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EXPEDITION REPORT

Expedition dates: 23 June – 6 July 2018

Report published: May 2019

Love / hate relationships: Monitoring the return of the wolf to the German state of Lower Saxony

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Authors:

Peter Schütte
Wolf commissioner

Matthias Hammer (editor)
Biosphere Expeditions

ABSTRACT

This report details wolf (*Canis lupus lupus*) active monitoring fieldwork by Biosphere Expeditions in collaboration with the State Wolf Bureau of the German state of Lower Saxony and local wolf commissioners. Field work was conducted from 23 June to 6 July 2018 in two one-week long groups comprising twelve citizen scientists. The aim of the expedition was to collect samples for DNA and dietary analyses. This was done by sending small groups into the field to search for scat samples.

24 citizen scientists took part in the expedition, 16 from Germany or its immediate neighbour states (67%) with two of them (8%) from Lower Saxony, three people each from North America and the United Kingdom (12.5%), as well as one person each from Iceland and Australia (4%). Before commencement of field work, which was exclusively conducted on public paths and bridleways, citizen scientists were trained for 1.5 days in sample detection, sampling and data collection techniques. The study area covered various priority areas in Lower Saxony as advised or requested by the State Wolf Bureau, wolf commissioners and the State Forestry Authority. Fifteen 10x10 km grid cells of the EEA grid system and almost 750 km were surveyed on foot or by bicycle. All grid cells were surveyed multiple times so that they were covered 29 times.

250 wolf scat samples were collected, 218 of which were included into the official wolf monitoring programme. 200 samples were frozen for dietary analysis and 25 of those were fresh enough for DNA analysis. Thirty-two tracks, a variety of fur remains and five suspected wolf kill carcasses were also found, but did not pass quality assessment procedures.

Eleven (5%) of the 218 scat samples collected were classified as C1 pieces of hard evidence on the SCALP classification system, 69 (32%) as C2 confirmed observation and 137 (63%) as C3 unconfirmed observations. One scat (1%) did not originate from a wolf. One direct sighting was also recorded as a C3 piece of unconfirmed evidence. Dietary analysis is ongoing and should be published in the next report.

DNA analysis of the 25 samples showed that 12 scats originated from wolf and one from fox. Three wolves could be identified as female and six as male. Two of the males were new to the monitoring programme. The DNA analysis also yielded the first genetic proof of the existence of the Wietze wolf pack. In addition, two areas of high wolf activity (in the districts of Lüchow-Dannenberg and Celle/Hannover) could be identified.

Scat samples collected for dietary analysis by the 2017 expedition have now been analysed. The 45 samples of C1, C2 or C3 classification yielded 30% roe deer (*Capreolus capreolus*), 29% wild boar (*Sus scrofa*), 18% red deer (*Cervus elaphus*), 8% fallow deer (*Dama dama*), 8% deer-like animal and 7% hare-like animal (Lagomorpha). When only biomass is considered, there are no significant changes; similar proportions of prey species were obtained from the 21 C1 samples only . An important and noteworthy aspect is the complete lack of livestock in the samples. This corroborates other studies that have shown that livestock comprises only a small proportion of a wolf's diet.

Just like the 2017 expedition, the quantity and quality of samples collected by the active monitoring effort of the 2018 expedition is remarkable. Official (passive) monitoring efforts in 2016/17 yielded 215 scat samples; in 2017/18 the number was roughly the same. This means that this two-week long citizen science, active expedition with 218 collected samples doubled the number of scats available from the official wolf monitoring efforts. The expedition also produced a quality ratio of 37% of C1 and C2 records, which is roughly the same as the 40% quality ratio of the official (passive) monitoring programme outside the expedition. All of this shows that with 1.5 days of training, contributions of citizen scientists towards wolf research and conservation can be both high quality and high quantity.

ZUSAMMENFASSUNG

Dieser Bericht beschreibt die Feldarbeit von Biosphere Expeditions im Rahmen eines aktiven Monitorings des großen Beutegreifers Wolf (*Canis lupus lupus*) in Zusammenarbeit mit dem Wolfsbüro des Landes Niedersachsen und einigen Wolfsberatern. Die Feldarbeit wurde vom 23. Juni bis 6. Juli 2018 in zwei einwöchigen Gruppen von max. 12 Bürgerwissenschaftlern durchgeführt. Ziel war es, aufgeteilt in Kleingruppen, Wolfshinweise, insbesondere Losungen für DNA-Beprobung und Nahrungsanalysen zu finden.

Von den 24 internationalen Expeditionsteilnehmern kamen 16 Personen aus Deutschland oder seinen unmittelbaren Nachbarstaaten (67%), inklusive zwei Personen aus Niedersachsen (8%), jeweils drei Personen aus Nordamerika und Großbritannien (12,5%) sowie je eine Person aus Island und Australien (4%). Vor Beginn der Geländebegehungen, ausschließlich auf öffentlich begehbaren Wegen, wurde eine eineinhalbtägige Schulung der Expeditionsteilnehmer durchgeführt. Das Untersuchungsgebiet umfasste verschiedene Schwerpunktgebiete in Niedersachsen, die vom staatlichen Wolfsbüro, Wolfsberatern vor Ort sowie den Niedersächsischen Landesforsten empfohlen bzw. angefragt wurden. Fünfzehn der 10x10 km großen Zellen des EU-Gitternetzes und fast 750 km wurden zu Fuß oder mit dem Fahrrad untersucht. Alle Rasterzellen wurden mehrfach besucht, so dass sie insgesamt 29 Mal abgedeckt wurden.

Die Expedition identifizierte insgesamt 250 Wolfslosungen im Gelände, 218 davon wurden in das offizielle Wolfsmonitoring aufgenommen. 200 der Losungsproben wurden zur Nahrungsanalyse tiefgefroren und an das Labor der Tierärztlichen Hochschule Hannover und die Landesjägerschaft Niedersachsen übergeben. 25 dieser Losungsproben waren frisch genug für DNA-Analysen. Die übrigen 32 Losungsproben sowie Spuren und Fellreste konnten aufgrund der strengen Datenqualitätsvorgaben nicht als Wolfshinweise genutzt werden.

Elf (5%) der 218 gesammelten Losungsproben wurden als C1 (eindeutiger Nachweis) nach dem SCALP-Verfahren bewertet, 69 (32%) als C2 (bestätigter Hinweis) und 137 (63%) als C3 (unbestätigter Hinweis). Eine (<1%) der Losungen stammte nicht von einem Wolf. Zusätzlich wurde noch eine direkte Sichtung als ein C3 (unbestätigter Hinweis) aufgenommen.

Durch die Analyse der 25 DNA-fähigen Losungen konnten insgesamt 12 Proben Wölfen zugeordnet werden, eine stammte von einem Fuchs. Es konnten drei Fähen und sechs Rüden identifiziert werden, zwei davon bisher nicht nachgewiesene, also unbekannte Rüden. Unter anderem konnte die Expedition den ersten genetischen Nachweis für das Rudel Wietze erbringen. Außerdem konnten zwei Gebiete mit hoher Wolfsaktivität identifiziert werden: eines im Landkreis Lüchow-Dannenberg und eines in der Region Celle/Hannover.

Die Nahrungsanalyse der Losungsproben, die im Jahr 2017 im Rahmen der ersten Expedition gesammelt wurden, ist nun abgeschlossen. 45 Proben, die mit C1, C2 oder C3a bewertet wurden, enthielten 30% Reh *(Capreolus capreolus)*, 29% Wildschwein *(Sus scrofa)*, 18% Rothirsch *(Cervus elaphus)*, 8% Damhirsch *(Dama dama*), 8% Rehartige und 7% Hasenartige *(Lagomorpha).* Betrachtet man die Biomasse, verschieben sich die Anteile geringfügig; werden ausschließlich die 21 als C1 bewerteten Losungsproben betrachtet, gibt es leichte, aber keine signifikanten Verschiebungen. Ein wichtiger Aspekt ist das Fehlen jeglicher Nutztiere in den untersuchten Proben. Dies bestätigt die generell geringen Anteile an Nutztieren in der Wolfsnahrung.

Ebenso wie bei der Expedition 2017 ist die Quantität, als auch die Qualität der Losungsproben, die im Rahmen der Expedition 2018 gesammelt wurden, beachtlich. Im Rahmen des offiziellen (passiven) Wolfmonitorings wurden im Jahr 2016/17 insgesamt 215 Losungsproben erfasst, im Jahr 2017/18 etwa dieselbe Anzahl. Das bedeutet, dass die zweiwöchige aktive Bürgerwissenschaftler-Monitoring-Expedition mit 218 protokollierten Losungsproben die Gesamtmenge an Losungsproben und somit wertvoller Daten für das offiziellen Wolfsmonitoring verdoppelt hat. Mit 37% C1- und C2-Bewertungen ist deren Qualität bemerkenswert hoch und vergleichbar mit den 40% des passiven offiziellen Monitorings außerhalb der Expedition. All dies belegt, dass Bürgerwissenschaftler mit eineinhalb Tagen Schulung einen quantitativ und qualitativ hochwertigen Beitrag zum Wolfsmonitoring leisten können.

Contents

Please note: Each expedition report is written as a stand-alone document that can be read without having to refer back to previous reports. As such, much of this section, which remains valid and relevant, is a repetition from previous reports, copied here to provide the reader with an uninterrupted flow of argument and rationale.

1. Expedition Review

Matthias Hammer (editor)
Biosphere Expeditions

1.1. Background

Biosphere Expeditions runs wildlife conservation research expeditions to all corners of the Earth. Our projects are not tours, photographic safaris or excursions, but genuine research expeditions placing ordinary people with no research experience alongside scientists who are at the forefront of conservation work. Our expeditions are open to all and there are no special skills (biological or otherwise) required to join. Our expedition team members are people from all walks of life, of all ages, looking for an adventure with a conscience and a sense of purpose. More information about Biosphere Expeditions and its research expeditions can be found at www.biosphere-expeditions.org.

This project report deals with an expedition to the state of Lower Saxony in Northern Germany that ran from 23 June to 6 July 2018 with the aim of conducting conservation research monitoring on wolves.

By the end of the monitoring year 2017/18, counts had confirmed 73 wolf packs in Germany (BfN 2018). Wolves first appeared in the German federal state of Lower Saxony in 2006 and have since then expanded to 21 wolf packs, two wolf pairs and one single wolf (LJN 2019) in 2018. With this expansion comes potential for conflict. Negative aspects of wolf presence often make news headlines and as such facilitate a heightened sense of fear. It is true that wolves can sometimes cause considerable losses to livestock, particularly sheep, which is often the main source of conflict (DBBW 2019), and as a result hunters often believe wolves will also decimate game populations (ARD 2018). The result is frequent demands for culls, which is the approach that eradicated carnivores from Germany and Western Europe in the past. The concurrent emergence of new threats to wildlife and their habitats through economic development and population pressure means that a more sensitive approach is required; one based on a sound, science-based understanding of the place of carnivores in ecosystems, but also taking into consideration their impact on local people. There is much to be done in order to achieve these goals. Field work conducted by Biosphere Expeditions aims to make an important contribution to this by providing science-based monitoring data for finding answers and strategies.

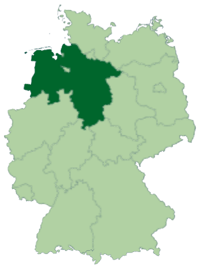
1.2. Research area

The expedition took place in Lower Saxony (German: Niedersachsen), a German federal state (Bundesland) situated in northwestern Germany, which among the sixteen German states is the second largest by area (47,624 square kilometres) and fourth largest by population (8 million). The state has a population density of 170 persons per square kilometre (Wikipedia 2018).

Figure 1.2a.
Flag and map of Germany,
base (red dot) and study area (red circle).

An overview of Biosphere Expeditions' research sites, assembly points, base camp and office locations is at Google Maps.

Below: Lower Saxony, one of 16 German states.



The state capital is Hanover (German: Hannover). There are seven other major cities in the state: Brunswick, Oldenburg, Osnabrueck, Wolfsburg, Goetingen, Hildesheim and Salzgitter. Important neighbours are the metropolitan areas of Bremen and Hamburg.

The Lueneburg Heath (German: Lüneburger Heide) is a large area of heath, geest and woodland in the northeastern part of Lower Saxony. It forms part of the hinterland for the cities of Hamburg, Hanover and Bremen and is named after the town of Lueneburg. Most of the area is a nature reserve. The extensive areas of heathland are typical of those that covered most of the north German countryside until about 1800, but which have almost completely disappeared in other areas. The heaths were formed after the Neolithic period by overgrazing of the once widespread forests on the poor sandy soils of the geest, as this slightly hilly and sandy terrain in northern Europe is called. The Lueneburg Heath is therefore a historic cultural landscape. The remaining areas of heath are kept clear mainly through grazing, especially by a north German breed of moorland sheep called the "Heidschnucke". Due to its unique landscape, Lueneburg Heath is famous in Germany and beyond as a recreation area.

Another landscape covered by this expedition was deciduous woodlands containing trees with broad leaves such as oak, beech and elm. They occur in places with high rainfall, warm summers and cooler winters and lose their leaves in winter. As some light can get through, the vegetation is layered and a shrub layer can also be found beneath the taller trees, containing species such as hazel, ash and holly. Grass, bracken and bluebells can also be found in the ground layer. Animals present include various species of deer, wild boar, red fox, badger, brown hare, golden eagle, osprey, raven, pine marten, stone marten, racoon dog and otter.

In addition there are also wetlands such as bogs that accumulate peat, a deposit of dead plant material - often mosses, and in a majority of cases, sphagnum moss.

Figure 1.2b. Typical heath landscape.

Figure 1.2c. Typical woodland landscape.

1.3. Dates

The project ran over a period of two weeks divided into two seven-day slots, each composed of a team of international citizen assistants, scientists, wolf commissioners and an expedition leader. Slot dates were:

23 – 29 June | 30 June – 06 July 2018

Team members could join for multiple slots (within the periods specified). Dates were chosen to coincide with the increased activity period during the raising of juvenile wolves.

1.4. Local conditions & support

Expedition base

The expedition team was based on the southern edge of the Lueneburg Heath nature reserve at [NABU Gut Sunder](), at a guesthouse / research station with all modern amenities. Team members shared twin rooms with modern showers and toilets. Breakfast and dinner was provided at base and a lunch pack was supplied for each day spent in the field.

Figure 1.4a. Expedition base: The "Seminarhaus" at NABU Gut Sunder.

Weather

Average summer daytime temperatures range between 10 and 30 ºC with an average of eight hours sunshine per day and up to ten days with rain per month. In line with this, the weather during the expedition was very variable from hot days with a lot of sunshine to cooler, overcast days and days with plenty of rain and thunderstorms (see appendix I for full weather records).

Field communications

There was patchy mobile phone coverage around the base and very little to no mobile phone coverage in the study areas. The expedition also used hand-held radios for groups working close together. The expedition base had WiFi internet. The expedition leader posted a blog on Wordpress, which was mirrored on the Biosphere Expeditions' social media sites.

Transport & vehicles

Team members made their own way to the assembly point at Bremen airport. From there onwards and back to Bremen all transport was provided for the expedition team. The expedition used a combination of cars from staff and expedition participants, supplemented by hire cars as necessary. Surveys were generally conducted on foot, but for some of the surveys the expedition team also used bicycles provided by NABU Gut Sunder.

Medical support and incidences

The expedition leader was a trained first aider and the expedition carried a comprehensive medical kit. The nearest hospital is located in the nearby town of Celle (30 km from base) or the university medical centre in Hanover (70 km from base). In case of immediate need of hospitalisation, and weather permitting, ambulance and rescue services were available. All team members were required to carry adequate travel insurance covering emergency medical evacuation and repatriation. Safety and emergency procedures were in place, but did not have to be invoked as there were no accidents or mishaps.

1.5. Expedition scientist

Peter Schütte was born in Germany and studied geography and geoinformatics at the Universities of Bremen (Germany), Gothenburg (Sweden) and Salzburg (Austria). He has worked in this field for several international mapping and remote sensing projects, one of which involved him in wildlife conservation in Namibia, where he was a member of Biosphere Expeditions' team of local scientists. Starting in 2004, Peter led expeditions in Namibia/Caprivi, Altai, Oman and Slovakia for Biosphere Expeditions. Working on projects involving cheetahs, leopards and lions in Namibia for years, he gathered experience in the field of human-wildlife conflicts. Back in his native Germany, Peter is now working to gain acceptance for the return of wolves to the country. He is involved in wolf monitoring and is working on human-wildlife conflict solutions, such as livestock protection measures.

1.6. Expedition leader

Malika Fettak is half Algerian, but was born and educated in Germany. She majored in Marketing & Communications and worked for more than a decade in both the creative field, but also in PR & marketing of a publishing company. Her love of nature, travelling and the outdoors (and taking part in a couple of Biosphere expeditions) showed her that a change of direction was in order. Joining Biosphere Expeditions in 2008, she runs the German-speaking operations and the German office, and leads expeditions all over the world whenever she can. She has travelled extensively, is multilingual, a qualified off-road driver, diver, outdoor first aider, and a keen sportswoman.

1.7. Expedition team

The expedition team was recruited by Biosphere Expeditions and consisted of a mixture of ages, nationalities and backgrounds. They were (in alphabetical order and with country of residence):

23 – 29 June 2018: Susanne Albinger (Austria), Rudolf Dinkelacker (Germany), Sieglinde Dittmann (Germany), Sylvia Dittmann (Germany), Edward Durell (Germany), Scott Duttfield* (UK), Clare Murphy (Iceland), Markus Orth (Germany), Roeland Pater (the Netherlands), James Sheppard* (UK), Patricia Smith (Belgium), Markus Stein (Germany), Lauren White (USA).

30 June – 6 July 2018: Jelle Boef (the Netherlands), Sieglinde Dittmann (Germany), Sylvia Dittmann (Germany), Andrew Down (UK), Anja Giles (Germany), Latika Keegan (USA), Mark Keegan (USA), Sita Liu (Australia), Sebastian Seely (UK), Beate Stahmer (Germany), Christine Weiss (Germany).

In addition for some or all of the time: Theo Grüntjens, Kenny Kenner (wolf commissioners), Charlotte Steinberg, Dorit Mersmann (biologists), Lea Wirk (of Wildlife Detection Dogs e.V.).

*Member of the media.

1.8. Partners

Biosphere Expeditions' main partner on this expedition was the state's environmental authority the NLWKN (Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz, Nature = Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency), which is officially responsible for the monitoring of all wildlife in the state. The authority's Wolfsbüro (wolf bureau) was established in 2015 with the remit to (a) gather and consolidate information about wolves in Lower Saxony, (b) organise the monitoring of this protected species in conjunction with the Hunter's Association of Lower Saxony (Landesjägerschaft Niedersachsen e.V., LJN), (c) support livestock owners suffering losses caused by wolves and (d) inform the public about issues concerning the wolf. Wolf management includes scientists, environmentalists, foresters, hunters, etc., and has at least one contact person in most of the 46 districts, the so-called 'wolf commissioners'. Wolf bureau staff were closely involved in all expedition activities. Other partners included the state forestry department, district and communal authorities, Kenner's Landlust, Wolfcenter Dörverden and NABU Gut Sunder (Nature and Conservation Union).

1.9. Expedition budget

Each citizen scientist paid a contribution of €1,840 per person per seven-day period towards expedition costs. The contribution covered accommodation and meals, supervision and induction, special research equipment and all transport from and to the team assembly point. It did not cover excess luggage charges, travel insurance, personal expenses such as telephone bills, souvenirs etc., or visa and other travel expenses to and from the assembly point (e.g. international flights). Details on how this contribution was spent are given below.

