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Co-created citizen science for community action

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Declaration

I confirm that I am the author of this thesis and that I have consulted all the references cited within. The thesis is a record of the research that I have conducted and has not previously been accepted for a higher degree.

Jade Lauren Gunnell

Abstract

‘Co-created citizen science for community action’ explores how co-created approaches to citizen science practice can be utilised to support communities to take action on the issues that matter to them. Co-created citizen science is the participation of citizens in the whole of the research process, from question identification through to dissemination of findings, and is conceptualised in contrast to contributory citizen science where citizens only participate in the data collection stage of the research process (Bonney et al. 2009; Shirk et al. 2012). This research project looked to address two aims; firstly, to present the diversity of co-created practice in citizen science, and by so doing uncover the way in which the concept of co-creation manifests itself in research process, as well as developing an understanding of the dimensions which affect the collaboration that takes place. And secondly, to examine the link between the nature of co-created practice in research and the subsequent outcomes of the projects, in order to understand how co-created methodologies influence the ability to deliver action outcomes for communities. In order to deliver these two aims two research questions were pursued; 1) How does the concept of co-creation manifest in citizen science projects? 2) What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?

Five case studies were compiled through the collection of narrative interviews, collecting personal stories from project managers, scientists and citizens who had participated in citizen science projects. Case studies all represented projects which were co-created in nature and aimed to deliver action for communities. Projects included a large carnivore conflict mitigation programme in a ranching community, a freshwater health monitoring project on a suburban waterway, a social science investigation into a communities’ relationships with their private water supplies, a wolverine population ecology assessment with fur trappers, and a project collecting noise pollution data in a city plaza with historic well-being issues associated with high levels of noise. The in-depth interview data was thematically analysed, using an inductive approach, and developed five rich, unique and multifarious case studies. Each case study offers different insights towards the two research questions, but collectively demonstrate a huge diversity in the way that co-

creation is adopted in research processes. All five projects had some positive impact for communities in the shape of action and change, although some communities were more satisfied than others in the outcomes of the projects.

Most significantly, the findings of the case studies question the traditional roles of scientists and citizen scientists in research processes, and highlight the central importance of the role of a project manager in delivering co-created citizen science processes. The case studies also bring into focus two often overlooked concepts in citizen science practice; concepts of governance and concepts of service. Examining the relationship between the concepts of governance and service, develops the first contribution to knowledge of this thesis, that of a 'Mutuality Saltire', which maps projects based on their relational dynamics and invites a reflection regarding how mutual the relationship between professionals and citizens is, in these processes. The case studies also reveal the limitations of science in problem solving for communities, demonstrating that where action objectives are pursued a much broader range of social, political and economic factors have to be navigated in order to create change. Here instead, it is the process of co-creation which is most significant in delivering action for communities. This leads the thesis to the second contribution to knowledge, that of '3 pathways of co-creation to action' which suggests three different relationships between co-created processes and action outcomes. Finally, this thesis suggests that rather than adopting the contributions to knowledge as further typologies of citizen science practice, the contributions can instead be used as tools of deliberation when planning how action outcomes might be achieved. They can also be used to reflect on the impact and influence of different relational dynamics on the process of co-creation itself.

Personal statement

I come to this PhD research with an academic background in ecology and conservation and in science communication. My undergraduate degree in ecology and conservation trained me in quantitative positivist research and provided me with a solid understanding of the process of natural sciences and a generally pro-science mind-set, whilst my masters degree in science communication helped me to broaden my philosophical education and develop a critical eye towards the role that science plays in society. With the learning I gained in my masters degree and my many years spent volunteering in and co-ordinating community activity around sustainability and the environment, I have witnessed in many ways the significant role that engagement can play in changing societies, cultures and personal lives. These foundations in philosophy of science and societal engagement underpin the theoretical perspectives from which I approach this research topic.

My professional and voluntary career to date has provided me with a wealth of relevant understanding and experience in order to pursue this research. In particular, before embarking on this PhD research, I spent two and half years working as a Citizen Science Project Officer at the Natural History Museum, London. I worked on developing and delivering national and international, field-based and online, citizen science projects, which were designed to engage the 'general public' in supporting the Museum's taxonomic research. Due to the professional positioning of the Museum, I was able to contribute to the development of citizen science at national and international levels. Prior to this I worked for two and a half years as a science educator at the Museum, building up a wealth of knowledge, techniques and practical experience in public engagement and participation. Equally, I have been volunteering in community engagement with the environment and sustainability for the last 13 years, delivering public engagement and education, campaigning for sustainable change, and delivering community action. In particular, I spent three years helping to co-ordinate Transition Towns Cambridge, part of an international grassroots movement which aims to create community action around climate change and peak oil. Through these experiences I have witnessed the

transformational potential that community activism can have, but also the vulnerabilities and barriers for change-making in this context.

Collectively this professional and voluntary experience means I approach this research most firmly as a practitioner. Recognising the power of community and the value of the scientific processes, I became interested in exploring the potential for action when community and science collaborate. Furthermore, with a strong understanding of engagement methodologies and practices I saw the potential that the concept of co-created practices could have in helping communities become more active agents in civic and knowledge production processes. As a result of these foci of opportunity my pursuit of this research topic is very much to explore how communities can be supported by scientific expertise and how it can be utilised as a problem-solving mechanism.

1 Introduction

This thesis looks to understand the way in which co-created approaches to citizen science can be utilised to help communities take action on the issues that matter to them. In order to unpick this potential the thesis examines five very different examples of co-created citizen science research, which aimed to achieve action for communities. The projects represented in the case studies each took a different approach to co-creation and all were recruited due to their stated intention to deliver action-orientated outcomes for the communities that participated in the research. Through close and detailed examination of these diverse cases two research aims are pursued. Research aim 1 of this thesis aims to sketch out the diversity of co-created practice in citizen science uncovering the way in which co-creation manifests itself in research processes and the dimensions which affect the collaboration that takes place. Research aim 2 of this thesis aims to examine the link between the nature of co-created practices and the outcomes of the projects, in order to understand how co-created methodologies influence the ability to deliver action outcomes, most specifically for the communities who participate.

As a starting point for the thesis I here introduce the three core conceptual themes underpinning the two research aims, and therefore running throughout the thesis. These themes are both the conceptual focal points of the thesis, but also the boundaries and framing of the thesis. The three themes are 1) instrumental and democratic philosophies in science: society relationships, 2) the nature and manner of co-creation, and 3) concepts of action and change. By introducing these three themes I describe the conceptual meanings and the framing of the key concepts needed to navigate the content of this thesis. In exploring these three themes I also speak to the social context and landscape within which this piece of work operates and has meaning and value. Having established the conceptual orientation points for the thesis I then go on to outline the research aims, methodology and findings of this body of work, thereby preparing you with a road map of what to expect through the text. Finally, I introduce some critical definitions of terminology, before outlining the structure of the thesis, demonstrating how the thesis will unfold chapter by chapter.

1.1 Instrumental and democratic philosophies in science: society relationships

1.1.1 Changing expectations of science: society relationships

A critical and underlying theme throughout the whole of this thesis is that of philosophies around the relationship between science and society. This theme is important not just in terms of making sense of the findings of the thesis and their relevance, but also in the methodological approach that was adopted to uncover insights around co-created citizen science practice. Throughout the thesis there is a concern, both methodologically and intellectually, around what it means to create knowledge; in what ways can knowledge be appropriately and reliably produced; who has a right and the capacity to be a part of that process; and how does the way in which that knowledge is produced influence the meaning and relevance of that knowledge to civic society. As part of a broader cultural zeitgeist that is questioning and challenging the role of experts, expertise and the application of knowledge for the betterment of society, we are starting to see changes in the relationship between science and society (Irwin, 1995, Jasanoff, 2003, Chilvers and Kearnes, 2016). These changes in relationship are fuelled to some point by high profile failings of science that undermined trust in expertise (Irwin, 1995, Jasanoff, 2003), and somewhat related to this, changing expectations and demands of society around democratic principles (Ashby, 2003). In response to these challenges science has in the last couple of decades started to transform, working towards being more open, more transparent and also looking to have a more demonstrable impact on broader society (Ashby, 2003).

1.1.2 The emergence of citizen science

One of the key practices that is emerging in the changing relationship between science and society is the practice of citizen science. Citizen science is the contribution of citizens to scientific research. The use of the term ‘citizen’ here relates to individuals who either have no formal scientific training relevant to the topic of research, or else contribute to the research voluntarily. They are therefore individuals who are participating in the project where the scientific research is not a part of their professional role. Whilst citizen science

has a long heritage in environmental and natural history monitoring (Miller-Rushing et al., 2012, Cooper, 2016), modern advances in communication and internet technologies mean that the practice of citizen science is expanding rapidly, and in many different ways (Miller-Rushing et al., 2012, Haklay, 2013, Bonney et al., 2014, Ceccaroni et al., 2017). Year on year there is more political and institutional interest, and finance available, for exploring how scientists and citizens might work together to address scientific and social challenges facing the planet (Silvertown, 2009, Bonney et al., 2016b, Robinson et al., 2018).

1.1.3 Instrumental and democratic philosophies in citizen science

Underpinning the concept of citizen science are two different quite distinct meanings of the phrase. The first and most dominant meaning refers to direct contributions of citizens to the scientific process, as intended by Rick Bonney's coining of the phrase in 1995. The second meaning of the phrase refers to contributions of citizens to the direction setting and application of the scientific knowledge, beyond the research itself, as intended by Alan Irwin's coining of the phrase, in 1995 (Irwin, 1995, Cooper and Lewenstein, 2016). Behind these two meanings there are different philosophies around the relationship between science and society. In Bonney's meaning the philosophical standpoint is instrumental, seeing citizens as instruments who can assist science in its endeavours (Cooper and Lewenstein, 2016). In Irwin's meaning of the phrase there is a more democratic philosophical standpoint orientated around ideas of the right and value citizens have in setting research agendas and deciding how research knowledge should be used and applied in policy (Irwin, 1995). Here science has a role as a democratic process through which citizens can gain and utilise knowledge (Cooper and Lewenstein, 2016). Regardless of the different foci of these two philosophies both represent a shift towards strengthening the relationship and participation between science and society, opening science up to public participation. Citizen science is of interest as a social process because it represents this increasing openness and engagement between science and society and this thesis will explore these different philosophical perspectives throughout.

1.2 The nature and manner of co-creation

Box 1.1: Public Participation in Scientific Research Typology (Shirk et al., 2012).

Contractual projects, where communities ask professional researchers to conduct a specific scientific investigation and report on the results.

Contributory projects, which are generally designed by scientists and for which members of the public primarily contribute data.

Collaborative projects, which are generally designed by scientists and for which members of the public contribute data but also help to refine project design, analyse data, and/ or disseminate findings.

Co-created projects, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all aspects of the research process.

Collegial contributions, where non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and/or professionals.

1.2.1 Public Participation in Scientific Research Typology

A second critical theme throughout this thesis which is explicit and central to the whole research endeavour is the concept of co-creation, as related to the concept of participation in scientific research. Two seminal works on citizen science were provided by Bonney et al. (2009) and Shirk et al. (2012) who, having studied several different case studies of citizen science, offered a typology of 'Public Participation in Scientific Research' (Box 1.1), suggesting that projects could be categorised based on the extent to which the public participated in the scientific process. The extent to which citizens participate in the research processes is defined in terms of how many stages of the process they participate in, but also the extent of the control they have over the scientific process (Bonney et al., 2009, Shirk et al., 2012). Their endeavour was not only to understand and typify the different types of practice, but also understand how these different types of practice might influence different outcomes. Many typologies of citizen science have been offered over the last decade and these are discussed in the literature review, but the typology offered by Bonney et al. (2009) and Shirk et al. (2012) has been particularly successful in the field of citizen science, being the most commonly referenced typology amongst

practitioners and academics (pers obvs). It is this typology that therefore provides the conceptual framework of participation in citizen science that underpins this thesis.

1.2.2 *The opportunity of co-created citizen science*

Of particular interest within this thesis is what Bonney et al. (2009) and Shirk et al. (2012) describe as 'co-created citizen science' (Box 1.1). This is of interest as an extreme position of collaboration between citizens and scientists where full and mutual partnerships can be aspired to. This is interesting and relevant because it challenges, at a very fundamental level, some of the problems and tensions that arise from the cultural shift towards a more open, transparent and impactful relationship between science and society, as discussed in section 2.1.1. On the first count a co-created approach to citizen science asks scientists to completely open up the process of science to citizens, and in doing so fundamentally challenge philosophical predispositions to positivist epistemologies. On the second count the approach is suggested to have promise for delivering more action-orientated outcomes (Wilderman et al., 2004, Bonney et al., 2009, Shirk et al., 2012) of greater relevance to the communities that participate (Corburn, 2007, Boivin et al., 2014), thereby directly addressing some of the broader socio-cultural challenges that science and policy face in relation to impact for society. This is of particular interest in this thesis, as the research aims to understand how co-created approaches deliver action for the communities that participate.

1.2.3 *Challenges in studying co-created citizen science*

There are however a number of challenges when investigating co-created approaches to citizen science. Firstly there is a difficulty and tension in the use of the word and the adoption of similar practices labelled with different terminology. Co-creation can be viewed as similar to, or synonymous with, terms and practices such as Participatory Action Research, Community-Based Participatory Research and Community Science (Wilderman et al., 2004). Secondly co-creation is not as widely adopted within the 'citizen science' field as contributory and collaborative approaches, resulting in a lack of literature explicitly labelled as 'co-created citizen science'. In order to navigate these difficulties in terminology and academic literature I have included knowledge and expertise from a

much broader range of work, moving beyond the realms of work that strictly labels itself as ‘citizen science’ and using work from a number of participatory research disciplines.

1.3 Concepts of action and change

1.3.1 The potential for action through co-created citizen science

The third and final critical theme for this thesis which runs throughout the entirety of the work is the concept of action and change. This was important for both the framing of the research enquiry, but also for delineating the boundaries of the work. The concept of action and change was an important orientation theme for the work because where citizen science, as will be discussed later in the forthcoming literature review, can have a wide range of outcomes and impacts, it is suggested that co-created and more participatory approaches to research can have much action-orientated and community relevant outcomes and impacts. This is important and of interest in the broader context of the idea of the relationship between science and society and how science might be opened up more in order to have more direct and positive impact at the civic level. As a result this thesis specifically recruited projects which had had a specific intention to deliver action for the communities that participated, and specifically examines the extent to which the projects achieved these objectives.

1.3.2 Defining ‘action’ in this context of this research.

However, the concept of action is a challenging and intangible notion that can mean many different things to many different people. The Oxford English Dictionary (2020) offers many different definitions for the word action, but most closely to the meaning intended here it offers “the performance of some activity or deed, typically to achieve an objective”. This meaning however doesn’t capture the more value-laden meaning of the word within a community-orientated context. Part of my motivation and interest in this work came from my own involvement in grassroots, community-activism. Here, for me, the meaning of the word ‘action’ is much more orientated around cultural and value-laden meanings of ‘to take action.’ The self-described definition I have therefore adopted for the purposes of this research, is “doing something in order to have a positive impact or influence, or to make positive change, around a concern or problem”. It is important to recognise, here,

that the word ‘positive’ is subjective to the framing of the problem, and therefore methodologically the pursuit of action in the projects needs to be examined from the many different perspectives of those concerned, including the communities who are the intended beneficiaries. Within this thesis the concept is used directly in relation to the idea that the community face a challenge, problem or concern. So the exploration of the concept of action within this thesis is to understand whether the projects and the community were able to make some positive change, or have a positive influence or impact on a problem.

1.4 Research questions

Having established some of the theoretical concepts underpinning the research I now introduce my research aims and questions, before moving on to briefly describe the research methodology (Chapter 3). This thesis is concerned with the utilisation of co-created citizen science processes and the potential that these have to enable the communities that participate in them to take action on the issues that matter to them. The interest in this topic originates from an intuitive understanding that by including citizens more fully in the research process, science research can potentially produce outcomes that are more relevant to real world scenarios and that are able to directly address challenges faced by communities. The research therefore looks to pursue two aims. The first aim is to understand how co-created approaches to citizen science work; how the concept of co-creation manifests itself in citizen science and how different dimensions of the practice influence the ability to collaborate in a co-created manner. The second aim is to understand the relationship between the co-created process and the ability to deliver action outcomes, specifically for the communities that participate in the scientific research. In order to pursue these two aims, the thesis addresses two research questions, including two sub questions for question 2.

1) How does the concept of co-creation manifest in citizen science projects?
2) What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?
    a) What is the link between co-created citizen science processes and action outcomes?

b) To what extent are action outcomes realised for the communities participating in the citizen science projects?

The methodological design for this thesis was developed in order to examine the roles, relationships and interactions between different actors participating in the projects, in order to address research question 1. Here I look to understand what different contributions different actors make to the project and the nature of their collaboration with one another, picking apart issues and concerns around participation and governance. The research was also designed to be address research question 2, looking to identify the different outcomes from the projects, the diversity of perspectives around whether the outcomes delivered action for the communities, as well as the different facets and features of the co-creation process that influence those outcomes. Here a broader contextual understanding of the landscape of co-created projects is necessary in order to understand how action can be made, but also the nuanced and subjective understandings of what was achieved through the research collaborations.

1.5 Multiple-case Study Design

1.5.1 The merits of case study methodologies.

A multiple case study research design was adopted for this research due to its ability to provide in-depth and detailed exploration of citizen science projects (Bryman, 2012), and to be able to draw insights from across a diverse range of scenarios. Firstly, a lack of detailed case study examples of co-created citizen science in the literature encouraged the production of these through this research, as case study examples can be highly valuable for developing practice within a discipline. However, there were also strong methodological reasons for adopting a case study methodology, where an interest in examining the roles and relationships of different actors in the projects required the examination of the complexity of social relationships, which Yin (2018) argues case studies are well placed to do. A case study methodology was also valuable for this research design because case studies are valuable for studying social phenomena within their context (Bryman, 2012) and understanding the ability of co-created projects to

deliver action outcomes, for the communities that participate, requires an examination of the projects within their contexts.

1.5.2 *Choosing a multiple, rather than single, case study design.*

The reason for adopting a multiple case study design, rather than a single case study design was because of an interest in developing a broader understanding of the diversity of practice in co-created citizen science. Due to the highly contextual nature of co-created practices, particularly where they look to deliver action outcomes for communities, it can only be expected that there is a lack of comparability between cases, as there are so many factors that can influence the process and the outcomes. Due to the lack of comparability and, therefore, a lack of generalisability across cases, it was important instead to highlight and celebrate diversity and uniqueness of practice. Hammersley & Gomm (2000) highlight in their work on case study methodologies how a case study approach is well suited for exploring the particularity and uniqueness of a case. The research, therefore, looked to recruit projects that had maximum variation, with the methodological logic that where commonality exists across this diverse and non-comparable cases, insights may well be more widely applicable.

1.5.3 *Introducing the five case study projects.*

Five case study projects were recruited for this research all of which had adopted a co-created approach to research as defined by Bonney et al. (2009) and Shirk et al. (2012) and all of which had intended to deliver some sort of action outcome for the communities that were participating. In order to try to link process to outcomes, a retrospective examination of projects was required and so projects were recruited that had either already concluded, or demonstrated action outcomes. In addition, it was difficult to find and access real world example of projects that were explicitly labelled as ‘co-created citizen science’ and so projects were included that may not have labelled themselves strictly as ‘citizen science’. The definitions offered by Bonney et al. (2009) and Shirk et al. (2012) were used to clearly define cases of co-created research both within and outside of the discipline of ‘citizen science’. Whilst recruiting suitable projects was challenging due to a seeming lack of examples that met my recruitment criteria, projects

were recruited which successfully represented a wide variety of approaches, context and purpose.

The first project the ‘Large Carnivore Mitigation Programme’ looked to help cattle ranchers reduce their conflict with large carnivores, such as grizzly bears, through an observational mapping programme, and through the implementation of mitigation innovations on cattle ranches (Chapter 4). The second project ‘Protecting Our Waterways’ looked to help citizen scientists concerned with the pollution of their local waterway, in freshwater monitoring, in order to assess environmental health of the waterway and produce a baseline dataset for the future (Chapter 5). The third project ‘Healthy Household Water’ involved a complex set of government and corporate stakeholders, researchers, community researchers and the community themselves in establishing the relationship that communities had with their private water supplies, in order to inform policy (Chapter 6). The fourth project ‘Conserving Wolverine Populations’ involved a partnership between fur trappers and a conservation research institution in establishing population sizes and the distributions of wolverines, out of the trappers’ concern that scientific understanding of population sizes was inaccurate and would affect the ability to appropriately manage populations (Chapter 7). The fifth and final project ‘Noise Pollution in the Plaza’ looked to address a historic urban noise pollution issue that was having a detrimental effect on well-being within the neighbourhood, through the development and distribution of citizen sensing methodologies and technologies (Chapter 8).

1.6 Narrative Interviews

With a constructivist epistemological standpoint for this research and with a concern for ensuring that multiple voices can be heard in the knowledge and understanding that is generated, a narrative interview method has been adopted. A constructivist epistemology suggests that all social phenomena are socially constructed and therefore subjective, leading to multiple realities of the same phenomena. From this the only way in which to understand social phenomena is to “interpret [social actors] actions and their social world from their point of view” (Bryman, 2012) p.30). In order to address the research questions for this thesis it seemed important to capture personal accounts and understandings of

the projects directly from those who had participated. A narrative interview method has been adopted in order to capture these personal accounts, as the method is a relatively unstructured and low intervention approach which would allow research participants the opportunity to provide rich and detailed accounts of their experience defined and framed in their own terms. What was also important was the need to capture the multiple realities of the same phenomena, and so several individuals from each case study were interviewed, representing a mixture of citizen scientists, researchers and project managers. Capturing these multiple realities would provide a much more holistic and thorough understanding of the nature of relationships between actors and the mechanics behind the relationships.

1.7 Research Insights

Thematic analysis within the case studies was used to establish key insights from each of the co-created projects (Chapters 4-8). These insights were then compared and synthesised to directly address the two research questions of this thesis; 1) How does the concept of co-creation manifest in citizen science projects? 2) What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate? The findings in relation to these two research questions are presented in the discussion (Chapter 9), but I will provide a 'sneak peak' of where the findings are heading, here.

1.7.1 How does the concept of co-creation manifest in citizen science projects?

In uncovering the insights for this research question we discover a more nuanced understanding of the diversity of applications and practice in co-created approaches to citizen science, that encourage us to think more critically about the way in which researchers and citizen scientists collaborate around the research process. Firstly, we find that co-created approaches to citizen science are applied in more diverse ways that is so far commonly recognised. Secondly, the findings encourage us to think more critically in terms of who is serving who, and where the boundaries of citizen scientists' involvement in governance are positioned. My first of two contributions to knowledge emerges in this space and speaks directly to practitioners of citizen science, asking them

to more formally establish equitable agreements on the nature of the partnership that researchers and citizen scientists will undertake.

1.7.2 What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?

Research question 2 looks more specifically at the way in which co-created processes deliver action for the communities that participate, and establishes, in the first instance, that both intentional and unintentional action outcomes are delivered through co-created research process, serving multiple stakeholders of the process. Further to this, the research provides some deepening insight into the role of co-created citizen science, suggesting that there are a number of different ways in which co-created practices can deliver action, but at the same time drawing into question the capacity of scientific processes to do so. My second contribution to knowledge emerges in here and again warrants attention from citizen science practitioners, who will be able to more purposively apply co-created practices to research through reflection on the contribution.

1.8 Key terms

There is much debate surrounding the use of terminology in the field of citizen science (Haklay, 2017, Eitzel et al., 2017). Most recently Eitzel et al. (2017) have published a very thorough article which unpicks several terminological challenges in the field of citizen science. Principle issues and concerns are around the semantics and value-ladenness of some of the terms that are currently in play, such as the use of the word ‘citizen’ and complications around how ‘scientist’ is defined (Eitzel et al., 2017). In a field that looks to be open and inclusive to as many different members of society as possible ensuring that terminology does not alienate or present a barrier to participation is highly important. However, debating and resolving the issues around terminology is outside of the scope of this thesis and so I offer my own definitions and justifications for the use of certain terms throughout the thesis. My principle aim with the use and meaning of these terms is to provide clearly defined and easily navigable concepts, making it as easy as possible for the reader to engage with and deliberate around the insights of this work.

‘Citizen scientists’:

“Individuals who have participated in a scientific research project who were participating either voluntarily or as paid employees, but whose profession is not academic research. More simply put, the individuals who participate in the project who are not doing so as part of their normal day job or training.”

Whilst there are many debates around the appropriateness of the term citizen scientists, I use this term here simply for ease, as despite its limitations it is a well-established and easily comprehendible term.

‘Researchers’:

Individuals who participate in the research project as part of their paid profession, and who are being paid specifically to deliver their academic expertise to the project.

I use the term researcher and not scientist, in this thesis, because in some of the case studies the academics are not from a natural sciences background, but are from other academic disciplines.

‘Project managers’

Individuals who participate in the research project who are employed to manage and deliver the project. They may or may not have scientific training appropriate for the topic of investigation, but their principle role is in project delivery.

In some cases project managers and researchers are the same individual within a case study. This is addressed later in the thesis.

‘Research participants’

Individuals who have participated in the research of this thesis, through the contribution of narrative interviews.

I have included this term here in order to distinguish between referring to individuals who participated in the case study projects as ‘citizen scientists’, and individuals who have participated in the interviews for this research as ‘research participants.’

1.9 Thesis structure

This chapter has introduced the focal concepts of the thesis and then briefly outlined the aims and methodology, followed by a few hints about where the findings and contribution to knowledge emerge. The intention of this chapter has been to prepare you, the reader, with a clear indication of what to expect in the forthcoming text. Here I now provide a succinct synopsis of each of the thesis chapters.

The structure of this thesis is divided into three parts:

Part 1 *of the thesis establishes the foundations of the research, exploring theoretical foundations and the emerging research gap, and research questions, through an examination of the literature (Chapter 2: Literature Review). It then deliberates and describes the methodological approach to the research, philosophically, in terms of research design and in terms of research methods and ethics (Chapter 3: Methodology).*

Chapter 2: Literature Review

Chapter 2 explores the theoretical foundations of this thesis from the lens and perspective of citizen science, examining the definitions and meanings of citizen science, its historic origins, its modern advancements, different typologies of citizen science and the types of benefits and outcomes that citizen science is able to achieve. All of this is discussed and explored in the context of the theme of philosophies of science and society. The review then presents a structured review of 181 ecological and environmental science papers that utilised a citizen science methodology. The review attempted to categorise the projects against the Bonney et al. (2009) and Shirk et al. (2012) typology, comparing these to the stated objectives, outcomes and limitations of the projects, in order to develop

a better understanding of the appropriate application of the approaches. Where this review fails to establish the relationships between models of participation and outcomes, I take a deeper look at theoretical understandings and arguments around participation, co-creation and the delivery action through participatory research and participatory design, as a foundation for the empirical work ahead.

Chapter 3: Methodology

Chapter 3 presents the methodological underpinnings of the thesis exploring the epistemological basis for the methods that were used, describing the advantages and limitations of a case study research design and narrative interview method, before providing a detailed account of the case study recruitment, research participant recruitment and interview process. The chapter then describes the way in which thematic analysis was conducted in order to draw insights and understanding from within and across the case studies, before discussing considerations around the representation and presentation of narrative data. The chapter also addresses the ethical considerations that were made throughout the research and the way in which research ethics and integrity were delivered.

*The thesis then moves to **Part 2** where the research findings of the methodology are described in the form of five case study chapters. Chapters 4 through 8 present each of the case studies examined for this research, providing an overview of each citizen science project, its context and the community-orientated challenges that it was trying to address. The chapters then present descriptions of the themes that were identified within the thematic analysis, before drawing together critical insights from across the case specifically in relation to the two research questions of the thesis.*

Chapter 4 presents the **'Large Carnivore Mitigation Programme'** which included several different projects that looked to help cattle ranchers reduce their conflict with large

carnivores. The case study describes a failed attempt at a citizen science mapping project, and a highly successful and long-term innovation project.

Chapter 5 presents the '**Protecting Our Waterways**' project which was led by a government agency who supported residents, with concerns about environmental pollution, in the delivery of ecological monitoring of a waterway. The residents wanted to establish the health of the waterway, in order to support its conservation. The project succeeded in establishing the health of the waterway and a baseline dataset for future monitoring.

Chapter 6 describes the '**Health Household Water**' project which was a social science research project commissioned by corporate and public organisations who wished to understand the relationship between communities and their private water supplies. Rather than utilising volunteer effort, the project employed community researchers.

Chapter 7 explores the '**Conserving Wolverine Populations**' project which was initiated by fur trappers who were concerned about the difference between their own and scientists' understanding of wolverine ecology and population health. They wanted to validate their knowledge of wolverine ecology in order to protect their stewardship roles and livelihoods. They collaborated with a research institution within their network, in order to validate their knowledge.

Chapter 8 explores the '**Noise Pollution in the Plaza**' project which recruited a team of citizen science volunteers to develop a methodology and technologies for citizen sensing for action. The researchers and 'community champions' then approached a community suffering from noise pollution, in order to help them deliver action through citizen sensing.

*The thesis concludes with **Part 3** and the realisation of the research aims; understanding how co-creation manifests in citizen science and understanding how co-created process lead to action outcomes for the communities that participate. In part 3 the findings presented across the five case studies are drawn together to answer the research questions and develop contributions to knowledge, before addressing research limitations and the scope for future work.*

Chapter 9: Discussion

Chapter 9 brings together the insights from across the five case studies in order to directly address the two research questions of this thesis. Here, the relevant findings and insights are presented in detail, before my two contributions to knowledge are described and discussed, along with the limitations of the research.

Chapter 10: Conclusion

In Chapter 10 I recount the whole journey of the thesis from beginning to end, placing the research findings and contributions to knowledge firmly in the context of the rest of the research, before highlighting a set of recommendations for practitioners and suggestions for future research for the academic community.

Part 1: Foundations for the research

In part 1 of this thesis I establish the theoretical foundations for the research, exploring the literature to identify a gap in knowledge and develop the research questions for the research enquiry. This is then followed by a presentation of the research methodology, both in terms of the philosophical foundations for the work, the research design and the research methods, establishing how these research choices are expected to deliver on the research questions.

2 Literature Review

This research endeavour is concerned primarily with the adoption of co-created citizen science practices in order to deliver action outcomes for the communities that participate. The principle aims of the research are to understand the way in which co-creation manifests in citizen science practices and the way in which a co-created process can deliver community action. In order to set a strong foundation for understanding co-creation and community action within citizen science, this literature review starts by providing a review of the landscape of citizen science broadly. The review starts by discussing the origins and meanings of citizen science, as well as the expansion in contemporary practice (section 2.1). This landscape part of the review is punctuated by insights from the science and technology studies and participatory research literature, which provide a contextual understanding of the emergence of citizen science and the way in which it is practiced. Here I establish that the advent of citizen science practice is part of a broader cultural shift in society, referred to as the 'participatory turn' (Chilvers and Kearnes, 2016). Next I examine the practice of citizen science, presenting a number of typologies of practice offered in the literature (section 2.2), and establishing the reasons for adopting the Bonney et al. (2009) and Shirk et al. (2012) 'Public Participation in Scientific Research' typology, as the conceptual foundation for this work. I then highlight the lack of understanding around the relationship between process and outcomes in citizen science (Shirk et al., 2012) and attempt to address this gap, with a structured literature review of 181 peer-reviewed scientific articles from the ecological and environmental science literature that utilised citizen science methods for their research (section 2.3). The review aims to ascertain the differences in application, outcomes and limitations of different models of participation, as outlined by Bonney et al. (2009) and Shirk et al. (2012). Unfortunately, the structured review reveals that the literature does not adequately report on citizen science methods to make it possible to categorise one model of practice from another. In this way the review methodology fails to provide a foundational understanding for the two research aims of this thesis; an understanding of how co-creation manifests in citizen science and an understanding of the link between process and outcomes. It does, however, provide insights into the motivations, objectives, outcomes and limitations of citizen science more broadly. Where the

structured review leaves a gap in understanding about the nature of co-created approaches to citizen science and the delivery of action-orientated outcomes generally, I then delve into the co-creation and participatory research literature to develop a theoretical foundation around the principles of practice, their relation to outcomes, and their relationship to community action, in order to support my empirical work (sections 2.4 – 2.6).

This literature review establishes that there are a lack of case study examples of co-created citizen science in the literature, and with this a limited understanding of the process and outcomes of such practices. Where citizen science is expected and considered to deliver action outcomes, there is little understanding about best practice or the link between process and outcomes. My two research questions and my research methodology look to directly address this gap, by providing detailed case study examples, examining what co-created practice looks like, the relationship between process and action, and the ability to deliver action for communities.

2.1.1 Boundaries and limitations of this literature review

Whilst co-created citizen science has many similarities to other participatory research processes, such as community-based participatory research and participatory action research, the focus and lens through which this research is carried out is firmly a citizen science lens. The intention of the research is to build an understanding of more participatory approaches to public participation in scientific research from a citizen science perspective. Where citizen science most commonly invites 'the public' to participate in research in a relatively limited way (ie. by collecting data), my interest was in examining how increasingly participatory approaches might be adopted within this cultural context. The majority of the literature consulted is therefore drawn from the citizen science literature, rather than a more strategic review of the wider participatory research literature. This has been done in order to ensure that the literature is manageable and focused, and that the research questions speak directly to the citizen science cultural context. The wider participatory research literature has been sampled, with some key works and authors presented in this review, but a comprehensive assessment of this body of work is outside of the scope of this chapter. This means that the framing of this

research is bound specifically within a citizen science conceptualisation of participatory research, rather than any other discipline or epistemological conceptualisation. The intellectual insights that emerge, whilst rich, are therefore limited in that they are bound within this specific academic-view.

2.2 The origins and meanings of citizen science

2.2.1 Difficulties in defining citizen science.

Defining citizen science has been a challenging task for the academic and practitioner community, and hasn't delivered a commonly agreed upon definition or typology, despite more than two decades of efforts (Ceccaroni et al., 2017). Many different nuances of definitions have been offered and these continue to evolve and be adapted (Eitzel et al., 2017), with particular concerns that the connotations of the phrase 'citizen science' are too limiting for the actual diversity of practice that is out there (Cooper and Lewenstein, 2016). Whilst most commonly citizen science is perceived to be the collection of data by non-professional scientist volunteers, to contribute to the research of scientific institutions, the practice has evolved to be much more diverse than that, and much encouragement has been made to recognise a diversity of participatory disciplines as akin to, if not the same as 'citizen science'. Citizen science is now viewed as a "flexible concept", utilised in many different ways and settings (Robinson et al., 2018) p.27) seen as a catchall term (Cooper and Lewenstein, 2016) for many different ways in which the public and science collaborate, including Crowdsourcing, Community Action Research (CAR), Community Based Natural Resource Monitoring (CBNRM), Community Based Participatory Research (CBPR), Participatory Action Research (PAR), Community Science, Participatory Forestry, Volunteered Geographic Information (VGI) and Citizen Science itself (Bonney et al., 2009, Shirk et al., 2012, Cooper and Lewenstein, 2016, Eitzel et al., 2017, Haklay, 2017). The diversity of these disciplines and the will to ensure that they can be recognised as one and the same thing led Bonney et al. (2009) to introduce the phrase 'Public Participation in Scientific Research' (PPSR). Here PPSR was defined as "intentional collaborations in which members of the public engage in the process of

research to generate new science-based knowledge" (Shirk et al., 2012) pg. 2). The phrase tried to encapsulate all of the different approaches, and also to broaden the connotations around citizen science, but hasn't been readily adopted (Cooper and Lewenstein, 2016).

2.2.2 Instrumental and democratic philosophies in citizen science.

One of the key problems identified with the connotations of the phrase 'Citizen Science' is that they fail to capture the two very different meanings of citizen science that exist. The coining of the term 'Citizen Science' occurred in two separate circumstances. Rick Bonney of Cornell Lab of Ornithology coined the term in 1995 to describe the voluntary contributions that bird watchers were making to Cornell's research projects (Bonney et al., 2009), whilst Alan Irwin, also in 1995, coined the term to refer to citizens' participation in the production of scientific policy (Irwin, 1995, Cooper and Lewenstein, 2016). The two uses of the term represent quite different, but equally relevant meanings of 'citizen science'. Bonney's citizen science is a "participatory" (Cooper and Lewenstein, 2016, pg. 58) citizen science, its purpose is as an instrument for scientific research and is commonly associated with voluntary contributions of data to research projects run by scientific institutions (Cooper and Lewenstein, 2016). It is the most commonly used use of the term, due to the way in which it dominates literature and practice (Cooper and Lewenstein, 2016, Ceccaroni et al., 2017). Irwin's citizen science is a "democratic" (Cooper and Lewenstein, 2016, pg. 58) citizen science, where citizens have an influence over the process of scientific research and the resulting outcomes of science. Here the premise is that citizens can do more than collect data for scientists, but have knowledge and expertise that can significantly value the development of formalised scientific knowledge, that they have the ability to more fundamentally influence what the scientific process looks like, and that morally science should be addressing societal needs and concerns (Irwin, 1995, Cooper and Lewenstein, 2016). Increasingly as the understanding and parameters of what citizen science is are diversified, it starts to be used in relation to a much broader set of practices including practices that address a more 'democratic' ideal for public participation in scientific research. Ceccaroni et al. (2017), in trying to move the academic debate away from a focus on specific, cleanly delineated definitions and more towards a

more formalised understanding of characteristics, suggests two forms of citizen science which they unpack the characteristics of and which parallel the two meanings that Bonney and Irwin's use of the term mean. They suggest that there are instrumental citizen science projects which have a traditional public: science structure and relationship, where scientists hold the expertise and power and the citizens simply volunteer to support the endeavour, in these types of projects the public are involved in very "specific and limited part[s] of the process" (Ceccaroni et al. 2017, pg. 8) as defined by the scientists, and once the project has finished all actor groups go back to what they were doing before, with no longer-lasting engagement or relationship. This type of citizen science is able to increase the scale and scope of scientific data collection and research. In contrast to this is the citizen science that Ceccaroni et al. (2017) call "capacity-building" (pg. 8) citizen science, in these projects it is groups of citizens that partner together to address a shared concern or objective, with a focus on delivering a mixture of "social, scientific, learning and/or environmental outcomes" (Ceccaroni et al. 2017, pg. 8). In these projects where community action is sought, projects may take place with or without scientists, and represent a much more active citizen engagement. Ceccaroni et al. (2017), suggest that a reframing of citizen science is required to create an understanding of citizen science that is more inclusive of this second meaning.

2.2.3 Characterising citizen science.

So then, in more practical terms, how do we characterise and define 'Citizen Science'? Firstly, Eitzel et al. (2017) suggest that we must be accepting of the fact that there is a diversity of understanding about what constitutes citizen science, and that we should work towards as broad a definition as possible, in order to serve as many groups of practice as possible. Further to this both Ceccaroni et al. (2017) and Haklay (2013) suggest that more useful than trying to delineate the precise boundaries of the field through a definition, it can be much more valuable to simply explore the characteristics of citizen science. Just this year the European Citizen Science Association (ECSA) have published a document which brings together a wide range of perspectives on citizen science from research, practitioners, civil servants and the public to outline a more inclusive understanding of what citizen science is (European Citizen Science Association, 2020a). This work builds

on the ‘Ten Principles of Citizen Science’ published by the European Citizen Science Association in 2015 (European Citizen Science Association, 2015), which are intended to offer a set of best practice standards to guide practitioners in looking to deliver excellence in citizen science (Robinson et al., 2018). The first principle addresses the most fundamental idea behind citizen science, that citizens are actively involved in scientific research. Whilst commonly citizens participate in the data collection stage of the project, the ‘Ten Principles of Citizen Science’ suggest that citizens should have the opportunity to participate in as many parts of the process as they wish (European Citizen Science Association, 2015). Miller-Rushing (2012) argue that the level of participation of the scientists or the citizens is not important, placing emphasis instead on their participation in “genuine scientific research” (pg. 285). Although ‘ECSA’s characteristics of citizen science’ broaden the notions of what genuine scientific research is, to include “basic or applied, inductive or deductive, local or global” research processes (European Citizen Science Association, 2020a) pg. 2). Further to this Shirk et al. (2012) highlight that involvement in the research should be intentional, rather than something passive or subjective, something that Haklay (2013) also highlights when discussing engagement in Volunteered Geographic Information.

