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"*Every individual matters.*
*Every individual has a role to play.*
*Every individual makes a difference.*"

-Dr. Jane Goodall

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# Chapter 1

# General Introduction

**Photo credits**: *Jacob Kaptein (National Geographic)*

Over the past century, our planet has experienced significant changes. The global population has more than doubled, greatly increasing humanity's environmental impact (Steffen et al., 2015). From habitat alteration and biodiversity loss to climate change and pollution, serious environmental challenges are shaping our planet and affecting all forms of life, including ours. To address human impacts such as plastic pollution, we need intensive monitoring, increased public awareness, and more effective mitigation measures (Nakhle et al., 2024). However, current research and governmental monitoring initiatives are lagging behind the pace of environmental changes (Fritz et al., 2019). One promising strategy to improve the spatial and temporal scale of data collection is by actively engaging the public in scientific research (Danielsen et al., 2021; Fraisl et al., 2022). This approach, called citizen science, has rapidly expanded across various research fields over the past few decades (Bautista-Puig et al., 2019; Kullenberg & Kasperowski, 2016). Public involvement not only provides valuable data for environmental science and policy but also enhances participants' scientific literacy and environmental awareness (Bonney et al., 2016; Silvertown, 2009). However, recruiting and retaining citizen scientists can be challenging, and more research is needed to understand who currently participates and how participation affects, for instance, their motivations and learning. Moreover, a narrow demographic profile persists in many citizen science projects: participants are often predominantly white, older, well-educated, and have higher incomes (Mac Domhnaill et al., 2020; Pandya, 2012; Pateman et al., 2021). New approaches are needed to engage a broader audience with citizen science.

This dissertation aims to enhance our understanding of environmental citizen scientists and investigate new methods to engage a broader audience in environmental monitoring. The rest of this chapter examines the history and evolution of citizen science, describes levels of engagement, clarifies terminology, and reviews what is known about citizen science participants. It concludes by presenting the research aims, outlining the dissertation structure, and briefly reflecting on my position as a researcher.

## 1.1 Citizen Science

### 1.1.1 History

Citizen science is broadly defined as the active participation of the public in scientific research (Bonney et al., 2009). Although the term "citizen science" emerged in the 1990s (Bonney, 1996; Irwin, 1995), it has deep historical roots and has evolved significantly over time. In the mid-19th century, before the professionalization of science, amateur naturalists conducted research independently, often as a hobby alongside their jobs. These early contributors played important roles in fields such as biology, for instance, in activities like bird counting. Some of these projects are still actively engaging the public today (Bonney et al., 2009; Miller-Rushing et al., 2012). With the professionalization of science, public participation declined in most research fields as research became restricted mainly to academic institutions. Nonetheless, researchers closely collaborated with volunteers in certain areas, such as archaeology and biology (Haklay, 2013). In the 1960s and 1970s, social movements advocated for public involvement in environmental decision-making

(Strasser et al., 2019). In response, scientists increasingly engaged with the public to foster trust, share knowledge, and democratize science. Over the past few decades, this engagement has further evolved, particularly as the so-called deficit model of science communication, which assumes that simply increasing public knowledge improves scientific literacy, proved insufficient (Smallman, 2018). Modern science communication instead focuses on interaction, dialogue, and participatory approaches like citizen science (Simis et al., 2016). Advances in digital technology over the past decades have further accelerated public involvement, enabling large-scale data collection and collaboration between professional researchers and volunteers through online platforms and mobile apps (Kullenberg & Kasperowski, 2016). Citizen science is now a widely used approach in environmental and ecological research, contributing to extensive datasets on public health, pollution monitoring, biodiversity, and more (Fraisl et al., 2022).

Beyond its practical expansion, citizen science can also be understood as part of a broader movement towards public participation in science and environmental governance. Since the 1960s, this movement has sought not only to collect data with the public but to question whose knowledge and experiences are valued in research. Early frameworks of participation, such as Arnstein's (1969) Ladder of Citizen Participation and Rowe and Frewer's (2005) typology of public engagement, highlight that participation can range from consultation to full co-creation, each with different degrees of influence. Similar continuums have since been developed within citizen science itself, distinguishing contributory, collaborative, and co-created projects (Bonney et al., 2009; Shirk et al., 2012). However, participation in citizen science is not equally accessible to all. Many projects still attract participants with higher levels of education and scientific literacy, reflecting broader patterns of inequality in opportunities for engagement (Haklay, 2013; Phillips et al., 2019; Pandya, 2012). Scholars of public engagement have argued that genuine inclusion requires attention not only to who participates, but also to how power, trust, and accessibility are negotiated throughout the research process (Felt et al., 2007; Chilvers & Kearnes, 2016). From this perspective, citizen science can be seen as both a scientific method and a social practice, one that has the potential to democratize knowledge production, but can also reproduce existing hierarchies if inclusivity and reciprocity are not carefully considered.

### 1.1.2 Aims and engagement levels

While the extent of public involvement may differ across citizen science projects, their aims are often similarly diverse. Most projects seek to generate scientific knowledge, but many also strive to benefit participants, for instance by increasing participants' scientific literacy which can be defined in different ways (Cronje et al. 2011; Phillips et al. 2018). For measuring changes in scientific literacy among citizen science participants, Price and Lee (2013) based their definition on a paper by Miller (2004), focussing on "the understanding of scientific inquiry (epistemological beliefs about science) and attitudes towards organized science and knowledge (science-related activities)." Other possible aims of citizen science projects include raising awareness, changing behaviours, and influencing policies (Brossard et al., 2005; Jollymore et al., 2017; Rambonnet et al., 2019). By engaging people who might otherwise not participate in science, citizen science can

also make research more inclusive, incorporating new perspectives and democratizing knowledge production (Austen et al., 2024; Viola et al., 2022).

Citizen science projects vary in the extent to which they engage the public. Bonney et al. (2009) distinguished three models of participation: contributory, collaborative, and co-created projects. Volunteers primarily contribute to the data collection phase in contributory projects, while in collaborative projects, they contribute to multiple stages of the research process. In co-created projects, volunteers and researchers work closely together throughout all project phases, from defining research questions to gathering and analyzing data, and even disseminating the results. While most citizen science projects adopt a contributory approach, an increasing number aim for a more collaborative or co-created approach (Haklay et al., 2023; Pocock et al., 2017). Haklay (2013) proposed a similar framework with four levels of participation: crowdsourcing, where volunteers perform simple data collection tasks; distributed intelligence, where participants help interpret or classify data; participatory science, when volunteers engage in multiple project phases; and extreme citizen science, when the public co-designs and implements the research.

In recent years, technological advancements have also introduced new participation opportunities through what some call passive citizen science or passive crowdsourcing (Ghermandi & Sinclair, 2019; Nascimento et al., 2024). This refers to projects or data collection efforts where people contribute data incidentally or without a formal project structure, often via digital platforms. This publicly shared data is then collected for research purposes (Ghermandi & Sinclair, 2019; O'Neill et al., 2023). Such ad hoc observations, for example wildlife photos shared via social media, can be an important source of data for ecological research (Edwards et al 2021). This emergent form of a more passive participation blurs the lines between traditional citizen science and other types of public involvement, highlighting both the democratizing potential of widespread data sharing by the public and the challenges of ensuring data quality and meaningful engagement with the public (Haklay, 2013; O'Neill et al., 2023).

In this dissertation, I use the term citizen science broadly to include different ways in which the public contributes to scientific research. Rather than a fixed category, I approach it as a continuum of participation (Haklay, 2013; ECSA, 2020). Along this continuum, people engage with science in different ways and to varying degrees of coordination and intention. At one end are structured, researcher-led projects that train volunteers and follow established methods, such as the Clean Rivers project. At the other end are more spontaneous or incidental forms of contribution, for example observations shared through social or news media, where people may not see themselves as participants in science. Seeing citizen science in this way helps to connect the different studies in this dissertation, which together explore how people engage with and contribute to environmental knowledge in diverse ways. This diversity in participation is also reflected in the continuing discussions about how citizen science should be defined and understood.

### 1.1.3 Terminology

Despite its growing popularity, the definition of citizen science remains a topic of debate among scholars (Eitzel et al., 2017). The term was first introduced by Irwin (1995) in the context of democratizing science by aligning scientific research more closely with the public's needs and values. Around the same time, Bonney (1996) coined the term citizen science to describe projects that actively engage the public in scientific research, such as helping to collect data. Since these two initiatives, opinions have varied on what constitutes citizen science. For instance, Strasser et al. (2019) argued that citizen science requires an active role for participants, thereby excluding more passive forms of public contribution to science, like donating computer power for large-scale research analyses. More recently, a study by Haklay et al. (2021) found that definitions vary across countries and communities, further complicating how we classify different public participation initiatives. This study also revealed that people are less likely to regard the previously mentioned passive contributions to science as citizen science since they are unaware that the data is used for scientific purposes. To address the different characteristics of citizen science, the European Citizen Science Association developed ten principles to guide various stakeholders on conducting effective citizen science (Robinson et al., 2018). They argue that instead of discussions about what is and is not considered citizen science, we should focus on criteria for good practice of citizen science. The ten principles include criteria such as the active involvement of participants, genuine scientific outcomes, mutual benefits, and ethical and legal considerations.

Additionally, the term "citizen science" has sparked discussions, as it may be perceived as excluding non-citizens (Eitzel et al., 2017). In response, some scholars and organizations have suggested alternative labels, such as "community science" or "civic science" (Cooper et al., 2021). In 2024, the American Citizen Science Association rebranded itself as "Advancing Participatory Sciences" (Shirk, 2024), though the impact of this change is still debated (Cooper et al., 2021). The terminology used in a project is crucial, as it can influence who feels invited to participate and even the quality of the data collected (Eitzel et al., 2017; Lewandowski et al., 2017). During the time that this research for the PhD dissertation was conducted, "citizen science" remained the most widely used term for public participation in research. Therefore, this term is consistently used throughout the dissertation.

## 1.2 Participants in citizen science

### 1.2.1 Background

Understanding who participates in citizen science is crucial for designing inclusive projects that can have a broader impact on science, society, and the environment. Previous studies show that the demographic composition of citizen science participants can vary based on the project's topic, design, and level of engagement (Geoghegan et al., 2016). For example, online projects typically attract more male and younger volunteers, while in-person environmental monitoring projects tend to engage more middle-aged or older adults and may feature equal or greater

female participation (e.g. Mac Domhnaill et al., 2020; Domroese & Johnson, 2017). One of the most consistent findings across various projects and countries is the overrepresentation of highly educated individuals among citizen science volunteers (Curtis, 2018; Edwards et al., 2018; Paleco et al., 2021). This overrepresentation likely reflects several factors; for instance, individuals with higher education may feel more confident in contributing (Haklay, 2013). Such demographic imbalances can limit the potential reach and impact of citizen science by underrepresenting specific backgrounds and restricting the diversity of perspectives that contribute to scientific inquiry (Pandya, 2012; Pateman et al., 2021). Engaging underrepresented groups, including those with lower educational backgrounds or limited prior exposure to science (i.e. lower science capital), can help bridge knowledge gaps and democratize scientific participation. In turn, involving a more diverse group of volunteers can enhance scientific research, as the inclusion of a wide array of experiences and viewpoints can improve science itself and ensure that findings are relevant to a broader public (Austen et al., 2024; Viola et al., 2022).

### 1.2.2 Motivation

To effectively recruit and retain participants in citizen science projects, understanding volunteer motivations is essential (Land-Zandstra et al., 2021). Studies indicate that volunteers' motivations vary based on factors such as project topic, participants' backgrounds, and cultural contexts (Lakomy et al., 2020; Sloane & Pröbstl-Haider, 2019). For instance, volunteers engaged in classifying galaxies in an online astronomy project were primarily motivated by a desire to contribute to scientific research (Raddick et al., 2010). In addition to this motivation, participants in a water quality monitoring project were also driven by the goal of helping the environment or their community (Alender, 2016). Volunteers monitoring air quality aimed to contribute to scientific research and were also motivated by their interest in the topic (Land-Zandstra et al., 2016b). These examples demonstrate that motivations can range from altruistic goals, such as helping science or the environment, to personal interests including enjoyment, learning, or social interaction.

Several theoretical frameworks have been proposed to categorize and compare motivations for citizen science. A commonly used approach is based on the functional theory of volunteerism from social psychology (Clary et al., 1998), which classifies motivations into categories such as values (altruism), understanding (learning), social, career, protective, and enhancement (personal growth). Another framework used is Batson et al.'s (2002) four types of motivation for community involvement: egoism (increasing own welfare), altruism (increase someone else's welfare), collectivism (increase group welfare) and principlism (moral principle). More recently, Levontin et al. (2022) developed a motivation framework for citizen science that is grounded in Schwartz's theory of human values (2012). Their framework highlights the interplay between individuals' core values (e.g., altruistic vs. egoistic), their desires for knowledge, and community-oriented goals, providing a nuanced way to examine why people engage in citizen science.

Importantly, motivations are not static but can evolve over time. Newcomers may initially join out of curiosity, a general interest in science, or a desire to connect with nature, while long-term volunteers often become more strongly driven by the feeling that they are contributing to a

more significant cause, such as advancing research or protecting the environment (Crowston & Fagnot, 2018; Rotman et al., 2012). A study by Ryan et al. (2001) showed that while helping the environment and learning were important motivations at the start of participation, social factors and project organization predicted long-term involvement of participants. However, most studies examining changes in motivation have compared different cohorts of participants at various stages rather than tracking the same individuals over time (Land-Zandstra et al., 2021) Longitudinal studies are needed to assess how an individual's motivation may increase, decrease, or shift focus with ongoing participation. Various barriers can also influence whether initial enthusiasm is maintained. Common challenges include time constraints, lack of feedback or recognition, and complicated protocols that frustrate volunteers, all of which can dampen motivation in the long run (Nov et al., 2014; West & Pateman, 2016). Understanding these factors is essential for sustaining volunteer engagement.



### 1.2.3 Impact on knowledge and attitude

Beyond contributing to scientific research, citizen science can offer learning benefits for participants themselves. Involvement in data collection and other research activities may enhance volunteers' topic-specific knowledge (e.g., understanding local water quality or wildlife ecology) as well as their overall scientific literacy including knowledge about science and attitude towards science (Brossard et al., 2005; Price & Lee, 2013). Attitude can be defined as "a learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object" (Fishbein & Ajzen, 1975). For example, participants in a frog-monitoring project improved their knowledge of amphibian biology and conservation after their involvement (Jordan et al., 2011). Some projects also reported increases in participants' understanding of the scientific process and boosted confidence in conducting science (Burgess et al., 2017).

In contrast, the evidence regarding changes in attitudes, such as those toward science or environmental issues, is mixed. In a study of a citizen science birdhouse project, participants' factual knowledge increased significantly, yet their attitudes toward bird conservation did not show a comparable change (Brossard et al., 2005). Similarly, a follow-up study found little change in general environmental attitudes or civic attitudes among volunteers, despite the knowledge gains (Crall et al., 2013). The extent of what participants learn or how their attitudes shift may depend on their prior knowledge, motivations, and whether the project includes structured educational components (Brossard et al., 2005; Phillips et al., 2018). Those with higher education or interest in the topic might exhibit smaller knowledge gains (Trumbull et al., 2000). However, even highly educated volunteers can increase their knowledge (Burgess et al., 2017). These learning gains can subsequently improve project outcomes: more knowledgeable volunteers often collect higher-quality data (Crall et al., 2013; Land-Zandstra et al., 2021). Further research is necessary to clarify how participation influences knowledge and attitudes over more extended periods.

## 1.3 Research aims

Our understanding of citizen scientists' backgrounds, motivations, and the impact of participation on their knowledge and attitudes has expanded in recent years. Since the topic and type of project can influence who volunteers and how their knowledge and attitudes are affected, it is essential to broaden our understanding in areas that remain understudied. One such area is plastic pollution, a growing environmental issue where citizen science is increasingly employed to monitor the extent and sources of this pollution (Nelms et al., 2022; Rambonnet et al., 2019; Zettler et al., 2017). However, few studies have focused on plastic pollution citizen science participants. One exception involves work with schoolchildren in educational settings (e.g. Locritani et al., 2019; Wichmann et al., 2022). But there is a significant gap regarding adult citizen scientists outside of formal education. We know little about who volunteers for plastic pollution monitoring, what motivates them, and how participating in such projects may influence their perspectives. Therefore, we collaborated with the Dutch Clean Rivers project (Schone Rivieren in Dutch) to conduct survey research among their participants.

At the same time, to enhance the impact of environmental citizen science, we must explore new strategies for engaging a broader audience than those typically reached. As noted, many projects struggle to attract volunteers beyond a relatively homogeneous group. One way to broaden participation is by tapping into existing communities or networks of individuals already active in environmental or animal-related work, even if they are not currently connected to research. By examining such communities, we can assess whether they are open to contributing data or participating in scientific research and what support they would need. A promising example of an existing volunteer community is that of Wildlife Rehabilitation Centers (WRCs). These organizations operate worldwide and often rely on volunteers to care for injured and orphaned wildlife. WRCs keep records of every animal admitted, which could be valuable for research on wildlife health, conservation threats, and environmental change (Mullineaux & Pawson, 2024; Pyke & Szabo, 2018a). As the records are collected largely by volunteers, the involvement of these volunteer communities could be perceived as citizen science. Although researchers are increasingly collaborating with WRCs, our understanding of the volunteers in this emergent field of citizen science, including their backgrounds, motivations, and data collection practices, is limited. Only a few studies, mainly from Australia and New Zealand, have examined aspects of WRCs' volunteers and their data collection practices (Englefield et al., 2019; Haering et al., 2020b; Yeung et al., 2017). To evaluate the potential of wildlife rehabilitators as contributors to citizen science, we need to investigate who these volunteers are, why they volunteer, what kinds of data they collect, and how they feel about collaborating with researchers. We did this among a group of WRCs in the Netherlands. To understand their affinity with science, the science capital framework was used which measures peoples' knowledge of scientific developments, attitude towards science, participation in scientific activities, and engagement with science in daily life (De Witt et al., 2016; Peeters et al., 2022b).

In addition to organized volunteer groups, today's general public also shares data online through social media and other digital platforms. These public observations, such as photos or reports of environmental phenomena posted on Twitter, Facebook, or news sites, are increasingly being utilized in scientific studies. Researchers have begun to recognize that this emergent form of more passive citizen science with incidental data can provide valuable insights, particularly on topics of broad public interest or rare events (Edwards et al., 2021). For instance, posts on social media have been used to track invasive species, document wildlife sightings, and even monitor pollution incidents (Abreo et al., 2019; Nascimento et al., 2024). However, the potential of this more passive form of citizen science remains largely underexplored for many research questions. In the context of plastic pollution and its effects on wildlife, observations shared by members of the public could offer information that formal citizen science projects might miss. For this purpose, we have collected pictures globally that were shared online about entanglement of animals in COVID-19-related personal protective materials such as gloves and face masks. This project focuses on the publics' potential to contribute to scientific research. The study emerged from an opportunistic discovery during a side project coordinated by the PhD candidate: the citizen science project 'The Canal Watch' ('De Grachtwacht' in Dutch), in which volunteers clean the canals of Leiden, the Netherlands. The discovery of a fish entangled in a single-use glove during the COVID-19 pandemic led to a spontaneous and innovative investigation into the potential of observations shared via social media for scientific purposes, as an emergent form of citizen science for environmental monitoring. This chapter will also broadly touch upon the types of audiences that can be reached. This dissertation addresses existing knowledge gaps to enhance our understanding of citizen scientists involved in plastic pollution research and explore methods for engaging more diverse participants in environmental monitoring. The specific research aims are to:

1. Identify the background and motivation of citizen scientists participating in plastic pollution research.
2. Monitor changes in these volunteers' motivation, attitudes, and knowledge over time through a longitudinal study.
3. Examine the potential for incorporating volunteer wildlife rehabilitators into scientific research as a form of citizen science.
4. Explore how public observations shared through news and social media can contribute to understanding plastic pollution's impact on wildlife.

## 1.4 Dissertation outline

Figure 1.1 provides an overview of the dissertation's structure and how the chapters address different or similar concepts. In brief, the dissertation is organized as follows:

- **Chapter 2** quantitatively examines the demographic background, motivations, and expectations of volunteers participating in Clean Rivers, a Dutch citizen science project on plastic pollution. Since 2017, this project has actively involved volunteers in cleaning up litter and monitoring the amount and types of plastic on riverbanks in the Netherlands, with the goal of achieving plastic-free rivers in 2030. This chapter focuses on the participants' profiles and motivations at the start of their involvement. In 2017, volunteers completed an initial survey before participating, and in 2018 a subset completed a follow-up survey after one year. This pre- and post-participation study of 122 respondents allowed us to evaluate the motivations of the volunteers, their expectations from the project, and how their motivation evolved after the first year.
- **Chapter 3** presents a longitudinal follow-up study that monitored Clean Rivers participants from 2017 to 2021. Through surveys, this study tracked 403 participants over several years to investigate the long-term effects of their involvement. This chapter examines how sustained engagement in the project influenced volunteers' motivation, attitudes toward nature and scientific research, and their understanding of plastic pollution and research methods. By monitoring the same group of volunteers over time, this chapter provides insights into motivation changes and whether continued participation impacts volunteers' knowledge and attitudes.
- **Chapter 4** utilizes a mixed-methods approach to explore the potential participation of wildlife rehabilitators in scientific research. Through in-depth interviews with representatives from thirteen Dutch WRCs and a survey among 205 volunteer rehabilitators, this chapter investigates the backgrounds and motivations of wildlife rehabilitators, their current data-collection practices, and their views on contributing to research. We evaluate rehabilitators' familiarity with citizen science, their willingness to share data with scientists, their confidence in the quality of the data they collect, and the topics and support they find most relevant for potential collaboration on research. This chapter also examines the opportunities and challenges of incorporating a largely untapped volunteer community into environmental citizen science.
- **Chapter 5** explores the role of public observations via social and news media as an emerging method for understanding the impact of plastic pollution on wildlife. This chapter investigates a specific case: the rapid increase of littered personal protective equipment (PPE) like face masks and gloves during the COVID-19 pandemic and its effects on animals. We compiled observations of wildlife and domestic animals affected by PPE litter by searching online news articles, social media posts, and other online reports. Chapter 5 discusses how these digital platforms can enhance data collection on environmental issues.
- **Chapter 6** synthesizes the dissertation's main findings, highlights the key strengths and limitations of this research, discusses its broader implications, and offers recommendations for researchers and practitioners interested in studying or using citizen science for environmental monitoring and conservation.

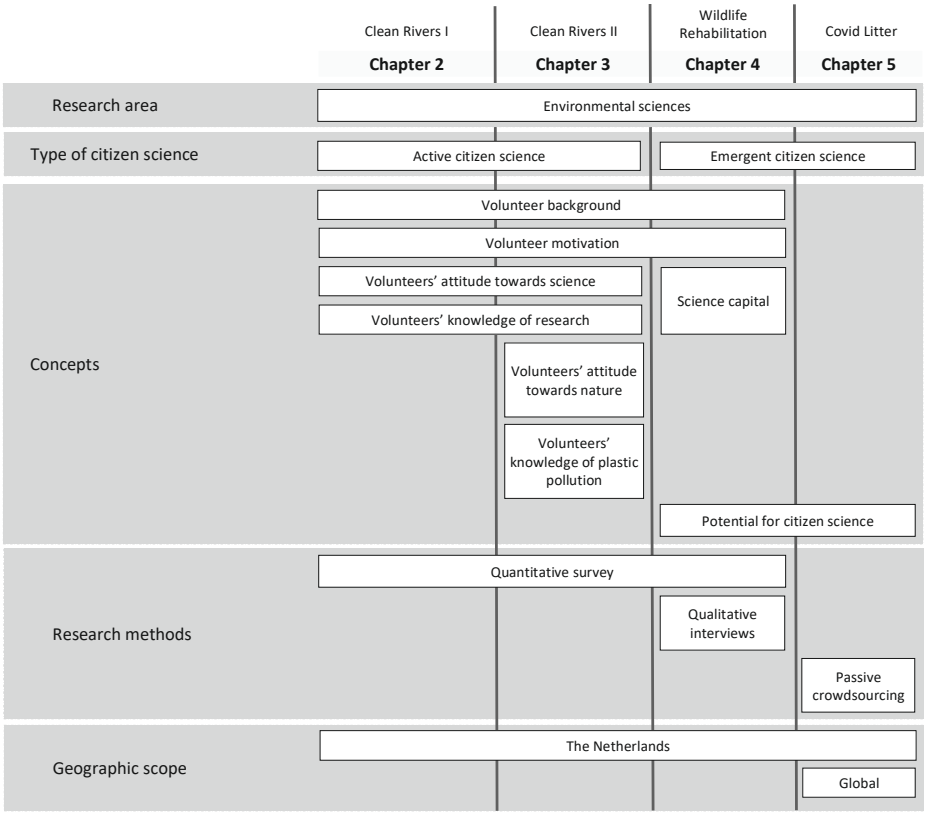


**Figure 1.1** Overlap and differences between chapters in terms of research area, type of citizen science, studied concepts, research methods and geographic scope.

## 1.5 Positionality

This dissertation examines topics in which I have been actively involved both professionally and personally. Therefore, it is important to reflect on my positionality, the background and biases I bring to the research, and to consider how these may have influenced the research process and outcomes (Holmes, 2024; Berger 2015). By being transparent about my role and perspective, I aim to ensure that the research remains both ethically sound and robust.

Before starting my PhD, I studied best practices and challenges in citizen science projects focused on plastic pollution by interviewing project coordinators across various initiatives (Rambonnet et al., 2019). This inspired me to become the founder and coordinator of a citizen science project addressing plastic pollution. This hands-on experience provided me with firsthand insight into volunteer engagement and project management. However, it is essential to note that in this dissertation, my focus is on the participants' experiences rather than the coordinators' perspectives. In other words, while my professional work with citizen science informed my

understanding of project operations, this PhD research centers on volunteers in other projects, not on those I directly coordinated.

I also have extensive personal involvement in wildlife rehabilitation, having volunteered at a local wildlife rehabilitation center (WRC) since 2014. This experience inspired my bachelor's research on hedgehog rehabilitation in 2015 and made me aware of some challenges and ethical issues inherent in wildlife rescue work. My dual role as both a researcher and an insider in the world of wildlife rehabilitation presents advantages and risks. On one hand, it likely helped build trust and rapport during interviews and surveys with rehabilitators, as I could relate to their experiences and demonstrate an understanding of their work. On the other hand, I needed to remain critically aware of potential biases, such as expectations or assumptions I might have due to my own experiences. To mitigate these risks, I collaborated closely with co-researchers who were not involved with the WRCs, providing an external check on the research design and interpretations. I also intentionally stepped back from some of my volunteer duties at the local bird shelter during the data collection period to avoid conflicts of interest and ensure that my interactions with study participants remained as impartial as possible.

By reflecting on these aspects of positionality, I acknowledge how my background may have influenced the research and have taken steps to ensure the credibility and neutrality of the findings. All interviews and analyses were conducted with an awareness of this dynamic, striving for a balance between insider insight and objective distance. This reflexive approach aimed to strengthen the integrity of the research outcomes presented in the chapters that follow.


SCHONE
RIVIEREN

# Chapter 2

# Citizen science against the plastic soup: Background, motivation and expectations of volunteers studying plastic pollution on Dutch riverbanks

**This chapter is based on**: Rambonnet, L., Reinders, H., & Land-Zandstra, A. M. (2023). Citizen science against the plastic soup: Background, motivation and expectations of volunteers studying plastic pollution on Dutch riverbanks. Research for All, 7(1), 1-17. https://doi.org/10.14324/RFA.07.1.14

**Photo credits**: *Schone Rivieren*

## Abstract

In the field of investigating and addressing plastic pollution, the public are increasingly involved in research as citizen scientists. Long-term monitoring for this topic is needed, and recruiting and retaining volunteers is challenging. Therefore, it is important to learn more about the demographic background, motivations and expectations of involved citizen scientists, and if these change during participation. Our research studied these aspects of the citizen scientists in the Dutch Clean Rivers project, who monitor plastic pollution on riverbanks. Participants (n=122) completed pre- and post-survey after one year of the project. While there was no gender bias, the participants were mostly middle-aged and highly educated, and almost half had previous experience with scientific research. Their motivation to participate was mostly activistic, as they wanted to tackle the source of plastic pollution and contribute to solutions. More personal motivations, such as wanting to learn more and because it is fun to do scientific research, decreased significantly after one year of participation. Their expectations were in line with the main motivations. Understanding the background, motivations and expectations of volunteers helps this project, and the field of citizen science in plastic pollution research.

## 2.1 Introduction

While citizen science, the active involvement of volunteers in scientific research, is already centuries old, it gained popularity over the past 20 years (Bonney et al., 2016; Kobori et al., 2016; Silvertown, 2009). Especially with the development of digital technology and the internet, citizen science has expanded both in the number of projects and across different scientific fields (Bautista-Puig et al., 2019; Pelacho et al., 2021). The goals of citizen science often include: (1) increasing or improving scientific output; (2) allowing volunteers to contribute to science and learn from the experience; and (3) influencing policy. This last goal is particularly relevant for environmental citizen science projects, such as those focusing on plastic pollution (Cigliano et al., 2015; Rambonnet et al., 2019; Zettler et al., 2017).



In the field of plastic pollution research, citizen science has become an important and effective way to reach all three of these goals (Hyder et al., 2015; Rambonnet et al., 2019; Zettler et al., 2017). Approaches involve for example water sampling, or monitoring beaches and riverbanks (Bosker et al., 2017; Rambonnet et al., 2019; Zettler et al., 2017). Most of the publications on the subject of plastic pollution are focused on marine environments; our knowledge about plastic pollution in freshwater ecosystems is lacking (Blettler et al., 2018). In addition, while the involvement of citizen science in this field has been gaining scientific attention in recent years (Cook et al., 2021) it has not been studied extensively.