Income	**€**
Expedition contributions	36,240
Expenditure	
Expedition base includes all food & services	9,130
Transport includes hire cars, fuel, taxis in Germany	1,308
Equipment and hardware includes research materials & gear etc. purchased internationally & locally	722
Staff includes local and Biosphere Expeditions staff salaries and travel expenses	8,987
Administration includes miscellaneous fees & sundries	1,191
Team recruitment Germany as estimated % of annual PR costs for Biosphere Expeditions	8,676
Income – Expenditure	**6,226**
Total percentage spent directly on project	**83%**

1.10. Acknowledgements

We are very grateful to all the expedition citizen scientsts, who not only dedicated their spare time to helping but also, through their expedition contributions, funded the research. Thank you also to those who brought their own cars and supported the expedition in this way too. Thank you to all our partners metioned above, especially those at the 'Wolfsbüro' at NLWKN and to all those professionals who provided assistance and information. Special thanks go also to all of the wolf commissioners (Wolfsberater) and helpers working on a voluntary basis in support of the expedition. Their efforts and local knowledge were crucial to the success of our field work. Thanks also to the state forestry department (Niedersächsische Landesforsten) for their co-operation. Furthermore thanks to the University of Veterinary Medicine Hannover Foundation (Institute for Terrestrial and Aquatic Wildlife Research) and Landesjägerschaft Niedersachsen (LJN), especially masters student Charlotte Steinberg who analysed the scat samples for diet. Biosphere Expeditions would also like to thank members of the Friends of Biosphere Expeditions and donors for their sponsorship. Finally, thank you to the staff of NABU Gut Sunder for being such excellent hosts and making us feel at home.

1.11. Further information & enquiries

More background information on Biosphere Expeditions in general and on this expedition in particular including pictures, diary excerpts and a copy of this report can be found on the Biosphere Expeditions website www.biosphere-expeditions.org.

Enquires should be addressed to Biosphere Expeditions at the address given on the website.

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2. Monitoring wolves in Lower Saxony

Peter Schütte
Wolf commissioner

Matthias Hammer (editor)
Biosphere Expeditions

2.1. Introduction

The Eurasian wolf (*Canis lupus lupus*) belongs to the canine family (Canidae), is a native species to Europe and was eradicated by humans in Western Europe more than 150 years ago. Wolves are habitat generalists and live in packs, which mostly consist of the two parents and their offspring of the last two to three years (DBBW 2018). Young wolves usually leave the parental territory, sometimes as early as at age ten months, but sometimes staying until age 22 months, at which point they search for their own territory and a mating partner. Body mass can vary from approximately 30 up to 80 kg (DBBW 2018). Wolves are highly territorial and defend their territory from other packs through howling, scent markings (defecation, urination, scratching), and attacks (Ronnenberg et al. 2017).

After an absence of more than 150 years, wolves, by and large from Eastern European populations, started to colonise Germany again at the turn of the millennium, and reached Lower Saxony in 2006 from Poland via Eastern Germany. The species was classified by the International Union for Conservation of Nature (IUCN) as Endangered in 2012 (Kaczensky et al. 2013) and is protected by European law through the Fauna Flora Habitat (FFH) Directive and German law (Federal Nature Conservation Act), where the wolf is listed in Annex II and IV of the FFH Directive. This listing requires that active management plans for the wolf should be in place. According to the Directive, the objective is to achieve and maintain a “favourable conservation status” (FCS) for the wolf population. This FCS is defined in the management plan guideline (Linnell et al. 2008) and stipulates that a population is in an FCS if all of the following eight conditions are met:

1) The population is stable or increases
2) The natural range of the species is neither being reduced, nor is it likely to be reduced in the foreseeable future
3) Wolf habitats are likely to maintain their quality
4) The size of the “favourable reference population” (FRP) has been reached (based on the IUCN Red List criteria)
5) The population is as large as, or greater than, that at the time the Directive came into effect
6) The “favourable reference range” (FRR) is occupied
7) An exchange of individuals within the population or between populations is taking place or is promoted (at least one genetically effective migrant per generation)
8) An efficient and robust monitoring system of the species is established

The FCS is set at a national level, but takes local population levels into account. Wolves in Germany together with those in western Poland form a self-contained population (the Central European Lowland Population) and this population is currently defined as isolated, as there is no unrestricted reproductive exchange with other populations. This fact alone shows that an FCS has not been reached.

All EU states are obliged to monitor the state of conservation of their country and to report to the European Commission every six years. Due to the federal system in the Federal Republic of Germany, this monitoring task is within the jurisdiction of each individual federal state.

In Lower Saxony, official wolf monitoring studies have shown that the wolf has in fact been breeding (LJN 2016). In addition, Fechter and Storch (2014) have shown that there are many more areas in Lower Saxony suitable for wolf re-colonisation than are currently being occupied by the species. Furthermore, recent wolf monitoring has shown that the wolf is so adaptable that it even colonises areas previously thought unsuitable for wolves (LJN 2016). Moreover, young wolves are by their nature always actively looking for new areas to found packs in and more wolves are pushing into the state from healthy breeding packs in the German states to the east of Lower Saxony. As a result, more wolves are spotted by people, there is increased media coverage, and unprotected livestock can be predated upon. These elements have resulted in decreasing wolf acceptance amongst local people (Deutscher Bundestag 2015), especially hunters and livestock owners, who play a crucial role in wolf survival (Deutscher Bundestag 2018). This means that the threat of real and perceived conflict with humans, livestock and game species is ever increasing, as is the need to educate and inform local people about the presence of wolves in their area. If the wolf is to have a future in Lower Saxony, people must be educated about the wolf's movements and habits, as well as about the correct application of livestock protection measures, so that human-wolf conflict can be reduced as much as possible or avoided altogether.

BMUB (2015) argues that human-wolf conflict resolution should encompass the following activities in the state’s wolf management: Informing stakeholders and the general public, measures to protect livestock from wolf depredation, interaction with the hunting community, effective and lawful procedures to deal with problem wolves, monitoring and research.

The Lower Saxony wolf management (MU 2019, NLWKN 2019) provides important contacts and chains of action for different situations and it also includes guidelines for wolf monitoring procedures in accordance with a nationwide set of standard criteria and protocols. The experiences of the last two decades in Germany suggest that co-existence of humans and wolves is possible (NABU 2014), but it requires effective and transparent information campaigns to inform stakeholders and the wider population. The return of the wolf certainly has its challenges, especially for livestock owners. They need quick chains of action and recommendations for best practice, e.g. livestock protection measures and strategies for public relation activities (NABU 2015). Several surveys in Germany and Austria since 2018 have shown that the population is significantly in favour of the wolf returning. However, an increase in livestock kills could result in the loss of public support, so it is crucial to work on solutions for co-existence between livestock on open pasture lands and free-roaming wolves.

In addition, detailed knowledge of temporal trends in the spread and abundance of wolves is an important basis for taking effective measures, thus monitoring of wolf populations is essential.

Since the wolf, as a habitat generalist, is able to adapt to many different habitats and circumstances, the species has found itself able to survive and propagate effectively in today's highly cultivated landscape in Germany. The wolf does not need, as is often suspected, a wilderness in order to survive. It simply needs an adequate food supply and retreat areas for breeding.

Wolf territories

At the end of the monitoring year 2017/18 there were 73 confirmed wolf packs in Germany (DBBW 2018). The distribution of territories occupied by the wolf today is largely a function of expansion from founder populations in southeast Saxony in the early 2000s, through the states of Brandenburg and Saxony-Anhalt northwest to Lower Saxony (Fig. 2.1a).

Prior to the project commencing, the numbers of wolves in Lower Saxony in the 2016/2017 monitoring year were eleven wolf packs, one wolf pair, two single wolves and eight unconfirmed territories (LJN 2017). In April 2018, before the 2018 expedition started, numbers had increased to 14 wolf packs, four wolf pairs, one single wolf and six unconfirmed territories (LJN 2018). In December 2018, after the expedition in June/July, numbers increased to 21 wolf packs, two wolf pairs and one single wolf (LJN, 2019, Fig. 2.1b). This demonstrates that the wolf population in the area is increasing.

Study area

The study area was in the state of Lower Saxony, mainly in areas around the Lueneburg Heath. Study sites were chosen in close collaboration with the state authorities responsible for wolf monitoring, mainly the wolf bureau, which advised where wolf population data were needed most, for example because there was little recent knowledge about breeding activity or other aspects of population dynamics, or because wolves had entered a new area.

Lower Saxony borders the North Sea in the north, where some areas are depressions below sea level. In the north-east the Elbe river is part of the state border. The southeast border runs through the Harz Mountains with the highest peak at 971 m. The northeast and west of the state are part of the North German Plain, while the south is in the Lower Saxon Hills. The Lueneburg Heath is located in the northeast of the state (Fig. 2.1d). The main large rivers are the Elbe, Weser, Aller and Ems.

The state of Lower Saxony was created after World War II and has geographic, historic and cultural roots. The state is divided into 37 districts (Landkreise, Fig. 2.1c). Districts are a constituent part of the German federal system. The constitution requires a vertical distribution of public power to politically constituted local authorities, namely municipalities, districts, states and the federal government. This ensures a decentralised service of public duties. The districts have to fulfill communal services such as, for example, handling of nature conservation issues.

Land use and land cover

More than half of Germany's surface area is used for agriculture, although this proportion is declining slowly, while settlements and traffic infrastructure steadily rise. Almost 60% of Lower Saxony is used for agriculture, 22% is occupied by forests, with settlements and traffic infrastructure forming the third biggest type of land use (18%) (Niedersachsen 2018) (Fig. 2.1d).

In densely populated Lower Saxony, a variety of infrastructure such as roads, railways, settlements or industrial areas divide up the landscape (Fig. 2.1d). The state's 799 nature reserves account for only 4.1% of its surface area (NLWKN 2017), so it is clear that large, uninterrupted habitats for wild animals do not exist within the heavily populated and cultivated landscape, forcing wildlife to live within a highly fragmented landscape.

The physical and biological ground cover and the ways in which it is used are very diverse in Lower Saxony. Although there are some larger areas of forests and agriculture, the state is very fragmented (Fig. 2.1e). In all four study sites, there are several settlements, a great variety of infrastructure, and also intensely farmed agricultural areas.

Wolf monitoring shows that wolf territories in Lower Saxony are predominantly in forest and heath regions, but there are also some in the middle of cultivated and densely populated areas (LJN 2018a/b).

Figure 2.1a.

Wolf territories in Germany on 30 April 2018 (source).

Rudel (blue) = wolf pack

Paar (red) = wolf pair

Einzeltier (yellow) = single individual

The text reads "73 packs, 31 pairs, 3 territorial individuals are known, as well as 266 juveniles (11 packs crossing state boundaries). Territorial wolves are present in the states of Bavaria, Brandenbug, Mecklenburg-Vorpommern, Lower Saxony, Saxony, Saxony-Anhalt, Thuringia".

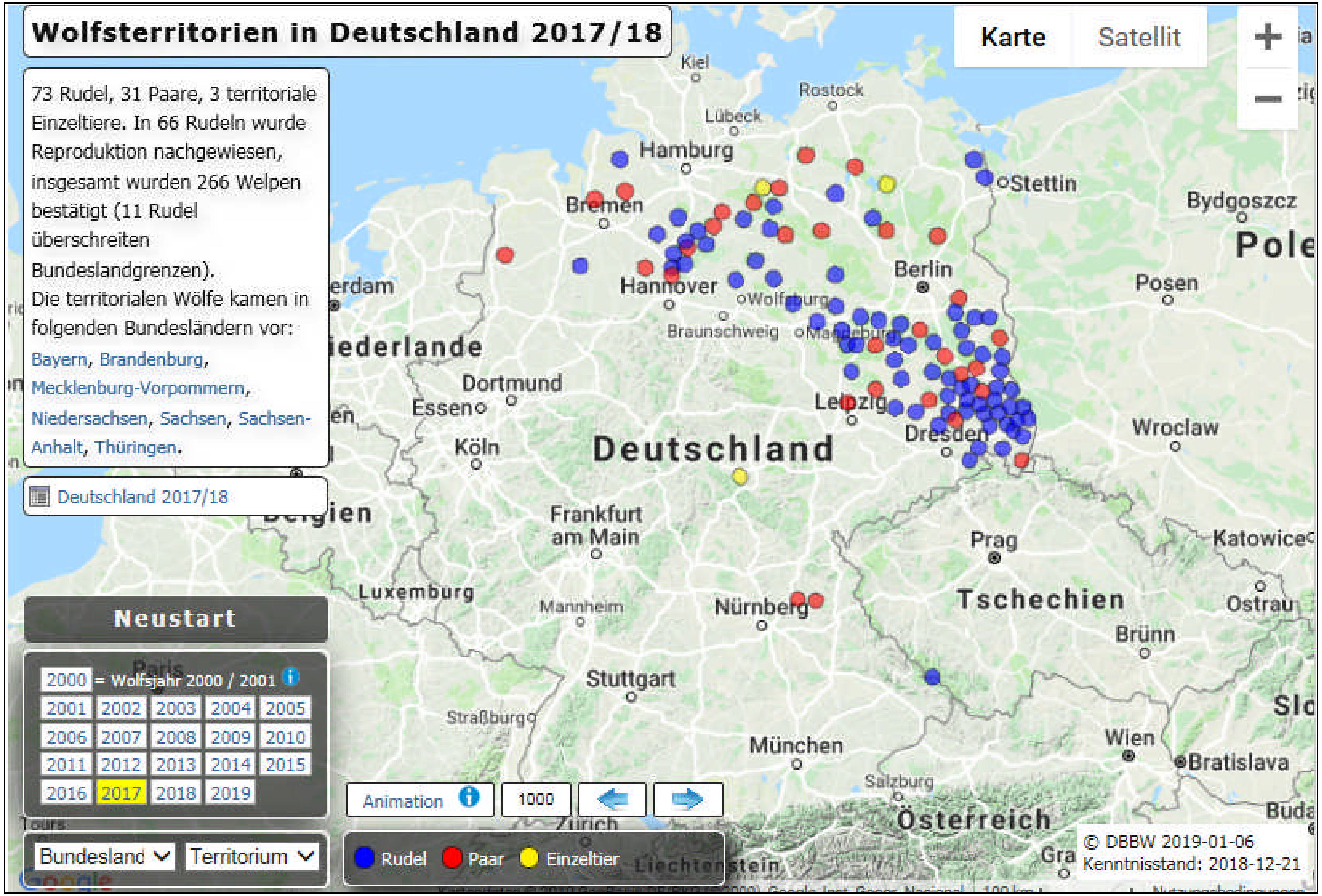

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Figure 2.1b.

Wolf territories in Lower Saxony on 13 December 2018 (source).

Wolfsrudel (orange) = wolf pack

Wolfsrudel (Nachweis ausstehend) (shaded orange) = wolf pack (to be confirmed)

Wolfspaar (red) = wolf pair

Residenter Einzelwolf (green) = resident individual

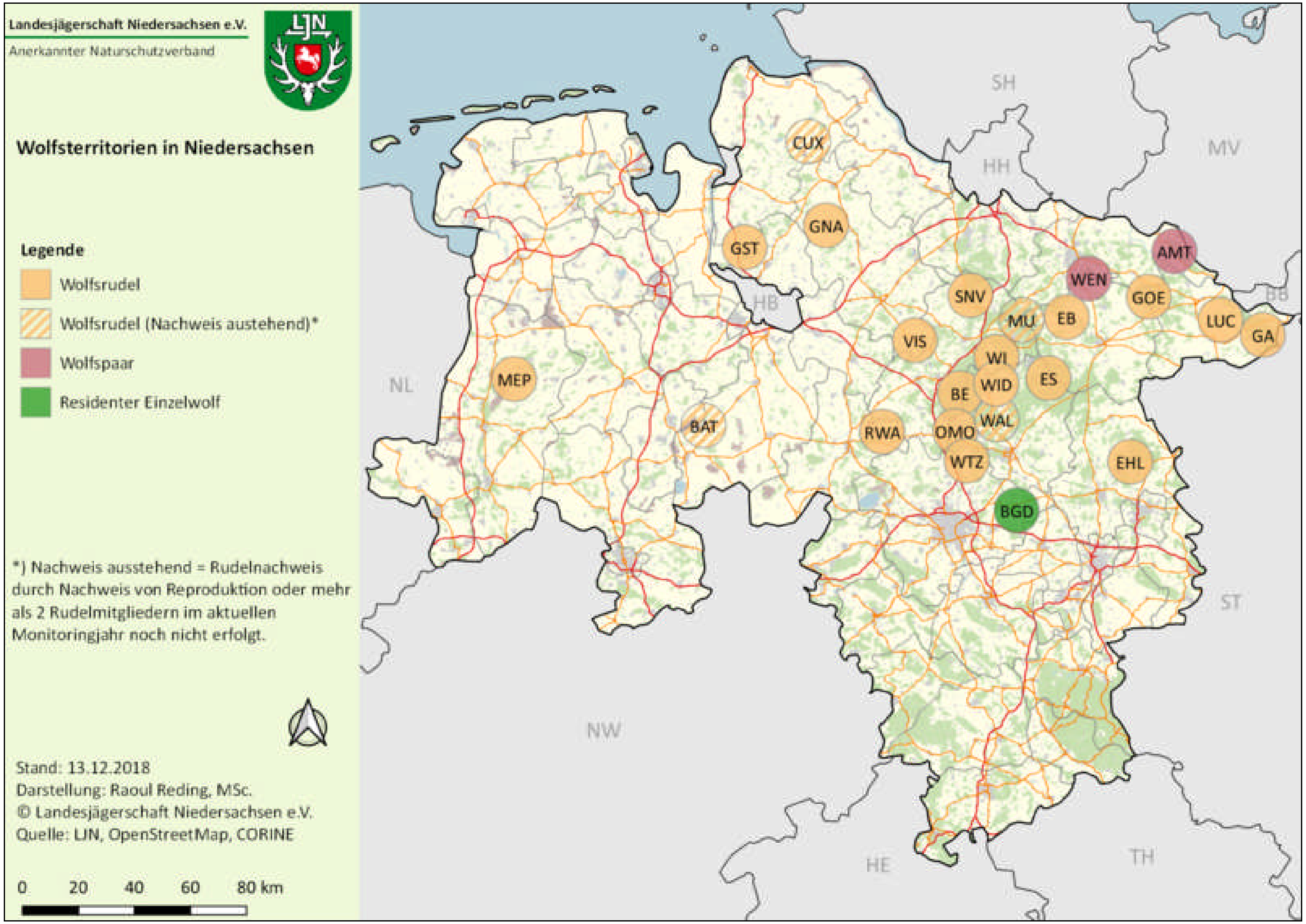


Figure 2.1c.

Districts and urban districts of Lower Saxony (source).

Figure 2.1d.

Land use of Lower Saxony (source).