A second fundamental characteristic that is repeatedly recognised as defining citizen science is that it should produce a genuine scientific outcome, indeed both Robinson et al. (2018) and Hecker et al. (2018) justify that it is this which sets citizen science apart from experiential learning or science education projects and opportunities. Bonney et al. (2014) go a step further to encourage that the use of the phrase ‘Citizen Science’ should be retained for projects and endeavours which “truly do science” (pg. 1437), where the outputs produced are reliable, can sustain peer-review and are accessible and usable by anyone. Whilst Bonney et al.’s (2014) call here is for a citizen science that again is highly scientifically focussed, Ceccaroni et al’s (2017) suggestion that citizen science needs to be reframed to be more inclusive of the ‘capacity-building’ type projects leads them to suggest the following as a definition,

> *“work undertaken by civic educators together with citizen communities to advance science, foster a broad scientific mentality, and/or encourage*

> *democratic engagement, which allows society to deal rationally with complex modern problems." Ceccaroni et al. 2017, pg. 8.*

Here Ceccaroni et al's (2017) definition is more inclusive of more 'democratic' intentions of the concept of 'citizen science' as was suggested by Irwin (1995), highlighting both the pure science focus that dominates citizen science practice, and the value of citizen science as a public science and policy literacy tool. It also highlights the value of the applied and action-orientated outcomes that can be delivered through citizen science processes, highlighting the potential to create action and change in communities. Further to this Ceccaroni et al.'s (2017) definition doesn't speak directly to the way in which citizens' should be involved in these processes, only that the work should be "undertaken… with citizen communities" (Ceccaroni et al. 2017, pg. 8) opening up the definition of citizen science to a much broader range of ways in which citizens might participate.

2.2.4 The notion of citizen science only exists due to the professionalisation of science.

The origins of the concept of 'citizen science' in both its meanings draws particular attention to the socio-political boundedness of public participation in scientific research. In the first instance when examining the historical origins of the type of instrumental citizen science described in section 2.1.2, where volunteer citizens support professional research through the contribution of scientific data, we begin to see that the notion of 'citizen science' in the 21st Century only exists because of the professionalization of science which emerged through the 17th and 19th Centuries (Haklay, 2013, Eitzel et al., 2017). The pursuit of science was originally a hobby and pastime of society's elites, who had other sources of income and the leisure time to be able to investigate natural phenomena (Cooper, 2016). Individuals in these positions, would not only collect data themselves and then conduct analyses and propose theories and hypotheses, but would also, as was the case with those such as John Ray and Carl Linnaeus, enlist the help of those without scientific skills in the collection of data (Miller-Rushing et al., 2012). That being said there are historical examples of large scale collection of data by those invested in the understandings of the data, such as the case in 3,500 years of locust outbreak data in China, and more than 640 years of grape harvest data from wine-growers in France

(Miller-Rushing et al., 2012). However, it was through the gentleman naturalists of the 19th Century that, scholars such as Cooper (2016) suggest, a culture of elitism began to emerge, where an informal peer-review process, awards and accolades emerged as a way of separating those with scientific knowledge, away from those without. From here science as a profession rapidly expanded (Cooper, 2016) and amateur naturalists who were still important in collecting datasets geographically, were marginalised.

2.2.5 Moving towards a democratisation of science.

In the context of elitism in science, as discussed above (section 2.1.4), Cooper (2016) sees citizen science as a process of taking science back and providing recognition for the multitude of ways of knowing. In Irwin's meaning of citizen science (1995), we see a parallel in that the concept of citizen science has emerged out of the socio-political constructs in the way that science has developed and built its relationship with the rest of society. In Irwin's citizen science, there is also a need for citizens to 'take back' some of the foundations of what it means to be knowledgeable, produce knowledge, and subsequently make decisions or act on that knowledge. Irwin's meaning emerges as part of a cultural zeitgeist which is challenging the idea that science is progress (Irwin, 1995), and a hero for society when crisis ensues (Jasanoff, 2003). A normative view of science is believed to have its power in being separate from subjective and social perspectives of the world and presents the public as ignorant and irrational (Irwin, 1995). In response, a critical view of the scientific process has emerged fuelled by a concern around the impact of science on our everyday lives (Irwin, 1995, Jasanoff, 2003, Chilvers and Kearnes, 2016), alongside the idea that the production of scientific knowledge is a social process intertwined into other social processes such as politics, governance and economy (Chilvers and Kearnes, 2016) and cannot therefore be considered objective and value-free. This represents a fundamental change in what is considered applicable, reliable and useful knowledge and requests a change to knowledge production systems, calling for the integration of other forms of knowledge and understanding (Jasanoff, 2003). In this context, participatory research approaches challenge and respond to the weaknesses of traditional science and act as an attempt to rebuild trust between science and society (Strasser et al., 2019). This shift in perception regarding the relationship between science

and society is sometimes referred to as the ‘participatory turn’ and looks to build a more open and participatory society (Chilvers and Kearnes, 2016). Ashby (2003) argues that this has emerged out of a reframing of some of the fundamental societal relationships that we operate around, such as the relationship between the economy and natural capital, health and the environment and humans with nature. Furthermore we are seeing, as part of this, a social shift with regards attitudes towards authority and democratic processes in what Chilvers & Kearnes (2016) refer to as a ‘legitimacy crisis’ around democratic processes. This broader change in social attitudes to authority and governance also sees a shift towards a concept of deliberation around science, rather than science being hegemonic as a cultural institution. This whole endeavour goes beyond challenging the process and culture of science (Haklay, 2013, Strasser et al., 2019), but also the existing social order (Strasser et al., 2019). Furthermore when it comes to the global communities ability to tackle the ‘wicked problems’ of the 21st Century, such as climate change and poverty, Turnhout et al. (2012) argue that it is not enough to rely on the traditional, standardised modes of scientific knowledge production as these aren’t able to sufficiently tackle complex problems.

2.2.6 Diversification of purpose in science and citizen science.

Both the ‘instrumental’ and ‘democratic’ meanings of citizen science have emerged out of cultural shifts in society that are looking to recognise and appreciate the value, and contributions, that citizens can make towards developing scientific knowledge and deciding how that knowledge should be used. Changes and expansion within the field of citizen science are both philosophical and tangible, and fill two major research gaps in society, that of large scale ecological questions that can’t be addressed by scientists alone, and those of smaller-scale, highly localised and specific research questions which are not of interest to the scientific community due to their limited opportunity for scientific outputs (Bonney et al., 2016a), but which have tangible impact for communities. These advancements serve both the needs for expansion by the scientific community, and the need from communities of citizens for their own knowledge that is reliable (Bonney et al., 2016a) and actionable. Further to this, citizen science can lead to the production of knowledge that is outside the mainstream foci for research institutions, thereby

transforming knowledge production through changing what type of knowledge is produced and the perspectives represented (Ottinger, 2010, Strasser et al., 2019). Philosophically and practically we are seeing a change in the way science is conducted, with transformation both within the practice and culture of science, but also even with the practice and culture of citizen science (Cooper and Lewenstein, 2016, Eitzel et al., 2017, Ceccaroni et al., 2017). Science is starting to operate outside its traditional professional boundaries, with a much wider range of goals, reflected in the many different names there now are for research processes (Eitzel et al., 2017), but the progress of science has also accelerated with an significantly increased capacity for big data science, through citizen science and technology. Even within citizen science the practice is shifting and evolving from a 'participatory' to a 'democratic' model of citizen science, where projects are increasingly looking to democratic goals for their projects (Cooper and Lewenstein, 2016), with an increased understanding within the discipline of the wider social and political impacts that citizen science can have (Hecker et al., 2018).

2.2.7 Reasons for citizen science's expansion

There are many reasons that can be attributed to the expansion of citizen science in the last couple of decades, but the reason that is most often expressed within the literature is that of technological advancement within society, including both hardware and software technologies and the internet (Miller-Rushing et al., 2012, Haklay, 2013, Bonney et al., 2014, Ceccaroni et al., 2017). Technology has improved the way in which citizen science can operate, making data collection, processing and analysis much simpler but also more advanced, making citizen science more accessible to participants, including non-text literate communities (see (Vitos et al., 2012), as well as much easier to find and sign-up, and has enabled a totally different genre of citizen science in online citizen science projects (Bonney et al., 2014). Furthermore, the advances in technology and the internet have increased the opportunity for citizens to participate in policy assessments through citizen science (Hecker et al., 2018). Tech and the internet have also increased the power of data analysis, improving statistical and computational tools, meaning citizen science methodologies can be developed that produce highly quality, rigorous results comparable to the quality of traditional research approaches (Miller-Rushing et al., 2012, Bonney et

al., 2014). Another reason for which citizen science has expanded is the encouragement through funding bodies to engage with civil society, and the significant investment of funds that has been offered by funding bodies, namely the European Commission funding stream H2020, to carry out citizen science (Silvertown, 2009, Bonney et al., 2016a). Haklay (2018) also highlights the impact that an increasingly educated and science literate society has had on the expansion of citizen science, demonstrating that the educated are over-represented in citizen science participant demographics, and that higher levels of education in some societies mean that more complex citizen science can be delivered.

2.3 The practice and philosophy of citizen science

2.3.1 The breadth of activity in citizen science

As expressed above citizen science has much diversity of practice. This diversity expands across scientific disciplines, a variety of scales and scopes of practice, and a multitude of different types of task and activity (Roy et al. 2012). Hecker et al. (2018) describe citizen science as operating in as wide a range of disciplines as astronomy, biology, environmental monitoring, public health, transport, agriculture and energy production. Projects can be highly localised in one very specific area or site, or spread internationally across continents (Roy et al., 2012, Bonney et al., 2014). Roy et al. (2012) also found that projects could be divided according to 'degree of investment', with projects being either simple or thorough in the effort that the project managers or the participants had to put in. They can be focussed on large-scale issues of global significance like climate change (see. Nature's Calendar (Woodland Trust, 2020)), or more small-scale, localised issues like the pollution of drinking water (see. (Flint Water Study, 2020). Projects can look at addressing a particular issue in the short-term, or focus on longer-term monitoring of scientific phenomena (Hecker et al., 2018). Projects can involve being 'out in the field' collecting data in situ and then sending it to the research project (see. (Echidna Conservation Science Initiative, 2020), or can be online, where participants are involved in processing the data rather than collecting the data (see. (Zooniverse, 2020). You can also get activities that are hypothesis-driven, or that are driven by a community need (Shirk et al., 2012).

2.3.2 Typologies of citizen science

Box 2.1: Public Participation in Scientific Research Typology (Shirk et al., 2012) pg. 4).

Contractual projects, where communities ask professional researchers to conduct a specific scientific investigation and report on the results.

Contributory projects, which are generally designed by scientists and for which members of the public primarily contribute data.

Collaborative projects, which are generally designed by scientists and for which members of the public contribute data but also help to refine project design, analyse data, and/ or disseminate findings.

Co-created projects, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all aspects of the research process.

Collegial contributions, where non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and/or professionals.

As mentioned above this huge diversity of practice and the increasing professionalization of the field of citizen science has led to academic attempts to categorise and create typologies of practice in order to assist the field of citizen science in discussing, navigating and understanding how the diversity of practice might be related to outcomes (Shirk et al., 2012). Understanding the different ways in which citizen science is practiced and used is an important starting point for developing practice, it not only helps us to unpick practice, but also to communicate across many different fields of participatory research with different names (Bonney et al., 2009, Shirk et al., 2012). Pocock et al. (2017) discuss how understanding the different types of practice is valuable for comparing their success, making it possible for practitioners to select the appropriate approach for their needs or circumstances. In light of this, several different typologies have been offered by scholars, each with an emphasis on slightly different characteristics, or phenomena of citizen science.

The Bonney et al. (2009) and Shirk et al. (2012) typology is the foundation for this PhD research, and is orientated around participation in the scientific process, with Shirk et al's (2012) typology simply expanding on the categorisations offered by Bonney et al. (2009) (Box 2.1). This typology emerged out of work that looked across a variety of disciplines

conducting participatory research, to understand how different approaches led to different educational outcomes. The spectrum of participation that the typology offers is graded by the extent to which the public are involved in the different steps of the research process and the amount of control they have over the different steps. This typology therefore draws attention to issues of both participation and power in academic: public research partnerships. In Box 2.1, from top to bottom, there is an increasing amount of participation of the public in the research process and in the control over the direction and delivery of the process, from Contractual to Collegial. The reason participation was focused on was because it was a clear commonality across the different disciplines carrying out participatory research, but also because participation through the process of research can be quantified, and there was seemingly a link between participation and the outcome of the projects. The research found very clearly that "meaningful programmatic differences exist not between fields of practice or research, but between project models based on degree of participation" (Shirk et al., 2012, pg. 5).

Table 2.1: Typology of Community Science (Wilderman et al., 2004) pg. 3).

	Who defines the problem?	Who designs the study?	Who collects the samples?	Who analyses the samples?	Who interprets the data?
Community Workers Model	Professionals	Professionals	Community	Professionals	Professionals
Consulting Model	Community	Professionals	Professionals	Professionals	Professionals
Community-based, participatory research Model	Community	Community	Community	Community	Community

A couple of years prior to the Bonney et al. (2009) typology, Wilderman et al. (2004) offered a typology that was also orientated around participation and power of citizen participants. In Wilderman et al's (2004) suggestion of models of participation five questions were deemed important for determining the type of project; 1) Who defines the problem? 2) Who designs the study? 3) Who collects the samples? 4) Who analyses the samples? 5) Who interprets the data? These questions very closely mirror what Bonney et al. (2009) and Shirk et al. (2012) suggest in terms of determining participation through the process but the questions they pose for determining this much more directly highlight the issue of power in these processes. The typology of community science offers three different models of participation; Community Workers Model, Consulting Model, Community-based Participatory Research Model (Table 2.1) (Wilderman, 2007).

Box 2.2: Levels of participation and engagement in Citizen Science projects (Haklay, 2013), p.115.

Level 4 'Extreme Citizen Science': Collaborative science – problem definition, data collection and analysis.

Level 3: 'Participatory science': Participation in problem definition and data collection.

Level 2: 'Distributed Intelligence': Citizens as basic interpreters. Volunteered thinking.

Level 1: 'Crowdsourcing': Citizens as sensors. Volunteered computing.

Haklay (2013) offered another typology that was also concerned with the matter of participation in the research process, but highlights a case of relationships between citizens and scientists that is at an extreme end of participation (Box 2.2). Haklay (2013) highlights a couple of important points in relation to his typology, first that projects have great complexity which can lead to having different participants contributing to a project at more than one of the levels of the typology. As a result of this diversity of participation, even within a project, Haklay (2013) encourages that whilst Level 1 is a 'business as usual' scenario, moving up to an 'egalitarian' scenario at Level 4, that the levels should not be considered value-laden, with Level 4 suggested as being better than the other levels. In fact, this sentiment can be recognised across the work of Wilderman (2007), Bonney et al. (2009) and Shirk et al. (2012), as all suggest that different approaches offer different benefits and outcomes, different opportunities and challenges. Finally, Haklay

(2013) highlights a point that is also important across the other typologies, that is that they demonstrate that citizen science challenges the traditions and 'norms' of modern scientific practice, challenging the boundary of scientists as being separate from the public. Haklay (2013) suggests that these more participatory processes don't present a technical challenge to science, but instead a cultural challenge.

Strasser et al. (2019) suggest that the typologies offered by Bonney et al. (2009), Shirk et al. (2012) and Haklay (2013) are inherently political; that their focus on the extent of participation in the research process reflects a concern with empowering citizens and democratising science, as it aims to reveal the size of the power imbalance between scientists and citizens. Wiggins & Crowston (2011) challenge this focus on the extent of participation, suggesting that it fails to acknowledge the influence of "sociotechnical and macrostructural" (Wiggins & Crowston, 2011, pg. 1) factors on the design and management of participation in participatory research projects. They conducted a review of 80 different facets across 32 different projects, looking to examine project demographics, organisational features, participation design, education facets, technologies, outcomes and much more. Manual clustering of the facets revealed that when the projects were organised around a primary goal they formed mutually exclusive groupings of the following primary goals; Action, Conservation, Investigation, Virtual and Education. So whilst Wiggins & Crowston (2011) present a typology from a different orientation than the other scholars mentioned above, they add further support to the idea that the way in which participants are involved in a project is linked to the intention for the projects.

Whilst it is generally recognised that there is much advantage in understanding different approaches and models of citizen science practice (see first paragraph of this section), the Pocock et al. (2017) systematic review of ecological and environmental citizen science found that projects cannot be easily categorised into discrete models of practice because they exhibit much variation. They argue that the typologies of citizen science proposed by scholars are "imposed upon the diversity of citizen science, rather than being a natural explanation emerging from it" (Pocock et al. 2017, p. 10). They further suggest that this explains the difficulties the field has in identifying absolute typologies and providing clear guidance on the adoption of citizen science approaches (Pocock et al.,

2017). It must, therefore, be held in mind, that the adoption of a typology as a lens through which to study citizen science phenomena, can only help to draw attention to particular characteristics of practice rather than a more holistic and consistent understanding.

2.3.3 Adopting the Public Participation in Scientific Research (Bonney et al. 2009) typology.

These typologies reflect a historical effort, within a growing field, to try to define different types of citizen science practice, in order to support the academic study of the phenomena. The effort of trying to label and delineate different types of practice creates a vocabulary of citizen science, which makes it easier for scholars and practitioners to discuss and explore the diversity of practice. Each typology, from Wilderman et al. (2004), to Bonney et al. (2009), to Wiggins and Crowston (2011), to Shirk et al. (2012) and to Haklay (2013) has built on the work of the previous scholars, in an attempt to refine and increase the fidelity of the typologies. They all endeavour to capture and represent the critical dimensions that describe the diversity of practice, and try, as close as possible, to represent a holistic understanding of these different practices.

The Public Participation in Scientific Research typology, as first described by Bonney et al. (2009) and further developed by Shirk et al. (2012), has been adopted for this research as it was a central concept in the brief advertised for the PhD project. It has also been adopted because of its prominence within the field. This typology has become the most widely adopted within the citizen science academic and practitioner community, and has become part of the common vocabulary around which practice is discussed. In the original CAISE report, Bonney et al. (2009) endeavoured not only to typify different types of practice but also to develop an umbrella term that would encapsulate broader participatory research practices. They wanted to build an understanding and recognition, of the association between citizen science and a broader suite of participatory research. Yet, whilst this typology is the most widely adopted and looks to take a broader, encompassing view of participatory research methodologies, it is limited in that it categorises projects based on a relatively limited suite of dimensions; stages of participation in the process and control over research process (Bonney et al., 2009). One

of the limitations of this is the fact that the typology doesn't recognise, or is not inclusive of, other dimensions that might influence the way in which citizen science is practised. These other dimensions may have as powerful an impact on the projects as the extent to which the citizens participate in the project. This means that by selecting and examining projects from this focus, other key drivers and dimensions of influence may not be captured. That being said the case study research design and inductive analysis approach that I have adopted for this research (see Chapter 3) work to capture a broader range of dimensions of practice and influence than the typology selects for. Further to this, when considering this research within the professional context, the prominence and prevalence of the PPSR typology within the citizen science community, means that research conducted to further investigate the ideas represented by the typology, can make valuable contributions to the field.

2.3.4 Linking process to outcome

Research aim 2 of this thesis is to establish how a co-created citizen science process can enable communities to take action on the issues they are facing. In this context, one of the intellectual concerns of this work is around the relationship between the processes of citizen science and the outcomes of the projects. Shirk et al. (2012) and Wiggins and Crowston (2011) both impress upon the relationship between the models and outcomes, with Shirk et al. (2012) expressing the importance of quality participation. However, there is a limited understanding of how models of practice deliver different types of outcomes. Bonney and his colleagues have raised the matter that in order for citizen science to deliver scientific and social outcomes, projects must be purposefully designed for those aims, but there is still much work to do for us to understand the link between the methods and the outcomes of projects (Bonney et al., 2014). Shirk et al. (2012) had previously highlighted that the impacts of projects, beyond their immediate outputs and outcomes, are rarely measured. This may be a result of what Bonney et al. (2016b) highlight as our lack of understanding about the appropriate methods for researching and evaluating outcomes. In order to try to draw broader correlations between the models of citizen science and the type of outcomes that could be achieved I conducted a structured review of ecological and environmental science literature that had utilised a citizen science

approach, to identify the different approaches utilised and the related outcomes of these projects.

2.4 A structured review on the utilisation of different approaches to citizen science

2.4.1 Rationale for the review

The adoption of the Bonney et al. (2009) and the Shirk et al. (2012) typology for this thesis is due the prevalence of this typology in the citizen science professional community. This is the typology that is most often referenced and discussed within the practitioner community, and it was therefore felt that exploring citizen science through these dimensions would be most fruitful in supporting the currently adopted framing and conceptualisation of the field. Where Bonney et al. (2009) and Shirk et al. (2012) have introduced their typology of participation they have done so with the presentation of a handful of examples of the different types of practice, but until now no-one has conducted a large scale review of the distribution of these different approaches across the practice of citizen science. This review therefore looked to explore the distribution of different models of citizen science and to understand what purposes and objectives these approaches were applied to and with what results. In this way the objective was to develop a clearer understanding of how different approaches might be most valuably and impactfully applied. The review involved a structured analysis of 181 peer-reviewed papers from the ecological and environmental sciences (see Bibliography, p.311), detailing scientific research that had adopted a citizen science methodology. Papers were categorised as models for participation in line with the Bonney et al. (2009) and Shirk et al. (2012) typology. The papers were thematically coded and analysed across the themes of motivations, objectives, outcomes and limitations in order to reveal trends in practice and outcomes, across the different approaches to citizen science.

2.4.2 Methods

The literature sample for this review was identified through an online database search for peer-reviewed literature and then a manual sifting of the search results, in order to identify a sample of 181 articles that would address the analytical questions of the review. To identify potential articles for inclusion in the review a search for journal articles with the phrase 'Citizen Science' in the article title or keywords was conducted in the database SCOPUS, on 9th February 2017. The results were imported into EndNote software and the duplicate references removed leaving 1315 articles. In order to further refine the search results, articles were excluded against the criteria detailed in Box 2.3. Articles were either excluded during a preliminary reading of all 1315 article abstracts, or later through the data analysis phase where more light was shed on their suitability for the review. After exclusion of articles based on the criteria in Box 2.3, and then the success of acquiring access of full text pdfs, followed by further elimination during the data analysis phase, 181 articles remained.

Box 2.3: Sampling criteria for article selection.

(if articles met these criteria they were excluded from the sample).

- Did not represent environmental or ecological science.
- Discussed multiple, rather than a single citizen science project.
- Represented projects which only involved citizen scientists in online science activities.
- Used citizen science data but had not delivered citizen science activity.
- Made no reference to the involvement of citizen scientists in science, or the development of citizen science practice.
- Only discussed the participation of citizen scientists in the science in two sentences or less.
- Were not written in English.

Data analysis first involved the development of a set of questions and the deductive codes which would be used to identify and organise the relevant data from the academic literature. The questions and codes developed for data collection were developed from my conceptual and practical knowledge, before being refined and adjusted through a pre-analysis of 30 randomly selected articles. The data collection addressed 7 questions

which were coded through a mixture of deductive and inductive coding (See Table 2.2) from specific sections of the academic articles under review. The definitions for the deductive codes used to identify which model of participation had been used in the project, had to be refined from the original definitions offered, in order to clearly categorise the literature (see Box 2.4). The review was conducted using NVivo 10 software, enabling both adequate storage and organisation of the review sample, but also effective data coding and analysis. Using NVivo10 query function the subthemes identified for motivations, objectives, outcomes and limitations were compared across the different models of citizen science, to look for presence and absence of themes in correlation to the different models of participation. Subthemes were quantitatively recorded in order to understand the representation of each theme across the sample. Representation of each theme is presented as a percentage of the papers which discussed the analytical theme, rather than a percentage of the whole dataset.

Table 2.2: List of questions used to characterise the models for public participation in citizen science.

No.	Questions	Coding method	Article headings data was collected from
1	What were the objectives of the project?	Inductive	Abstract; Introduction
2	Were the objectives knowledge/action objectives?	Inductive Deductive: (Knowledge/ Action)	Abstract; Introduction
3	What reasons for using a citizen science method are described?	Inductive	Abstract; Introduction
4	Was the citizen science method described, Contractual, Contributory, Collaborative, Co-created or Collegial?	Deductive: (Contractual/ Contributory/ Collaborative/ Co-created/ Collegial – see Box 2.4)	Methods
5	What are the reported outcomes and benefits of the citizen science project?	Inductive	Abstract; Introduction; Discussion; Conclusion
6	What are the reported limitations of the project?	Inductive	Abstract; Introduction; Discussion; Conclusion
7	How thoroughly were the methods of the citizen science project reported in the paper?	Deductive (High/ Medium/ Low)	Methods
NB: Where articles were not structured under these headings or where there were ambiguities in the way the information was presented, data for all 7 questions was collected from across the whole paper.			

Box 2.4: Definitions of Models for Public Participation in Citizen Science used in review.

(Definitions are adapted from (Shirk et al., 2012))

Contractual: Project is identified by citizens who ask scientists to conduct the research for them and where the citizens do not participate in the research process

Contributory: Project is designed by scientists and for which members of the public contribute data only.

Collaborative: Project which is designed by scientists, but the citizen scientists are involved in refining the project design, data collection, data analysis, and/ or dissemination of findings, but not question identification, hypothesis development or data interpretation.

Co-created: Project in which citizen scientists are involved in co-designing the project, question identification, hypothesis development and/or data interpretation. They may additionally be involved in data collection, data analysis and dissemination of findings.

Collegial: Project where citizens design and deliver a citizen science project independently of professional scientists or scientific institutions, or with some consultation from scientists.

2.4.3 Results

Identifying models of participation in citizen science

Most significant to this review was the finding that authors of the literature under review rarely labelled the approach to citizen science that they had adopted, as per the typology of Bonney et al. (2009) and Shirk et al. (2012). Only 16 papers (9% of the sample) specifically referred to and defined themselves against this typology. This undermined the methodology for the literature review, as identifying the model of participation was fundamental in being able to compare characteristics. In response to this challenge I began to categorise the projects through closer examination of the methodological descriptions, against the definitions highlighted in Box 2.4. As I conducted this process, I began a quantitative assessment of the extent to which the citizens' involvement in the research was described. I found that 22% of papers described the citizen contribution in 6 paragraphs or more, 40% of papers in 3-5 paragraphs and 38% of papers in 1-2 paragraphs. Even when papers described the citizen science methods more extensively, it was still not possible to conclusively identify which model of participation had been used. Finally, this meant that it was not possible to compare different models of participation against the other data collected in this review. Whilst it was not possible to clearly identify the different approaches to citizen science through this review, Roy et al.'s (2012) review of citizen science and environmental monitoring projects, and Pocock et al.'s (2017) review of the ecological and environmental science literature did manage to do so, and found that the majority of projects were contributory in nature, with very little representation of collaborative and co-created approaches to citizen science. In fact Pocock et al. (2017) found that 93% of projects were contributory, as opposed to collaborative or co-created.

Due to the fact that this review was unable to identify the different approaches to citizen science practice, the following results represent trends in citizen science projects across a wide variety of practices and levels of participation, but exclusively within the ecological and environmental sciences.

Motivations for adopting citizen science

Motivations for adopting a citizen science approach were wide ranging, including scientific, public engagement, environmental, social and civic opportunities, and were referenced in 127 of the papers (70%). The practice of citizen science is dominated by a motivation to advance science (88% of papers discussing motivations) and to facilitate public engagement and education (51% of papers discussing motivations). The interest in advancing science is due to the recognition that citizen science has the capacity to expand the production of science beyond what scientists and research budgets can achieve alone, by increasing the size, geographic scale and temporal scale of datasets. Whilst the interest in public engagement and education is due to the recognition that citizen science increases the awareness, interest and understanding of science and the environment, increasing and improving the 'publics' engagement with both. Other motivations themes included Fostering Support for the Environment (19%), Utilising Citizen Scientist's Skills, Resources and Passion (15%), Civic Engagement (12%), Building Relationships (10%), the fact that citizen science data and methods have been validated as rigorous (10%), Community Empowerment (8%), Supporting Environmental Management (7%) and finally Fostering Support for Science (6%) (all figures are a % of the 127 papers that discussed motivations).

Objectives when using citizen science

The literature sample demonstrated that citizen science is applied to a wide variety of knowledge and action-orientated objectives. Here we define knowledge objectives as goals aiming to increase understanding of conceptual or practical phenomena, for example, estimating the changes in population of bat species in Great Britain (Barlow et al. 2015), and action objectives as goals aiming to increase the implementation of practical phenomena, for example, 'engag[ing] citizens in the removal of marine debris from the beaches' (Martin, 2013). I identified evidence of stated project objectives in 172 papers (95% of literature sample). I found six different types of knowledge objective across 154 papers (89% of papers describing objectives) and 12 different types of action objective across 82 papers (47% of paper describing objectives), demonstrating the dominance of knowledge objectives in published ecological and environmental citizen science. Generating scientific knowledge was unsurprisingly the most dominant objective

across the literature, identified in 133 papers (77% of papers describing objectives). Other knowledge objectives included assessing Citizen Science's suitability for scientific research (18%), assessing the suitability of scientific methods (4%), understanding how to support citizen engagement in science (1%), understanding citizen's attitudes and values (1%), and assessing the legitimacy of citizen's knowledge in just one paper (all percentages calculated as a percentage of the papers that discussed objectives). The main action objectives represented in the literature were unsurprisingly the delivery of public engagement and education objectives, discussed in 48 papers from the sample (27%). The other action objectives included generating and processing data (17%), environmental management (11%), developing scientific methods (5%), building citizen science capacity (4%), community support and development (4%), building relationships and partnerships (2%), knowledge exchange (1%), and the developing commercial services and tools, regulatory compliance, achieving resource savings, and creating an open participatory cultures, all represented by just one paper each. All percentages calculated as a percentage of the papers that discussed objectives.

Outcomes achieved through citizen science

Citizen science as applied in ecological and environmental sciences achieves a number of scientific, social, environmental and economic outcomes. Six overarching themes for the types of outcomes realised through a citizen science approach, were identified from 150 papers within the sample (82%), with the advancement of science as the most dominant outcome from across the research sample, reported in 128 papers (85% of papers that describing outcomes). This was followed by the advancement of citizen science (45%), educational and empowerment impacts on communities such as learning and skills development, creating a sense of ownership and changes in attitudes towards the environment (28%), environmental management and policy-making (16%), resource savings where the use of citizen science approach is recognised as a cost-saving or cost-effective way of carrying out the research (14%) and building relationships and networks between citizens, scientists and government bodies (9%). What was particularly interesting about these findings was that they are not as diverse and nuanced as what

was expressed and represented as objectives and intentions for the projects (all figures are percentages of papers that discussed outcomes).

Limitations of citizen science

The literature revealed a set of scientific, public engagement and resource limitations when using a citizen science approach, I identified seven different types of limitation from across 55 papers from the sample (30%). The most commonly reported limitation within citizen science was reported as data quality and suitability for addressing scientific problems (36 papers, 65% of papers discussing limitations), such as incomplete datasets, the requirement for expert validation, spatial and observer bias, or the methods and tools not being appropriate for the science or the citizen scientists. The other reported limitations were public engagement difficulties, such as trouble recruiting, retaining and motivating citizen scientists (29%), the limitations of citizen skills and experience (25%), resource requirements for running the projects being prohibitive (25%), scepticism around the reliability and validity of a citizen science approach (7%), balancing the science with the public engagement objectives and needs (7%) and finally challenges with analysing citizen science datasets (5%).

2.4.4 Discussion

The literature review whilst not successful in its original intentions of being able to identify the different motivations, objectives, outcomes and limitations of the different models of citizen science practice, as defined by Bonney et al. (2009) and Shirk et al. (2012), did present some valuable findings. Firstly, the lack of reference to the citizen science typologies, within the literature sample suggests a separation between the mainstream utilisation of citizen science practices, and the academic: practitioner citizen science community focused on developing understanding of and best practice in citizen science. A lack of communication and engagement between the broader utilisation of citizen science and the citizen science research community, is likely to mean that the broader application of citizen science practice is not advancing and developing in line with research on best practice.

Secondly, the relatively sparse representation of the citizen science methods across the literature presents a fundamental scientific problem, on both the front of the replicability of scientific research, and on the replicability of citizen science practice. Without detailed descriptions of the citizen science methods that have been employed, particularly around how citizens participated in the research and the methods and tools used to support their engagement, the concept of replicability within scientific research is undermined. Citizen science as part of the method of research will impact on its results, and should therefore be described in as much detailed as possible. Firstly, this allows for critical examination of the research methodology in assessing the reliability of the findings, and secondly to allow for the replicability of the research in order to verify or falsify the findings. Furthermore, whilst the lack of methodological reporting has an impact on the process of science, it also restricts the ability to develop citizen science practice from one research project to a next, as scholars are unable to gain insights of best and poor practice.

Thirdly, whilst the literature suggests that there are wide ranging opportunities and intentions in citizen science, practice remains concerned with scientific advancement and public engagement, with relatively few examples of the more socially and civically orientated intentions. Citizen science in the environmental and ecological sciences at the point of this review is still dominated by the 'instrumental' citizen science, as associated with Bonney's definition, rather than the 'democratic' citizen science, as associated with Irwin's definition. Citizen science in this way is still being driven by an interest in developing and progressing science, with some interest in increasing citizens' engagement in the science, largely in order to generate greater support for scientific endeavours. This is citizen science for science's sake. However, the diversity of other intentions and objectives reflected in the literature also reveal that there is some interest and awareness within the ecological and environmental sciences to a broader range of civically and politically influential opportunities in citizen science, exploring therefore, citizen science for society's sake.

Finally, it was curious to see how there were a much broader range of objectives identified within the literature sample, than there were outcomes noted at the end of the research papers. This demonstrates that there is a recognition, or at least an understanding, that citizen science can have a vast array of scientific, social, environmental and political

impacts, and an interest and sense of value in achieving a broad range of objectives. However, the fact that the wide range of objectives that were highlighted are not then represented in the reported outcomes of the project, suggests that this wider range of outcomes were not evaluated for. This in turn, suggests that these objectives may have been stated as assumed and implicit outcomes that would emerge naturally without purposive effort or design. I now explore the understanding of the outcomes in citizen science through the findings of this structured review and the wider academic literature.

2.5 Outcomes in Citizen Science

2.5.1 Scientific, social and environmental impacts in citizen science.

A commonly and widely acknowledged opportunity and benefit of citizen science is the fact that it can deliver both scientific and social outcomes at the same time. Many proponents of citizen science, particularly those who have an instrumental philosophy with regards citizen science, suggest that projects should have an authentic scientific objective regardless of any other outcomes they aim to achieve (Bonney et al., 2014, European Citizen Science Association, 2015). In contrast, those who consider citizen science more from the democratic philosophy prioritise the communities' interests over scientific outcomes, and suggest that even rigour can be deprioritised to make way for the communities needs and interests (Wilderman et al., 2004). Regardless of where the emphasis of the endeavour is driving, or what approach is being adopted, citizen science has now been demonstrated as having wide-ranging opportunity and impact. The structured review above demonstrates how scientific, social, environmental and economic goals can be achieved through citizen science. Shirk et al. (2012) suggest that there are three types of outcomes in citizen science; scientific outcomes for research, knowledge and skills outcomes for both scientists and participants, and policy, capacity and action-orientated outcomes for socio-ecological systems. Wilderman & Shirk (2010) discussing community science approaches, most specifically, draw parallel conclusions on the thematics of the outcomes of participatory research processes, suggesting three major types of outcomes from these types of project; research findings, science education and then community action. What these typological offerings suggest, alongside the findings from the structured review above, is that there are four social realms within which

citizen science has impact; 1) the scientific institutional realm, 2) the individual and personal realm, 3) the broader social, collective realm, and then finally 4) the realm of the physical environment. As discussed above there is an association between projects with instrumental philosophies having a primary interest in the delivery of scientific outcomes, whilst those with democratic philosophies having a primary interest in the delivery of social outcomes.

2.5.2 Scientific outcomes in citizen science

One of the reasons for the propulsion and expansion of citizen science practice over the last couple of decades is because of the evidence demonstrating how adequately citizen science can fulfil scientific goals (Bonney et al., 2016b) and more than this, how citizen science can increase the capacity of science to address questions and problems (Miller-Rushing et al., 2012). Citizen science has been recognised as a powerful way to increase the temporal and geographic scope of scientific datasets, and collect high quality data in large quantities, leading to science being able to answer questions it didn't previously have the capacity or ability to address (Cooper et al., 2007, Wiggins and Crowston, 2011, Miller-Rushing et al., 2012, Roy et al., 2012, Pocock et al., 2017). There is also evidence that the inclusion of local knowledge in research improves the quality of models and risk assessments (Ottinger, 2010). Beyond this there is an interest in the ability that citizen science has to change the relationship between science and society, increasing the relevance of the knowledge produced, increasing the profile of science and increasing the value held of science (Hecker et al., 2018).

2.5.3 Science education outcomes

Where the dominant practice of citizen science is from the philosophy of instrumentalism and with that there is a dominant focus on the scientific outputs that can be achieved, this space of instrumentalism is also highly interested in the science education benefits of citizen science, seeing this as a way to further expand science within society (Bonney et al., 2016b). The science education outcomes of citizen science are wide ranging, starting most fundamentally with increased knowledge of scientific topics, and improvements in scientific literacy and skills (Cooper et al., 2007, Miller-Rushing et al., 2012, Roy et al.,

2012, Shirk et al., 2012, Cooper, 2016, Ceccaroni et al., 2017, Pocock et al., 2017, Hecker et al., 2018). It is also suggested that citizen science engagement acts as a type of work experience supporting citizens in their pursuit of scientific careers (Ceccaroni et al., 2017). This increased understanding and engagement with science increases the science capital of the participants (Hecker et al., 2018) and increases citizens' sense of ownership over the knowledge and expertise that they have (Shirk et al., 2012).

However, as Shirk et al's (2012) trinity of citizen science outcomes suggests there are more than just learning and science education benefits for citizen participants, but that engagement in citizen science leads to changes in personal relationships and increases the ability of communities to take action. Where citizen science practice engages with ecological and environmental sciences, the knowledge and engagement of the natural world that is created through participation increases citizens' sense of place, their enjoyment of, and their relationship with nature, often leading to an increased stewardship (Shirk et al., 2012, Hecker et al., 2018). Further to this there is evidence of empowerment outcomes for citizens and their communities (Hecker et al., 2018), with an increase in community resilience and in increase in the social networks of individuals and communities (Ceccaroni et al., 2017). This empowerment is related to both scientific and policy processes with participants having a greater ability to impact and influence research agendas and policy (Ceccaroni et al., 2017). Interestingly the impacts on the scientists involved in these partnerships are scarcely mentioned or addressed, but Shirk et al. (2012) does highlight how scientists increase their understanding of local areas and their appreciation of local knowledge, as well as getting an increased sense of hope and a change of scenery through engaging more directly and actively with people in communities.