To monitor plastic pollution effectively, and to study the impact of seasonal or policy changes, repeated measurements over a wide geographical spread are necessary. This results in the need for long-running citizen science projects with large groups of volunteers (Cook et al., 2021). However, for such widespread and long-term projects, it is challenging to recruit enough volunteers, and to keep them involved. It is therefore important to gain knowledge about the background, motivations and expectations of citizen scientists, and how these might change during participation (Eveleigh et al., 2014; Nov et al., 2014; Wright et al., 2015). This knowledge is also important for data quality and quantity, as these can be influenced by the characteristics of the citizen scientists (Gunko et al., 2022; Nelms et al., 2022).

In order to gain more understanding of these aspects of citizen science related to plastic pollution research, we studied the Dutch Clean Rivers project (Schone Rivieren in Dutch). In this project, which started in 2017, volunteers monitor the macroplastic litter and plastic pellets on riverbanks twice a year. The project's ultimate goal is plastic-free rivers in the Netherlands by 2030 (Van Emmerik et al., 2020b). Our study included pre- and post-surveys focusing on volunteer background and experience, motivations and expectations during the first year of the project.

### 2.1.1 Volunteer background and experience

The background and previous experience of citizen scientists varies highly between projects, and most likely depends on the topic and type of activity (West & Pateman, 2016). Although our knowledge about the background of citizen scientists in plastic pollution research is limited, there

have been numerous studies about the demographics of nature volunteers and citizen scientists in other environmental research. Most of the projects using citizen science in environmental research focus on biodiversity monitoring (Pocock et al., 2017). For nature volunteers and biodiversity recorders, an over-representation of middle-aged and highly educated volunteers seems to be a trend (e.g. Ganzevoort & Van Den Born, 2020). For gender, no clear pattern has been found (Mac Domhnaill et al., 2020; Ganzevoort & Van Den Born, 2020). However, qualitative data in one study suggest that beach clean-ups may have an over-representation of women (Nelms et al., 2022).

Understanding the background and previous experiences of volunteers may contribute to improvements of individual projects, for example, through focused communication or the provision of relevant activities (Land-Zandstra et al., 2021). Another issue that makes the study of volunteer backgrounds important is the aim of diversity. A recent study by Nelms et al. (2022) in the UK showed that one of the key themes for clean-up organisations is the need to engage volunteers with diverse backgrounds in terms of gender and age. Involving diverse volunteers in citizen science projects will offer a broader audience the benefits of participation, such as knowledge, skills, enjoyment and social bonding (Phillips et al., 2019; Stedman et al., 2009). In addition, it may also ensure that the goals of projects, such as behaviour change or increased awareness of environmental issues, are spread among a diverse population.

### 2.1.2 Motivations

Besides knowing who participates in citizen science on plastic pollution, it is also important to know the reasons for their participation (Land-Zandstra et al., 2021). Knowing why people participate in a project will support recruitment and retention of volunteers (West & Pateman, 2016). Several studies have looked into volunteers' motivations in different types of citizen science projects, and have discovered variations among projects. Volunteers often join a project because they have an interest in the topic (Eveleigh et al., 2014; Land-Zandstra et al., 2016b; Raddick et al., 2010). Another often-cited reason is to contribute to science in general (Domroese & Johnson, 2017; Land-Zandstra et al., 2016a; Martin, 2017). Some people join a citizen science project because they want to learn something (Alender, 2016; Martin et al., 2016; Rotman et al., 2012). Other relevant motivations are because the activity is fun, or because volunteers want to engage with people with similar interests (Chu et al., 2012; Lee & Roth, 2003; Rotman et al., 2012).

With such a range of different motivations, it is helpful to define various categories of motivation. West and Pateman (2016) published an overview of studies that aimed to categorise volunteers' motivations to participate in a project, focusing on intrinsic and extrinsic factors. Intrinsic motivations include being interested in, enjoying, or being satisfied by a project, while extrinsic factors include social pressure, rewards, punishment or fear (Nov et al., 2014). Intrinsic motivations may have a larger impact on volunteer engagement and retention (West & Pateman, 2016).

Another framework that is helpful in this sense is that of Rotman et al. (2012), based on Batson et al.'s (2002) four categories of motives for community involvement: egoism, altruism, collec-

tivism and principlism. Egoism reasons are related to the goal of increasing one's own welfare (for example, having fun or an enjoyable experience). Altruism reasons are focused on increasing someone else's welfare (for example, to help a researcher). Collectivism reasons include increasing the welfare of a group (for example, to help cure Alzheimer's disease). Principlism relates to reasons that uphold some moral principle (for example, justice).

Some researchers have suggested that motivations may change over time. According to Rotman et al. (2012), initial motivations for volunteers in ecological citizen science projects were more egoism related, while altruism and collectivism reasons played a larger role for sustained motivation. Crowston & Fagnot (2018) found that beginners in massive virtual collaborations were often motivated by curiosity, while people who had been in the project for longer periods of time were also motivated by social obligation, shared ideology and satisfaction about their contributions. In contrast, in a study about a citizen science project about flu symptoms, there were no large differences between beginners and long-term volunteers; for both groups, contribution to science and health were the most important reasons (Land-Zandstra et al., 2016a). It is important to note, however, that differences between beginning and sustained volunteers at one point in time do not necessarily mean that individual motivations change over time. It could also mean that people with a certain motivation are the ones that stay longer, and not that the motivations of longer-term volunteers have changed from when they started the project. Therefore, it is important to follow volunteers throughout their involvement in the project via longitudinal studies.



### 2.1.3 Expectations

Different types of motivations may have different implications for the expectations that volunteers have. For example, they may have expectations in terms of communication with project organisers and scientists, information about outcomes of the project, availability of data and findings, engagement with other volunteers, rewards and recognition (Crowston & Fagnot, 2018; De Vries et al., 2019; Land-Zandstra et al., 2016a, 2016b; Rotman et al., 2012).

There are different ways the public can be involved in science through citizen science. While they can be involved in all phases of the scientific process, in most projects, volunteers either collect data or analyse existing data. Understanding how volunteers want to be involved may also help to keep them motivated (Rotman et al., 2014).

### 2.1.4 Current study

The aim of the current study was to investigate the background, motivations and expectations of volunteers on the Clean Rivers project. We surveyed volunteers on the project before and after their first cycle of participation (training, monitoring and feedback about the results). The aims of the current study were to: (1) explore the background of the participants; (2) determine their initial motivations; (3) determine their motivations after one full cycle of the projects' activities; and (4) explore the expectations they had about the project and their participation.

## 2.2 Methods

For this study, a mixed-methods approach was chosen, using a survey. We combined closed and open questions in order to get quantitative data for well-researched topics such as motivations and demographics, and qualitative data for topics that were under-researched, such as expectations. To clarify, we call all citizen scientists on the Clean Rivers project 'volunteers'; when we refer to our study participants, we write 'participants'.

### 2.2.1 Project description: Clean Rivers

In the Clean Rivers project, citizen scientists monitor 100-metre sections along major rivers in the Netherlands, such as the Meuse and the Waal (a branch of the Rhine). The project was developed by the Institute for Nature Education and Sustainability, the Plastic Soup Foundation and the North Sea Foundation. During the monitoring, citizen scientists clean-up and collect data about the amount and types of litter on their 100 metres of riverbank. Volunteers are recruited through social media, local newspapers and digital newsletters. They attend a training workshop before they start monitoring, which teaches them about the project, the organisers, the river pollution problem and the monitoring protocol. This training includes a hands-on fieldwork session to practise the protocol. The monitoring protocol River-OSPAR is based on the OSPAR (Oslo and Paris Conventions) guidelines, so that data from the rivers can be compared internationally with other data sets on plastic pollution (Van Emmerik et al., 2020a; 2020b; Wenneker & Oosterbaan, 2010). After the training, volunteers monitor their assigned track twice a year, once in spring and once in autumn. They always monitor in pairs, of which at least one member attended the training. After the monitoring period, there is an evaluation meeting; results are shared with the volunteers via this meeting and a report. Furthermore, a larger annual event provides them with workshops, inspiration sessions and networking opportunities. In addition to the citizen scientists, the project also recruits clean-up volunteers, who only collect litter, without monitoring. While the project started in 2017, and is still running in 2023, this study only focuses on the first cycle of participation, and only on the citizen scientists.

### 2.2.2 Data collection

To study the motivations and experiences of the citizen scientists throughout the project, pre- and postsurveys were designed, in Dutch. Both surveys consisted of a combination of multiple choice questions, five-point Likert scale, and open questions. When registering online for the project and the training workshop, participants received a request to fill in the online survey, explaining that they were not required to do so, and that it would not influence their participation in the project itself. People who had not filled in the online survey were provided with the opportunity to fill in the paper version at the training location before the training started. By filling in the survey, participants gave informed consent for the use of their data. For the consent and processing of the data, ethical guidelines of Leiden University were followed, and the data were processed confidentially; no identifiable information was included in the final database.

This pre-survey contained 31 questions, of which 14 were used for the current study. These questions concerned participants' initial motivations, their expectations, their prior knowledge and experience, and their demographics. Questions regarding motivations were split into two parts. One section was about motivations to join the project in general, so that we could compare them with clean-up volunteers in the same project. The other section was about motivations to participate as a citizen scientist specifically. Both sections were based on existing surveys on motivations of volunteers and citizen scientists (for example, Batson et al., 2002; Land-Zandstra et al., 2016a, 2016b; Raddick et al., 2010). In order to make sure that the statements were relevant and complete, we adapted some of the statements. The survey was pilot-tested with a group of 18 volunteers in a pilot version of the Clean Rivers project.



Participants who had identified on the pre-survey that they were willing to participate in future surveys got an invitation to fill in the online post-survey. This test was conducted after one cycle of the project (training workshop, monitoring, evaluation meeting and communication of results). On the posttest, there were 42 questions, of which 5 were used for the current study. Those about motivations and preference for information were repeated to measure any changes. In this article, we report on the results of the background, motivations, and expectations of the participants in the Clean Rivers project.

### 2.2.3 Participants

A total of 221 Clean Rivers participants filled in the pre-survey between September 2017 and January 2018 (75 per cent online, 25 per cent on paper). In comparison, around 230 people attended the training workshops in that period. In June 2018, a personal link was sent to 203 participants who had indicated that they wanted to participate in follow-up research. Between June and October 2018, 163 participants completed the post-survey, representing a response rate of 80 per cent. Of the respondents, 41 were removed from the sample because they did not monitor (for a variety of reasons, such as illness or lack of a monitoring partner) or because they had filled in the pre-survey after the training. This resulted in a sample of 122 participants for this study.

To check whether the 99 dropouts between the pre- and post-surveys were different from the 122 remaining participants, chi-square analyses were performed. We found no significant differences between dropouts and stayers in terms of gender ($\chi^2(1)=0.930$, $p=0.335$) or education level ($\chi^2(4)=8.663$, $p=0.070$).

Therefore, we conclude that the current sample is representative of the group of Clean Rivers participants.

### 2.2.4 Data analysis

Descriptive analysis was carried out to provide characteristics of the Clean Rivers sample. To determine any significant differences in motivations between the pre- and post-surveys, a paired sample t-test was performed. Chi-square analyses were done to discover any significant correlations between categorical variables. We used Cramer's V to determine effect sizes for the chi-

square tests. To determine any groups of similar motivations to participate as a citizen scientist, principal component analysis (PCA) was performed. This analysis included ten variables, and we used varimax rotation. In order to check the assumptions for doing a PCA, the Kaiser–Meyer–Olkin test resulted in a KMO value of 0.814, meaning that the sample was considered good enough for a factor analysis (Hutcheson & Sofroniou, 1999; Kaiser, 1974). In addition, Bartlett's test of sphericity was significant ($\chi 2=508.701$, $df=21$, $p < 0.001$), showing enough correlation between variables. The analysis resulted in two components with eigenvalues above 1. It was defined as greater than 1, and therefore significant. Together, they explained 79.4 per cent of the variance. To explore the open-ended question about the expectations of the volunteers, a qualitative analysis was done using thematic analysis (Braun and Clarke, 2006). The expectations were manually and inductively coded, and data were analysed in SPSS (Version 27). As the survey was conducted in Dutch, statements and codes were translated into English for the purpose of this article.

## 2.3 Results

### 2.3.1 Volunteer background and experience

In total, 122 participants completed both the pre- and post-surveys and were involved in active monitoring. As Table 2.1 shows, the participants were mostly middle-aged, as the average age was 54 years (SD=12.7; range=18-71). Only 7 participants (6 per cent) were younger than 30 years. A little over half of the participants were women (53 per cent). The educational level of the participants was quite high, as 75 per cent had finished higher education. When asked about their employment status, 41 per cent reported that they were either retired or had no paid job.

In terms of previous involvement in scientific research, 43 per cent had had experience with scientific research, in their studies or in their profession, but only 12 per cent of the participants had participated in a citizen science project before, for example, a garden bird count. The involvement of the participants in environmental organisations and activities was relatively high. More than three-quarters of the participants already had volunteer experience (77 per cent), while 39 per cent of all participants had experience with environmental volunteering. Also, more than half of the participants (52 per cent) had experience in cleaning up the environment.

**Table 2.1** The background of the Clean Rivers citizen scientists who participated in the study (n=122).

| | Frequency | Percentage (%) | | Frequency | Percentage (%) |
|---|---|---|---|---|---|
| **Age (n=122)** | | | **Science experience (n=104)** | | |
| ≤ 24 | 4 | 3 | As pupil | 10 | 8 |
| 25-34 | 8 | 7 | As student | 21 | 25 |
| 35-44 | 12 | 10 | As researcher | 12 | 10 |
| 45-54 | 26 | 21 | In citizen science | 9 | 12 |
| 55-65 | 45 | 37 | No experience | 67 | 55 |
| ≥65 | 26 | 22 | **Volunteer experience (n=122)** | | |
| **Gender (n=122)** | | | Currently | 59 | 48 |
| Female | 64 | 53 | In the past | 35 | 29 |
| Male | 58 | 47 | Soon | 9 | 7 |
| Other | 0 | 0 | Never | 19 | 16 |
| **Education (n=122)** | | | **Member environmental organisation (n=122)** | | |
| Secondary school | 9 | 7 | IVN | 22 | 18 |
| Vocational training | 22 | 18 | Other environmental organisation | 56 | 46 |
| University of Applied Sciences | 62 | 51 | No | 51 | 42 |
| Research university | 29 | 24 | **Clean-up experience (n=122)** | | |
| **Employment status (n=122)** | | | Own initiative | 38 | 31 |
| Student | 3 | 3 | Neighbourhood clean-up | 21 | 17 |
| Employed fulltime | 43 | 35 | Riverbank clean-up | 19 | 16 |
| Employed parttime | 26 | 21 | National clean-up | 13 | 11 |
| Retired | 32 | 26 | Coastal clean-up | 6 | 5 |
| Unemployed | 18 | 15 | No experience | 58 | 48 |

## 2.3.2 Motivations

The motivations statements were divided into two sections: one containing reasons for joining the project in general, and one containing reasons for becoming a citizen scientist.

### *Motivations for the project in general*

Participants indicated their agreement with various motivations to participate in the Clean Rivers project in general (Table 2.2). Almost all provided statements scored positively (scores above 3). They most strongly agreed with the motivations that they wanted to do something about the plastic soup (*Plastic soup*, 4.75), that litter in nature or on the streets disturbed them (*Disturbing*, 4.74), and that they liked to commit themselves to a better environment (*Environment*, 4.65).

The motivations of the participants in the post-survey revealed a mostly similar picture to the pre-test regarding the main three motivations (*Disturbing*, 4.82; *Plastic soup*, 4.78; and *Environment*, 4.69). A few statements scored significantly lower in the post-survey than in the pre-survey: because they liked to be outdoors (*Outdoors*, 4.22); because they liked to recreate near or on the water (*Recreation*, 3.37); participating as part of work/association responsibilities (*Responsibility*, 2.08); and because they liked to commit themselves to volunteer work (*Volunteering*, 3.66).

Respondents were also asked to pick the most important motivation from the same list of motivations. The most important initial motivation was *Plastic soup* (39 per cent), closely followed by *Disturbing* (33 per cent; Figure 2.1).

**Table 2.2** Participants' agreement with statements about their motivations to participate in the Clean Rivers project (average on a five-point Likert scale).

| ***I participate in Clean Rivers, because...*** | **Keyword** | **Pre-test** | **Post-test** |
|---|---|---|---|
| I can help doing something about the Plastic Soup | *Plastic Soup* | 4.75 | 4.78 |
| Litter in nature or on the streets disturbs me | *Disturbing* | 4.74 | 4.82 |
| I want to commit myself to a better environment | *Environment* | 4.65 | 4.69 |
| I like to be outdoors | *Outdoors* | 4.49 | 4.22* |
| I like to join a bigger movement to improve the world | *Bigger movement* | 4.16 | 4.19 |
| I like to commit myself to volunteer work | *Volunteering* | 3.86 | 3.66* |
| I'm interested in the kinds of litter present in the rivers | *Interest* | 3.82 | 3.66 |
| I like to recreate near or on the water | *Recreation* | 3.75 | 3.37* |
| I live or used to live close to the Maas or the Waal | *Neighbourhood* | 3.68 | 3.66 |
| It is part of my tasks/responsibilities I have at my work/association | *Responsibility* | 2.35 | 2.08* |

**Note:** Participants' scores before (pre-survey) and after (post-survey) one cycle of participation, scored on a five-point Likert scale, ranging from *totally disagree* (1) to *totally agree* (5) (n=122).
*Significant differences between pre- and post-surveys: $p<0.05$. For the motivation *Interest* only, the sample size is 121 in the pre-test.

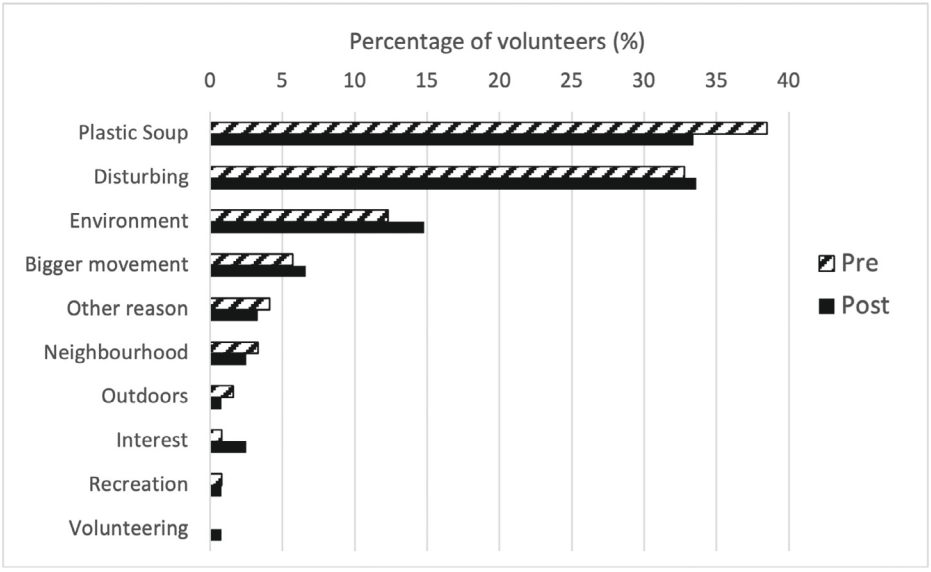


**Figure 2.1** Most important general motivation for Clean Rivers participants to join the project before their participation and after one cycle of participation (n=122).

***Motivations for citizen science***

In addition to their general motivations for the project as a whole, participants were asked about their motivations to participate specifically as a *river litter researcher*, meaning collecting data in addition to cleaning up litter. The statements were again answered on a five-point Likert scale. Table 2.3 shows that the most important motivations were: 'with the results, we can tackle the litter at its source' (*Source*, 4.67); 'it's important to gather as much information about litter in the rivers as possible' (*Information*, 4.58); and 'my contribution can help the government/companies take measures' (*Measures*, 4.55). The motivations 'to me, it seems fun to perform scientific research' (*Fun*), 'I hope to learn something about performing scientific research' (*Learn*) and 'I'm interested in the performance of scientific research' (*Interest*) decreased significantly in the post-survey. Again, respondents had to indicate their most important motivation (Figure 2.2). During the pre-survey, their most important motivations to participate specifically as a river litter researcher were *Source* (48 per cent) and *Measures* (27 per cent). In the post-test, the motivation *Source* (57 per cent) increased, while *Learn* (2.5 per cent) and *Information* (2.5 per cent) decreased.

**Table 2.3** Participants' agreement with statements about their motivation to participate specifically as a 'river litter researcher', meaning collecting data in addition to cleaning up (average on a five-point Likert scale).

| **I want to become/have become a river litter researcher, because...** | **Keyword** | **Pre-test** | **Post-test** |
|---|---|---|---|
| with the results we can tackle the litter at its source | *Source* | 4.67 | 4.74 |
| it's important to gather as much information about litter in the rivers as possible | *Information* | 4.58 | 4.59 |
| my contribution can help to let the government/companies take measures | *Measures* | 4.55 | 4.68 |
| to me it seems fun to perform scientific research | *Fun* | 3.96 | 3.58* |
| I like to contribute to scientific research | *Contribute* | 3.95 | 3.89 |
| I hope to learn something about performing scientific research | *Learn* | 3.94 | 3.42* |
| I'm interested in the performance of scientific research | *Interest* | 3.87 | 3.61* |
| I want to become/have become a river litter researcher, because... | *Keyword* | Pre-test | Post-test |
| with the results we can tackle the litter at its source | *Source* | 4.67 | 4.74 |
| it's important to gather as much information about litter in the rivers as possible | *Information* | 4.58 | 4.59 |

**Note:** Participants' scores before (pre-project) and after (post-project) one year of participation, scored on a five-point Likert scale, ranging from *totally disagree* (1) to *totally agree* (5) (n=122).
*Significant differences between pre- and post-surveys: p<0.05.

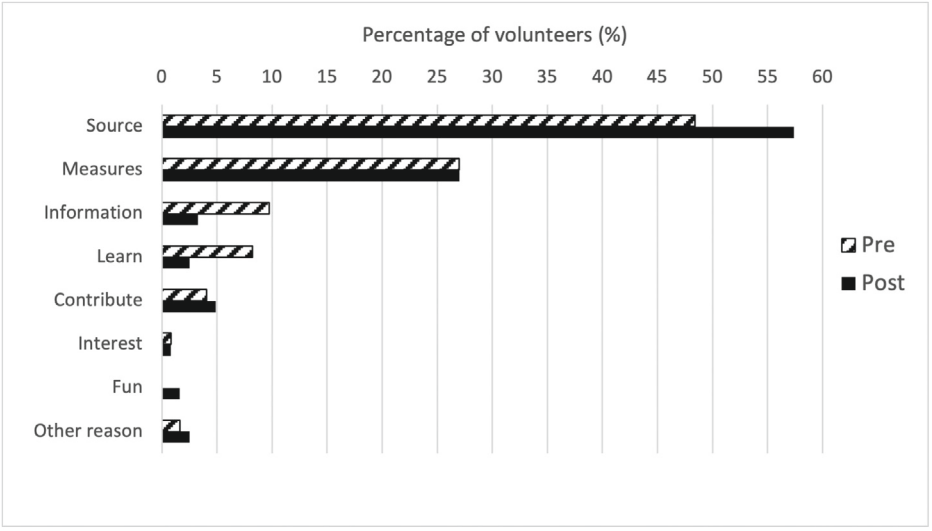


**Figure 2.2** Most important motivation to participate in the Clean Rivers project specifically as a citizen scientist between the pre- and post-surveys (n=122).

### *Activistic and personal motivations*

To understand whether some citizen science-related motivations correlate with each other, a principal component analysis was performed. In Table 2.4, the loadings show that there are two groups of citizen science motivations that are strongly correlated with each other. Together,

they explain 79.4 per cent of the variation. One group, Component 1, consists of more personal motivations – *Fun*, *Interest*, *Contribute* and *Learn*. The other group, Component 2, involves the more activistic motivations – *Source*, *Measures* and *Information*. When one motivation within a group scores higher, other motivations are scored higher as well. When we look at the most important motivation in the pre-survey, we see that only 16 people have chosen motivations from the 'personal' group of motivations, while the majority (n=104) have chosen the more activistic motivations. In the post-survey, only 12 people chose a more personal motivation.

**Table 2.4** The loadings of a PCA for the motivations to participate as a citizen scientist (n=121), showing the estimated correlations with the estimated components (the two components explain 79.4 per cent of the variation.

| | **Component 1 (43.8%)** | **Component 2 (35.6%)** |
|---|---|---|
| Interest | 0.888 | |
| Fun | 0.881 | |
| Learn | 0.870 | |
| Contribute | 0.840 | |
| Source | | 0.910 |
| Measures | | 0.901 |
| Information | | 0.883 |



### 2.3.3 Expectations

Participants answered an open question about what their expectations were regarding their participation in the project. Thematic analysis resulted in 16 codes (Table 2.5). More than half of the participants shared multiple expectations. For example, one participant said: 'hanging out with other nature lovers and enjoy the waterside where we will collect important data. From this, policies can be designed to reduce the enormous pile of litter in nature.' Many participants (n=40) mentioned that they expected to contribute to something (*Contribute*). For example, participants contribute to 'minimising litter and specifically plastic' and 'scientific research around the litter problems of the river Meuse'. Participants (n=24) also mentioned research-related expectations (*Research*), such as 'making a meaningful contribution to research and cleaning up litter'. Some expectations (n=22) were aimed at a cleaner environment (*Clean environment*). For example, one participant expected that 'Clean Rivers will eventually lead to cleaner seas and thereby a dramatically healthier planet.' Several participants (n=17) did not have any expectations, or 'like to be surprised'. More personal motivations were also mentioned (n=16), such as that they expect to learn something (*Knowledge*). One person mentioned: 'as river litter researcher learning to categorise and quantify litter around rivers. Gain knowledge about the impact of each category on the environment.' Another more personal expectation focused on social aspects during the project (*Social*) (n=13). For example, a participant said, 'In addition to the results, I would like to gain some new social contacts.'

**Table 2.5** Overview of codes and code description for participants' expectations about the project.

| Code | Code description | Frequency |
|---|---|---|
| Contribute | Contribute or help with [...] | 40 |
| Research | Studying litter, analysing it, categorising it, mapping it, quantifying data | 24 |
| Clean environment | Cleaner or better planet, seas, land, nature, or surroundings | 22 |
| Knowledge | Improving own knowledge and/or awareness | 16 |
| Minimising litter | Either minimising the amount of litter currently present of in general preventing litter | 14 |
| Social | Meeting like-minded people or inspiring companies or people | 13 |
| Feeling | Feels good or powerful | 11 |
| Prevention | Prevention for example by tackling source | 10 |
| Cleaning-up | Cleaning-up litter | 9 |
| Outdoors | Being outdoors | 9 |
| Stakeholders | Governmental, companies and consumers | 7 |
| Measures | Measures for stakeholders for example | 5 |
| Plastic soup | Plastic soup | 3 |
| Awareness | Public/consumer/companies/governments | 3 |
| No expectations | No expectations | 17 |
| Other | | 19 |

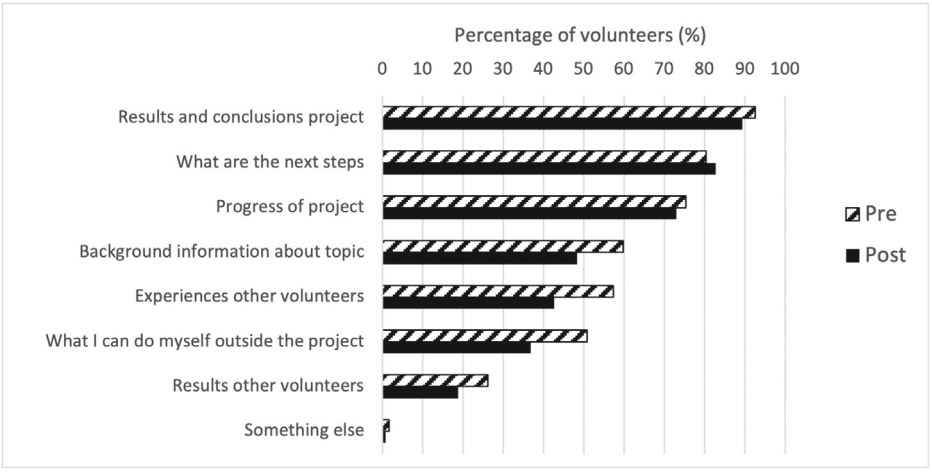


**Figure 2.3** The percentage of participants (n=122) who are interested in the various types of information, during the pre- and post-surveys.

During the pre-survey, the participants were also asked about their interest in being involved in the analysis of the results, for example, giving feedback on the conclusions or helping to interpret the results. Almost half of the participants (48 per cent) answered that they would like to be involved; 28 per cent said it depends on, for example, 'the complexity' or 'how much time it would take'; and 24 per cent did not want to be involved in the analysis of the results.

During both the pre- and post-surveys, the participants answered a question about their information needs. They said that they were mainly interested in the results and conclusions of the project, in which next steps will be taken, and in the progress of the project (Figure 2.3). In the post-survey, we saw clear decreases in their interest in the experiences of other participants, as well as in what they can do themselves outside the project and the background information about the topic.