Main roads (red)

Railways (black)

Rivers (blue)

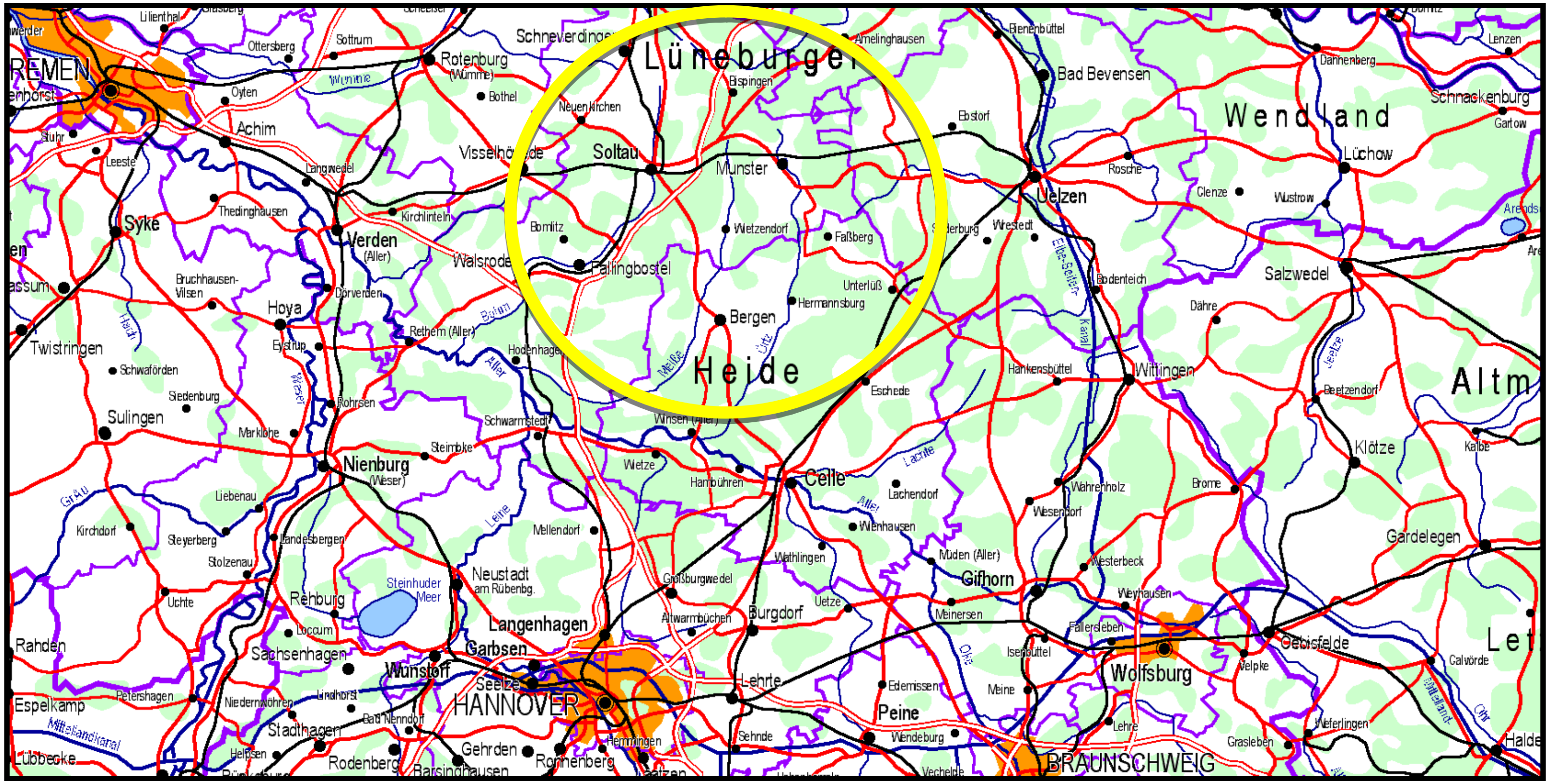
Forests (green)

Agricultural areas (white)

Urban areas (orange)

District boundaries (purple)

The Lueneburg Heath (Lüneburger Heide) is marked by a yellow circle



Climate

Lower Saxony is located in the west wind zone, Central Europe’s temperate zone, in a transition area between the maritime climate of the western part and the continental climate of the eastern part of Europe. Hence there are noticeable climatic differences within the state. The northwest has an Atlantic climate with a low temperature amplitude. Further inland the climate is more continental with stronger temperature differences between summer and winter, the precipitation is lower and seasonally unevenly distributed. The highest rainfall is recorded in the Harz mountains. The average annual temperature is around 8°C.

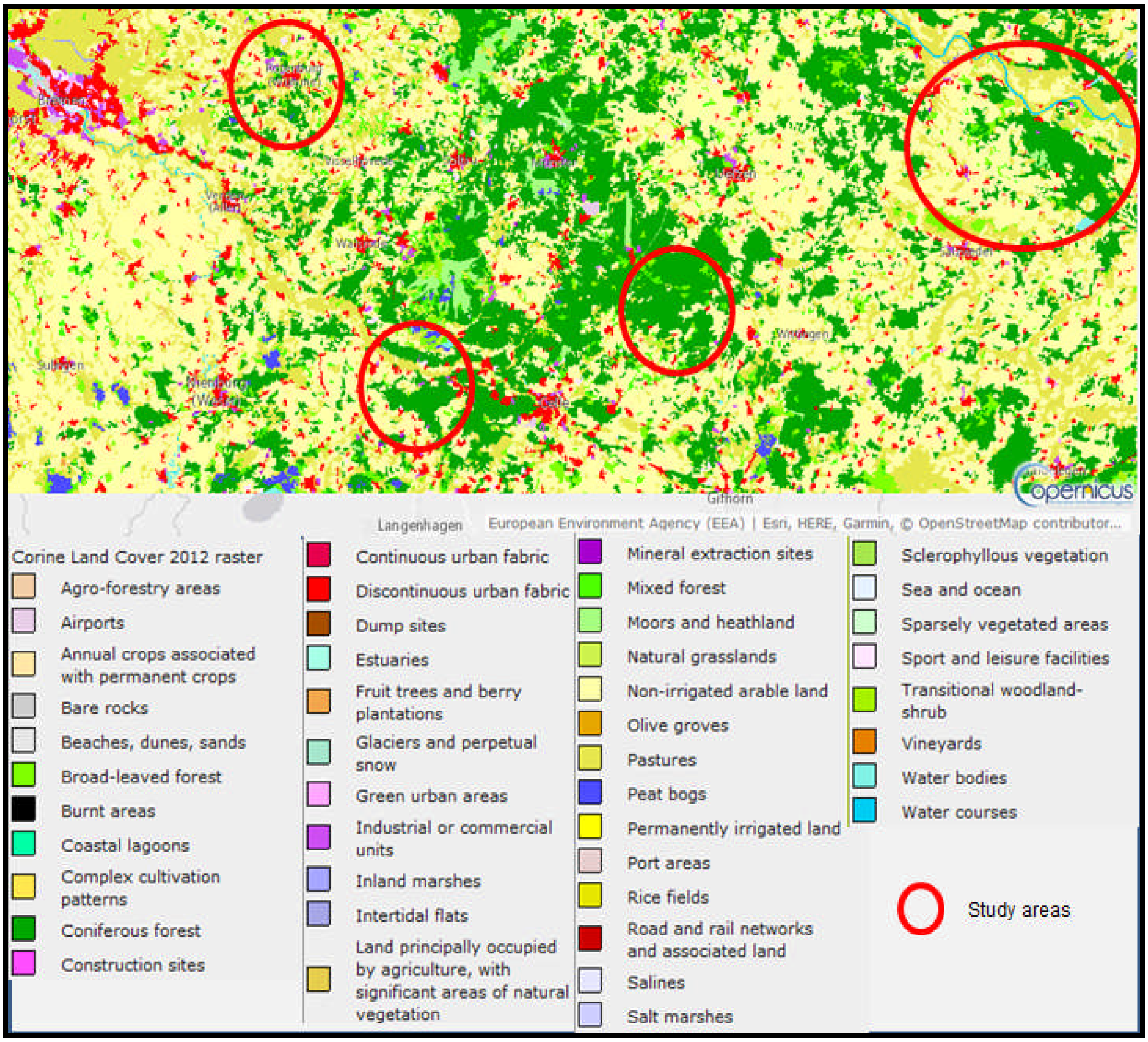


Figure 2.1e. Land use cover in main study areas, map adapted from CORINE.

Survey areas and habitats

Field work covered 15 standard 10 x 10 km cells of the EEA grid system (European Environment Agency 2018) in four different survey areas, situated in the districts of Celle, Heidekreis, Luechow-Dannenberg, Lueneburg, Northeim, Rotenburg and Uelzen (Fig. 2.1f), and covering a variety of habitats such as forest, swamp, heath, agricultural and forestry land (Figs. 1.2b & c, 2.1g-j). All study sites were chosen in consultation with the State Wolf Bureau, local wolf commissioners and forestry departments.

Survey routes were always on public paths, forest or hiking trails, never on private ground or off public pathways. This was done in order to avoid any trespassing, but equally importantly to increase the chances of finding wolf sign, because wolves predominantly use public pathways and other human infrastructure for travelling and territorial marking (Reinhardt et al. 2015a).

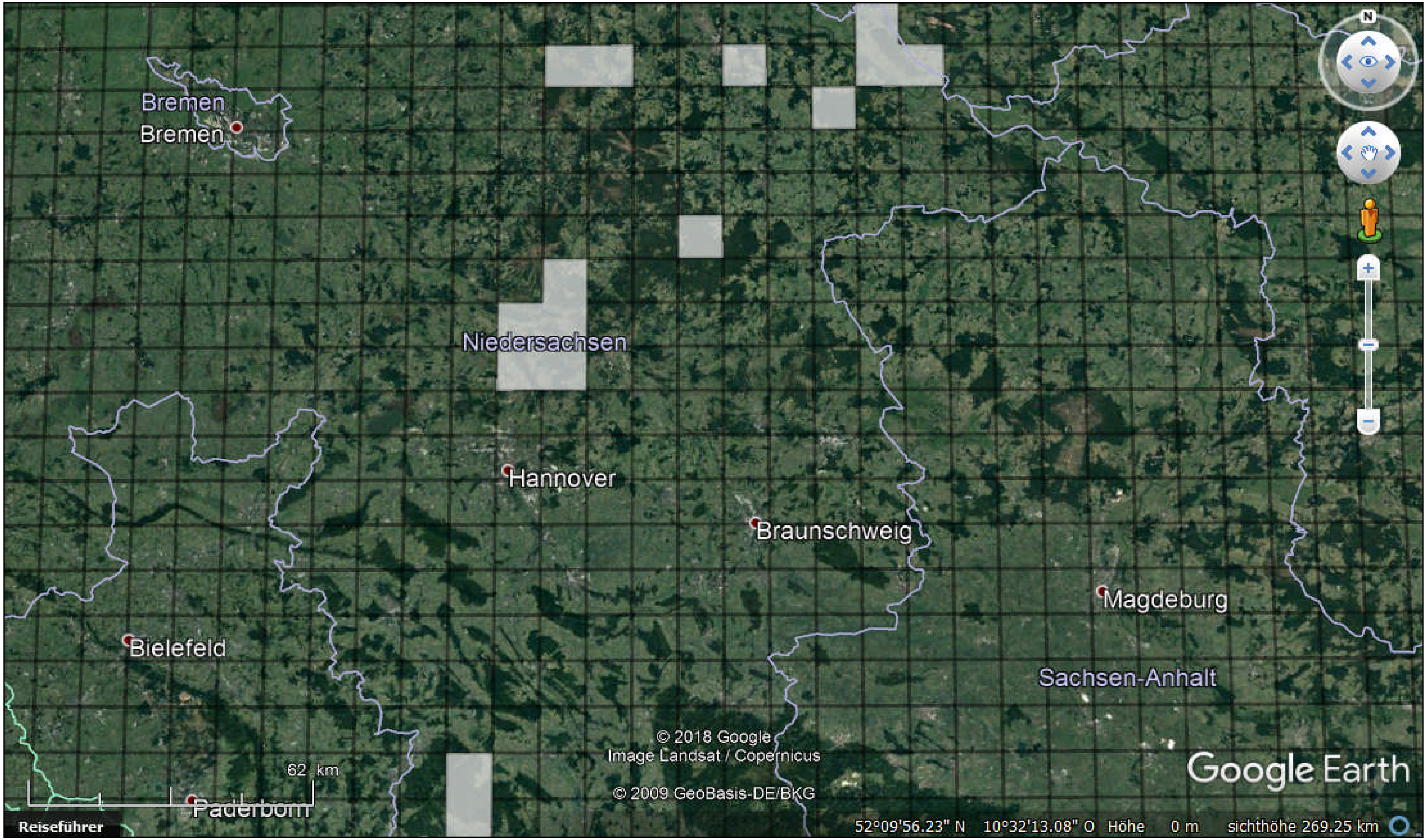


Figure 2.1f. 15 EEA grid cells covered during the 2018 surveys (indicated as pale shading).

Figure 2.1g. Forest and field edge habitat. Photo courtesy of Daniel McCourt.

Figure 2.1h. Open woodland habitat.

Figure 2.1i. Conifer forest habitat. Photo courtesy of Graham Makepeace-Warne.

Figure 2.1j. Open marshland habitat. Photo courtesy of Angela Holz.

2.2. Materials and methods

2.2.1 Monitoring

In Lower Saxony, wolf monitoring is usually conducted via a passive system. This means that those responsible for collecting data only become active when they receive messages about wolf signs such as scats, sightings, kills, etc. from the local population (LJN 2018c).

Data are collected and evaluated following nationwide standards for the monitoring of large carnivores in Germany (Reinhardt et al. 2015a) and are collated in quarterly reports. In Lower Saxony, for better or for worse and as a result of a political decision, the agency responsible for collation, analysis and publication is the State Hunter's Association of Lower Saxony (LJN = Landesjägerschaft Niedersachsen). The LJN works in cooperation with wolf commissioners. Wolf commissioners are appointed by the state's Ministry of Environment and work on a voluntary basis. Their remit is to support wolf monitoring efforts and educate the public about wolves. There are about 120 wolf commissioners distributed across Lower Saxony's districts. In addition to their role as advisors, where they would for example advise livestock owners about livestock protection, they also record reports of sightings, livestock and game kills and other evidence of wolf occurrence.

According to Reinhardt et al. (2015a), interpretation of data collected via passive means should be done "very carefully as these data are collected randomly and not systematically". There is thus a clear need for active monitoring efforts to detect more signs of wolf presence, collected specifically and systematically. Active wolf monitoring methods are used in certain areas by the LJN, the State Wolf Bureau, the wolf commissioners and also by Biosphere Expeditions in the current and former studies.

Breitenmoser et al. (2006) define active monitoring as data and information collection specifically for the purpose of monitoring a species or a population. Scale, resolution and timing of field activities, as well as the collection methods, are designed with the monitoring objective in mind, as well as species biology and environmental conditions. The aim is to collect data that have the least possible bias so that the results of the monitoring programme can answer the question asked with as little bias as possible.

In official wolf reports, the spatial condition of a population is described through the occurrence and distribution area. This refers to the area that is populated by the species. Monitoring data is displayed in the EEA grid system (on 10 x 10 km grid cells) (European Environment Agency 2018) (Figs. 2.2.1a & b). In the official wolf monitoring system in Germany, a grid cell is considered occupied if it produces at least one observation, classified as C1 (hard evidence) (Reinhardt et al. 2015b). In the absence of a C1 record, at least three C2 records (confirmed observations) are required (see appendix II for details and definitions of the SCALP classification system).

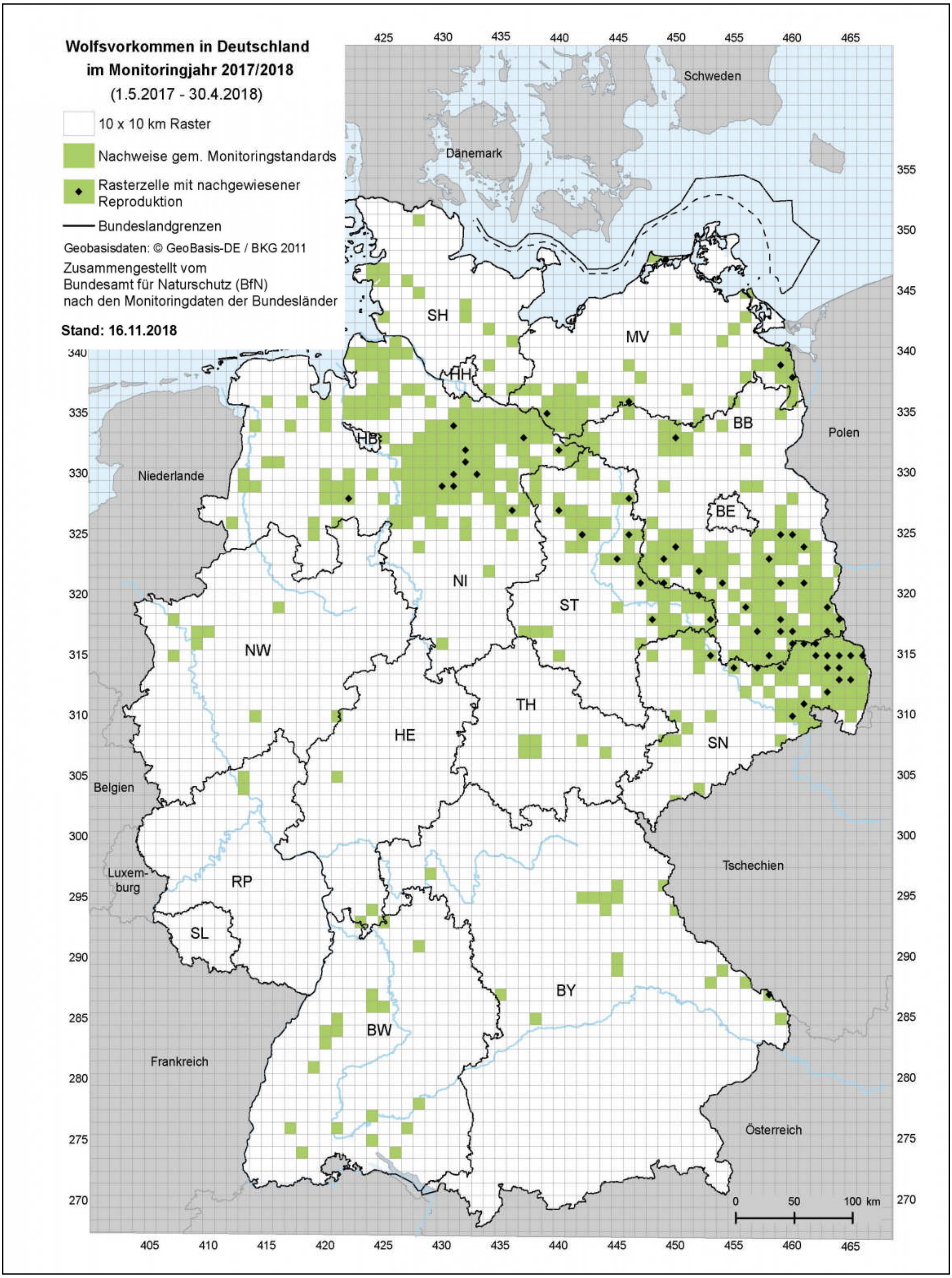


Figure 2.2.1a. Distribution of wolves in Germany in 2017/2018 on the EEA grid system (source).
Green cell = wolf presence confirmed in accordance with monitoring standards.
Green cell with black dot = wolf presence and reproduction confirmed.

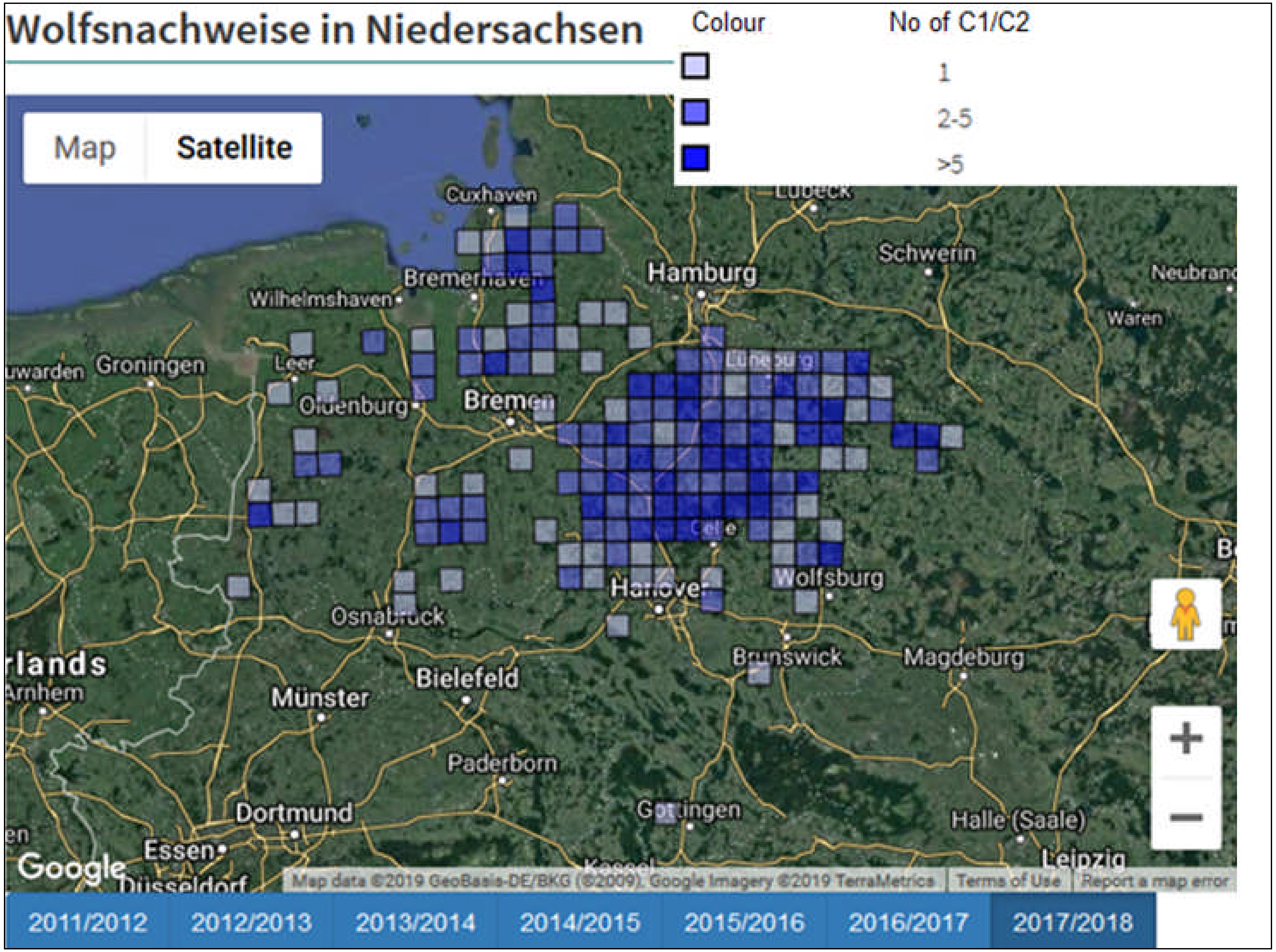


Figure 2.2.1b. Distribution of wolves in Lower Saxony in 2017/2018 on the EEA grid system (source).