2.5.4 Socio-political outcomes of citizen science

There is a dominance of focus within the field and the literature on the scientific and public engagement outcomes of citizen science, and very little focus or reporting on the more socio-ecological outcomes of citizen science, as described by Shirk et al. (2012). The prevalence of interest and reported outcomes in citizen science tends to be around the scientific outcomes (85% of the literature in the structured review above) and individual

outcomes of projects (28% of the literature in the structured review above), due to a strong framing that citizen science should be beneficial to both science and the citizen scientists that participate. However, there is growing interest and understanding of the broader social and environmental implications of citizen science projects, which, as noted in section 2.5.3 above, includes an increased ability to create community action. In the structured review above, 16% of the literature reporting outcomes discussed outcomes around environmental management and policy-making, whilst 9% of papers discussed the improvements in social relationships, either with or between communities, and between communities and governmental organisations. Citizen science is therefore somewhat recognised as having value and impact on broader societal relationships and on social governance and management through policy-making. Policy-making and management decision-making is of growing interest in the field of citizen science as it becomes more and more recognised that the historic and geographically widespread datasets collected by citizen scientists are valuable for the development of policy making and environmental management decision-making, but also useful for assessing policy implementation (Cooper et al., 2007, Miller-Rushing et al., 2012, Pocock et al., 2017, Hecker et al., 2018). In fact, Cooper et al. (2007) discuss how citizen science doesn't just increase the scale of the science that can be produced, but also the management monitoring too. Roy et al. (2012) discuss how policy initiatives have highlighted the significance of volunteers' contributions to environmental monitoring, which is seen as balancing the interests of various stakeholder groups, and developing transparency in the monitoring and policy-making processes, which increase the effectiveness of environmental protection. For Ottinger (2010) the strength of public participation in environmental decision-making is in the decision-making being more robust, and the fact that the more democratic process ensures that decisions are more representative of the concerns of the broader society. Hecker et al. (2018) highlight that the policy-making influence of citizen science has value at community levels all the way through to international level, indicating that it can have power and influence at many levels of society. Both Cooper et al. (2007) and Shirk et al. (2012) highlight the socio-ecological outcomes of citizen science that are created due to an increased engagement of citizens either in policy (Shirk et al. 2012) or in the environment through increased stewardship

(Cooper et al. 2007). Roy et al. (2012) second this highlighting how citizen involvement in environmental monitoring supports public debate. Furthermore, Danielsen et al. (2007), discuss how for the same investment from a government participatory approaches to biodiversity monitoring lead to more action than conventional monitoring approaches. Within the context of environmental and ecological sciences this builds to a recognition that citizen science influences environmental and resource management, addressing environmental degradation and improving the health and quality of ecological habitats (Shirk et al., 2012).

2.5.5 The emerging gap in knowledge

So far this literature review has established that more democratic and participatory models of citizen science are more likely to have action-orientated outcomes. However, the field of citizen science shows a dominance towards more instrumental philosophies, where science is produced for science's sake, resulting in a lack of examples of more participatory models of citizen science practice. Due to the lack of case studies of more participatory approaches and a lack of empirical work, there is a limited understanding of the link between process and outcome (Shirk et al., 2012, Bonney et al., 2016b) and the way in which action can be delivered for communities. In response to this gap in knowledge, I now delve into the co-creation and participatory research literature in order to develop a theoretical foundation to address the research aims of 1) how co-created manifests in citizen science and 2) how co-created citizen science process can deliver action for communities.

2.6 Co-created practice in citizen science

2.6.1 Defining the difference between co-created and community-led science.

Whilst this research project is interested in how co-created models of citizen science can deliver outcomes for communities, the research is investigating the phenomena of co-creation, rather than of community science. The term 'community science' or 'community-led science' has been used in a number of ways. For Wilderman et al. (2004) and Wilderman and Shirk (2010) the phrase 'community science' is used interchangeably with 'citizen science' and 'participatory research', demonstrating an utilisation of the term that

means public participation in scientific research. For Cooper et al. (2007) the phrase ‘community science’ is used as an umbrella term for any scientific research process that involves the public in some part of the process. There use of the term includes ‘citizen science’ and ‘participatory action research’ models of practice (Cooper et al., 2007). However Bonney et al. (2016b) and Haklay (2017) use the phrase ‘community science’ to indicate particular types of citizen science practice, identifying community science as a specific approach to public participation in scientific research rather than an over-arching concept. Bonney et al. (2016b) decision-making for public health or conservation (Bonney et al. 2016, pg. 9). Whilst Haklay (2017) also highlights that ‘community science’ looks to deliver benefits at the community level, his presentation of the concept also impresses that the goals of the project are the community’s goals and that the projects are “initiated and driven by a group of participants” (Haklay, 2017, pg. 4). So whilst Bonney et al. (2016b) suggest that community science is about projects which look to deliver impact for communities, Haklay (2017) suggests that community science is about projects where the community lead and drive the research process.

Bonney et al. (2016b) and Haklay (2013) both acknowledge the strong association between community science projects and co-created, or participatory, research approaches, but both groups of scholars recognise that the two can occur without each other. The two concepts, whilst closely associated, highlight different and separate, but both important, dimensions of citizen science practice. The concept of ‘community science’ emphasises the objectives and intentions of the projects and the driving force of the project, whilst the concept of ‘co-created citizen science’ emphasises the manner in which the project is conducted. The overarching aims of this research are to understand how the process of co-creation manifests in citizen science, and how this leads to the community action. Whilst examples of community science could be examined in order to address these research aims, not all community science projects will necessarily adopt a co-created approach to research. The focus in this research is therefore on projects which adopted a co-created process, regardless of who were the leaders and drivers of the projects. This is because the primary interest is in understanding how more participatory processes of collaboration between scientists and citizens, might deliver

benefits for citizens, and this interest does not assume that the citizens have to initiate a project in order for them to gain substantial advantage and benefit.

2.6.2 Defining co-creation

With this focus on understanding how co-created research process can help to deliver community action, it is important to understand more clearly what is meant by the concept of co-creation. Bonney et al.'s (2009) and Shirk et al.'s (2012) typology of public participation in scientific research defines co-created citizen science as,

> *"projects, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all aspects of the research process." (Shirk et al., 2012, pg. 4).*

Here the parameter which determines the model of participation utilised is the "degree of participation" that the public have in the research process, which Shirk et al. (2012, pg. 3) indicate is defined in this piece of work as "the extent to which individuals are involved in the process of scientific research: from asking a research question through analysing data and disseminating results". The typology and the definition of co-created citizen science is therefore driven by notions of which parts, and how many parts, of the scientific process the public participate in, but not the manner in which the participation takes place.

The concept of co-creation has its origins in the Scandinavian participatory design movement (Sanders and Stappers, 2008), as well as in management and service design sectors (Skarlatidou et al., 2019), which went through a period of enlightenment that recognised that including end users in the process of design could increase the value of the outputs of those processes. In this space some definitions have a similar leaning towards a focus on the stages of the process in which the public participate in, with Voorberg et al. (2014) defining co-creation as the "active involvement of end-users in various stages of the production process" (Voorberg et al. 2014, pg. 1335). However, Sanders & Stappers (2008) and Sanders & Simons (2009) add some focus on the manner in which the public participate in the process, through their emphasis on "collective creativity" (Sanders & Stappers, 2008, pg. 6). Suggesting that co-creation doesn't just

include the public in following the guidance offered by the researcher, but that their own creativity influences the process too. Their suggestion also emphasises that it is both the researchers and the end-users' creativity together that influences the process, not just one or the other.

Pieters and Jansen (2013) highlight a misinterpretation of the concept of co-creation, suggesting that some have used the concept to describe participation in focus groups and similar participatory processes. In order to try to more clearly define the intention of the meaning of co-creation they suggest the term "complete co-creation" defining it as, "a transparent process of value co-creation in ongoing, productive collaboration with, and support by all relevant parties, with end-users playing a central role," (Pieters and Jansen, 2017) p.15). Here Pieters and Jansen (2017) add extra detail and embellishments on the meaning of the concept of co-creation, which suggest much more depth in the relationship and partnership that is built between the public and the researchers. The mention of transparency suggests the importance of the publics' observation and awareness of decision-making processes and governance around the endeavour. The mention of 'on-going' suggests importance around a longer commitment between end-users and researchers. 'Support by all relevant parties' demonstrates that multiple stakeholders should be a part of the process, and 'end-users playing a central role' demonstrates how the end-users should be key and central actors within the process. This more thorough definition of the concept provides more of a sense of a holistic and multi-faceted endeavour between multiple actors, of which the end-users are as, if not more, important as the 'professional' actors.

Voorberg et al.'s (2014) review of the concept of co-creation in the social innovation literature identified a number of concepts that were commonly associated with the concept of co-creation. Some of the concepts identified were similar to Shirk et al.'s (2012) and Voorberg et al.'s (2014) broad definition, simply focused on public involvement in the process, whilst other concepts followed Sanders and colleagues' (Sanders and Stappers, 2008, Sanders and Simons, 2009) and Pieters and Jansen's (2017) definitions highlighting the public as valuable and central partners in the process. Other concepts highlighted the development of relationships between governmental and citizen actors, suggesting that co-creation involved the development of sustainable relationships

between the two, and further to this a scenario of joint responsibility between the professionals and the citizens for delivery of services (Voorberg et al., 2014). These two concepts suggest that one of the avenues of co-creation is to build longer-term relationships and an increased efficacy, agency and participation of citizen society.

2.6.3 Typologies of co-creation

Box 2.5: Typology of co-creation in social innovation (Voorberg et al., 2014).

1) Citizen as co-implementer
2) Citizen as co-designer
3) Citizen as initiator

Box 2.6: Typology of customer co-creation (O'hern and Rindfleisch, 2010).

1) Collaborating – open contribution, customer-led selection
2) Tinkering – open contribution, firm-led selection
3) Co-designing – fixed contribution, customer-led selection
4) Submitting – fixed contribution, firm-led selection

Voorberg et al.'s (2014) review of co-creation in the social innovation literature identified a typology of co-creation/ co-production, which highlighted three different ways in which the public participated in the research and innovation process (Box 2.5). Voorberg et al.'s (2014) typology indicates once again that there is a focus on the parts of the process in which the public participate, rather than the manner or character of the participation itself. O'Hern & Rindfleisch (2010) offer us another typology, very firmly situated within the business product development process (Box 2.6), which typifies different ways in which co-creation might manifest itself in terms of the manner of their participation, rather than which parts of the process they participate in. Here the focus is much more on who has the decision-making power and how much creative freedom the citizens are given within the process. The co-creation either has 'open contribution', meaning citizens can

contribute ideas to any part of the product or process, of ‘fixed contribution’ where the firm invites the citizens to contribute to specific parts of the process they have identified. The other dimension, for which co-creation is typified, is around who has the lead on decision-making for the product or service, either ‘customer-led selection’ where the citizen chooses which of the elements they want included in product or service, or ‘firm-led selection’ where it is the firm that chooses. Whilst this typology is framed heavily around product development and design, it highlights dimensions of co-creation that typologies orientated around extent of participation do not bring to our attention; those around power.

2.6.4 Diversity of co-created practice in participatory research

Literature from international development, policy-making and ecological and conservation sciences, demonstrate a wide variety of ways in which these notions of collaborative creativity and decision-making are utilised in participatory research processes. Whilst there is a trend within participatory research and decision-making processes for government, academic and charitable organisations to initiate and manage the projects (Arvai & Post, 2012, Boivin et al. 2014, Corburn, 2007, Gray et al. 2016, Kendall et al, 2015), there are a number of different ways in which the communities then participate in the process, with varying degrees of influence and leadership being held by the communities. In some projects and processes the professional organisations adopt a largely facilitatory role. Arvai & Post (2012), Bennett & Smith (2007) and Phillip et al. (2010) all describe projects where the professional actors provide the methodologies and frameworks for the research process, and then facilitate the communities’ participation. The communities and professionals work closely together, with much support, expertise and guidance from the professionals, but the professionals remain outside of the processes of decision-making and creativity. In the cases of Arvai & Post (2012) and Bennet & Smith (2007) the communities are able to have complete independence from the influence of the professionals, whilst in Phillips et al. (2010), which describes a participatory research project in a secondary school, the teachers did veto some of the ideas and directions of interest that the students identified. As an extreme example of the collaborative relationship between professionals and communities, Kendall et al.

(2015) describe a project where the professionals provide the community with a framework and a couple of rules to work to, and then are completely left to run the project for themselves, with limited intervention from the professionals through the life of the project.

In contrast to processes of participatory research where creativity and decision-making is not shared by the different actor groups Corburn (2007), Garcia & Brown (2009) and Boivin et al. (2014) all describe participatory research projects where the professionals and the community members have worked together making creative contributions through several stages of the project, each sharing the decision-making process of the research. Garcia & Brown (2009) describe a project where youths and scientists actively collaborated in the development of a scientific method, the collection of data and the analysis of that data, rather than the community carrying this work out themselves. Similarly, in Boivin et al. (2014) a deliberative process is designed which enables healthcare professionals and community members to equally participate in the discussion and decision-making around healthcare priorities, leading to the production of a list of priorities that is a product of both groups knowledge and expertise. Corburn's (2007) case study provides an example of the changing relationships of professionals and communities through the life of the project. In this case study scientists presented an urban community with an environmental health research project they intended to carry out, looking for approval from the community to carry out the work. Through this process the community managed to seize some of the power for the research process, by persuasively demonstrating an alternative focus for the research which had much greater relevance and significance to the community. Subsequently, the professionals and the community worked together to deliver the research for this altered agenda. So in this case where the original intention of the research institution was to carry out a piece of independent research on environmental health, the project was instead transformed into a collaborative research and action endeavour.

Whilst the way in which participatory research processes are utilised can vary from project to project, there is a common understanding of the need to transfer power to communities, through the processes adopted. Projects are motivated by a desire to put more control and ownership in to the hands of communities, providing them with support for self-

governance and leadership, in decision-making and problem-solving processes (Hubbard et al. 2011, Garcia & Brown, 2009, Kendall et al., 2015 and Arvai & Post, 2012). Key mechanisms for enabling this shift of power and ownership come from adopting 'bottom-up' approaches (Kendall et al., 2015) or looking to be more inclusive in what's considered within decision making processes, looking to have a wide range of "personal, social and organisational implication[s]" represented in the process (Bennett & Smith. 2007) pg. 2489).

2.6.5 Most valuable locations of participation in research

Whilst section 2.6.4, above, examines an understanding of the variation in collaborative creativity and decision-making in different participatory research projects, the aforementioned interest in which stages of the research process citizens participate in (section 2.6.2) requires an examination of which stages are considered most valuable for participation. Wilderman et al. (2004), Bonney et al. (2009) and Sanders and Simons (2009) all highlight particular parts of the research process which citizens should participate in through the co-creation process. Bonney et al. (2009) and Sanders and Simons (2009) both highlight how citizens are, and should be, a part of identifying and defining the problem that is to be addressed by the research. Wilderman et al. (2004) further highlight the importance of citizen participation in the analysis and interpretation of the data, as this increased their understanding of the research they had been a part of, as well as their ownership of the results, but also ensures that the results of the research are informed by the citizens' own knowledge. Both the objective identification and project design, and the analysis and interpretation of the results, are highlighted as being highly challenging parts of the process within the co-created approach (Wilderman et al., 2004). These processes are considered to be challenging for both the citizens and the service providers, either due to the difficulties of negotiating conflicts and moving beyond established power dynamics, or else in the challenge of facilitating and making the process accessible to citizen participants (Wilderman et al., 2004).

2.6.6 Failures and challenges in participatory research practice

Whilst participatory research projects present a lot of promise for empowering communities, enhancing research, and delivery action, the delivery of such processes is challenging due to them being inherently orientated around shifting power relationships (Bradbury and Reason, 2012). Whilst projects' focus and efforts are driven towards handing over power and control to communities (see section 2.6.4) their efforts may not always deliver complete emancipation. Kendall et al. (2015) found that the participatory process used to facilitate school improvements did not succeed in including marginalised voices, despite having specifically included project structures to try and address this issue. Building relationships across power boundaries is also challenging with Phillips et al. (2010) describing how in their research team failed to build a relationship with the teachers that meant the teachers could be open and honest about the challenges they faced in delivering the Participatory Action Research process in school. Further to this Cornwell & Campbell (2012) report that through a participatory research sea turtle project neither the professionals nor the volunteers felt that they were epistemic equals. These examples demonstrate how fundamental and multi-faceted issues of power are in collaborative processes and that whilst the aim, purpose and design of participatory research processes is to redistribute power and to generate emancipation for communities, this remains the most critical challenge and failing.

2.6.7 Organisational challenges

Another significant challenge identified within the literature is the organisational change required of institutions that adopt co-created approaches to research and design practices. These processes require such different ways of working and different attitudes towards the relationship between organisation and end-user/ citizen participant that it can take several years to be embedded into organisational culture and the change needs to be supported from the highest level of the organisation (Sanders and Simons, 2009). One of the most striking challenges that co-created approaches to research present is the increased time, effort and resource required in order to create success. Wilderman et al. (2004) and Garcia & Brown (2009) discuss how the citizens' increased control over the process leads to an increased need for technical support from the service providers in the relationship. Whilst this translates into more time, effort and contact for both the service

provider and the citizen participant, it also translates into an increased need for training (Garcia & Brown, 2009, Phillips et al., 2010). Wilderman et al. (2004) highlight the need for increased training in study design, analysis and interpretation, data presentation and good research decision-making, and how this training is more specialist and more technical than might be required in projects of a contributory nature.

2.6.8 Changing roles of citizens in research

One of the impacts of this different way of approaching collaboration with the public is the change in roles of both the citizen participants and the researchers. The normative role of citizens in science is either having no role, having a role as public support and advocacy for science, or in the case of citizen science a role as data collector. Citizens' increased participation in research therefore shifts their role significantly. Sanders & Stappers (2008) encourage that the citizens play the role of experienced experts in the co-creation process, and the power of this can be seen in other participatory research and co-creation examples such as Corburn's (2007) case study on community research in Brooklyn, New York and Hoover's (2016) case study of community researchers in the Akwesasne Mohawk community. In both instances the community members proved invaluable in sharing their local knowledge which shaped and expanded the reliability and impact of research processes. The role and influence of communities bringing local knowledge into research and policy processes, through participatory approaches, is widely recognised. It is seen as broadening and strengthening the relevance and value of science through the inclusion of a broader range of social, cultural, economic and political factors (Arvai & Post, 2012, Corburn, 2007, Cornwell & Campbell, 2012, Garcia & Brown, 2009). Further to this, Wilderman et al. (2004) highlight how the recruitment and volunteer retention of the citizen community is often the role of the citizens in environmental monitoring programmes. As an organised entity the community organisations have the social capital to be able to reach, encourage and successfully motivate other citizens to participate. Further to this however, the Corburn (2007) and Hoover (2016) case studies show how the citizen's role also becomes about accessing the community in order to collect data, and that this increased ability to access the community, by being a part of the community,

has a significant influence on the quality and reliability of the data that is collected in the research.

Box 2.7: Four levels of creativity (Sanders and Stappers, 2008).

1) Doing
2) Adapting
3) Making
4) Creating

Interestingly however, Sanders & Stappers (2008) highlight how the role/ contribution that citizens play in design co-creation depends on the level of creativity they have in relation to a particular task (Box 2.7). They also suggest that the personal perceptions of the individual, about their own creativity, influence how they feel about how they can participate in the process. Whilst this idea is heavily grounded in the concept of design and creativity, the idea could be translated over to the conceptualisation of research, where different individuals will have different abilities to contribute to the research process depending on their scientific literacy and training, and their sense of validity in doing so.

2.6.9 Changing roles of researchers in research

As the citizens' role in the research process changes, so does the researchers. Where researchers ordinarily have the role of designing and delivering the research in its entirety, as they relinquish some of the control and responsibility for this process over to the citizens their role starts to change to one of facilitation (Arvai & Post, 2012, Bennett & Smith, 2007, Phillip et al. 2010) (Wilderman et al., 2004, Sanders and Stappers, 2008). In facilitating the citizens' engagement in the process of research, and in the research itself, the researchers find themselves not only providing technical assistance but also programmatic assistance (Garcia & Brown, 2009) (Wilderman and Shirk, 2010), providing the tools and methods that enable the citizens to participate in the process (Bennett & Smith, 2007, Boivin et al. 2014, Kendall et al. 2015) (Sanders and Stappers, 2008). A part of this process involves capacity-building within the community through training and providing the necessary support and infrastructures that the citizen participants need

(Garcia & Brown, 2009) (Wilderman et al., 2004, Wilderman and Shirk, 2010). As facilitators the researchers are working towards facilitating the will of the community, but in doing so they need to decide which community of stakeholders they are serving in the process (Wilderman et al., 2004). Further to this, Wilderman et al. (2004) highlight how the researchers have to be careful with the extent to which they exhibit control over the process, when their primary role is facilitation. Whilst the researchers' role has seen a shift from that of scientist to that of facilitator, they still have a fundamental role, in providing scientific expertise within the process, to ensure the validity and credibility of the data outputs (Wilderman, 2007, Wilderman and Shirk, 2010).

2.6.10 Philosophies of collaboration

Box 2.8: Factors important for quality in co-creation (Voorberg et al., 2014).

- Trust
- Mutual respect
- Ethical commitment to participants
- Transparency of decision-making

Box 2.9: Prerequisites for co-creation (Sanders and Simons, 2009).

- Belief that all people are creative
- Diversity is a key driver
- Joint problem definition, not just joint problem solving
- Continuous dialogue and conservation
- Design tools, materials and methods that put all players on common ground
- A focus on experiences, not just products and services
- A focus on whole experience, not just a single touch point

In this new type of relationship between citizens and researchers and with new roles in play for this type of a partnership, the relational dynamics between the two parties need to be carefully negotiated. Voorberg et al. (2014) and Sanders and Simons (2009) offer

a set of attitudes and behaviours that need to be included within these types of processes, in order for them to be successful (Box 2.8 & 2.9). Both Voorberg et al. (2014) and Sanders and Simons (2009) highlight ideas around the actors' attitudes to one another, noting issues such as trust, mutual respect and belief that everyone has creativity that they can contribute to the process. They both also raise issue with the matter of power, addressing how governance should either be shared or transparent, and that the process of participation should be designed in such a way as to balance out the power differential. Sanders & Simons (2009) also offer the idea of taking a holistic view of the process, not just thinking about the end point, deliverables, or single instances of contact and participation, but thinking about the process, and experience of that process, as a whole. Voorberg et al. (2014) also importantly highlight the matter of commitment, and that in these types of processes the researchers need to make ethical commitments to those participating in the process within them. Voorberg et al. (2014) go on to highlight that there are two sets of influencing factors that determine the success of co-created approaches, firstly organisational factors which are focused on how compatible organisations are to enable citizens to participate in the process, and secondly the citizens' own willingness and capacity to participate. In both of these instances Voorberg et al. (2014) highlight how it is the organisational actors who are responsible for addressing these factors and removing barriers to participation for the citizens.

2.6.11 Knowledge outcomes through co-creation

Shirk et al. (2012) suggest that the outcomes of a project relate to the degree to which members of the public are engaged in the research, hence the interest and concern with the typologies of public participation in scientific research. Understanding what different approaches to practice are available for participatory research, and knowing the differences in impacts and outcomes of those approaches is important for the development of the field and the expansion of citizen science practice. A richness of knowledge outcomes are known to be possible from co-created approaches to research. Corburn (2007) and Hoover (2016), mentioned above, both provide examples of cases where a co-created or community approach to science research had significant empirical benefits for the research in question. Either the local residents were able to increase the

access of the researchers to the community thereby collecting data that had a higher fidelity, or else the local residents were able to identify the most pertinent questions, highlight methodological flaws based on locally contextual factors, or influence the understanding of the results by highlighting facets of the local community or context that scientists would never have been aware of. That being said, Wilderman et al. (2004) highlight how knowledge created through a co-created approach can be less accurate and precise than a contributory approach. However, lay experience filling the knowledge gaps of professional scientists, and providing other important contexts for research projects, is widely seen as a valuable outcome of participatory research projects (Bennett & Smith, 2007; Corburn, 2007; Cornwell & Campbell, 2012). Lay communities are able to provide professional researchers with expertise and insights that are specific and grounded in the reality of the research subject, knowledge that researchers who are often detached and remote from the environments they study, would never otherwise have access to (Bennett & Smith, 2007; Corburn, 2007; Cornwell & Campbell, 2012). Corburn (2007) argues that this increases the legitimacy and the public accountability of the knowledge that is produced. Further than this the collaborative processes of deliberation that take place between professional scientists and communities of citizens, lead to knowledge and understandings that are closer in alignment with one another (Boivin et al. 2014; Cornwell & Campbell, 2012). The closer alignment comes both in terms of increased agreement around the reality of a situation, but also an increased understanding and appreciation for each other's perspectives (Boivin et al. 2014; Cornwell & Campbell, 2012). Beyond the academic knowledge outcomes of participatory research and co-created processes, community knowledge outcomes are also realised (Boivin et al., 2014; Garcia & Brown, 2009; Gray et al., 2016; Kendall et al. 2015). The process of being involved in participatory research processes involves a process of social learning for participants, and helps them to develop other forms of expertise (Gray et al., 2016; Garcia & Brown, 2009). Engagement in these types of processes also has an awareness raising influence on the communities in question and can lead to conceptual changes (Garcia & Brown, 2009; Kendall et al. 2015; Boivin et al. 2014; Gray et al. 2016).

2.6.12 Action outcomes through co-creation

Wilderman and Shirk (2010) suggest that co-created approaches have a strong correlation with action-orientated outcomes, with Wilderman et al. (2004) and Wilderman and Shirk (2010) suggesting that co-created approaches have superiority over other approaches, for creating action. One of the key ways in which co-created and participatory approaches to research create action is through social change. This takes many forms, including through education, increasing scientific literacy and skill building (Bonney et al., 2009, Phillips et al., 2010). Another notable way in which participatory research processes create social change is through community empowerment. Participatory research processes put the decision-making into the hands of the communities, therefore giving them more control over their own realities, and more power to tackle the issues they face (Wilderman et al., 2004, Phillips et al., 2010, Garcia and Brown, 2009, Gray et al., 2015). These processes can, as Kendall et al. (2015) describe, lead to the development of new leadership structures within the community, which in Kendall et al.'s (2015) case study also resulted in an increase in community engagement.

Whilst co-created research processes look to be able to create change to the shape and structure of the communities that participate, they also create change by delivering tangible action. At a political level Wilderman and Shirk (2010) and Shirk et al. (2012) highlight that co-created approaches create timely policy decisions, but they also demonstrate that tangible action and change can be created at the community level too, with communities' having an increased capacity for resource management, for transforming knowledge into action, and being able to sustain endeavours beyond researchers' presence (Wilderman et al., 2004, Wilderman and Shirk, 2010). This is supported by Garcia and Brown (2009), Hubbard et al. (2011), Gray et al. (2015) and Kendall et al. (2015) whose case studies all demonstrate that participatory research processes increased communities' capacity, enabling them to successfully change practices in a way that benefited them and their objectives. Gray et al. (2015) highlights that, through these participatory research processes, volunteers also had an increased confidence in the plans that they had developed. Finally, processes of this nature also enabled communities to have an impact on institutions external or peripheral to the research projects. In Hubbard et al.'s (2011) case study on provisioning community-supported water and sanitation interventions in rural Peru, communities were able to

attract funding and resources from external institutions, gained political support thereby keeping their issues high on the political agenda, but also influenced a change in funding strategy for critical organisations, who became more willing to fund projects of this nature.

Action outcomes from participatory research processes are commonly suggested as being more relevant and impactful that those generated through non-participatory means (Corburn, 2007, Boivin et al., 2014). This is considered to be the case because the inclusion of community members means that their knowledge, contexts and experiences influence the process of research and thereby create outcomes that are more representative of their lived experience, and are more aligned to their challenges and issues (Corburn, 2007, Bennett and Smith, 2007, Garcia and Brown, 2009, Arvai and Post, 2012, Cornwell and Campbell, 2012). As a result the action outcomes are more likely to be successful and are more likely to be adopted by the community (Corburn, 2007, Arvai and Post, 2012, Boivin et al., 2014, Kendall et al., 2015). Whilst a co-created or participatory research process can directly deliver tangible action, Voorberg et al. (2014) suggest that in many cases projects around social innovation are using a co-created approach as a goal in its own right, rather than as a means to other outcomes. Here co-creation is seen as a social innovation and a form of action, worthy as an objective in its own right. Whilst all these examples above establish that co-created approaches to research can deliver a wide range of action outcomes that directly benefit and deliver action for communities, what they don't establish is how those outcomes are achieved.

2.7 Delivering action and change through citizen science

2.7.1 Revisiting the definition of action

In the introduction to this thesis I established the definition and meaning attributed to the concept of action, for the purpose of this research (Section 1.3.2). With a research aim of understanding how action can be delivered for communities, through co-created processes, here my utilisation of the notion of action is contextualised within the concept of community action and change. I therefore define action as "doing something in order

to have a positive impact or influence, or to make positive change, around a concern or problem".

2.7.2 Failings of traditional research in delivering action

The starting point for understanding how action and change can be realised, for communities, through citizen science, is to understand the extent to which it has been realised through traditional science. This brings us to address the perceived failing of science to deliver impact for society. Whilst there are many examples of the benefits and success that scientific and technological advancements have delivered for society, alongside these benefits emerge uncertainties and failures (Irwin, 1995, Jasanoff, 2003). Both Irwin (1995) and Jasanoff (2003) describe examples of science's failure to adequately assess risks for the public and its lack of omnipotence in controlling technology and science. The BSE crisis in the UK in the 1980s – 1990s, is a commonly cited example of science's failure to deliver accurate scientific knowledge about the risks to human health, which resulted in a loss of life. Irwin (1995) highlights that one of reasons for the failings during the BSE crisis, and in many other case studies, was the science-centred world view which placed scientific knowledge on a pedestal, as infallible, and therefore the best way to make decisions.

2.7.3 A 'Critical view' of science

The failings of this enlightenment perspective towards science have resulted in a 'culture of uncertainty' and a 'critical view of science' where society is more wary and questioning of the impacts that science might have on our lives (Irwin, 1995). Here the whole notion of science's unquestionable delivery of 'progress' is challenged (Chilvers and Kearnes, 2016). We have discovered that sometimes science is unable to deliver accurate knowledge that can reasonably understand and manage the risks around scientific and technological advancements (Irwin, 1995, Jasanoff, 2003), that sometimes the outcomes of science deliver as many dangers and problems and the solutions they offered (Chilvers and Kearnes, 2016, Jasanoff, 2003), that the standards, measures and procedures of science that are relied upon by international governance in order to create progress do not always deliver outcomes that are relevant to localised communities (Turnhout et al.,

2012), and that sometimes innovations delivered by science and research fail to address the fundamental problems that society faces. Ashby (2003) describes how research in natural resource management has failed to address poverty and rural vulnerability.

2.7.4 Increasing pressure on research to deliver solutions

Ironically, whilst there is an increasing scepticism about science's unequivocal ability to deliver relevant and reliable impact and progress, there is also an increased pressure upon universities and research institutions to deliver actionable knowledge that can deliver transformation, for society, in the face of global wicked challenges (Trencher et al., 2017). Funding bodies are investing heavily in funding calls and programmes that address societal challenges and look to develop innovation and economic progress, such as the H2020 funding stream provided by the European Commission (Bonney et al., 2016a). The 'critical view' of science does not call science out as obsolete in tackling global and even local challenges, but rather acknowledges the insufficiency of traditional approaches to science in tackling complex environmental and social problems, and the need for the integration of the knowledge of "ordinary" (Turnhout et al., 2012, pg. 454) citizens in order to generate innovation (Turnhout et al., 2012). The problem is seen as being the positivist and reductionist nature of science (Ashby, 2003), and therefore it is a transformation in the way that knowledge is produced that is needed in order for science to adequately address societal challenges.

2.7.5 The shift towards participatory research

Central to the argument for a transformation to the way in which knowledge is produced is the problems associated with knowledge being developed in isolation from the rest of society. Whilst science's value has always been championed based on its being "impartial and 'value-free'" (Irwin, 1995) pg. 27), Cooper (2016) argues that,

> *"The human race faces a host of big problems that scientists alone can't solve….. Scientists….can't cure these woes while their methods are cordoned off, available only to a few. To generate effective solutions, we need to relocate the scientific process of discovery away from its isolation." (Cooper, 2016, pg. 9).*

This drawing knowledge production out of its isolation is part of the broader cultural zeitgeist looking to increase the openness of different societal institutions, including science, but also democracy, called the “age of participation” (Chilvers and Kearnes, 2016) pg. 2). In this ‘age of participation’ we see a redistribution of expertise, and the inclusion of multiple ways of knowing into the decision-making processes governing society (Chilvers and Kearnes, 2016). Cooper et al. (2007) describe how the field of conservation has called for a more “deliberative” and “inclusive” conservation practice, that develops a “democratic science” where scientists “take responsibility” for the findings of their work, and the subsequent impact (Cooper et al. 2007, p. 6). Ashby (2003) reflects on what this ‘age of participation’ looks like in science,

> *“researchers are only one of many stakeholder groups, each with different kinds of knowledge and often with competing ideas about the purpose of research, as well as of the use of the natural resources in question… in order to do research for development, researchers are beginning to relinquish classical, reductionist notions of control and objectivity. One of the major challenges is for researchers to recognise that their results and their impact on NRM depend on relationships with other stakeholders, who may have more power to visualise and to realise the desired outcome of interventions than researchers do. As a result, the participation of key stakeholders alongside scientists in a jointly managed process of investigation and learning based in action is a central feature for research for development. In such science, quality depends on the quality of participation of all the relevant stakeholders in research and development, and in the overall innovation process” (Ashby, 2003, pg. 2).*

This ‘age of participation’ sees opportunity in a number of places. Mauser et al. (2013) discussing the need for transdisciplinary research in order to address our global challenges, argue that co-creation of the whole research process with a variety of different stakeholders is important because of the need to bring together both reductionist and contextual knowledge systems, in order to arrive at the most appropriate solutions for

sustainable change. Both Irwin (1995) and Turnhout et al. (2012) similarly argue that including numerous modes and sources of knowledge influences the 'practical effectiveness' of knowledge, but also the innovative possibilities. They argue that without including a variety of "ways of living with and knowing nature" (Turnhout et al., 2012, pg. 455) knowledge production will be unable to create the diversity of actions and solutions required that might be locally relevant to societies. Ashby (2003) adds to the debate by suggesting that without stakeholder participation in research processes it is not possible to arrive at a shared agreement around what the research reveals and what would be suitable solutions and actions. She argues that in addition to this the understanding built on the research does not take into account broader societal influences and dynamics of the ecosystem in question, because those perspectives and viewpoints are not included (Ashby, 2003). Irwin (1995) speaks more directly to the power dynamics within society that either enable or create barriers to action, suggesting that without opening the scientific process up to broader society the production of scientific knowledge maintains the power imbalances that pervade society and prevent citizens from taking action. In this way the structure of science's relationship with society is in its own way oppressive, preventing emancipation of citizens. Irwin (1995) argues that whilst citizens are unable "to take control of their own lives, health and environment" sustainability is not possible (Irwin, 1995, pg. 7). Similarly Ashby (2003) argues that it's only through collective processes of research, learning and action that innovation can take place, and innovation is the only way to achieve successful, sustainable resource management.

2.7.6 Participatory research delivers action

Emerging from these sentiments, multiple approaches to participatory research and citizen science have emerged through the mid 20th Century to present day. Through these practices it has been established that participatory research processes have much capacity to deliver action outcomes that are relevant and impactful for communities. Participatory research approaches are considered to deliver progress in areas like conservation, natural resource management and environmental protection through the types of outcomes and outputs that they can achieve (McKinley et al., 2017). What is also widely recognised is that the more participatory in nature the research process is the

more likely action outcomes can be delivered (Ashby, 2003, Bonney et al., 2009, Wilderman and Shirk, 2010, Shirk et al., 2012, Gray et al., 2015, Trencher et al., 2017). The way in which participatory research processes are able to deliver actionable and relevant change in society is generally discussed around two principle mechanisms, firstly increasing the capacity, legitimacy and relevance of scientific knowledge and secondly empowering civic society.

2.7.7 Increasing the capacity and relevance of science

One of the ways in which participatory research is seen as being better able to deliver action is through enhancing the knowledge and evidence it produces. Eitzel et al. (2017) and McKinley et al. (2017) discuss citizen science as part of the evidence-based decision-making process, in that very fundamentally it delivers scientific outputs that give decision-makers access to the knowledge and understanding that they need to create policy and change. However, McKinley et al. (2017) bring our attention to the fact that citizen science increases the capacity of science, thereby increasing the access of decision-makers to the knowledge that they need. Corburn (2007) also raises the importance of the increased capacity of science through participatory research processes, but discusses the way in which lay communities can fill in the gaps in researchers' knowledge, particularly around local contexts and understandings, and as Boivin et al. (2014) and Cornwall & Campbell (2012) highlight, this leads to the citizen and researcher knowledge being closer in alignment. In fact, this bringing together of lay and scientific knowledge increases the legitimacy and accountability of science (Corburn, 2007, Ashby, 2003). The inclusion of lay perspectives and knowledge also ensures that the knowledge is inclusive of and reflective of the social, economic and cultural contexts of the problem being addressed, but also provides an opportunity for citizens to challenge the scientific method, pushing it away from its positivist philosophical start point (Corburn, 2007), further increasing legitimacy and accountability, and increasing participants confidence in the outcomes of the science (Ashby, 2003). The final way in which participatory research is seen as supporting science in delivering action, is through the way in which it increases the relevance of the scientific findings (Corburn, 2007, Mauser et al., 2013, McKinley et al., 2017). All in all, by increasing the capacity of science, improving the fidelity of science

to the lived experiences of society, increasing science's legitimacy, accountability and its relevance, the scientific knowledge that is produced provides decision-makers with knowledge that it more likely to be effective and impactful for civic society.

2.7.8 Empowering communities

The second way in which participatory research is seen to create action and change is through the process of community empowerment. Shirk et al. (2012) describe how citizen science offers "outcomes for participants such as enhanced self-efficacy and community capacity, social capital and agency – in short, the skills and social resources to put knowledge into action" (Shirk et al., 2012, pg. 9). A starting point for this empowerment is the way in which participatory research processes redress power imbalances in the knowledge production system. What many scholars acknowledge is that participatory research creates the opportunity for a shift of power by providing citizens with control and ownership over the object of investigation and the process of investigation (Ashby, 2003, Garcia and Brown, 2009, Hubbard et al., 2011, Arvai and Post, 2012, Kendall et al., 2015). Power is seen as having a critical influence on the process of research and its outcomes, where a participatory research process has failed it is often because power and learning have not been adequately addressed (Ashby, 2003). Further to this, participatory research processes support communities in developing the self-governance and leadership in decision-making and problem-solving processes, developing new structures to organise themselves (Garcia and Brown, 2009, Hubbard et al., 2011, Arvai and Post, 2012, Kendall et al., 2015). Collectively these influences mean that research processes deliver solutions that are more effective and more widely adopted by communities (Garcia and Brown, 2009, Hubbard et al., 2011, Arvai and Post, 2012, Kendall et al., 2015) and that communities have more power to act on the issues they are facing (Ashby, 2003). In fact, Cooper et al. (2007) express how "combining the power of the Internet with a populace of trained citizen scientists can provide unprecedented opportunity to mobilize a community to address new environmental problems, almost like having the environmental equivalent of a "fire brigade" ready to act as the need arises" (Cooper et al. 2007, p. 8).