## 2.4 Discussion



As the number of citizen science projects has been rapidly growing, more and more volunteers are becoming involved in scientific research. However, recruiting and retaining volunteers is challenging, and knowledge about the citizen scientists in plastic pollution research is lacking. Therefore, we studied the background, motivations and expectations of volunteers in the Clean Rivers project in the Netherlands. We found that these citizen scientists are middle-aged and well-educated and that, although a large proportion of the participants have had experience of volunteering and clean-up activities, only a few had experience with citizen science. Their motivations were mainly activistic, as they want to tackle the source of the litter and contribute to new measures from the government and industry to solve the problem of plastic pollution. More personal motivations decreased significantly after the first cycle of the project, while the activistic motivations remained the most important. Participants' expectations were in line with their motivations: expecting to contribute to results and knowledge about plastic pollution, and making an impact on solving the plastic pollution problem. Several participants mentioned that they are expecting more personal aspects, such as enjoying being outdoors and meeting new people.

### 2.4.1 Volunteer background and experience

The average age of the participants (54 years) and the low representation of young people (below 30 years, 6 per cent) are in line with other citizen science and nature volunteering projects. While there is not a trend in the average age of citizen scientists, an over-representation of middle-aged volunteers is common in citizen science projects and Dutch nature volunteers (Ganzevoort & Van Den Born, 2020). While young people are generally more concerned about environmental problems (Gifford & Nilsson, 2014; Liere & Dunlap, 1980), their numbers in citizen science projects remain low. It is not clear what causes this discrepancy (Herodotou et al., 2020). Specifically for Clean Rivers, a possible factor that might have influenced the recruitment of younger participants is that the monitoring sites are in remote locations.

Regarding the large proportion (75 per cent) of highly educated Clean Rivers participants, studies of the public perception of plastic pollution found that more highly educated people also have a higher level of concern for the environment. This possibly explains their over-representation in the current project (Hartley et al., 2018). Similarly, Ganzevoort and Van den Born (2020) found that 65 per cent of Dutch nature volunteers were highly educated. A high representation of highly

educated people is also in line with other studies on citizen scientists (Mac Domhnaill et al., 2020; Raddick et al., 2010). The fact that many citizen science projects attract highly educated volunteers may reproduce the inequalities and under-representation that we see in the science field (National Academies of Sciences, Engineering and Medicine, 2018). Projects should put great effort into attracting a more diverse audience. A targeted recruitment strategy in which volunteers from diverse backgrounds are personally invited could be one strategy to acquire a more diverse group of volunteers. Also, the recruitment message could be adjusted to target a more diverse audience, which has proven to be effective in a study focusing on Dutch citizen science projects (Brouwer & Hessels, 2019).

In contrast to the skewed sample with regard to age and level of education, the gender distribution in the Clean Rivers project was quite equal, and comparable to the Dutch population (53 per cent female, 47 per cent male, 0 per cent other; CBS, 2018). Although there does not seem to be a trend regarding gender in citizen science projects, our sample is more balanced than the study on Dutch nature volunteers, in which 63 per cent were men (Ganzevoort and Van den Born, 2020). Previous studies did find that women are more environmentally aware about the problem of litter and strategies to mitigate the problem (Hartley et al., 2018; Soares et al., 2021).

Although most of the participants of the Clean Rivers project had experience in volunteering, and more than half had experience in clean-up initiatives, only 7 per cent had experience in citizen science. This means that a new audience is being involved in citizen science. Possibly the topic of plastic pollution has drawn them to this project, and has given them an introduction to citizen science.

### 2.4.2 Motivations

Our results show that the most important motivations of the participants to take part in the Clean Rivers project in general, and as a citizen scientist in particular, had to do with the overarching goal of tackling plastic pollution and improving the environment. These activistic motivations scored higher overall than the more personal motivations, such as enjoyment and learning. This is in line with the recruitment message of the project, which also focused on these activistic goals. It may be that attracting such a volunteer population results in highly motivated volunteers who will stay with the project for a longer time (West & Pateman, 2016). However, the project will also only reach people who are already on board with the goals of the project.

When comparing motivations in the pre- and post-surveys, the more personal motivations, such as being interested in scientific research, wanting to learn, and considering it to be fun to participate in scientific research, declined significantly. This is in line with previous research. For example, Rotman et al. (2014) found that for initial participation, more 'self-directed' motivation is important, such as personal interest, but for continued participation, 'commitment for conservation' is more important. However, in the current study, the altruistic motivations already scored high from the beginning. More long-term monitoring of the volunteers' motivations and how they may change can contribute to our understanding of changes in motivations over time.

Although each project has its unique characteristics, it would be good to use an overarching framework for motivation, so that different projects can be compared (Levontin et al., 2022).

Participants in our study also acknowledged the importance of collecting as much information as possible. This is a promising outcome, as Nelms et al. (2022) found that one of the challenges for collecting 'scientifically meaningful data' was volunteers' motivation. In their study, volunteers were more interested in cleaning up than in collecting data. Clean Rivers participants seem to be aware of the importance of collecting data, which will presumably improve the data quality.

### 2.4.3 Expectations

When participants were asked about their expectations for the project, most mentioned that they expected to contribute to results, knowledge, a cleaner environment and reducing plastic pollution. These expectations line up with their predominantly activistic motivations. Although personal motivations were not as important as more activistic motivations, some volunteers did mention that they expected to learn from their participation in the project, to meet like-minded people and to feel good. In addition, they wanted to receive information about results, the next steps and the progress of the project. These results fit the fact that volunteers wanted to make a change. They are also similar to the findings of McAteer et al. (2021), who found that one-quarter of the volunteers in marine community science projects in their sample could be described as activists who wanted to be involved, not only in providing data, but also in disseminating results, raising awareness and really making change happen.

Knowing that volunteers are most interested in the results and outcomes of the project makes communicating the results of the project with them important, showing them how valuable their efforts are (De Vries et al., 2019). Seeing the impact that their work has on science or policies can influence their motivation, and possibly contribute to the retention of volunteers (Eveleigh et al., 2014; Nelms et al., 2017; Zettler et al., 2017).

### 2.4.4 Limitations and future research

A few limitations of our study should be taken into account. First, the response rate for the pre-survey was quite high, but it declined for the post-survey. Although we checked for differences in demographics between the people who did and the people who did not respond to the post-survey, we cannot be sure that the groups are not different in terms of motivations or expectations. Possibly, people with a more activistic motivation could have been more inclined to stay in the project and to complete the survey. This should be considered for future studies.

In addition, the motivation questions were asked at the start of the survey. Answering these may have had an impact on respondents' answers to other questions, such as about their expectations.

### 2.4.5 Implications

The key findings from this study are that the Clean Rivers project attracted a highly educated and somewhat older age group, and that most citizen scientists in the project have strong activistic motivations. This has several implications for the project, of which some have already been implemented. First, information that was given to participants during evaluation meetings and symposia was aligned to this motivation. For example, project organisers presented the main conclusions from the data, and the steps that they were taking regarding action towards the main polluters, emphasising the value of the data of the volunteers. Second, during recruitment of new volunteers, the activistic motivation can be taken into account in order to attract highly motivated volunteers. However, the recruitment of new volunteers should also focus on trying to attract a more diverse group of volunteers by using different media and messages, for example, using a social media campaign to attract a younger audience.

Although the current study investigated only one project, we can draw some implications for the field of citizen science in general. First, we conclude that each project will have a different profile of most important motivations, and that those motivations will correspond to different expectations. Being able to predict or determine those motivations and expectations will help recruit and retain volunteers in the long run. Assumptions about motivations should not be taken for granted. Last, a topic such as plastic pollution may draw a new audience to citizen science. These newcomers may then become aware of the impact that collecting data and performing research can have on tackling environmental problems.

# Chapter 3

# Longitudinal study of motivation, attitude, and knowledge of citizen scientists

**This chapter is based on:** Rambonnet, L., Rodenburg, F. J., & Land-Zandstra, A. M. (2024). Longitudinal study of motivation, attitude, and knowledge of citizen scientists monitoring plastic pollution on Dutch riverbanks. *Citizen Science: Theory and Practice*, 9(1). https://doi.org/10.5334/cstp.667

**Photo credits***: Schone Rivieren*

## Abstract

Across the world, the number of citizen science projects focusing on plastic pollution is increasing. These projects often last for multiple years, which makes retaining volunteers challenging. However, our knowledge is limited regarding the effect of long-term involvement on citizen scientists' motivation, attitude, and knowledge, especially for plastic pollution projects. Therefore, this study measured citizen scientists' motivation, attitude, and knowledge in the Dutch Clean Rivers project before and during monitoring plastic pollution on riverbanks between 2017 and 2021.

In total, 403 Clean Rivers participants completed a pre-survey, and a portion of them participated in one or multiple post-surveys throughout the years of monitoring. They were especially driven by *Project Action* motivations and *Environmental* motivations like tackling the source of pollution and doing something about the plastic soup, rather than being motivated by an *Interest in Scientific Research* like the desire to learn about scientific research. *Project Action* motivations increased significantly, especially within the first year of participation. Participants' attitudes towards nature and science were initially high and did not increase significantly. Furthermore, while participants' knowledge of plastic pollution was already high at the start, their knowledge of scientific research was not, and both increased significantly, especially in the first year of participation. The findings of this longitudinal study can contribute to improving the recruitment and retention of volunteers in current and future citizen science projects.

## 3.1 Introduction

The participation of the public in scientific research, also known as citizen science, is increasingly being used in different research fields (Kullenberg & Kasperowski, 2016; van der Velde et al., 2017). One of these fields is the research into plastic pollution: Volunteers may, for example, collect water samples for microplastic research, monitor beach litter, or track plastics floating in rivers (Hidalgo-Ruz & Thiel, 2013; Cook et al., 2021; Kiessling et al., 2021). Using citizen science has many benefits, such as being able to conduct research on a bigger scale, increasing scientific literacy in volunteers, and empowering participants (Crall et al., 2013; Van Emmerik et al., 2020c). However, collaboration between researchers, volunteers, and other stakeholders can also be challenging (Rambonnet et al., 2019; Nelms et al., 2022). Therefore, studying the practice of citizen science has become a topic of research itself.

One of the challenges in citizen science projects is the recruitment and retention of volunteers. In many projects, the number of people who stay with a project after the first contribution is relatively low (Franzoni & Sauermann 2014; Fischer et al., 2021). This poses a challenge, especially for plastic pollution projects, which need data for long periods (Nelms et al., 2017; Rambonnet et al., 2019). To improve the retention of volunteers, more knowledge is needed about the background and attitudes of the citizen scientists so projects can adjust accordingly (Measham & Barnett, 2008; West & Pateman 2016). Therefore, increasingly more research has been conducted focusing on the motivations, attitudes, and prior knowledge of citizen scientists (e.g., Brossard et al., 2005; Geoghegan et al., 2016; Land-Zandstra et al., 2016a; West & Pateman 2016; West et al., 2021).

Motivation, attitude, and learning can differ between projects for various reasons such as the different levels of participant involvement, the target audiences, and the topics covered in the project (Lotfian et al., 2020). For citizen science projects focusing on plastic pollution, research about citizen scientists is relatively scarce. Most of the studies that have been done focused on projects with school children or students as a target audience (e.g., Kiessling et al., 2021; Oturai et al., 2022; Wichmann et al., 2022). In addition, little is known about how these characteristics are changing over time and how projects can adjust to these changes (Rotman et al., 2014; West & Pateman 2016; Aristeidou & Herodotou 2020).

To decrease these knowledge gaps and contribute to the sustainability of plastic pollution projects and citizen science projects in general, our study examined the longitudinal changes in motivation, attitude, and knowledge of citizen scientists in a Dutch plastic pollution project: Clean Rivers (Schone Rivieren, in Dutch) between 2017 and 2021.

### 3.1.1 Motivation

Motivation of citizen scientists is one of the topics within the field of citizen science that has received much attention. Phillips et al., (2019) described it as "the underlying psychological need for why someone does something, expressed as the initial cause for participation or why they

stay involved in the project." Many different motivational frameworks have been developed to identify volunteers' motivations in general (e.g., Clary et al., 1998; Batson et al., 2002; Finkelstein, 2009). For example, Batson et al., (2002) defined "four motives for community involvement:" egoism, altruism, collectivism, and principlism. The first three motives are, respectively, about increasing the welfare of yourself, others, or a group. Principlism means that someone is motivated because of certain principles, like justice. Another framework distinguishes between intrinsic motivations, which means that volunteers are "satisfied by the volunteer activity itself" and extrinsic motivations, when volunteers "require an outcome separate from the volunteer work in order to be fulfilled" (Finkelstein, 2009). For citizen science, these frameworks are being used to study participants' motivation. Also, new ones have been created. Raddick et al., (2010) found twelve motivation categories based on interviews with Galaxy Zoo users and tested these through a survey.

The most important motivation for environmental volunteers in general and in citizen science projects in particular appears to be "helping the environment" (Bruyere & Rappe 2007; Sloane & Pröbstl-Haider 2019). However, in a study about Dutch biodiversity recorders, the most important motivations were "being connected to nature," "learning more about nature," and "contributing to nature conservation and management" (Ganzevoort et al., 2017).

Unfortunately, only a few studies monitored longterm citizen scientists' motivation. Rotman et al., (2014) found that initial motivation is more egoistic, that is, from a personal interest, whereas in the long term, more collectivistic and altruistic motivations, such as commitment to conservation, are important. However, the existing literature is ambiguous. For example, for both new and longer-committed volunteers of a flu tracking project, altruistic or collectivistic motivations were the most important (Land-Zandstra et al., 2016a). In contrast, for longterm volunteers counting birds, science and conservation motivations were the most important motivations (Larson et al., 2020). In another study on volunteers studying water flow, motivations regarding learning were important for both short-term and long-term participants (Shinbrot et al., 2021). Ryan et al., (2001) discovered that for new environmental volunteers, a desire to help the environment and to learn new things were important, but in the long term, social factors were more important. In contrast, for citizen scientists in a mosquito project, various motivations were initially important whereas learning and the feeling that participation was useful were especially important for continued involvement (Asingizwe et al., 2020).

The motivation of citizen scientists may differ between projects based on several factors such as volunteers' cultural background, the project topic (Sloane & Pröbstl-Haider, 2019), and the communication strategy (Land-Zandstra et al., 2016a). However, studies on the motivation of citizen scientists in plastic pollution projects are limited to a previous study on the Clean Rivers volunteers (Rambonnet et al., 2023). Participants joined mainly because of activistic motivations like contributing to the environment and enforcing measures. Although these motivations increased after the start of their participation, their personal motivations, such as the fun of doing scientific research, decreased significantly.

In conclusion, motivation has been an important topic within citizen science research, and the longitudinal change of motivation is not fully understood yet. In addition, current knowledge of motivation for citizen science projects on plastic pollution is lacking.

### 3.1.2 Attitude

Often, environmental citizen science projects aim to change peoples' attitude towards nature or science. Learning more about the impact of participation on volunteers' attitudes can help projects connect more people with science and nature. Attitude has been defined as "a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object" (Fishbein & Ajzen 1975). Being outdoors in places volunteers would normally not visit, engaging in more focused nature observation than they would normally do, and being involved as a researcher in a project, may all influence how volunteers perceive nature and science or their sense of connection to nature (Nisbet et al., 2009). By involving volunteers in the scientific process via citizen science projects, volunteer attitudes towards nature and science can be positively influenced (Bell et al., 2008; Bonney et al., 2009; Cronje et al., 2011).



For other projects, participation did not affect volunteers' attitude towards nature and science. For example, for volunteers studying bird houses, their attitude towards the environment and science did not change (Brossard et al., 2005). Also, for citizen scientists who monitored urban bees, their attitude towards bees and science did not change significantly (Druschke & Seltzer 2012). It could be that attitude does change after longer engagement, but the long-term impact of citizen science on attitude has not been studied extensively yet (Greving et al., 2022).

Attitude, like motivation, is often measured in different ways, making it hard to compare projects or draw clear conclusions across projects. Although it can be difficult to measure attitude, it is important to include it when studying the effect of participation on volunteers and to learn which audience is being reached.

### 3.1.3 Knowledge

Another goal of many citizen science projects is to increase the knowledge and understanding among volunteers regarding science and the project topic. As with attitude, it is important to measure if projects are achieving this goal and how the duration of participation can affect this. Participants' knowledge about how science works may increase by being involved in steps of the scientific process such as collecting and analyzing data (Bonney et al., 2009, 2016). In addition, volunteers may also learn more about the specific topic of a project (Cronje et al., 2011; Jordan et al., 2011; Crall et al., 2013).

The impact of citizen science on volunteers' knowledge may depend on the motivation of the volunteers to participate. Comparable to motivation and attitude, the project's design may also play a role. For example, the impact on volunteers' science knowledge may depend on the time spent reflecting on the scientific process and the contact volunteers have with researchers (Jordan et al., 2011; Crall et al., 2013). It is unknown if long-term involvement affects volunteers'

knowledge, but previous research found that influencing adult learning needs a longer period of interventions (Merriam et al., 2007).

### 3.1.4 The aims of our study

To increase our understanding of the motivation, attitude, and knowledge of citizen scientists and how the duration of participation affects this, we monitored volunteers of the Dutch project Clean Rivers. Our research question was: How does long-term participation in a citizen science project concerning plastic pollution affect participants' motivation, attitude towards science and nature, and knowledge about plastic pollution and scientific research?

## 3.2 Methods

To study the longitudinal changes in motivation, attitudes, and knowledge of citizen scientists in a plastic pollution project, we surveyed volunteers of the Dutch Clean Rivers project over four years (2017–2021). Since 2017, Clean Rivers volunteers have monitored plastic pollution twice a year on 100-meter tracks of river bank along large Dutch rivers such as the Meuse and the Waal (van Emmerik et al., 2020c; www.schonerivieren.org/english). These volunteers were recruited through the collaborating organisations and (social) media. They collect data on the amount and the types of (plastic) litter. The project also contains activities for groups who clean up river banks but do not collect data. In addition, various activities were organized, such as feedback sessions about the results and a yearly conference. Our study focused only on the citizen scientists, who collect data. They participated in a pre-survey when they entered the project (2017–2020) and were invited to participate in three post-surveys (2018, 2020, 2021). When we report on the volunteers of the project in general, the term volunteers will be used. We will use the term participants when we report specifically on the volunteers who participated in the surveys.

### 3.2.1 Participants

Between 2017 and 2021, 438 participants filled in the presurvey; this was almost all of those who participated in the required training session, providing us with a representative sample of the active citizen scientists. Participants were encouraged to fill out the survey in the welcome mail and when they arrived at the training session. Thirty-five participants were removed because their responses were too incomplete, resulting in a total of 403 participants in this study. The response rate for the post-surveys was 70% (n=142) in 2018, 54% (n=183) in 2020, and 45% (n=154) in 2021.

On average, the participants were 52 years old, 55% identified as female, and 72% were highly educated, having completed their highest degree at either a university of applied sciences or a research university (Table 3.1). We checked for differences in participants' backgrounds to estimate the effect of the non-response on our sample. We did not find any significant differences in the backgrounds of people who participated in the first and the last surveys regarding age, gender, and education.

### 3.2.2 Data collection

The pre-survey was distributed before volunteers attended training about the project and the research protocol. The post-surveys were distributed after the first round of monitoring and then again in years 3 and 4 of the project. The pre- and post-surveys were distributed online using the web-based software Qualtrics. The pre-survey was also distributed on paper to volunteers who had not completed the survey before they arrived at the training session.

**Table 3.1** Background of the Clean Rivers' participants during the pre-survey.

| | Frequency | Percentage (%) |
|---|---|---|
| **Age (n=390)** | | |
| ≤ 24 | 15 | 4 |
| 25–34 | 41 | 11 |
| 35–44 | 63 | 16 |
| 45–54 | 78 | 20 |
| 55–64 | 99 | 25 |
| ≥ 65 | 94 | 24 |
| **Gender (n=399)** | | |
| Female | 219 | 55 |
| Male | 180 | 45 |
| **Education (n=396)** | | |
| Secondary school | 36 | 9 |
| Vocational training | 67 | 17 |
| University of applied sciences | 170 | 43 |
| Research university | 115 | 29 |
| Other | 8 | 2 |

The survey was conducted in Dutch, but for this manuscript, relevant statements were translated into English (Appendix 3.1). Before answering the questions, participants gave informed consent to use their data. Participants scored different motivation statements on a Likert scale from 1 to 5 (completely disagree to completely agree). Their motivation was assessed with two sets of statements: 1) to participate in the project in general and 2) to participate as a citizen scientist (river litter researcher) in particular. Questions related to motivation in the pre-and post-survey were based on previous surveys by Batson et al., (2002), Raddick et al., (2010), and Land-Zandstra et al., (2016a; 2016b). Statements about attitude were divided into eight statements about attitude towards science (based on Price & Lee, 2013) and nine statements about attitude towards nature (based on Nisbet et al., 2009). Three of these last statements were negatively formulated and reverse-coded. Both types of attitude statements were scored on a Likert-scale from 1 to 5 (completely disagree to completely agree). We have chosen existing surveys focusing on broad concepts of attitude, so that these outcomes could be compared with other projects. For the questions on knowledge level, the topics were based on input from the Clean Rivers project team and were specific for this project. Participants scored their self-perceived knowledge level

for each topic on a scale of 1 to 10 (comparable to the Dutch school grading system with 6 being a sufficient grade).

The survey was tested with a group of volunteers from a pilot version of the project. We previously reported on the pre-survey and the first post-survey of the first group of volunteers who started in 2017 (Rambonnet et al., 2023).

### 3.2.3 Statistical analysis

Descriptive statistics of participants' backgrounds were performed using Excel (version 16.67; see Appendix 3.2 for the total dataset). For the Likert-scores, the mean, median, and interquartile range were calculated to show both the average score as well as the spread in the data. Other statistical analyses were conducted in R, version 4.2.1, using the RStudio IDE (R Core Team 2022, RStudio 2022; see Appendix 3.3 for data analysis report). Logistic regression was used to estimate differences in age, gender and education by survey participation (first or last survey). No significant differences were observed. A conditional independence network was estimated to determine clusters of related statements, using the rags2ridges package (Peeters et al., 2022a). This analysis determines groups of statements that correlate strongly to each other but not to other statements (for a more detailed description, see Appendix 3.4 for conditional independence networks: motivation, attitude, and knowledge). To account for the repeated measures of individuals, mixed models were fitted, using the glmmTMB package (Brooks et al., 2017). Violations of distributional assumptions (i.e., can the test statistic be reasonably assumed to follow a normal distribution) were checked through visual diagnostics with the DHARMa package. Marginal effects plots of the resulting models were generated using the package sjPlot, as these show the effect of one predictor on the outcome while keeping the other predictors constant at a representative level (Lüdecke 2023). No confounding effect of age, gender, or education was observed. The effect size is expressed on the scale of the linear predictor (in terms of logits for logistic models and mean change for normal models). When p-values were 0.0001 or larger, the actual p-value was reported.

## 3.3 Results

### 3.3.1 Motivation

Before their training, when participants were asked about their motivation to join the project in general, they most strongly agreed with the statements that litter disturbed them (*Disturbing,* 4.77), that they wanted to do something about plastic soup (i.e., plastic pollution in the oceans; *Plastic Soup,* 4.72), and that they wanted to commit themselves to a better environment (*Environment,* 4.71). Participants also picked their most important motivation to participate in the project. Almost a third chose *Disturbing* (33%, n=133) and another third chose *Plastic Soup* (32%, n=129). When asked about their reasons for becoming a citizen scientist specifically, the highest scoring statements indicated that volunteers wanted to tackle the source of the litter (*Source,* 4.65), wanted to help make sure measures were taken against companies/government

(*Measures,* 4.60) and believed it is important to gather information about river litter (*Information,* 4.53). For this set of statements, almost half of the participants chose *Source* (49%, n=193) as the most important reason to participate as a citizen scientist, and almost a third chose *Measures* (32%, n=126).

To look for patterns and to ease further analysis, we analyzed the conditional independence networks of all motivation statements together and found three clusters. The first set of motivations was labeled *Environmental*, covering motivations related to how participants see themselves contributing to a better environment (*Disturbing, Plastic soup, Environment,* and *Bigger movement*; Table 3.2). The second cluster was labeled *Project Action*, focusing on motivations related to what actions the project could take (*Source, Measures,* and *Information*). We labeled the third cluster *Interest in Scientific Research*, including motivations regarding a personal interest in and enjoyment of conducting scientific research (*Fun, Learn, Contribute,* and *Perform).* All other motivations did not cluster together. Further analyses were performed using the three clusters only.



**Table 3.2** Pre-survey motivation of Clean Rivers participants.

| I participate in Clean Rivers, because... | Keyword | Cluster | Likert-score | |
|---|---|---|---|---|
| | | | Mean | Median (IQR) |
| litter in nature or on the streets disturbs me | Disturbing | *E* | 4.77 | 5 (5-5) |
| I can help doing something about the Plastic Soup | Plastic Soup | *E* | 4.72 | 5 (5-5) |
| I want to commit myself to a better environment | Environment | *E* | 4.71 | 5 (5-5) |
| I like to be outdoors | Outdoors | | 4.41 | 5 (4-4) |
| I like to join a bigger movement to improve the world | Bigger movement | *E* | 4.22 | 5 (4-5) |
| I like to commit myself to volunteer work | Volunteering | | 3.90 | 5 (3-5) |
| I'm interested in the kinds of litter present in the rivers | Interest | | 3.79[b] | 4 (3-5) |
| I like to recreate near or on the water | Recreation | | 3.70[a] | 4 (3-5) |
| I live or used to live close to the Maas or the Waal | Neighborhood | | 3.61 | 4 (3-5) |
| it is part of my tasks/responsibilities I have at my work/association | Responsibility | | 2.32[a] | 2 (1-3) |
| ***I want to become/have become a river litter researcher, because...*** | | | | |
| with the results we can tackle the litter at its source | Source | *PA* | 4.65[c] | 5 (5-5) |
| my contribution can help the government/companies take measures | Measures | *PA* | 4.60[c] | 5 (4-5) |
| it's important to gather as much information about litter in the rivers as possible | Information | *PA* | 4.53[c] | 5 (4-5) |
| I like to contribute to scientific research | Contribute | *ISR* | 3.98[c] | 4 (3-5) |
| to me it seems fun to perform scientific research | Fun | *ISR* | 3.92[c] | 4 (3-5) |
| I hope to learn something about performing scientific research | Learn | *ISR* | 3.88[c] | 4 (3-5) |
| I'm interested in the performance of scientific research | Interest | *ISR* | 3.81[c] | 4 (3-5) |

Note: *E: Environmental, PA: Project Action,* and *ISR: Interest in Scientific Research.*
Mean, median and interquartile range (IQR), on a 5-point Likert-scale ranging from totally disagree (1) to totally agree (5) (n = 400). a(n = 399), b(n = 398), c(n = 395), because of missing data.

## Longitudinal change of motivation

To analyze how motivation may have changed throughout participation in the project, we analyzed the longitudinal changes with respect to the number of months people had participated in the project through a mixed effect model (Figure 3.1). The first cluster, *Environmental,* showed an increasing but not significant trend (Figure 3.1a; effect size 0.00534, $p = 0.311$). The *Project Action* cluster did show a significant increase over time (Figure 3.1b; effect size 0.03549, $p = 0.00056$). The cluster of *Interest in Scientific Research* motivations showed a decrease over time, which was not significant (Figure 3.1c; effect size −0.00457, $p = 0.0668$).

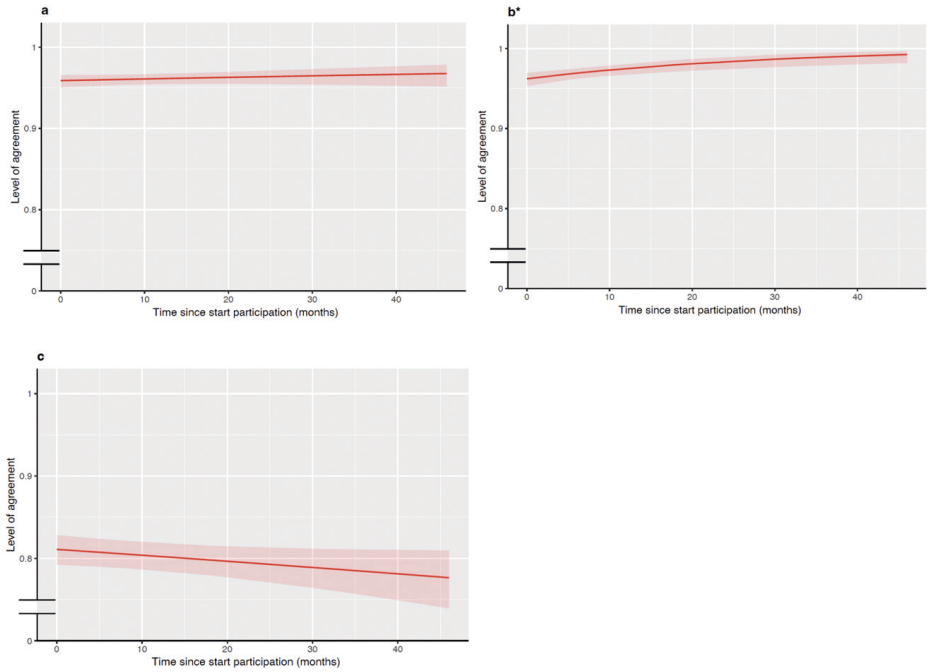


**Figure 3.1** Trends in average agreement score of (a) Environmental, (b) Project Action, and (c) Interest in Scientific Research motivations. *p = 0.00056. Scores range from 0 (corresponding to Likert-score 1) to 1 (corresponding to Likert-score 5). Shaded areas represent the uncertainty in the predicted trend (95% confidence band). Note that we have truncated the y-axis to increase visibility of the trends.