For demographic analysis and accurate population size estimation, Reinhardt et al. (2015b) recommend working with population indices such as the number of packs and scent marking pairs. The population size is usually given in sexually mature individuals. Validated and categorised monitoring data can then be used to deduce the area of occurrence or population size and to distinguish between adjacent territories, pack size and reproduction. The recommended methods to estimate these parameters are described by the authors, who also provide the following definitions:

- Single resident wolf: single wolf living in an area for at least six months

- (Scent marking) pair: male and female wolf marking together but not (yet) having reproduced

- Pack (family group): a group of more than two wolves living in a territory

- Reproductive pack (family group): group consisting of at least one mature wolf with confirmed reproduction

- Mature wolf: equal to or older than 22 months

- Pup: wolf in its first year of life; since most pups are born at the beginning of May, the transition from pup to yearling takes place on 1 May. Accordingly, the official monitoring year is from 1 May to 30 April.

- Yearling: wolf in its second year of life

2.2.2. Signs and methods used during the expedition

In order to glean useful, high quality data, we followed Reinhardt et al.'s (2015b) monitoring methods and ways of documenting and evaluating findings in the field. Citizen scientists conducted so-called presence sign surveys, i.e. they searched for signs of wolves such as tracks, scats, scratch marks, kills or direct sightings. Since wolves often use existing human pathways for travelling and territorial marking, such pathways were surveyed on foot or by bicycle, sometimes with the use of specially trained dogs to detect scats. Citizen scientists were given an area to survey each day and they walked or rode along selected pathways slowly and in small groups and documented the route covered, as well as all signs found. Data were collected in standardised data sheets (see appendix III for week-by-week survey results).

Presence sign surveys can be conducted all year round under almost all environmental conditions (Reinhardt et al. 2015b). The method is simple but laborious, and often there is simply a lack of personnel to examine areas. This is where citizen science can make a significant contribution, as Foster-Smith & Evans (2003) and many others have shown.

We collected and assessed the following wolf signs, following Reinhardt et al. (2015a):

Tracks

It is not possible, even for experts, to make a clear distinction between a dog and wolf of similar size from single footprints or a few visible steps. Only paw prints over a longer track make the distinction apparent, because wolves typically use an energy-saving gait called ‘direct register trot’. Tracks of wolves in direct register trot appear as very straight track lines with hind paws placed in the prints of the front paws, a so-called overprint pattern. Dogs, by contrast, show a much more erratic track.

Instructions for the expedition team were to record only direct register trot lines that (a) could be followed for at least 100 m and (b) where at least three separate measurements of three separate paw prints showed that the overprint or front paw was at least 8 cm in length without claws and (c) where at least three separate measurements of three separate step lengths showed that the step length was longer than 1.10 m. After a training phase for citizen scientists lasting two days, all tracks found and fitting the criteria were to be photographed, measured and recorded in the field and then quality assessed by project staff back at base on the same day before entering into data records (see appendix III). Approved records would have yielded a C2 confirmed observation on the SCALP classification system (appendix II), but no tracks fitting the criteria were found during the expedition.

Scat

Wolves use faeces as territorial markers, so faeces can often be found on paths or crossings, often in exposed spots. Faeces can be identified as wolf, because they often contain hair and/or large fragments of bones and other prey remains. Additionally they usually emit a typical strong wolf-like smell. Faeces of wolf puppies cannot be distinguished from those of foxes. Scat is a major source of information as fresh faeces can provide genetic material, which is important for the genetic monitoring and identification of individuals.

Citizen scientists were trained and then collected faeces during their surveys, following a set protocol designed to eliminate contamination. Samples for genetic analysis were stored in a container of ethanol (96%); samples for dietary analysis were frozen. Faeces yield a C1 piece of hard evidence if genetic analyses confirm it is wolf scat, or a C2 confirmation observation if all of the following criteria are met: (1) Scat found by wolf track, (b) scat contains hair, bones, hooves, teeth, (c) diameter > 2.5 cm, (d) length > 20 cm, (e) photographic documentation and (d) written documentation.

Sightings

Direct sightings are the second most common signs for wolf presence in Lower Saxony (LJN 2017). Wolf sightings yield a C1 piece of hard evidence if a photo or video record exists and the animal is confirmed as wolf by an expert or experienced person. Wolf sightings yield a C3 unconfirmed observation if there is no photo or video record, or if the animal could not be categorically confirmed as a wolf.

Kills (game or livestock)

The assessment and documentation of kills requires considerable experience as well as permission by the owner and authorities. As such, kill assessment can be conducted by wolf commissioners or veterinarians only. Citizen scientists can assist with, but cannot conduct kill assessments. Kills yield a C1 piece of hard evidence if genetic analysis confirms wolf as the predator. Kills yield C2 confirmed observations if the carcass was skinned and typical wolf kill characteristics were found. These can be a combination of (a) a well-placed, bloodless bite on the throat, (b) drag mark > 5 m, (c) more than 5 kg eaten during the first night after the kill, (d) more than 50% of bites have penetrated the skin, (e) the intercanine distance is between 4.0 and 4.5 cm. Photo and written documentation is also required.

Hair

Hair samples can yield a C1 piece of hard evidence only via genetic analysis. Microscopic examination of hair can only determine if a wolf (or canid) can be excluded, but not confirm a wolf. The citizen scientists were instructed to collect possible wolf hair in dry paper and then inside a plastic bag for storage. However, no wolf hair was collected during field work on this expedition.

Camera trapping

Camera traps are a useful tool to gain basic data about wolves. Once an appropriate spot is found, cameras can collect data on wolf presence, pack size, the physical condition of individuals or disease symptoms. Camera trap photos yield a C1 piece of hard evidence if the animal is visible from the side or as completely as possible from the front and all wolf characteristics are visible, or if the animal is clearly identifiable (transmitter collar, known wolf with distinguishing features), or if the animal was identified as a wolf by an experienced person. Camera trap photos yield C3 unconfirmed observation if the animal cannot categorically be confirmed as a wolf, but also cannot be excluded. The expedition had camera traps available and expedition participants were trained in their usage. However, due to Germany's very strict property and data privacy restrictions no suitable areas to place cameras were found and no camera traps were used during the expedition.

Usage of genetics

Genetic monitoring of wolves is based on non-invasively collected sample material, such as scat or hair. This project collected scat samples, stored them and sent them via the State Wolf Bureau to the laboratory of the Research Institute Senckenberg for genetic analysis as detailed by the Senckenberg Institut für Wildtiergenetik (2018).

Scent dogs

Scent dogs are trained to detect the scent of a target species represented by scats, hair, or other signs, allowing conclusions about the presence of a species. They can help to detect species where the human senses and abilities to find signs of the target species are limited. The use of scent dogs as a wolf monitoring method is relatively new to Germany, but has been widely used elsewhere (Long et al. 2007).

Long et al. (2007) describe the training and use of scent dogs, and state that they are "highly effective at locating scats from forest carnivores and are an efficient and accurate method for collecting presence-absence data on multiple species". Long et al. (2008) also compared the effectiveness of scent dogs with other monitoring methods and found that scent dogs yielded the highest raw detection rate and probability of detection, as well as the greatest number of unique detections compared to other measures, such as camera or hair traps. Reinhardt et al. (2015a) and WWF (2016) suggest and recommend the testing of this method, especially in new territories with unknown wolf presence or in the periphery of areas of occurrence. Given this, the project sought the help of scent dogs, and a dog handler team from Wildlife Detection Dogs e.V. kindly supported the expedition, helping to find hidden scats next to the road, behind obstacles or in the high grass where citizen scientist were unlikely to detect scat.

2.2.3. Expedition work

Field training

All field training was provided as part of the expedition and no prior knowledge was required. The first two days of each week were dedicated to training the citizen scientists through a mixture of background talks and presentations, as well as classroom sessions and practical lessons in the field. Training included recognising wolf sign ID (tracks, scat, kills/carcasses, hair or urine), sample collection and handling in accordance with Kaczensky et al. (2011) and Senckenberg Institut für Wildtiergenetik (2011). Documentation of findings was also covered, using data sheets and photos following Reinhardt et al. (2015a), as well as equipment training on GPS receivers, camera traps, radios, and use of rulers/yardsticks, cameras and scat collection kits to collect data. Standardised datasheets, translated from and closely based on those of the official wolf monitoring programme, were designed for surveys, tracks, scats, camera trapping and sightings, and citizen scientists were trained on how to complete them correctly.

Typical expedition day

Survey routes were decided in advance with input from wolf commissioners, landowners, land users and foresters. They were confirmed in the morning of the expedition day, depending on the weather. Each morning the expedition team divided into sub-teams of two or more people, who were assigned to survey a certain area that day. Each group was equipped with field and tracking guides, rulers and yardsticks, datasheets, GPS devices, radios for communication between groups, and a scat collection kit consisting of a plastic box with paper, bag, surgical gloves and tubes containing alcohol for collecting samples from which DNA can be obtained from scat or hair. Surveying was done on foot or bike according to the terrain. Cars were used to reach the survey starting points. Teams had lunch in the field and returned to base in the afternoon to log results and discuss findings with the expedition scientist as part of a standard data quality assessment procedure. The day ended with a review session where groups presented results to each other, discussed the survey day and planned the next.

Data collection protocols and use

When tracks, kills, scats or other signs of wolf were found, citizen scientists recorded them using GPS receivers, cameras and datasheets in line with monitoring standards. Data recorded included the GPS position of the find along with details such as the number of individuals (in the case of a sighting), characteristics of footprints and tracks (length, width and estimated age of the footprint, etc.), the direction of movement of the individual and the substrate type. Route and track data were recorded into a GPS device using the track log and waypoint features and these were backed up and consolidated onto a laptop once back at base. Photos were taken in line with the monitoring standards and also stored onto the expedition laptop following a clearly specified naming protocol. Samples suitable for DNA analysis were collected in the field into a tube with 96% ethanol and sealed into a plastic bag. Samples for dietary analyses were collected into sealed plastic bags and deep frozen. All samples were labelled and recorded.

All samples and data were quality assessed by qualified staff. Only those approved were analysed and sent on for further analysis. Samples for dietary analyses and assessment of their SCALP status were stored at -18°C before they were handed over to the laboratory at the University of Veterinary Medicine Hannover Foundation (Institute for Terrestrial and Aquatic Wildlife Research, Prof. Siebert) after the expedition. Scat samples fresh enough for DNA analysis and assessment of their SCALP status were stored in 96% ethanol immediately after they were found and sent to the laboratory of the Research Institute Senckenberg for analysis after the expedition via the State Wolf Bureau, which performed another quality assessment. Great care was taken to avoid direct contact and therefore contamination of the samples.

The photo documentation and data sheets of each team were reviewed, quality checked and supplemented by notes for further data processing. GPS data were checked and visualised in GIS in the EEA grid system and shared with the expedition team during the daily review session.

The data gathered by this study form part of the official wolf monitoring programme of Lower Saxony. All relevant data were integrated into the official database and as such were reviewed by the official wolf monitoring programme and assessed by SCALP categories. Since our data form part of the official wolf monitoring programme, they are published in the official LJN annual monitoring report, as well as in their quarterly reports.

2.3. Results

Over two weeks (i.e. two groups) of surveying, participants walked 638 km and cycled 100 km, covering 15 cells of the EEA 10x10 km grid in total, all of them multiple times so that grid cells were covered a total of 29 times (Fig. 2.1f, Table 2.3a).

Table 2.3a. Number of grid cells and length of routes surveyed by the expedition teams during the two expedition weeks. Note that the team split into four or fewer groups each day.

Week	Grid cells (N)	Routes total (km)	Routes day 2** (km)	Routes day 3 (km)	Routes day 4 (km)	Routes day 5 (km)	Routes day 6 (km)
1	14	307.72	15.70	105.85	77.36	58.61	50.20/69.10
2	15	330.68	21.10	75.87	77.50	63.01	93.20/31.80
Total	**29***	**638.40 (foot)** **100.90 (bike)**					

*As all surveys took place within 15 grid cells, some grid cells were surveyed multiple times
** Day 2: training day, survey in one group

Scat, sighting and their SCALP status

The expedition found a total of 250 (probable) wolf scats in twelve EEA grid cells. 32 scats were too old and/or rotten for any further analysis and discarded. 218 were admitted for SCALP assessment. Of those 218, 200 were frozen for dietary analysis and sent to the laboratory at the University of Veterinary Medicine Hannover (UVMH) Foundation (Institute for Terrestrial and Aquatic Wildlife Research) and LJN for analysis of wolf diet. 25 of the 200 samples were fresh enough (less than 48 hours old) to yield material for DNA analysis, so a small sample of these 25 scats was put in ethanol and sent to the Research Institute Senckenberg for genetic analysis & SCALP assessment (Fig. 2.3a & Table 2.3b).

Samples shown to be from wolf by genetic analysis were scored as a C1 piece of hard evidence. Samples with typical content such as bones, hair and teeth, as well as the right size to originate from a wolf were scored C2. Old, rotten or bleached samples, which in their appearance were likely to be from wolf were scored C3. One sample where wolf could be genetically excluded was scored as a false positive. In addition to these data, one incidence of a wolf sighting during the expedition was recorded and submitted to LJN.

Table 2.3b. Samples gathered by the expedition and submitted for analysis.

Week / group	Scat samples total	Scat samples for diet analysis	Scat samples for genetic analysis	Wolf sightings
1	125	111	11	0
2	93	89	14	1
Total	**218**	**200**	**25**	**1**

125 scat samples were collected in week one, and 93 in week two (Table 2.3b). In total, 11 (5%) of the 218 samples were classified as C1 pieces of hard evidence, 69 (32%) as C2 confirmed observations, 137 (63%) as C3 unconfirmed observations and one (<1%) did not originate from a wolf (Fig. 2.3b). The one direct sighting of a wolf was classified as a C3 unconfirmed observation, as there was no photo or video taken (because the encounter only lasted a few seconds).

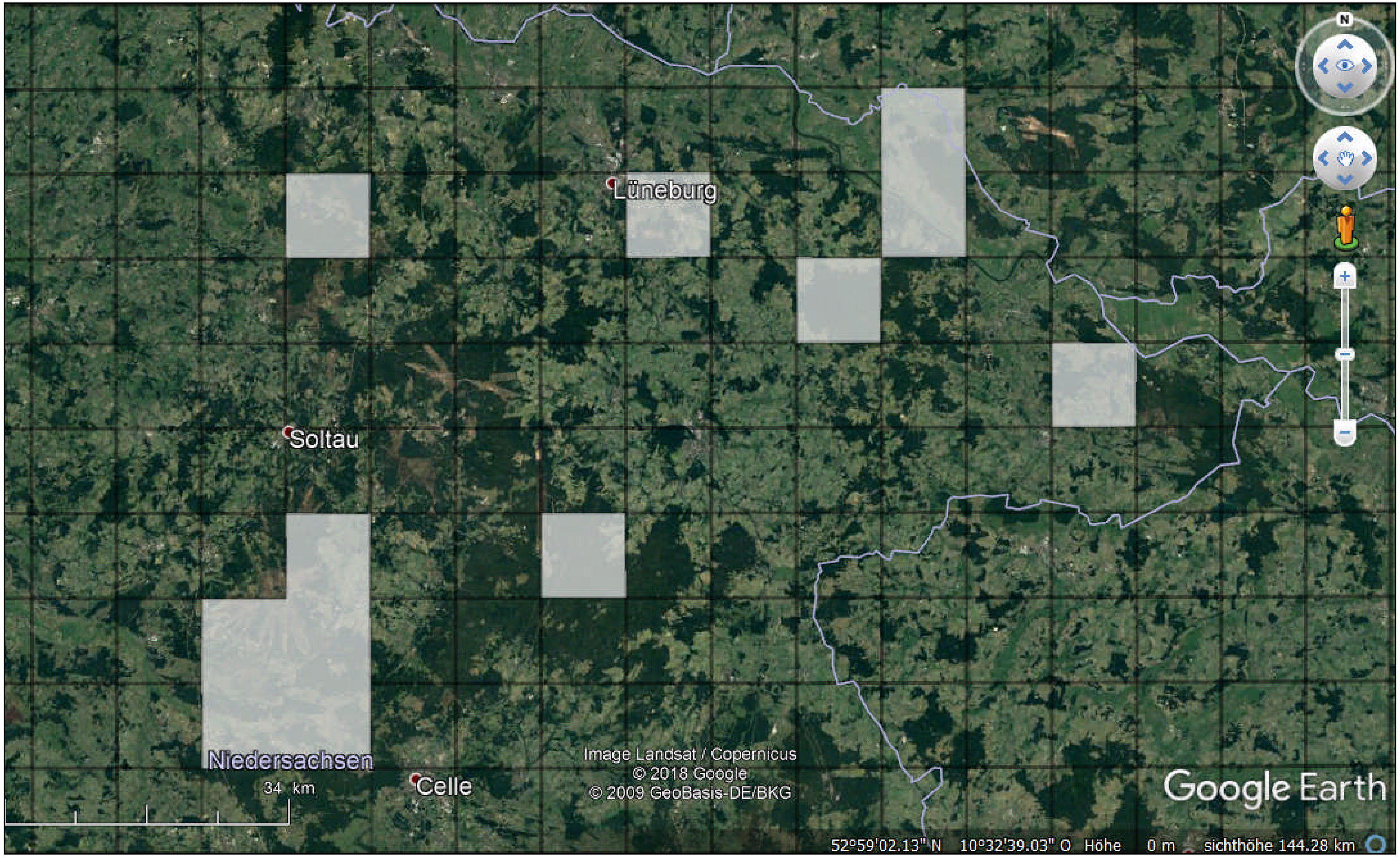


Figure 2.3a. 12 EEA grid cells in which wolf scat samples were collected.