2.7.9 Direct tangible action outcomes

An important reflection about these two principle ways in which participatory research is seen to deliver action outcomes is that they do not necessarily reflect the direct delivery of tangible action as a part of the research projects, instead creating the appropriate knowledge and the social infrastructures through which action might be able to be achieved. That being said, there are some examples within the literature of direct and tangible action outcomes being delivered. Ballard et al. (2018) demonstrate how participatory research processes can deliver conservation outcomes directly or indirectly, and that co-created approaches deliver impact more directly. Hubbard et al. (2011) provides a great case study example of how a scientific research process is built around a purposive delivery of action in the building of sanitation infrastructures within the community. Here the researchers provided support to the community through organising the stakeholders and leveraging investments in order to overcome political barriers to delivery of health outcomes. One facet that is raised in this work and which is discussed by other scholars, is how participation in these research processes can lead to direct behaviour change in participants (Garcia and Brown, 2009, Hubbard et al., 2011, Kendall et al., 2015). Key to this tangible action is the learning and knowledge transfer process that takes place through participatory research (Garcia and Brown, 2009, Gray et al., 2015, McKinley et al., 2017). These processes of learning lead to the development of new understandings, which subsequently lead to action through change in behaviour.

2.8 Towards a co-created citizen science for action

2.8.1 Identifying the gap in knowledge

Whilst there are many references and case studies demonstrating that participatory research can deliver action outcomes, with some insights and indications of why, what is lacking from the literature is a more detailed understanding of the way in which the process of participatory research results in the action outcomes, and how they deliver action for communities. Bonney et al. (2009), Wilderman and Shirk (2010) and Shirk et al. (2012) all establish that evaluation of citizen science is lacking, and that as a result there is a lack of measured outcomes for projects, with outcomes often inferred and assumed. Within explorations of the citizen science typologies offered by Wilderman et al. (2004), Bonney et al. (2009), Wiggins and Crowston (2011), Shirk et al. (2012) and

Haklay (2013) all suggest that more participatory citizen science processes are most aligned to the delivery of action-orientated goals, but are unable in the scope of these published articles to address how action is created through these more participatory processes. Even within the broader participatory research literature there is an established understanding that more participatory research approaches increase the quality of science and empower communities, thereby creating the conditions for community action (see sections 2.6.7 – 2.6.9), but they don't establish the link between process and outcome. This is seconded by Ballard et al. (2018) whose examination of conservation outcomes through citizen science highlighted a gap in knowledge around the pathways to conservation goals through citizen science processes. Shirk et al. (2012) specifically speaks to this challenge stating,

> *"with information on PPSR outcomes both limited and dispersed across fields, little in the way of empirically based guidance has been available to inform strategic decisions about aligning goals, outcomes and trade-offs in the design and refinement of projects" (Shirk et al., 2012, pg. 2).*

One of the barriers to this understanding is understood to be a lack of multiple case study research to compare the relationships and understanding from across a range of practices and contexts (Trencher et al., 2017). Trencher et al. (2017) also highlight a lack of understanding of the mechanisms and success of these types of process from a non-academic perspective.

In response to these gaps in knowledge my research looks to achieve two aims. The first aim of the research is to sketch out the diversity of co-created practice in citizen science uncovering the way in which co-creation manifests itself in research processes and the dimensions which affect the collaboration that takes place. The second aim of the research is to examine the link between the nature of co-created practices and the outcomes of the projects, in order to understand how co-created methodologies influence the ability to deliver action outcomes, most specifically for the communities who participate. In order to address these aims a multiple-case study methodology has been adopted and is introduced in the next chapter (Chapter 3). These case studies have been compiled in order to address the following research questions:

1. How does the concept of co-creation manifest in citizen science projects?
2. What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?
    a. What is the link between co-created citizen science processes and action outcomes?
    b. To what extent are action outcomes realised for the communities participating in the citizen science projects?

I now move on to Chapter 3 to present my research methodology.

3 Methodology

I have established in the literature review above that whilst co-created approaches to citizen science are understood to be highly effective at delivering action-orientated outcomes, there is little understanding, represented within the academic literature, about how action for communities is achieved. A lack of empirical work looking to establish the link between process and action (Shirk et al., 2012), and a lack of multiple-case study research designs which can draw comparisons (Trencher et al., 2017), are suggested as reasons for this lack of knowledge. Furthermore, the dominance in citizen science of projects which adopt 'instrumental' philosophies in order to serve the needs of science, results in a lack of examples of more 'democratic' approaches to citizen science which look to serve the needs of communities. In order to address these gaps I look to answer the following research questions:

1. How does the concept of co-creation manifest in citizen science projects?
2. What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?
    a. What is the link between co-created citizen science processes and action outcomes?
    b. To what extent are action outcomes realised for the communities participating in the citizen science projects?

I look to answer these questions through a detailed analysis of five co-created citizen science projects. These case studies will demonstrate the diversity of co-created practice in participatory research approaches and establish the action-orientated outcomes that are achieved through the projects. A narrative interview approach is used in order to develop a detailed representation of the social complexities of each project, and to establish links between the features of the co-created process and the ability to take action.

This methodology sets the foundations of the empirical work of this thesis by first discussing the ontological and epistemological philosophy from which the research methodology emerges, making a justification for the adoption of a constructivist epistemology (section 3.1). I then go on to describe why a multiple-case study research

design was adopted, and how that serves to answer the research questions of this thesis (section 3.2). Next I introduce the narrative interview approach that was adopted to collect the case study data, highlighting the rich insights that can be garnered through this relatively unstructured approach to data collection, and the practical challenges that ensued (section 3.3). Finally I discuss my use of thematic analysis both to draw together insights from within, and across, the case studies (section 3.4).

3.1 Identifying the ontological and epistemological starting point

This first section of the methodology represents a very personal account and understanding of the philosophy of science. It acts as both a framing of the methodology and research, but also as a positionality statement, indicating the logic behind my approach to the research design and execution.

3.1.1 Constructivist ontologies of the social world

I approach this research endeavour from the ontological standpoint of constructivism, believing that the social world and social phenomena are all constructed by and being continually revised by social actors, rather than being independent and external to them (Bryman, 2012). From this stand point I assert that all social phenomena are created by the actions and behaviours of human actors, and not by any other forces of nature (Lynch, 2016, Simandan, 2014). These actions and behaviours, as Schütz (cited in (Bryman, 2016) argues, are dictated by the meanings and relevance that individuals place on the social world around them. These meanings and relevance come from the cognitive frameworks that the individuals hold in their minds, such as norms and values (Simandan, 2014). These norms and values are thereby the driving force of these social constructed realities, and are themselves socially constructed, being determined by cultural and social evolution (Hanson, 2002, Simandan, 2014, Lynch, 2016, Popper, 1970). This subjectivist constructivist philosophical position asserts that the reality of social phenomena and the process of creation of these phenomena (ie. the actions and behaviours of humans), cannot be separated from one another, they are one and the same thing (Taylor, 2018). Social reality is therefore embodied, only existing within the realms of conscious interpretation (Keaton and Bodie, 2011). Social reality is also dynamic, always evolving

through a feedback loop between an individuals' actions and behaviours, the resulting experience of the social reality, and the cognitive framework that drives the experience and resulting behaviours.

3.1.2 Social phenomena have multiple realities

Due to social reality being subjective, embodied and dynamic in nature, and because it can only exist between multiple human actors, it therefore has multiple realities and subsequently there is no single, objective and absolute truth (Feyerabend, 1978, Hanson, 2002, Lynch, 2016). By its very nature of being social, social reality cannot be created by one person alone, it only exists through the interaction of multiple actors. Since all of these actors have a diverse range of cognitive frameworks developed by their own unique experiences of life, these actors can experience the same social event in very different ways. As a result of the phenomena being both subjective and embodied, our experience of the phenomena is the reality; the social world cannot exist without our interpretation of it (Keaton and Bodie, 2011). This means that there are multiple realities of the same social phenomena, and these multiple realities can all be unique to each individual. Whilst this ontological position can be challenging within a 'Western' philosophical context, built around Christian principles of morality, where we interpret life around the concepts of 'right' and 'wrong', the acceptance of all human experience as reality means that all human experience can be viewed as valid, and thereby all human behaviour and social phenomena can be explained. This position does, however, reject the concept of absolute truth, as absolute truth cannot exist if we accept multiple conflicting realities as true.

3.1.3 In search of subjective and situated truths

The rejection of the concept of a single, objective absolute truth is critical from an epistemological standpoint, as it separates the social and natural sciences from one another. It means that in social sciences we are looking to reveal multiple subjective realities, situated in specific contexts (Flyvbjerg, 2001), rather than a single objective, universal truth that can be generalised across all phenomena, as is pursued in the natural sciences (Bloor, 1976, Latour and Woolgar, 1979, Popper, 1970). In terms of

epistemology this is an interpretivist standpoint which impresses that the natural and social worlds are distinctly different and thereby require different methodological approaches in order to understand them (Flyvbjerg, 2001, Lynch, 2016, Simandan, 2014). So whilst in the natural sciences we traditionally take a positivist, deductive approach in order to develop reductionist understandings of very specific physical phenomena (Flyvbjerg, 2001, Popper, 1970), in the social sciences we take an interpretivist approach in order to capture the diversity and multiplicity of social phenomena (Simandan, 2014). In a social science approach we do not look to be able to create generalised theory that can be applied across populations, but rather we look to understand in depth how a complex set of characters and variables, defined by the human actors, leads to certain social scenarios and phenomena.

3.1.4 Acquiring social truths in practice

The only way to acquire this subjective and situated knowledge is through exploring the meaning and relevance of the social worlds of the multiple human actors within that phenomenon. Since the social world is constructed through the cognitive frameworks of the social actors, it is only by examining these cognitive frameworks and the resulting realities of the actors, from their perspective, and within their context, that we can get any idea of how the phenomena functions (Bryman, 2012, Flyvbjerg, 2001, Lynch, 2016). As Bryman (2012) recounts, in order to understand the social world we must "interpret [social actors] actions and their social world from their point of view" (Bryman, 2012, pg. 30). Simple external observation of the phenomena by a researcher, without gathering data and insights from the actors is likely to lead to much misinterpretation of the reality of the phenomena, and fails to gather any insights about the internal functioning and drivers (the cognitive frameworks) of that phenomena. Of course because there are multiple realities to ever social phenomena, gathering data from multiple actors is essential for ensuring representation of the multiplicity of that phenomena.

3.1.5 Challenges of the social construction of knowledge

Both problematic and advantageous in the pursuit of knowledge, if the fact that the production of knowledge is itself socially constructed (Bloor, 1976, Flyvbjerg, 2001, Latour

and Woolgar, 1979, Popper, 1970). The practicalities of the production of knowledge and the cognitive processes involved in the production of knowledge are all mediated by social interaction and cognitive frameworks. Knowledge production is therefore a socially constructed process, and by that merit a subjective process (Feyerabend, 1978, Flyvbjerg, 2001, Taylor, 2018). I do not believe that objectivity is possible in the observation and interpretation of the world, as all observation and interpretation is mediated through the cognitive frameworks that we hold, which have themselves been socially constructed (Hanson, 2002). With a subjective observer and particularly when that observer is external to the social phenomena under study, there is much opportunity, as is widely recognised and discussed in research practice, for bias and misinterpretation to emerge. For example, two researchers, from two different disciplines can make wildly different conclusions about the same phenomena (Hanson, 2002). Researchers have to exercise a large level of reflexivity to minimise bias, and the establishment and acknowledgement of their positionality is essential for being able to understand the merits and limitations of the interpretations they make of the data (see (Latour and Woolgar, 1979). It is also important in the context of this argument to remember that the researchers' interpretations of the social reality will differ from the realities of the actors involved in the phenomena (Bloor, 1976). This is unavoidable, because the only way to be able to 100% accurately capture the reality of individual actor is to observe the social phenomena from their cognitive framework, and we haven't yet succeeded in achieving brain transplantation or telepathy. This is where methodologies of participant observation, ethnography and autoethnography are so important and powerful. By becoming a part of the social phenomena the researcher becomes a part of the construction of the social reality and thereby has ownership over one of the realities of that phenomena. By being able to understand the phenomena from the inside the researcher is able to directly observe one reality of the phenomena, and have a close perspective on the potential realities of the other actors (Salk, 1979) (see also (Latour and Woolgar, 1979).

3.1.6 Overcoming the personal tensions in my ontological and epistemological position

These challenges presented by the socially constructed nature of knowledge have been a personal tension for me throughout the research, but examination of the role of researchers in the exploration of the social world demonstrates a number of valuable functions that the constructivist researcher offers society. The matter of subjectivity in social reality and in the production of knowledge has been a tension for me throughout this research process, as having originally trained in positivist epistemologies of natural science, where subjectivity can be overcome by the process of falsification and deductive reasoning, in social science research the layers of subjectivity, the dynamism of social reality and the inability to directly observe the multiple realities of a social phenomena mean to me that social science will always struggle to 'get at' the 'truth'. However, whilst there are challenges and potential failings of subjectivist social science research, there is also power and value in the subjectivist position of knowledge production. Researchers take on a reflective role for society when practising research. By 'taking a step back' and observing social phenomena from the outside, and then taking the time to explore multiple perspectives, philosophies and knowledge systems, in light of the social phenomena, they can bring new understandings and perspectives that may cut through the barriers and blockages in the social process. By being reflexive and critical about what they see, hear and experience in the process themselves, they can start to reveal the underlining processes that are driving these social phenomena. Almost like conducting thought experiments, they can play around with our cognitive frameworks and the conceptual models of our cognitive frameworks, to see whether other cognitive orientations might produce other results.

3.1.7 Moving towards a research design for examining co-created citizen science

My ontological and epistemological perspective as outlined above (section 3.1) is the foundation for the research design, methods and analysis choices that I have made in this methodology. Three points made above are particularly important for the methodological choices that have been made in this research. Firstly, the notion of multiple realities means that the research design needs to capture multiple perspectives of each co-created citizen science project. This resulted in my purposeful pursuit of interviews with actors who had different roles and perspectives in the projects (discussed

further in section 3.3.7). Secondly, the idea that social reality is dictated by the cognitive frameworks that we hold within our minds, meant that the research methods needed to capture, as close as possible, the inner working for the actors' minds. This resulted in my decision to adopt narrative research methods (discussed in section 3.3). Thirdly, the concept of situated truths and the resulting limitations of generalisability meant that the research needed to focus on diversity of practice and construct multiple case studies, with maximum variation, in order to demonstrate that diversity. This is discussed next in section 3.2.

3.2 A Case Study Research Design

3.2.1 Defining a case study approach

A case study is an in-depth and intensive examination of a clearly defined and contemporary, social entity or phenomena, examined within its 'real world' social context (Hammersley and Gomm, 2000, Bryman, 2016, Yin, 2018). The social entity or phenomenon, more commonly referred to as the 'case', varies, and can include an individual, an organisation, a process, or an event (Yin, 2018). Hammersley and Gomm (2000) suggest that as a methodology case study research separates itself from other methodologies such as experiment or social survey, by:

- being concerned with a single or small number of cases
- collecting large quantities of data for each of those cases
- not carrying out the direct control of variables or context
- not having the quantification of data as a priority.

The methodology has been applied to many different types of research enquiry, including exploratory, descriptive, explanatory and causal enquiries (Yin, 2018). It has been used inductively to generate theory and deductively to test theory, utilising both qualitative and quantitative methods of data collection and analysis (Bryman, 2016, Yin, 2018). But the way in which a case study approach is utilised is very much dependent on the epistemological leanings of the researcher.

3.2.2 Implications of a constructivist perspective in the case study methodology

As a methodology, case study has been adopted for a variety of epistemological positions, including both naturalism (positivism) and constructionism (interpretivism) (Hammersley and Gomm, 2000, Flyvbjerg, 2001, Moses and Knutsen, 2012, Yin, 2018). However, for the purposes of this research I will only explore the utilisation of case study from the constructivist position. There are there principle methodological implications that need to be addressed with regards the application of a case study approach from the constructivist perspective, and these are generalisability, induction vs deduction and objectivity vs subjectivity. These are of principle interest because they greatly impact the way in which the methodology is executed.

A common discussion around the conceptualisation of case study methodology is the notion of generalisability. Whilst this notion is critical to a naturalist perspective, which looks to produce knowledge that reflects universal truths and can therefore be applied to multiple scenarios, from a constructivist perspective this is an unnecessary and inappropriate request to make of the methodology. For constructivists the utilisation of a case study methodology is not to produce generalisations about the laws of the social world, but instead to demonstrate the particularity and uniqueness of the case (Hammersley and Gomm, 2000). In fact, whilst Yin (2018) suggests that case study may not be able to produce statistical generalisations but can produce analytic generalisations, (Bryman, 2016) positively refutes the idea that generalizability can be achieved at all. This boils down to the idea of whether or not it is possible to make generalisations from single or heavily situated, contextual observations. In the case of this research I collect multiple case studies, with maximum variation, in order to generate some analytic generalisability as suggested by Yin (2018). By purposefully examining highly diverse instances of co-created practice in citizen science, where similarities and patterns emerge across these distinctly different cases there can be some suggestion that these similarities may be found in other cases outside of the research. However, in highlighting these trends, there is no expectation in this methodology that it would be possible to claim absolute generalisability in all other cases, only to highlight potentially important features that need attention.

Leading from the concept of generalisability the second principle concern around the practice of a case study methodology, from a constructivist perspective, is whether a practice of induction or deduction is adopted from the data. The practice of induction or deduction is related to conceptualisation of theory production and testing. Practices of induction build from the data up to the proposal of a theory or hypothesis, whilst practices of deduction start with a theory or hypothesis and work down to the data to test that theory or hypothesis. In the absence of a necessity for generalised and universal theory a constructivist approach to case study methodology does not utilise the case study to test hypotheses, as it does not see the hypothetico-deductive method as appropriate. Instead the constructivist approach to case study builds up from the data inductively, not to generate universal theory, but to build stories and narratives of the uniqueness of the case, and to identify patterns within that case. This is the intention within this research.

Finally, whether the researcher is objective or subjective when engaging in the inductive process of data analysis is the third principle of concern for the constructivist approach to case study methodology. Whilst a constructivist position negates the idea that a researcher can be truly objective at all, there is an acceptance of the understanding of reflexivity. This means that a researcher can make choices about the extent to which they influence and shape the data they are engaged with. So, when inductively assessing the data within the case study does the researcher try to represent the data simply as it is, giving as much clear, un-interpreted voice to the actors of the 'case' as possible. Or do they provide their own analysis and interpretation of the data, in order to provide it with a different and new meaning. Here I consider that in compiling the case studies and presenting them in this thesis, it is impossible for me not to influence the data. It is important to be mindful then of my positionality, as described in my personal statement (p. 21) when approaching the data, but also in adopting a narrative interview method I seek to reduce my influence on the data collection process.

3.2.3 Application of a case study approach in this research

A case study approach was primarily adopted for this research because of a lack of detailed examples of co-created citizen science projects in the peer-reviewed and grey literature, and due to a recognition that the co-creation of citizen science was governed

by the complex social relationships between the citizens and scientists involved in the project, that were situated in unique contexts. Yin (2018) states that a case study approach is particularly valuable at examining complex social processes where there may be multiple variables influencing the social phenomena. A case study approach therefore provided the opportunity to make an in-depth examination of the complexity of social processes with the citizen science projects, whilst also providing the field with thorough examples of co-created citizen science in practice. In addition to the need to address the complexity of these social phenomena there was also an interest in the potential causal link between the process itself and the outcomes of the project. It is increasingly recognised that case study designs, including multiple-case study designs, are able to play a role in understanding causal relationships between factors (Bryman, 2012). The research therefore hoped to 'detect patterns of association' (Bryman, 2012) between characteristics of the projects and their outcomes, looking to identify the core variables that influence the ability of a co-created process to achieve action outcomes for the communities in question. Furthermore, I recognised that due to the complexity and unique nature of each co-created citizen science project a single case study would be limited in its ability to provide insights and knowledge of relevance to the broader practice of the field. It was important to capture the workings of several projects in order to develop a better understanding of the landscape and diversity of practice of the approach, but also to help identify 'patterns of association' that might cut across examples and could be validated as potentially transferable to other contexts.

3.2.4 The case study research design

Multiple-case study design

A multiple case study design was used for this research. Due to the establishment, within the literature review, of a lack of examples of co-created citizen science and a lack of understanding of how these processes function and operate, it was deemed important and necessary to take a multiple-case study design. This would increase the number of case examples available to the field but also help to develop understanding of the diversity of practice. As discussed by Flyvbjerg (2001) the value of a single case research design is in the ability to falsify generalisations developed within the theory of the topic. He

further indicates a number of reasons for why a case might be selected, either as an extreme, critical or paradigmatic case. However, being able to identify an extreme, critical or paradigmatic case, or being able to falsify theory requires that a theory has been established. Flyvbjerg (2001) acknowledges that sometimes the nature of the case is unknown until after the case study has been conducted. Within this research due to the limited literature addressing the topic of concern, there was no theory around which to select cases or for which a single case study might be able to falsify. As a result this research could be considered 'exploratory' in that one of its aims was to strike out into a landscape relatively unknown (at least in the research literature) and find out what might be out there. By using a multiple-case study design it would be possible to increase knowledge of the practice simply by presenting a number of different examples of how this approach to citizen science was being utilised, and thereby directly addressing question 1 of this research; "How does the concept of co-creation manifest in citizen science projects?"

Maximum variation cases

Whilst a multiple-case study design can be used to compare similar scenarios and social phenomena, making direct comparisons to build theory, due to the complexity of social phenomena it can be difficult to find comparable cases. Certainly in the case of this research it was expected that there would be so few example of co-created citizen science to engage with that it would be very difficult to find comparative cases. And in fact, with so little evidence and example of co-created practice out there it would be valuable simply to demonstrate and present the diversity of interpretation and practice of the concept. So rather than looking for a comparative multiple-case study design, instead I worked towards gathering a maximum variation sample. Flyvbjerg (2001) presents 'maximum variation' case sampling alongside the 'extreme', 'critical' and 'paradigmatic' case sampling. He describes the purpose of 'maximum variation' cases being "To obtain information about the significance of various circumstances for case process and outcome" (Flyvbjerg, 2001, pg. 79). Whilst Flyvbjerg (2001) discusses this in the context of identifying a number of cases that vary only by one dimension, again in these circumstances there was no established theory to suggest what dimensions might be

worth considering. I therefore worked to gather as much variation as possible, in order to identify the variety of dimensions that may have some significance to the process, drawing together the sample in an inductive way. Gathering a maximum variation sample was valuable because by investigating a diversity of practices and contexts it would be possible to, firstly, simply highlight and record some of the diversity of practice and interpretations of co-created citizen science taking place in the field. Secondly, and subsequently, where any patterns emerged across the case studies, because of their huge diversity this might reveal factors significant in a more generalisable way.

3.2.5 Recruiting case study projects

Case study criteria

Whilst the case study design was looking to achieve maximum variation across the cases, criteria still needed to be identified to ensure that the cases would directly address the research questions and were appropriate for the research methodology. The following criteria were used to recruit and select case study projects.

Projects must have:

1. Used a co-created participatory research process, where citizens work with researchers throughout the whole research process, from question identification through to data interpretation and dissemination of findings.
2. Specifically aimed to achieve action outcomes from the outset.
3. Completed in the last 12-24 months.
4. Focused on environmental or ecological sciences.

And finally:

5. Where it would be possible to interview the project manager/ coordinator who ran the project, a scientist involved throughout, and at least three citizen volunteers who participated.

Criteria 1 & 2 would ensure that the case study projects would address the research questions. Criteria 3 was included to try to reduce problems created by a reduction in researcher participants' memory of event, which could affect the quality of the data. Criteria 4 was included in order to try to ensure that projects were of the 'natural sciences', rather than anthropology, humanities, or other types of intellectual process. I sought to examine projects that would be considered citizen science in the traditional sense, ie. engaging in biological or environmental data, as a way of defining the scope of the research and the space within which the research could speak, post publication. I felt the 'natural sciences' was a good place to start because the practice of citizen science has emerged in that scientific space. Criteria 5 was to ensure that the case studies could be built around the knowledge and understanding of multiple perspectives and, as is discussed above (section 3.1.2), multiple realities. From my constructivist position the case studies could not be considered 'complete' unless they represented the voices of what might be perceived as the three 'critical' roles within a citizen science project, the project manager, the scientist and the citizen scientist. Due to my intentional bias towards the citizens' voice, I wanted to ensure that there was more than one representation of citizen scientists' in each case study.

Recruitment process

Case study recruitment took place across citizen science, action research, participatory action research and community-based participatory research professional networks. Whilst this may seem counterintuitive for a research project that is looking to study citizen science projects, where I expected that there would be few examples of co-created citizen science practice within the field of citizen science, I knew that there were likely to be projects that I considered to be 'citizen science' that would be labelled under some other name within this broader network of disciplines. I distributed a summary of my research objectives and my sampling criteria (detailed above) by email, to academic and practitioner mailing lists, and to personal contacts, in order to establish contact with relevant projects. Snowballing sampling was a natural tendency within the recruitment process, as contacts would often suggest other academics, practitioners, citizen scientists or projects that they felt would provide relevant case studies for the research. Where

suggestions were made I would directly contact the individual or organisation to enquire whether they had any relevant projects. Where a project closely met the case study criteria and the project manager was interested in my research project, I would send them the 'Participant Information Sheet 1' (Appendix 3), and then follow this up with a telephone or web call, to discuss the research and its requirements in more detail. This initial call would help to ascertain whether the project was appropriate for the study and provide the project manager with an opportunity to ask questions and raise any concerns about participation, before going away to consider whether or not to contribute. Whilst some project managers took complete autonomy over the decision for the citizen science project to participate in my research, or not, others would go and speak to their colleagues, organisational management, or in some cases citizen scientists in order to decide more collectively whether it was an appropriate opportunity or not. Project recruitment was a very slow process with a low response rate. Outreach for projects began in February 2018 and continued through to November 2018. Despite distributing emails out to over 80 direct contacts, internationally, from both the citizen science and participatory research disciplines, as well as to five network mailing lists (Citizen Science ListServe; British Ecological Society Special Interest Group on Citizen Science ListServe; ActionResearch+ Mailing List; European Citizen Science Association Newsletter; Massachusetts Bay National Estuary Programme mailing list) each reaching hundreds of people, only 20 suggested projects came back.

3.2.6 Selecting the case study sample

The low and slow response rate during the recruitment of case studies, and the emergence of some unexpected opportunities led to a negotiation between what projects were available to me, the sampling criteria and the ambition of gathering a maximum-variation sample. In terms of responding the low response rate I expanded criteria 3 from 'project completed within the last 6-12months', to, as stated above, 'project completed within the last 12-24months'. Then in order to seize opportunities that I believed would shed interesting light on the diversity of co-created citizen science practice, I prioritised achieving a 'maximum-variation' sample, over criteria 4. This resulted in the inclusion of a project focused on noise and a project focused on public engagement with private water,

neither or which really address the ecological of environmental sciences, but both of which included unexpected or uncommon approaches to the co-creation of citizen science. Despite exercising some flexibility with the sampling criteria, criteria 1, 2 and 5 were considered fundamental to my research questions and objectives and were therefore upheld during the case selection process. Of the 20 projects that responded to my research call many were rejected because I didn't consider them to have involved citizens in the whole of the research process. Some projects that initially got in touch would have been valuable to the research but did not maintain communication with me and could not therefore be pursued. Table 3.1 details all the projects which contacted me which I rejected, and on what terms, and Table 3.2 indicates the five case studies that were included in this research, to what extent they met the criteria of the research, and what they offered in terms of maximum-variation. In trying to achieve maximum variation I considered; who initiated the project and how, how citizens' were involved in the research process, the environment and ecological topics being addressed, whether projects were successful or not, and the discipline of practice from which the co-created research had emerged.

Table 3.1: Prospective projects which were rejected from the research sample

Project/ Organisation Name	*Criteria 1: Project co-created citizen science*	*Criteria 2: Action-orientated*	*Criteria 3: 6-12months*	*Criteria 4: Environmental / Ecological Sciences*	*Criteria 5: Project Manager, Scientist & Citizen Scientist*
Projects which were accepted but didn't follow up					
Curieuzeneuzen	Yes	Yes	No 24 months ago	Yes	Yes
ALLARM	Yes	Yes	Yes	Yes	Yes
Project which were rejected for not meeting criteria 3					
NatureWatch Caught on Camera & Communities Listening for Nature	Yes	Yes	Ongoing	Yes	Yes
Chesapeake Monitoring Cooperative	Yes?	Yes	Ongoing	Yes	Yes
Otsego County Conservation Association	Yes	Yes	Ongoing	Yes	Yes
Stokholm Environment Institute	Yes	Unknown	Up and coming	Yes	Unknown
Projects which were rejected for not being co-created citizen science					
RSA Fellows Wellbeing Network	No	No	No	Yes	Unknown
Flint Water Study	No	Yes	Ongoing	Yes	Unknown
LandSense	No	Yes	Yes	Yes	Yes
Projects which were of interest but didn't return contact					
Dampbusters	Yes	Yes	Yes	Yes	Unknown
Community Partnership for Self Reliance (Alaska)	Unknown	Yes	Unknown	Yes	Unknown
San Diego Waterman's Association	Unknown	Yes	Unknown	Yes	Unknown
Saltwater Paspalum	Unknown	Yes	Unknown	Yes	Unknown
Peatlands Programme UK	Unknown	Unknown	Unknown	Yes	Unknown

Table 3.2: Projects that were accepted for the research sample.

Project Name (all project names are pseudonyms)	Criteria 1: Co-created project	Criteria 2: Action-orientated	Criteria 3: 12/24 months ago	Criteria 4: Environmental/ Ecological Sciences	Criteria 5: Project Manager, Scientist & 3 x Citizen Scientists	Maximum variation opportunity
Large Carnivore Mitigation Programme - mapping project	Yes	Yes	No - 5 years ago	Yes	Yes	Project was an example of failed project.
Protecting Our Waterways	Yes	Yes	Yes	Yes	Yes	Project represented what might be considered a 'typical' co-created citizen science scenario, with project managers designing a process for the citizen scientists to participate in.
Healthy Household Water	Yes	Yes	Yes	No	Yes	Project employed community researchers, rather than working with volunteer citizen scientists.
Noise Pollution in the Plaza	Yes	Yes	Yes	No	Yes	Project provided intensive training of volunteers as community champions, in order to infrastructure the capacity of the community to participate. Research also utilised co-creation and design methods to specifically develop citizen sensing methodology.
Conserving Wolverine Populations	Yes	Yes	Yes	Yes	Yes	Project was initiated by trappers and they were involved management of the whole project.

3.3 Narrative Interview Methods

For a constructivist perspective one of the key ways in which I felt it appropriate to build the case studies was to capture multiple perspectives of the events of the projects, something Yin (2018) expresses as a typical constructivist approach to case studies. For me the need to capture multiple perspectives was two-fold. Firstly, in order to honour the idea that the social world has multiple realities, each reality unique and embodied within the mind of each social actor. In this way, the only way to understand the social world is to understand the multiple realities. Secondly, in an effort to ensure that the citizen actors within the project were provided with much voice. I perceived there to be a lack of direct representation and voice of citizen scientists in the existing citizen science literature, with most representations of citizen science projects presented from the point of view of the researchers or project managers and I wished to start to redress this balance by ensuring that several 'citizen' voices were represented in each of the case studies. With the focus on capturing the voice and 'reality' of each of the actors' experiences, narrative research methodology emerged as an exciting opportunity.

3.3.1 Defining narrative research

> *"Narrative is a way of understanding one's own and other's actions, of organizing events and objects into a meaningful whole, and of connecting and seeing the consequences of actions and events over time (Bruner, 1986; Gubrium & Holstein, 1997; Hinchman & Hinchman, 2001; Laslett, 1999; Polkinghorn, 1995)... in addition to describing what happened, narratives also express emotions, thoughts, and interpretations… narrative makes the self (the narrator) the protagonist, either as actor or as interested observer of others' actions… [it] highlights the uniqueness of each human action and event rather than their common properties (Bruner, 1986; Polkinghorne, 1995)." (Chase, 2008).*

Narrative research collects and analyses people's stories in order to gain a nuanced and deep understanding of the complex dynamics between people, events and their context. As Chase (2008) expresses above, narrative helps us to understand human action, organise that understanding into a meaningful whole and gain a perspective on the causality of events. In-line with constructivist epistemology, it also helps us to understand the inner cognitive workings of those telling the story, providing a more fundamental understanding of people's actions, but also their social reality and the uniqueness of that reality.

3.3.2 Narratives reveal the complexity and functionality of social phenomena

A narrative methodology is a powerful tool to adopt in this research because of types of things it is able to reveal about the social phenomena under study. In terms of revealing the social facts of the phenomenon narrative starts by being able to identify the different characters, events and the landscape (context) of a social phenomenon. It is its ability to uncover the detail and complexity of that social phenomena, including the numerous influencing factors and the relationship between these that made it a highly advantageous methodology to adopt. A narrative approach is not limited to expressing these factors in separate terms, but can draw the complexity of the social phenomena together into "a meaningful whole" (Chase, 2008). This makes it especially valuable as a method within a case study research design, as it helps to develop understanding of a project in its entirety, rather than in small, discreet elements. The Oxford English Dictionary offers the following definition of narrative, "an account of a series of events, facts, etc., given in order and with the establishing of connections between them; a narration, a story, an account" (OED, 2020). Narratives can therefore be seen as a sequence of causally-related events, making them useful for suggesting causal relationships. This research aimed to understand the causal links between the events and interactions that took place, the influence of the actors on this process and the final outcomes of the projects, making narrative research a perfect companion addressing research question 2 of this thesis; "What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?". In addition, narrative is able to provide a rich and multifarious lens through which to examine the actor's "self, position

and experience" (Chase, 2008) as it gives expression to something internal about the narrator (Squire et al., 2008). From a constructivist standpoint this is highly valuable, because in a socially constructed world it is this internally embodied framework of values, perceptions, knowledge and experience that dictate behaviour in the social world. With this methodology it would therefore be possible to both understand why actors behaved in the way that they did, but also the impact of their experiences of the social phenomena on them as individuals. This would help to explain some of the way in which collaboration emerged within the citizen science projects, and the extent to which the communities were satisfied with the research outcomes, thereby addressing both of the research questions of the thesis.

3.3.3 The alignment of constructivist epistemologies and narrative methods

Whilst the above addresses the value of a narrative approach for revealing 'social facts', there are two ways in which a narrative approach provides particular methodological advantages for the constructivist endeavour. Firstly, by submitting oneself to a purist narrative approach to data collection, as was attempted here, the researcher gives the steering wheel of the research to the participants. As the narrator the research participant has full control over the story-telling, including its content, its structure, its perspective and its emphasis. This is important because it means that the researcher has less influence over the content and focus of the data, which means that a more accurate representation of the actors' reality, rather than the researchers expectation and own cognitive frameworks, can be acquired. Secondly, and building on from the first point, the willingness to allow the research participant to dictate their experience of the social phenomena in their own way is an act of giving the participant 'voice'. "Storytelling is a powerful means of expression especially for voices that may be difficult to hear or represent in typical ways" (Parsons et al., 2015), pg. 247). By providing this opportunity to a variety of stakeholders from within the social phenomena, the research is able to produce a more accurate representation of the multifaceted reality of the case study. It also acts as a way of existing the established power structures (Squire et al., 2008), both with the research but also within, in this instance, the world of citizen science. Within this research, I, as the researcher, relinquish some of the control over what is considered

‘significant’ and ‘important’ in relation to the social phenomena. Furthermore, within the world of citizen science, it is my perspective that citizens’ voices are rarely represented in the reporting of citizen science research. Coupled with my specific research interest in how co-created citizen science processes serve communities, it seemed pertinent to include multiple representations of ‘citizens’ in each case study, in order to attempt to redress the balance around whose knowledge, insights and perspectives make up our understanding of the citizen science phenomena. Whilst some may criticise this as a bias Shirk et al. (2012) suggest that a “focus on public is not at the exclusion of the interests of science researchers, but rather … elevate[s] the needs and interests of public participants in contexts where those interests have historically been marginalised” (Shirk et al., 2012, pg. 5).

3.3.4 Methodological challenges of a narrative approach

Of course as with any methodology there are challenges that need to be overcome and addressed when delivering the research, and a particularly pertinent one within the practice of narrative research is the control that research participants have over the content and direction of the research data being in conflict with the researchers’ need to deliver their research objectives. As mentioned above, a narrative approach to interview means that the interviewee is given the freedom to express events in their own words and as a reflection of their own experience. In this way the focus and direction of the narrative is chosen by the interviewee, and may not align with the research questions or objectives. For a researcher this can be problematic as it may not, therefore, deliver on their research needs. Rather than trying to manipulate the utilisation of a narrative approach to ensure that it will meet the needs of the researcher Chase (2008) discusses the importance of a conceptual shift required of the researcher in conducting narrative research. She impresses that a central point of narrative research is to be able to reveal the particularity of an individual’s personal experience of life events, and that these are highly likely to diverge from the sociological questions and answers a researcher is expecting. Whilst, in the first instance, researchers panic and worry about not collecting the right data for their research, they later realise that this seeming divergence is actually the whole point and incredibly significant in the research. It is, however, this necessity to start with these

free and open ended narratives, so that the research participants can speak in their own voice, which means an inductive approach to the data analysis is so important. By the very nature that the researcher submits to the research participant and allows the data to naturally emerge out of their recollection of reality, the method is inductive, and so then an inductive approach to analysis is the only way to honour that knowledge production process.

3.3.5 Epistemological challenges of a narrative approach

Not only does the narrative approach provide some methodological challenges, but it also provides so epistemological challenges, due to the nature of the construction of narratives in research. For starters, because the constructive of a narrative is retrospective it cannot represent what happened at the time of the events. Instead narrative reconstructs the events of the social phenomena in the present, and utilises the existing cognitive framework (values, knowledge and experience) of the research participant to do that. Since our cognitive frameworks are fluid and dynamic, constantly changing and evolving depending on our life experience, and because our memories often lack accuracy, the narrative account that an individual provides of a social phenomena will change and evolve as time passes. If one requires an accurate representation of what happened within that specific moment in time, then other methods such as participant observation and in-situ reflective diaries would be more appropriate. In this context, due to the ability to access these types of projects and the timeframe of this thesis, the research was exploring projects post-event. So rather than the narratives collected for this research being able to account for the events as they happened at the time, with any accuracy, instead the research places trust in the knowledge and insights of each individual and harnessing the value of reflection and cumulative knowledge from each individual, trusting that their insights can provide accurate representation of the diversity of experience and understanding of how the social phenomena works. Whilst to a naturalist or positivist scientist this may seem ‘wishy washy’, to a constructivist scientist this is the only way of understanding the social world.

3.3.6 Methodological application of narrative research

Whilst narrative research can be embraced as an entire methodology, in this research it was being used to support the multiple-case study design, and was only applied to the data collection element of the research process. I utilised a narrative interview method simply to collect the research data, to build the evidence for the case studies. To me, for this research project, the opportunity of a narrative research approach was in capturing individuals' stories, those stories being heavily directed by the research participants and thereby highly accurate, and in providing 'voice' to people not usually represented in the literature. Narrative analysis was not conducted, as whilst it would have provided many interesting insights and was an approach I was interested to explore, the research questions and case study design of the research meant that a thematic analysis was a more effective and appropriate way to collate insights and understanding from across the interviewees' experiences within a case (see Section 5 for more details).