## 3.3.2 Attitude

Regarding participants' attitudes towards nature and science, we measured their average agreement with a set of statements on a 5-point Likert-scale. Table 3.3 shows the average scores for each statement during the presurvey. The last four statements were reversely coded to correct for their negative wording. Both types of attitudes were positive at the start of the project (all scores above three for positive statements and below three for negative statements).

**Table 3.3** Clean Rivers participants' attitude towards science and nature (pre-survey).

| **Attitude towards science** | **Likert-score** | |
|---|---|---|
| | **Mean** | **Median (IQR)** |
| I am interested in news about natural science | 4.14 | 4 (4–5) |
| I am interested in science | 4.10 | 4 (4–5) |
| I pay attention if a natural science news item crops up in a media source I am already following | 3.90 | 4 (3–5) |
| I use knowledge of natural science in everyday life | 3.43 | 4 (3–4) |
| I actively seek out stories about natural science in the news | 3.38 | 3 (3–4) |
| I use knowledge of natural science to evaluate claims made about natural science | 3.23[a] | 3 (3–4) |
| I am knowledgeable about natural science | 3.19 | 3 (2.5–4) |
| I am likely to attend a lecture or course about natural science | 3.03 | 3 (2–4) |
| **Attitude towards nature** | | |
| I do mind if some plants and animal species become extinct | 4.41[b] | 5 (4–5) |
| Conservation is necessary because nature is not strong | 4.40[b] | 5 (4–5) |
| I feel very connected to all living things and the earth | 4.37 | 5 (4–5) |
| My relationship to nature is an important part of who I am | 4.36 | 5 (4–5) |
| People don't have the right to use natural resources in any possible way | 4.30[b] | 5 (4–5) |
| I always think about how my actions affect the environment | 4.12[a] | 4 (4–5) |
| The thought of being deep in the woods, away from civilization, is not frightening | 4.01[b] | 4 (3–5) |
| I enjoy being outdoors, even in unpleasant weather | 4.00 | 4 (4–5) |
| My ideal vacation spot would be a remote wilderness area | 3.75 | 4 (3–5) |

*Note: Mean, median and interquartile range (IQR), on a 5-point Likert-scale ranging from totally disagree (1) to totally agree (5) (n = 399). [a] n = 398, because of missing data. [b]Originally formulated as negative statements, scores have been reversed.*

Conditional independence networks showed that the two lists of statements neatly clustered together within attitude towards science and attitude towards nature. Therefore, we calculated means for further analysis. Participants' attitude towards science was positive, with an average Likert-score of 3.55. Their attitude towards nature scored even higher, with an average score of 4.19.

***Longitudinal change of attitudes***

We again performed a mixed model regression analysis to detect any changes in attitude throughout participation in the project (Figure 3.2). Although the attitude towards science showed a positive trend, it did not change significantly (Figure 3.2a; effect size = 0.00117, $p = 0.504$). Attitude towards nature also did not change over time (Figure 3.2b; effect size = 0.00013, $p = 0.922$).

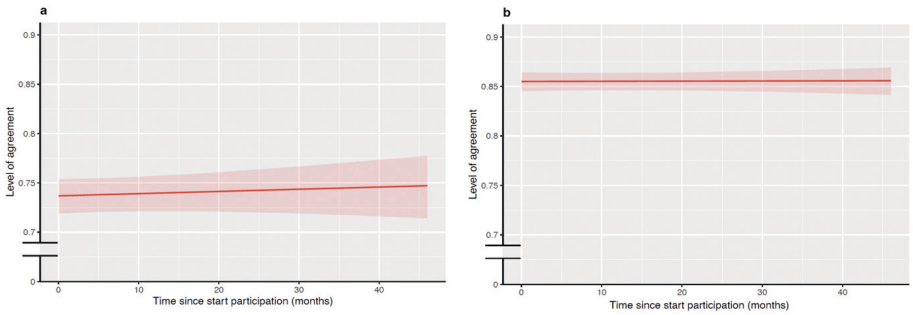


**Figure 3.2** Trends in average agreement score of (a) attitude towards science and (b) attitude towards nature. Scores range from 0 (corresponding to Likert-score 1) to 1 (corresponding to Likert-score 5). Shaded areas represent the uncertainty in the predicted trend (95% confidence band). Note that we have truncated the y-axis to increase visibility of the trends.

### 3.3.3 Knowledge

We measured participants' self-reported knowledge by asking them to rate their knowledge about seven topics on a scale of 1 to 10 (from very little knowledge to a lot of knowledge). Participants' knowledge was sufficient (above 6; aligning with the Dutch scoring system in schools) for three of the seven topics: *ways to act sustainable in daily life*, consequences of litter for nature, and *causes of litter*. Conditional independence network analysis showed two clusters of questions, one containing topics more related to plastic pollution (*causes*, *extent*, and *consequences*) and another with topics related to scientific research (*using protocols*, *conducting scientific research*, and the *OSPAR protocol*). Table 3.4 shows the average score for each topic, with higher scores for all topics concerning plastic pollution.

#### *Longitudinal change of knowledge*

Regression analysis with a mixed effects model showed a significant increase in participants' knowledge of plastic pollution (Figure 3.3a; effect size = 0.11587, $p < 0.0001$) as well as their knowledge of scientific research (Figure 3.3b; effect size = 0.42933, $p < 0.0001$). The increase was the steepest after the first-time people participated in the project, although their knowledge kept increasing in the long term.

**Table 3.4** Average self-reported score for knowledge of plastic pollution and scientific research (pre-survey).

| Topic | Cluster | Score |
|---|---|---|
| Ways to act sustainable in daily life | Plastic pollution | 7.2 |
| Consequences of litter for nature | Plastic pollution | 6.9 |
| Causes of litter | Plastic pollution | 6.5 |
| The extent of plastic pollution in the Netherlands | Plastic pollution | 5.5 |
| The process of scientific research | Research | 5.0 |
| The use of protocols (like observation schedules and tally sheets) during scientific research | Research | 5.0 |
| The OSPAR-declaration | Research | 2.2 |

Note: Scored from 1 to 10 (n = 398).

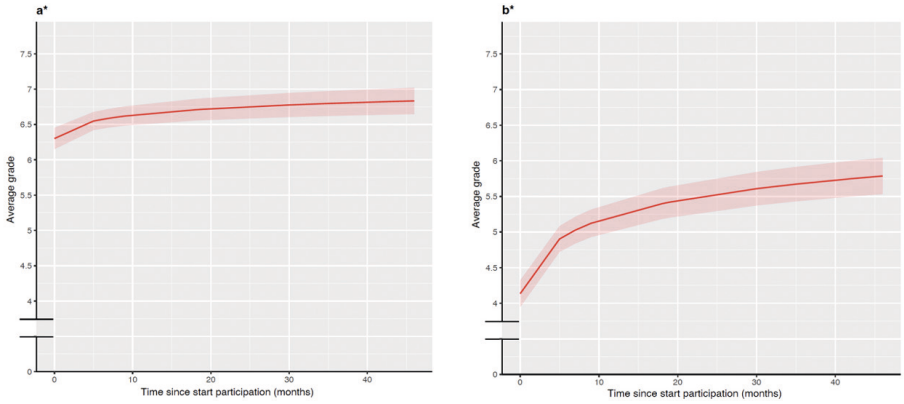


**Figure 3.3** Trends in average knowledge score about (a) plastic pollution and (b) research. *p < 0.0001. Measured on a scale of 1 to 10. Shaded areas represent the uncertainty in the predicted trend (95% confidence band). Note that we have truncated the y-axis to increase visibility of the trends.



## 3.4 Discussion

In this study, we surveyed volunteers of the Dutch citizen science project Clean Rivers about their motivation, attitude, and knowledge during four years of the project. Below, we discuss the most important findings in more detail.

### 3.4.1 Motivation

At the beginning of the project, the most important general motivations for Clean Rivers participants were that they found litter *Disturbing,* wanted to do something about *Plastic Soup,* and wanted to commit to a better *Environment*. Their most important motivations to become a citizen scientist were to tackle litter at the *Source,* contribute to *Measures,* and gather as much *Information* about litter as possible. Analysis showed three clusters of related motivational statements; *Environmental, Project Action,* and *Interest in Scientific Research. Environmental* and *Project Action* motivations scored higher than more personal motivations during the pre-test.

These types of motivation are in line with most environmental and conservation projects, where helping the environment was found to be the most important motivation of volunteers (Bruyere & Rappe, 2007; He et al., 2019). In contrast, for biodiversity recorders in the Netherlands, the most important motivations were a personal connection to nature, learning about nature, and contributing to nature conservation—both personal and environmental motivations (Ganzevoort et al., 2017). Possibly, the Clean Rivers project attracted people with *Environmental* and also *Project Action* related motivations, rather than motivations related to an *Interest in Scientific Research*, partly through the framing of recruitment messages (Land-Zandstra et al., 2016a; Lee et al., 2018). Clean Rivers communicates that they want to tackle the source, and their main goal is to have plastic-free rivers in 2030.

Over time, *Project Action* motivations increased significantly, where *Environmental* and *Interest in Scientific Research* motivations did not change significantly. This indicates that people became more focused on solving plastic pollution rather than a growing concern for the environment in general or because of personal interests. Possibly, even if their *Project Action* motivations were already high, they got more excited about being able to make a difference through their experiences with the project and the actions that were taken by the project.

Our findings contrast with previous studies in which the more personal and environmental motivations changed significantly throughout participation (Ryan et al., 2001; Larson et al., 2020). However, the literature is ambiguous and longitudinal studies tracking citizen scientists' motivation throughout participation are limited. Most studies compared new volunteers with longer committed volunteers or only looked at one pre- and post-survey (Ryan et al., 2001; Land-Zandstra et al., 2016a; Shinbrot et al., 2021).

Understanding participants' motivation to participate is important to take into account for the further development of the Clean Rivers project and similar projects. For example, in the Clean Rivers project, more attention was given to what the project was doing with the data to change government regulations instead of solely focusing on detailed analyses of the data to generate new scientific knowledge. This may have further impacted the *Project Action* motivation, which could explain the significant increase of this type of motivation over time.

### 3.4.2 Attitude

Participants' attitudes towards science and nature were already highly positive when they started participating in the Clean Rivers project. Both did not change significantly throughout their participation. Our results align with participants of the invasive species citizen science project that Crall et al., (2013) studied. They also found a "slightly positive attitude towards science and a strong positive attitude towards the environment before participation." Also comparable to our results are volunteers who monitored birdhouses, as their attitudes towards science did not change (Brossard et al., 2005). Although one study did find a change in attitudes (Price & Lee, 2013), attitudes seem to be challenging to change, especially when already high. Possibly this kind of project attracts people with high science and nature attitudes (Bonney et al., 2016). Therefore, if a project wants to attract a diverse audience to citizen science and have a greater impact on participants' attitudes, it is important to try to recruit and attain people with different science and nature attitudes.

### 3.4.3 Knowledge

Participants' self-reported knowledge about scientific research and about plastic pollution increased significantly throughout participation in the project, especially after the first training and first monitoring round. This is in line with many other citizen science projects that show a learning effect (Bonney et al., 2016). It seems plausible that the training before their first monitoring session contributed to this learning impact. Previous research also shows that learning is influenced by participating in a project's "social components" and not only by contributing

data (Price & Lee, 2013). The fact that knowledge did not increase as much in later years may have been because the protocol for data collection remained the same throughout the project or because of the method of asking for self-reported knowledge. In addition, participants were not strongly motivated by a desire to learn, possibly explaining the lack of increase in knowledge in later years.

Interestingly, participants' initial knowledge of science was relatively low compared with their topic knowledge, even though 72% of the participants was highly educated. A possible explanation is that the project attracted people who were already aware of plastic pollution rather than people who had an interest in scientific research. This is also reflected in their motivations.

### 3.4.4 Limitations

An important limitation is the choice of questions in the survey. First, the self-reported questions could influence participants' judgments and may have resulted in more socially desirable answers (Milfont, 2009). To tackle this, anonymous data processing was ensured, and it was emphasized that the answers would not influence their participation. In addition, the researchers were independent of the project organisation.



Another challenge is that comparing results from different projects is difficult because various frameworks and questions are used across projects. Although we do make some overarching comparisons, more specific comparisons such as meta-analyses are impossible because different studies use various instruments. It would help the field if projects administer universal instruments for measuring motivation and attitudes, for example, the newly developed framework for motivation by Levontin et al., (2022) and the review on measuring the impact of citizen science on environmental attitudes, behaviour, and knowledge by Somerwill and Wehn (2022). However, a possible trade-off of generalizable surveys could be that we are missing some changes in more specific, topic-related attitudes (e.g., towards plastic pollution).

The last limitation is that we do not have complete data on the number of times participants have performed a monitoring session. We asked them if they had monitored in the year before each survey. This gave us a general indication of whether they had been active during the project. More detailed information could have made our analysis more fine-grained. However, even without monitoring, volunteers could have been involved in the project in other ways, such as co-organizing online events.

## 3.5 Conclusion

Action-related motivations are the most important for participants monitoring plastic pollution on Dutch riverbanks in the Clean Rivers project, and these motivations increased significantly throughout the project. Participants' attitude towards nature and science was already positive and did not change significantly during participation. However, participants' knowledge about plastic pollution and scientific research increased significantly, especially after the first training and monitoring session. Knowing that the motivations of plastic pollution volunteers are mainly related to the actions the project might take could contribute to the recruitment and retention of this project and other citizen science projects focusing on plastic pollution. For example, when a project aims to tackle the source of plastic pollution, emphasizing this aspect in the projects' recruitment message may effectively attract volunteers. Furthermore, communicating how the results contribute to prevention may enhance the retention of volunteers. However, to impact people's attitudes and knowledge towards science and nature, it is important to try to recruit and attain people with different science attitudes to attract a more diverse audience.

# Chapter 4

# Wildlife rehabilitation centers and their potential for citizen science

**This chapter is based on:** Rambonnet, L., Hulscher, M., Schilthuizen, M., Smeets, I., & Land-Zandstra, A. M. (2025). Wildlife rehabilitation centers and their potential for citizen science. *Manuscript submitted for publication.*
*Pre-print available on Open Science Framework: http://www.doi.org/10.17605/OSF.IO/ZF4KB*
*Dataset available on Open Science Framework: https://www.doi.org/10.17605/OSF.IO/ZF4KB*

**Photo credits***: Ghislaine Holswilder*

## Abstract

Under growing anthropogenic pressures, wildlife rehabilitation organizations care for sick, injured and displaced wildlife. Records on admitted wildlife are increasingly used for scientific research to understand threats to wildlife, including diseases. As volunteers are actively involved in wildlife rehabilitation, their contributions can be viewed as a form of citizen science. However, we know little about rehabilitators' backgrounds, motivations, and experiences with data collection and research.

To fill this gap, we interviewed representatives from thirteen Dutch wildlife rehabilitation centers and surveyed 205 Dutch rehabilitation volunteers. Our findings show that rehabilitators are primarily driven by an interest in and a desire to help animals. Women and middle-aged volunteers were overrepresented in the sample, compared to the Dutch population, while educational and employment background as well as their attitude towards science, were representative. Regarding the data collection, they are positive about the quality although finding location can be improved. Rehabilitators are open to sharing the data, especially to study success rate and diseases. Interviewees believed that education is an important part of their work. However, taking on tasks like research and education are experienced as challenging due to a lack of time and funding.

The involvement of wildlife rehabilitators in scientific research could extend the benefits of citizen science to a broader and more diverse audience than typically reached by citizen science or nature volunteering. By understanding wildlife rehabilitators' roles, challenges, and preferences, this study highlights the potential to involve them in scientific knowledge generation, thereby broadening the scope of citizen science.

## 4.1 Introduction

Anthropogenic events like floods, wildfires, oil spills threaten wildlife conservation. Since the 1960s and 1970s, when major oil spills impacted thousands of animals, volunteers have taken action to rescue wildlife (Newman et al., 2003). Many grassroots efforts evolved into wildlife rehabilitation centers (WRCs), with new centers still emerging (Wimberger et al., 2010). Globally, WRCs provide temporary care for injured, sick, or orphaned wildlife, aiming for their release. Increasingly, database programs enable researchers to access and utilize WRC data (Loyd et al., 2017; Miller et al., 2023). In response, Pyke & Szabo (2018a) proposed adding 'Research' to the traditional rehabilitation phases: 'Rescue, Rehabilitation, and Release.'

Research topics include WRCs' rehabilitation success (Lukesova et al., 2021; Paterson et al., 2021) and understanding anthropogenic threats (e.g. Kornreich et al., 2024; Thrift et al., 2023), and emerging diseases (e.g. Caliendo et al., 2022). Previous research shared some challenges regarding data quality and standardisation as well as volunteer retention (Haering et al., 2020b; Long et al., 2020). As WRCs rely on volunteer-collected data and public reports, their involvement in research resembles citizen science. Applying insights from this field could improve data quality, volunteer retention and overall outcomes and benefits for all involved. Understanding rehabilitators' motivations and experiences with data collection is key. Therefore, this study explores WRCs' potential research role from the perspective of their staff and volunteers.



### 4.1.1 Rehabilitation and research

Previous studies proposed that wildlife rehabilitators' roles in data collection can be considered citizen science (Ciprari et al., 2022; Pyke & Szabo, 2018b). This describes a scientific research method where people without a relevant academic background are involved in the scientific process, which benefits both parties and advances scientific knowledge (Bonney et al., 2016). This concept is clarified in ten principles described by Robinson et al. (2018), including the possibility for citizen scientists to "participate in multiple stages of the scientific process."

Many wildlife rehabilitators are already involved in the data collection, and they could also be involved in developing the research questions and, if desired, other phases of the scientific process. Another principle of citizen science is that "programs are evaluated for their scientific output, data quality, participant experience, and wider societal or policy impact" (Robinson et al., 2018). Previous studies using WRCs' records did emphasize potential sampling biases and the need for standardizing data collection (e.g. Long et al., 2020). Thus, when involving WRCs in scientific research, it is important to consider their data quality. Regarding the sharing of the data by the WRCs, trust can also play an important role, just as it did for biodiversity recorders (Ganzevoort et al., 2017). Therefore, learning about rehabilitators' experiences, preferences, and motivations for data sharing is crucial.

### 4.1.2 Rehabilitators' background and motivation

Previous studies show that over 75% of wildlife rehabilitators are female (Englefield et al., 2019; Haering et al., 2020b; Yeung et al., 2017). Middle-aged individuals were most represented, although males were more prevalent in older age groups (Englefield et al., 2019; Haering et al., 2020b). Around 75% had completed tertiary or vocational education, and nearly half worked full- or part-time (Haering et al., 2020b; Yeung et al., 2017). Australian wildlife rehabilitators volunteered a median number of seven hours per week (Haering et al., 2020b). Motivations mainly centered on a desire to help wildlife and an interest in animals (Englefield et al., 2019; Haering et al., 2020b).

Given the limited research on wildlife rehabilitators, we also examined studies on volunteers and citizen scientists in environmental projects. Gender ratio varies by project type and topic with women often more represented in nature volunteering, although men were overrepresented among Dutch nature volunteers (Ganzevoort & Van Den Born, 2020). Both nature volunteers and citizen scientists appear to be mainly of middle or high age (Mac Domhnaill et al., 2020; Ganzevoort & Van Den Born, 2020).

Previous studies on environmental volunteers showed that 'helping the environment' or 'contributing to nature conservation' are the most important motivations; though many different motivations were considered important, including 'learning about the natural environment' and 'socializing with people with similar interests' (Bruyere & Rappe, 2007; Ganzevoort & Van Den Born, 2020). Environmental citizen scientists are primarily motivated by helping wildlife or contributing to science and nature conservation (West et al., 2021).

With growing interest in research collaboration with WRCs, assessing volunteers' involvement in science is important. This can be determined using the science capital framework, which includes concepts such as knowledge of scientific developments, attitude towards science, participation in scientific activities, and engagement with science in daily life (De Witt et al., 2016; Peeters et al., 2022b). Understanding WRC volunteers' demographics, motivations and science capital can aid in recruitment and retention, as well as a beneficial involvement in scientific research.

### 4.1.3 Public education

As WRCs depend on residents to report wildlife needing rescue, they frequently interact with the general public. Because of this contact, some studies highlighted the potential role WRCs could play in knowledge dissemination between research and the public, such as diseases (Caliendo et al., 2022). However, our knowledge of the educational practices of WRCs is lacking. A previous study on New York state rehabilitators did find that over half were involved in additional educational activities, reaching both schools and youth as well as the general audience (Siemer et al., 1991). These activities involved mostly one-to-one dialogues and lectures. As dissemination and public education is an important part of the scientific process, we should find out how WRCs are taking up this role.

### 4.1.4 Dutch wildlife rehabilitation

Our study focussed on Dutch WRCs and their potential role in scientific research. In 2022 65 centers cared for over 115,000 wild animals annually (Asselbergs & De Baerdemaeker, 2024). A recent report highlighted that collected data at centers is underutilized for research, such as monitoring population trends or serving as an 'early-warning' system for diseases (Ottburg & Lammertsma, 2023). Most studies with Dutch WRCs focussed on marine mammal data, examining population trends, entanglement, and diseases (Osinga et al., 2012; Salazar-Casals et al., 2022; Wijngaarden et al., 2021). Other examples include studies on coronaviruses using bat feces collected at a WRC (Jaramillo Ortiz et al., 2023), and an avian influenza outbreak at a center (Caliendo et al., 2022). This current study investigated Dutch wildlife rehabilitators' background, motivation, science capital, data collection practices and their attitudes and ideas about research and education.

## 4.2 Methods

Because previous research was limited, we applied a mixed-methods approach to the current study. First, we conducted qualitative interviews with Dutch WRC representatives to learn about different centers' experiences, preferences, and ideas regarding their volunteers, recordkeeping, scientific research, and public education. Next, partially based on the interviews, we distributed a quantitative survey among Dutch WRC volunteers to identify their backgrounds, experiences, and ideas regarding recordkeeping and scientific research. We obtained approval from the ethical committee of Leiden University (reference number 2022-013). Before participating, the interviewees and the survey participants gave informed consent to process their data anonymously for research purposes. As the interviews and surveys were conducted in Dutch, we translated the interview protocol (Appendix 4.1), the survey (Appendix 4.4), and the quoted answers in the results section into English for this paper.



### 4.2.1. Qualitative interviews

We conducted semi-structured interviews with founders, coordinators, or other representatives from Dutch WRCs between November 2022 and February 2023. We approached fourteen centers, and to include a wide variety of views, we selected centers that differed in years since founding, geographic location, number of volunteers, and the species of animals they rehabilitate (Appendix 4.2). We interviewed people from thirteen different centers; one center declined to participate. Four interviews were held with two interviewees simultaneously. We treated each interview as one data point, as the interviewees represented the views of the same center. The interview protocol was based on existing literature and consultation with experts. Pilot interviews were conducted, and the protocol was adjusted afterwards by removing some questions to shorten the length of the interview. The protocol consisted of five topics: volunteers, data collection, data sharing, and communication (Appendix 4.1). All interviews were recorded and transcribed for data processing purposes.

The interviews were thematically analyzed using both deductive and inductive coding by the first author with the software Atlas.ti (version 24). As a result, a codebook was created, containing five themes mentioned above and thirty codes (Appendix 4.3). To ensure reliable coding, ten per cent of all coded segments were also checked by a second coder, resulting in a Cohen's Kappa of 0.844.

### 4.2.2. Quantitative survey

The quantitative survey for WRC volunteers was designed using Qualtrics XM and contained 25 questions with multiple-choice, open, and Likert-scale type questions (Appendix 4.4). The questions were divided into three parts: motivation (e.g. reasons for joining the WRC and motivation), research (e.g. data ownership and attitude towards science), and profile (e.g. age, gender, level of education). Questions were based both on the qualitative interview results and on previous research. For the question on motivation, we used the Citizen Science Motivation Scale developed by Levontin et al. (2022). We selected sixteen motivation statements from the 58 original statements, covering all fifteen motivational categories. In the second part about research, the question regarding data ownership was adopted from Ganzevoort et al. (2017). In the third part about the participants, the question about their attitudes toward science was adopted from Peeters et al. (2022). The age and employment categories were based on the Central Bureau for Statistics of the Netherlands (Statistics Netherlands) to compare the sample with the general population. The survey was pilot-tested with volunteers from one Dutch wildlife rehabilitation center, which was excluded from the final sample. After the pilot test we adjusted the survey by clarifying questions, excluding some questions that made the survey too long, and adding a few questions based on the interviews. The survey was sent to 53 Dutch WRCs, for which a corresponding email address was found online. The survey was also distributed via a newsletter from two larger Dutch animal protection organizations.

We received a total of 224 responses. Nineteen responses were excluded based on three criteria: 1) filled in less than 46% of the questions (n=13), 2) no details on the type of WRC (n=1), or 3) not a volunteer at an official WRC (n=5). This resulted in a final sample of 205 survey participants in April and May 2023. They represented 28 rehabilitation centers that cared for various wildlife species such as birds, bats, hedgehogs, and other mammals. Unfortunately, no volunteers from marine mammal centers responded to the survey. The answers were analyzed using RStudio (version 2024.04.2+764). Demographics were analyzed using descriptive statistics and compared to available data from Statistics Netherlands. The significance of the differences between our sample and the Dutch population was calculated using a chi square-test for goodness of fit. Only the genders female and male were included in these correlation tests, as only one participant identified as "other." For the Likert-scores, the mean, median, and interquartile range were calculated to show both the average score as well as the spread in the data. Answers to open questions were coded inductively for analysis using Microsoft Excel (version 16.88).

## 4.3 Results

Below, we present the interview and survey results per topic: the rehabilitators' background and motivation, rehabilitation and research, and public education. Quotations from the interviews were added to exemplify recurring themes and insights that we identified in the interview data. We refer to the WRCs' representatives who were interviewed with "interviewees", "centers" and "WRC." For the survey participants, both "participants" and "respondents" are used. When interviewees or participants mention WRC volunteers in general, these are referred to as "volunteers."

### 4.3.1 Rehabilitators' background and motivation

During the interviews, it became clear that organizations differed in set-up, with varying numbers of volunteers. Over half of the centers have several paid employees for tasks like coordination, veterinary care, and communication. More than half of the interviewees mentioned that they generally have enough volunteers but there is a shortage in the high season, during spring and summer. Also, several interviewees believed volunteers stay shorter periods of time than in the past, possibly due to more busy lives. They experience this as a challenge because training volunteers costs time.



The survey showed that 96.6% of the 205 total participants were involved in the care of wildlife (n=198). A fifth of the participants was also involved in communication and education activities such as answering the phone (20%; n=41) and giving guided tours or guest lectures (20%; n=41). Regarding the number of hours per week, the median was five hours per week (n=204) and almost half of the respondents worked at least three and less than six hours per week (47.9%, n=93). The median years of respondents' volunteer experience at a WRC was four years (n=203) and over a third had less than three years of experience (35%, n=71). A complete overview of respondents' general background can be found in Appendix 4.5.

***Demographics and scientific attitude***

The majority of survey participants identified as female (82.7%, n=163), 15.7% (n=31) as male, one respondent identified as another gender, and two persons rather did not share. Over half of the respondents were between 40 and 64 years old (52.3%, n=103), a quarter were between 20 and 39 years (25.9%, n=51), and 20.3% (n=40) were between 65 and 79 years and a few were younger than 20 years old (1.5%, n=3). Regarding education, 38.1% finished tertiary education (n=75) and 28.9% vocational training (n=57). Almost half of the respondents had paid work (45.7%, n=90), while nearly a quarter were retired (23.4%, n=46) or had no paid job (20.3%, n=40). A complete overview of respondents' demographics can be found in Appendix 4.6.

From the 5-point Likert-scale statements regarding science capital, we found that participants most strongly agreed with "*I do things that help me learn about science*" (*M*=4.1) and "*I have an interest in science*" (*M*=3.7). The other two statements about being aware of scientific developments and talking about science with others in their daily lives scored lower (*M*=3.3 and *M*=2.8; Appendix 4.7).

### *Motivation*

Most interviewees became involved in wildlife rehabilitation because they encountered an animal needing rescue, which was also an important reason for the survey participants to become active at a WRC (22.4%, n=46; Appendix 4.5). Also, an interest in animals played a role for several interviewees. Most interviewees mentioned their volunteers were involved because they wanted to "*help animals*" or "*do something in return for nature.*" However, they also noted that some volunteers were motivated by personal interest: "*Volunteers think birds are very interesting.*" Some interviewees mentioned their preference for volunteers' motivation: "*The most important motivation for volunteers should always be helping the animals.*" This preference, as well as the other mentioned motivations, aligned well with survey participants' main motivations being *helping animals* (*M*=4.8), *interest in animals* (*M*=4.8), and *enjoy the work* (*M*=4.6), although also other motivations seem to be important for the participants, including *learning* (*M*=4.3; Figure 4.1; Appendix 4.8).