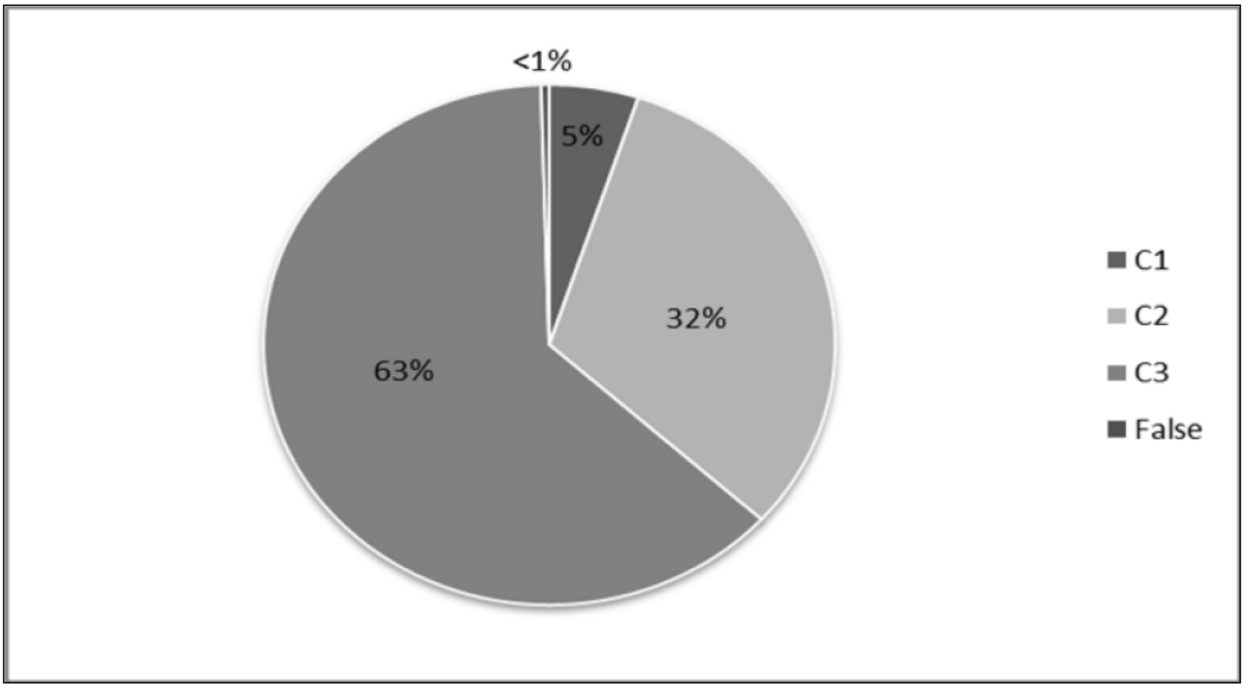


Figure 2.3b. The 218 scat samples collected by the expedition by their SCALP classification.

In week 1, three scat samples were scored as C1, 38 as C2 and 84 as C3. In week 2, eight scat samples were scored as C1, 31 as C2, 55 as C3 and one was non-wolf false positive (Fig. 2.3c).

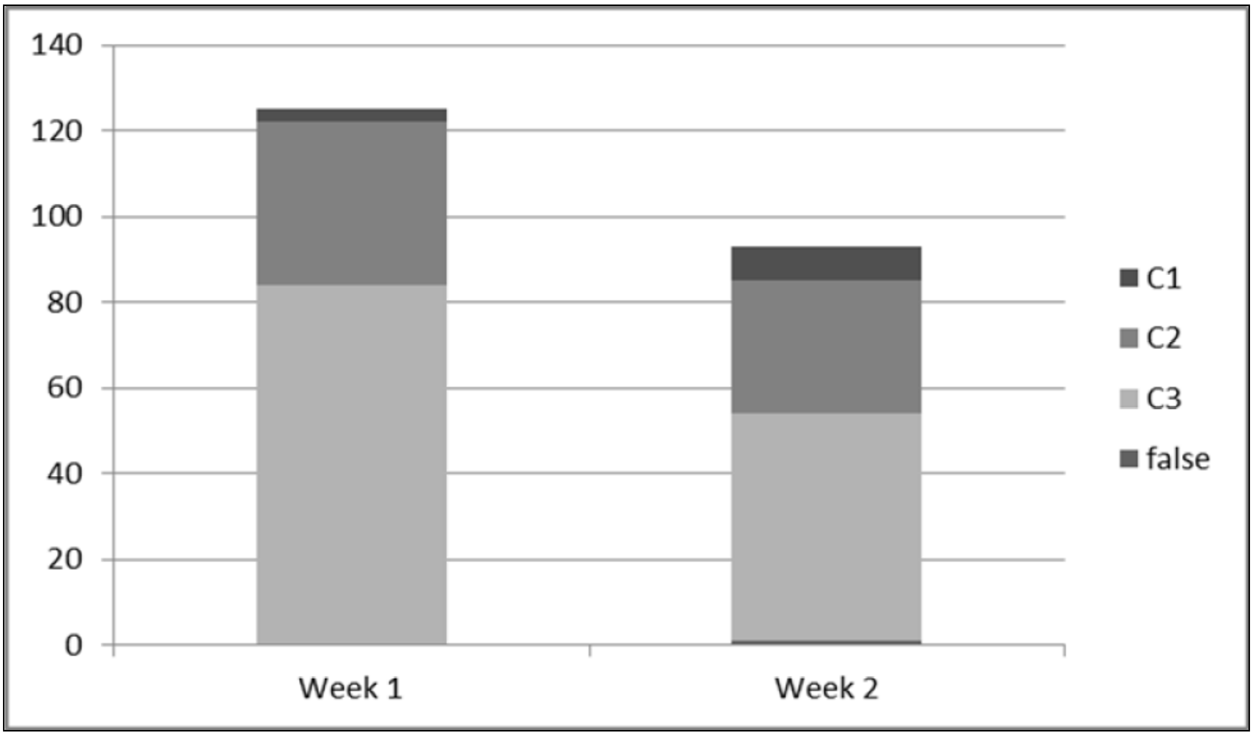


Figure 2.3c. The 218 scat samples collected by the expedition by their SCALP classification.

Dietary analysis

The 2018 expedition submitted 200 scat samples for dietary analysis, which is currently being conducted by masters student Charlotte Steinberg at UVMH and LJN. Results will be published in the 2019 expedition report. The 2017 expedition submitted 75 scat samples for dietary analysis (also analysed by Charlotte Steinberg) with results as follows:

Of the 75 samples submitted by the 2017 expedition, only 45 (those that scored C1, C2 and C3a = unproven evidence, nearly conforming to C2 criteria) were examined. Samples were washed and sorted, and prey remains such as hair, bones and hooves were assigned to individual prey species or groups such as lagomorphs (hares and rabbits). As reference material the UVMH collection was used. This collection contains hairs of different potential prey species, including different genders, age groups and parts of the body. The hair is used for macroscopic identification (length, colour, shape), but also for microscopic alignment (reference slide). Furthermore, the collection includes bones and teeth of different species, genders and ages.

Roe deer (30%) and wild boar (29%) comprised the most frequent remains found in all 45 scat samples analysed, followed by red deer (18%), fallow deer (8%) and a general deer species category (8%) for deer remains that could not be identified down to species level. Lagomorphs represented 7% (see Table 2.3c and Fig. 2.3d). No livestock remains were found.

Table 2.3c. Number of prey remains found in N = 45 samples of C1, C2, C3a quality (multiple content poss.).

Roe deer	Wild boar	Red deer	Lagomorphs	Fallow deer	Deer unidentified
20	19	12	5	5	5

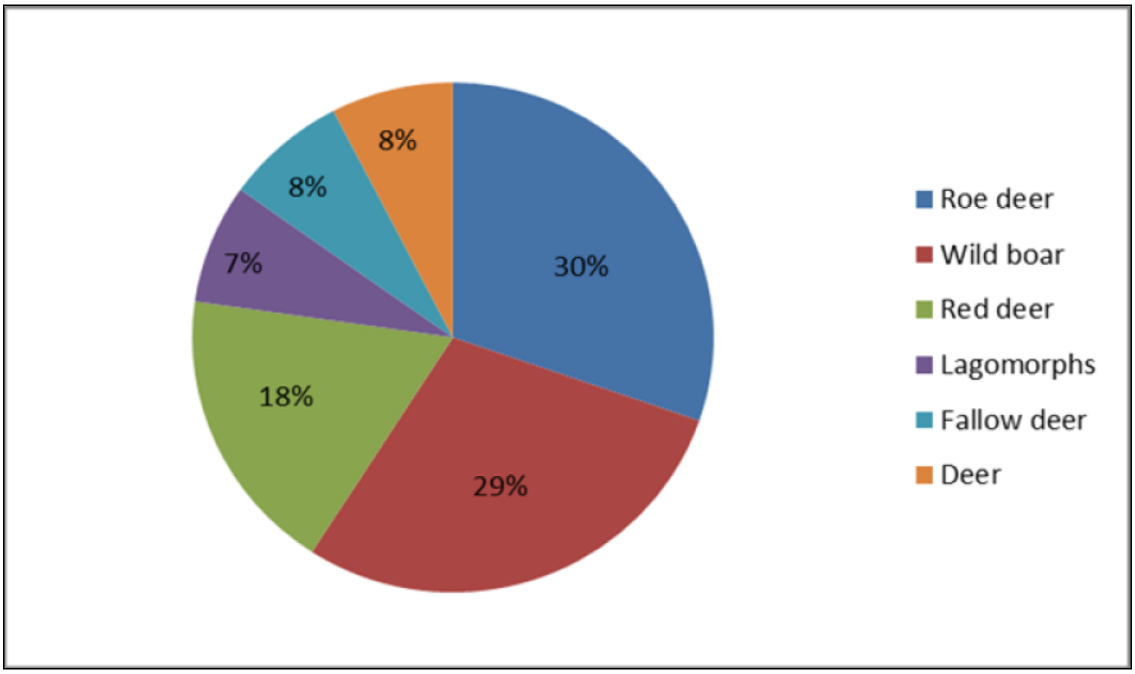


Figure 2.3d. Percentage of prey remains found (N = 45 samples of C1, C2, C3a quality).

From items found in scat, calculation of prey animal biomass is possible following Ruehe (2003). This yields wild boar (34%), red deer (33%), roe deer (12%), fallow deer (11%), unidentified deer (9%) and lagomorphs (1%) (see Fig. 2.3e).

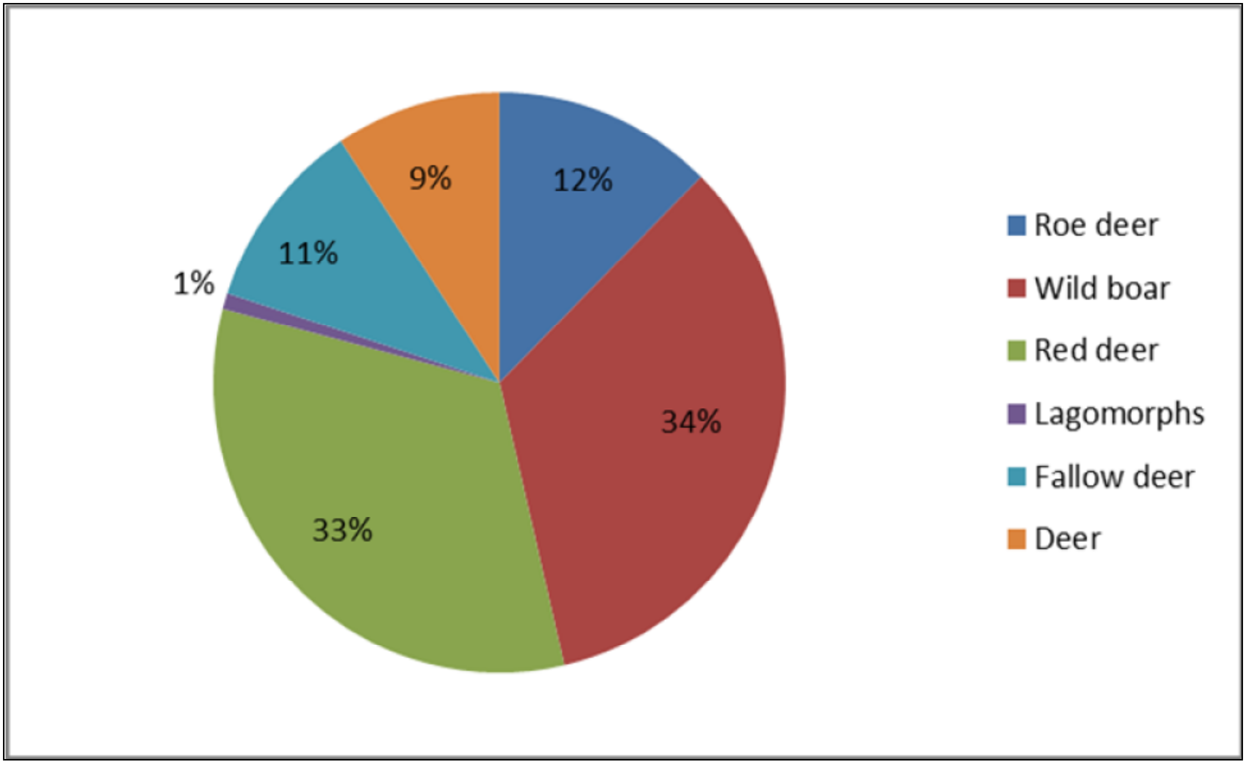


Figure 2.3e. Percentage of prey animal biomass found (N = 45 samples of C1, C2, C3a quality).

Dietary analysis of C1 scats only

When only C1 scats (N=21) are considered, results remain broadly the same, with prey remains found for roe deer (38%), wild boar (28%), red deer (22%), lagomorphs (9%) and fallow deer (3%) (Table 2.3d and Fig. 2.3f), corresponding to prey animal biomass of red deer (42%), wild boar (35%), roe deer (17%), fallow deer (5%) and lagomorphs (1%) (see Fig. 2.3g)

Table 2.3d. Number of prey items found in N = 21 samples of C1 quality only (multiple content possible).

Roe deer	Wild boar	Red deer	Lagomorphs	Fallow deer
12	9	7	3	1

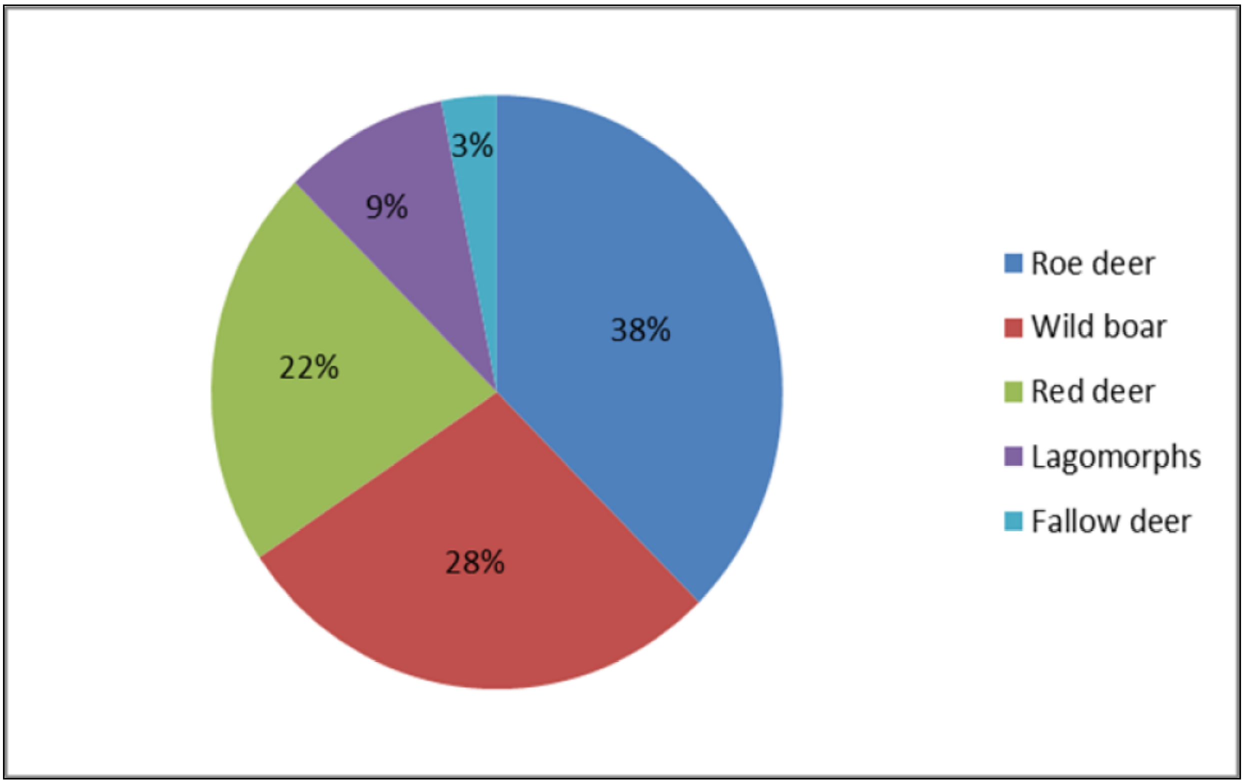


Figure 2.3f. Percentage of prey items found (N = 21 samples of C1 quality only).

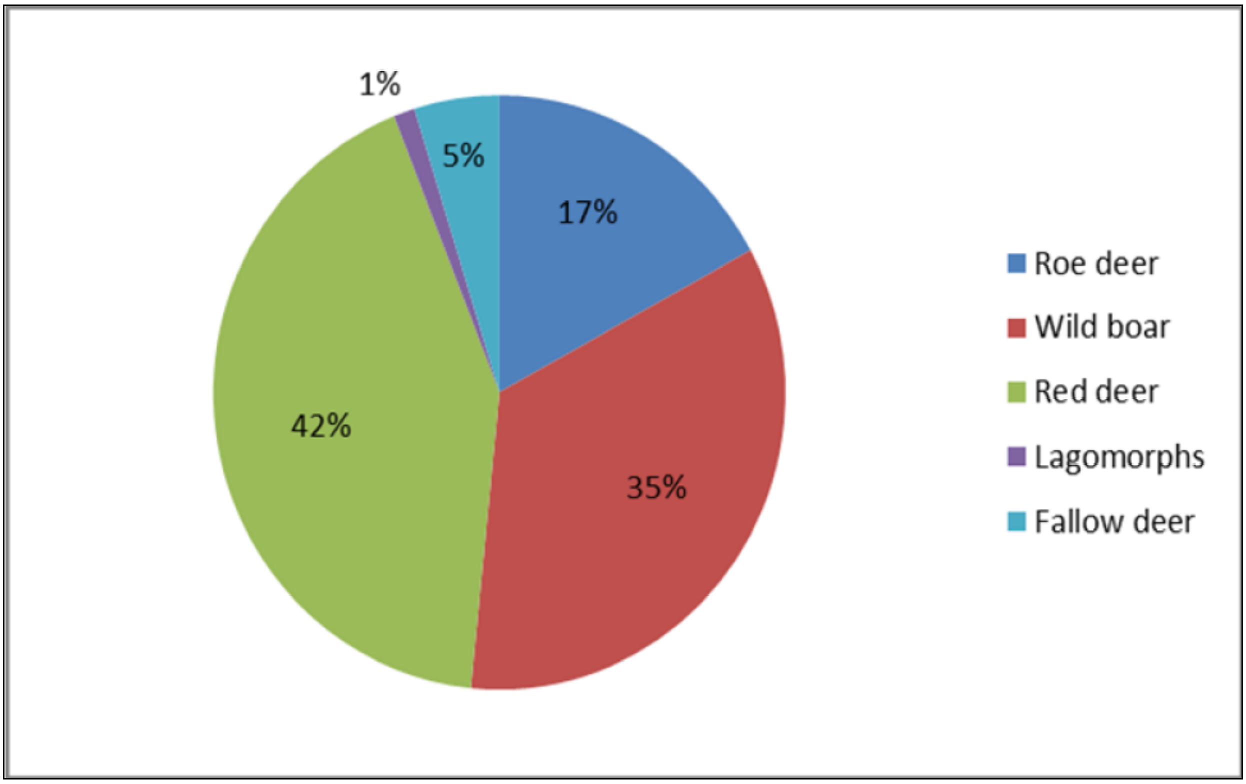


Figure 2.3g. Percentage of prey animal biomass found (N = 21 samples of C1 quality only).

Genetics

25 scat samples were sent for DNA analysis. Twelve of them originated from wolves (Table 2.3e) and one came from a fox. For the remaining twelve samples it was not possible to determine the originating species as wolf. This may be because the sample quality was too poor (too old, too wet) and therefore DNA could not be extracted and sequenced. Ten samples could be assigned to individual known wolves through comparison of existing DNA material: six male wolves and three female wolves, one of them two times (Table 2.3f). For two samples the species wolf, but no single individual, could be identified; these two individuals were logged for the first time through the expedition.

Table 2.3e. Results of genetic analyses.

	DNA wolf	DNA no wolf	Species not determinable	Total DNA samples
Week 1	4	0	7	11
Week 2	8	1	5	14
Total	**12**	**1**	**12**	**25**

Table 2.3f. Details of the ten samples that could be assigned to known individual wolves.