3.3.7 Compiling case studies from narrative interviews

In order to gather together multiple perspectives, and therefore realities, of the cases under examination, I endeavoured to interview at least one project manager, one scientist and three citizens from each project. These ratios would have three impacts. They would ensure that the critical 'role types' of a co-created citizen science project would all be represented within the case studies. They would ensure that, through a higher representation of citizen scientists, it would be possible to ascertain the extent to which citizens' goals and needs were served by the process, thereby addressing question 2 of the research questions. It would also ensure that the amount of data collected would be manageable. In some situations the project manager and the scientist were the same person, and by responding to the research call and agreeing for the project to participate in my research, both the research project, and some of the research participants who were project managers or scientists were self-selecting.

Prior to conducting interviews with case study participants, the project manager from each project was asked to complete a pre-survey. The survey was constructed and administered using the Bristol Online Surveys platform, due to its wide range of features, its compliance with UK data protection and accessibility laws and the institutional support offered at University of Dundee. The survey collected general background information

about the project, including objectives, outcomes and an outline of the process used in the project under study (Table 4.1 – 4.5). The information provided in these pre-surveys was not used in the thematic analysis of the case studies as it only represented one perspective on the project, but was used to write the case study chapters (Chapters 4-8) and in preparing for the narrative interviews by providing me, the interviewer, with a formal overview of the project.

3.3.8 Recruiting interview participants

Ensuring privacy and anonymity through participant recruitment

Recruitment of participants involved a cycle of engagement from the project manager to the potential participants, and then from the potential participants through to me, in order to ensure privacy and anonymity. The project managers of the cases were the gatekeepers to the project in almost every way, it was through them that the citizen science projects were brought to my attention and it was only through them that I would be able to know who the other project actors were, and be able to access them. The project manager and I would discuss the interviewee requirements for the research project and then discuss and agree on a strategy for recruitment based on the individual circumstances of the project and its culture. This meant that the recruitment strategy for each case study was different from the next. But one thing that remained the same throughout the strategy for each case study is that the project manager would send out communications to all the potential research participants, as identified in our discussion, describing the research project and inviting them to participate in the research. By facilitating this invitation through the project manager we observed ethical practice around the privacy of the research participants. I would be unaware of who had participated in the project unless they were interested to participate in my research. Furthermore, the potential participants were asked to contact me directly if they were interested in participating, rather than responding to the project manager. This meant that they would be able to maintain a certain amount anonymity from the project manager in participating in the research and would then be more likely to talk freely in the interview. It also meant that they had the freedom to choose whether or not to participate, without a sense of

pressure from the project manager, as the project manager wouldn't know who had and hadn't agreed to participate.

All individuals who contacted me would be provided with 'Participant Information Sheet 2' (Appendix 4) and 'Participant Consent Form 2' (Appendix 2), for them to consider before agreeing to participate. They would also be offered a web or telephone call in order to ask me any questions about the research, before they decided to make a commitment. If participants decided that they would like to participate they were then asked to complete the consent form and send it to me, either by post or electronically, before an interview date was arranged. The return of consent forms was, in some cases, facilitated through the scientific organisations that had worked on the project, where individuals did not have access to the appropriate technology at home. In these instances these individuals lost their anonymity from the project manager of the project. Whilst citizens were sent general open invitations to participate due to the voluntary nature of their participation in the citizen science project, the scientists were more directly requested to participate, due to the lack of scientists involved in each of the projects and the necessity to have this voice represented in the case studies. If scientists hadn't responded to the invitation to participate the project manager would then more directly contact them to request their participation.

Managing bias in the sampling

The fact that the recruitment of research participants had to be facilitated through the project manager meant that biases could potentially creep into the sampling of interviewees. Project managers are likely to have a bias towards wanting the project they participated in to be represented in a good light, and so may be inclined to invite those they know will sing the praises of the project. Although generally conversations with the project managers reflected their interest in supporting good quality research that would help them to better understand their own projects, and their awareness that a variety of perspectives would need to be captured in order to ensure that good quality and accurate data were collected. What happened in practice is that the project manager and myself would discuss and negotiate the strategy that would be used for sampling. Whilst some project managers simply sent out email invitations to everyone that had participated,

others engaged in a consideration of who would be the most appropriate actors to be interviewed. These considerations were surrounding matters such as any language barriers, research fatigue, how outgoing the individuals were and any personal circumstances that might prevent individuals participating. Whilst these types of considerations mean that the project manager did influence who might be invited to interview, it was important for me to recognise their knowledge and expertise in what would be appropriate. I also ensured that I explicitly discussed the need for variety in the participant sample, asking them to consider individuals that may not have had a positive experience of the project, individuals that may be more introverted and therefore less vocal, or individuals who were more peripheral to the community, or had more peripheral engagement with the project. In this way I was trying to ensure that some of the more marginalised and less often represented voices could be included in the case studies, as these would inevitably provide very different insights and perspectives on the projects. Again it's important to mention that the participant recruitment for both the scientists and the citizens in each case study was different, and each case study provided its own unique challenges in this area. 28 individuals were interviewed from across the five case studies. Table 3.3 details the representation of different types of actor that were interviewed for each case study.

Table 3.3: Representation of different actors groups in interviews for each case study.

	Researchers/ Project Managers	**Citizen Scientists**
Large Carnivore Mitigation Programme	3	4
Protecting Our Waterways	2	3
Healthy Household Water	3	2
Conserving Wolverine Populations	2	4
Noise Pollution in the Plaza	2	3

Note: Researchers and project managers are recorded together due to the difficulty of distinguishing between the two roles.

3.3.9 Conducting narrative interviews

Preparing interviewees for narrative interviews

In order to support interviewees in engaging with an unconventional interview method I provided them with a 'Story Timeline Tool' (Appendix 5) to help them prepare. Being an unconventional method, it was likely that a narrative interview approach might be difficult or uncomfortable for research participants to engage with. The highly unstructured nature of the method could mean that participants felt unsure and unconfident about what was expected of them, what they needed to say and what would be considered valuable for the research. In order to overcome some of these uncertainties and to try to get the best out of each of the research participants I developed a 'Story Timeline Tool' that would support the participants in preparing for the interview and then could be used as a reference for them during the actual interview process. The tool was designed in order encourage the participants to think about their experience, of the citizen science project they had engaged in, in terms of a narrative or story, and to map out some of the different events that took place, the actors that were involved and their own perceptions of what was successful and unsuccessful throughout the project. It also encouraged the participants to reflect on the objectives of the project, their personal objectives for the project and whether or not these were delivered on. The tool was therefore intended to give the participants an opportunity to reflect on their experiences and jog their memories before the interview, and provide them with some structure and some indication of the types of things they might discuss, so that they felt confident about engaging, whilst still providing them with free reign in the actual interview itself.

Of the 28 people that participated in the research only 11 completed the 'Story Timeline Tool'. The tool had been offered for individuals to complete on a purely voluntary basis, and I suspect that what restricted the uptake of the tool was the restrictions on people's time. Those that did complete the tool were asked to send a copy of their completed tool to me before the actual interview, so that I would be able to have a look and prepare for the interview myself. As discussed above with regards consent forms, some individuals could only return these documents through the scientific organisation that had worked on the citizen science project with them, thereby forfeiting their anonymity. Both participants

and myself then brought a copy of the tools to the interview to be used as a reference material, although this was very rarely used. The use of the 'Story Timeline Tool' diverges from a purist approach to narrative research, which would argue that such a tool bares too much influence on the structure and the voice of the participant's story. There is certainly a tension here. However, in all research there is a need to negotiate between the methodology, the needs of the research participants and the needs of this research. The approach as applied here aimed to balance the opportunity of the methodology to reveal the nuances behind socially constructed scenarios and provide voice to those involved in the social phenomenon, whilst also bringing out the best in the participants by ensuring they feel confident and safe in their participation.

The practicalities of interviewing

Due to the international nature of the case studies and variation in access to technologies amongst the participants, interviews were conducted in one of three ways; online web call, telephone or face to face. Webcalls were my primary and go to setting and were conducted with video where possible, but I would also try to arrange to in person, face to face, meetings were possible, simply because I feel more comfortable meeting people face to face and I think it is polite where possible. Some of the individuals in remote countries, for whom it was not practical for me to visit and to whom a telephone call would have been prohibitively expensive, did not have access to the technology that could support an online webcall, and so they accessed such technology through the scientific organisations they had worked with on the project. For the face to face interviews these were conducted at the interviewees' home, or a public setting, such as a library, café or work place. The interviews were scheduled for an hour and took somewhere between 45 minutes and an hour. Although in one extreme case the interviewee and I talked for two hours. The interviews were started with me providing and introduction to the research project, an explanation of the process of the interview, and direct acknowledgement of the consent requirements that the participant had requested of me, and an opportunity for the participant to ask me any questions before we started. The interviews were then opened with a general question of "So tell me how the project got started?" or "So tell me how you got involved in the project". This question was intended to kick start the main

part of the interview which is a narrative account of the project from the perspective of the interviewee. I had a series of narrative prompts to hand that I could use to help more the interview forward or to gain more detail on a topic the interviewee had raised (Appendix 6). As the interview approached one hour I would then ask three final interview questions.

1. "What were the biggest success of the project?"
2. "What were the biggest weaknesses or failures of the project?"
3. "Is there anything else that we haven't discussed, which you think is really important to the project, that you would like to share?"

I would then ask the participant a series of demographic questions (Appendix 6), before asking the research participant if they had any questions for me, and explaining to them what would happen next. The interviews were audio recorded either through my computer or my phone, and during the interviews I would take notes of things that stuck out to me as being significant. At the end of each interview, as soon after the event as possible, I would sit and write notes about all the things that stuck out to me about the interview, or seemed significant in some way and why I felt this way.

Eliciting narratives in interview

Three skill sets were influential in my ability to draw narratives out of the interview scenarios; ability to build a relationship, questioning techniques, and ability to build relationships. My ability to build rapport and trust, and to encourage openness in the research participants was very influential on the way in which the participants would engage in the interview dialogue. I was lucky to find that I was able to quickly build rapport with the research participants and in some circumstances I could see them noticeably open up as the interview progressed and they gained the confidence to share more and more personal or in some cases controversial insights with me. My approach to building relationships with the research participants included using humour, demonstrating my fallibility, demonstrating empathy, understanding and honesty and encouraging participants through affirming what they were telling me, and reiterating that the focus of the interviews was their opinion and experience, rather than right or wrong, as well as

reiterating that they had freedom and choice in participating in the research and could withdraw at any time.

Whilst building a relationship with the participants was foundational to the interaction throughout the interview, my questioning technique was important for facilitating and encouraging that dialogue. Since the aim of the interview was to support the research participants in sharing their narrative and reducing my influence over that narrative, I had shortlisted a bank of neutral narrative questions (Appendix 6), such as “So what happened next?” which I would use in pauses in the interview to encourage the narrative along. What was important was to try to use as many neutral questions and comments as possible in order to not influence the participants’ opinions or content. But it was also important, for building rapport and trust, that I wasn’t robotic and clinical in my engagement with the interviewee, so I also offered comments and reflections, particularly about what I had heard in other interviews, in order to spark the interviewee’s own reflection and consideration, or to look to validate a recurring idea. There were times in the interviews were I would get very excited and my mind would go off on a tangent about what the interviewee was sharing with me, but I would hold back from launching my own opinion and comments on these matters, in order not to heavily influence the interview. One of the tensions that I found myself navigating through the interview process was interest and desire to probe deeper into what an interviewee had said, but then finding that by probing I had moved the interview away from a narrative format and more into a conceptual discussion, and so I would have to re-orientate the interview by using the narrative questions again, or directly bring the interviewee back to focusing on a specific event.

Finally, managing the interview process required much reflexivity on my part, both being aware of and responding to the needs of the research participant, and being aware of and modifying my interactions in the data production process. With regards the research participants I needed to look out for cues about how they were experiencing the interview process to deal with any stress, lack of confidence, or guidance they might need. I also needed to pay attention to the tempo and speech patterns that individuals had, so I could be clearer about when an individual had stopped speaking so that I wouldn’t interrupt them mid flow. I found that I was too keen to fill silences and offer comments, and so

learnt through the process of the research to hold back and allow more space for the interviewee to talk freely. My own confidence in carry out these types of interviews grew as the research progressed. In the first 6 interviews I wasn't confident that I was capturing narrative accounts, that I was asking the right questions in the right way, or that the research participants were comfortable with the process. However as the research progressed and I started to recognise the richness of the content I was collecting and the diversity of experience and shapes of the research content, I felt more confident with the practice.

Outcomes of the narrative approach

Taking such an unstructured approach to the research means that there was humongous variation in the nature and content of the interviews. Whilst for a naturalist minded researcher this would be significantly unnerving, and certainly was to me in the beginning, to the constructivist researcher and a narrative researcher this is exactly what you would expect, because you are capturing that diversity of the realities of the social world. Whilst you can expect lots of variation and this variation is welcomed, there were a number of things about the way in which the interviews panned out which highlighted challenges with the narrative interview approach. Whilst some of the interviews involved the participants freely and confidently discussing the events, their experiences and their thoughts, others were more reserved, with some directly asking me to ask them questions. It is likely that personality and confidence significantly affect how a research participant engages with the process, and so on reflection I think alternative ways to prime interviewees for a narrative process could be valuable for giving them the confidence to speak freely. Although I suspect that for some people this does not align with their personality type, and so would never necessarily emerge. In terms of this research the fact that some of the interviews have a more dominant question and answer structure is of no problem to this research, because I did not use a narrative analysis approach. In fact I think that a narrative analysis approach wouldn't have been possible on some of these interviews, because of that question and answer dynamic that emerged. However, the purpose of utilising a narrative research approach in this research was to collect data

that was largely interviewee guided and responsive and would enable a richness, and this certainly was achieved.

3.4 Case Study Analysis

3.4.1 Coding the interviews

Immediately after each interview I recorded notes of the ideas and comments that had left out at me during the conversation. I then transcribed each interview manually, verbatim, only omitting conversational content at the beginning and end of the interview that was not data for analysis. All people's, organisational and place names were given pseudonyms in order to maintain the anonymity of the research participants. I then wrote a narrative description for each of the interviews which summarised the story that each research participant had told. Once all of the interviews were transcribed for a case study, they were imported in to NVivo 11. NVivo 11 software was utilised due to its capacity to handle large amounts of data and the ease with which coding can be carried out, managed and organised. Interviews were coded one by one, and coded inductively, with attention being paid to each sentence of the interview and the relevant codes for each sentence constructed. What was considered interesting and led to coding was broad in significance, recorded not just in relation to the specific research questions of this research enquiry, but also within the broader context of the field of citizen science. This broader approach was used to ensure that focus on the research questions did not mask any other significant ideas that the data might be communicating. What was considered interesting was influenced by my positionality as a citizen science practitioner where key concerns or focuses are orientated around the process of citizen science projects, (eg. motivations, objectives, actors, roles, outcomes), and my positionality as a community activist where key concerns are orientated around the empowerment of community actors (eg. governance, relationships, participant satisfaction). I also worked reflectively to ensure that my mind was open to other insights and nuances in the data that I might not expect. The intention was to let the interview data tell me what was important, rather than my research questions and cognitive frameworks determining where the scope and the boundaries of what might be considered insights. Whilst carrying out the coding I held Richards (2015) 'Taking off from the data' framework in mind, and where I found some

data that piqued my interest I would produce an annotation in the transcript to describe what I thought was interesting about it. In this way critical and thematic insights began to emerge from the data. Where themes and ideas were naturally emerging from the data across a case or across an interview, I would record notes of these and my insights and reflections in an Nvivo memo constructed for each of the case studies. In this way I began to generate an organic idea of the key ideas that were emerging within in case.

3.4.2 Thematic analysis within the case studies

Conducting coding in an inductive manner and through the assignment of very detailed and specific codes for each data point, meant that codes emerged rapidly and expansively. This led to copious and sometimes unmanageable amounts of data. In order to manage the data an initial thematic analysis was conducted alongside the coding process. Intermittently throughout the coding of interviews, I would review and revise the codes, grouping similar codes together. The coding process was therefore iterative, generating themes and connections as the data was coded. These thematic groupings often emerged as operational eg. Objectives, Roles, Activities, Outcomes, which reflects the practitioner positionality that I brought to the research. Once all interviews were coded for a case study I would conduct further thematic analysis on the data. This phase of the thematic analysis was very thorough, approaching each theme and sub theme in the case studies codes and comparing the codes with one another to check that they shared meaning or conceptualisation, or whether they needed to be reassigned somewhere else. I also checked whether any other additional meanings had been missed, revised the titles of the codes or themes, and looked for patterns within the codes that might reveal more themes or subthemes. Through this more critical analysis of the data more conceptual themes would emerge from the data, such as ‘Revealing truths’. Throughout this process I continued to keep notes of the emergence of the themes, the insights that this developed and the questions that it raised, in order to maintain a critical reflective approach to the data. The insights from the case studies were emergent, with each interview highlighting new significances for the case, but also for the interviews that have been coded before. The coding and thematic analysis process was therefore iterative across interviews, with me returning to previous interviews to follow up on coding that had emerged in others.

The code books were constructed for each case study independently, so that each case study had its own set of themes. Codebooks for each case study can be found in Appendices 7 – 11. They represent the coding structure at the first and second levels of granularity.

3.4.3 *Writing up the case studies*

In writing up the case study chapters (Chapters 4-8) I drew insights and ideas together in three different ways. In order to create a description of each project I consulted the narrative descriptions that I had produced for each interview, as well as the themes from the data analysis that discussed what happened in the project and the background and contextual elements of the project. These provided me with an overview of the project from the multiple perspectives of those who had participated. In order to represent the thematic insights that had been generated from the data analysis, I addressed each theme in turn by reviewing the data coded in each of the subthemes and then generating a summary of the trends and comments contained. Finally, I drew together the key insights from across the case by reviewing the thematic summaries, consulting my notes for the case study and through my knowledge and expertise in citizen science and community engagement reflecting on where the most salient and interesting ideas for the case study were situated.

3.4.4 *Analysis across case studies*

In order to develop an analysis across the case studies I returned to the research questions of this thesis.

1. How does the concept of co-creation manifest in citizen science projects?
2. What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?
    a. What is the link between co-created citizen science processes and action outcomes?
    b. To what extent are action outcomes realised for the communities participating in the citizen science projects?

With these in mind I reflected upon the salient and key insights that had been developed across the case studies and my ideas and insights that were generated in my research diary. From here I mind mapped the key ideas and themes from the case studies against the two research questions (Appendix 12). The arrival at these insights was organic and had been emerging throughout the coding and thematic analysis process within the case studies, and as I moved from one case study to another. Having concluded writing the case study chapters this now became a more formal process through the activity of reviewing the cases and mind mapping the insights. The mind maps were then used as the foundation for structuring my discussion, which was in itself an analytical process, as I further mind mapped each of the themes to be discussed and the evidence for these, and then consulted and reflected to articulate this within the discussion chapter (Chapter 9).

3.5 Delivering on research ethics

3.5.1 Ensuring participant consent

In order to ensure the well-being of all my research participants through their contribution to this research and the reporting of the data that they shared I took a number of steps in line with research ethics standards. Firstly I ensured that all research participants had provided informed consent and had a full and comprehensive understanding of what their participation would involve and how their data would be used. The informed consent was administered through the provision of a 'Participant Information Form' (Appendix 3 & 4) and a 'Participant Consent Form' (Appendix 1 & 2). Two versions of each document were produced in order to account for the additional data that the project managers provided in terms of completing a questionnaire about the project (see section 3.3.7). The potential research participants were also provided with the opportunity to contact me to ask any questions they had about the research and what participation involved, and at the beginning of each interview I discussed these matters with them again. Participation was voluntary and would only be accepted once I had received a completed consent form. Participants had the opportunity to withdraw from the interview at any time, and could withdraw their data from the interview up until the data analysis commenced.

3.5.2 Protecting participant data

Through contribution to this research I held personal data of the research participants as well as interview audio recordings and transcripts. All data was stored in the online data storage facilities that the University of Dundee provide, in order to comply with data protection legislation. The files were stored in password protected folders that only myself and my supervisors had access to, and with the personal data saved separately from the interview data. The personal data for the participants was filed separately from the interview data. When the interview data was transcribed it was anonymised in order to protect the identity of the participants. Project names, organisational names and place names were also given pseudonyms in order to protect the identity of those who participated. This was due to the fact that the projects I have studied for this research are so unique that it would be conceivable from someone to identify the project, and those discussed in the data. Having this level of anonymity was intended to reduce the ability to identify the individuals who had participated in the research. All participants were asked within the consent form what level of anonymity they required for their data, and whilst not all required the project, organisational or location names to be anonymised, where one person from a case study did the whole data set for that case was anonymised. This was in order to prioritise privacy where it was requested. In addition there were moments in a few of the interviews were research participants asked for some of the content to be 'off the record', or for the recording to be stopped so that they could discuss matters they didn't want reporting. I complied with these requests and removed any 'off the record' content form the interviews. Research participants were given the opportunity to review the transcript of the interview if they were concerned about some of the comments or suggestions they had made. Only one participant took me up on this offer, but motivated by the desire to ensure they hadn't made any erroneous claims.

3.5.3 Protecting privacy

A number of unexpected issues emerged during the collection of the data which raised concerns for me about the privacy, dignity and safety of my research participants, and led to me revising my expectations of how I would present and share the data after the research. In approaching the narrative interviews I hadn't anticipated how personal the

research participants' stories would be. A number of the projects I examined were trying to tackle problems that were entwined very deeply in the personal lives of the citizens that participated. As a result the narratives included much detail about the personal livelihoods, lived experiences, personal relationships and emotional responses of the research participants. They also involved controversial anecdotes implying the conduct of illegal activity and the inclusion of libellous claims. These highly personal accounts and controversial content raised concerns for me about protecting individuals, particularly when the projects are so unique that they could feasibly be identified. Anticipating that the presentation of the data in the thesis would be a summation of data from across cases and wouldn't directly represent the research participants in such detail, my particular concern was with sharing the raw data in the University of Dundee data repository, as is requested by my funding body EPSRC, even though all but one participant had given permission to do so. As a solution I have decided to edit the content of the interviews to remove highly personal and controversial content, before submitting the dataset to the repository. Furthermore, as part of the consent for participating in the research all interview audio files will be permanently deleted in September 2020.

3.6 In pursuit of co-created citizen science case studies

The above methodology chapter has deliberated the constructivist epistemology from which I approach this research and mapped out the research design and research methods that I have utilised in the pursuit of the research questions of this thesis. I have adopted a multiple-case study design in order to fill a gap in the literature of co-created citizen science case studies, but also as a way to provided rich and detailed accounts of the complex social realities of participatory research. The multiple-case study design looks to capture maximum variation in projects, in order to chart the diversity of practice within the field and to look for trends and insights that cross-cut this diversity. This will address research question 1 of this thesis "How does the concept of co-creation manifest in citizen science projects?" In order to collect data for the case studies a narrative interview method was adopted. This would provide highly detailed and participant led accounts of what happened in the projects and being a narrative some of the causal relationship between the events that took place. In so doing the narrative interviews

would help to address the second research question of this thesis, “What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?” Using an inductive and iterative coding and thematic analysis process the research methods allowed the data to speak for itself, rather than being heavily influenced by theoretical frameworks of participatory practice and action outcomes. We now move to Part 2 of the thesis where I present to you the five case studies that have been compiled through this research design.

Part 2: Five case studies of co-created citizen science

In Part 1 of this research I started by presenting an understanding of the landscape and diversity of citizen science practice and argued that there was a well-established understanding that more participatory approaches to citizen science are able to deliver action-orientated outcomes. However due to a lack of case study examples and empirical work looking to determine the link between process and action, there was a gap in knowledge around how project design in more participatory approaches might best lead to producing action and change. The lack of examples of more participatory approaches reflects a dominance in practice for more 'instrumental' approaches to citizen science which look to harness the benefits of public participation in research in order to deliver scientific needs. This led to the identification of two principle research questions:

1. *How does the concept of co-creation manifest in citizen science projects?*
2. *What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?*
    a. *What is the link between co-created citizen science processes and action outcomes?*
    b. *To what extent are action outcomes realised for the communities participating in the citizen science projects?*

In order to address these questions I have adopted a constructivist epistemological stance towards the research endeavour, looking to understand the situated-ness and multiple realities of the co-created citizen science projects. This has transpired into a multiple-case study design, with case studies compiled through narrative interviews and thematic analysis.

In Part 2 of this thesis I present the five case studies of the research in Chapters 4 – 8. Each chapter begins with an overview of the project, followed by an introduction to the characters and organisations mentioned in the chapter. Next each of the themes that

emerged from the thematic analysis are described. Finally I assimilate the key insights from within the case, exploring the learning that they contribute to this research enquiry. Here, first, I introduce all five case studies through the data provided by the project managers in the pre-survey questionnaires (Table 4.1 – 4.5). The data in the tables has been anonymised in line with the case study chapters.

Table 4.1: Large Carnivore Mitigation Programme profile	
Notes: see Case study in Chapter 4. *(All project and organisational names are the pseudonyms used in the case studies).* *(This description reflects the mapping project only, but the case study discusses a broader range of activity).*	
Description	Large Carnivore Mitigation Programme was a citizen science program that enabled landowners (producers) to report carnivore observations though an on-line mapping tool. Carnivores included grizzly bears, wolves and coyotes, all of whom predate on cattle, and for grizzly bears get into grain bins and crops. The goal was to engage landowners in documenting interactions to create their own information to better understand when and where interactions were occurring. The notion was that though experiential learning on their own properties and then sharing information across the landscape a more robust understanding of carnivore interactions would occur. This would enable enriched dialogue around community efforts to reduce negative interactions. In theory we also felt this would provide the community with a voice at the table in discussions on carnivore management though their own data collection process.
Objectives	Document where carnivore and agriculture interactions where occurring and understanding the types of interactions. Enhancing the understanding and voice of producers in conversations around carnivore management. Monitor effectiveness of solutions (actions taken) to reduce negative carnivore interactions.
Outcomes	Development of program and data collection tool. Hiring of local coordination. Poor results in terms of data collection and by-in from local community (people liked to call coordinator to report observations but not share in database). Failure to continue with other program components (genetic sampling) and monitoring mitigation measures.
Project start	Development 2010, launch 2012.
Project finish	2013
Number of participants	25
Citizen scientists	Landowners, producers whom ranch cattle for a living. Bluelake Institute worked with Riverfern Conservation Group
Researchers	Bluelake Institute, a university and a senior biologist from government environment department
Other participants	Cracknell Biodiversity Conservation Association was helpful in promoting the program
Management team	Professional research team

Table 4.2: Protecting Our Waterways profile	
Notes: see Case study in Chapter 5. *(All project and organisational names are the pseudonyms used in the case studies).*	
Description	Protecting Our Waterways was a water quality monitoring citizen science project coordinated by Natural Environmental Agency (NEA). The project combined NEA freshwater expertise and local community knowledge. Citizen scientists participated in the co-design of the study by contributing local knowledge that identified sampling sites and potential pollutants of interest based on historical land use. Co-monitoring then involved citizen scientists being trained in monitoring techniques, and sampling was undertaken fortnightly for 10 months (& then an additional 4 months to follow up on a pollution result). Citizen scientists monitored 10 sites along [waterway] and its major tributaries for pH, temperature, ammonia, turbidity, electrical conductivity and phosphate. The citizen scientists' sampling was complimented by additional sampling by NEA scientists. Afterwards, NEA and citizen scientists came together to co-interpret the data that had been collected.
Objectives	The objectives of the project were too: Engage the community in the science behind NEA. Increase the visibility of NEA in the community. Collect data to determine baseline water quality for the waterway (no previous data existed for the waterway and it was assumed water quality monitoring had not been formally conducted there). Build a two-way working relationship between NEA and the local community.
Outcomes	An engaged* community became actively involved with monitoring the environment, increasing their environmental awareness and scientific literacy. Water quality data able to be compared to state policy. Greater positive awareness of NEA in the community. *The local community have a strong environmental awareness. They are a community who have actively voiced their concerns about the air quality in the region following a major industrial crisis.
Project start	February 2017
Project finish	April 2018
Number of participants	22
Citizen scientists	14 citizen scientists were involved in the project. They were local community members with an interest in the health of the waterway. In general, older/ now retired members of group had careers in science and engineering professions.
Researchers	Three NEA freshwater scientists were involved in the project at different stages. Their main role was to provide freshwater expertise, advice on water quality sampling parameters (e.g. pH, electrical conductivity) and analysis and interpretation of results.
Other participants	The citizen science team (led by project coordinator, assisted by other team members). Plus a local authority who were waterway managers and partners in the project.
Management team	The project was managed by NEA, in particular by the project coordinator

Table 4.3: Healthy Household Water profile	
Notes: see Case study in Chapter 6. *(All project and organisational names are the pseudonyms used in the case studies).*	
Description	Although the quality of public water has improved dramatically since 2002, there are issues with private water supplies which are the responsibility of owners and users. The project aimed to understand the ways in which communities could be better engaged with their private water supplies, recognising that communities are best placed to identify specific local circumstances.
Objectives	What are the attitudes to private water supplies and their management in the case study communities? What are the main concerns users' have with their private water supplies? How can we engage with people around private water supplies? How can that engagement be improved?
Outcomes	Communities value their access to private water supplies. Communities have detailed awareness of the problems of private water supplies but there were gaps in knowledge and a desire for improvements to this knowledge. Improvement, repair or investment costs are seen by many as a major barrier to change because they have the (perceived) potential to be limitless. Engagement can provide the basis and capacity for greater levels of private water supply related activity. Possible improvements can be made. Many of these would promote enhanced equitability, resilience, access to water, and a reduction of health risks. Communities often require locally-specific solutions. There are considerable opportunities for solutions to be co- produced by agencies and communities. A lack of sensitivity in engagement may lead to a community not willing to engage.
Project start	July or August 2015
Project finish	January 2017
Number of participants	24
Citizen scientists	There were 8 community researchers who were employed on the project, and other local community members participated in focus groups and workshops (sometimes 25 - 30 people from communities of around 100 people).
Researchers	Researchers from the Farming Futures Institute and researchers from Ludlaw Repton University. Researchers from each institute co-led the research.
Other participants	National Waters Research Programme (NWRP) managed the project. The Steering Group (included several public and corporate stakeholder bodies).
Management team	NWRP establish user groups around themes focussed on the main policy areas to help identify, prioritise and coordinate research and other activity between policy makers, their implementation partners and researchers. Crucially their establishment ensures that NWRP projects deliver added value by informing not just for one user organisation but a wider partnership.

Table 4.4: Conserving Wolverine Populations profile	
Notes: see Case study in Chapter 7. *(All project and organisational names are the pseudonyms used in the case studies).*	
Description	The Trappers' Society (TTS) and Ferendale Conservation Association (FCI) collaborated on a citizen science partnership to determine broad-scale distribution and habitat associations of wolverines using long-term fur harvest records, trapper local knowledge, and field data. We conducted a questionnaire survey with trappers to determine locations where wolverines were present or absent, perceptions of wolverine population trends, trapper attitudes and effort; we identified course-scale habitat associations based on trappers' responses. The follow-up field component of our study relied largely on trapper volunteers to inventory wolverines on their registered traplines. We collected field data using non-invasive run pole camera traps designed to photograph wolverines so that biologists could differentiate individuals based on unique throat and chest markings. Trappers contributed tissue samples from harvested wolverines, and the run poles collected hair samples for genetic (DNA) analysis.
Objectives	From a research perspective, our objectives were to: identify variables associated with habitat selection; gain a better understanding of trapper attitudes toward an iconic yet sometimes problematic species; and characterize wolverine genetic relationships to better understand how animals in the state are related to those in neighbouring jurisdictions. The trappers wanted to demonstrate to the scientific community that wolverines were more common and wide ranging than previously thought. Equal in importance to our organizations' research goals was the desire to work with volunteer trappers to achieve these objectives. By partnering with trappers to collect field data, we wanted to capitalize on the opportunity to engage with an experienced stakeholder group eager to work with researchers toward a common purpose. We also hoped to engage this group of resource users in discussions about habitat conservation and the need to maintain areas of low disturbance within a working landscape.
Outcomes	Research outcomes: 2 technical reports; 1 peer reviewed paper; 2 more in review (so far). We learned that wolverines in the boreal sometimes meet life history needs in ways that are different than wolverines in the mountains, where most other research has occurred. Though most of the previous focus had been on the mountains population, the majority of wolverines in the province are actually located in the boreal forest, just as the trappers had been trying to tell us. Conservation outcomes: We have a much better understanding of the amount of space that wolverines require. Both trapper local ecological knowledge and camera trap data demonstrated a strong association between wolverine distribution and areas with lower amounts of human disturbance. Forest management companies have started to incorporate our research findings into their planning exercises. Trappers have asked us to work with them to help monitor harvest sustainability for other species
Project start	November 2011
Project finish	Reporting is ongoing
Number of participants	164
Citizen scientists	The Trappers' Society

Researchers	Ferendale Conservation Institute
Other participants	We also worked collaboratively on sub-components of the wolverine project with researchers from two universities, but those aspects probably don't fall under the "co-created" concept.
Management team	The project was overseen by a planning group that included reps from both TTS and FCI. However, much of the day-to-day project management was conducted by FCI, with responsibilities delegated to various staff. Each trapper participant had a staff person identified as a point of contact. The ultimate scientific oversight for the project was the responsibility of a researcher in FCI.

Table 4.5: Noise Pollution in the Plaza profile	
Notes: see Case study in Chapter 8. *(All project and organisational names are the pseudonyms used in the case studies).* *(Information provided here reflects the broader research programme that the project studied in the case study was a part of).*	
Description	This project aimed to show how open source software and hardware, digital maker practices and open design can be effectively used by local communities to make sense of their environments and address pressing environmental issues in air, water, soil and sound pollution. The project rolled out nine pilots, in three different cities from three different countries (engaging over 1000 people), where communities of citizens collaborated with experts to co-create the technologies and knowledge resources, while addressing issues that they were concerned about. For example, in the plaza, citizens collected data to demonstrate that noise levels in the area were above those recommended by the WHO and the local legislation. They organised a campaign that included data visualisations and a citizen assembly, which moved the City Council into action.
Objectives	Citizen sensing projects have often struggled to scale up due to their sole focus on the technology. Noise Pollution in the Plaza aimed to lower the barrier of entry to tech and provide a lean yet powerful methodology for civic engagement that supports community building, data sense making, and collective action for impact.
Outcomes	Nosie Pollution in the Plaza achieved policy change. Engaged communities. Participants developed new skills. Launched a toolkit, which was co-created with citizens to ensure it responds to people's needs. It has been tested in 9 pilots across Europe, and is currently being scaled up through the OpenTech Innovation Hub (1000 hubs around the world). Future implementations will benefit communities in other countries. Large media coverage. Communities reported feeling "empowered". Project documentary seen by almost 40K people.
Project start	Dec 2015
Project finish	Dec 2017
Number of participants	1000
Citizen scientists	All sorts of communities, from citizens affected by urban pollution to activists, researchers, technologists and policy makers
Researchers	University, research institutes, and NGOs
Other participants	All sorts of communities, from citizens affected by urban pollution to activists, researchers, technologists and policy makers
Management team	Research institutes.

4 The Large Carnivore Mitigation Programme

This case study is set in a rural agricultural community, dominated by livestock farming. The farmers of this community are at least third generation farmers on the land, and many of their families are the original agricultural settlers on the landscape. The farmers keep herds of cattle on large, wild landscapes more than 100km from the nearest city. They share the landscape with a wide range of wildlife, including large carnivores, some of which are of conservation importance or interest. Amongst these large carnivores bears and wolves have been increasing in presence on the farmers' land since the 1990s and have been killing their livestock, damaging their grain stores and posing a threat to life for the community. This has put a significant amount of economic and psychological strain on the farming community, who found themselves ill-equipped and unsupported by government to manage this changing relationship with the local wildlife. The community felt at conflict with the government whose policies and laws prevented them from managing the carnivore populations themselves. This conflict was further aggravated by university research which aimed to establish the population size of the large carnivores, but reported population sizes that were far smaller than what the community believed they were observing on the land. In fact within the three decades that the conflict between the farmers and the large carnivores has been growing, many government and non-government funded research initiatives have been conducted on the large carnivores in the area, some supportive of the farming community and others that have created political problems for the community and their plight. This case study specifically explores some of the initiatives that the community have been engaged with or impacted by.

The initiative that brings me to this case study is a co-created citizen science project run by a non-government funded research institute that works across the region within which the farming community are situated. In 2010 they began to develop a co-created mapping project that looked to support the farming community in collecting their own data. The research institute looked to help the farming community better understand the extent to which their relationship with large carnivores was negative and what they could do to reduce conflict, but also to equip the community with their own scientific data that could be used to create dialogue with the government and policy-makers. The project was

developed through collaborative decision-making between the research institute and some of the community leaders from the farming community. A local scientist was then recruited by the community to coordinate the project. The project was launched in 2012, asking local farmers and other residents to submit their sightings of large carnivores. These records would then be mapped to build a better picture of the distribution and nature of human-carnivore interactions. But the project was wrapped up in 2013 due to a lack of engagement from the community. The project found there to be either a lack of interest or willingness to engage with the project, or a lack of willingness to share data with government organisations. The fact that this project failed makes it a valuable case for this research, because it has the potential to reveal important insights about what causes failure and success in co-created citizen science. But as the narratives and data below reveal this mapping project was of little significance to the community and they instead wanted to discuss a much broader, longer-term, effort to manage and mitigate large carnivore conflict in the community.

The initiative that was most significant to the research participants was the ‘Large Carnivore Mitigation Programme’, a government-funded initiative that supported farmers in installing infrastructures that would prevent large carnivores from causing damage on farms. The programme emerged when a government biologist was employed specifically to work with the farming community on the issue of large carnivore conflict. This biologist fostered relationships with the farmers and together they designed infrastructures that would mitigate the impact of the large carnivores visiting the farms, such as bear proof doors for granaries, and communal shipping containers for disposing of dead cattle. The biologist then managed to secure funding, initially from private sources and later from the government, to finance the installation of these mitigation infrastructures on individuals’ farms. The funding was given to a local community organisation to administer and they would decide and distribute funds to individual farms considered most in need. This process proved successful, leading to reductions in large carnivore damage, which subsequently led to further funding and an expanded catchment for mitigation works. The mitigation programme has now been in operation for over ten years, but with declining funds in more recent year. The programme has led to a 90% reduction in large carnivore conflict on the farms where mitigation has been implemented, but is not yet resolved, as

the carnivores are displaced to other farms. An essential tenant of my narrative methodology is that whatever the research participants have to say is what is important to the research. So rather than viewing the fact that this programme does not involve a scientific process, as a problem for this research, I view this as a significant finding. This case study therefore takes a broader scope than examining the co-created mapping project described in the previous paragraph. Instead it encompasses the communities' broader experiences and relationship with numerous research and adaptive management initiatives that have engaged with questions around large carnivores in this community, looking to understand the relationship between the collaborative nature of these initiatives and their outcomes.

4.1 Who's who in the Large Carnivore Mitigation Programme

The narratives that are the foundation for this case study come from three farmers and three scientists that were involved in different aspects of the collaborations and work described above. They are introduced in the figure below (Box. 4.1). Also introduced in the table below are other characters and organisations that appear in the narratives and data. This case study covers a broad scope of activities and interactions and as such there are many people who are mentioned, but whose voices are not represented in the data. The voices that are represented in this case study have been included because they represent both the community's experiences and those of the scientists who worked with them, but across both the mapping project and the LCMP. All personal and organisational names are pseudonymised. In order to make it easy to follow who is who through the case study chapter each pseudonym is followed by a tag referencing which actor type they are in the project. The tags are as follows: (Cit) = Citizen scientist; (Res) = Researcher; (PM) = Project manager; (RPM) = Researcher: Project manager.