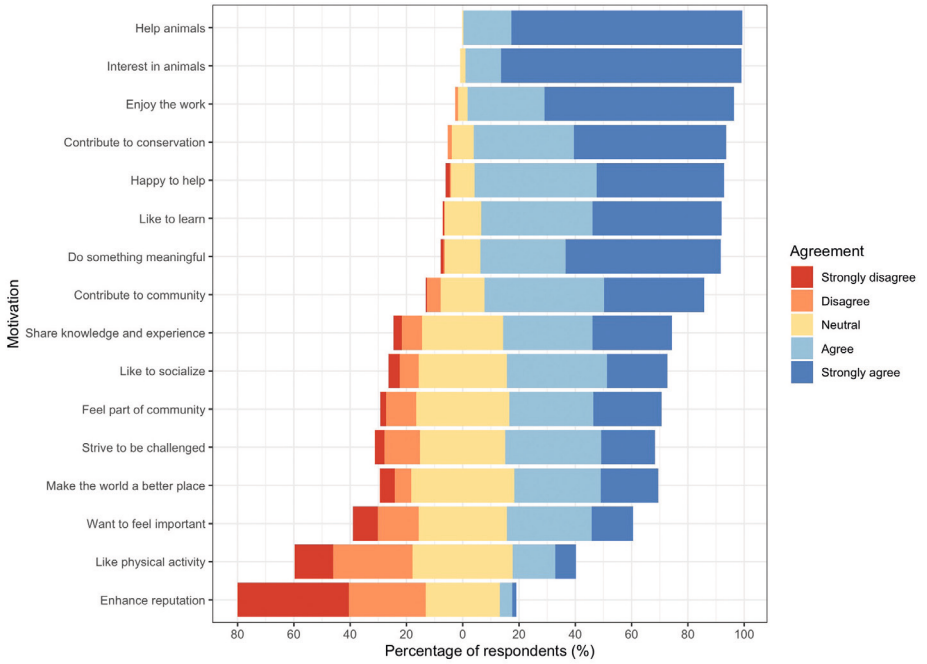


**Figure 4.1** Diverging stacked bar chart of respondents' motivations (n=205), scored on a Likert scale, ranging from 1 (Strongly disagree) to 5 (Strongly agree) and ordered from high to low positive scores. Option "Don't know/rather not say" not included, see details in Appendix 4.8.

### 4.3.2 Rehabilitation and research

***Record keeping***

The motivation for data collection by WRCs, according to the interviewees, is, firstly, to have an overview of the animals in their center and to monitor and improve animal condition and treatment: "*It is good for us to see what the success percentage is per species. [..] I saw that thirteen per cent of our cases were due to fractures, which made us think about following training to specialize ourselves more in treating fractures."* Secondly, WRCs are required to send the provincial government an annual overview of all admitted wildlife. However, almost none of the interviewees received a response: *"As far as I know, nothing is being done with our data. They just see if we registered the animals, released them within the province, and then it goes into a drawer."* Thirdly, the centers use an overview of the animals they treat to substantiate the need for more funding.

We saw similar reasons among the survey respondents' ideas about what the data is being used for. Most of them think they know what the data is used for (68.8%, n=141; Appendix 4.9); of these, over half elaborated on their answer (56%, n=79). The most mentioned purpose was for monitoring the animal rehabilitation process (n=19), to share with the government because of the permit (n=15), and to have an overview of the animals (n=15), for example, for improving rehabilitation practices or substantiating the need for funding. Eight respondents mentioned that the data is being shared with knowledge institutions or other research organizations.



***Data quality***

While almost every center initially collected the data on paper, they all digitized part of their data, primarily species, date, and reason for admission. For this purpose, most used Microsoft Excel or Word, while some used database software hosted by an external organization. The level of detail in the finding location varied between WRCs. Some recorded the full location of the finding, including street and house number if available, while others only recorded the municipality. For some centers, the provincial government required a certain level of detail. A few centers only recorded municipalities to show the need for funding. Also, different ideas regarding the release of an animal influenced the chosen level of detail for the finding location. While some centers release animals in the centers' backyard, some also release wildlife at the finding or another more suitable location. Most interviewees were critical regarding the accuracy of the location when this was recorded by animal ambulance organizations that transport wildlife from the public to the WRCs. Some mentioned that the animal ambulance volunteers did not always register the original finding location, instead of the collection location, due to time pressure: "*They do what they can. If they have the information, they share it. However, you cannot expect this, especially in busy times when they are running around.*" In addition, over half of the interviewees noted that the cause of admission is sometimes missing, uncertain, or questionable, and some interviewees made remarks on the correct identification of species. A third of the interviewees mentioned the data quality depends on the experience of the animal ambulance volunteers: "*[...] there are certainly people with many years of experience, but most volunteers are too new and have too little information.*"

Around half of the survey participants were involved in data collection (51.2%, n=105; Appendix 4.9). They were generally positive about the data quality they collected themselves, feeling the most confident about *Species* (*M*=4.4) and equally confident about the quality of *Reason for admission* and *Finding location* (*M*=4.1; Appendix 4.10), although some participants added remarks on the difficulty of identifying the reason for admission. Some participants mentioned that more experienced staff members register animals upon arrival, which could be beneficial for the data quality. In line with the interviewees, some respondents noted that the data quality also depends on the individuals or organizations that drop off the animals.

***Research***

All interviewees were positive about collaborating with researchers. Half of the survey respondents thought their organization owns the data but should share it with anyone interested (50%, n=102). A third thought that their organization is the owner, and they don't have to share the data (32.8%, n=67), and almost ten per cent thought there is no data owner, and data should be publicly available (8.8%, n=18). The others did not have an opinion or thought that it depends on if it will help wildlife conservation (8.3%; n=17; Appendix 4.9).

When asked about citizen science, over two-thirds of the participants were unfamiliar with this term or the Dutch word 'burgerwetenschap' (69%, n=140), When this term was explained, 78.2% (n=158) thought the WRCs' practices could be a form of citizen science. When asked what type of research would be interesting and important, most interviewees were interested in studying the success of their rehabilitation practices. They also saw it as an important opportunity regarding disease monitoring: "*I think the signaling function we have for wildlife diseases is one of importance for the upcoming years. That is something we need to prepare for, also regarding quarantine space*." These two research priorities align with survey participants' research interest in the success of their rehabilitation practice (74.6%, n=153) and monitoring diseases (63.9%, n=131; Appendix 4.9).

However, over half of the interviewees mentioned a lack of time, energy, and financial resources to execute their research ideas: "*Of course, you can do [research] within your own center [...], but our people are already happy when they can still keep their eyes open at the end of the day. What is needed is good collaboration with scientists."* Several WRCs mentioned existing collaborations with research organizations and natural history museums. With these organizations they share both data as well as animal carcasses. One center emphasized the importance of deceased wildlife: "*when you bring a wild animal to a center, it is often more dead than alive, so a lot die. However, these dead animals also hold much information on ecology and public health*." The respondents were primarily neutral towards initiatives that require extra effort, time, or interest (e.g., gaining insights into data from colleagues and contributing to more research with this data).

Also, with these kinds of collaborations, centers need more time and resources. Some interviewees were also hesitant about future research collaborations due to a lack of feedback from previous research collaborations: "*The student did not send the results, which is too bad because you invest much time, especially when you collect samples*." This sharing of results was also of great

importance to the respondents (*M*=4.2; figure 4.2; Appendix 4.10). When getting the results from an academic institute, one WRC also shared their difficulty understanding it: "*[the report] was very technical and not plain simple language, it was not even all in Dutch but also Latin was used.*"

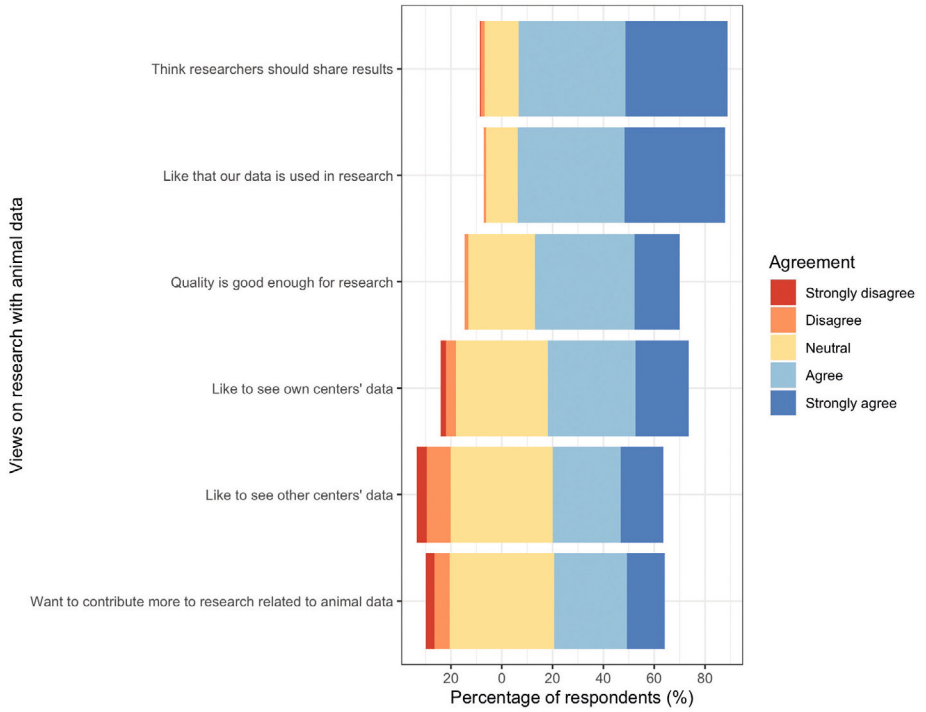


***Figure 4.2.*** Diverging stacked bar chart of survey respondents' agreement with statements regarding their views on scientific research with their centers' animal data (n=199), scored on a Likert scale, ranging from 1 (Strongly disagree) to 5 (Strongly agree) and ordered from high to low positive scores. Option "Don't know/ rather not say" not included, see details in Appendix 4.10.

Some interviewees emphasized the importance of sharing knowledge between centers to improve their rehabilitation practice. For example, the hedgehog centers mentioned a meeting with a national hedgehog working group where a hedgehog expert taught them different methods for researching hedgehog feces, and an international hedgehog expert and book author was also invited to give a talk. The interviewees experienced this as both "*fun and interesting.*"

### 4.3.3 Public education

All centers engaged with the public; for example, via phone, when people reported wildlife needing rescue or reached out for advice and face-to-face when people dropped off animals at the center. Most centers also organized educational activities like open days and school visits. All interviewees thought public education is an important part of their work, and several interviewees mentioned how it helps with prevention: "*Over 80% of wildlife admissions are caused by human activities. So, if you can connect humans and their natural environment more through*

*education, you can minimize the negative encounters between humans and wildlife."* Their educational messages mainly focussed on how the public can create a nature-friendly environment. In addition, almost half of the interviewees mentioned they teach people when wildlife does and doesn't need help: *"Often people have very good intentions, but with these good intentions also many animals unnecessarily end up in the center."* An example of this is animals appearing orphaned, like young birds: *"chicknapping, when people find a young bird and immediately pick it up [...].* However, almost all interviewees mentioned a lack of time and capacity: "*During the past few years, we noticed it became increasingly difficult to keep everything running. So, the focus goes to wildlife care, especially in spring and summer.*

## 4.4 Discussion

This study examined wildlife rehabilitators' backgrounds and perceptions of data collection and involvement in research and education. Interviews with thirteen WRC representatives and a survey of 205 WRC volunteers, revealed a positive attitude toward research and education but highlighted time and funding as key barriers.

### 4.4.1 Rehabilitators' motivation and background

Wildlife rehabilitators' primary motivations were *helping animals* and *having an interest in animals*, although many other motivations such as *enjoyment* and *learning* were important too. These findings align with prior studies highlighting "love for and desire to help injured animals" (Kidd et al., 1996) and "to help native animals" (Haering et al., 2020b) as key motivations. Nearly half of the respondents had less than four years of experience, consistent with retention challenges noted in earlier research (Kidd et al., 1996). To improve recruitment and retention, WRCs could address diverse motivations by for example offering activities that foster their interest in and knowledge of wildlife. More research is needed to explore how motivations evolve over time.

Dutch wildlife rehabilitators were predominantly women (84%) and middle-aged (40-64 years), consistent with earlier studies (Englefield et al., 2019; Haering et al., 2020b). Only 1.5% of the rehabilitators were under 20 years, which is comparable to 1.1% of Dutch biodiversity recorders (Ganzevoort & Van Den Born, 2020). This reflected possibly a minimum age requirement of 16 years at most WRCs. Engaging younger age groups via other activities could foster interest in nature conservation and perhaps future volunteering (Brewer, 2006). Educational backgrounds were diverse, with 38% of rehabilitators having finished higher education, comparable to 36% nationally (Statistics Netherlands, 2024a). This contrasts with studies on nature volunteers and citizen scientists, which reported higher percentages (Ganzevoort & Van Den Born, 2020; Mac Domhnaill et al., 2020). Rehabilitators' attitude toward science aligns with the general Dutch population; although rehabilitators are more likely to engage in scientific activities, like museum visits (Verkade & Smeets, 2023). Involving them in scientific research could further enhance their knowledge and scientific attitude (Bonney et al., 2016; Rambonnet et al., 2024).

Regarding rehabilitators' involvement, respondents reported spending a mean of 8.1 hours per week volunteering, nearly double the national average of 4.3 hours (Statistics Netherlands, 2024b). However, our mean is skewed by a few participants who reported a relatively high number of hours, up to 100 hours per week. The median of five hours was lower than previous studies, likely due to differences in operating structures. Australian rehabilitators, for instance, work from home and care for species requiring longer rehabilitation periods (Englefield et al., 2019; Haering et al., 2020a). Comparable to a previous study by Haering et al. (2020b), half of the rehabilitators worked also a part- or full-time job elsewhere. However significantly more people worked part-time than full-time compared to the Dutch population (Statistics Netherlands, 2024a).

### 4.4.2 Rehabilitation and research

Survey participants were generally positive about the quality of their data, while interviewees were more hesitant, citing concerns about the reliability of finding locations and reasons for admission. This aligns with Haering et al. (2020b), who noted differing opinions between volunteers and coordinators on record-keeping. Positivity may reflect genuine confidence, a tendency to give positive answers (acquiescence bias), or a desire for approval from coordinators (social desirability bias). Concerns stemmed, for example, from errors during digitization and reliance on volunteers from animal ambulance organizations. Training both WRC and animal ambulance staff could enhance data quality and volunteer knowledge (Rambonnet et al., 2024; Ratnieks et al., 2016).



Participants expressed interest in research on rehabilitation success, wildlife diseases, and preventing wildlife rescue. While few respondents mentioned their centers shared data with researchers, over half thought their organization should share the data with those interested. This aligns with findings that half of Dutch biodiversity volunteers view their data as a public good (Ganzevoort et al. 2017; Lawrence & Turnhout, 2010), highlighting opportunities for greater collaboration between WRCs and researchers. Emphasizing how scientific research aligns with wildlife rehabilitators' motivation to help animals could further encourage involvement. Sharing research outcomes with centers can sustain motivation for future collaborations. Offering lectures or workshops by researchers may further inspire them. Since many are unfamiliar with the term 'citizen science' or its Dutch equivalent 'burgerwetenschap,' clear communication is key. Future studies could explore best practices and challenges faced by other collaborators, such as research institutions and policymakers, to enhance WRCs' role in knowledge generation.

While WRCs are positive about participating in scientific research, they face challenges such as limited time and funding. This aligns with a recent report highlighting WRCs' research potential if the government ensures the centers' stability and continuation (RDA, Raad voor Dierenaangelegenheden, 2022). Researchers should account for these constraints, involve WRCs in funding proposals, and give back through lectures or workshops.

### 4.4.3 Public education

In addition to wildlife care, WRCs view education as vital to preventing the need for wildlife rehabilitation. This aligns with prior studies emphasizing their role in public education (Willette et al., 2023). The WRCs especially want to educate the public on when a young animal needs help and how the public can make their gardens more nature-friendly. Recently a Dutch report stressed improving public knowledge about helping wildlife (RDA, Raad voor Dierenaangelegenheden, 2022). Heathcote et al. (2019) suggested that analysis of WRC data on anthropogenic causes could "guide the planning of public education and mitigation initiatives". Future research could explore public knowledge and attitudes toward wildlife and WRCs' role in improving them.

### 4.4.4 Limitations

This study has several limitations. First, it focused only on The Netherlands and only on the WRCs, not the animal ambulance organisations. This choice was made to scope the current research to organizations dealing with wildlife and not domestic animals. Comparing our findings with similar studies in other countries may help the field further.

Another limitation of this study is the self-selection bias that might have occurred as it was voluntary to fill out the survey. For example, this could have resulted in more positive responses to scientific research. Also, a possible social desirability bias might have occurred. Even though the interviews and surveys were processed anonymously, representatives and survey participants might have unintentionally or intentionally spoken more positively about their center or wildlife rehabilitation in general.

A third and last limitation of our study is the timing. The interviews and survey were conducted just after the COVID-19 pandemic and during the period when bird flu became endemic in the Netherlands. As a result, educational activities like open days and school guest lessons happened less frequently as mentioned by some interviewees.

## 4.5 Conclusion

We found that WRCs and their data-collecting volunteers are willing to share their data with interested people, including researchers. Their interest lies mainly in improving the success of their rehabilitation work, monitoring and preventing diseases, and other causes of admission. However, although centers acknowledge the importance of research and knowledge exchange, their limited time and capacity make them prioritize caretaking above research and education. More financial support is needed to fulfill the potential of WRCs for citizen science, taking on the roles of conducting or aiding research and educating the public.

Our study also found that helping and being interested in wildlife were the most important motivations for Dutch wildlife rehabilitators to volunteer at a WRC. These motivations need to be addressed to retain volunteers and when involving them in scientific research efforts. Also,

as their age and educational background are more representative of the general population than previous studies on citizen scientists and nature volunteers, involving wildlife rehabilitators in scientific research could engage a more diverse audience.

# Chapter 5

# The effects of COVID-19 litter on animal life

**This chapter is based on:** Hiemstra, A. F., Rambonnet, L., Gravendeel, B., & Schilthuizen, M. (2021). The effects of COVID-19 litter on animal life. *Animal Biology*, *71*(2), 215-231. https://doi.org/10.1163/15707563-bja10052

**Photo credits***: Auke-Florian Hiemstra*

## Abstract

During the COVID-19 pandemic, Personal Protective Equipment (PPE) is massively used, resulting in a new wave of litter: protective face masks and gloves. Here we present the first case of a fish entrapped in a medical glove, encountered during a canal clean-up in Leiden, The Netherlands. We also report the first cases of birds using medical face masks as nesting material, which were also found in the Dutch canals. To place these new findings in context, we collected online reported interactions of animals with PPE litter, since the start of the pandemic. This resulted in the first overview of cases of entanglement, entrapment and ingestion of COVID-19 litter by animals and the use of it as nesting material. To understand the full scale of this problem, we welcome anyone to contribute to our overview by submitting their observations online at www.covidlitter.com. To further prevent PPE litter, it is recommended that, when possible, reusable alternatives are used.

## 5.1 Introduction

After the outbreak of the COVID-19 virus was first identified in Wuhan, China, in December 2019, the World Health Organization officially declared the virus a pandemic on 11 March 2020 (World Health Organization, 2020). During the past months the pandemic has resulted in almost 90 million confirmed cases and almost two million deaths globally as of early January 2021 (John Hopkins University of Medicine, 2020). While we have seen reductions in air pollution (Chen et al., 2020; Dutheil et al., 2020), $NO_2$ emissions (NASA, 2020), and $CO_2$ emission (Myllyvirta, 2020), plastic pollution seems to be increasing (Fadare & Okoffo, 2020; Silva et al., 2021). To protect humans against this virus, personal protective equipment (PPE) is being used more frequently. China, for example, increased face mask production by 450% in just one month (Bown, 2020). It is estimated that we have a monthly use of 129 billion face masks and 65 billion gloves globally (Prata et al., 2020). Similar to the usage of other single-use plastic items, this also means an increase of PPE littering our environment (Fadare & Okoffo, 2020). PPE litter, also referred to as COVID-19 litter, mainly consists of single-use (usually latex) gloves and single-use face masks, consisting of rubber strings and mostly polypropylene fabric. Three months after face masks became obligatory in the UK, PPE items were found on 30% of the monitored beaches and at 69% of inland clean-ups by the citizen scientists of the Great British Beach Clean (Riglen, 2020). Even on the uninhabited Soko Islands, Hong Kong, already 70 discarded face masks were found on just a 100-meter stretch of beach (Kassam, 2020). A growing public concern about PPE litter became apparent during March and April 2020, as a Google News search on 'PPE' and 'litter' showed a sudden increase in news articles (Canning-Clode et al., 2020). As a response to the increase of COVID-19 litter, many states in the USA have raised the fines for littering PPE, sometimes up to $5,500 as in Massachusetts (O'Laughlin, 2020).



The #glovechallenge, in which people shared their observations of gloves and face masks (figure 5.1), resulted in more than 11,000 photos of COVID-19 litter from all over the world (Cardona, 2020). A Dutch COVID-19 litter project reported 6,347 photos of gloves or face masks littering The Netherlands during the months of May and June (Groot, 2020). Initially, these products were mainly found in close vicinity to supermarkets and healthcare institutions, but when face masks became compulsory in public transport, they were also increasingly being found near bus, tram, and train stations. By now the use of face masks is mandatory or highly recommended in many countries (Sylva et al., 2020). As a consequence, the increase in production and consumption of PPE litter inevitably leads to interaction with animal life.

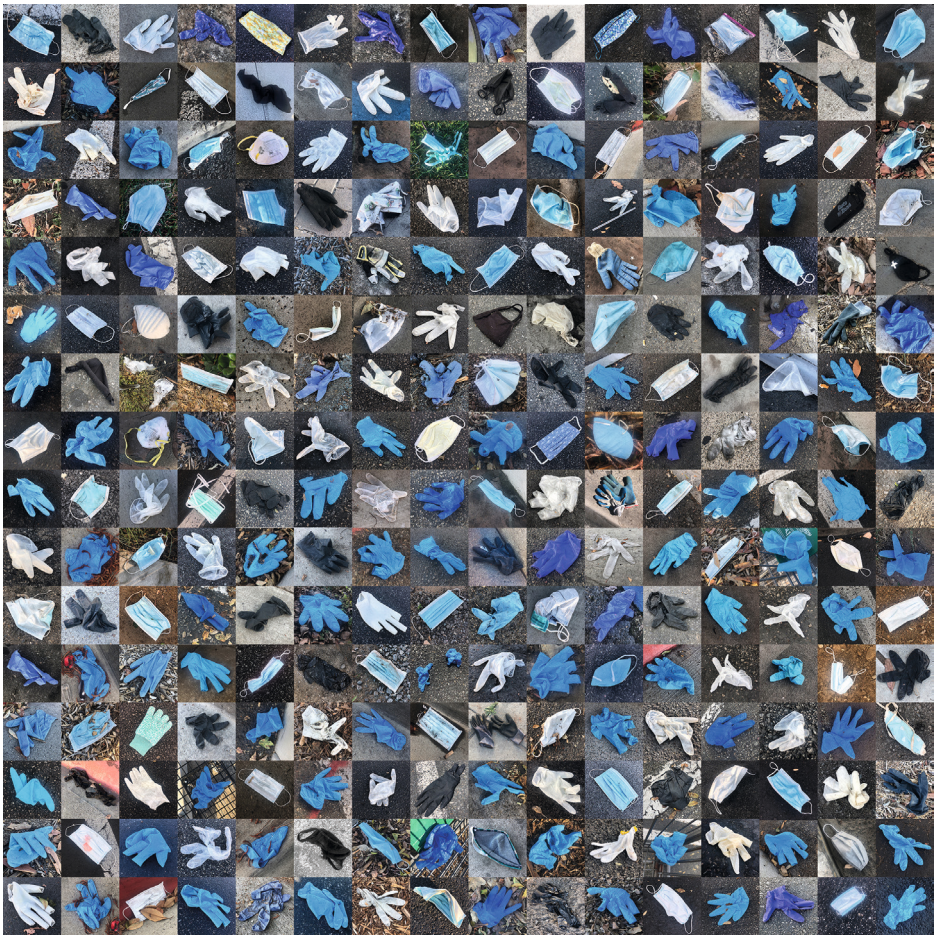

**Figure 5.1** Compilation of 256 images of PPE litter from Vista, CA, USA. Photograph by Janis Selby Jones.

While the percentage of COVID-19-related litter may be small in comparison with packaging litter (Groot, 2020), it can be seen as a typical example of our single-use society. Both masks and gloves pose a risk of entanglement, entrapment and ingestion, which are some of the main environmental impacts of plastic pollution (Ryan, 2018; Kuhn & Van Franeker, 2020). Plastic can have enormous impacts on animals, some direct, others indirectly. An entanglement, for example, can be acute, resulting in immediate death by suffocation or drowning, or chronic, meaning it may exhaust the animal, restrict feeding to the point of starvation or result in strangulations, wounds, infections or cause amputations (Butterworth et al., 2012). Face masks littering the environment could also be an emerging new source of microplastics (Fadare & Okoffo, 2020), but the masks already cause harm prior to degrading. The Iranian cartoonist Alireza Pakdel drew a predictive cartoon regarding the effects of COVID-19 litter at the start of the pandemic, showing a fish entangled in a face mask facing another fish entrapped in a glove (Pakdel, 2020). Such situations have by now been found in real life — and are presented here. This is the first

overview of case studies of the increasing threat of entrapment, entanglement, ingestion of PPE and its inclusion as nesting material by birds.

## 5.2 Methods

Volunteers participating in the Plastic Spotter canal clean-ups collect floating litter using canoes in Leiden, The Netherlands (Rambonnet et al., 2020). Their encounter of a fish entrapped in a latex glove sparked our interest, which was fueled further by the find of face masks and gloves in bird nests. To place these observations into context we collected all observations of interactions of animal life with COVID-19 litter reported online since the start of the pandemic. For this, we used both Google web search and Google image search, as a method to rapidly collect sightings (Leighton et al., 2016). Search terms that were used, in combination, are: 'litter', 'waste', 'PPE', 'COVID', 'COVID-19', 'corona', 'face mask', 'glove', 'entanglement', 'entangled', 'entrapment', 'entrapped', 'ingestion', 'ingested', 'bird nest'; both in English and in Dutch. These search terms, used as hashtags, were also used to explore social media platforms Twitter, Facebook and Instagram for observations. If supporting information on the observation was lacking in the articles and posts we found, we traced back the origins of the photos and articles, using reverse image search or by searching the names of the observer, to collect any further information on the locality, date, observer, and any other details. When these details could not be found online, we tried to contact the observers and reporters when possible.



## 5.3 Presentation of the concerns

The first case of the impact of COVID-19 litter discussed here originates from Leiden, The Netherlands. Already two weeks after the first Dutch case of COVID-19, a face mask was found as litter in the Leiden canals (pers. obs.). Since then, each weekly canal clean-up resulted in multiple face masks and gloves, sometimes up to 70 items. At the time of writing, so far many hundreds of face masks and gloves have been found, and counting.

It is known that riverine ecosystems are directly affected by plastic pollution (Van Emmerik & Schwarz, 2020). The canals of Leiden harbor not only hotspots of plastic (Tasseron et al., 2020), but also 22 species of fish (Van Aarsen, 2018; Verkade, 2018), some of which are protected by national laws and European regulations. The first evidence that freshwater fish suffer from the recent wave of PPE litter is presented here, with the find of a dead perch (*Perca fluviatilis*) entrapped in a latex glove, with only its tail sticking out (figure 5.2). The fish was found in the Oude Vest, Leiden, by citizen scientists during a Plastic Spotter canal clean-up on the 2nd of August 2020, making it the first victim of COVID-19 litter from The Netherlands. The glove was partially ruptured around the base of the thumb, where the fish was entrapped, which could be the result of a struggle. The spiny dorsal fins might have prevented a backward exit. When found, the glove was partly inside-out, meaning that it had been worn before being discarded.

As the glove could potentially be contaminated with the COVID-19 virus, precautions were taken by the volunteers during the handling of the specimen and the PPE litter it was entrapped in. The perch, still in its glove, is stored in ethanol as part of 'De Grachtwacht' collection located in Leiden, The Netherlands (GW9899-1E). Two years previously, the first fish entrapped in a glove near Tossa de Mar, Spain, was a widely shared news story (Regen, 2018). The polyethylene glove, meant for food preparation, became a classic example of the negative effects of plastic in our oceans. The newly found perch entrapped in a medical latex glove, however, shows that plastic litter also impacts the lesser-studied freshwater ecosystems and that the new wave of PPE latex gloves littering our environment could make entrapments like these more frequent in the future.

**Figure 5.2** An entrapped perch (Perca fluviatilis) in a PPE glove (GW9899-1E), found during a Plastic Spotter clean-up in the canals of Leiden, The Netherlands. Photograph by Auke-Florian Hiemstra.

However, interactions with COVID-19 litter are now always directly negative, as the use of plastic in nest construction is becoming more common (Jagiello et al., 2019). Birds now have also started to include COVID-19 litter into their nests. To our knowledge, we here present the first cases of the incorporation of medical face masks into bird nests. This behaviour was firstly seen by a common coot (*Fulica atra*), a species known for its anthropogenic nests (Hiemstra et al., 2021), breeding on the Keizersgracht, Amsterdam, The Netherlands on the 3rd of June 2020 (pers. obs.). This face mask was later preserved in the Grachtwacht collection (GW9792-2). A nest made by common coots near the Beestenmarkt, Leiden, The Netherlands, showed both a medical face mask and a latex glove, and was collected on the 6th of September 2020 (pers. obs.; GW9792-3 and GW9792-4) (figure 5.3). Gloves were also used as nesting material by sparrows (*Passer* sp.) in a residential area in Warsaw, Poland (Szulkin, 2020). Even packaging of pocket tissues was incorporated into coot nests in spring 2020 (pers. obs.; GW9792-5). Since sniffing is a symptom of COVID-19, this unlikely nest item may be pandemic-related as well.

**Figure 5.3** Nest of common coot (Fulica atra) partly built with face mask (GW9792-3) and glove (GW9792-4). Nest located at the Beestenmarkt, Leiden, The Netherlands, collected on the 6th of September 2020. Photograph by Auke-Florian Hiemstra.