No.	Individual	Gender	Territory	Sampled in week
1	GW317m	male	Schneverdingen	1
2	GW432f	female	Goehrde	2
3	GW504m	male	Goehrde	2
4	GW533m	male	Wietze	2
5	GW964f	male	Die Lucie	2
6	GW1027m	male	Amt Neuhaus	2
7	GW1034f	female	Goehrde	1
8	GW1034f	female	Goehrde	2
9	GW1039m	male	Goehrde	2
10	GW1040m	male	Amt Neuhaus	2

GW317m: GW317m is the male wolf in the Schneverdingen territory. Genetics show that he originated in the Central European wolf population (CEP), but it is unclear in which pack he was born. He has been known since the monitoring year 2015/2016 and was mating with female GW472f, a descendent from the pack in the Gartow area (district Luechow-Dannenberg). Reproduction was detected in the years 2016/2017 with at least two litters, 2017/2018 (7 puppies) and 2018/2019 (4 puppies) (LJN 2019).

GW432f and GW504m: These two individuals are the parents of the Goehrde pack. In 2015 both animals were first identified and they formed a pair in the Goehrde area. In 2016 reproductive activity and pack formation was documented through a sighting of six puppies. Reproduction continued in 2017 with a minimum of nine and in 2018 with at least five offspring (LJN 2019).

GW533m: This male wolf, originating from Luebtheen (state of Mecklenburg-Vorpommern) was initially identified once in 2016, not far from the Wietze area, where he was re-identified by the expedition in 2018. In August 2018 a new wolf pack was detected in the Wietze area, when at least seven offspring were photographed by camera trap (LJN 2019). The DNA via the scat sample was the first genetic evidence of this pack. It seemed likely, though at that time not finally confirmed, that he was the permanent male wolf of the territory. Further genetic evidence from the area from November and December 2018 gave final proof by identifying two offspring of GW533m in the area. One was identified through a scat sample, the other was found dead after a traffic accident.

GW964f: This is the female wolf of the pack in 'Die Lucie' nature reserve (district Luechow-Dannenberg). Her original pack within the CEP is unknown. In 2017 a young male of the wolf pack near Niesky (state of Saxony) was genetically detected in the same area several times. In 2017 four offspring and in 2018 another four were recorded, and therefore the existence of a new pack was confirmed (LJN 2019).

GW1027m: This male wolf was confirmed in the Munster area in late June 2018. He originated from the Munster/Bispingen pack. He was then identified in Amt Neuhaus by the expedition, suggesting that he is a transient wolf on the move.

GW1034f: This female wolf was identified in the Goehrde area in early June 2018 for the first time. The second piece of evidence was found by the expedition. In total the 2018 expedition was able to identify her twice. Her origin and territory are unclear. Genetics have shown that she belongs to the CEP.

GW1039m: This male wolf was genetically identified for the first time by the expedition. His origin is the Goehrde are. He was found illegally shot dead in the area on 25 August 2018 (LJN 2019a). He was the sixth wolf found illegally killed in Lower Saxony since records began in 2003. In total 62 wolves were found dead over the period January 2003 – March 2019, most of them killed by traffic.

GW1040m: This male wolf, a descendent of the pack in the Goehrde area, was genetically identified for the first time by the expedition in the Amt Neuhaus area.

Other possible wolf signs

During the expedition, other possible signs of wolf presence were recorded, but did not pass quality assessment procedures and as such were not submitted to official records. Instead they serve as hints for upcoming investigations and expeditions. Of this type of sign, a total of seven tracks (conditions or measurements for rating not met), 32 scats (too old, not clear, no wolf-like smell) and a variety of fur remains were recorded (Fig. 2.3h).

Scent dogs

Wildlife Detection Dogs e.V. kindly supported the expedition for four field work days, with one dog accompanying a group for a full survey day each day. A total of five wolf scats were found by the dog. Four of them would not have been found without a scent dog. Surveys with dog assistance took place primarily in areas with little knowledge about the wolf presence in order to investigate new uncovered areas.

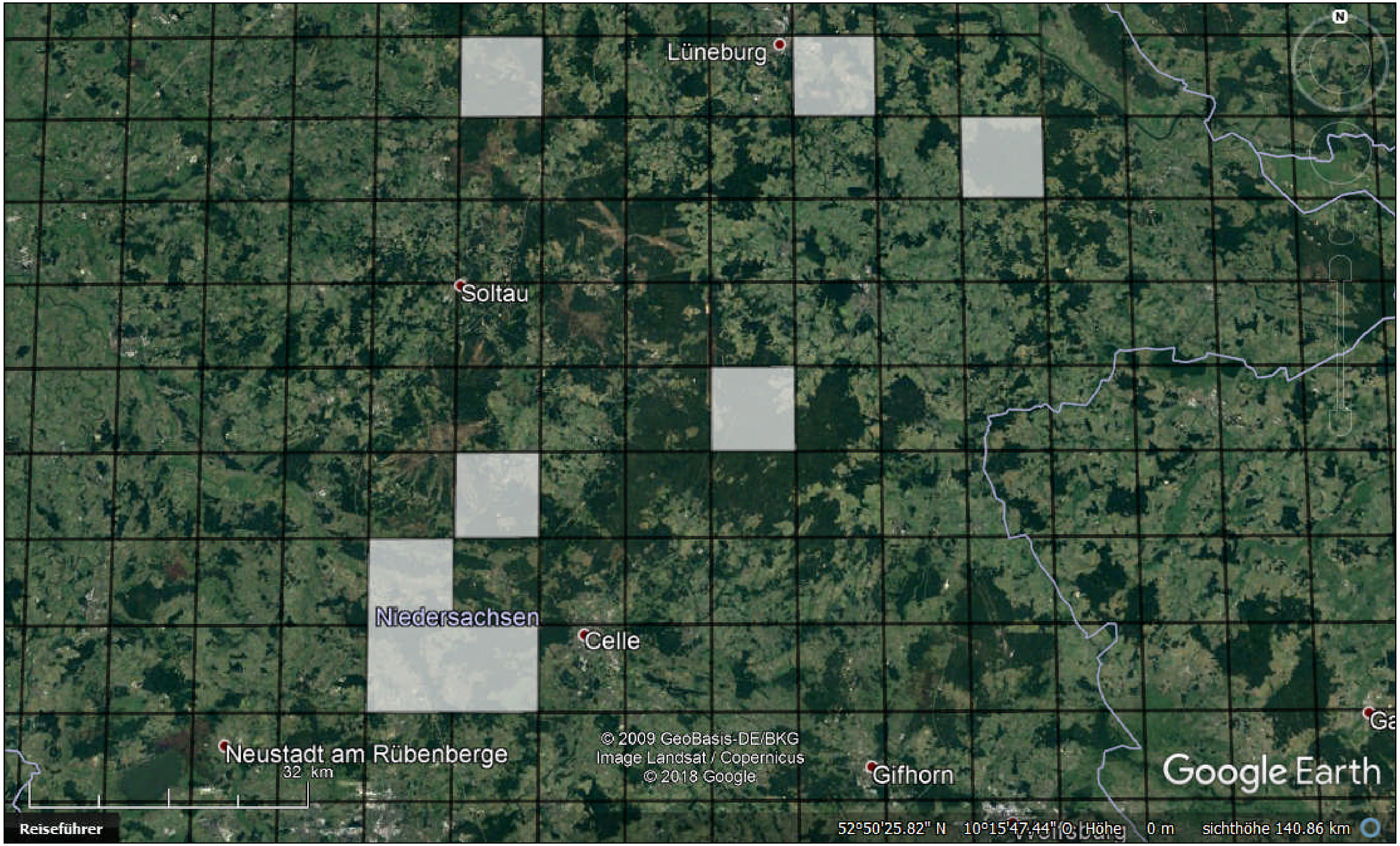


Figure 2.3h. Possible wolf signs (tracks, scats, hair) recorded from 24 June - 05 July 2018 in 9 EEA grid cells.

Direct sighting

There was one wolf sighting of three animals by a survey team of two citizen scientists during a survey in the Goehrde area. This encounter was scored as a C3 unconfirmed observation, as there was no photo or video taken (because the encounter only lasted a few seconds).

2.4. Discussion and conclusions

2.4.1. Wolf monitoring science

Areas of wolf activity

The work of the 2018 expedition focused on collecting wolf scat samples for identification of individual wolves via DNA and for dietary analyses. The number of scat samples found in the survey areas allowed the expedition to identify two areas of high wolf activity in the district of Luechow-Dannenberg and the Celle/northern Hannover area (Figs. 2.4a & b). In Luechow-Dannenberg, 94 (43%) scat samples were collected and in the Celle/Hannover area 40 (18%).

Other areas with wolf activity were identified in the districts of Uelzen with 30 (14%) collected scat samples, Harburg/Heidekreis 13 (6%) and Lueneburg 9 (4%) (Fig. 2.4a & b).

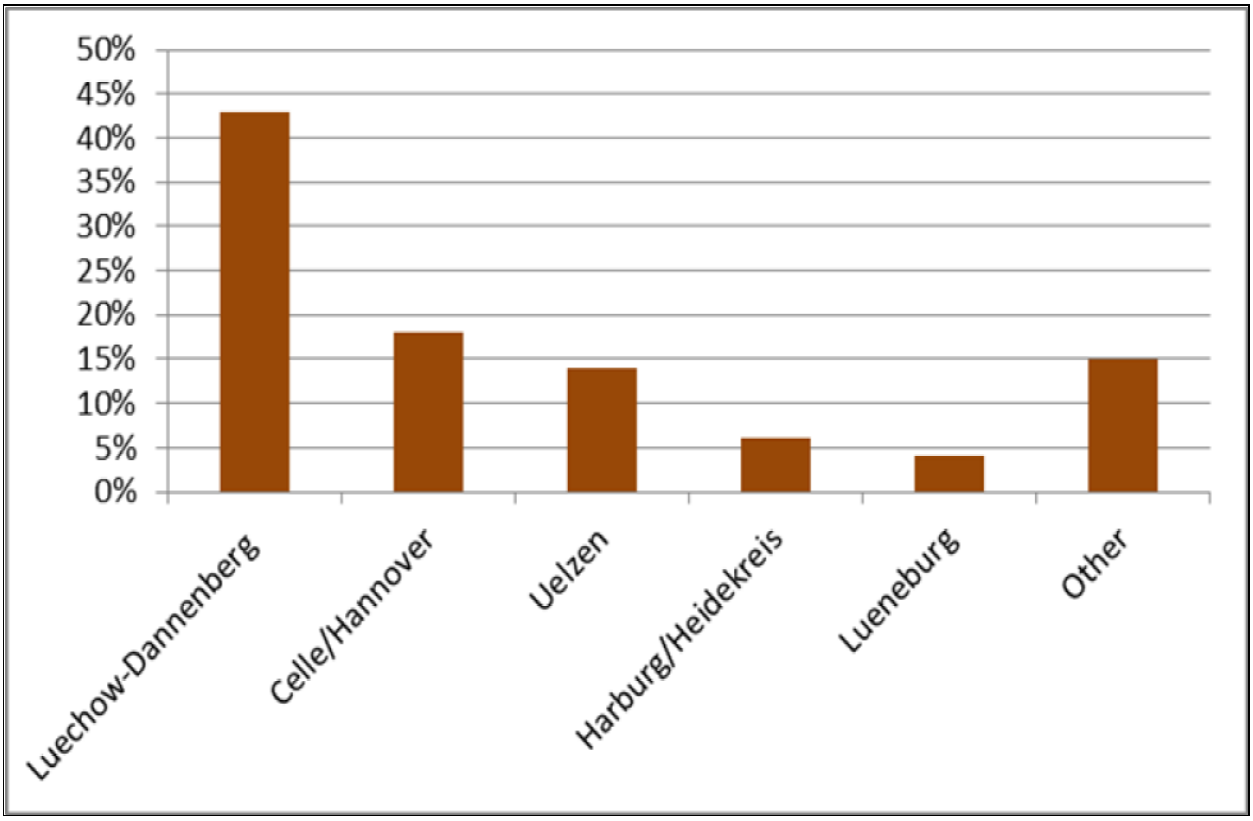


Figure 2.4a. Scat samples (n = 218) by area collected by the expedition.

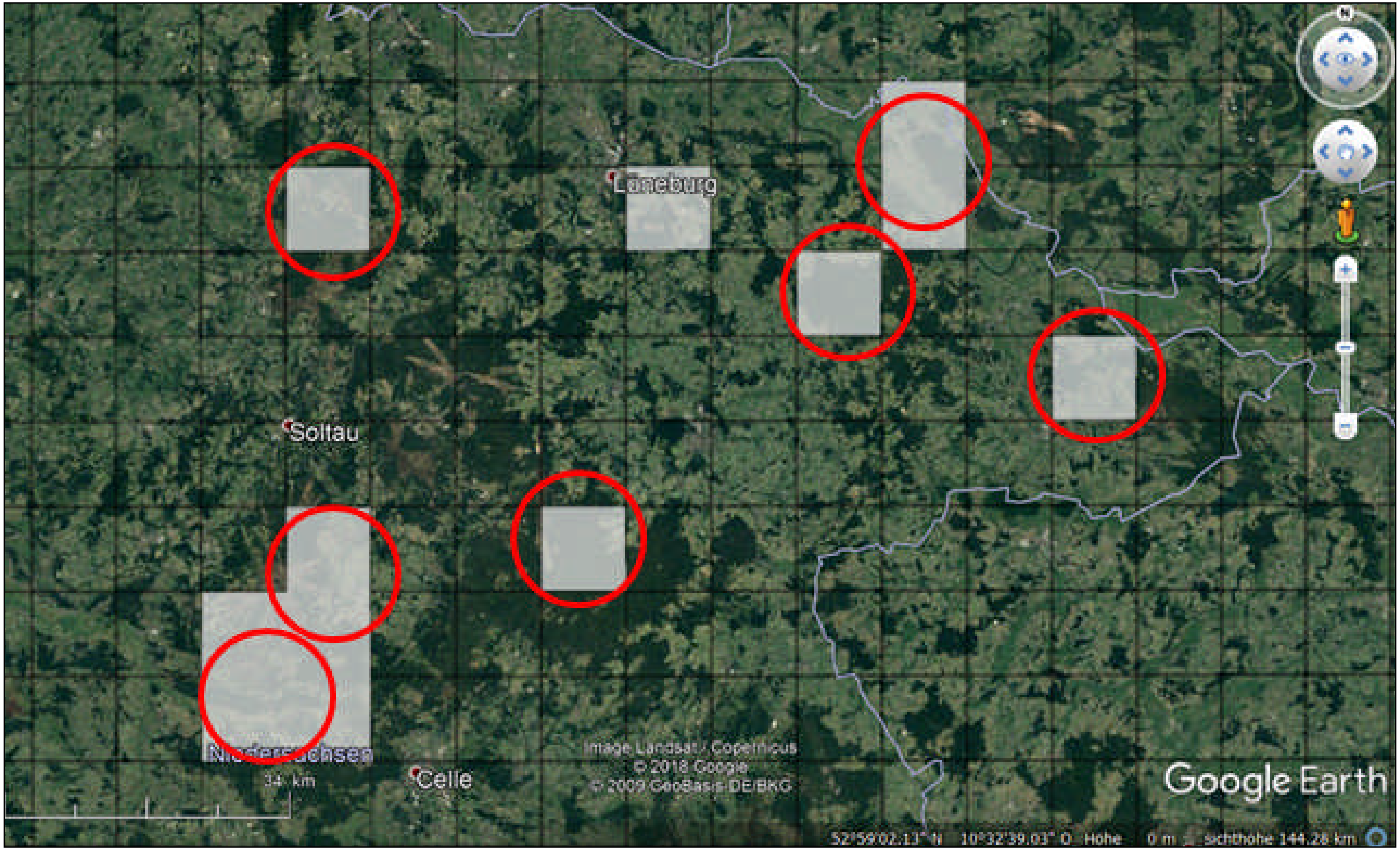


Figure 2.4b Areas of high wolf activity (red circles) identified by the expedition.

Efficiency of effort – data quantity and quality, and cooperation with local stakeholders

The total number of scat samples (218) collected by the expedition over two weeks in 2018 to assist official wolf monitoring efforts is outstanding. For comparison, the official wolf monitoring programme recorded a total of 215 scat samples in the entire monitoring year of 2016/17 (LJN 2017) and about the same amount in the year 2017/2018 (personal communication, official report to be published). So our two-week long expedition will double the scat sample overall. It will be interesting to calculate the exact increase of sample size through citizen science once the 2017/2018 monitoring year numbers are published, but it is clear already that our work has made a very significant contribution to wolf monitoring efforts in Lower Saxony in terms of quantity.

In terms of quality, the work of the citizen scientists was excellent too. The amount of C1 and C2 scats collected by the expedition was 37% in 2018 and 54% in 2017 (Schütte and Hammer 2018), compared to 40% collected by the official wolf monitoring programme in the monitoring year of 2016/17 (LJN 2017). This clearly shows that with a day and a half of training, citizen scientists can make high quality and high quantity contributions. The main reason to also send C3 scat samples to the laboratory was the demand for samples for the dietary analysis. At the start of the expedition it was unknown that only C1, C2 and C3a samples would get analysed. So it could be assumed that the percentage of C1 and C2 records could be even higher, if the focus had been on those only.

Our main goal was to collect wolf signs, with an emphasis on finding scat samples, in Lower Saxony in order simply to assist official wolf monitoring efforts and supplement the wolf monitoring database. However, data collected by this expedition led to some important conclusions about some of the wolf territories and newly identified individual wolves. We conducted the 2018 surveys partly in areas with similar or the same survey routes as in the previous year (Schütte and Hammer 2018). But new areas were added too. Thanks to the outstanding cooperation of some wolf commissioners, study areas could be selected precisely, so that a high number of usable scat samples could be collected. This is also the main reason why the inaugural 2017 expedition collected only 76 scats with four groups (Schütte and Hammer 2018), whereas the 2018 expedition collected 218 scats with two groups.

In addition, and thanks to the co-operation of the State Forestry Department (Niedersächsische Landesforsten), new areas were included in our monitoring activities, and in some areas we were asked by the State Forestry Department to conduct surveys. This is in marked contrast to the State Forestry Department's conduct in 2017 when it forbade the expedition to enter certain areas due to smear and misinformation campaigns by anti-wolf elements amongst the hunting community and/or political class (see Schütte and Hammer 2018 for details).

The distances of survey routes varied from day to day. This was due to very varied habitats and different vegetation on the tracks. Especially in June and July, vegetation growth was extremely high due to high rainfall and heat. Thus wide gravel forest roads could be surveyed faster (sometimes by bike) than little used, overgrown forest tracks or an overgrown path in a swampy area. In addition, groups differed in walking/cycling and surveying speed, often as a function of the number of signs found and for some study areas the travel time to the survey area was two hours each way.

A total of ten individual wolves were identified via DNA samples collected by the expedition in 2018 (six in 2017), one of them two times, namely the adult female GW1034f. Two wolves were genetically identified for the first time by expedition finds, GW1039m and GW1040m, both descendents from the pack in the Goehrde area. In addition, by identifying GW317m (Schneverdingen), GW964f (Die Lucie) and wolf pair GW432f and GW504m (Goehrde), insights into their movement ranges and possible offspring could be gained. The evidence of GW533m in the Wietze area was evidence for the establishment of a pack there, corroborated by the sightings and later the genetic identification of offspring.

Thus far there has been no more genetic proof of other animals. GW1027m, originating in Munster and sampled in Amt Neuhaus, demonstrates the migration of young wolves through other territories in search of their own. Exact information about territory, kinship and offspring or migration routes can only be gleaned partially by the official wolf monitoring programme. For a comprehensive picture, there simply is not enough information in the form of DNA samples. In other words, despite all efforts, not least of the expedition, many more samples and a well-planned active monitoring effort are necessary.

For the monitoring year 2016/17 reproduction was detected in 87% of the wolf packs in all of Germany (DBBW 2018b). This means that an increase in the wolf population is highly likely and that more territories will be occupied, including in Lower Saxony. Active monitoring is essential to track those changes.