Box. 4.1: Large Carnivore Mitigation Programme Case Study Characters and Organisations

Case Study Narrators

(The narrators are presented in the order they were interviewed).

Steve (RPM) – scientist, living within the farming community, employed to coordinate the citizen science mapping project.

Matthew (Cit) – farmer, currently chairman of River Fern Conservation Group, works as a contractor for Cracknell Biodiversity Conservation Association as the area community representative for mitigation projects.

Judy (PM) – project officer at Bluelake Institute, who initiated the citizen science mapping project.

Thomas (PM) – government biologist employed to work with community on tackling large carnivore conflict.

Billy (Cit) – farmer, participated in the Large Carnivore Mitigation Programme as a community member, husband of Tina.

Tina (Cit) – farmer, observed husband Billy's participation in Large Carnivore Mitigation Programme.

Robert (Cit) – farmer, formerly chairman of River Fern Conservation Group.

Other Characters

Chloe – university academic carried out a genetic population assessment on grizzly bears.

Organisations

Bluelake Institute – conservation research institute that initiated and ran the co-created citizen science mapping project.

River Fern Conservation Group – community, conservation organisation.

Cracknell Biodiversity Conservation Association – non-profit biodiversity conservation organisation.

4.2 Case Study Themes

4.2.1 Project objectives

Project objectives were discussed just by Judy (PM) and Steve (RPM) and in relation to the objectives for the mapping project work. Steve (RPM) had a very personal endeavour to try to reduce the conflict between the landowners, the wildlife and the wildlife advocates, where the wildlife and the landowners could peacefully co-exist on the land. More specifically with regards the mapping project Steve (RPM) and Judy (PM) seemed to have a couple of different objectives, altering the ranchers' understanding and

perceptions of the types of interactions they were having with the large carnivores, recognising that not every sighting of a bear was a different individual, and that not every sighting was a negative interaction. They also sought to get the ranchers to think about managing their land differently to reduce the conflict, such as not leaving deadstock out on the land. In addition, Judy (PM), who recognised that the ranchers had a conflict with science, wanted to help them to understand what science could and couldn't tell us. Collecting sightings data across the community was the ultimate objective of the mapping project, because Judy (PM) saw the potential it had for bringing awareness and greater understanding in the above mentioned ways.

4.2.2 *Failures of the mapping project*

The programme that Bluelake Institute were trying to set up would have involved three different projects, a genetic analysis project, a mapping project and a camera trapping project. Unfortunately they didn't secure enough money to carry out all three projects and so they decided to just focus on the mapping project. The mapping project's failure was in its inability to recruit and motivate enough people to contribute data to the project. There were a number of different reasons offered by scientists and citizen scientists in the narratives, regarding why people hadn't participated in the project, including not recognising the value of the observations they were making, not having the time to participate, apathy due to participation in the project being "another chore to deal with", a frustration that submission of data wasn't leading to any change, a lack of understanding about what the project was supposed to be achieving and a lack of trust in sharing data. Judy (PM) comments that maybe citizen science wasn't the right approach for a community that were particularly protectionist and didn't trust scientists or the government. Thomas (PM) who felt that the project was a great idea because the ranchers were very concerned about and had issues with the numbers of large carnivores that had been suggested on the landscape, reflected that maybe it just wasn't the right time for this type of a project in the community.

4.2.3 *Community tackling the large carnivore issue*

Community's lack of agency in tackling the large carnivore issue

One of the biggest problems for the community in being able to deal with the large carnivore conflict was their lack of agency in being able to manage the carnivore populations or mitigate the damage they were causing. Historically it had been legal to shoot large carnivores and so ranchers with the help of wildlife biologists had managed populations on their land in this way, but with a change in conservation ethics the practice of shooting bears and wolves has become illegal. Where ranchers had once had independence in managing the wildlife on their land, they were now dependent on government intervention and wildlife management policy. The ranchers were angry at not being provided with other means for managing the situation, whilst being expected to take the economic losses and safety risk of having these species on their land. The ranchers were particularly frustrated that the government hadn't yet published their grizzly bear recovery programme, publishing the population size that they wanted to maintain on the landscape. With less than 20% of the voting population being agricultural and without the personal contacts or power to lobby government directly, the ranchers felt the challenges they were facing weren't being represented in the urban government capitals. However, on the side of the community was their resilience and their supportive community, which had grown closer in the face of these challenges. Already working together on land management and conservation through the River Fern Conservation Group, a group of 10 ranches started to discuss ideas and come up with suggestions for how the conflict might be mitigated. They had a clear sense that any work or response in this area had to be community-wide in order to successfully reduce conflict, and it was essential that they could acquire external funding to overcome financial barriers to the organisational change in their business operations.

Critical support from government biologist and local NGO

The ranchers were a small and informal conservation group who did not have the capacity to acquire or manage funds for the mitigation projects they hoped to run. The help and support of government, through Thomas (PM), and of a local NGO Cracknell Biodiversity Conservation Association, was crucial for the ability of the mitigation programme to "have any legs". Discussions with their local government biologist, Thomas (PM), who had incidentally been employed to tackle the very same issues, led to the acquisition of funds

from a local gas plant and from the government's unspent budget. Thomas (PM) not only helped them access money, but also helped build political support within the government, he also had extensive professional networks that he could draw on to build the right support and infrastructures for the work. The municipal government and the Cracknell Biodiversity Conservation Association held the budget for the River Fern Conservation Group, who would then carry out the work. Thomas (PM) and his team then started to work on securing a multi-year grant to fund the expanding programme of works, and on successfully being awarded the grant looked to place the funds in the community, but the River Fern Conservation Group couldn't manage the sum and it was decided that it would be better if Cracknell Biodiversity Conservation Association took over the reins of the project, with ranchers sitting on a committee to help decide on how the funds should be distributed. This had huge benefits for the community and the programme. It meant that the River Fern Conservation Group could go back to their local landscape management and conservation work because they no longer had to manage the programme, and because the Cracknell Biodiversity Conservation Association were a not-for-profit, with staff who could dedicate their time to applying for grants, the programme was able to acquire larger amounts of money and a more reliable source of funds. This meant that instead of serving 10 ranches in the community, the programme could now support several municipal districts, leading to a better capacity and responsiveness to problems as they emerged. Now, whilst the project was being co-ordinated and run through a local organisation, what the ranchers and Thomas (PM) maintain is that one of the important factors and successes of the project was that it was rancher driven, they came up with the ideas and they delivered the work on the ground, and this is, as Matthew (Cit) describes is, essential for getting their buy-in and long-term commitment, and means that efforts can be maintain if professional bodies or individuals leave the project.

4.2.4 Community's relationship with society

Negative and disinterested perspectives of wider society to ranching community

The ranching community had difficult relationships with the government, scientists, the wider public and the wildlife interest groups, characterised by a lack of understanding from society of the ranchers' challenges, and a lack of trust from the ranchers of the

government and of scientists. There was a perceived lack of understanding from the government, public and wildlife interest groups regarding the risks and challenges that ranchers face, as well as a lack of value of ranchers' knowledge and experience by the government and scientists. This meant that there could be a lack of public support for the funds that were being invested into tackling the problem and meant that lots of work had to be done by individuals like Thomas (PM) to raise awareness and build support within senior government. Unfortunately, with the regular turnover of government staff and politicians, this process of building support would have to be started again and again, and not all governments had the same level of receptivity. Further to this many scientists showed a lack of willingness to collaborate with or incorporate rural knowledge into their research, and the ranchers were frustrated that the scientists and decision-makers weren't including their experience into the decision-making that affected their lives. The ranchers had an awareness that they needed to work harder to promote and advocate their role in society, their value and the challenges that they faced, but they were up against the wildlife interest groups who were anti-rancher and have a significant influence on the media.

Lack of trust in government and scientists

One of the biggest sources of conflict between the ranching community and the government and scientists was around the population figures for grizzly bears, with the government and some in the scientific community suggesting a small population size that needed conserving, in contrast to the ranchers' experiences of having regular interactions with them. This coupled with some historic negative interactions with scientists, meant that much of the ranching community had a severe lack of trust in scientists, and were unwilling to work with them. They also had a lack of trust in the government, being sceptical of them because they were not supporting the ranchers' needs. There were several ways in which the governments' lack of support was reported, including a hesitancy at the municipal level to engage with the issue at all, a lack of willingness from municipal government to have the deadstock bins on their land, a lack of feedback of results and outcomes at the government level relating to the work being done in the community, not releasing the grizzly bear recovery plan to indicate the target population

for grizzly bears, a waning willingness to provide funds for the Large Carnivore Mitigation Programme and the fact that programme was never institutionalised within the government, but was instead something that Thomas (PM) was managing to achieve through sourcing spare budget and grants. This lack of trust meant that Thomas (PM) was critical for bridging the gap, drawing support down from government, and convincing the ranching community to engage and participate. Whilst the community had a negative relationship with the government at the overarching level, they did have a positive relationship with a lot of the government staff working locally. The government staff who were either from ranching backgrounds or who had extensive experience of working on agricultural programmes, had a lot more understanding and appreciation for the ranching communities concerns, challenges and priorities, and seem to have worked well with them.

4.2.5 Scientists and community working together

Being human and community dimensions led

The narratives for this case study revealed several rich insights into how to build and maintain partnerships with communities. Most dominant in the narratives and represented by both Thomas (PM) and Judy (PM) was the idea of being human and community dimensions led, this was in relation to either tackling wildlife conflict and conservation issues, or to partnerships and collaboration in general. The central premise was that in order to achieve success you must take into consideration and work around or within the needs, priorities and values of the community. Without working with these dimensions, and only focusing on the scientific and intellectual dimensions of a project, there was little hope of being able to successfully engage and maintain engagement of communities. In practical terms this meant things like working with the community on their turf, making sure the timing is right for them to engage, integrating the project into the way the community already operates and works with one another, using their communication methods and channels and making sure the tools are appropriate for them to engage with. These things were particularly important when engaging the ranching community because one of the biggest barriers for them as business owners was the time and effort requirements involved in participating.

Establishing relationships

Trust was raised as something critical to partnerships and engagement. Judy (PM) highlighted that Thomas (PM) had made such an investment into building a relationship with the community that they had a lot of trust in him, but that she feels that for the mapping project Bluelake Institute needed to have put more time into building that trust with the community. Interestingly when Judy (PM) and Thomas (PM) describe the partnership that they had with the ranching community they seem to have had slightly different relationships with them. Judy (PM) describes a relationship that is much more an equal partnerships with shared idea-generation and decision-making, whilst Thomas (PM) describes a relationship where the community drive the decision-making, but he and his colleagues act as a facilitators of the process. In addition to this time and communication were seen as important factors for building and maintaining relationships between the community and researchers. Communication was important and needed to be given lots of attention by researchers. Particularly it was important that researchers didn't assume that the community were meeting the communication needs themselves and that the researchers had to actively be a part of that process too. Communication needed to be done directly in the community, for best results, rather than remotely. As facilitators of the process Thomas (PM) was important in opening up lines of communication so that the partnership and collaboration could work well. Finally time was important for these types of processes with both Thomas (PM) and Judy (PM) providing examples, both from within and outside of the project, of the need to have several years to build the relationships, the understanding and the trust between the community and the researchers, in order to build the success and the outcomes.

The role of scientists

The data describing the role of the scientists in this case covers the work and contributions of Steve (RPM), and Thomas (PM) and some of his colleagues. In the instance of Steve (RPM) he was working to try to involve locals in the participation of the large carnivore mapping project, whilst Thomas (PM) and his colleagues were focused directly on trying to help deliver mitigation for the conflict. Whilst the different contexts mean that the work of Steve (RPM) and Thomas (PM) were orientated and focused in different ways, and

therefore different, they were both in a position of trying to facilitate a process within the community, and very much had a held the perspective of being at service to the community. Steve's (RPM) role was to encourage participation in the citizen science project and through this he was responsible for the recruitment and management of public participation in the mapping project. He worked as a promoter of the projects, an educator to help people engage with the topic, and also would support and facilitate the contribution of data to the mapping project. Thomas (PM), and his colleagues' role, on the other hand, had a different and much broader focus. Here their role was to facilitate the delivery of mitigation measures within the community. The principles of collaboration for the endeavour were brought by Thomas (PM) and his colleagues, with them intentionally setting up the project and relationship so that they would be supporting, advising and providing resource to the community, but that the community would be in the driving seat with regards to decision-making. In this role of facilitating there were two critical things that Thomas (PM), in particular, but some of his colleagues too, were able to offer the community. Firstly there were the social connections that they were able to bring for the community, building the bridge between the community and the government, but also being able to connect the community with other similar communities that they could visit to get ideas from. Secondly, Thomas (PM) was critical through this ability to access funds and grants that provided the capital for the community to deliver the mitigation. Finally it's important to mention that in the case of both Thomas (PM) and Steve (RPM) there principle role and value to the community was not in delivering scientific research, but instead in facilitating community engagement and participation in science and action processes.

Scientists qualities and conduct

One of the themes that emerged strongly in the data for this case study was the theme of 'Scientists qualities and conduct'. Interviewees provided lots of anecdotes of the types of qualities and the conduct that scientists and other scientific professionals exhibited when working with communities around the production of scientific research. Stories were characterised very strongly as either examples of scientists working well with the

community, or scientists working badly with the community, and revealed a number of key qualities that affected whether or not these relationships were positive or negative.

Openness was a critical concept influencing whether or not the scientist/community relationship was positive or not. Scientists that took time to meet with the community directly, listen to their concerns, values and needs, were forthright and transparent, willing to share data, resources and knowledge to help the community and were receptive to the community were seen as working well with them. In contrast the community had experienced interactions with scientists who were unwilling to respect and acknowledge their knowledge and opinions, were unwilling to share data with them, used scientific language that made their work inaccessible to the community and were unwilling to compromise around the implementation and delivery of research on the ranchers land. Linked to the idea of openness was the concept of humility, with those scientists who were open to the community willing to ask the community for their help and their knowledge, and also being willing to learn from their mistakes, whilst those who didn't work well with the community let their egos rule their work, wanting to get specific outcomes from their research in order to support their reputation, and at the expense as one rancher saw it of the truth. Linked to the idea of openness to the community emerged the concept of commitment. Those scientists and professionals who worked well with the community exhibited a significant amount of commitment to them, including a willingness to get in trouble with their employers by working outside of their job description in order to support the community, prioritising time with the community over other commitments, willing to stay the course with the community being there until the problem was solved and willing to back the community up in the media. Controversially in some of the interviews was the theme of honesty and integrity, with some anecdotes suggesting that those researchers who didn't work well with the community and produced research which was in conflict with the ranchers understanding of large carnivores on the landscape, had biases that led them to producing inaccurate results, and even more than this led them to changing and falsifying research findings in order to satisfy their own agendas. If nothing else this highlights the level of conflict and tension between the community and some of the scientific professionals working within the region.

Finally when examining the success that had abounded the mitigation programme the theme of ‘Having the right team of people’ emerged. Here, very explicitly, interviewees discussed the importance of having the right group of people working together in order for there to be success. One of the qualities that made the people ‘the right group of people’ was the fact that they ‘were wired the same way’, meaning that they had the same set of attitudes and ethics for collaborative working and working with the community, which meant that the project could be delivered in a community and human-dimensions focused way, and thereby leading to success. However, Thomas (PM) highlights that getting these types of people together can be down to luck, or organisations need to purposefully recruit for these mentalities. Also within this theme of ‘Having the right team of people’ was the idea that you have key individuals who help push the partnership in the right direction, usually through social interaction, such as the office administrator who connects that community to the professionals, or the community leader is involved who can build those connections and navigate the community and the project together.

Ranchers qualities and conduct

Finally, there was little but some comment on the roles and qualities of the ranching community who participated in the partnerships. Critical and of importance in these comments was the idea of community leaders being able to help the project to make the right decisions and execute implementations at the right time, in the right way. Other influences that were described that either assisted or provided barriers to the project included the fact that the ranching community can be very private and secretive about what goes on their ranches. They don’t want other members of the community or the government to know what is going on, on their land, or how their business is fairing, and so they are unwilling to share data and information from their land. This led to lack of success of the mapping project, as the projects’ requirements were at odds with the communities’ sense of privacy. At the same time the ranching community exhibited significant levels of selfless-ness, looking to support decisions that support the rest of the community over themselves. Two members of the community were willing to take the risk of deadstock bins on their land, when the municipal government weren’t willing to, so

that all their neighbours were able to securely dispose of deadstock. This was critical for some of the success of implementation of the mitigation programme.

4.2.6 The role of policy

The role of policy in the large carnivore conflict was of huge significance and importance to the ranching community with regards how the problem came about, but also how the problem could be managed and solved. It was the creation and implementation of policy from the regional government that left a lot of the ranching community sceptical and distrusting of the government, because many of the policy decisions that the government were making were having negative consequences on the ranchers. There were several examples of legislation or policy that either didn't make sense to the ranchers, didn't marry up or work with their operations, created lots of bureaucracy for them, or else caused them problems. There could be relatively small changes to policy or legislation, that didn't even directly affect the ranchers' operations, but which would have unintended consequences that created big problems for them. One example is that during the BSE outbreak the organisations that used to collect that ranchers' deadstock for free, in order to process them at factories for their natural materials, were suddenly being charged for disposal of cattle at their end. They then pushed the cost of this disposal on to the ranchers, but because the legislation stated that the ranchers could dispose of deadstock on their own land, and because ranchers weren't managing to sell their livestock for much money on the market, they chose to do this instead, and this became an attractant for large carnivores. So this type of thing was a general conflict and problem for the ranchers with regards policy and governance. But more specifically for this particular case study and issue the biggest problems for the ranchers were that the government had not published the grizzly bear recovery programme, and this made it very difficult for the ranchers to know how best to manage their ranches and business, because they didn't know how many bears they were expected to operate with. Further to this the ranchers were frustrated that the scientists and government were making decisions and policy that significantly affected their livelihoods, but which they were not a part of the conversation.

4.2.7 The role and value of science

Positive and negative opportunities of science

The ranchers' perceptions of science and data in this case study is quite nuanced and complicated. The ranchers very rarely spoke about science or data in their narratives and when directly asked about the importance of science in helping them to address the problem they seemed puzzled or confused by the question, not understanding the relevance to the narrative they were telling. Yet, when they did mention science or data the ranchers' provided several different anecdotes of their experiences of working with scientists, or the impact of science on their large carnivore conflict, both positive and negative. For example they explain that some scientists had no respect for them, would not consider their knowledge and experience, conducted poor quality science that produced false results, or even lied or falsified data in order to meet their own agendas. On the other hand there was work conducted by some scientists who worked really well with the ranchers, conducted, in their opinion, high quality science, and as a result produced grizzly bear population figures that the ranchers deemed to be accurate. Across all the narratives several different roles that data or the science played in the context of the large carnivore conflict were revealed including identifying the hotspots for conflict in order to prioritise mitigation implementation, influencing the policy-making process that affected the problem, and the opportunity empower the ranchers with their own data to take to the decision-makers. However, in contrast, Billy (Cit) highlighted that sometimes data could make things worse because it could be warped and twisted to suit particular agendas.

Revealing truths through science

A powerful theme that emerged in the narratives of this case study was the idea of the role of science and data in "revealing truths", and the difficult that science has with doing so. There was a lot of contention for many years, around the population estimates for grizzly bears in this community's area. A number of genetic research projects had taken place to estimate the population sizes and the ranching community had been deeply dissatisfied with the findings, with both the ranchers and wildlife officers believing such low figures, as were suggested, to be laughable. Even amongst the scientific community there were scientists criticising each other's work and then conducting research that

suggested even smaller population sizes. The problem for the ranching community was that the figures coming out of these research projects were what the government were using to inform their policy, and the community were in debates with the government for decades arguing “there’s more than you’re thinking.” Some of the problems that the ranchers highlight were behind these research projects were scientists having an agenda and wanting or being invested in finding small population sizes because that would justify their jobs and careers, the scientists sampling methods being completely illogical and “totally off hand scientific”, and unwilling to collaborate with and include the knowledge of the professionals on the land. Despite this the scientists’ estimates were accepted and adopted by the government. However, later on a different scientist came to the community who produced population estimates, through genetic sampling, that were much more in line with what the ranching community believed were on the landscape, and demonstrated that there were much larger populations of large carnivores. Most of the rural community were in agreement with the figures. They were described by Robert (Cit) as “hard numbers”, and the community generally saw this research to be more reliable because of the thoroughness of this scientist’s methodology, her lack of an agenda for the findings, and that she worked with the ranchers knowledge and advice rather than ignoring it. Unfortunately there seems to still be some dispute around the figures.

4.2.8 Project outcomes

Outcomes of the large carnivore mitigation programme

The first thing to reiterate here is that the mapping project, and the starting point for this case study exploration, was not a successful project. The mapping project did not manage to produce enough data to say anything meaningful about the large carnivore populations or their interactions with rural community. The Large Carnivore Mitigation Programme mitigation programme however has been a very successful and has been running for more than a decade. The biggest success for the community has been that it has actually had the desired effect of reducing the conflict between the ranching community and the large carnivores. Matthew (Cit) suggests that he has seen a 90% reduction in conflict on his ranch, thanks to the work they have done, but Billy (Cit)

highlights that where they reduce the conflict on their ranches the problem just gets pushed somewhere else. As a part of the process of reducing conflict with large carnivores through mitigation the community learnt a lot about what did and didn't work for doing so. Through experimenting and making mistakes, the ranchers got to learn about what could and couldn't prevent grizzly bear's ingenuity. Judy (PM) also highlights that whilst the mapping project was not a success in terms of citizen science, that they were successful in general engagement, fostering dialogue in the communities and helping them to understand what options were available to them in turns of reducing the problem. Both Steve (RPM) and Judy (PM) felt that this dialogue had continued after the project, leaving the community with more awareness and changing perceptions. Another outcome of the mapping project was that it led Judy (PM) and Steve (RPM) onto other pieces of work on the same issue.

Successes from other scientists

Of particular success and benefit for the ranchers, that wasn't an outcome of this project, but which had a significant impact on them was Chloe's work, which the narratives all represent enthusiastically. Chloe's work, as far as the rancher sympathetic community see it, provided proof that there were a lot more large carnivores on the landscape than had been suggested by the scientific community and the government before. This for the ranchers was evidence of all the damage they had been experiencing, and it changed the views of the government, bringing their support for the conflict issues. This new estimate of the population also helped the ranchers and the agencies better understand what they were dealing with and how to manage resources properly. Two other impacts of Chloe's work are that Steve (RPM) believes that her work led to a decrease in the resentment of the community in some of the research that had come before, but it is also highlighted that through the process Chloe fitted into the community really well and has become a part of the community moving her family to the area to live there.

4.3 Key Insights

Having described the themes that emerged from the analysis of the narrative interviews in this case study, I now discuss the key insights that have emerged that relate to the principles research questions of this thesis.

1. How does the concept of co-creation manifest in citizen science projects?
2. What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?

4.3.1 The role and value of scientists in the community

A very surprising reflection in this case study is the role that the professional scientists and biologists play for the community in these collaborative endeavours. Facilitation of the research process is a critical role that is played by both Steve (RPM) and Thomas (PM) in the mapping project and the Large Carnivore Mitigation Programme respectively and highlights a common thread across many of the case studies that a critical role of the researchers in these processes is providing the project management of these processes for the communities, rather than the science. This means that there are a different set of skills required of the researchers in order to deliver these types of projects, including competent public communication skills, recruitment and engagement skills, marketing and promotion, people and volunteer management, and social skills. What was further fascinating was observing the role that Thomas (PM) was reported to have played for the community in the Large Carnivore Mitigation Programme, whilst the Large Carnivore Mitigation Programme did not have a core scientific element to it and therefore Thomas (PM) was never in a position to collate and process data and results with and for the community, I was surprised and it was important to see that he actually played a valuable and essential role in bridging the gap between the community and the government, through the acquisition of funding and political support for the community's conflict and the mitigation work. This is not the kind of role that you would expect a biologist to be playing within a project, but demonstrates how much wider a collaborative scientists' skills repertoire needs to be when collaborating with a community, and how the practice of science is not always a central tenant of the work that needs to take place.

4.3.2 The role and value of science

One of the most striking things about this case study was how insignificant the actual process of science seemed to be for most of the interviewees, particularly the ranching community. The majority of interviewees rarely spoke directly or explicitly about science, and when pressed to do so many would express puzzlement as to why science was relevant. This demonstrates that science was not perceived to be a dominant influencer in the ranching community's ability to address large carnivore conflict. Instead interviewees spent more time talking about social relationships and dynamics, finance and politics, and practical interventions that they were carrying out in order to address the issue. Where science was discussed this was in relation to the controversy around population estimates and the influence that this had on policy making at the provincial level. Science played a role in influencing policy, which would ultimately affect the ranching community's ability to tackle large carnivore conflict, but this was something separate from and out of the realms of direct influence for the ranching community. For the ranching community, science didn't have a role to play in their own abilities to tackle the large carnivore issue, they were findings success through other means. Science played a role in the overall picture, but it was something relatively inaccessible and removed from the ranching community, and not something they could readily utilise for their own means.

This case study demonstrates the limitations of science in being able to reveal truth and resolve conflicts. The population size of grizzly bears within the province is a highly contentious issue that was only exacerbated by research carried out by provincial scientists who suggested that the population size was very small, contrary to the ranching communities' observations. Later genetic research carried out by another researcher suggested larger population sizes, in-line with the ranching communities observations, but at conflict with and not accepted by the authors of the original research. Whereas science is expected to be able to reveal and mediate truth within society, helping to find answers and solutions, it is often unable to do so. Whether or not scientific findings are accepted by society depends on a number of social and economic pressures, motivations and drivers. Scientific findings are always open to criticism and rejection, and their influence on the policy and governance around problems is determined by politics and those individuals who have power. In terms of the ability of science to support change

and action, science is unable to provide definitive answers and solutions to problems. It can support communities in gathering evidence in support of the crises they face, but whether or not that evidence can have impact does not solely rely on the science itself, but also on a whole suite of other social, political and economic factors that have to be carefully negotiated.

4.3.3 Being human dimensions led

Being human and community dimensions led was one of the most striking concepts in this case study, because it highlighted the importance in these types of processes of not being blinded by the scientific process that a 'citizen science' or 'collaborative science' endeavour might involve. Often citizen science projects are designed around the scientific process, but this case study highlights how important it is, especially when dealing with issues of concern or conflict, to be working with the needs, priorities and opportunities of the people's that are involved or affected by the issue. Understanding how a community works and operates is essential for being able to do this, which either involves establishing a long-term relationship with the community for whom you will be working, or else ensuring that someone within the project management team is a member of the community and can represent their needs and concerns. This need for bringing the human dimensions of these projects to the foreground of the interactions and efforts could be a challenging concept for some of those working in citizen science, because it could feel like the fundamentals of working with the science are being lost, masked or deprioritised. However, when working with a community in a collaborative or co-created way, or else working towards tackling a particular issue, addressing these dimensions of the project is essential for successfully addressing the problem and engaging the community.

4.3.4 Reflecting on the research questions

When reflecting on the research questions in relation to the insights gathered above a couple of important ideas emerge. Firstly in the relation to question 1 and the way in which co-created citizen science manifests, the case study suggests that there is a need to focus on the social processes of the projects, not the scientific processes of the

projects. In this way the needs, interests, barriers and opportunities within the communities are prioritised, rather than some notion of scientific method and advancement. In this way, the role of the researchers and project managers changes from one of scientific expert to one of social facilitator. Secondly in relation to question 2 and the way in which these processes deliver action outcomes for communities, the insights reveal the importance of researchers and project managers in building the capacity of communities to address their problems, providing critical resources to enable change. The case study also reveals that the value of scientific process and the ability to rely on the scientific process for change is contextual. The influence of the findings of are mediated by broader socio-political drivers, and cannot be seen as a ‘golden bullet.’

5 Protecting Our Waterways

The ‘Protecting Our Waterways’ project took place in an industrial community which had suffered a serious mine fire a few years before. During the mine fire the government authorities had come under fierce criticism from the public regarding the adequacy of communications around the disaster. In response, the government identified a need to strengthen relationships between the authorities and the public and made funding available to the relevant authorities to deliver projects that would strengthen public relations. The Natural Environment Agency, responsible for environmental regulation in the area of the mine fire, pitched for the money with the idea of running a citizen science project. The intention was that whilst the citizen science project would theoretically be able to strengthen relationships between the local public and the Natural Environment Agency, it would also support the community in being able to address a topic of their concern. Consultation work run by the Natural Environment Agency for other purposes had identified concerns in the area around the health of a local waterway, and so it was decided that the citizen science project would look to assess the water quality in the waterway of concern. The citizen science would thereby be able to ascertain whether there was a pollution problem in the waterway, and also provide baseline data of water quality, filling data gaps in the Natural Environment Agency’s records.

The Natural Environment Agency’s citizen science team set about designing the project in a way that would engage the community throughout the research project. They then invited local residents to participate through an open call in the local newspaper. Citizens were recruited, paired up and then trained in water quality assessment protocols. The data collection explored the pH, salinity and potential presence of heavy metals, as well as invertebrate populations and eDNA (environmental DNA). The citizen scientist pairs each took responsibility for a different stretch of the waterway and would survey their patch on a fortnightly basis. The Natural Environment Agency staff and the citizen scientists would meet up for workshops, either discussing the next part of the monitoring process, or else carrying out new activities such as eDNA sampling. During the project there was the identification of a potential pollution event in the waterway, which the citizens were really interested to explore further. The project had been designed to have

some financial flexibility that would enable them to follow up on emerging results and interest in the community. So the project was extended for 8 months to explore the potential pollution incident, by focussing on two sites more intensively, rather than monitoring the whole waterway. This activity concluded that there was no pollution in the waterway and no further need to collect data, and so the project was brought to a close. During this extended period the project also identified the presence of a rare fish in the waterway system. The project ran for one year in total. The success of the project led the Natural Environment Agency to develop an air quality monitoring project, which some of the citizen scientists signed up to participate in. The Natural Environment Agency recognised an improved relationship between themselves and the local community and have since used the baseline data to assess arising pollution challenges in the area.

5.1 Who's who in the Protecting Our Waterways project

The narratives that make up this case study come from three citizen scientists who participated in the Protecting Our Waterways project, the project officer who co-ordinated the project for the majority of its lifetime, and one of the scientists who supported the project and engaged with the citizens. These narrators are introduced in the figure below (Box. 5.1). Also introduced in the figure below are other characters and organisations that appear in the data. All personal and organisational names are pseudonymised. In order to make it easy to follow who is who through the case study chapter each pseudonym is followed by a tag referencing which actor type they are in the project. The tags are as follows: (Cit) = Citizen scientist; (Res) = Researcher; (PM) = Project manager; (RPM) = Researcher: Project manager.

Box. 5.1: Protecting Our Waterways Case Study Characters and Organisations

Case Study Narrators

(The narrators are presented in the order they were interviewed).

Liam (Cit) – local resident who has grown up in and works in the area.

John (Cit) – local resident, retired, moved to the area two years before project started.

Vanessa (Cit) – local resident, retired, active in the local environmental movement.

Susie (PM) – project officer co-ordinating Protecting Our Waterways, employed by Natural Environment Agency.

Andrew (Res) – senior scientist at Natural Environment Agency, who supported the delivery of the project and engaged in some public facing activities.

Other Characters

Peter (PM) – former project officer of 'Protecting Our Waterway' at Natural Environment Agency

Charlie (PM) – citizen science programme manager at Natural Environment Agency

Organisations

Natural Environment Agency – State funded organisation responsible for environmental regulation in area.

Local Waterways Partnership – a management authority for looking after waterways in the region.

5.2 Case Study Themes

5.2.1 Serving multiple objectives

One of the interesting facets of this project was that it was trying to serve two quite distinct objectives for three different groups of 'actors'. For the citizen scientists involved in the project the sole objective of the project was to establish the health of their local waterway. They were concerned about environmental health within the area and wanted to find out whether or not their local waterway was polluted. Equally the Local Waterways Partnership who were peripheral partners on the project, and who have responsibility for the management of the waterway, were interested in gaining data on the water quality, in order to review their management plan. Whilst the Natural Environment Agency had a gap in their data records for this waterway and so adopted filling that gap as an objective for the project, it wouldn't ordinarily have been a priority waterway to monitor. For the

Natural Environment Agency the principle objective of the project, and the reason for adopting a citizen science approach, was to improve their relationship with the local residential community. In fact the funding provided for the project was provided specifically for this remit, and the selection of a water quality monitoring project on that specific waterway was secondary, selected in order to successfully engage the community by tapping into a matter of their concern. What's also important to note is that were knowledge based objectives existed they were orientated around more 'soft' science outcomes, ie. acquisition of baseline data, as opposed to 'hard' science outcomes such as the publication of peer-reviewed literature.

5.2.2 Differing motivations for institutions and citizens

Whilst the Natural Environment Agency were motivated by their organisational responsibilities and their motivations were strongly aligned to their objectives, the citizen scientists' motivations had a much more wide ranging set of drivers. The Natural Environment Agency's principle objective of building a stronger relationship with the community was motivated by their organisational responsibilities, when the government conducted an enquiry into the way the Natural Environment Agency and other emergency response organisations communicate with the public during an emergency. The Natural Environment Agency were required to respond to the enquiry identifying ways in which they could improve public relations and they pitched the idea of a citizen science project, for which they then received government funds. In contrast the citizen scientists' motivations came from a much more personal and wide ranging set of drivers. Firstly, there was a general environmental concern shared by the citizen scientists, with a desire to investigate and respond to potential environmental degradation. For some this environmental concern included the dimension of 'connection to place', in that some individuals had a particular concern about the area they lived in or had grown up in. For some citizen scientists they were also motivated by the project's alignment with their personal interests, with one citizen scientist having a hobbyist interest in science and the others in environmental issues more broadly. They saw the project as an opportunity for them to learn more about these personal interests. Finally one of the citizen scientists was motivated by a sense of altruism, being un-employed he wanted to be of help in some

way, and saw this as an opportunity to help scientists who “can’t get everywhere and do everything.”

5.2.3 *Scope of the project*

During the project the identification of a potential ammonia pollution event in the waterway, led to an extension of the project from 6 months to 12 months. Flexibility had been built into the programme so that it would be possible for the project to follow any leads that emerged from the findings. Despite this at the end of the project both citizen scientists and also Andrew (Res) saw that there was so much more scope for work in the area on the matter of water quality monitoring. During the delivery of the project a number of citizen scientists were vocal about wanting to include additional and different sites for monitoring, than had been suggested by the Natural Environment Agency, they had concerns about pollution in areas other than what the Natural Environment Agency had identified. At the end of the project Vanessa felt like there were so many unanswered questions and investigations that she would like to see carried out, to address wider concern about the ecological dynamics of the area and other potential pollution problems and risks. Andrew’s (Res) interest in the broader opportunities for the work beyond the end of the project was driven by his sense of value over the longer-term and location specific monitoring that the project had achieved, which the Natural Environment Agency cannot ordinarily deliver. Andrew (Res) saw that there was value in monitoring more water ways in the area to provide a broader perspective of what was going on in the valley. He also saw that in the future it would be valuable to do hotspot monitoring for longer and to repeat certain sampling techniques, for example doing macroinvertebrate sampling more than once in a single project.

5.2.4 *The value and role of actors*

The role of citizen scientists

Three different types of actors were represented in the narratives from this case study, the citizen scientists, the project and programme managers, and then scientists, each with different roles and values for the project. The role of the citizen scientists in the project was to collect data for the monitoring of the waterway and to interpret the findings

of the data. They were involved in data collection independently of the Natural Environment Agency staff, but also with the Natural Environment Agency staff on workshop days when they carried out activities such as eDNA sampling and macroinvertebrate sampling. Whilst Susie (PM) talks extensively about the co-interpretation process she designed and facilitated the citizen scientists through, talking about it in terms of them owning the data and driving the interpretations, the citizen scientists do not seem to recognise their role in this process referring to the Natural Environment Agency as the data interpreters. They do however recognise the local knowledge contributions they made to the project, reporting both historical knowledge contributions and contemporary observations that had an impact on the project, either through the inclusion of additional sites for monitoring, the identification of the presence of a rare fish, or aiding the interpretations of the research findings. Both John (Cit), Vanessa (Cit) and Susie (PM) all report how the citizen scientists' sharing of their local knowledge was gradually acknowledged as valuable by the Natural Environment Agency and led to an increased collaborative effort from the Natural Environment Agency, who began to actively seek the citizens insights. This knowledge was valuable because the Natural Environment Agency staff were not local and so would never have been able to access that data otherwise. The citizen scientists are also recognised for their value in increasing the capacity of the Natural Environment Agency to monitor and regulate on environmental health. They were able to contribute much human resource which the Natural Environment Agency are unable to deliver either in time or money. A final role and value that the citizen scientists provided in the project was peer-to-peer learning and support. John (Cit) discusses how he paired up with Vanessa (Cit) in order to benefit from her previous experience in water monitoring and that he learnt a lot about the local area from her. Whilst Liam (Cit) discusses how he helped many of the other citizen scientists with learning how to and carrying out the digital tasks required to submit data to the Natural Environment Agency.

The role of the scientific agency

Whilst there were two distinct roles represented within the Natural Environment Agency, that of the project managers and that of the scientists, the citizen scientist narrators largely

discussed the Natural Environment Agency in whole terms, rather than specifically distinguishing the project managers from the scientists. This paragraph therefore discusses the role and value of the Natural Environment Agency, as a whole. Ultimately the role of the Natural Environment Agency was to design and co-ordinate the project, carry out the research process and to support the citizen scientists in participating in the project. These three facets are important because they clearly frame what the relationship between the citizens and the Natural Environment Agency was, this was a project and process very much owned and governed by the Natural Environment Agency with the citizens contributing to certain discreet parts of the process. The organisation, co-ordination and financing of the project was all managed through the Natural Environment Agency. They also were largely responsible for the research process, designing the project and the protocols, identifying the sampling sites, collating and analysing the data, assessing its quality, reporting that data back to the citizens, and ultimately supporting, checking and validating the citizens' interpretations of that data. The project was very much owned and run by the Natural Environment Agency and so it was, therefore, their responsibility to support the citizens in participating in the project. Their role in this sense included training the citizens', providing them with the freedom and confidence to collect the data independently, work alongside them in some of the sampling activities, explain the science and the results in simple terms, listen to and respond to citizens comments and questions, validate their interpretations of the data and provide a final report of the project. Interestingly, the citizen scientists saw this project as a very good example of collaboration, which raises an interesting consideration about what citizen scientists expect from collaborative endeavours with scientists.

Distinguishing the roles of the scientists and project managers

Within the Natural Environment Agency the difference between the roles of the project managers and the scientists is interesting to examine as it brings a more nuanced understanding of the differing roles that project officers and scientists play in these types of processes. One thing that is clear from the case study is that it was the project managers that were the most active and engaged actors in the project, from the Natural Environment Agency and who engaged the most with the citizen scientists. Andrew (Res)

describes how the amount of time that Susie (PM) and Charlie (PM) gave to the project was highly important for the project being a success, and that if the projects were reliant on the intermittent contributions of individuals like himself, as had been the case in this project, then they would be at risk of failure. Whilst the scientists weren't as heavily involved in the project as the project managers were they still played significant and valuable roles. To the project managers they were the technical advisors, supporting and guiding decision making about the design of the project. Their role was informal, with them casually dipping in and out of the activity of the project. To the citizen scientists their role and their value was in the knowledge that they could bring to the project and the resulting educational benefits that the citizens received from hearing from their expertise. They also played an important role in validating the contributions that the citizen scientists had made. The scientists equally had value in enriching the citizen scientists' experience of the project, Liam (Cit) who was a science enthusiast describes how much he enjoyed the opportunity to engage with and work alongside scientists. Despite such impactful contributions and value, their engagement with the citizen scientists was low, attending two or three workshops throughout the year. This low level of engagement with the citizen scientists is reflected in Andrew's (Res) lack of knowledge about them as a community.