Our observations may have been the first Dutch cases, yet the first reported victim of COVID-19 litter globally, to our knowledge, was an American robin (*Turdus migratorius*; Denisuk, 2020). This bird appears to have died after becoming entangled in a face mask at Chilliwack, BC, Canada, on the 10th of April 2020 (pers. comm. Sandra Denisuk; figure 5.4). After that, a young gull (*Larus* sp.) was found walking with a face mask tangled around its legs in Chelmsford, Essex, UK (RSPCA Essex South, 2020). It had struggled with the mask for two weeks and its limbs and joints were swollen, but it recovered in the South Essex Wildlife Hospital. A juvenile peregrine falcon (*Falco peregrinus*) on the Yorkshire coast, UK, with its talons entangled in a face mask, eventually managed to free itself (BBC, 2020a). Cygnets from a mute swan (*Cygnus olor*) from Lake Bracciano, near Rome, Italy, were observed with face masks around their beak (WWFItalia, 2020), and a mallard (*Anas platyrhynchos*) with a mask hanging around its neck, seen in Casentino, Italy, was referred to by local media as "The duck unable to take off the mask" (ArezzoNotizie, 2020). A recent find of a dead gull in Rotterdam, The Netherlands, which was hit by a car, also had a face mask entangled around its legs. Although this entanglement may not have been the cause of death, it may have weakened the bird as a chronic entanglement, prior to the car-collision (Kompanje, 2021) The bird, together with its face mask, has been preserved in the Natural History Museum of Rotterdam (NMR 9989-172803).

**Figure 5.4** First victim of COVID-19 litter, an American robin (Turdus migratorius) entangled in a face mask at Chilliwack, BC, Canada on the 10th of April 2020. Photograph by Sandra Denisuk.

However, not only birds are affected by face masks. While bats already suffer from roost destruction because they have been associated with the start of the COVID-19 outbreak (Rocha et al., 2020; Shereen et al., 2020), they also face the risk of entanglement in PPE litter. A serotine bat (*Eptesicus serotinus*) was found in Nijmegen, The Netherlands, entangled in two face masks (Van Otterlo, 2020). A red fox (*Vulpes vulpes),* entangled in a face mask, and a European hedgehog (*Erinaceus europaeus*), entangled in a glove, were reported in the UK (BBC Breakfast, 2020). A hedgehog entangled in a face mask was found in The Netherlands (Egelopvang het Stekeltje, 2020). Also, a checkered pufferfish (*Sphoeroides testudineus*), entangled in a face mask, was found dead during a clean-up at Pace Picnic Island, west of Miami Beach, USA (Clean this beach up, 2020). Two shore crabs (*Carcinus maenas*) were encountered in lake Étang de Berre, France, of which one was found deadly entangled in a face mask, while another entangled crab was walking around with a face mask (Opération Mer Propre, 2020b). A common octopus (*Octopus vulgaris*) in the sea near Cannes, France, was filmed hiding under a face mask. "Even the octopus protects himself against Covid 19" was the description below the video on YouTube (CGTN, 2021; Opération Mer Propre, 2020a).

COVID-19 litter is also ingested by animals, as the find of a Magellanic penguin (*Spheniscus magellanicus*) in Brazil illustrates (Penza, 2020). The stomach of this animal, found on Juquehy Beach in São Sebastião, north of São Paulo, revealed an ingested face mask. Multiple long-tailed macaques (*Macaca fascicularis*) were seen chewing on a face mask in Genting Sempah, Malaysia (Rasfan, 2020). Young gulls (Laridae sp.) have also been observed fighting over a face mask on Weymouth beach, UK, as they were hunting for food, and one flying away with it in its beak (Klein, 2020). Young gulls carrying a face mask were also observed at the port of Dover, and at the coast of Weston-super-Mare in the UK (Reuters Pictures, 2020; Simmons, 2020). Ingestions

of COVID-19 litter have also been seen in several domestic animals like a cat (*Felis catus*) (ACCT Philly, 2020) and four dogs (*Canis lupus familiaris*) (DeFina, 2020; Kaur, 2020; Small Animal Hospital University of Glasgow, 2020; van Gerwen, 2021). Even a six-year-old child ingested parts of a presumed blue face mask, accidentally baked into a McDonalds chicken nugget (BBC, 2020b). All the above interactions of animals with PPE litter can be found summarized in table 5.1.

## 5.4 Conclusions

This is the first overview of reported cases of entanglement, entrapment, ingestion, and the use of COVID-19 litter as nesting material. Although the actual number of cases will be much higher than the number of cases found (Laist, 1997) we already signal COVID-19 litter as an emerging threat to animals. PPE litter has already been found in terrestrial, freshwater and marine ecosystems. Also, its impact is observed in all of these habitats, by both vertebrates and invertebrates, ranging from birds and mammals to fishes and crabs. However, to fully understand the scope of the impact of PPE litter, more research is needed.

As we only searched articles in English and Dutch and found mainly cases from the UK, USA and The Netherlands, we expect that more examples of interactions between animals and PPE litter can be found from sources in other languages. For example, using reverse image search on a photo encountered on social media, we traced back the source of the report of an entangled bird to a local Italian newspaper (ArezzoNotizie, 2020). This was also done for a photo of an entangled crab, which was encountered on an English website (CGTN, 2021). We were able to trace it back to French social media pages where we also encountered another observation of an entangled crab and the octopus hiding under a face mask (Opération Mer Propre, 2020a, b). To understand the full scale of the problem, we encourage anyone to add their observations to our regularly updated overview, accessible online at www.covidlitter.com. Especially litter pickers, animal rescue centers, bird watchers and nature photographers have proven to play a vital role in observing and sharing interactions of animals with PPE litter, and we encourage them to keep reporting any new observations.



As we deal with a recently introduced and relatively easily recognizable type of litter, monitoring its impact on animals can provide us with a unique insight of the impact such a type of single-use plastic can have. The pandemic is not over yet, and the amount of PPE used may only increase, and will continue to threaten wildlife way beyond the time access to a vaccine becomes available. In addition to this, the already littered items will degrade into micro- and nanoplastics and stay in the environment for hundreds of years (Fadare & Okoffo, 2020; Kassam, 2020). To better understand the scope of the impact of face masks and gloves, it is also important to monitor PPE litter.

To achieve this goal, we acknowledge the importance of citizen science initiatives that collect data on litter, for example during beach cleans (Rambonnet et al., 2019). We encourage citizen science efforts to increase the monitoring of PPE litter and we recommend updating the stan-

dardized method for monitoring beach litter, the OSPAR guideline (OSPAR, 2010; Silva et al., 2020). We believe that separate categories for latex gloves and face masks should be added. The Great British Beach Clean also asked their volunteers to monitor this type of litter in September 2020, which helped to map the extent of PPE litter in the UK (Matthews, 2020). As this material is a potential biohazard, and precautions should be taken during clean-ups as COVID-19 can survive up to three days on for example plastic surfaces (Van Doremalen et al., 2020). Litter monitoring campaigns help us understand the scope of this new category of problematic litter.

Other initiatives call on people to cut up disposable gloves and snip the straps on face masks before discarding them, as this could help prevent animals from getting entangled (RSPCA, 2020; Toliver, 2020). A similar strategy is being used for plastic six-pack rings, which should also be cut up before being discarded to prevent entanglements (Stachowitsch, 2019). In addition, it is recommended to take the impact of PPE litter on the environment into account when developing PPE products (Schweitzer et al., 2018).

The PPE products that are designed to keep us safe are actually harming animals around us. It is striking that all the reported findings of entanglement, entrapment, ingestion, and incorporation of PPE into nests so far involved single-use products. Switching to reusables will result in a 95% reduction in waste, according to the UCL Plastic Waste Innovation Hub (2020). To minimize the amount of COVID-19 litter and its effect on nature, we urge that, when possible, reusable alternatives are used. People may suffer from the coronavirus pandemic, but nature is getting sick of our plastic.

**Table 5.1** Overview of interactions between animal species and PPE litter with date of observation if known, date of online report, country where it was observed, species name, type of PPE litter, type of interaction and the name of the observer or reporter. An up-to-date version of this table can be found on www.covidlitter.com, where anyone can also add any new or missing observations

| | Date of observation | Date of online report | Country | Species | PPE item | Interaction | Observer or reporter |
|---|---|---|---|---|---|---|---|
| 1 | 10-04-2020 | 23-04-2020 | Canada | American robin (*Turdus migratorius*) | Face mask | Entangled | Sandra Denisuk |
| 2 | Unknown | 14-04-2020 | Poland | Sparrow sp. (*Passer* sp.) | Gloves | Nest material | Marta Szulkin |
| 3 | Unknown | 11-05-2020 | USA | Cat (*Felis catus*) | Glove | Ingested | ACCT Philly and Art City Vets & Urgent Care |
| 4 | 03-06-2020 | This paper | The Netherlands | Common coot (*Fulica atra*) | Face mask | Nest material | Marieke Elsinga |
| 5 | Unknown | 01-07-2020 | France | Common octopus (*Octopus vulgaris*) | Face mask | Other: hiding | Opération Mer Propre |
| 6 | 19-07-2020 | 19-07-2020 | UK | Gull sp. (*Larus* sp.) | Face mask | Entangled | RSPCA Essex South |
| 7 | 19-07-2020 | 24-07-2020 | UK | Peregrine falcon (*Falco peregrinus*) | Face mask | Entangled | Steve Shiley |
| 8 | Unknown | 22-07-2020 | UK | Red fox (*Vulpes vulpes*) | Face mask | Entangled | South Essex Wildlife Hospital |
| 9 | Unknown | 22-07-2020 | UK | European hedgehog (*Erinaceus europaeus*) | Glove | Entangled | South Essex Wildlife Hospital |
| 10 | 31-07-2020 | 31-07-2020 | USA | Checkered pufferfish (*Sphoeroides testudineus*) | Face mask | Entangled | Tiffany Menichetti (Clean this beach up) |
| 11 | 02-08-2020 | This paper | The Netherlands | Perch (*Perca fluviatilis*) | Glove | Entrapped | Brandon Hartley and Marie Diamond (Plastic Spotter) |
| 12 | 24-07-2020 | 05-08-2020 | USA | Dog (*Canis lupus familiaris*) | Face mask | Ingested | Animal Rescue League of Boston |
| 13 | Unknown | 07-08-2020 | UK | Gull sp. (*Larus* sp.) | Face mask | Carrying | Roger Lovell |
| 14 | 11-08-2020 | 11-08-2020 | UK | Gull sp. (*Larus* sp.) | Face mask | Carrying | Peter Nicholls |
| 15 | 31-08-2020 | 01-09-2020 | UK | Gull sp. (*Larus* sp.) | Face Mask | Carrying | Nicholas Hayman |
| 16 | Unknown | 05-09-2020 | UK | Dog (*Canis lupus familiaris*) | Face mask | Ingestion | University of Glasgow's small animal hospital |
| 17 | 06-09-2020 | This paper | The Netherlands | Common coot (*Fulica atra*) | Face mask and glove | Nest material | Auke-Florian Hiemstra and Liselotte Rambonnet |

**Table 5.1 Continued**

| | Date of observation | Date of online report | Country | Species | PPE item | Interaction | Observer or reporter |
|---|---|---|---|---|---|---|---|
| 18 | Unknown | 14-09-2020 | Italy | Mute swan (*Cygnus olor*) | Face mask | Other: playing | Paolo Nicolai |
| 19 | Unknown | 20-09-2020 | Italy | Mallard (*Anas platyrhynchos*) | Face mask | Entangled | Jacopo Casali |
| 20 | 23-09-2020 | 23-09-2020 | France | Shore crab (*Carcinus maenas*) | Face mask | Entangled | Opération Mer Propre |
| 21 | 23-09-2020 | 23-09-2020 | France | Shore crab (*Carcinus maenas*) | Face mask | Entangled | Opération Mer Propre |
| 22 | 11-09-2020 | 15-09-2020 | Brazil | Magellanic penguin (*Spheniscus magellanicus*) | Face mask | Ingested | Argonauta Institute for Coastal and Marine Conservation |
| 23 | Unknown | 10-10-2020 | The Netherlands | Serotine bat (*Eptesicus serotinus*) | Two face masks | Entangled | Mirjam van Otterlo |
| 24 | 20-10-2020 | 23-10-2020 | The Netherlands | European hedgehog (*Erinaceus europaeus*) | Face mask | Entangled | Egelopvang 't Stekeltje |
| 25 | 30-10-2020 | 30-10-2020 | Malaysia | Long-tailed macaque (*Macaca fascicularis*) | Face mask | Other: chewing | Mohd Rasfan |
| 26 | Unknown | 24-11-2020 | UK | Dog (*Canis lupus familiaris*) | Face mask | Ingested | Mike Glanton & Zetland Vets Hospital |
| 27 | 01-01-2021 | 04-01-2021 | The Netherlands | Gull sp. (*Larus* sp.) | Face mask | Entangled | Erwin Kompanje |
| 28 | 01-01-2021 | 07-01-2021 | The Netherlands | Dog (*Canis lupus familiaris*) | Face mask | Ingested | Janneke van Gerwen |

# Chapter 6

# Synthesis, discussion, and recommendations

**Photo credits:** *Ghislaine Holswilder*

Public participation in environmental monitoring has become increasingly important to address major global environmental threats and mitigate their consequences. Citizen science facilitates large-scale data collection while enhancing scientific literacy and environmental awareness (Bonney et al., 2009; Haklay et al., 2021). However, the success of citizen science depends on the recruitment and retention of participants, which requires a better understanding of their backgrounds, motivations, and engagement over time (Robinson et al., 2018). Despite the rising number of citizen science projects tackling plastic pollution, research on the characteristics and experiences of participants remains limited (Follett & Strezov, 2015; Nelms et al., 2022; Rambonnet et al., 2019). Moreover, existing studies have mainly concentrated on schoolchildren rather than adult volunteers (Locritani et al., 2019; Wichmann et al., 2022). Furthermore, innovative strategies are required to broaden participation beyond the highly educated demographic typically involved in citizen science (Pateman et al., 2021). This dissertation addresses these gaps by examining participants in plastic pollution citizen science projects and exploring alternative data collection methods for environmental monitoring. This chapter synthesizes key findings, discusses their implications, and offers recommendations for researchers and practitioners.

Plastic citizen science provides a distinctive context for studying how people engage with environmental research. Unlike many other citizen science fields, plastic pollution is highly visible and directly connected to people's daily lives, linking individual behaviour with global environmental problems (Rambonnet et al., 2019; Krawczyk et al., 2025). Its tangible and local character makes participation immediately meaningful: volunteers can see the problem and contribute to visible improvement. This combination of action and observation means that participation often feels both scientific and practical, or even activist in nature (Wyles et al., 2017; Nelms et al., 2022). Studying this context helps to understand how awareness, motivation, and civic engagement reinforce one another in citizen science (Pateman et al., 2021).

## 6.1 Synthesis

### Aim 1: Identify background, motivation, and expectations of plastic pollution citizen scientists

This objective was addressed in the first study (**Chapter 2**), which examined citizen scientists involved in the Clean Rivers project, a collaborative citizen science initiative monitoring plastic pollution along Dutch riverbanks since 2017. We surveyed 122 Clean Rivers volunteers before and after their first year of participation to assess their backgrounds, motivations for joining, and expectations of the project. The participants were predominantly highly educated (about 75% held higher education degrees) and middle-aged (58% were between 45 and 65). The gender distribution (approximately 53% female, 47% male) closely matched that of the general Dutch population, indicating that Clean Rivers engaged both men and women nearly equally. Over half of these volunteers (52%) had participated in a cleanup activity before joining, suggesting a pre-existing interest in environmental action. However, only a small group (12%) had prior experience with citizen science specifically. When asked about their motivations and expectations,

volunteers expressed strong environmental drives. They were highly motivated by a desire to address plastic pollution at its source, gather information to inform solutions, and contribute to government or company initiatives to reduce plastic waste. Their expectations focused on making actual contributions to outcomes, such as a cleaner environment and informing policy, rather than on personal benefits. For instance, fewer participants cited learning new things or socializing with like-minded individuals as motivators compared to those who wanted to "be part of the solution" to plastic pollution. These findings established a baseline profile: Clean Rivers attracted volunteers with above-average education who were already environmentally aware, with their primary motivation being the fight against pollution and making a tangible impact.

## Aim 2: Monitor changes in plastic pollution citizen scientists' motivation, attitude, and knowledge throughout participation

This aim was addressed through the one-year follow-up in Chapter 2 and the longitudinal study in **Chapter 3**, which tracked Clean Rivers volunteers from 2017 to 2021. We monitored 403 participants over several years to observe the evolution of their motivation, attitudes toward nature and science, and knowledge. Regarding motivation, both activist and project-action motivations remained high over time. In **Chapter 2**, after one year of participation, most participants were as motivated by environmental concerns and project goals as they were before the project. Motivations related to tackling litter at its source increased significantly, while personal motivations, such as "I thought it would be fun," decreased. This trend persisted in **Chapter 3**; commitment to the cause (plastic-free rivers) remained high over the four years, while personal motivations declined. Importantly, participation was primarily driven by environmental action and a desire for change rather than social or learning opportunities. Participants maintained a positive attitude toward nature and scientific research, reflecting their educational background and cleanup experience (**Chapter 3**). These pro-environmental attitudes did not change significantly with participation. Conversely, participants showed significant gains in knowledge. **Chapter 3** indicated that volunteers' understanding of plastic pollution and research methods increased, particularly after their first year, likely due to mandatory training and hands-on monitoring experiences. While the project boosted volunteers' environmental action motivations, it had a lesser impact on personal motivations or attitudes. However, it did provide measurable educational benefits, particularly in knowledge gain.

## Aim 3: Examine potential of wildlife rehabilitation centers for citizen science

This aim was addressed in **Chapter 4** through interviews and surveys with the wildlife rehabilitation community in the Netherlands. We conducted qualitative interviews with representatives from 13 WRCs and a quantitative survey involving 205 volunteer rehabilitators. This mixed-methods approach allowed us to characterize the volunteers and assess their experiences and perspectives regarding data collection and research. Unlike the Clean Rivers participants, the educational levels of the rehabilitators were more representative of the general Dutch population. Their affinity for science was similar to that of the general public, but the demographics showed a skew: 83% were female, and 52% were middle-aged (40–64 years old). Rehabilitators reported various motivations for volunteering, primarily focused on helping wildlife and their

interest in animals. They held positive attitudes toward research and data sharing, and they were willing to share their data with researchers if provided with feedback. They felt confident in the quality of their data but mentioned that there is room for improvement, with several suggesting additional training for all organizations involved in data collection. Interest in research topics was directed toward studies that could enhance their practices, such as the success of rehabilitation techniques and threats to wildlife. Educating the public was also seen as important in reducing the need for rehabilitation. A significant challenge was the limited time and resources available; many centers operate on tight budgets. In summary, wildlife rehabilitators form a group of possible participants in citizen science that are a better representation of the general public than many existing projects. In addition, they provide valuable environmental data and are open to collaboration. However, researchers must accommodate their time constraints and align with their interests. Training and feedback are essential for successful collaboration.

## Aim 4: Explore potential of observations shared via news and online media for research

**Chapter 5** examined a promising data source: reports of animals impacted by COVID-19 litter, specifically masks and gloves, during the pandemic. It began with a citizen scientist's discovery in early 2020 of a fish entangled in a single-use glove. An ad hoc crowdsourcing approach compiled a dataset from Dutch and English online news and social media, documenting 28 instances of animals affected by PPE litter from April 2020 to January 2021. These instances encompassed various species and locations, underscoring the pollution's widespread effects on domestic pets and wild animals across diverse environments in several countries. The impacts on animals varied: some became entangled in mask ear loops or gloves, others ingested plastic, and some birds utilized masks for nesting. Observations were made by wildlife rehabilitators, veterinarians, photographers, birdwatchers, and dog owners who noticed their pets chewing on masks. This data arose from a network of observers who were unaware of their contributions to research. By integrating fragmented reports from social media and news outlets, we clarified the issue of COVID-19 litter affecting wildlife, a task nearly impossible through traditional scientific monitoring. This study demonstrated that online crowdsourced observations could serve as an early warning or complementary monitoring tool for environmental impacts. It also emphasized the need for careful validation; we verified each case by cross-checking sources and contacting individuals for further details or evidence. Ultimately, this study illustrated that public observations via media can significantly enhance understanding of human impacts on the environment, especially when data is rapidly or geographically widespread.

## 6.2 Key strengths and limitations

This PhD research highlights significant strengths. First, it investigates the general adult audience engaged in plastic pollution citizen science, addressing a gap identified in previous studies primarily focused on youth. By surveying volunteers in the Clean Rivers project, we enhance our understanding of who participates in environmental citizen science and its effects. Second, it includes a longitudinal study that tracks participants' motivation, knowledge, and attitudes over several years, rare for citizen science volunteers. This long-term view is essential for understanding the lasting impacts of participation and maintaining volunteer engagement. Third, this research looks into innovative methods to increase participation, attracting a more diverse audience. Clean Rivers primarily attracted highly educated volunteers; thus, we collaborated with wildlife rehabilitators and utilized crowdsourced data from online observations of wildlife interacting with COVID-19 litter. This illustrates the potential for involving individuals less likely to engage in traditional citizen science. Overall, this dissertation demonstrates that integrating existing volunteer communities and data sources bridges knowledge gaps in environmental science and engages a broader public in monitoring.

This research also has some limitations in its methodology and scope. A primary limitation is related to the measurement frameworks. Different instruments assessed motivation in the Clean Rivers studies compared to the wildlife rehabilitator study. Clean Rivers volunteers employed motivation scales from Batson et al. (2002), Raddick et al. (2010), and Land-Zandstra et al. (2016a; 2016b), along with an attitude scale for science (Price & Lee, 2013). In contrast, for rehabilitators, we utilized Levontin et al. (2022) for motivations and a science capital measure (Peeters et al. 2022b). These differences reflect the rapid evolution of the field of citizen science research, with the development of newer tools for assessment of impacts on participants' environmental attitudes, knowledge and behaviour (e.g., Somerwill & Wehn 2022). For the purpose of this dissertation, this is not a problem, since we have not directly compared Clean Rivers participants with WRC volunteers. However, caution is necessary when comparing results across chapters, as the questions and scales vary.



A second limitation involves potential biases in data collection. Participation in the surveys and interviews was voluntary, which introduces the risk of self-selection bias, as more enthusiastic volunteers may skew the results positively. In the Clean Rivers study, participation in the initial survey was strongly encouraged, resulting in a high response rate. Although follow-up surveys were optional, we found no significant demographic differences between respondents and non-respondents. Respondents may nevertheless have provided socially desirable answers, contributing to social desirability bias, such as exaggerating pro-environmental attitudes (Latkin et al. 2017). Because the measures of motivation, attitudes, and knowledge were self-reported, they should be interpreted as participants' subjective perceptions rather than objective assessments of these concepts. Self-reported data are inherently sensitive to recall inaccuracy and self-presentation effects, meaning that participants might have over-emphasized certain motivations or remembered their reasons for joining differently over time. We attempted to

minimise these biases by ensuring anonymity in interviews and framing questions neutrally, yet they remain important to consider when interpreting the findings.

We widely distributed the questionnaire in the wildlife rehabilitator survey, but centers that were more open to collaboration might have biased the sample. Nonetheless, the participants' educational and scientific backgrounds were representative of the general public, suggesting that the sample is not significantly skewed. However, participants likely had a pre-existing interest in our study topic. To reduce social desirability bias, we ensured anonymity in interviews and framed questions neutrally. Still, our findings primarily reflect the views of the volunteers who engaged with us, possibly excluding non-respondents. Future research should actively reach out to non-respondents to gain a better understanding of their perspectives.

A third limitation concerns the integration of data from online news and social media. Verifying online observations involves biases, including discovery bias, as we can only include cases shared via search engines. Cases from regions less active on social media may be overlooked, underrepresenting incidents there. Confirming information from online posts is challenging; although we contacted observers and sought photographic evidence, this process was often time-consuming and not always successful. More research is needed to establish best practices for integrating news and social media observations into scientific studies, including efficient data validation methods and understanding biases in opportunistic data.

## 6.3 General discussion and recommendations

This section interprets our findings in light of previous research and discusses their broader implications. The discussion is organized around key themes: participant background, motivation, participant impact, and integration of new data sources and volunteer communities. Within each theme, I also provide recommendations for researchers studying citizen science and for practitioners (including scientists and project leaders who implement citizen science projects) which are summarized in figure 6.1 at the end of this chapter.

### 6.3.1 Participant background

A key finding from this PhD research is that the Clean Rivers citizen science project predominantly engaged volunteers similar to those in other initiatives. The gender distribution among participants reflected that of the general public. However, differences in age and education were evident: over half of Clean Rivers participants were middle-aged (45–65), and nearly three-quarters held higher education degrees. This reflects a common trend in citizen science, wherein many projects tend to attract well-educated, middle-aged individuals (Mac Domhnaill et al., 2020; Pandya, 2012; Pateman et al., 2021). Previous studies have suggested that environmentally themed projects especially appeal to people who are already aware of or concerned about environmental issues (Crall et al., 2013). Our results support this notion: Clean Rivers volunteers

had a strong affinity for science and nature, likely related to their educational backgrounds and prior involvement in environmental activities.

In contrast, wildlife rehabilitators had a more varied educational background, aligning more closely with the national population. This suggests that by engaging existing communities of volunteers collecting data, we might reach individuals who do not typically participate in citizen science. It is worth noting, however, that the wildlife rehabilitator group was predominantly female, consistent with patterns in the animal care and wildlife rescue sector reported in other studies (e.g. Englefield et al., 2019; Haering, 2020b). We did not collect detailed background data for the ad hoc COVID-19 litter reporters. Still, it included a diverse mix of scientists and members of the public, including wildlife rehabilitators, veterinarians, dog owners, and photographers. Social media as a reporting platform can potentially engage a broad audience. A very large proportion of the Dutch population for example, uses social media; approximately 88% of those aged 12 and older are active online daily, with the youngest age groups being the most active (CBS, 2020). This indicates that social media content like wildlife observations could come from a broad audience, including younger people who are typically harder to reach in volunteering and citizen science (e.g. Ganzevoort & van den Born 2020; Pateman et al., 2021). However, more research is needed to understand the background of those who share data that can be used in scientific research.

Some argue we don't need everyone to participate, as individuals self-select based on interests (Montanari et al., 2021). However, a primary goal of citizen science is to democratize science and involve communities in relevant issues (Heigl et al., 2019; Strasser et al., 2019). Engaging diverse participants can make science inclusive and empower those who might not interact otherwise. A diverse volunteer base also brings different perspectives and innovations to research (Bäckstrand, 2003; Lidskog, 2008). Thus, researchers and practitioners should strive to expand participation. Our work suggests integrating established volunteer communities, like WRCs, to better represent and benefit the public. By connecting with volunteers who are already active on the topic, we can diversify contributions to citizen science.



It is also crucial to consider the barriers that prevent certain groups from participating. While our project, Clean Rivers, did not specifically study non-participants, we can identify potential barriers such as accessibility, time, and costs. For example, Clean Rivers required volunteers to physically visit riverbank locations to collect data, which could exclude individuals without access to a car or the ability to afford travel expenses (Pateman et al. 2021; Skarlatidou et al. 2019). Thus, a project that does not reimburse travel may inadvertently exclude lower-income individuals. In the case of wildlife rehabilitators, many cited time constraints as a barrier to getting involved in additional activities like research or public education and the need to prioritize animal care. Researchers who wish to collaborate with such groups need to be mindful of these limitations: for instance, by aligning research activities with rehabilitators' existing work interests, including funds for their involvement, developing simple data collection methods that fit into their routine, and sharing the research results with that community. Communication and framing also play

a key role in overcoming participation barriers. Clean Rivers may have framed its call to action in ways that appealed more to those already environmentally aware. If recruitment materials emphasized "citizen science" and data collection, it might attract individuals with a science background and higher education, as familiarity with the term is greater among those with more education (Lewandowski et al., 2017). Among rehabilitators, only 25% recognized "citizen science," the same percentage found in the study by Lewandowski et al. (2017). This suggests that many potential contributors might not identify with the concept if it is not well-known or explained.

**Implications for researchers:** Examining the drivers and barriers faced by underrepresented groups, such as financial limitations or a lack of familiarity with the terminology, is crucial. Further research is needed on how the public perceives citizen science and which communication strategies are most effective for increasing participation from diverse backgrounds.

**Implications for practitioners:** Understanding participants' demographics and addressing potential barriers, such as financial support and accessible communication, can help recruit and retain a diverse audience. Integrating existing volunteer groups, a more diverse audience could also be engaged in scientific research. This is especially true when the focus is not just on scientific outcomes, but also on how these outcomes relate to people's interests and needs, such as the benefits for wildlife.

### 6.3.2 Motivation

Motivation plays a crucial role in both attracting and retaining citizen science volunteers. A key finding in this research was that Clean Rivers volunteers and wildlife rehabilitators had motivations closely aligned with the respective project goals. Clean Rivers participants were primarily driven by a desire to address plastic pollution at its source and contribute to policy solutions. Over time, action-oriented and environmental motivations increased, while personal motivations, such as an interest in scientific research, diminished. This suggests that while initial curiosity may attract volunteers, long-term commitment is sustained by a sense of purpose and impact. Wildlife rehabilitators' motivations were diverse but largely centered on helping animals and supporting conservation, aligning with the mission of rehabilitation centers. Since these volunteers did not join for research purposes, integrating scientific tasks into their work should connect with their core motivations, such as improving animal care. People are likely to take on additional tasks if they align with their primary interests (Clary et al., 1998; Deci & Ryan, 2000).