The results of the dietary analysis are based on prey remains in the scat samples collected in the survey areas of the 2017 expedition. They do not represent the food spectrum of wolves in general, but give hints about the food items of wolves in the study areas as well as information about more important and less important prey species. Based on the available sample of 45 scats, wild ungulates (mainly roe deer, wild boar, red deer) are the food base of wolves. It is significant that no remains of livestock were found. This corrobarates previous studies, which showed that the proportion of livestock in the wolf's diet is very low or absent altogether (DBBW 2018b). This may vary regionally, depending on the availability of wildlife prey and unprotected grazing livestock. We await the completion and publication of the laboratory research on dietary analysis overall and of the scat samples collected during the 2018 expedition. Of course wolves do attack, kill and consume livestock, but the data collected by this expedition suggest that this is rare.

Expedition participants in almost 750 km of survey covered (638 km on foot and 100 km on bicycles) had at least one encounter. No wolf was seen in four weeks and over 1,100 km of survey in the 2017 expedition (Schütte and Hammer 2018). It is clear that the chances of encountering a wolf during daytime, even when looking for wolf signs in suitable habitat, are very small. Reports in the media and by anti-wolf campaigners of the state being "overrun" by wolves are therefore clearly exaggerated.

2.4.2. Team composition

24 citizen scientists took part in the 2018 expedition, divided into two groups of twelve persons each and lasting a week. 16 people came from Germany or its immediate neighbour countries (67%), two of them (8%) from Lower Saxony. Three participants came from North America (12.5%), another three from the UK (12.5%), as well as one person each from Australia (4%) and Iceland (4%). In 2017 the composition was 49 citizen scientists: 42 from Germany or its immediate neighbour states (86%) with four of them (8%) from Lower Saxony, three from North America (6%), two from Australia (4%), as well as one person each from India (2%) and Singapore (2%).

One of the criticisms levied at the expedition in the media around the time of the 2017 expedition was that it was "absurd and illogical" to import foreigners from as far away as Australia to conduct citizen science work and that local people should do the work instead. Of the 63 citizen scientists, the vast majority came from Europe with 8% from Lower Saxony. Biosphere Expeditions does not exclude people from expeditions based on their origin and as such will continue to host those from around the world who commit their time and funds to this project, irrespective of their ethnic origin, creed, colour, etc. However, it is agreed that local involvement is highly desirable and we will continue and increase our efforts to recruit local people through a combination of local media work and by making free placements on the expedition available for local people. It is also important to note that all wolf commissioners involved in the expedition were local and that some of them specifically requested help to cover their large survey patches.

2.4.3. Media coverage and attitude toward the expedition

Media coverage continues to be overwhelmingly positive. If there is negative coverage, it is exclusively in the local, provincial media. The smears and misinformation campaign that marred the inaugural 2017 expedition (see Schütte and Hammer 2018 for details) have largely ceased. We believe this is due to the significant results published in the 2017 report, demonstrating that citizen science is valid and helpful, as well as the Biosphere Expeditions / State Wolf Bureau clarification of facts on 14 July 2017 and the open letter to Helmut Dammann-Tamke on 9 October 2017 (one of the main perpetrators of the smear and misinformation campaign). Indeed there have been messages of incredulity about the way the expedition was portrayed in 2017 by elected politicians and state authorities, as well as messages of support, for example by well-known wolf expert Ulrich Wotschikowsky. The fact that the State Forestry Department turned from aggressively questioning the expedition and forbidding access to certain areas in 2017 to being highly cooperative, including working with the expedition on areas to be surveyed, in 2018 is a very welcome case in point.

The hostility that the expedition was, and in some cases is, treated with demonstrates what an emotionally and politically charged subject the return of the wolf has become. The way in which this issue is discussed is in parts absurd and bears no relation to the relatively small number of wolves resident in Germany (see above), or the perceived or actual harm they do to humans or livestock, which is absent (in case of humans) or insignificant (for example in comparison to the damage from other wildlife species).

Positive aspects and opportunities connected to the wolf's return are almost entirely absent from the discussion (see below), which appears to be dominated by a vocal anti-wolf minority, which does not reflect the welcoming stance of the significant majority of Germans and indeed Austrians. With recent declarations by influential politicians, especially on the conservative and liberal side of the political spectrum, but also by the social democrats, that wolves must be killed and controlled, despite their strictly protected status in German and EU law, there is concern that the vocal anti-wolf minority may be gaining the upper hand in the discussion about the wolf's future in Germany.

2.4.4. The future of the wolf in Germany – challenges and opportunities

Despite these calls for wolves to be killed, the wolf has returned to Germany to stay. It is a highly adaptable generalist that can live almost anywhere in Germany's highly cultivated and fragmented landscape. It is also a highly protected species that has the full protection of the law. Although some conservative politicians have unilaterally declared, without any basis in scientific fact, that the wolf in some German states has reached a favourable conservation state that can trigger management measures, including culls, the species is in fact nowhere near this state. Calls for culls are therefore unwarranted as well as counterproductive, because shooting a wolf almost never solves the problem at hand. Herds still have to be protected, whether there are one or several wolves, who can travel great distances in a single day, in the region; removing a wolf also upsets existing pack structures, which invariably leads to an increase in livestock attacks (Wielgus and Peebles 2014). Wolves also do not "learn" anything, as is often asserted, if a wolf is killed, even if the surviving wolves witness the kill, as they are unable to make the connection between a livestock attack that occurred at a different time and place and the retaliatory killing.

Most people in Lower Saxony will never see a wolf in the wild or suffer any detrimental effects through the wolf's presence in their state. A significant majority of Germans also support the wolf's presence in their country. The key to successful human/wolf co-existence in densely populated and cultivated Germany therefore lies in supporting those who are exposed to genuine risks by wolf presence. Since wolves very rarely represent a threat to humans, including children, this means supporting livestock owners and listening to their experiences and concerns. Livestock protection measures in areas frequented by wolves are a must and they must be applied consistently and effectively. Advice exists on how to do this and support networks are available for livestock owners, as are compensation schemes if effective livestock measures were in place and livestock predation by wolves still occurred, which is rare. However, because of the federal system in Germany, such schemes are often disjointed, bureaucratic, slow and differ significantly from state to state. Nationwide schemes and procedures are rare, but in our opinion essential and our advice is to nationalise them and generate true nationwide, effective, efficient and unbureaucratic support and compensation schemes. The wolf's return does have its challenges and it is important not to leave those facing the brunt of them exposed and fending for themselves.

That said, it is by and large the challenges that receive most attention, with opportunities through the wolf returning being largely ignored. It can be argued that especially in nature-based, sustainable tourism there are many, currently untapped, areas of opportunity. The expedition covered in this report is a case in point. We believe the citizen scientists who contributed their time and money to take part in this project deserve our respect, rather than derision. They also serve as a showcase of how the wolf can attract people to Germany; people who went on record to say that the species makes Germany "even more attractive" and that "the world could learn from how people in Germany are trying to coexist with wolves" (source). We argue that this enthusiasm and positive view of Germany has great potential for tourism. Many countries achieve significants amounts of income through nature-based tourism and tourism operators should be encouraged to consider this and its implication for Germany. The expedition covered in this report serves as a showcase and demonstrates how (citizen) science, domestic and international visitors, wolf research and conservation, local NGOs and providers of touristic services all benefit.

2.4.5. Summary

The wolf has returned to Germany to stay. Those who do not like this and employ misinformation, populism and demagogy to incite conflict and highly emotional, politically charged and irrational arguments against wolves must be countered each time with calm, factual and science-based discourse. Those who are exposed to real risks through wolves, namely livestock owners, should be listened to, supported and compensated as necessary, ideally through an effective, unbureaucractic and nationwide support and advice system.

We believe that a system of regionally active, trained professionals is needed, who can respond to questions about and issues around wolves directly, unbureaucratically and competently, and act close to the ground and in close cooperation with the local population and stakeholders. So far the federal and state goverments, as well as agricultural and vetenerinarian bodies, have failed to create appropriate structures, which are necessary when a large carnivore returns to a cultural landscape.

In addition, we believe that more must be done to stop illegal wolf killings. The records of wolves found dead, taken since 2003, show that illegal shooting of this protected species is the second most common form of death (13%) after traffic accidents (78%); the remaining 9% is due to diseases or other reasons (NLWKN 2019a). A particularly sad example of this is male wolf GW1039m whose existence was shown by the expedition, only to be found shot dead shortly after in August 2018. Presumably there is a high percentage of unreported killings which constitute criminal offenses. Here, the investigative authorities and courts must work harder to stop this and prosecute perpetrators, as for example in the neighbouring federal state of Saxony-Anhalt.

Whilst there are challenges that come with wolf presence, there are opportunities too, which have been largely ignored. We see the biggest potential in rural communities generating income through tourism based on nature and wolf presence.

Next to large-scale, national issues, this project on a Lower Saxony state and regional scale, and in close collaboration with the State Wolf Bureau, not only reached its goals, it exceeded, now also in its second year, all expectations. It is clear that the efforts of well-trained citizen scientists deployed as part of a well-planned fieldwork expedition can be very productive and that highly valuable data can be acquired through targeted active wolf monitoring work conducted by citizen scientists. This refutes those who doubted that citizen science could make a useful contribution. This doubt was especially prevalent amongst hunters, hunting associations and some forestry landowners before and during the inaugural 2017 expedition, but has changed in some quarters after the results of the 2017 expedition were published. For example, the State Forestry Department now supports the expedition and it is hoped that the results presented here will encourage others too to give up their negative and non-collaborative stance, as well as their publically voiced populist prejudices based on erroneous assumptions and assertions. The authors are, and always have been, ready to collaborate in the spirit of successful wolf conservation and wolf/human co-existence in Lower Saxony.

2.4.6. Recommendations for future expeditions

Repeat the expedition on an annual basis

- Adapt/improve methods and logistics as necessary, based on an annual review of activities.
- Establish camera trapping efforts wherever possible within the limitations of privacy and property laws.
- Find funding to extend the use of scent dogs during the expedition to establish and promote their effectiveness for wolf monitoring purposes.
- Test new methods such as video scats (Canu et al. 2017).
- Gain support from more wolf commissioners and district nature conservation authorities for active monitoring in areas of specific interest.
- Offer support to other projects being involved in wolf monitoring.

Improve communications with stakeholders.

- Repeat offers to stakeholders, such as hunting associations and forestry departments, to use/involve/allow the efforts of Biosphere Expeditions, e.g. camera trapping and sign surveys.

Involve local, national and international citizen scientists

- Seek grant and other support, or fund internally, free placements for local people on the expedition.
- Work with the media to encourage more local participation.

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Appendix I: Overview of temperature and rainfall values at NABU Gut Sunder during the expedition (own records)

Date	°C at 07:00	°C at 17:00	Rainfall (mm) 07:00 / 16:00
24 June 2018	11	14	0 / 1
25 June 2018	13	17	0 / 0
26 June 2018	12	18	1 / 0
27 June 2018	13	22	0 / 0
28 June 2018	13	23	0 / 0
01 July 2018	12	22	0 / 0
02 July 2018	12	23	0 / 0
03 July 2018	12	24	0 / 0
04 July 2018	12	26	0 / 0
05 July 2018	16	14	0 / 0

Appendix II: SCALP criteria

SCALP categories (Reinhardt et al., 2015b) are applied to all wolf signs in Germany. In line with these categories the data of the expedition's findings were categorised in the official monitoring database as:

Category 1 (C1): 'Hard evidence' - such as animals found dead, observations verified with photos, captured animals, locating via telemetry and genetic analysis.

Category 2 (C2): 'Confirmed observation' - verified reports from trained people such as kills of livestock and wild animals, tracks.

Category 3 (C3): 'Unconfirmed observation' - kills, tracks and scats that are not verified, and signs that are not verifiable such as animal sounds or sight observations.

False: 'false observations' - observation for which wolf can be ruled out.

'Evaluation not possible' - signs that cannot be evaluated due to lack of information.

Appendix III: Week-by-week survey results

Effort & results week 1

Survey days		5
EEA 10x10 km grid cells covered		14
Scats found / in EEA cells		125 / 8
Day	Distance covered by teams (km)	Remarks
Sun, 24 June	15.7	One training group only
Mon, 25 June	105.85	Maximum four small groups
Tue, 26 June	177.36	Maximum four small groups
Wed, 27 June	58.61	Maximum four small groups
Thu, 28 June	50.2/69.1	Maximum four small groups/bicycle
Total	**307.72/69.1**	

Effort & results week 2

Survey days		5
EEA 10x10 km grid cells covered		15
Scats found / in EEA cells		93 / 9
Day	Distance covered by teams (km)	Remarks
Sun, 01 July	21.1	One training group only
Mon, 02 July	75.87	Maximum four small groups
Tue, 03 July	77.5	Maximum four small groups
Wed, 04 July	63.01	Maximum four small groups
Thu, 05 July	93.2/31.8	Maximum four small groups/bicycle
Total	**330.68/31.8**	

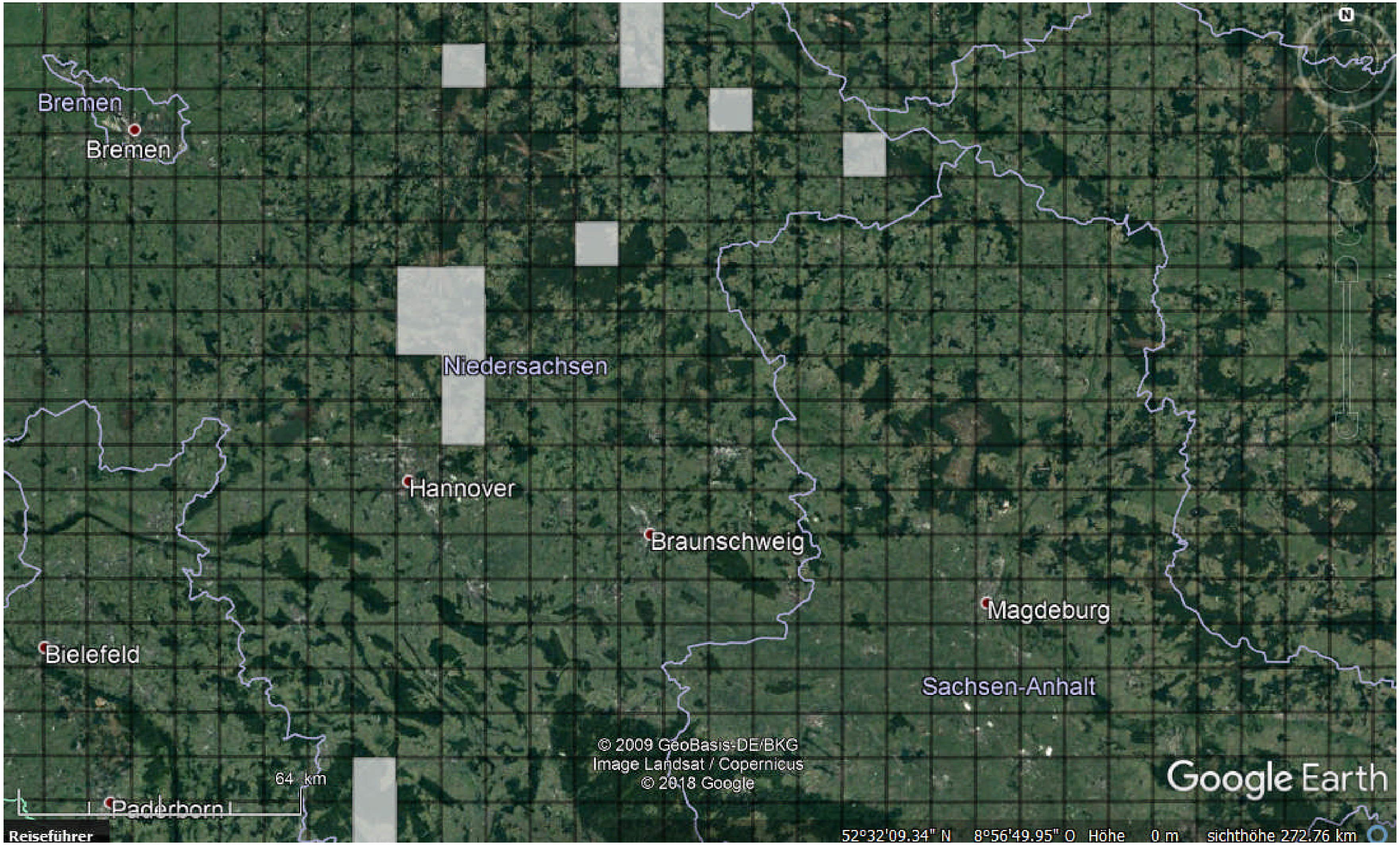

Figure IIIa. EEA grid cells covered in week 1.

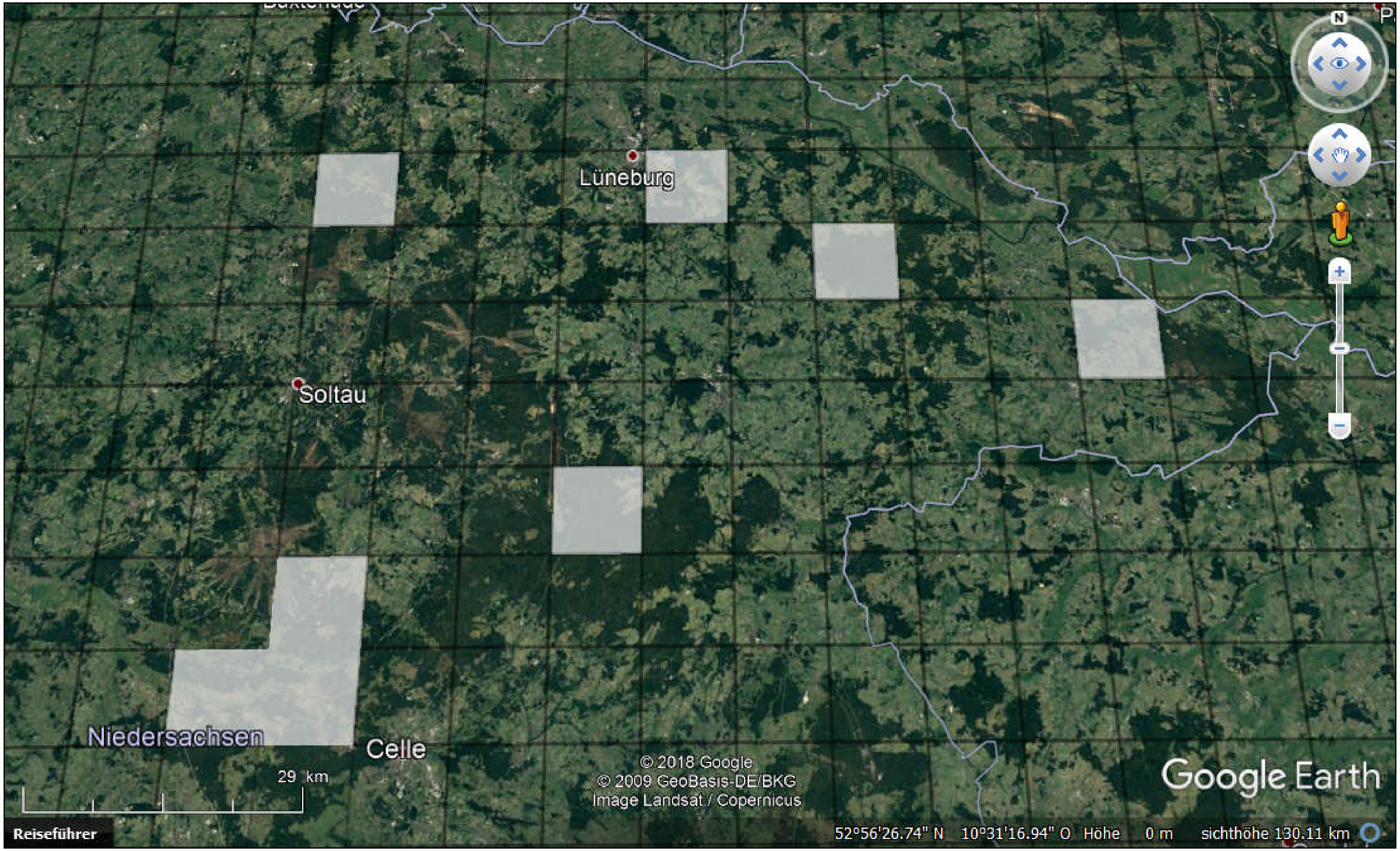

Figure IIIb. 125 scats were found in eight EEA grid cells in week 1.