5.2.5 *Relationships*

Positive relationships between the community and the scientific agency

One of the emerging ideas from the discussion of relationships within the narratives is the concept of building social connections with the community. The relationship between the citizen scientists and the Natural Environment Agency was mostly framed around the citizens' experience and the impact of the relationship on them. The citizens' relationship with the Natural Environment Agency was primarily through Susie (PM), Peter (PM) and Charlie (PM) and so it was their behaviour that would have influenced the citizen scientists' perspective of the Natural Environment Agency as an entire organisation. The citizens also had contact with Natural Environment Agency scientists, but on a less regular basis. It is not clear from the data whether the citizens recognised the difference between the Susie (PM), Peter (PM) and Charlie (PM) as the citizen science team and the scientists of the Natural Environment Agency, or whether they refer to them all as

scientists, but overall the citizens express their relationship and engagement with the Natural Environment Agency in a very positive light. Liam (Cit) loved spending time "working with" the scientists, and demonstrates how to him this was a real privilege and special opportunity. When reflecting on engaging with the Natural Environment Agency John (Cit) highlights how friendly and collaborative they were and that by the end it was like they were friends. Vanessa (Cit) and Susie (PM) express how as the project progressed the citizen scientists grew more confident in engaging with the Natural Environment Agency, demonstrating a strengthening and a maturing of the relationship between them. In addition all three citizen scientists indicate to one extent or another that there have an ongoing relationship with the Natural Environment Agency through participation in the next citizen science project. The Natural Environment Agency are described in many terms with regards the way they interacted with the citizen scientists that demonstrate a positive relationship and can be represented by words such as supportive, collaborative, educative, guiding, and mutual.

Actors at service of one another

Finally an interesting insight emerges in the sub text of the data that both the citizens and the Natural Environment Agency felt like they were providing a service to the other. The citizen scientists language is very much orientated around "helping" the scientists and the project being the ownership of the Natural Environment Agency, and that they were simply helping it happen. At the same time Susie (PM) and Andrew (Res) talk in terms of this project being for the citizens and that they provided the support to deliver on the community's interest and that the data and findings were there's. This is interesting because it shows a divergence in understanding about the relationship between the two actor groups on the project, but also may give some indication as to why there is a lack of sense of mutual collaboration across the project.

5.2.6 Partnership and collaboration

Enabling citizen participation

Content discussed around participation and collaboration within the project was orientated around the involvement and engagement of the citizens in the project. With

both citizens and the Natural Environment Agency giving a strong impression of the Natural Environment Agency's efforts to making the project as accessible as possible to the citizen scientists, but also to maximise their engagement in the process. The citizen scientists report a clear sense of the project being open to anybody and of the Natural Environment Agency working around their needs and limitations, for example, Liam (Cit) reports how a staff member met up with him after office hours to provide him with sampling training, so that it would fit around his job. The Natural Environment Agency were actively examining the needs and limitations of the citizen scientists throughout the project and then adapting the engagement and communication strategies to encourage more active participation and dialogue.

Communication

Generally the citizen scientists were pleased with the level of communication, reporting that there was lots of engagement and updates from the Natural Environment Agency, both digitally and through regular meetings and workshops. They also expressed that they got lots of opportunities to ask the Natural Environment Agency staff questions, and share their thoughts and insights. In fact, the case study demonstrates how the citizen scientists were able to share their local knowledge in a way that was impactful to the project. Likely to have been important in making this possible, is what citizen scientists describe as the Natural Environment Agency being good at listening to the citizens. Yet whilst there was clearly some strong efforts from the Natural Environment Agency in ensuring high level of participation and that this was generally well received by the citizens, the project wasn't flawless in this sense. One citizen scientist expressed how they felt that the communications were sometimes lacking and that they didn't always get adequate responses to their questions or queries. Also the Natural Environment Agency were unable to engage with a Facebook group the Liam (Cit) had established for the project, due to organisational social media restrictions. There were also numerous examples in the interviews from both citizen scientists and the Natural Environment Agency staff, where they expressed that they didn't know certain things about the project, such as how the project got started, why certain decisions were made and what happened

to the data at the end. This suggests that there were some limitations to the communication taking place across the project.

Citizen sense of confidence and validity

Generally the citizen scientists' exhibited a lack of confidence in their participation in the project, reflecting that particularly in the beginning they weren't sure that they were collecting the data correctly. Although they also generally acknowledged that the data collection protocol was a straight forward task for them to do, and that their confidence increased during the project. There were also a number of different mechanisms and interactions within the project that validated the citizens' participation, thereby increasing their confidence. These included their data being compared to scientists' data to demonstrate its accuracy, citizens being asked to collect the data independently of the scientists, and the project being extended. There were however, some limitations to the extent to which the citizen scientists felt they made a valid contribution to the project. Whilst the citizens engaged in a process of interpreting the project data and then presenting that to the Natural Environment Agency scientists, the citizens didn't explicitly discuss this event in these terms. When they did mention presenting findings to the scientists they expressed it much more as an educational opportunity, independent of the analysis and interpretation process the Natural Environment Agency would have carried out on the data. One citizen scientist repeatedly referred to the citizens' interpretative contributions to the project as mere 'speculation' and that the scientists knew the right answers. Further to this in some cases, despite being directly asked, the citizen scientists were unable to explicitly recognise the wider contributions that they made to the project. This represents a general lack of sense of validity in contributing to the science of the project, the citizen scientists saw their contributions as restricted to data collection and some local knowledge sharing.

Citizen sense of autonomy and ownership

Another mechanism through which a sense of validity can be fostered is through enabling autonomy for the citizen scientists, and certainly the Natural Environment Agency seem to have granted some autonomy to the citizens in the project. The citizen scientists were set up to collect the data independently of the scientists and so had autonomy over the

data collection process, including what time of day and which day of the week they would collect the samples. General decision-making sat with the Natural Environment Agency, such as the selection of the sampling sites, but there were times when the citizen scientists managed to influence the decision-making process, with Vanessa (Cit) encouraging the addition of two extra sites for monitoring. The extent to which this autonomy was limited is reflected in the absence of any sense of ownership of the project from the citizen scientists. The subtext of their interviews presents the project as being a Natural Environment Agency project that they were happy and willing to support, with no evidence that they felt ownership for the project or the data. John (Cit) is the only citizen that talks about the ownership and he talks explicitly about the scientists owning the science. In contrast to this, Susie (PM) and Andrew (Res) have a strong sense of the citizens having ownership over the data and interpretation of the data, with Susie (PM) discussing “their results” and “their findings”. This is interesting because it reveals that whilst the Natural Environment Agency were psychologically very open to the citizens being a part of and owning this process, but somehow that didn’t translate into the citizens’ experience.

Governance of the project

Building on from these ideas of autonomy and ownership, one thing that is striking in the data for this case study is that whilst the Natural Environment Agency worked hard to try to include the citizen scientists in as much of the process as possible and to share that process with them, the actual governance and decision-making of the project was conducted independently of them. The focus of the project, the direction it took and the decisions about what types of activities would take place and how were all decided by the Natural Environment Agency independently of the citizen scientists. This would parallel with and potentially explain why citizen scientists were unaware of many facets of the project, because they hadn’t been privy to the more overarching and strategic discussions about the project. That being said, whilst the citizens were not actively engaged in the governance of the project, there were ways in which they were able to influence the project, such as providing evidence for why other locations should be added to the sampling list and providing local knowledge that explained some of the data they were

finding. So whilst the Natural Environment Agency did not actively involve the citizens in the decision making processes for the project, they listened and were open enough to the citizens' insights to be able to incorporate them into their decision-making. Despite the fact that the citizen scientists could recount that there inputs did have an impact on the project, they saw the governance and decision-making of the project as sat with the Natural Environment Agency, demonstrating as suggested above a lack of sense of ownership.

5.2.7 Critical incidences

There were a couple of critical incidences which seem to have been very influential or significant in the project. The first is the local knowledge that some citizen scientists were able to provide the project about local historic land use, that significant helped in understanding the context of the research area, influencing the methodology and the interpretations of the data. The other critical incidence that made the project possible in the first place, was the fact that significant funding became available specifically for use in the area after an industrial disaster in the area had led to high levels of pollution and conflict between the community and public organisations like the Natural Environment Agency. This access to funding meant that the project and prospect of citizen science could even be considered in the area. Finally, the discovery of a rare fish in the waterway, would be considered amongst ecologists as a very significant event, but interestingly on Susie (PM) and Vanessa (Cit) talked about this discovery at any length and with any excitement. For Liam (Cit), John (Cit) and Andrew (Res), it was simply an interesting thing that happened alongside the other interesting things in the project.

5.2.8 Science comprehension

Susie (PM) describes in her interview, and it is evident in the citizen scientists' interviews that there were varied levels of scientific literacy amongst the citizen scientists of the project. Susie (PM) describes how the level of scientific literacy had not been determined at the beginning of the project. This was problematic later in the project when they realised that the citizen scientists were struggling to engage with and understand the science. Susie (PM) describes how on recognising this they started to adapt their public

engagement techniques. This contributed to an increase in the citizens' confidence participating in the project. Across the three citizen scientist interviews there are very different levels of description of the science in the project, from being able to explain the science in detail to only being able to describe the how the results were presented to them. Vanessa (Cit) in particular describes how the citizen scientists didn't always understand the science behind what they were doing, or the findings of the work, and that sometimes the Natural Environment Agency's explanations weren't sufficient to help them understand. Despite this Vanessa (Cit) explains and provides evidence that this did not prevent them carrying out the protocol, and in fact it was Vanessa (Cit) who seems to have found the first evidence of a rare fish in the waterway. Also two of the citizen scientists interviewed demonstrated what might be considered more advanced scientific skills, or certainly confidence in their engagement in science, through offering hypothesis of relationships between the waterway pollution and other ecological factors, or through critiquing the methodology that the Natural Environment Agency had provided for the research. Further to this Andrew's (Res) interview reveals his sense that the citizen scientists were successful in engaging in the interpretation processes of the project when he explains that the citizen scientists presented the data in a "scientific manner" and with "well-supported conclusions".

5.2.9 Outcomes

Whilst the project was successful in determining the health of the waterway in question, and collated a baseline dataset for future comparative assessments of the waterways' health, the outcomes described for the Protecting Our Waterways project were largely orientated around the citizen scientists' engagement. Most widely discussed was the citizen scientists' satisfaction in the project. Their satisfaction was significant, with many comments about just how much they enjoyed the experience, how they were pleased when the project was extended and disappointed when it finished. The citizen scientists gained enjoyment from learning about science and the environment, meeting like-minded people, doing field work and the ability to investigate a local concern. Another aspect of the project they were particularly satisfied with was the quality of experience they had with working with the Natural Environment Agency and its scientific experts. This was a

very positive experience for the citizen scientists who enjoyed engaging with the Natural Environment Agency's knowledge and being able to ask them questions, but also found that they were good at listening to the citizen scientists and considering their opinions. Learning was a notable outcome of the project which took place both for the citizen scientists and the Natural Environment Agency. Whilst the citizen scientists learnt about the Natural Environment Agency's work and the science of freshwater systems, as well as how science works and the environment functions, the Natural Environment Agency learnt a lot about how to conduct co-created and more participatory methods of citizen science. Andrew (Res) also highlights how he gained a greater understanding and appreciation for how people engage with nature and what values they draw from natural spaces. The learning on the part of the Natural Environment Agency also led to a change in their attitudes with regards citizens' knowledge, as they gained a recognition of the value that citizens' knowledge had and could contribute to science. A final notable outcome of the project was that the Natural Environment Agency had managed to foster an interest from the citizen scientists in continuing to engage with them and their citizen science programme, as well as becoming involved in other voluntary organisations.

5.2.10 The value of citizen science

Most of the comments regarding the value of citizen science were orientated around the value it had for science. Firstly, this project successfully identified a pollution hotspot in a local community, that wouldn't otherwise have been identified, and Andrew (Res) talks repeatedly about how valuable it is to have citizen scientists in locales, collecting long-term continuous datasets, because the scientific community don't have the capacity to do so themselves. Susie (PM) also highlights the value that the citizen scientists' local knowledge had on the project, revealing understandings of the data that the scientists wouldn't have arrived at because they don't know the history of the location. One of the things that John (Cit) highlights as a value is the fact that a citizen science approach actually meant that an issue would be addressed. John (Cit) and Vanessa (Cit) were aware of previous failed attempts to monitor for pollution in the location, and John (Cit) felt that it was a success of citizen science that they had succeeded in this case. He also felt that there was huge value in citizen scientists participating in these processes

because it meant that they knew what was going on in their local area from direct experience, rather than from a report of which they couldn't be sure of the fidelity. Finally, Susie (PM) hails the opportunity that these processes bring in creating two-way working relationships between the community and scientists, where it is acknowledged that both parties have something positive to bring to the table.

5.2.11 Resourcing as critical to enabling citizen science

Financial and human resources are seen as the critical factors for enabling citizen science to take place. The consensus from John (Cit) and Andrew (Res) was that financial resource needs to be secured for these projects in order to make them possible, and that the Protecting Our Waterways project was well supported in that sense. Further to this John (Cit), Susie (PM) and Andrew (Res) all discussed how human resource can be a limiting factor for projects. Both John (Cit) and Susie (PM) discussed this in terms of previous attempts at citizen science in the community having failed because they couldn't recruit enough volunteers to fulfil the data collection needs. Whilst Andrew (Res) speaks specifically to the human resourcing within the NEA to co-ordinate the project, explaining how the amount of time that Susie (PM) and Charlie (PM) were able to give to the project was critical to its success. Susie (PM) in addition to this explains that their ability to extend the project came down to having built some flexibility into the programme, specifically to enable them to respond to any opportunities from the project's findings.

5.3 Key Insights

5.3.1 Providing a service

An interesting observation within this case study is the fact that both the Natural Environment Agency staff and the citizen scientists felt that they were at service of the other actor group. The Natural Environment Agency staff felt that in responding to public criticism about communications from the Agency, through the provision of a citizen science opportunity that addressed local community concerns, they were serving the communities needs and interests. In contrast the citizen scientists did not reflect any awareness of this motivation and driver from the Natural Environment Agency, and instead saw their contribution as serving and fulfilling the needs of the Agency to collect

data from the local area. The contrast in these two perspectives highlights the existence of notions of service within citizen science projects and raises questions about whether a unified understanding of the purpose and drivers of the project is required.

5.3.2 *Scientists provisioning and governing the process*

The nature of the way in which the Natural Environment Agency establishes and manages the project has an impact of the nature of the relationship between the Agency and the community, and the communities' sense of ownership over the project. In starting from a position of seeking to provide a service to the community, in order to compensate for poor relations in the past, the Agency set out to design a scientific process through which the citizen scientists can participate. Whilst the activity is scientific, the focus for delivering a service to the community is on participation, engagement and experience, rather than the scientific outcomes. With this starting point and subsequent focus for the project the Agency establish a relationship with the community that feels like a public engagement relationship, rather than a scientific partnership. This is further reinforced by the Agency having ownership for the governance of the process and managing the project independently of the citizen scientists. It is also reinforce by the Agency taking on the role of trainers and facilitators of the process, rather than peers. This leads to the citizen scientists' lack of a sense of validity in contributing to a genuine scientific process. This doesn't however take away from the fact that significant enjoyment and learning were achieved for the citizen scientists through the project. Worth further consideration here is the fact that the citizen scientists were not a part of the governance of the project. All the management and decision-making for the project was conducted independently of the citizen scientists. So whilst they participated through many parts of the scientific research, they actually had very little control over the process or the project. This led to a lack of sense of ownership in the project, and their sense of service to the Natural Environment Agency.

5.3.3 *Differing perceptions of contribution and ownership*

A final important insight to raise here is the differing perceptions that the citizen scientists and Natural Environment Agency staff had regarding the contributions and ownership of

the project. Firstly there were opposing perspectives on who owned the project, with the Agency staff and the citizen scientists both viewing the other actor group as the owner. Secondly, there were opposing perspective about how the citizens' contributed to the science of the project. The Agency saw the citizens as participating significantly throughout the scientific process, whilst the citizen scientists only recognised their role in data collection and providing local knowledge. This contrast in perspectives was particularly clear around the ideas of how the citizens contributed to the interpretation phase of the project. This observation is important because such contrasting perspectives reflect a lack of mutual understanding around the nature of the project, which adds further evidence to a lack of sense of partnership and unitedness between the actor groups.

5.3.4 Reflecting on the research questions

The insights from this case study are particularly valuable to question 1 of the research, "How does the concept of co-creation manifest in citizen science projects?" It reveals that some co-created citizen science projects form more of a public engagement relationship with the citizens, than a research partnership relationship. In these circumstances the researcher: project managers take on the role of provision a process and an experience for the citizen scientists, rather than working in partnership with them. With this sense of provisioning and service, the citizen scientists are excluded from the decision-making processes governing the project, reducing their sense of ownership for the project. Furthermore, even when citizen scientists are involved throughout the scientific process there can be a distinct lack of common understanding of the purpose, contributions and ownership of projects. This demonstrates that participation throughout the scientific process does not equate to mutuality of engagement between the actors.

6 Healthy Household Water

The ‘Healthy Household Water’ project took place across four rural communities where many of the residents have private water supplies, rather than mains supplied water managed and regulated by public bodies and private business. The household water in these communities comes straight from rural lands often owned by other people, entering homes without treatment, and through systems managed by the home owners themselves. Within the country in which this project was situated an on-going government funded research programme exists that brings together relevant stakeholders (public bodies and private businesses), referred to in this case study as institutional stakeholders, to research and develop policy around critical and national issues related to water. Through consultation with the institutional stakeholders private water supplies was identified as a research and policy priority and led to the development of research proposals that were advertised for tender. A government agricultural research institute and a university, who both responded to the tender independently, were recruited to deliver the work. The research aimed to understand how communities engaged with their private water supplies, what their attitudes to the private water supplies and their management were, what their concerns were and how their engagement could be improved.

Suggested by the university research team, it was decided that the project would recruit and employ community researchers and adopt a community-based collaborative research methodology, across the four case study areas identified by the institutional stakeholders. The project would also involve community engagement events that would encourage wider dialogue and discussion about private water supplies with the residents of the case study areas. Through a formal recruitment process, two to three individuals were recruited for the community researcher posts, from each area. Those recruited then participated in a training event where they were introduced to the research and its methodology and their responsibilities as researchers. During this training session community researchers were asked to define the research area within their communities, provide feedback on the interview questions that had been designed to collect data from local stakeholders within their community, and identify who those key local stakeholders

were. Once back in their communities they were responsible for collecting interviews from these key stakeholders, submitting the data to the academic research team for analysis.

The academic research team and the community researchers then worked together to develop and run the engagement events for the communities. The first events involved collecting data for the research project through dialogue with the communities about their relationship with their private water supplies. These revealed that the community wanted to be able to talk to the institutional stakeholders about their private waters supplies, and so the second events involved the institutional stakeholders presenting on private water supplies and engaging in dialogue with the communities. Throughout this process decision-making about the direction of the research was negotiated between the research team, the research programme management and the institutional stakeholders. Whilst the programme has been funded for a year, a lack of conclusion around some of the decision-making led to a four month period of inactivity in the project, and an extension of the project from 12 to 18 months. At the end of the project all those who had been formally involved were invited to meet for a closing event to discuss the knowledge and insights and potential policy implications of the work. The project succeeded in its ambition to develop a greater understanding of how communities related to and could be engaged with their private water supplies. The case study communities did not receive any infrastructural changes to their private water supplies through this project, but they did gain a greater understanding of them and in some cases changed the way they managed them.

6.1 Who's who in the Healthy Household Water project

The narratives that make up this case study come from the two researchers responsible for delivering the research project, one of them from the agricultural institute and the other from the university, the research lead who was responsible for managing the research programme that this project came out of, and two community researchers, each from a different case study location. These narrators are introduced in the figure below, along with other characters and organisations that appear in the data. All the personal and organisational names are pseudonymised. In order to make it easy to follow who is who

through the case study chapter each pseudonym is followed by a tag referencing which actor type they are in the project. The tags are as follows: (Cit) = Citizen scientist; (Res) = Researcher; (PM) = Project manager; (RPM) = Researcher: Project manager.

Box. 6.1: Healthy Household Water Case Study Characters and Organisations

Case Study Narrators

(The narrators are presented in the order they were interviewed).

Jake (RPM) – a researcher from Ludlaw Repton University, who was recruited to design and co-ordinate the research project, with Connie.

Connie (RPM) – a researcher from Farming Futures Institute who was recruited to lead the project, designing and co-ordinating the project with Jake.

Patricia (Cit) – a community researcher employed on project from one of the case study communities.

Tony (PM) – a research lead at National Waters Research Programme, responsible for co-ordinating the programme which included HHW as a project.

Lesley (Cit) – a community researcher employed on the project from one of the case study communities.

Organisations

Ludlaw Repton University – state funded university.

Farming Futures Institute – state funded agricultural research institute.

National Waters Research Programme – state funded research programme for developing water related policy and expertise.

Other terminology

Institutional stakeholders – refers to the consortium of public and private bodies who commissioned the research.

Steering group – refers to the actors that were involved in decision-making for the HHW project and included the institutional stakeholders, the National Waters Research Programme and the research team.

Research team – refers to the Connie, Jake and their academic team, but does not include the community researchers.

Professional researchers – refers to Connie and Jake and their academic team.

Community researchers – refers to community residents who were employed to carry out research activities in their local area. This includes Patricia and Lesley and their peers.

6.2 Case Study Themes

6.2.1 Objectives and beneficiaries

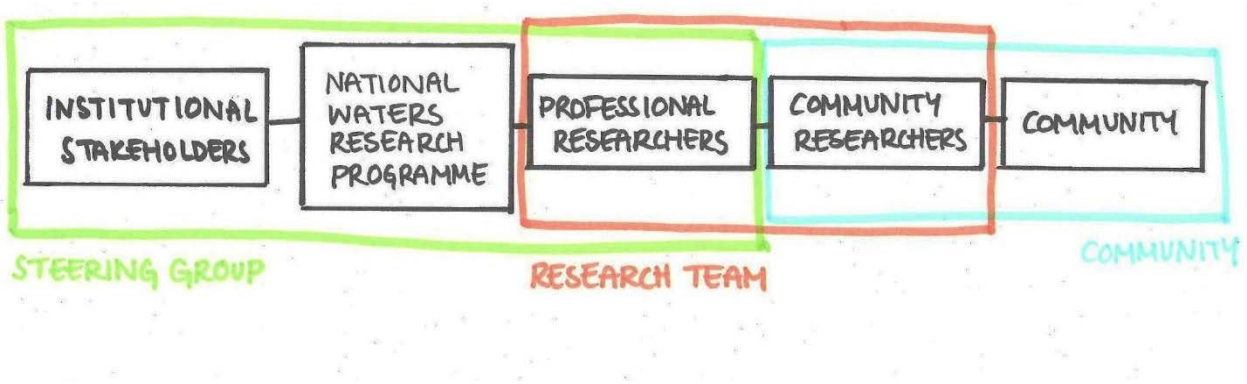
This project was firmly driven by the institutional stakeholders who had commissioned the research through the National Waters Research Programme in order to gather the evidence they need to develop policy. There were a number of questions the institutional stakeholders wanted to gain an understanding of but most specifically they wanted to understand communities' relationships with their private water supplies. The research therefore looked to build knowledge about people's perceptions of water quality and how they felt about their water supply. The institutional stakeholders were also interested in where the economic tipping point was for providing communities with other ways of accessing water. This project was therefore largely knowledge-orientated, but with an indirect action-orientated impact through policy implementation at some time in the future. In terms of more tangible action outcomes there was no intention from the institutional stakeholders to deliver water supply solutions or infrastructures to the communities. Interestingly Connie (RPM) seemed to expect that there would be some sort of tangible outcome for the communities, but the community researchers did not. A further important point for this case study is that neither the professional researchers, nor the community researchers set the objectives or had ownership over the objectives. Where the project had built in some flexibility in order to shape the second part of the project directly in response to what emerged in the first part, the institutional stakeholders still had ultimate decision making power over the direction, and vetoed the use of citizen science for household water quality testing, and asked the research to steer clear of the issues of land ownership and private water supplies due to their legal nature.

6.2.2 Relationships and interactions

In terms of the relational structure of this project there were five different actor groups that were involved in this project and the relationship between them was largely linear (Fig. 6. 1). The five actor groups included the institutional stakeholders, the National Waters Research Programme, the professional researchers, the community researchers and then the community themselves. The five actor groups had different working relationships

with the other actors. The institutional stakeholders, National Waters Research Programme and professional researchers formed a steering group to guide the research, the professional researchers and community researchers formed the research team and finally the community researchers were of the community. The linear nature of the organisational structure for the project meant that some actor groups were intermediaries to the others, and there were very few occasions where all actor groups came together. In addition the linear relationship existed in four independent channels, with the four different case study communities. The community researchers from the four communities participated in the project independently of each other, only meeting at the very beginning and very end of the project. The professional researchers did establish an online platform for them to engage with one another, but they did not adopt this, choosing instead to share their thoughts and ideas with the professional researchers.

Fig. 6.1: Organisational structure of the Healthy Household Water project



Relationship within the steering group

The steering group included the institutional stakeholders, the National Waters Research Programme and the professional researchers and the relationship within the group was largely described as the professional researchers serving the needs and priorities of the institutional stakeholders. Within the steering group there was a direct and constant process of negotiation about what the project would involve, and Tony (PM) describes how these negotiations could, and were often, made openly and “fairly robustly”. The interviews also discussed, however, that this sometimes led to tensions when the

institutional stakeholders and the professional researchers would disagree about the activities of the project. Connie (RPM) describes Tony (PM) and the National Waters Research Programme as intermediaries between the professional researchers and the institutional stakeholders. She describes how this actually slowed the research down due to the lack of direct communication and deliberation. Tony (PM), who has a position as an intermediary, describes working closely with both the institutional stakeholders and the professional researchers. With Connie (RPM) he explains that they worked closely on decision making around the implementation of the research, whilst with the institutional stakeholders he worked closely with them to ensure that the project met their needs and priorities through a process of co-creation. In his position of serving the institutional stakeholders priorities he describes how regardless of whose opinion he agreed with, he had to take the institutional stakeholders position in the decision-making. Connie (RPM) explains how all the decision making was done by the institutional stakeholders and how she felt the professional researchers didn't get a say. Both Connie (RPM) and Tony (PM) discuss how this lack of control over the process was frustrating to the professional researchers. Overall Tony (PM) expresses that he felt that National Waters Research Programme and the institutional stakeholders should have given the professional researchers more academic freedom and that for future projects it would be better to spend more time in the early stages of the project, establishing the boundaries and requirements of the research.

Relationships in the research team

The research team was comprised of the professional and the community researchers, whose responsibility was to deliver the research project. In almost all circumstances the relationships within the research team were all newly established. In the case of the professional researchers, Jake (RPM) and Connie (RPM), they were from separate research institutions and had applied for the research tender independently, but were asked by the National Waters Research Programme to partner on the project. A tension arose in this relationship when Connie (RPM) was designated as the project lead by the National Waters Research Programme, but Jake's (RPM) research methodology was adopted. This meant that there were sometimes challenges around determining who was

supposed to be leading the decision-making and management of the project. Amongst the community researchers, whilst Patricia (Cit) was friends with the other community researcher recruited from her village, Lesley (Cit) had never met her community research partner before. Interestingly for Patricia (Cit) tensions arose with her partner who would make decisions independently, whilst Lesley (Cit) made a close friends in her community research partner. In working together the community researchers seem to have organised themselves by making decisions collectively, but carrying out tasks independently. This relationship was largely positive, as the peer-to-peer working provided local support and confidence in their roles.

The relationship between the community researchers and professional researchers is a particularly important one for this research because the community researchers were employed by the professional researchers, rather than being volunteers. The working relationship is described as being collaborative and deliberative with lots of examples of the way in which the community researchers contribute to the project intellectually and practically, shared a division of labour with the professional researchers. The community researchers found it to be a pleasant and supportive working relationship, but Lesley (Cit) did describe some bureaucratic and line management complications as a result of the employment and management of the project being administered across the two research organisations. She felt that there were different expectations of the community researchers from the two organisations, leading to an inconsistency in management. In terms of decision-making it seems clear that the community researchers were able to contribute in some ways, but that the professional researchers were the ultimate decision-makers, which in some ways parallels the power relationship between the institutional stakeholders and the professional researchers as discussed above. However, Lesley (Cit) explains that she found an emphasis on the community researchers to come up with ideas and make decisions as confusing and that she just “wanted someone to tell you what to do.”

Relationship between the community and the research

The utilisation of community researchers recruited from the community was a purposeful methodological decision from the professional researchers, due to the understanding that

by being members of the community and having an established relationship with the community they would be able to access a richer and deeper dataset that professional researchers would be able to. However, differing expectations from the community about the role of the community researchers were described, with some thinking they were there to problem solve and others being aware that this wasn't the case. Patricia (Cit) surmises that is was precisely because the community didn't think the community researchers could solve problems for them that they were open and willing to talk to the community researchers about their experiences and concerns. Patricia (Cit), Tony (PM) and Connie (RPM) all reflect that the communities engagement with professional researchers and institutional stakeholders would encourage the community to defer to the 'professionals' expertise and lead to them expecting solutions and change.

These notions and expectations of the interactions between institutional stakeholders and the community led to a reluctance by some actors for the two to meet within the project. The institutional stakeholders and the community have a long-term indirect relationship as service providers and service users. This relationship is characterised as tense and frustrated on the part of the community, who feel they do not get the support they need from the institutional stakeholders. This in turn leaves the institutional stakeholders defensive, unwilling to engage and cautious of feedback from the community. However, the project revealed that the community wanted opportunities to engage with the institutional stakeholders, and despite reservations that this would lead to conflict or that the community would become submissive and defer to the institutional stakeholders, thereby influencing their engagement in the project. In the end the opportunity led to a knowledge exchange process where the institutional stakeholders were able to share their knowledge with the community, and through the research the community researchers shared knowledge of the community scenario with the institutional stakeholders. Both Patricia (Cit) and Lesley (Cit) described their appreciation that the institutional stakeholders took the effort to visit and engage with the community, seeing it as a way of the community getting some back in return for their contributions to the project.

6.2.3 Roles and contributions to the project

The role of the institutional stakeholders and the National Waters Research Programme

Whilst the project was set to serve the needs of the institutional stakeholders and their role in the project was to set and reinforce the direction and the boundaries of the project, the National Waters Research Programme's role was to manage the development of the research and ensure that it was delivered to meet the institutional stakeholders' interests and needs. As the direction setters for the research the institutional stakeholders were the ultimate decision-makers throughout the life of the project. Through the steering group they had the sign-off rights on all decision-making and they actively exercised these rights vetoing certain suggestions from the professional researchers, such as citizen science water quality testing in the home. As discussed in section 6.2.2 the institutional stakeholders did also, reluctantly, visit the case study communities providing presentations and demonstrations about private water supplies, answering questions and offering advice. In contrast the National Waters Research Programme were the central pin for the research programme, co-ordinating and facilitating the development and delivery of the research. They worked with the institutional stakeholders to identify the research priorities, identify the case study areas and develop the research proposals. They then recruited the academic research partners to deliver the research, and as managers of the programme they were the communication bridge between the institutional stakeholders and the professional researchers, negotiating tensions between the two when they arose. They also attended the community events that took place in the case study areas, although it's not clear what role they played here other than perhaps an observational role.

The professional reseachers role

The professional researchers' role was to deliver the research for the institutional stakeholders, who Jake (RPM) described as their "clients". They therefore were responsible for developing the research methodology, the analysis of the data, and the reporting of the insights and findings through output reports. Having chosen to utilise a community researcher methodology they also had to recruit and line manage the community researchers, and they worked closely with the community researchers consulting them on their knowledge and insights from the community. Within this they

worked with the community researchers to develop and deliver appropriate engagement events within the community and to manage the communities' expectations of the project. Where the National Waters Research Programme played a bridging role between the institutional stakeholders and the professional researchers, the professional researchers played a bridging role between the community researchers, their communities and the research programme, through the steering group. As members of the steering group it was the professional researchers' responsibility to communicate research suggestions, findings and insights to the steering group from the field work and the community. They had to present their research plans to the steering group for approval, deliver progress reports and finally deliver output reports which could sometimes include unpalatable findings. Interestingly the community researchers identified educational roles as a part of the professional researchers' contributions to the project, which they themselves did not recognise. Patricia (Cit) and Lesley (Cit) saw the professional researchers' engagement with the community as providing education and from Lesley's (Cit) perspective this was their thanks in exchange for the data and information that they had given to the research.

The community researchers role

The community researchers' role was two-fold, they were responsible for helping deliver the research and they were responsible for connecting the research with the community. As employees the community researchers were formerly tasked with research responsibilities including supporting the development of the research design through identifying the boundaries of the case study communities, the key stakeholders who might be interviewed, and making suggestions about the structure of the interview questions. They also contributed to the research by mapping the private water supply systems in their communities and helping decide what content should be included in the community profiles that were written up. They then conducted interviews with the key stakeholders that were chosen by the professional researchers, and they conducted the initial analysis of the interview data by summarising the data against a set of headings (eg. "Financial implications" and "Technical support") provided by the professional researchers. Finally in terms of the research outputs Jake (RPM) and Connie (RPM) describe how the

community researchers presented their findings and insights, and engaged in conversations about the recommendations of the project in the closing event. In contrast to this Patricia (Cit) expressed how she felt unable to contribute to this part of the project due to her lack of expertise. As with the National Waters Research Programme and the professional researchers, the community researchers also had a role as 'middle men', but in this scenario it was between the community and the professional researchers. The community researchers were seen as critical in managing the communities' expectations of the project, ensuring that they understood the aims and objectives of the project and what they would and would not get out of it.

6.2.4 Characteristics of the actor groups

Characteristics of the community researcher

The community researchers are largely characterised in terms of having significant capacity to contribute to research projects through significant knowledge of the topic and the communities, and in some cases through technical knowledge, but also in their general ability to contribute to research processes. Jake (RPM) suggests that most people could contribute to any part of the research process, but what they can actually contribute to needs to be carefully determined within a project. In contrast Lesley (Cit) describes how her and her community research partner weren't always sure that they were doing things right. The community researchers were also characterised in terms of their limitations described as not being representative of a whole community because no-one can represent a totality, but also from the perspective of the community researchers themselves not being able to instruct the institutional stakeholders about the best course of action because they didn't have the expertise to do so. Importantly, but not explicitly characterised by the narrators is the fact that the community researchers are employees of the project, and certainly for Lesley (Cit) this affected the way she engaged with the project motivated more by the financial incentive than having any more intrinsic motivation for the project.

Characteristics of the professional researchers

The professional researchers were characterised in two very different ways by Jake (RPM) and Connie (RPM). Jake (RPM) talked in terms of having a clearly bounded contribution to make to the issue, in delivering evidence for policy-makers and that his commitment to the issue stopped there as he then had to move on to the next project. Whilst Connie (RPM) talks in completely different terms of being on unchartered research ground, having never worked with National Waters Research Programme, or on water-related projects, or with community researchers before.

Characteristics of the institutional stakeholders

The institutional stakeholders are characterised as clients made up of a set of senior individuals from several organisations. This characterisation is particularly insightful as it implies a lot about the relationship the research has to the institutional stakeholders demonstrating that the professional researchers are delivering a service to a group of individuals, who Tony (PM) describes as negotiating the direction of the project amongst themselves. Further to this the institutional stakeholders are characterised in terms of their attitude towards the issue of private water supplies and the communities that live with them. They are referred to as being prejudiced with false preconceptions about the communities' relationship to their private water supplies, but also that they had a set of strong opinions and that they would become defensive when presented with findings that didn't meet their expectations and as a result willing to change the direction of the research to avoid such matters.

National Waters Research Programme staff characteristics

Finally Tony (PM) is the only personal characterised who represents the National Waters Research Programme, and his characterisation is self-described, when he explains that in his position managing the research programme he wanted to remain neutral around topics of conflict, and be sensitive to the potential for the research to be biased by the institutional stakeholders.

6.2.5 Outcomes

Knowledge outcomes

Knowledge production was the main focus of this research project and an increase in understanding about private water supplies, the communities' relationship with these and how to conduct collaborative research processes were reported across interviewees, demonstrating that the project had a significant impact on knowledge. Further to this the project led to the development of new research projects to further expand understanding of the issues and there was an awareness that the national government had taken the insights in order to write policy for them.

Community outcomes

Whilst these are not outcomes that directly affect the communities in the short-term, the narratives did reveal that there were certain unintentional impacts on the communities that participated, such as changes in management practices and an increasing sense of community around the issues. For example, Patricia (Cit) and Lesley (Cit) both talk about recognising they were one of a whole group of people in the same situation, knowing other people in the community they could talk to about private water supplies and supporting each other with the challenges, as well as building friendships. Patricia (Cit) and Lesley (Cit) also explained how some members of the community had changed the way they manage their private water supplies. There was also evidence of attitude change with Patricia (Cit) reporting that having a private water supply now felt more normalised, and Connie (RPM) explaining that she now wouldn't ever drink private water. Jake (RPM) also explains how the quality of the presentations by one of the community researchers at the closing event, led the steering group to realise that the community researchers were to be taken seriously.

Failure to deliver action for the community

Largely for both Connie (RPM) and Lesley (Cit) they felt that the project hadn't resulted in action or change taking place in the communities. Connie (RPM) expressed that the communities had got what they wanted from the project through the institutional stakeholder events, but that this wasn't going to produce change for them with their private water supply scenarios. Further to this there was the emergence of issues within the community through the research, such a land ownership issues, that couldn't be addressed by the project, and Patricia (Cit) explained how frustrating it was to not be able

to help people. Interestingly there was a lack of awareness in the community and professional researchers about the impact of the project in the other communities and in the realm of policy. The professional researchers were not aware because they had moved onto the next projects and the community researchers were unaware because they didn't have the necessary communication channels to know.

6.2.6 Taking action

There was discrepancy amongst the interviewees regarding whether or not the project was supposed to deliver action or not, Connie (RPM) and Tony (PM) talk in an implied sense of an intention that the project might create change, and yet Jake (RPM) and Lesley (Cit) articulate clearly that that was never the objective of the project. One of the critical barriers to enacting change in the communities was that the communities didn't view there to be a problem with having private water supplies. Whilst the research was driven by a concern about the health implications of private water supplies, due to the quality of the water, the community were much more concerned about the reliability and quantity of the supply. There was therefore a dissonance around conceptualisations of what the problem was. Beyond a lack of acceptance that there was a problem, Connie (RPM) reflected how putting solutions into communities was more difficult than she had expected. There was a lack of suitable solutions available influence by the community not being ready for solutions, nuances of the community scenario meaning solutions wouldn't be effective, and also unintended consequences of toll and services. Another barrier was the communities' lack of willingness to spend money of application that may not generate return. The capacity to take action was also socially influenced and highly dependent on the dynamics within the community, with some communities having more capacity than others. For example in one community a dominant landlord restricted the agency of the community to make change. Jake (RPM) and Connie (RPM) express that often the change-making process comes from outside of the community through the policy-makers and the funders, with their resources and power being highly influential. In corroboration within this Patricia, as a community researcher, had a sense of not being able to help community members with their problems, but also not having the assertiveness to tell the institutional stakeholders what needed to be done.