Previous research has identified common motivations for volunteers, including environmental concern, knowledge gain, enjoyment of nature, and social interaction (Measham & Barnett, 2008). Clean Rivers volunteers prioritized environmental impact over social aspects, indicating they were attracted to the project because of its direct, action-oriented approach. To maintain engagement, project leaders could highlight volunteers' primary motivations, such as policy

impact and environmental improvements. Although social interaction and learning were not primary motivators for most, organizers could still offer optional workshops or networking opportunities to accommodate volunteers who value those aspects. Since Clean Rivers primarily attracted environmentally conscious individuals, outreach strategies could be adjusted to engage broader audiences, such as younger participants or those not initially concerned with plastic pollution. Highlighting different benefits, such as community engagement, could help diversify participation. However, recruitment messages and communication in general should be transparent to avoid misrepresenting the volunteer experience, as inaccurate expectations may lead to disappointment (Skarlatidou et al., 2024; Vegt et al., 2023). Monitoring shifts in motivation over time is important for sustaining engagement. Introducing new activities or responsibilities can help maintain interest if initial enthusiasm declines. For instance, Clean Rivers participants' decreasing interest in learning suggests they may have felt overqualified; offering advanced training or new roles could re-engage these volunteers. Similarly, wildlife rehabilitators should be actively involved in designing data collection processes to ensure they are simple, relevant, and seamlessly integrated into their existing routines. This approach would improve both motivation and data quality (e.g. Hoover, 2016; Pandya, 2012).

Although motivations for reporting COVID-19 litter incidents were not formally assessed, contributors likely shared observations to raise awareness. Acknowledging their contributions and informing them about their data use could encourage continued participation in environmental monitoring efforts.

**Implications for researchers:** To understand what influences retention, researchers need to monitor participants' motivation, especially after the impact of the first years on motivation. We recommend comparing those who remain involved with those who stop participating.

**Implications for practitioners:** To keep volunteers motivated, projects could organize activities and adjust their communication in ways that align with volunteers' motivations. For example, science projects on plastic pollution could highlight the actions participants can take, such as advocating for policy changes. To keep wildlife rehabilitators involved, projects could stress how their contributions to scientific research also contribute to wildlife preservation, for example, via lectures.



### 6.3.3 Impact on participants' knowledge and attitude

Citizen science often aims to enhance participants' understanding of project topics and shape their attitudes toward science. In the project Clean Rivers, although the participants were generally well-educated, we observed significant improvement in their understanding of plastic pollution and scientific research practices, especially during their first year of involvement. This improvement can be linked to the mandatory training they received at the start, which aligns

with studies showing that proper training can increase volunteers' knowledge (e.g. Brossard et al., 2005; Phillips et al., 2019). Clean Rivers conducted annual events to share results and workshops, transitioning to an online format in 2020-2021 due to COVID-19, which may have affected their effectiveness. We only assessed participation in monitoring sessions and did not account for involvement in other activities. To better evaluate the impact of these initiatives during long-term participation on participants' knowledge and attitude, we recommend including them in future research.

Our findings align with previous studies indicating that volunteers maintain positive attitudes toward nature and science, which remain unchanged by participation (Brossard, 2005). Positive attitudes may be more difficult to shift or may require different interventions. Engaging a more diverse audience with a lower affinity for science could lead to greater changes in attitude (Edwards et al., 2018). Since the science capital of wildlife rehabilitators reflects that of the general Dutch public, linking them to scientific research could positively affect this capital.

**Implications for researchers:** To understand how participation in citizen science affects participants' knowledge and attitude, we need to monitor their engagement in different project activities, such as training sessions and webinars.

**Implications for practitioners:** Organize training and other learning activities relevant to the projects' topic or scientific research to potentially increase participants' knowledge, regardless of their educational background.

### 6.3.4 Integrating other data and volunteers

This dissertation explored new methods of integrating existing sources of volunteers and data into scientific research. While structured citizen science projects adhere to protocols to ensure data quality, blending external data sources presents challenges. Wildlife rehabilitators prioritize animal care over research, possibly resulting in inconsistencies in the data gathered. Social media observations also differ in detail and reliability. Nevertheless, WRC volunteers regard their data as valuable and are receptive to standardization (Grogan & Kelly, 2013). To enhance data quality, projects should provide training and ensure that rehabilitators receive feedback on research outcomes.

Training should be adapted to the available time and experience of volunteers. Short online tutorials, onboarding sessions, or peer-learning workshops can strengthen confidence in data collection without adding large time commitments. Periodic refresher sessions or training volunteers of an organization as ambassadors of the project can maintain data quality and motivation over time.

Successful collaboration between scientists and volunteers requires reciprocity and ongoing feedback. In practice, this can include sharing summarized results with participants through for example newsletters, websites, or short annual reports that clearly show how their contributions informed analyses or policy outcomes. This could lead to continued engagement of volunteers and demonstrates the impact volunteers can have on science, society and nature. Feedback should not only communicate results but also invite dialogue, for instance by asking participants for input on research questions or interpretations of data. The citizen science project Clean Rivers communicates their findings in different ways and formats, including a newsletter, yearly event, webinars, reports and factsheets.

Collaboration should build on the existing practices and capacities of volunteers and organizations. In wildlife-rehabilitation settings, this could mean integrating standardized data fields into existing registration software. Co-design sessions or advisory groups involving both scientists and volunteers can ensure that research questions reflect community priorities and that results are translated back into practice. Structural support from funders and institutions is vital. Including budget lines for coordination, volunteer training, and feedback activities in citizen science projects enables long-term collaboration and inclusivity. These relatively small investments can substantially increase data quality and retention while ensuring that citizen science projects remain mutually beneficial for researchers and participants. Social media and news observations provide a scalable but unstructured data source for environmental monitoring. Our COVID-19 litter study showed that integrating online reports provided insights impossible to gain through traditional citizen science. Experts' verification, cross-referencing reports, and platforms like Observation.org could improve data reliability (Ghermandi & Sinclair, 2019; Nascimento et al., 2024). The terminology surrounding such data is debated. Some researchers classify passive data collection as crowdsourcing rather than citizen science, as contributors are often unaware that their posts are being used for research (Haklay et al., 2021; Strasser et al., 2019). While WRC volunteers already collect data, they could be informed about and engaged in scientific collaborations. Establishing standardized databases and co-developing protocols with WRCs would enhance data consistency and usability (Department of Planning, Industry and Environment NSW, 2020). However, social media contributions may continue to be viewed as opportunistic data collection rather than active participation, which complicates adherence to the ten principles of citizen science (Robinson et al., 2018). Despite these limitations, informal data sources can complement traditional monitoring. Our findings indicate that rehabilitators and citizen-based observations yield valuable insights into environmental issues, such as the impact of plastic pollution on animals. Policy makers have already utilized crowdsourced data to tackle environmental concerns (Tulloch et al., 2013)

In conclusion, integrating non-traditional data sources expands citizen science participation, especially among underrepresented groups. Although challenges persist in assuring data quality and ethical usage, these approaches can improve environmental monitoring and policymaking.

**Implications for researchers:** Further research is needed on the potential of existing volunteer communities like wildlife rehabilitators and online data sources for scientific research, their data quality and validation.

**Implications for practitioners:** Support the integration of existing volunteer communities and data sources in scientific research by being aware of peoples' limited time and resources. Explore volunteers' needs and interests, and when needed involve them in funding proposals, co-create data collection methods, offer training and actively share the results with the volunteers.

## 6.4 Final reflections

Building on the practical recommendations outlined in Section 6.3, this final reflection looks beyond the specific case studies of this dissertation to consider what they reveal about the broader role of citizen science as a societal practice. While **Chapter 5** focused more on public contributions through incidental observations than on participants themselves, it broadens our understanding of how diverse forms of engagement, both active and passive, can support environmental monitoring and potentially reach wider audiences. Together, the studies in this dissertation contribute to two central goals: understanding the current demographic and motivational profiles of citizen scientists, and identifying strategies to engage broader and under-represented audiences in environmental research.

This dissertation sheds light on the backgrounds, motivations and knowledge of citizen scientists participating in plastic pollution research. As reflected in broader citizen science trends, participation was mainly limited to highly educated individuals. While participants' knowledge of the topic and of scientific research increased during their involvement, their attitudes towards science and nature were already positive and remained largely unchanged. To make citizen science more inclusive, it is crucial to recognise that knowledge, interest and motivation exist across many social groups, but that opportunities to participate often do not.

This dissertation also explored new ways of reaching and benefiting a wider public through citizen science by examining an existing community of volunteers who already collect data with scientific potential, and by studying observations shared online. These approaches demonstrate that a broader range of people can meaningfully contribute to research, even if they do so informally or unintentionally. The challenge lies in connecting with and motivating these contributors, to both share their knowledge and deepen their own understanding and engagement. Scientists should actively involve the public in research when possible and share results that highlights participants' contributions to research, society and nature. Doing so strengthens scientific knowledge while also benefiting society and the environment.

Stronger links between science, society and policy are particularly important given the urgency of today's environmental challenges. Yet while current citizen science initiatives are valuable, they are not sufficient to reach or benefit a truly diverse audience. To involve a more representative segment of society in the co-creation of scientific knowledge, researchers must also create space for people to share ideas, raise questions and participate in shaping the research process itself. This requires dialogue, mutual respect and a willingness to learn from non-academic perspectives.

If science is to be truly democratised, it must open its doors more widely and build inclusive, mutually beneficial relationships with society. Researchers could also look for other doors that are, or could be, opened, such as those of wildlife rehabilitation centers. Rather than expecting the public to enter the doors of science, researchers might more often step through the doors of society.

Just as effective science communication is increasingly based on dialogue rather than one-way dissemination, citizen science should also be a two-way street. Researchers cannot expect the public to engage simply because they are asked to, or because science needs them. They must also engage with society to understand its motivations, questions and concerns. Citizen science should be as much about helping society as it is about helping science. At the same time, researchers must remain aware of their own positionality and maintain independence, objectivity and critical reflection.

Volunteering, especially for students and early-career researchers, can help scientists stay grounded in the world beyond academia, to understand how knowledge circulates in society and what motivates people, much like an anthropologist observing a culture of practice. Researchers are, after all, explorers of knowledge not only behind laptops or in laboratories but also through listening to and learning from people. Truly democratising science also requires structural change in how research is funded, evaluated and communicated, so that inclusive and collaborative public engagement is not merely encouraged but genuinely sustained.

An open, inclusive and reflexive approach to citizen science is not only possible but necessary to make research more relevant and impactful. Recognising citizens not merely as data collectors but as partners in knowledge creation can move science towards being more democratic, more responsive and more deeply connected to the living world it seeks to understand.

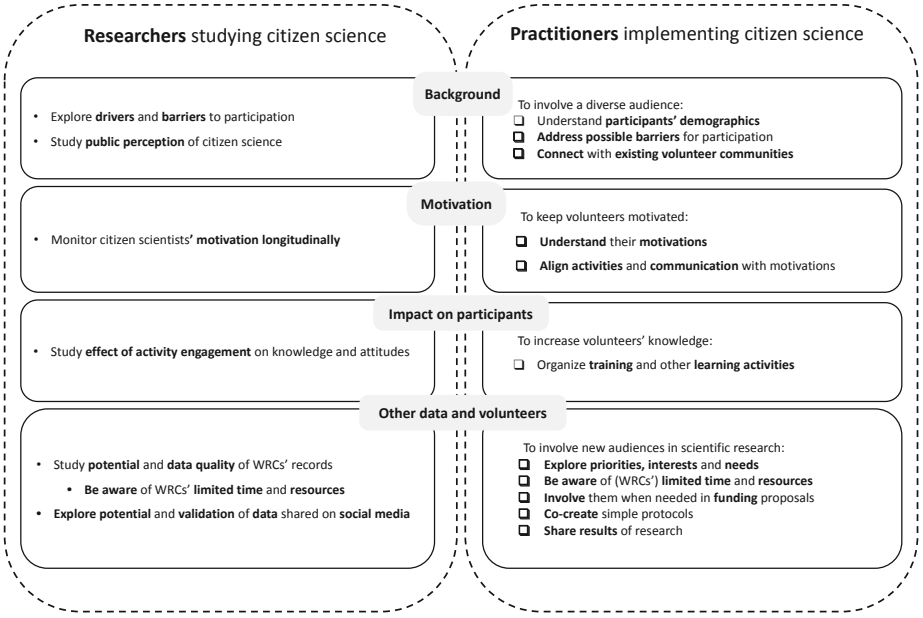


**Figure 6.1** Recommendations for researchers studying citizen science and practitioners implementing citizen science regarding the background of volunteers, their motivation, a projects' impact on participants and the integration of other data and volunteer sources in scientific research.

6

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**Photo credits**: *Liselotte Rambonnet*

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# Appendices

**Photo credits:** *Anjès Gesink*

# Appendix 3.1

Pre- and post-survey questions
*All questions were mandatory, and it is specified in which survey the question was asked and when it was a single-choice question.*

**The following statements are about your motivation to participate in Clean Rivers. Per statement you can indicate to what extent it is a motivation for you to participate as a volunteer.** (*pre- and post-survey*)
*Likert scale: Totally disagree – disagree – neutral – agree – totally agree*
I participate in Clean Rivers, ...
...because I am disturbed by the litter in nature and on the streets
...because I live(d) close by the Maas or the Waal
...because I like to recreate near or on the water
...because I like to volunteer
...because this way I can help to tackle the plastic soup
...because I am interested in the kinds of litter that is present in the rivers
...because I like to join a bigger movement to improve the world
...because I like to be outside

**What is your most important motivation to participate in Clean Rivers?** (*single choice, pre- and post-survey*)
- o Because I am disturbed by the litter in nature and on the streets
- o Because I live(d) close by the Maas or the Waal
- o Because I like to recreate near or on the water
- o Because I like to volunteer
- o Because I am interested in the kinds of litter that is present in the rivers
- o Because I like to join a bigger movement to improve the world
- o Because I like to be outside
- o Other reason, namely...(*open answer*)

**As a river litter researcher you are going to collect data that will be used for scientific research. Per statement you can indicate to what extent it is a reason for you to fulfill the role as researcher in Clean Rivers.** (*pre- and post-survey*)
*Likert scale: Totally disagree – disagree – neutral – agree – totally agree*
I want to become a river litter researcher, because...
...because I like to contribute to scientific research
...because I am interested in the performance of scientific research
...because I hope to learn about conducting scientific research
...because it would be fun to do scientific research
...because with the results litter can be tackled at the source
...because my contribution can help to force governments or companies to take measures against litter
...because it is important to collect as much information as possible about litter in the rivers

**What is your most important motivation to become a river litter researcher?** *(single choice, pre- and post-survey)*

- o Because I like to contribute to scientific research
- o Because I am interested in the performance of scientific research
- o Because I hope to learn about conducting scientific research
- o Because it would be fun to do scientific research
- o Because with the results litter can be tackled at the source
- o Because my contribution can help to force governments or companies to take measures against litter
- o Because this way I can help to tackle the plastic soup
- o Because it is important to collect as much information as possible about litter in the rivers
- o Other, namely... *(open answer)*

**Below you will find a couple of statements regarding your attitude towards nature. Per statement you can indicate to what extent you agree or disagree.** *(pre- and post-survey)*
*Likert scale: Totally disagree – disagree – neutral – agree – totally agree*

- My relationship to nature is an important part of who I am
- People have the right to use natural resources in any possible way
- I feel very connected to all living things and the earth
- I always think about how my actions affect the environment
- Conservation is unnecessary because nature is strong
- My ideal vacation spot would be a remote, wilderness area
- The thought of being deep in the woods, away from civilization, is frightening
- I enjoy being outdoors, even in unpleasant weather
- I don't mind if some plants- and animal species become extinct

**Below you will find a couple of statements regarding your attitude towards natural science. With natural science we mean the knowledge of and research on nature and nature conservation. Per statement you can indicate to what extent you agree or disagree.** *(pre- and post-survey)*
*Likert scale: Totally disagree – disagree – neutral – agree – totally agree*

- I actively seek out stories about natural science in the news.
- I am likely to attend a lecture or course about natural science
- I am knowledgeable about natural science
- I use knowledge of natural science to evaluate claims made about natural science
- I pay attention if a natural science news item crops up in a media source I am
- already following
- I use knowledge of natural science in everyday life
- I am interested in news about natural science
- I am interested in science

**Below you will find a couple of statements. Give yourself a grade per topic that represents your knowledge about that topic. Grade 1 means very little knowledge and a 10 a lot of knowledge. A 6 or higher is sufficient**. *(pre- and post-survey)*

- Causes of litter
- Consequences of litter for nature
- The extent of pollution by litter in the Netherlands
- Ways to act sustainable in daily life *(post-survey 2020 and 2021)*
- The OSPAR-declaration
- The process of a scientific research
- The use of protocols (like observation schedules and tally sheets) during scientific research

**What is your gender?** *(single choice, pre-survey)*
o Male
o Female
o Other

**What is your year of birth?** *(open question, pre-survey)*

**What is your highest level of education?** *(single choice, pre-survey)*
o None
o Primary school
o VMBO *(secondary school)*
o HAVO *(secondary school)*
o VWO *(secondary school)*
o MBO *(vocational training)*
o HBO *(university of applied sciences)*
o WO *(research university)*
o Other, namely...

## Appendix 3.2

Dataset 2017–2021.
DOI: https://doi.org/10.5334/cstp.667.s2

## Appendix 3.3

Data analysis report.
DOI: https://doi.org/10.5334/cstp.667.s3

## Appendix 3.4

Conditional independence networks: motivation, attitude, and knowledge.
DOI: https://doi.org/10.5334/cstp.667.s4

# Appendix 4.1

Interview protocol

**I. Organization**

1. When was [organization name] founded?
   a. By whom?
   b. What was the purpose of founding [organization name]?
2. When did you become involved with [organization name]?
   a. Why did you become involved?
3. Approximately how many people work there now?
   a. Paid?
   b. Volunteers?
   c. Is the number sufficient?

**II. Volunteers**

1. How are tasks divided between paid staff and volunteers?
2. What are the responsibilities of volunteers?
3. What do you see or hear as the main motivation for volunteers?

**III. Communication**

1. How do you communicate about your work to the public?
   a. Membership booklet
   b. Website
   c. Newsletter
   d. Social Media
   e. Newspaper
2. Why do you do this?
3. What topics do you communicate about?
4. What message would you most like to convey to the public?
5. How do you experience the communication with the public?

**IV. Data Collection**

1. What kind of data do you collect regarding the animals you rescue?
   a. Species
   b. Gender
   c. Age
   d. Location
   e. Reason for rescue
   f. Treatment
   g. Outcome
   h. Ring number
   i. Any other data not listed?

2. Who collects the data?
3. Why do you collect this data?
4. How is this data recorded?
   a. On paper
   b. Digitally
   c. What system?
5. How many years of data do you have?
   a. On paper
   b. Digitally
6. How accurate is the data being kept?
   a. For example, species name
   b. Is the reason for rescue accurately determined?
   c. Location?
7. Does anyone check the data?
8. How do you find the process of collecting data?
   a. What's going well?
   b. Challenges?

**V. Data Feedback**

1. What happens with this data?
2. Do you use the data yourselves?
3. Is there anything notable about your data?
4. Would you like to know more about the data you collect?
5. Do you share the data with others?
   a. Volunteers
   b. Policymakers (municipalities/provinces/ministries)
   c. Other wildlife rehabilitation centers
   d. Other organizations (water boards, etc.)
   e. Researchers
   f. Public
6. How is this data shared?
7. When is this data shared?
8. How is it received?
9. How do you find the process of giving feedback on the data?
   a. What's going well?
   b. Challenges?
10. With whom would you like to share the data?
    a. Why?

# Appendix 4.2

Overview of interviewees, the centers they represent, their founding year, the number of volunteers, the interviewees' role(s), the province, location and specialisation.

| Center | Founded | Volunteers | Role interviewee(s) | Province | Location* | Animals |
|---|---|---|---|---|---|---|
| Avolare | 2018 | >50 | Coordinator and founder | Overijssel | Urban | Wildlife |
| Das & Boom | 1981 | 0-50 | Coordinator | Gelderland | Urban | Badgers |
| De Fûgelhelling | 1975 | >50 | Coordinator | Friesland | Rural | Wildlife |
| Ecomare | 1952 | 0-50 | Rehabilitation coordinator | North Holland | Rural | Marine mammals and birds |
| Egelopvang Den Haag | 1988 | <50 | Senior volunteer | South Holland | Urban | Hedgehogs |
| Egelopvang Roosendaal | 1999 | 0-50 | Founder and coordinator | North Brabant | Rural | Hedgehogs |
| Ooievaars buitenstation De Lokkerij Reestdal | 1981 | 0-50 | Founder and coordinator | Drenthe | Rural | Storks |
| SOS Dolfijn | 2004 | >50 | Coordinator and research manager | North Holland | Rural | Marine mammals |
| Vogelasiel Bergen | 1997 | 0-50 | Coordinator | Limburg | Rural | Wildlife |
| Vogelhospitaal Haarlem | 1956 | >50 | Coordinator | North Holland | Urban | Birds |
| Vogelklas Karel Schot | 1980 | >100 | Chairman of the board | South Holland | Urban | Wildlife |
| Vogel- en zoogdieropvang De Mikke | 1983 | 0-50 | Founder, coordinator and senior caretaker | Zeeland | Rural | Wildlife |
| Vogelrevalidatiecentrum Zundert | 1980 | >50 | Coordinator | North Brabant | Rural | Wildlife |

*Urban when located within ten kilometers from a city with more than 100,000 inhabitants

# Appendix 4.3

Interview codebook containing themes and codes, derived from thirteen qualitative interviews with wildlife rehabilitation centers' representatives.

| **Theme 1: Organization** | |
|---|---|
| **Code** | **Description** |
| **Paid employees** | When the rehabilitation center employs paid staff, referring to the number of employees and/or their tasks. It can also include plans for expansion or wishes for more paid employees in the future. |
| **Finances** | If current and future financial matters are discussed, such as funds to finance specific needs, where the money comes from, and what it's needed for. This also includes when the public believes that rehabilitation centers only have paid employees. |
| **Motivation senior** | About the motivation and reasons of the interviewees for being active at the rehabilitation center, either as volunteers and/or paid staff. |
| **Founding and aim** | Information about the founding of the rehabilitation center, including the reasons and general focus. This can include details like the year it was established, the location, and the types of animals they care for. It can also refer to the overall purpose of the center, such as both rehabilitation and education, and specific decisions they make, like choosing not to name the animals. |
| **Collaborations** | About collaborations with external organizations and initiatives, such as other municipalities, rehabilitation centers, veterinarians, park rangers, and animal ambulances. This includes which organizations they work with, the extent of the collaboration, and their experiences and challenges. For collaborations related to knowledge exchange and research: for future plans, see theme 5, code collaborations. |
| **Future rehabilitation** | When discussing wishes or challenges for the future of the organization, such as tasks, staffing of paid employees, collaborations, and also data collection. |
| **Circumstances** | Regarding the effects of COVID-19, avian flu, and invasive species on the organization, including educational activities and other interactions with the public. This does not refer to the impact of COVID-19 and avian flu on research. |
| **Theme 2: Volunteers** | |
| **Code** | **Description** |
| **Number of volunteers** | The number of volunteers an organization has, including caretakers, education volunteers, and external volunteers (e.g. people with outdoor hedgehog enclosures). |
| **Availability and retention** | When there are enough volunteers or a shortage of volunteers, as well as discussions about why volunteers stop or how long they remain active. |
| **Motivation** | About the reason(s) why people volunteer at the organization, which can also include desired motivations. |
| **Tasks** | On the division of tasks, the responsibilities of the volunteers, and the types of volunteers, such as educational staff. |
| **Theme 3: Communication and education** | |
| **Code** | **Description** |
| **Best practices** | When something goes well in terms of communication and education, such as reaching many people or leading to donations. |

| Code | Description |
|---|---|
| **Events and open days** | About special open days or other occasions when people can visit the rehabilitation center. |
| **Goal and style** | About the purpose of the communication and education efforts of a center, the key messages they want to convey to the public. This can also include the manner or style of communication (e.g., positively critical). |
| **Platform** | Through which medium they communicate with the public, such as television, radio, social media, website, booklets for donors, or school visits. |
| **Challenge** | Challenges in communicating with the public. |
| **Theme 4: Data collection** | |
| **Code** | **Description** |
| **Purpose** | When a reason for collecting data on the animals is mentioned, such as for care, finances, or research. |
| **Availability** | How many years of data are still available. This might not always be an exact year but rather an indication, such as data from many years ago. |
| **Quality** | When the accuracy and completeness of the collected data are discussed and whether this is considered important, for example, for releasing animals. This could also include parties that determine data quality, such as animal ambulances. |
| **Type** | Which data are recorded, such as location of discovery, date, cause, specific details, and chip number. |
| **System** | How the data is recorded, such as on paper or digitally, and which programs or tools are used. It can also include wishes for modifications to the current system or for a new system. Does not refer to old systems, which may relate to the code: 'Availability.' |
| **Theme 5: Data usage** | |
| **Code** | **Description** |
| **Trends in animal intake** | About the number of animals taken in per year, any increases or decreases, possible explanations for growth or decline, and potential implications. |
| **Internal use** | When a rehabilitation center conducts research using its data for internal purposes, for example, to improve success rates. |
| **Research ideas** | When ideas are shared about how the data or deceased animals could be used for research. For example, research on success rates, identifying diseases like avian flu, or the impact of weather conditions. |
| **Cause of admission** | About the reasons why animals end up in a rehabilitation center. |
| **Notable observations** | When it concerns specific insights based on the data about the animals they care for. If it relates to the number of animals, it belongs to code: 'Trends in animal intake.' |
| **Collaborations** | About collaborations for knowledge exchange and research on treatment methods, data, and diseases, such as partnerships and knowledge sharing with foreign rehabilitation centers, working groups, bird banders, and other knowledgeable parties. This also includes reporting and exchanging banding data (in the Griel database). |
| **Feedback** | About whether feedback is received from researchers, students, and government organizations with whom data or deceased animals are shared. It can also concern wishes or experiences regarding the format or content of the feedback. |

| Code | Description |
|---|---|
| **Challenge** | When challenges in conducting research are discussed, such as a lack of manpower, funding, or knowledge. |
| **Animal release** | When it concerns the release of animals, the reasoning behind the choice of a specific release location, and any data that are important for this decision. |

# Appendix 4.4

Quantitative survey design

*Thank you very much for completing this questionnaire. Thanks to your contribution, we will learn more about the volunteers at Dutch wildlife rehabilitation centers, which include centers for all wildlife (such as birds and hedgehogs). We are curious to know who works there, why, and how volunteers look at the animal data the centers collect. This questionnaire consists of three categories: Motivation, Research, and Profile, and completion takes about 10 minutes.*

*The questionnaire is completely anonymous. Your name cannot be traced.*
*- Only the researchers make use of the completed information.*
*- You can stop completing the questionnaire at any time.*
*- The summary of the results will be shared with all rehabilitation centers.*

o I agree to the processing of the data I fill in.

*This research is conducted by [authors' organization]. If you have any questions about this research, please contact [author name] at [author email address].*

**Part 1:**
**Motivation**
Here are some questions about your experience and motivation as a volunteer at a wildlife rehabilitation center.
**Q1 What is the name of the wildlife rehabilitation center where you volunteer? Please be as specific as possible.**
If you volunteer at several centers, please choose the one you have the most experience with.
_____

**Q2 What tasks do you have at your center?**
Multiple answers possible.
o Answering the phone
o Taking care of animals (intake, care, feeding, cleaning)
o Maintaining social media
o Coordinating
o Giving guest lessons

o Showing visitors around
o Other, namely: _____

**Q3 How many years of experience (estimated) do you have as a volunteer in wildlife rehabilitation?**

_____

**Q4 On average, how many hours per week (estimated) do you work for your current center?**

_____

**Q5 How did you end up at your current wildlife rehabilitation center?**

o Multiple answers possible.
o Through friends and/or family
o Through social media
o Through a (newspaper advertisement
o When I found an animal in need myself
o Via a search engine
o Through a visit to the center
o I don't remember
o Other, namely: _____

**Q6 We are curious about your reasons for volunteering at a wildlife refuge. To what extent do the following reasons for participation apply to you on a scale of 1 (completely disagree) to 5 (completely agree)? If you have no answer for a particular item, please use 'don't know/ don't prefer to say'. I volunteer because...**

| | 1 | 2 | 3 | 4 | 5 | Don't know / Would rather not say |
|---|---|---|---|---|---|---|
| ...I want to learn something | | | | | | |
| ...I want to do some physical activity | | | | | | |
| ...I want to be part of this volunteers' community | | | | | | |
| ...I want to contribute to this community | | | | | | |
| ...I enjoy this activity | | | | | | |
| ...I want to contribute to the conservation of nature | | | | | | |
| ...I want to make the world a better place | | | | | | |
| ...I am happy to help | | | | | | |
| ...volunteering makes me feel important | | | | | | |
| ...I want to share my knowledge and experience | | | | | | |
| ...I strive to challenge myself | | | | | | |
| ...I am interested in animals | | | | | | |

| | 1 | 2 | 3 | 4 | 5 | Don't know / Would rather not say |
|---|---|---|---|---|---|---|
| ...I want to enhance my reputation | | | | | | |
| ...I want to help animals | | | | | | |
| ...I want to feel part of something worthwhile | | | | | | |
| ...I want to socialize with other people | | | | | | |

**Q7 Do you have any other motivation?**
Not required.

**Part 2:**
**Research**
For rehabilitation of an animal, centers record the animal species, finding location, reason for admission, and date, among others. This part of the questionnaire deals with these data. Please note that the questions are not about privacy-sensitive data such as the reporter's name or phone number.