Figure IIIc. Possible wolf signs were found in five EEA grid cells in week 1.
Signs included two unclear tracks and 46 possible wolf scats (too old, not clear, no wolf-like odour).

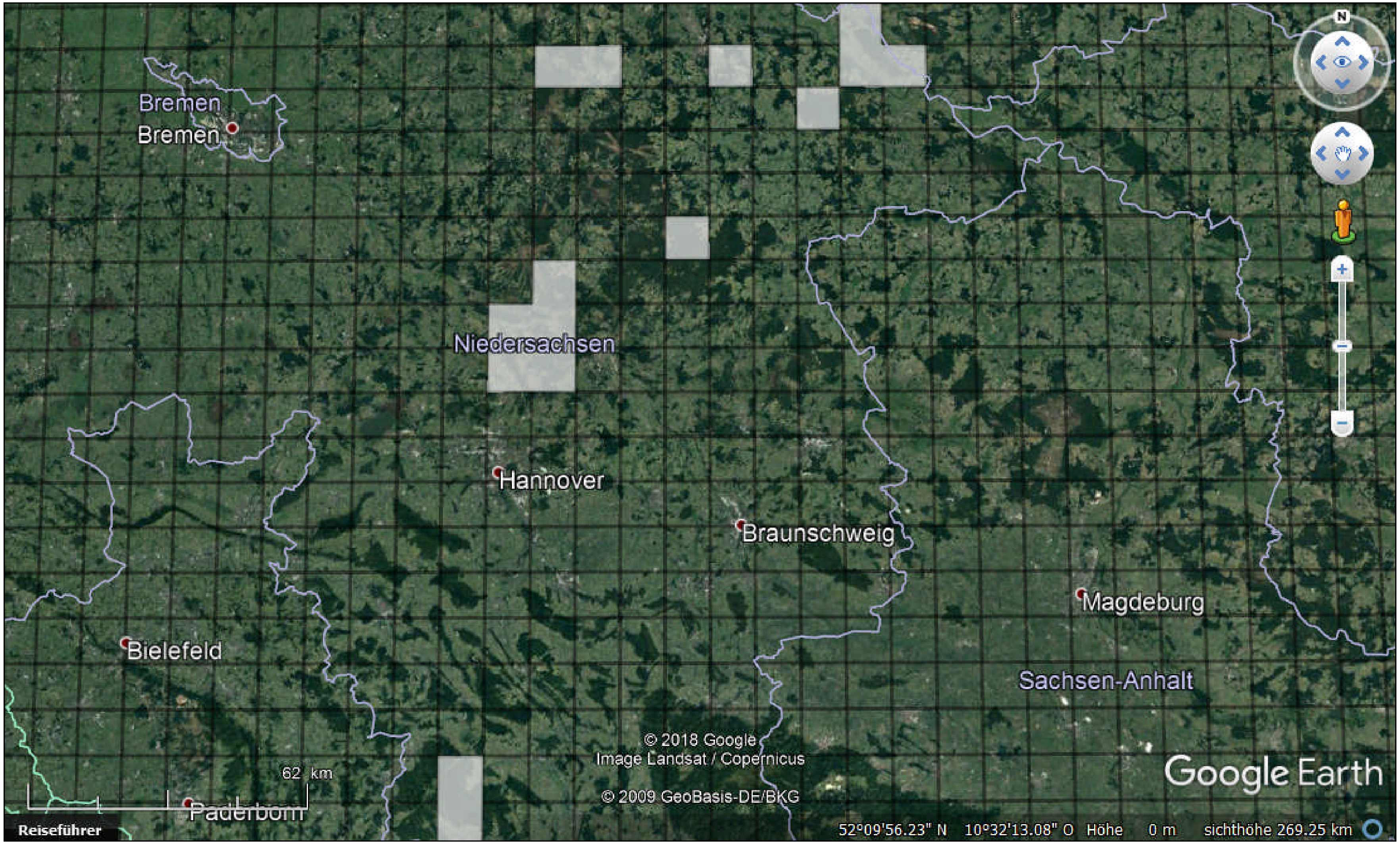

Figure IIId. 15 EEA grid cells covered in week 2.

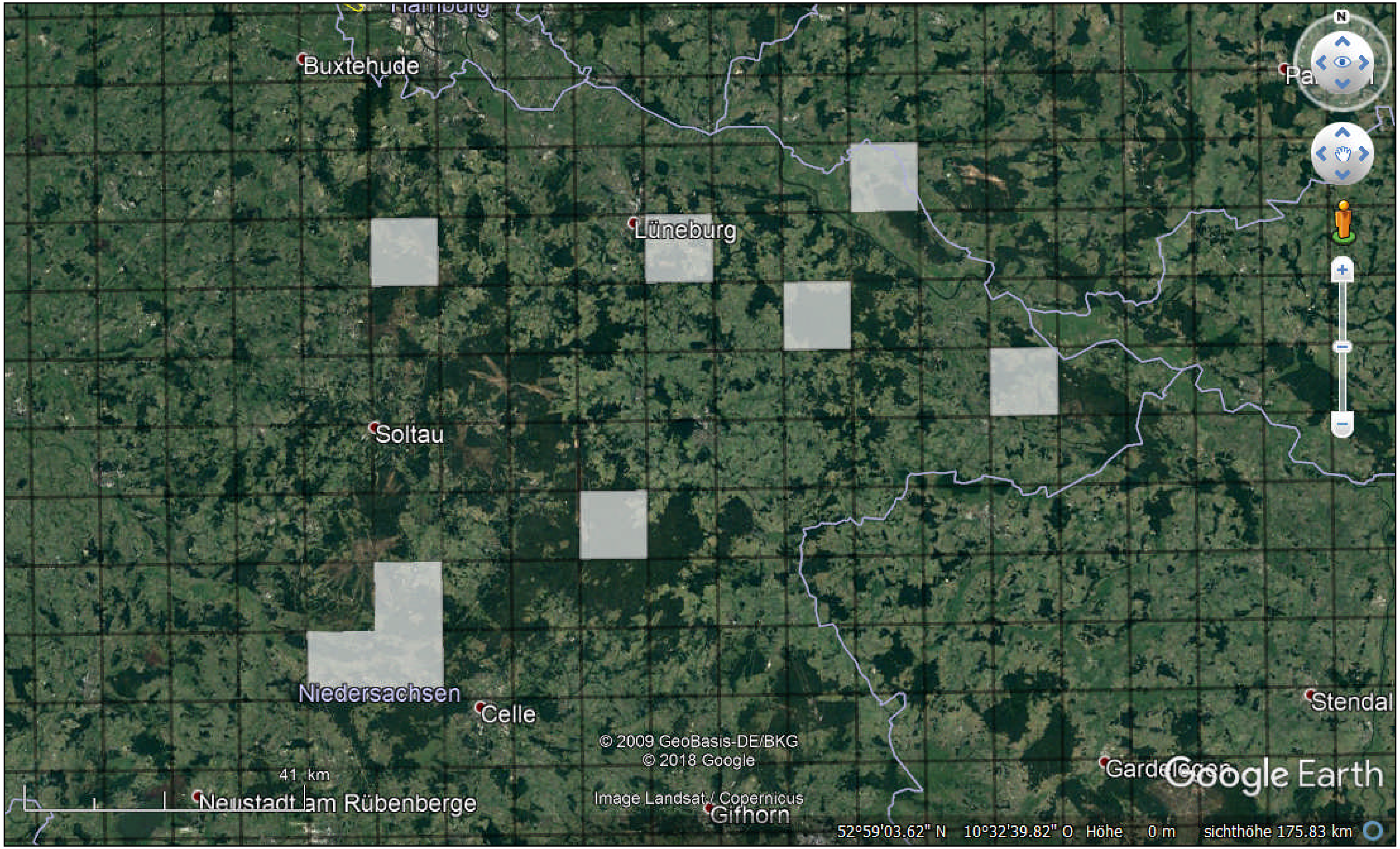

Figure IIIe. 93 scats were found in nine EEA grid cells in week 2.

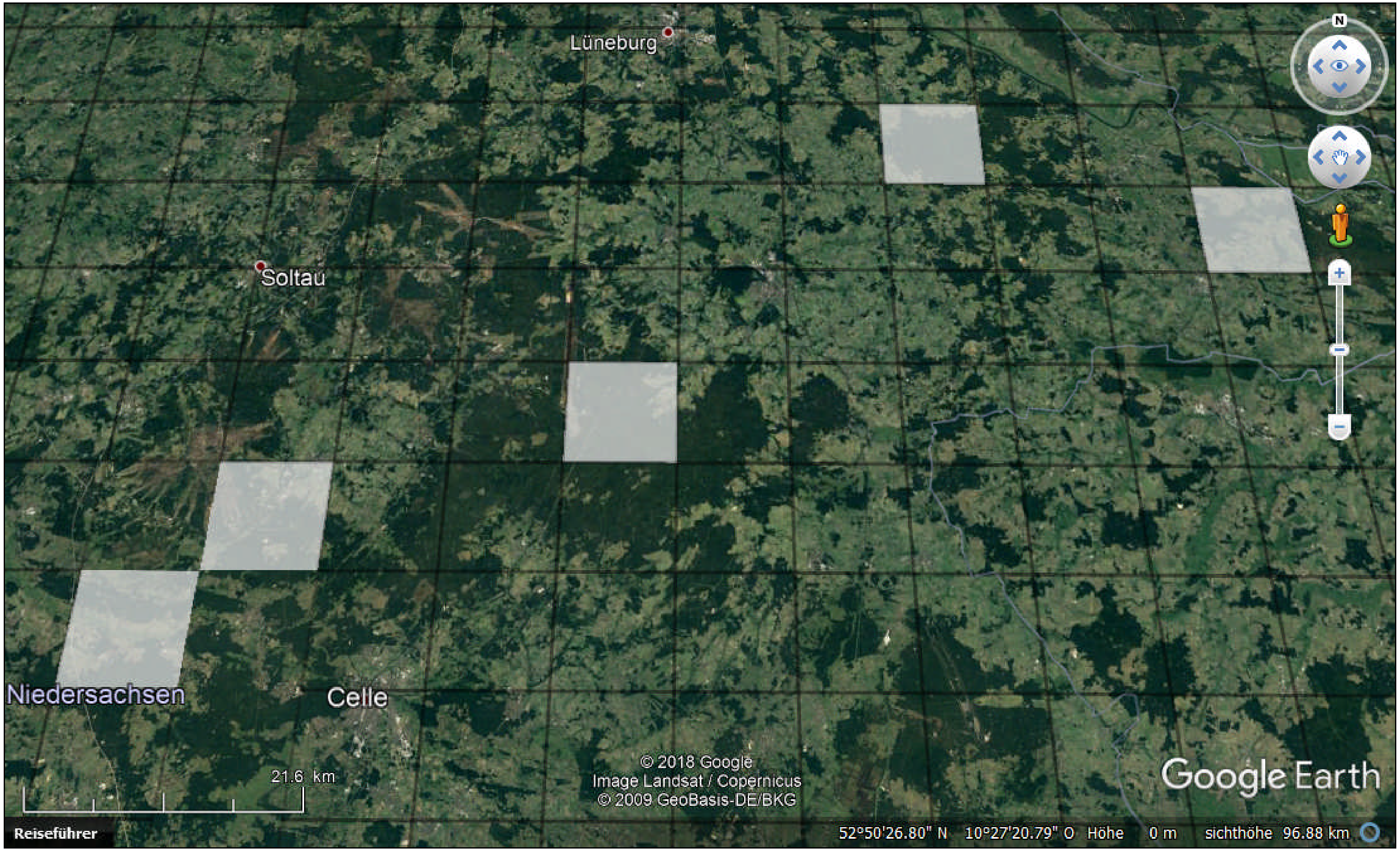

Figure IIIf. Possible wolf signs were found in five EEA grid cells in week 2.
Signs included five unclear tracks and four possible wolf scats (too old, not clear, no wolf-like odour).

Appendix IV: Photo impressions

Figure IVa. Expedition team visits Wolfcenter Dörverden as part of training on day one.

Figure IVb. Guided tour in the Wolfcenter Dörverden as part of training on day one.

Figure IVc. Maps of the survey areas.

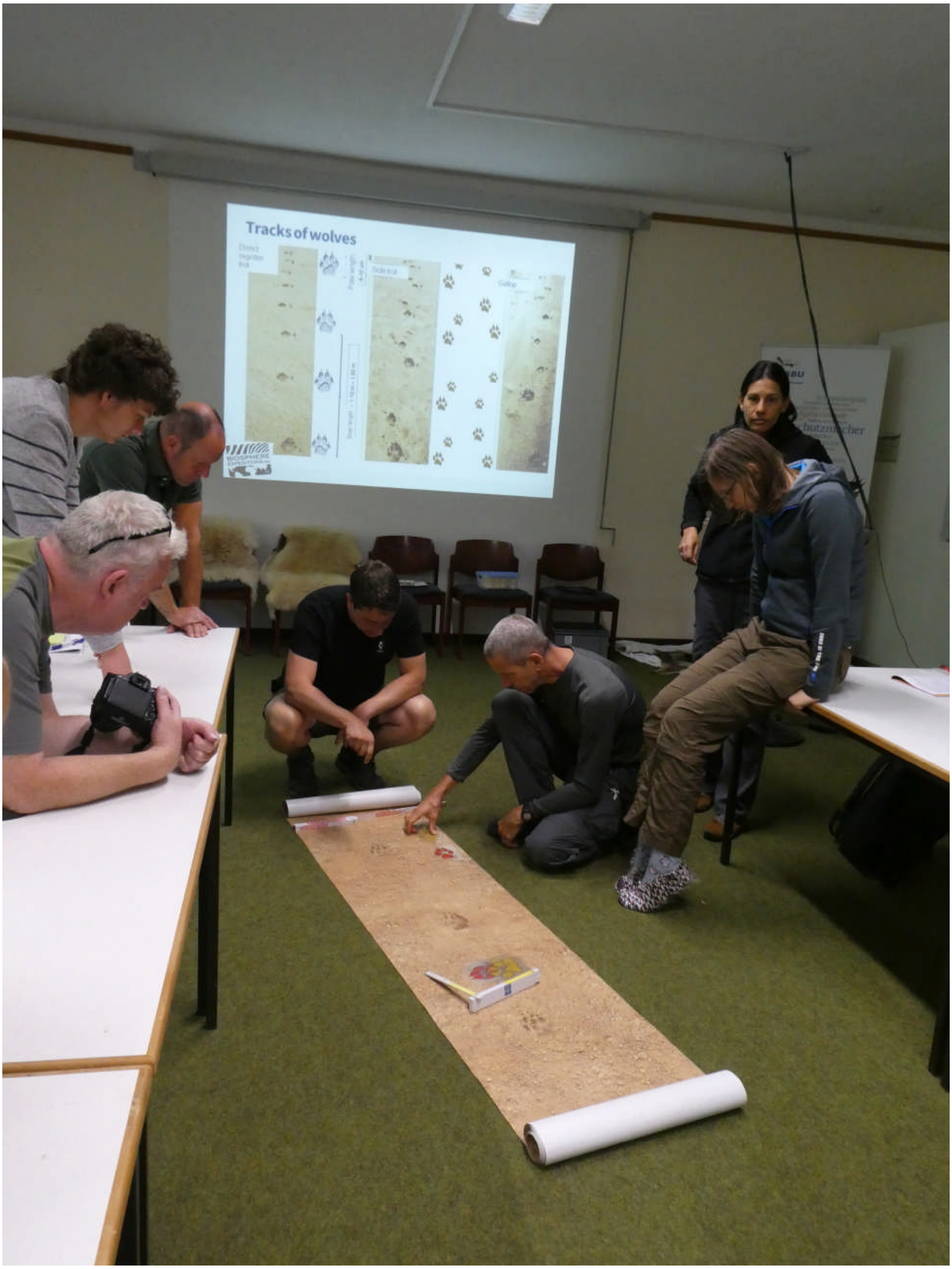

Figure IVd. Theoretical lesson on wolf tracks by Peter Schütte as part of the training on day one.

Figure IVe. Practical lesson outdoors by Peter Schütte and Theo Grüntjens as part of the training on day two.

Figure IVf. Blackboard with day-to-day plan, remarks, etc. (left).
Research equipment and datasheets on the table (middle); procedures and plans on the pin board (right).

Figure IVg. Survey equipment.

Figure IVh. A team is briefed on the map before heading off into the field.

Figure IVi. Survey on foot in a small team on a forestry track.

Figure IVj. Survey by bicycle in a small team on a forestry track.

Figure IVk. Wolf scat spotted in a typical location on a forestry track.

Figure IVl. Remains of a wolf scat.

Figure IVm. Wolf scat spotted by scent dog Molly.

Figure IVn. Lunch in the field.

Figure IVo. Lot of work labelling and sorting findings of the day.

Figure IVp. A day's wolf scat finds.

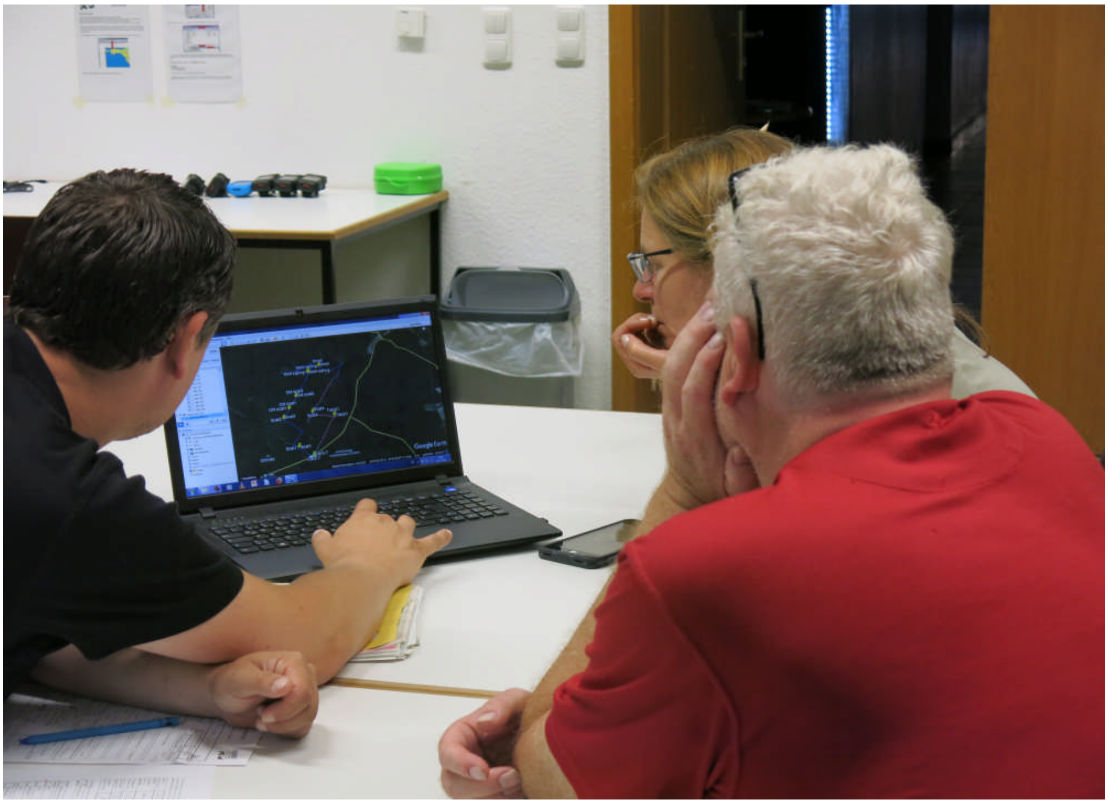

Figure IVq. Data entry into the laptop.

Figure IVr. Visiting a shepherd breeding livestock guarding dogs for livestock damage prevention.

Figure IVs. Planning the next day.

Figure IVt. Overnight camp at Kenner’s Landlust in the Goehrde.

Appendix VI: Expedition diary and reports

A multimedia expedition diary is available on https://blog.biosphere-expeditions.org/category/expedition-blogs/germany-2018/.

All expedition reports, including this and previous expedition reports, are available on www.biosphere-expeditions.org/reports.