were euthanased for welfare reasons; these could have been caused by foxes and/or perhaps dogs. No road casualties were reported in 2014, but five were reported in 2015, all on the Outer Circle near the Zoo car park.

9.7 The findings from the questionnaire sent to local residents, the provisional results from the genetic study and findings from the 2015 survey reinforce the interpretation that the population is isolated. None of the questionnaire responses reported recent sightings of hedgehogs within 1 km of the park. Although our surveys did not find any hedgehogs on Primrose Hill one questionnaire return stated that they were present in 1999/2000 but thereafter disappeared. Overall, the evidence strongly suggests that the current population of hedgehogs in The Regent's Park is small, vulnerable and isolated.

Recommendation 1. Work should continue with the principal aim of conserving the population of hedgehogs in The Regent's Park. In order to achieve this The Royal Parks needs a plan of action that retains and further develops the necessary resources for the continuing ecological study of the hedgehog population, including funding, volunteer and staff resources, and academic partnerships.

Recommendation 2. Continue regular monitoring of the hedgehog population with the help of volunteers. Carry out standardised spotlighting surveys (with individual identification marking) in spring and autumn in 2016 and in the years thereafter to provide the demographic data needed to understand whether the population is stable or declining.

Recommendation 3. In order to identify the factors limiting the survival and breeding success of the population, record animals found dead or injured and seek to identify the cause of death or injury and underlying conditions thought to be a significant compromise to health. Evaluate and implement viable and sustainable ways of reducing risk to hedgehogs from identified negative factors. Including, for example the trial use of the 27 nest boxes deployed in the park in autumn 2015 which will continue into 2016 in order to assess their value to hedgehogs.

Recommendation 4. Retain the capacity to deploy GPS and/or VHF tracking of selected individuals to provide detailed information on hedgehog movements and locations as required.

Recommendation 5. Further progress measures (as have begun to be implemented) to enhance habitat quality for hedgehogs within The Regent's Park as recommended in the 2014 report. For more detail see Appendices 5 and 6.

Recommendation 6. Ensure that management changes and other interventions in the Park are systematically recorded – whether designed to benefit hedgehogs or whether they may have negative impacts. Where possible, evaluate the outcomes of such changes in terms of hedgehog conservation objectives and seek to maximise benefit e.g. the creation of long grass areas, changes to hedge management, reduction of hazards, the mitigation of habitat loss as a result of alternative use (temporary or permanent) including works associated with HS2.

Recommendation 7. Evaluate the outcomes of the current genetic study. Consider what further work may be required and consider a range of future actions to secure the genetic future of the hedgehog population.

Recommendation 8. There should be a readiness to carry out additional studies or implement measures that may help conserve this important population. Seek better, more cost-effective field methods and academic collaborations with regard to for example: improved GPS/VHF tracking technology; studies of hedgehog survival and reproduction e.g. juvenile mortality, winter survival, studies of diseases or toxicology; mitigating predation; food availability in different parkland habitats.

Recommendation 9. Continue the programme of community engagement and staff training in order to raise awareness of the need for hedgehog conservation and to recruit volunteers for the study.

11. Acknowledgements

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The **Meyer Family** for believing in the project team, being adventurous and trialling new survey techniques, for loving hedgehogs and for enabling this project to happen.

John Gurnell and Nigel Reeve for sharing their wealth of wildlife knowledge with the team for a second year and for their incredible patience, leadership, enthusiasm, skill in the field and sheer dedication to the project.

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The **veterinary team at ZSL** have once again been fantastic at assessing hedgehog casualties and

We're also hugely grateful to Julia, Lydia and Becki from the **Garden Wildlife Health Project** team who carried out post-mortem examinations on all the hedgehog carcasses submitted.

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1,660 hours of fieldwork would not have been possible without the **100+ Hedgehog Hero volunteers** giving up their evenings and nights to patiently search the park in darkness for hedgehogs and deliver 4,000 hedgehog questionnaires to local residents.

A special thank you to the **volunteer supervisors** who took on the added responsibility of leading groups in the field with confidence and enthusiasm.

Experts and assistance:

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The incredibly talented **Rosie Lom** for designing our 'Hedgehog Hero' t-shirts and illustrating ten little life-like hedgehogs!

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