**Q8 Do you record animal data yourself?**
o Yes
o No

**Q9 For the statements below, please indicate the extent to which you agree.**
**visible when question 8 is 'yes'*

| | 1 | 2 | 3 | 4 | 5 | Don't know / Would rather not say |
|---|---|---|---|---|---|---|
| I can correctly identify which animal species it is. | | | | | | |
| I know where the animal was found. | | | | | | |
| I can correctly indicate the reason for its admission. | | | | | | |

**Q10 Can you explain your answer?**
*visible when question 8 is 'yes'

_____

**Q11 Do you know what happens to animal data after it is recorded by your center?**
*For example: animal data such as species name, date of admission and reason for admission*
o Yes
o No

**Q12 Can you explain your answer?**
***Not required.***

_____

**Q13 Who, in your opinion, is the owner of animal data your organisation and/or you collect?**

o There is no owner, everyone should be allowed to see and use the data (public interest).
o The organisation is the owner, but interested parties should be able to see and share the data.
o The organisation owns the data but does not have to share it.
o I own the data I collect.
o Other, namely: _____

**Q14 Have you ever heard of the terms 'citizen science' and/or 'burgerwetenschap'?**

o Yes, citizen science
o Yes, burgerwetenschap
o Yes, both
o No, neither

**Citizen science or citizen science is research done in a collaboration between scientists and citizens. During such research, citizens collect or study data. This data is important to draw certain conclusions about a topic. An example is the National Garden Bird Count, which teaches us more about the species and number of birds in gardens.**

**Q15 Do you think data collection by your center could be a form of citizen science?**

o Yes
o No
o Do not know

**Q16 Can you explain your answer?**

*Not required.*

_____

**Q17 Animal data may be of interest to researchers, e.g., to universities and other research institutes. Please indicate the extent to which you agree with the following statements:**

| | 1 | 2 | 3 | 4 | 5 | Don't know / Would rather not say |
|---|---|---|---|---|---|---|
| I like the idea of animal data from our center being used for research. | | | | | | |
| The quality of the animal data is good enough for further research. | | | | | | |
| I would like to gain insight into the animal data collected within my center. | | | | | | |
| I would like to contribute in more ways to research related to animal data from my center. | | | | | | |
| I think researchers should provide feedback on what they have done with the data. | | | | | | |
| I would like to have insight into animal data collected at other centers. | | | | | | |

**Q18 Are there topics for further research that interest you?**

*Multiple answers possible.*

- o Spread of diseases (such as bird flu and yellow)
- o Number of animal species and number of animals
- o Impact of humans on animals
- o Success rate of rehabilitated animal
- o Prevention of animals in distress
- o Other, namely: _____
- o I don't know/I'm not interested

**Q19 Can you explain your answer?**

*Not required.*

_____

**Part 3:**
**Profile**
**The following are some questions about your background.**

**Q20 Please indicate the extent to which you agree with the following statements:**

| Statement | 1 | 2 | 3 | 4 | 5 | Don't know / Would rather not say |
|---|---|---|---|---|---|---|
| I am generally informed about scientific developments. | | | | | | |
| I am interested in the insights and methods from science. | | | | | | |
| I sometimes do things where I can learn something about science, such as visiting a museum, looking up information on the Internet, watching television or videos about science. | | | | | | |
| I regularly talk about science with others during my studies, at work, and in my leisure time. | | | | | | |

**Q21 What is your highest completed education?**

*If you are currently pursuing education, it does not count as completed.*

- o Primary school
- o LBO/VBO/MAVO/VMBO
- o HAVO/VWO
- o Intermediate vocational education (MBO)
- o Bachelor course of higher professional education (HBO)
- o Bachelor's and/or master's degree in scientific education (WO)
- o PhD
- o I would rather not say
- o Other, namely: _____

**Q22 Which work situation applies to you?**

o Working full-time (35-40 hours per week)
o Working part-time (less than 35 hours per week)
o Retired
o Studying
o Not currently in paid employment
o I would rather not say
o Other, namely: _____

**Q23 In which category does your age fall?**

o Younger than 20 years
o 20-39 years
o 40-64 years
o 65-79 years old
o 80 years or older

**Q24 I am...**

o Female
o Male
o Other
o I'd rather not say

**Q25 Finally, if you have anything else to say, you can mention it here.**

*Not required.*

_____

# Appendix 4.5

General background of survey respondents covering the type of wildlife their center rehabilitates, their initial reason for contact with the center and the tasks they perform. Additionally, the number of hours volunteered per week and years of experience are reported. Frequencies and percentages are presented for all variables, with the mean, median and interquartile range for volunteer hours and experience.

| **Their center treats (n=205)** | **Frequency (n)** | **Percentage (%)** | | |
|---|---|---|---|---|
| Wildlife | 124 | 60.5 | | |
| Hedgehogs | 81 | 39.5 | | |
| **Initial contact with WRC (n=205)** | | | | |
| Found an animal in need of rescue | 46 | 22.4 | | |
| Search engine | 37 | 18.0 | | |
| Friends or family | 35 | 17.1 | | |
| Visited the center | 31 | 15.1 | | |
| Other | 31 | 15.1 | | |
| Social media | 23 | 11.2 | | |
| Advertisement | 16 | 7.8 | | |
| Don't know | 8 | 3.9 | | |
| **Involved in (n=205)** | | | | |
| Animal care | 198 | 96.6 | | |
| Answering phone | 41 | 20.0 | | |
| Other | 40 | 19.5 | | |
| Giving tours | 30 | 14.6 | | |
| Coordinate | 20 | 9.8 | | |
| Managing social media | 17 | 8.3 | | |
| Guest lectures | 11 | 5.4 | | |
| **Hours of volunteering at WRC per week (n=204)** | | | **Mean** | **Median (IQR)** |
| <3 | 22 | 11.3 | 8.1 | 5 (3.5-8) |
| 3-<6 | 93 | 47.9 | | |
| 6-<9 | 41 | 21.1 | | |
| >9 | 48 | 24.7 | | |
| **Experience at WRC in years (n=203)** | | | **Mean** | **Median (IQR)** |
| <1 | 20 | 9.9 | 6 | 4 (2-8) |
| 1-<3 | 51 | 25.1 | | |
| 3-<8 | 79 | 38.9 | | |
| 8-<20 | 44 | 21.7 | | |
| >20 | 9 | 4.4 | | |

# Appendix 4.6

Survey respondents' demographic data are presented, including frequencies an percentages for gender, age, educational level and type of employment. Chi-Square statistics, degrees of freedom and p-values are reported to indicate significant differences (in bold) compared to the Dutch population.

| **Gender (n=197)** | **Frequency (n)** | **Percentage (%)** | **Dutch population** | **χ2** | **df** | **p** |
|---|---|---|---|---|---|---|
| Female | 163 | 82.7 | 50.3 | 88.241 | 1 | <0.0001 |
| Male | 31 | 15.7 | 49.7 | | | |
| Other | 1 | 0.5 | | | | |
| Rather not say | 2 | 1.0 | | | | |
| **Age (n=197)** | | | | | | |
| <20 | 3 | 1.5 | 21.1 | 71.463 | 4 | <0.0001 |
| 20-39 | 51 | 25.9 | 25.9 | | | |
| 40-64 | 103 | 52.3 | 32.8 | | | |
| 65-79 | 40 | 20.3 | 15.3 | | | |
| >79 | 0 | 0.0 | 4.9 | | | |
| **Educational level (n=197)** | | | | | | |
| Primary or secondary school | 59 | 29.9 | | | | |
| Vocational training | 57 | 28.9 | | | | |
| University of applied sciences bachelor degree | 45 | 22.8 | 36.2 | 0.80397 | 1 | 0.3699 |
| University bachelor, master or doctoral degree | 30 | 15.2 | | | | |
| Rather not say | 6 | 3.0 | | | | |
| **Type of employment (n=197)** | | | | | | |
| Full-time (35-40 hours per week) | 32 | 16.2 | 52 | 65.067 | 1 | 0.01075 |
| Part-time (<35 hours per week) | 52 | 26.4 | 48 | | | |
| Retired | 46 | 23.4 | | | | |
| Studying | 14 | 7.1 | | | | |
| Freelance, varying hours | 6 | 3.0 | | | | |
| Currently not employed | 33 | 16.8 | | | | |
| Not able to work | 7 | 3.6 | | | | |
| Rather not say | 7 | 3.6 | | | | |

## Appendix 4.7

Science capital of Dutch wildlife rehabilitators is presented (n=196), including median, interquartile range and mean, scored on a Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree). The mean score from the Dutch general public is also added (Verkade & Smeets, 2023).

| Statement | Wildlife rehabilitators | | Dutch general public |
|---|---|---|---|
| | Median (IQR) | Mean | Mean |
| I do things that allow me to learn about science | 4 (4-5) | 4.1 | 3.6 |
| I have an interest in science | 4 (3-4) | 3.7 | 3.6 |
| I am generally aware of scientific development | 3 (3-4) | 3.3 | 3.2 |
| I regularly talk about science with others in my daily life | 3 (2-4) | 2.8 | 3.1 |

## Appendix 4.8

Motivation of respondents, showing the total number of respondents per statement (excluding answer option "don't know/rather not say"), with mean, median and interquartile range scores on a Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree). Also added for the motivational statements are the corresponding categories and higher-order motivations, based on the Citizen Science Motivation Scale by Levontin et al. (2022).

| Statement | N | Mean | Median (IQR) | Category | Higher-order motivation |
|---|---|---|---|---|---|
| Help animals | 204 | 4.8 | 5 (5-5) | Universalism-nature | Self-transcendence |
| I am interested in animals | 205 | 4.8 | 5 (5-5) | Self-direction | Openness to Change |
| I enjoy this activity | 203 | 4.6 | 5 (4-5) | Hedonism | Openness to Change |
| Contribute to conservation | 203 | 4.4 | 5 (4-5) | Universalism-nature | Self-transcendence |
| Doing something worthwhile | 204 | 4.4 | 5 (4-5) | Hedonism | Openness to Change |
| I want to learn something | 203 | 4.3 | 4 (4-5) | Self-direction | Openness to Change |
| I am happy to help | 203 | 4.3 | 4 (3-4) | Benevolence | Self-transcendence |
| I want to contribute to my community | 203 | 4.1 | 4 (4-5) | Benevolence | Self-transcendence |
| I want to share knowledge and experience | 203 | 3.7 | 4 (3-5) | Teaching | |
| I want to socialize with other people | 203 | 3.7 | 4 (3-4) | Social expansion | Openness to Change |
| I want to make the world a better place | 203 | 3.6 | 4 (3-4) | Universalism-social | Self-transcendence |
| I want to be part of this volunteers' community | 205 | 3.6 | 4 (3-4) | Social expansion | Openness to Change |
| I strive to challenge myself | 204 | 3.5 | 4 (3-4) | Stimulation | Openness to Change |
| Volunteering makes me feel important | 204 | 3.3 | 3 (3-4) | Power | Self-enhancement |
| I want to do some physical activity | 205 | 2.7 | 3 (2-3) | Stimulation | Openness to Change |
| I want to enhance my reputation | 203 | 2 | 2 (1-3) | Face | Self-enhancement |

# Appendix 4.9

Survey respondents' ideas and opinions regarding scientific research with wildlife rehabilitation centers are presented, including the frequency and percentage of respondents per answer.

| **Know what happens to data (n=204)** | **Frequency (n)** | **Percentage (%)** |
|---|---|---|
| Yes | 141 | 68.8 |
| No | 63 | 30.9 |
| **Records data themselves (n=204)** | | |
| Yes | 105 | 51.2 |
| No | 100 | 48.8 |
| **Data owner (n=204)** | | |
| No owner. everyone should be allowed to see and use the data (public interest). | 18 | 8.8 |
| Organisation is owner, but interested parties should be able to see and share the data. | 102 | 50.0 |
| The organisation owns the data but does not have to share it. | 67 | 32.8 |
| I own the data I collect. | 0 | 0.0 |
| Other | 17 | 8.3 |
| **Citizen science terminology (n=203)** | | |
| Yes, citizen science | 14 | 6.9 |
| Yes, burgerwetenschap | 12 | 5.9 |
| Yes, both | 37 | 18.2 |
| No, neither | 140 | 69.0 |
| **WRC data suitable for citizen science? (n=202)** | | |
| Yes | 158 | 78.2 |
| No | 9 | 4.5 |
| Don't know | 35 | 17.3 |
| **Topic (n=204)** | | |
| Success of rehabilitation | 153 | 74.6 |
| Monitoring diseases | 131 | 63.9 |
| Prevention of causes | 125 | 61.0 |
| Understand human impact on wildlife | 116 | 56.6 |
| Species populations | 109 | 53.2 |
| Don't know | 17 | 8.3 |
| Other | 10 | 4.9 |

# Appendix 4.10

Respondents' views on scientific research in collaboration WRCs and their animal data, are presented. The total number of participants who provided a response (excluding "don't know/rather not say"), along with their mean, median and interquartile range scores, scored on a Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree), are included.

| **Data quality (n=105)** | **N** | **Mean** | **Median (IQR)** |
|---|---|---|---|
| Species | 105 | 4.4 | 5 (4-5) |
| Finding location | 105 | 4.1 | 4 (4-5) |
| Reason of admission | 105 | 4.1 | 4 (4-5) |
| **Ideas regarding research (n=199)** | | | |
| Doing research with WRCs is a good idea | 190 | 4.3 | 4 (4-5) |
| Researchers should share results | 194 | 4.2 | 4 (4-5) |
| WRC data quality is good enough for research | 168 | 3.9 | 4 (3-4) |
| I am interested in our own data | 194 | 3.7 | 4 (3-4) |
| I want to contribute more to research | 187 | 3.5 | 3 (3-4) |
| I am interested in data of other centers | 193 | 3.4 | 3 (3-4) |

# Nederlandse samenvatting

Publieke betrokkenheid bij onderzoek wordt steeds belangrijker om grootschalige milieuproblemen, zoals plasticvervuiling, beter te begrijpen en aan te pakken. Dankzij burgerwetenschap kunnen burgers actief bijdragen aan wetenschappelijk onderzoek. Dat levert niet alleen meer gegevens en kennis op en meer perspectieven uit de maatschappij die wetenschappelijk onderzoek kunnen verbeteren, maar het kan bijvoorbeeld ook de kennis en houding van de deelnemers positief beïnvloeden. De impact van dergelijke projecten hangt echter af van wie er meedoet, waarom mensen zich aanmelden en hoe hun betrokkenheid zich in de tijd ontwikkelt.

Hoewel het aantal burgerwetenschapsprojecten rond plasticvervuiling de laatste jaren toeneemt, is nog weinig bekend over de achtergrond, motivatie en ervaringen van de deelnemers. Uit eerder onderzoek naar burgerwetenschappers, blijken vooral hoogopgeleiden deel te nemen. Voor meer impact op de wetenschap en de maatschappij, is het belangrijk te onderzoeken hoe deelname inclusiever kan worden gemaakt. Dit proefschrift onderzoekt daarom hoe burgerwetenschap rond plasticvervuiling kan bijdragen aan zowel wetenschappelijke kennis als maatschappelijke inclusie. Het verkent wie er deelnemen, wat hen drijft, hoe hun kennis en houding zich ontwikkelen tijdens meerdere jaren van deelname, en hoe door bestaande vrijwilligersorganisaties of platforms meer mensen kunnen worden betrokken om wetenschap en samenleving beter te verbinden.

## Vrijwilligers in plasticvervuilingsonderzoek

Het eerste onderzoek richtte zich op vrijwilligers van het Nederlandse burgerwetenschapsproject Schone Rivieren, dat sinds 2017 plasticvervuiling op rivieroevers monitort. Uit enquêtes onder 122 deelnemers bleek dat de meeste vrijwilligers hoogopgeleid en middelbaar van leeftijd waren, met een evenwichtige verdeling tussen mannen en vrouwen. Hun motivatie was sterk actiegericht: zij wilden niet alleen opruimen maar met name bijdragen aan oplossingen voor plasticvervuiling en invloed uitoefenen op beleid. Dit vonden ze ook belangrijker dan meer persoonlijke motivaties zoals meer willen leren of mensen leren kennen. Schone Rivieren trekt daarmee vooral milieubewuste burgers aan die een tastbare bijdrage willen leveren aan een schonere leefomgeving. Deze bevindingen tonen hoe burgerwetenschap betrokkenheid stimuleert, maar ook dat zij vooral reeds milieubewuste groepen bereikt.

## Verandering van motivatie, houding en kennis

Om te begrijpen hoe deelname mensen beïnvloedt, zijn *Schone Rivieren*-vrijwilligers over meerdere jaren gevolgd (2017–2021). Uit metingen bij 403 deelnemers blijkt dat de motivatie om plasticvervuiling aan te pakken hoog blijft, terwijl persoonlijke drijfveren zoals deelname voor de gezelligheid iets afnemen. Hun positieve houding tegenover natuur en wetenschap veranderde nauwelijks, maar de kennis over plasticvervuiling en onderzoeksmethoden groeide duidelijk, vooral na trainingen en deelname in het eerste jaar. Dat onderstreept het belang van hands-on ervaring binnen burgerwetenschap. Deze resultaten laten zien dat een burgerwetenschapsproj-

ect over plasticvervuiling vooral de reeds betrokken burger versterkt, een uitdaging die in de volgende studie centraal staat.

## Dierenopvangcentra als partners in burgerwetenschap

Het derde onderzoek richtte zich op wildopvangcentra in Nederland als mogelijke partners voor wetenschappelijk onderzoek. Deze centra verzamelen waardevolle gegevens over verwondingen, ziektes en doodsoorzaken van wilde dieren, die onder andere inzicht kunnen geven in de gezondheid van ecosystemen en de impact van menselijk handelen op de natuur. Interviews met vertegenwoordigers van dertien centra en een enquête onder 205 vrijwilligers laten zien dat hun opleidingsniveau representatiever is voor de Nederlandse bevolking dan dat van *Schone Rivieren*-deelnemers, al is de groep overwegend vrouwelijk en middelbaar van leeftijd. Hun belangrijkste motivatie is het helpen van dieren, maar ze staan positief tegenover samenwerking met onderzoekers, mits er terugkoppeling plaatsvindt. Extra training en ondersteuning kunnen de kwaliteit en bruikbaarheid van hun gegevens vergroten. Een belangrijke uitdaging voor toekomstige samenwerking is de beperkte tijd en financiële middelen van wildopvangcentra en de prioriteit bij de directe zorg voor wilde dieren. Wildopvangcentra lijken een onderbenutte maar waardevolle bron van kennis, die kan bijdragen aan inclusievere burgerwetenschap.

## Publieke waarnemingen via sociale media

Het vierde onderzoek verkende de mogelijkheden van online waarnemingen via nieuws- en sociale media als aanvullende databron. Tijdens de coronapandemie werden wereldwijd berichten gedeeld over dieren die verstrikt raakten in mondkapjes en handschoentjes. Door deze meldingen te verzamelen, werd een dataset samengesteld van 28 gevallen van interacties tussen dieren en dit zwerfvuil. Zulke online observaties van mensen met diverse achtergronden, waaronder fotografen, ecologen, dierenartsen en hondeneigenaren kunnen fungeren als vroegtijdige waarschuwing voor nieuwe milieuproblemen, zoals de plotselinge toename van dit corona-afval. Bovendien tonen ze dat deelname aan wetenschap niet altijd bewust of georganiseerd hoeft te zijn: toevallige waarnemingen kunnen waardevolle informatie opleveren en zo traditionele monitoringsmethoden aanvullen.

## Conclusie en aanbevelingen

Dit proefschrift laat zien dat burgerwetenschap rond plasticvervuiling vooral milieubewuste, hoogopgeleide volwassenen aantrekt die gemotiveerd zijn om bij te dragen aan oplossingen. Hun kennis neemt toe door deelname, maar hun houding en motivatie blijven grotendeels stabiel. Om burgerwetenschap inclusiever te maken, kunnen bestaande vrijwilligersgemeenschappen die representatiever zijn voor de samenleving, zoals wildopvangcentra, waardevolle partners zijn. Daarnaast kunnen publieke waarnemingen via sociale media nieuwe inzichten bieden in milieueffecten die anders onopgemerkt zouden blijven.

Burgerwetenschappers dragen zo niet alleen bij aan kennis, maar ook aan het agenderen van milieuproblemen en het stimuleren van maatregelen om vervuiling te voorkomen. Succesvolle samenwerking tussen burgers en wetenschappers vraagt om wederkerigheid, feedback en

aansluiting bij de interesses en mogelijkheden van deelnemers. Door projecten zo te ontwerpen dat deelnemers daadwerkelijk invloed ervaren en leren van hun bijdrage, kan burgerwetenschap niet alleen leiden tot meer kennis en oplossingen, maar ook tot een sterker gevoel van gezamenlijke verantwoordelijkheid voor natuur en milieu.

Samen tonen de vier studies dat burgerwetenschap niet alleen een middel is om data te verzamelen, maar ook een manier om bruggen te slaan tussen wetenschap en samenleving. Om dit potentieel te benutten, moeten wetenschappelijke instellingen structureel ruimte maken voor samenwerking met diverse vrijwilligersgroepen en voor de integratie van bestaande databronnen. Dat vraagt om erkenning, financiering en wederkerige relaties, waarin deelnemers niet slechts dataverzamelaars zijn, maar medeproducenten van kennis.

# Curriculum vitae

Liselotte Rambonnet was born on 8 August 1991 in 's-Hertogenbosch, the Netherlands. From a young age, she was fascinated by nature. As a child, she joined a local young birdwatchers' group and helped safeguard a nature area ('het vogeleiland') in Goutum, Friesland. In 2009, she completed her secondary education at the Stedelijk Gymnasium in Leeuwarden and began studying Archaeology at Leiden University. She specialised in archaeozoology, the study of ancient animal remains, and participated in excavations in Germany and on Sint Eustatius (Dutch Caribbean). To further study animals, she enrolled for a biology bachelor at Leiden University, after completing her Bachelor of Arts in Archaeology in 2012. After finishing her bachelor's degree in biology, she did a Master of Science in biology with a specialization in science communication and society at Leiden University.

As a biology student, Liselotte became active in various university committees, including the symposium committee and the programme's education committee. She was also a student ambassador and worked for the communication departments of both the Institute of Biology and the Faculty of Science. Her academic interests ranged from science communication to wildlife conservation. She completed a practical internship at Artis Zoo in Amsterdam (education department), did research at Naturalis Biodiversity Center (on nature-inclusive building and hedgehog rehabilitation), at the Center for Environmental Sciences in Leiden (research on effects of light pollution on plants) and at the Science Communication and Society department of Leiden University (studying the best practices and challenges of citizen science for plastic pollution research).

Following her graduation in 2017, Liselotte started working as a project leader at the Citizen Science Lab at Leiden University. She co-founded a citizen science project on plastic pollution in the Leiden canals which she still coordinates: Canal Watch (De Grachtwacht).

In 2019, she began her PhD research at the Department of Science Communication and Society (SCS). Her research focused on the role of volunteers in environmental research, particularly in the context of plastic pollution and wildlife rehabilitation. During her PhD trajectory, Liselotte supervised bachelor and master students in both science communication and biology. She co-coordinated the bachelor's course *Science Communication for Biologists* twice and presented her findings at several national and international conferences. Her work received (inter)national media attention, from the Guardian and National Geographic to the New York Times.

In April 2025, Liselotte started working as a senior caretaker at the Bird Rehabilitation Center in Leiden and joined Taxon Foundation as a freelance project coordinator in June 2025. With Taxon, she works on making biodiversity monitoring more inclusive for people with visual impairments. Liselotte wishes to pursue postdoctoral research on the impact of wildlife rehabilitation on scientific research and nature conservation.

# Publications

## This dissertation

- Rambonnet, L., Hulscher, M., Schilthuizen, M., Smeets, I., & Land-Zandstra, A. M. (2025). Wildlife rehabilitation and its potential for citizen science. *Manuscript submitted for publication.*
- Rambonnet, L., Rodenburg, F. J., & Land-Zandstra, A. M. (2024). Longitudinal study of motivation, attitude, and knowledge of citizen scientists monitoring plastic pollution on Dutch riverbanks. *Citizen Science: Theory and Practice*, *9*(1). https://doi.org/10.5334/cstp.667
- Rambonnet, L., Reinders, H., & Land-Zandstra, A. M. (2023). Citizen science against the plastic soup: Background, motivation and expectations of volunteers studying plastic pollution on Dutch riverbanks. *Research for All*, *7*(1), 1-17. https://doi.org/10.14324/RFA.07.1.14
- Hiemstra, A. F., Rambonnet, L., Gravendeel, B., & Schilthuizen, M. (2021). The effects of COVID-19 litter on animal life. *Animal Biology*, *71*(2), 215-231. https://doi.org/10.1163/15707563-bja10052

## Other publications

- Tasseron, P., Zinsmeister, H., Rambonnet, L., Hiemstra, A. F., Siepman, D., & van Emmerik, T. (2020). Plastic hotspot mapping in urban water systems. *Geosciences*, *10*(9), 342. https://doi.org/10.3390/geosciences10090342
- Rambonnet, L., Vink, S. C., Land-Zandstra, A. M., & Bosker, T. (2019). Making citizen science count: Best practices and challenges of citizen science projects on plastics in aquatic environments. *Marine pollution bulletin*, *145*, 271-277. https://doi.org/10.1016/j.marpolbul.2019.05.056
- Miller, J. A., Freund, C., Rambonnet, L., Koets, L., Barth, N., van der Linden, C., Geml, J., Schilthuizen, M., Burger, R., & Goossens, B. (2018). Dispatch from the field II: the mystery of the red and blue *Opadometa* male (Araneae, Tetragnathidae, *Opadometa sarawakensis*). *Biodiversity data journal*, (6), e24777. https://doi.org/10.3897/BDJ.6.e24777

# Academic activities

## Conference presentations

- DierenLot National Meeting for Animal Rescue Workers (2024) – presentation Wildlife Rehabilitation
- Belgian Wildlife Disease Symposium (2024) - poster Wildlife Rehabilitation
- European Citizen Science Association (2024) - presentation Wildlife Rehabilitation
- European Science Open Forum (2022) - poster Covid litter
- European Citizen Science Association (2022) - presentation Covid litter
- European Citizen Science Association (2022) - poster Clean Rivers
- Etmaal (2022) – presentation Clean Rivers
- CitSciVirtual (2021) - presentation Clean Rivers
- Etmaal (2021) – presentation Clean Rivers
- European Citizen Science Association (2020) - presentation Clean Rivers

## Teaching

- Guest lecture on wildlife rehabilitation, Master's course *Urban Ecology & Evolution*, Leiden University (2023, 2024)
- Course co-coordinator, Bachelor's course *Science Communication for Biologists*, Leiden University (2022, 2023)
- Guest lecture on citizen science, Honours course *Leiden Municipality Challenge*, Leiden University (2022)
- Guest lecture on citizen science, Bachelor's biology course, University of Applied Sciences Almere (2021)

## Supervision of research projects: MSc Science Communication & Society

- Alexandra Velthuijzen (2024): *Content analysis on representation of wildlife rehabilitation in national Dutch newspapers*
- Daniël Mirck (2024): *Representation of wildlife rehabilitation centers in Dutch newspapers*
- Amber Raven (2022): *Passive citizen science: Exploring motivation and attitudes of social media users who share photos of animals and plastic litter*
- Megan Hulscher (2022): *Background and motivation of animal rescue volunteers and their attitude towards record-keeping and sharing*
- Annefleur Stok (2022): *The representation of wildlife rehabilitation centers in the dissemination of knowledge via Dutch national newspapers*
- Janneke Kluvers (2021): *The relevance of an online dialogue to increase engagement between Dutch citizens and the science journalistic content by NEMO Kennislink*
- Esther Domenie (2021): *No microscope needed: Microbial literacy in children explored with drawings, mind maps and surveys*
- Annelies Bes (2020): *Exploring citizen science terminology in regional and national Dutch newspapers*

## Supervision of research projects: MSc Biodiversity & Sustainability

- Charlotte D'Leon (2024): *Unravelling the impact of entanglement and entrapment on terrestrial and freshwater wildlife using rehabilitation data*
- Melanie van Grevenbroek (2024): *Monitoring wildlife in an urban environment: how land use, roads and other factors influence observation*

## Funding and awards

- Travel grant Jo Kolk Studiefonds (2024)
- Travel grant Jan Joost ter Pelkwijkfonds (2024)
- Travel grant Catharine van Tussenbroekfonds (2024)
- Science Communication Initiative Award for 'De Grachtwacht' (2023)
- Top 50 Inspiring Women in Leiden (2022)
- Young Sustainable Top 100 (2020, 2021)
- Trouw Duurzame Top 100 (2020)

## Outreach

- Overview of outreach activities available at: www.liselotterambonnet.nl/media

## Courses

- The active bystander (2024)
- Writing an excellent grant proposal (2024)
- R Course (2023)
- Job Orientation (2023)
- Scientific Conduct for PhDs (2022)
- BKO-module Uitvoeren van Onderwijs (2021)
- Media training (2021)
- Qualitative Interviewing (2021)
- Mindfullness (2021)
- Speed reading for PhDs (2021)
- Qualitative analysis (2021)
- Scientific English (2021)
- Academic Outreach (2020)
- Managing your brain (2020)
- Time management (2020)

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A

**Mute swan** *(Cygnus olor)*

**Period**
June – September 2013

**Cause of admission**
Orphaned and entangled

**History**
While her parents were swimming with her brothers and sisters, this young cygnet became entangled in fishing line. As the day went on, the family had to move on, leaving her behind. Passers-by alerted the wildlife rescue volunteers, who freed her. An attempt to reunite her with her family failed because the parents no longer recognised their own offspring.

**Outcome**
Together with several other orphaned cygnets, she was raised in a swan nursery. Every day she could eat and swim as much as she wanted. By September she had grown big and strong. She was released, along with her companions, in a beautiful wetland area.

**Source**
Gesink, A. (2014). *Vogels huilen niet: Klein vogelleed in de grote stad* (p. 76). Lecturis.