6.2.7 *Community experiences and reactions*

There were contrasting experiences of the project from the two community researchers that were interviewed. Whilst Patricia's comment focus very much on her personal experience and describe overall how much she enjoyed her involvement in the project and had a sense of the project being worthwhile and her contribution having a sense of work and achievement, Lesley's (Cit) comments are more orientated around what the community got out of the project and were less positive about the project, with a sense of a lack of understanding of the purpose and a lack of sense of impact on the community. This lack of sense of impact was in some ways paralleled by Patricia's comments which described a lack of sense of agency in being able to help the community with their problems, enable the efforts of the project to have impact at a wider scale, or be able to tell the stakeholder clients what needed to be done to address the issues. Despite this she demonstrated a satisfaction in the support from the professional researchers, found the project interesting, and took enjoyment from giving people the opportunity to discuss the challenges they were facing and the experiences that they had. Jake (RPM), Patricia (Cit) and Lesley (Cit) all raise the fact that whilst quite a few people came to the first event in the communities, less people attended the second. Jake's (RPM) perspective on this was that through the first event community members had had a huge catharsis, managing to get things off their chest, whilst Patricia (Cit) and Lesley's (Cit) comments are much more around a lack of relevance of the events to the community, either they had a private water supply that wasn't the same as other people's and so felt like they just had to do their own thing on their own, or they realised that there wasn't anything coming to change or help the community. Further to this Lesley (Cit) makes a number of comments about the lack of relevance and impact of the project on the community, explaining that the community didn't understand what the project was about and what it was supposed to be trying to achieve. Their attitudes and perceptions about their private water supplies didn't align with those of the researchers and so they didn't see the need for water treatments. Also whilst Lesley (Cit) appreciated the effort the institutional stakeholders went to to visit the community, she doesn't think that the community appreciated it.

6.2.8 *Challenges and limitations of the project*

A number of different challenges and limitations were identified by interviewees about the project, orientated around three dimensions of the project; community participation in the project, researcher participation in the project and addressing an issue of concern. Firstly, there were a number of issues that affected the way in which the community researchers participated in the project. Both community researchers interviewed expressed a lack of clarity, understanding and confidence in what they were supposed to be doing as part of the project, but also in what the intended and actual outcomes of the project were. This created a sense of a lack of comprehension about the purpose and impact of the project. Another difficulty was related to the wider community contribution and participation in the project, and was related to the influence that powerful stakeholders have on the communities interaction. Whether powerful community stakeholders, or external stakeholders, their presence at public events was seen as restrict how open, honest and forthcoming the community were about the challenges they were facing and their experiences of the topic. This could be because their landlord was at the meeting and they wanted to avoid conflict with them, or because 'experts' were in the room and they wanted to hear what they had to say about the issues. Interestingly there is also discussion in the case study interview of the ways in which the professional researchers contributions to the project were challenged. Due to the 'client'-orientated nature of this project the stakeholder clients had the say over what happened in the project, and this is seen to have constrained what the researchers were able to do with the research process in some cases leading to conflict. Tony (PM) discusses how in the future they would work much harder at the front to clearly establish the boundaries of the project and what could and couldn't take place, so that the professional researchers have clear guidance and goal posts to work with. Finally the weaknesses and challenges raised with regards addressing an issue with concern, were around the identification of that issue and then the scope of the project to address that issue. Patricia (Cit) discusses how there was little momentum around the issue of private water supplies within her community, because it wasn't perceived as such a big and pressing issue within the community there wasn't the momentum to engage and do anything about it. But because of this lack of momentum and the limited scope within the project, it wasn't possible to galvanise the participating communities around the issue, or even to expand that work to other similar communities.

6.2.9 Community researchers as the strength of the project

A community research approach was seen as the strength of the project overall. Researchers and community researchers alike had a sense that through utilising a community research approach the project produced better quality research, that was able to get to the bottom of the issues much more deeply and more quickly than if professional researchers had conducted the work alone. The value of the community researchers was seen as influencing the framing and scope of the research, the accessibility of data and insights and the success of the public engagement, leading ultimately to better quality research and what the professional researchers considered successes in public engagement. The value of the community researchers had three merits their local knowledge, their connection and relationship with the community, which Jake (RPM) refers to as “cultural capital”, and their lack of ‘expert’ status. Most significantly the community researchers value was in the fact that they knew the community well and so they knew what would and wouldn’t work, what was and wasn’t relevant, what would and wouldn’t be acceptable to the community, and how to approach and engage successfully with the community. This knowledge increased the success of the projects engagement with the community, leading to high attendance at the community events. Their knowledge of the community also meant that they were able to suggest a number of different people to interview that the scientists would never have considered, because they don’t have the understanding of the community and the problem. This was considered to have increased the rigour of the research. Another powerful value of the community researchers was the fact that they were members of the community themselves. This meant that they had established relationships with the community that meant that the community were more willing to engage with the project, attending the public events but also engaging in the interviews. It also meant that there was more consistency of engagement for the community with the project because the community researchers were always there rather than having researchers parachuting in and out. Finally, the value of the community researchers in engaging the community also came from the fact that they weren’t seen as ‘experts’, as this avoided the ‘expert’: ’non-expert’ dynamics which meant that the community engaged more openly. It was considered that if experts had been conducting the interviews the community might have felt like they

were ‘having something done to them’ and would be less willing to engage, or else they would be asking the experts for knowledge, answers and solutions, rather than offering and sharing their own insights. By having the community researcher the community were offered more of a sense of familiarity in their engagement in the project and a spokesperson they could ‘theoretically’ trust to represent them and their interests in the research.

6.3 Key Insights

6.3.1 Project beneficiaries

This case study provides an interesting contrast to the other case studies because it was set up in order to deliver outputs for a group of institutional stakeholders who did not participate in the practical delivery of the project. The work and contributions of all the other actors was in this way tailored to serve the needs and interests of these ‘clients.’ There was no formal intention to delivery outcomes for the community, although for some individuals in the project, including professional researchers, this was an implied intention of engaging with a community. It is interesting therefore that a collaborative research model was utilised in delivery of the research, as there was potentially little compensation for those that participated if it hadn’t been for the community researchers being employed or the effort to deliver community events. This collaborative research methodology was however developed into the project after the identification of the projects objectives.

6.3.2 Impact of powerful stakeholders

One of the impacts of having institutional clients for the research project was that they held the power for what the research would explore and largely how it would be delivered. This amount of control over the research process and their absence from the day to day delivery of the research, left the professional researchers stifled in their contributions to the project and the with limited freedom to follow their expertise. There is potentially a philosophical tension between having a project that utilises a participatory research methodology, within a structure where power is very heavily weighted with one external stakeholder. Also interesting is that, again with the context of participatory research, the community from where the knowledge is gathered, and the actors who are the knowledge

end users, have very little contact in the project. Again its important to recognise that the participatory methodology was retrofitted to the research objectives and context, but what the case study demonstrates is that tensions and conflict that emerge in the knowledge production process when one stakeholder holds so much power and collaborative interactions are dispersed and not centralised.

6.3.3 Citizen scientists employed as community researchers

Another important comparison point of this project in contrast to the others is that the citizen scientists were employed, and paid for their time. Jake (RPM) saw this as a significant ethical issue, with the feeling that it was unethical to ask citizens to voluntarily carry out work that a professional researcher would be paid to do. He also felt that when working for a client it was important to employ the community researchers, because that enabled you to have more control over the quality of the contributions to the research. The fact that the community researchers were paid might also be more appropriate in the context of what is discussed in sections 6.3.2 and 6.3.3 above. In that where the relationship between the research and the community is more contractual and there is financial compensation, the tensions that arise in terms of power and collaborative are maybe not so significant. Certainly, one thing that I noticed within the data is that the community researchers were very much motivated to participate by the fact that it was an employment opportunity. This is contrast to citizen scientists participating voluntarily, where the motivations are usually intrinsic.

6.3.4 Challenges in creating change.

In terms of the ability of the project to create change, this case study presents a number of stark points. Firstly, the project did not formally intend to deliver any benefit or change to the community, its purpose was to deliver knowledge insights for the institutional stakeholders. It can be argued that where there is no intention to deliver action or change, there is a limited likelihood that it will happen. Secondly, there were different conceptualisations about the problem with the private water supplies. Whilst the research was concerned with water quality, the community were concerned with quantity and reliability. The problem had not been defined with the community and therefore the

motivations, interests and drivers of the research and the community were not aligned. As can be expected its difficult to create change within a community, if they don't see the need. That being said, the simple process of engagement between the communities and the research project did create dialogue and knowledge exchange between different stakeholders, and as Patricia (Cit) and Lesley (Cit) describes, this increased the sense of community around the issues of private water supplies, raised awareness within the community and in some cases did create behaviour change at private residences. So whilst the set-up of the project may not be expected to deliver change, change was created by the simple existence of the project.

6.3.5 Reflecting on the research questions

This case study contributes ideas to both research question 1 and 2 of this research. In terms of understanding "How does the concept of co-creation manifest in citizen science projects?" the case study reveals that when there is a powerful stakeholder involved in the research project and that stakeholder retains the power, the opportunity to co-create and to ensure that all stakeholders interests and needs are addressed, is limited. It also shows that the contract of engagement that the citizen scientists have with the project, whether voluntary or employed, influences the way in which they engage with the project. When employed they are likely to be motivated by the financial incentive rather than more intrinsic factors and they have different expectations of how they contribute to the project, as reflected in Lesley's (Cit) comments about just wanting to be told what to do. In terms of gaining insights into the second research question of the research "What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?" the research reveals a need to ensure that action objectives are a purposeful and intended part of the research, and that the understanding of what action or change is needed is shared by all the stakeholders. It also demonstrates that participatory research methodologies can be utilised and valuable in serving the needs of institutions and actors who do not directly participate in the research.

7 Conserving Wolverine Populations

This project took place across the rural landscapes of a whole region in which fur trapping is a permitted commercial activity. Fur trappers in this region hold licenses to trap animals in specifically defined areas known as traplines. Regulated by quota legislation the trappers harvest a variety of mammal species in order to trade their furs and to support conservation management of population sizes. The fur trapping season takes place between September and February and involves the trappers spending substantial amounts of their time in the rural wilderness. As a result the trappers have an intimate knowledge of the landscape in which they hold a trapline and the wildlife that inhabits the land. Trappers had noticed a conflict in scientists' evaluations of wolverine populations and their own observations, and were concerned that the scientists' conclusions would lead to a reduction in the wolverine quotas. Scientists were reporting low population figures and only recognised them as being present in the mountains, whilst trappers were regularly observing evidence of wolverines including their presence in boreal forest. Conversations within the trappers' community organisation led to two trappers identifying the need for the trapping community to produce their own data on wolverine population sizes and they decided to approach a government-funded research institute with whom they already had an established relationship, in order to forge a research partnership. The research institute were happy to partner with the trappers as they were looking for opportunities to engage stakeholder groups in conservation and land management discussions.

The project was developed and managed by a team of three trappers and the research institute staff, through open and deliberative discussions that drew on the knowledge and expertise of all partners. Together they agreed on shared objectives, identified research questions and negotiated a research methodology. The project would look to assess wolverine population sizes, distribution and habitat associations through a combination of camera trapping and genetic analysis of hair samples. A questionnaire would also be conducted with the trapping community to develop an understanding of trappers' attitudes towards wolverines. The trappers worked to promote the project across the trappers' community organisation to recruit participation in the data collection, and the research

institute dedicated some staff time to the management of this participation. In the first year a small team of trappers worked with the research institute to develop the field methods and then run a pilot year for data collection. After the success of the pilot year, the project was expanded to include more trappers but looking specifically at populations in the boreal forest. Trappers were responsible for managing the data collection on the traplines, but research institute staff would make occasional visits to the traplines to ensure that the trappers were appropriately following the research protocol. The trappers would submit the data to the research institute who would conduct the analysis. At the end of each year a meeting was held with the project team to discuss and interpret the data. During the project a parallel project emerged with a university student who wanted to conduct radio collar tracking of wolverines to look at their ranges. Tensions between the university student and the research institute meant that the trappers supported the university student with this project independently of the research institute. After the pilot year and then three years of data collection the project had to be wrapped up due to financial restrictions at the research institute. However the project resulted in the production of two technical reports, and three peer-reviewed papers (one currently in review), and one of which was written with trappers as co-authors. The project revealed new understandings about wolverine habitat associations and behaviour that were previously unknown to science. The work also had an impact on the conservation of wolverines with forest management companies integrating the knowledge into their management plans. The project has also lead to further collaborations between the research institute and the trappers' community organisation.

7.1 Who's who in the Conserving Wolverine Populations project

The narratives that make up this case study come from the three trappers that were involved in the management of the project, one trapper who participated in the project purely as a data collector, a research institute scientist who managed the trappers' participation in the project and conducted the scientific research, and the programme manager who oversaw the project. The narrators are introduced in Box 7.1 below, along with other characters and organisations that appear in the data. All the personal and organisational names are pseudonymised. In order to make it easy to follow who is who

through the case study chapter each pseudonym is followed by a tag referencing which actor type they are in the project. The tags are as follows: (Cit) = Citizen scientist; (Res) = Researcher; (PM) = Project manager; (RPM) = Researcher: Project manager.

Box. 7.1: Conserving Wolverine Populations Case Study Characters and Organisations

Case Study Narrators

(The narrators are presented in the order they were interviewed).

Tim (RPM) – programme manager at Ferendale Conservation Institute who oversaw the delivery of Conserving Wolverine Populations.

Phil (Cit) – a trapper who was a member of the Conserving Wolverine Populations project management team, who was also The Trappers' Society representative on the Ferendale Conservation Institute board.

Alice (RPM) – biologist working at Ferendale Conservation Institute who was responsible for the day to day running of the Conserving Wolverine Populations.

Connor (Cit) – a trapper who was a members of the Conserving Wolverine Populations project management team.

Kevin (Cit) – a trapper who was a member of the Conserving Wolverine Populations project management meetings team, who was also a member of the Ferendale Conservation Institute board.

Shaun (Cit) – a trapper who participate in the Conserving Wolverine Populations project, after the pilot year, purely as a data collector.

Organisations

Ferendale Conservation Institute (FCI) – government funded conservation research institute whose remit is to delivery research relevant to regional landscape stakeholders, such as The Trappers' Society or the Ferendale Hunters' and Fishers' Society.

The Trappers' Society – a membership organisation for fur trappers operating within the region.

7.2 Case Study Themes

In this case study thematic analysis identified three key concepts with regards collaboration between citizens and scientists, each of which included several themes. The three key concepts were as follows;

- **‘Interactions’** defined as the things that take place between and the exchanges between the citizen and scientist partners, for example, ‘Communication’ or ‘Conflict’.
- **‘Qualities/ Character traits’** defined as the individual qualities and assets that individuals or communities bring to the collaboration, for example, ‘Attitudes’ or ‘Knowledge’.
- **‘Collaborative Infrastructures’** defined as the intellectual and physical resources and assets that the partners bring, create and share within the collaboration, for example, ‘Goals’ or ‘Time’.

7.2.1 Interactions

Nature of collaboration and partnership

The data in this case study reveals a highly collaborative and horizontally structured management of the Conserving Wolverine Populations project, with evidence of the trappers contributing to and influencing the direction and decision-making of the project throughout its life. Critical to the project being so collaborative was the fact that three trappers were members of the project management team, attending all management meetings at the Conserving Wolverine Populations offices. An influential factor in this being the case was that the trappers approached the Ferendale Conservation Institute (hereby referred to as FCI) to initiate the project, rather than the FCI initiating it themselves. Both Tim (RPM) and Alice (RPM) emphasise in their narratives that this project was the trappers’ project, FCI and the trappers worked together to deliver it but essentially this was the trappers’ idea and the outputs were for them. Tim (RPM) places real emphasis on the FCI’s efforts to make sure that the project was trapper driven and that the FCI were there to help the trappers deliver it. Within the trappers narratives however there is contradiction regarding this relationship. Kevin (Cit) demonstrated a sense of the trappers being assertive and defining the boundaries of the FCI’s engagement with them and in other circumstances sharing an equal part in the decision-making. Connor (Cit) on the other hand repeatedly expressed that this project was the FCI’s project, that they were “the boss” and led the decision-making for the project because they had the knowledge and expertise to do so. He saw the trappers as simply

there to “help out”, but did describe examples of how the trappers’ knowledge was considered by the FCI in the decision-making for the project. As a possible reason for the difference in these perceptions is the fact that Kevin (Cit) was a member of the FCI board, whilst Connor (Cit) wasn’t. Having an already established relationship with the FCI and a formal position within their organisation, he is more likely to feel a sense of working with the organisation, than for them as Connor (Cit) did.

Building trust

The ability of FCI and the trappers to collaborate so closely was dependent on building trust and strong relationships, and interestingly in the narratives the emphasis is very much on what the FCI did to build the trappers’ trust in them. Trust was a particular barrier to engagement for the wider trapping community because they had previous experiences with scientists which had not been favourable to them. They also had a negative relationship with the government who they knew had funded the project, and so they were concerned that the data from the project might be used by the government to their detriment. One of the most critical ways in which trust was built between the FCI and the trappers was through the process of collaboration itself, although this required the trappers to be willing to give the FCI a chance. A key way in which this became possible seems to have been through the fact that Kevin (Cit), Connor (Cit) and Phil (Cit) were working directly with the FCI. There were several ways in which the FCI built the trust of the trappers and managed to build strong relationships with them, these included; spending time within the trapping community on their territory, by attending trapping meetings so that people could put faces to names and realise that the FCI staff were actually of the same community, visiting the traplines and spending the weekend with the trappers in their cabins where FCI staff and trappers were able to spend social time together and get to know each other’s philosophies on life, regular and open communications about the project, demonstrating that they trusted the trappers, and showing support and concern for the well-being of the trappers.

Communication

Communication was one of the most widely talked about types of interaction between the trappers and the FCI, and again was discussed in terms of the way in which the FCI

communicated with and listened to the trappers, rather than the other way around. Communication from FCI was considered successful in the project and utilised several different media (ie. phone, digital and face to face). The quality of collaboration in the project is in some way evidenced by the way in which communications were characterised by the research participants, who used words and phrases such as “maintained”, “two-way”, “open”, “frank”, “regular”, “free-flow”, “non-corporate” and “mutually beneficial”. However, the FCI staff also commented that trappers are difficult to communicate with, because they are difficult to get hold of and don’t use email. An important aspect of communication that featured within Alice (RPM) and Connor’s (Cit) narratives was the concept of listening, with Alice (RPM) demonstrating how the FCI staff made the effort of “sitting down and having coffee… and listening to [the trappers’] stories.” Connor’s (Cit) narrative reveals that ‘listening’ had two different manifestations within the project, firstly he felt as if the FCI would genuinely hear and consider what he had to say, but secondly, he recognised that they didn’t always listen, in that they didn’t always act on what he said. Connor (Cit) explains how this wasn’t problematic because even if they didn’t adopt his idea he knew that he had been listened to and his opinions considered, and sometimes the FCI were right to ignore the trappers’ comments.

Deliberation and negotiation

Now whilst Connor’s (Cit) narrative gives the impression that the decision-making power sat with the FCI and that the trappers’ were just there to consult and make suggestions, what he does reveal is that there was a process of deliberation taking place between the FCI and the trappers. In this process of deliberation there is a real sense of their being differences and sometimes conflicts in the trappers and the scientists’ knowledge and experience, which had to be negotiated. Disagreements emerged across the project from determining the objectives, the activities that would take place, the differences in knowledge of the topic, and around methodological decision-making. Generally these disagreements are down played by the trappers as nothing serious and a sense in the data that sometimes there were tensions between FCI and the trappers’, is out shadowed by a strong sense of successful negotiation and persuasion. Both trappers and FCI staff recognised that there was a need to negotiate around the way in which the science was

conducted, and both had moments where they had to try to persuade the other of their position. An interesting theme that emerges in the trappers' narratives is the idea of being right or wrong, revealing that the trappers' and FCI staffs' knowledge and opinions were sometimes pitched up against each other. What was important in this respect was that both parties were able to humbly acknowledge and accept when they were wrong and the other party right. In conclusion to all this, there is a very strong and clear sense of equality, partnership and mutual collaboration in the interactions between the trappers and the FCI staff. Whilst some of the trappers may not have had a sense of ownership over the project, they still demonstrate lots of ways in which the two partners collaborated closely and worked together well.

7.2.2 Qualities and characters traits

Characteristics of the scientists

The key way in which the FCI were characterised within the case study is that they were very open to the trappers, both in a willingness to engage with and work with the trappers, and in an openness to the trappers' knowledge and ideas. They worked to let the trappers ideas lead the research, actively seeking out their knowledge and opinions. However Tim (RPM) does reflect that it took some time for the scientists to completely open up to the trappers' knowledge, because their own understanding of wolverine ecology was biased and blinded by the published literature. One of the ways it seems that the FCI were able to be so open to the trappers and their knowledge was due to the purpose and organisational culture of the FCI, whose mandate was to provide services to government and stakeholders. In this way the organisation is set up to actively look for ways to connect with and work with stakeholders, rather than conducting research in isolation. This attitude of actively wanting to engage with stakeholders emerged in other ways, with Alice's (RPM) excitement to work with trappers having previously done so, Tim's (RPM) demonstration of loyalty to the trappers through backing them up in public conflict with scientists and also the trappers had a real sense that the FCI staff had their best interests at heart. The trappers all had strong praise for the effort, attitude and quality of the FCI staff, all referring to them as "good", "great" or "awesome" people.

Characteristics of the trappers

The trappers were characterised in terms of the depth of their knowledge and understanding of the landscape, but also in terms of their diversity as a community. The trappers culturally have a philosophy orientated around a conservation and sustainability ethic, with a love and passion for wildlife and the landscape. They see themselves as stewards of the land, and due to this some trappers expressed a huge sense of responsibility and obligation to engaging with land issues. They're relationship with the landscape means they have an incredible depth of knowledge about its ecology, based on long-term experience and observation. The interviewees had a significant sense of having valuable knowledge to share and demonstrated defiance to criticisms from the scientific community such as "Well you're just a trapper, you don't know nothing", with responses such as "We're not a bunch of dummies." Despite their own sense of valuable knowledge, they were aware that they did not have credibility within society, particularly from scientists, and found that their knowledge about wolverines was in conflict with the scientific community. In relation to science there was a diversity of attitudes to, and understanding of, science within the trapping community. Due to negative experiences with science many were anti-science, leading to a scepticism and lack of trust in engaging with scientific research projects. Some trappers didn't have an appreciation or understanding of the scientific process with one trapper describing his opinion that aspects of the FCI methodology were a waste of time, and Alice (RPM) explaining that trappers didn't understand the value of absence data. Some trappers however were pro-science with positive experiences of working with scientists in their professional roles, but with recognition that science has its limitations. The trappers also had significant professional diversity as a community, made of a wide range of professions such as academics, doctors, business men, farmers and film makers. Co-ordinated together through The Trappers' Society they were well equipped to participate in the project, but not all members are actively engaged. Furthermore some of the trappers had a close relationship with the FCI. Phil (Cit) when he talks, talks as much from the perspective of being a part of FCI as he does a trapper, and Kevin (Cit) was also a member of the FCI through the board.

Motivations

Motivations to participate in the project, for both scientists and trappers were wide ranging, with a mixture of altruistic, selfish and obligatory drivers. Aside from unsurprising motivations such as acquiring knowledge or data, some interviewees cites more altruistic and social motivations for participating in the project, such as helping out, giving something back and working together across the scientist and trapper community. In contrast to this other reported motivations were much more self-orientated such as learning new things, ensuring access to wolverine harvest quotas and improving public relations for the trapping community. In addition to this one of the drivers for FCI was their obligations to government as an organisation. For some participants, however, there was simply an interest in the topic or the project or a desire for the project to be a success.

Commonality

Through the process of collaboration the trappers learnt that the FCI scientists "they're just like us", giving them a great sense of commonality. They recognised that the FCI scientists were outdoorsy people like them, passionate and in love with nature, and that they too were hunters, trappers and farmers, "he does the same thing we do, he's no different from us."

7.2.3 Collaborative infrastructures

Collaborative philosophy

A very striking feature of this case study is a mutual sense of collaboration between the FCI and the trappers, and all actors discuss quite explicitly the attitudes they had towards working together. An important starting point for collaboration was the fact that both the FCI and the trappers had an openness to working with one another. The FCI's organisational purpose meant that they had a culture of engagement and openness towards stakeholders, but equally the trappers exhibited an openness to the FCI, or at least a willingness to move beyond any scepticism. Kevin (Cit) discusses that between the trappers and the FCI there was a shared understanding and agreement about what it meant to collaborate together, and that when conflicts would arrive they would return to their commitment to these collaborative attitudes. Honesty and humility were corner

stones of their working relationship. For example, one of the foundations for how they worked together was in the way in which they would abandon their egos and agendas at the door, when coming together. Another way in which they collaborated well was in both actor groups being able to admit when they were wrong and admit the limitations of their knowledge. The value that the partners' placed on one another was also important for collaboration, with Kevin (Cit) describing how it's important for different types of knowledge to have equal or appropriate weight in a partnership. He described how the trappers' knowledge was consulted and included in the project's decision making and analysis processes, with Shaun (Cit) highlighting that the FCI felt that the trappers had something to offer the project. Valuing the partner also included the notion of respect, with Alice (RPM) explaining that she had a deep level of respect for the trapping community, due to their depth of knowledge, experience and observations of the landscape. A final foundation that strengthened the collaborated between the FCI and the trappers was the high level of commitment that both had. This commitment had several directions including a commitment to achieving the objective and successfully completing the project, a commitment to working together, a willingness to commit extensive amounts of time and energy to the project, and a commitment to the research findings whatever they might turn out to be, even if they had detrimental implications for the trappers' activities. Trappers' commitment was particularly reflected in their willingness to continue to volunteer long weekends and long-drives to collect data well outside of their traditional trapping season, and to run the camera trap poles where no wolverines were expected to be. Whilst collaboration was generally discussed in positive terms, Kevin (Cit) does discuss there were a number of situations where collaboration would not be a viable option and you just need someone to lead.

Division of labour

In this case study the thematic analysis around roles emerged in a slightly different way to other case studies, rather than being segregated into the different actors, the data emerged as different role types, with both scientists and citizens' contributions represented within each. There were many ways in which the scientists and the trappers contributed to the same activity or task, but they often did so in different ways. For

example, both trappers and scientists contributed finances to the project, but with the scientists this came as direct and core funding from FCI, whilst the trappers largely contributed in terms of the expenses they accrued in managing the run poles and some cash donations to support the project. With data collection the trappers held complete responsibility for the collection of data in the field, whilst the scientists collected knowledge based data from the trappers. An important difference in the trappers and scientists contributions was the division of labour in project management, with the trappers responsible for the management of the field work including distribution and resourcing of camera traps, and the scientists responsible for the overall management and facilitation of the project and its science, such as communications, report writing, staff co-ordination, trapper management and support, and research guidance. A critical distinction in the roles of the trappers and the conservation partner was in the type of knowledge that they contributed, the trappers brought an extensive experiential knowledge of the landscape and its wildlife, whilst the conservation partner brought the formalised scientific understanding of wolverines and an expertise in the scientific process. Each bringing a valuable different knowledge perspective to the project, meant that they both contributed to the project conceptualisation, question development, hypothesis development and method development, much of which involved a negotiation between the requirements of a scientific process and the practicalities of trapping wolverines. With regards more socially-orientated aspects of the project both parties contributed to the recruitment of trappers, with the FCI attending trapper meetings and the trappers utilising their relationships and networks to encourage participation, but they also both contributed to the communication of the project results to the trapping community.

Complimentary value of the different actors

Whilst there were many ways in which the trappers and FCI staff contributed in the same way to the project, or towards the same activities, there were some ways in which the contributions were different. Most fundamentally this was in the fact that the FCI staff conducted the data analysis for the project, without the trappers' involvement. Phil (Cit) explains that data analysis was "not in our wheelhouse", they simply didn't have the

expertise to contribute to that part of the process, but Tim (RPM) explains that the trappers did still want to be a part of that process and so the FCI made sure that the process was visible to them. That being said it is explained that the trappers were consulted on the model that emerged from the data, and the model was assessed against their trapper knowledge as a way of ground-truthing the findings of the research. The FCI were also responsible for the report and paper writing for the project, but in some circumstances they did consult the trappers on the documents to get their input and approval, and some of the papers were co-authored by them. The other notable thing which the conservation partner led on was quality control, both in whether the methods would deliver scientifically acceptable results, but also in whether the trappers were delivering the protocol appropriately. Whilst this demonstrates that the scientists' value in the project was bringing the scientific expertise, the value of the trappers as citizen scientists was addressed much more explicitly, and orientated around three different types of contribution; their knowledge, their resource contributions, and their ability to catalyse and motivate the engagement of the trapping community. Their knowledge helped to identify potential gaps in understanding of wolverine ecology, identify appropriate research questions and develop effective methodologies for capturing data. They also made a significant resource contribution to the project in terms of man power, time and transport and subsistence expenses, which Tim (RPM) had calculated to be equivalent to $300,000-500,000 a year. Even more than the financial benefit that the trappers' involvement provided, there is also the quantity of data that the trappers were able to collect and the remoteness of the data points. The trappers also had significant value in drawing in the participation of the other trappers. All in all, it's these types of contributions which brought Alice (RPM) to exclaim "we couldn't have done it without them," and even the trappers had a sense of their involvement being critical to the success of the project, with Connor (Cit) explaining that it would have been a disaster without them.

Objectives

The objectives of the project were something that were discussed as negotiated at the very beginning of the project, with Tim (RPM) and Alice (RPM) expressing that the scientists and the trappers' goals for the project weren't always aligned, and that they had

to work to find a commonality of objectives. Both trappers and scientists were concerned with gaining knowledge but this was discussed in different ways, with some participants discussing this in terms of filling knowledge gaps in wolverine research, and others discussing this in terms of proving trappers' observations of wolverine populations to be right. After the desire to deliver knowledge around wolverines the trappers and scientists objectives then differed, with scientists being focused on the citizen science experience for the trappers, wanting to ensure that they not only felt engaged, but that they felt valuable, had ownership of the project, and that the findings of the research would be accessible. Trappers in contrast were concerned with policy-orientated objectives, wanting to ensure access to a wolverine quota, wanting to reduce wolverine predation on their catches of other species, and increasing understanding and support within the government and the public for trapping. In some cases the trappers were married enough to their objectives that they would be willing to find other research partners in order to deliver on their interests, if the FCI weren't willing to. This seems to be how the university student wolverine collaring project came about. This is interesting because it reveals how focused and determined the trappers were to deliver on their interests.

Resources

Both the scientists and the trappers contributed significant amounts of resources to the project, in order to make it a success. There was a huge financial cost to the FCI to cover staff time and travel costs, and the FCI also secured a grant which they used to try to offset the trappers' expenses, which included fuel, equipment and food. Both the FCI and the trappers contributed significant amounts of time and people power to the project, the FCI through the overall management of the project and support and liaison with the trappers, and the trappers through several months of data collection in remote parts of the region. As mentioned above Tim (RPM) calculated that if he had got staff to do what the trappers had done it would have cost $3-5 hundred thousand to cover the staff and travel expenses. The trappers were able to contribute a quantity of resources that the FCI simply didn't have in terms of finance or human resource capacity. Time was an important resource not just in terms of the time it took to carry out the activities of the project, but also the time it took to build the project. Tim (RPM) expresses that whilst the

concept of collaborating with a ‘citizen’ organisation like this is a good one worth carrying out, the FCI would have to think carefully next time about whether they could justify the expense and whether the research topic was a high priority.

7.2.4 Outcomes

Relationship-orientated outcomes

There are a wide variety of outcomes represented in the interviews for this case study, of particular interest were the relationship, engagement and science outcomes of the project. Very significantly for the project was the relationship orientated outcomes. Firstly, the FCI and the trappers built a strong and positive working relationship, including some friendships, and as a result they continue to engage regularly with each other and are continuing to collaborate on projects. A lot of this was down to the success of the collaboration between the two parties, which both trappers and scientists saw as an outcome in its own right. Further to this the trappers gained significant benefit from the project through the way in which it raised their profile and improved their public relations. Whereas trappers had previously experienced a lot of disdain and a lack of respect from both scientists and the wider public, particularly those concerned with wildlife conservation, the project had actually provided the trappers with press attention and demonstrated not only their care for the environment and wildlife, but also their capability, and the value of their knowledge in research. As a result the trappers now found that they commanded a certain level of respect from the scientific community, and were being approached from researchers and organisations from across their region interested in working with them. As a fundamental underpinning of this was the fact that the project had led to attitude change from both the trappers and scientists, more broadly, both of who had more appreciation for different perspectives and attitudes towards the environment and for each other’s knowledge.

Engagement outcomes

Engagement was another place in which outcomes were achieved from the project. From within the project the project had managed to sustain high and continuous levels of participation from many trappers. Beyond the project there had been increased

engagement of trappers within the trapping community, with Shaun (Cit) in particular finding himself taking on leadership roles within his local sector of the trapping community. Tim (RPM) also observed that the trappers seemed to have become more publically vocal about their opinions, particularly with regards conflict with industry. Finally, there was the experience of both the trappers and the FCI scientists involved in the project. The trappers were very pleased with the project and the outcomes that it had delivered, and both the trappers and the scientists were willing to participate in this type of work again, and were in fact doing so. This demonstrates the success of the project in meeting the needs and the interests of both the parties involved.

Science outcomes

Knowledge outcomes were orientated around the new knowledge about wolverines that was generated by the project, including how the knowledge validated the trappers understanding of wolverines on the landscape. In addition learning outcomes were generated from the project, with both scientists and trappers learning new things about wolverines, but also learning more about each other's work. The scientific outcomes of the project included significant amounts of video and photographic data of a wide variety of species, and evidence of behaviour not seen before. The project also led to the development of new monitoring projects between the trappers, the government and the FCI and a number of scientific publications. The science of the project had a number of strengths. Firstly there research focused specifically on boreal habitats which wolverines were not known to live in. Secondly, the science being built on several different sources of data such as trapper questionnaires, camera trap data and trappers' harvest data. Thirdly, the camera trap data revealed things about wolverine behaviour that weren't previously known. Fourthly, it was recognised that both the scientists and trappers' knowledge improved the quality of the science, with the scientists' knowledge and methodologies bringing the credibility, and the trappers' specialist knowledge of the landscape ground-truthing the research. In contrast to this the science had a number of challenges and limitations. Firstly, the sampling for the research couldn't be 100% randomised due to limitations in the accessibility of the landscape, either through it not being possible for anyone to access a certain place, or because the trapline was not

actively managed. This meant that there were gaps in the sample and the sample size was lower than might have been desired. Secondly, compromises had to be made about what types of data and how much data were collected, in order to make the project accessible to the trappers. Some of the covariate data that would have been highly desirable to give extra meaning and understanding to the camera trap and hair sample data was not requested from the trappers, as it was seen as too much to ask. Alice (RPM) felt that the pure, hard science of the project maybe didn't meet the necessary standards, and this seemed to be evident in the difficulty that the project with publishing some of its scientific articles. However, most specifically the difficulty in publishing the data from the research was with the qualitative data collected through trappers' questionnaires. This non-traditional way of collecting data was not seen as acceptable by many research journals, and was seen as biased because the trappers were surveyed opportunistically, rather than randomly.

7.3 Absences from the thematic analysis

There was a proportion of the narrative interviews that discussed the matter of a parallel radio collaring project that was conducted between the FCI, the trappers and a University partner. The data referring to this project has not been represented here, because it reflects a separate project that mostly involved collaboration between the trappers and the university partner.

7.4 Key Insights

7.4.1 Establishing equality in partnership

This case study presents a strong sense of partnership and collaboration, with both trappers and scientists contributing substantially throughout the process of the research, each providing contributions of critical importance to the success of the project. There are a number of features of this project which seem to have enabled this mutual sense of partnership. Firstly, the fact that the purpose of the FCI organisation is to provide scientific services to both the government and its land user stakeholders means that they have a culture of service embedded within the organisation. This is important because it means

they actively look to meet the needs of other organisations, as part of their organisational objectives, and are used to collaborating with and working with other organisations. Secondly, the FCI already had an established relationship with the The Trappers' Society. Whilst for some members of the trapping community there was a scepticism around engaging with the FCI, the fact that both Phil (Cit) and Kevin (Cit) were members of the board meant that there was already an established relationship and connection through which collaboration could take place. Thirdly, and interplaying with the first point, the trappers initiated the project. They identified the need for a research project in this area and through their connection to the FCI decided to approach them as collaborators. By initiating the project the trappers held power over the project, giving them more influence to negotiate the objectives and methods. Fourthly, the reason that the trappers approached the FCI was that they wanted to have their knowledge validated and they did not have the scientific expertise or credibility to be able to deliver this goal. This need for scientists to help deliver the trappers objectives means that the trappers had to share their power over the project, in order to meet the objectives. Whilst the trappers could see the value in the scientists' expertise, equally important and the fifth feature of the project which seems to have delivered successful collaboration, is the fact that the scientists valued the trappers' knowledge and actively incorporated it into the scientific process. The fact that both the scientists and trappers had different types of knowledge, both of which were equally valuable and critical to the project, and that both parties could appreciate this value, meant that the two could collaborate on the science mutually. Finally, and following on from this point, is that the trappers and the FCI established from the beginning an understanding of what it meant to collaborate effectively with one another. Furthermore they all made a commitment to working together successfully, which they agreed could only be achieved through their principles of collaboration. That commitment to working with each other meant that whenever any conflict or tension arose within the project, all parties were able, and willing, to return to engaging with each other in a constructive and supportive manner.

7.4.2 Division of labour

Another valuable dimension of co-created research processes that this case study reveals is the idea of divided labour. Often public participation in scientific research is conceptualised in terms of citizens carrying out the stages of the scientific process in the way that a scientist would. However, built on the foundations of the two sets of actors having different value to bring to the project, here we see evidence of the actors dividing the labour of the project based on each other's strengths and weaknesses. This further adds to the sense of mutual partnership and engagement in order to deliver on the outcomes of the project.

7.4.3 Reflecting on the research questions.

In summary this case study provides multiple insights around the way in which co-creation might manifest in a research process, thereby helping us to answer question 1 of the research. Here we are presented with ideas around what foundations need to be built within a project in order to work in a highly collaborative manner. These include notions of who is serving who, how the roles and responsibilities of a project are shared and distributed, the attitudes that the actors have towards one another, a shared need for the other actors skills and knowledge, and a shared understanding and commitment to principles of working together. These foundations go some way to balancing the power between the actors and creating a sense of mutual endeavour. Furthermore, there is an agreed social contract, whether explicit or implicit, between the actors, which both sets of actors commit to and honour.

8 Noise Pollution in the Plaza

The Noise Pollution in the Plaza project was part of a larger government-funded research programme which carried to explore how co-created processes of engagement could be used to develop technological sensing tools within communities that could then be deployed to collect data on the environmental challenges that the community faced, in order to catalyse some action or change around the issue. The programme was made up of a consortium of several universities, research institutes and NGOs across three different countries. Whilst the consortium worked together to research the engagement process to develop understanding about co-created technological development and deployment, each country independently conducted three pilot projects, over a total of three years, to experiment with and explore different methods of co-creation and public participation in citizen sensing.

Noise Pollution in the Plaza represents the work that took place in one of these three countries and involved three pilot projects, the first and third pilot were a continuation of each other and will be the focus of this case study, but the second pilot involved public engagement with schools groups around environmental sustainability. Pilot one of the Noise Pollution in the Plaza project started with the recruitment of volunteers who were interested in participating in a co-created process around urban environmental challenges, technological development and citizen sensing. The focus of the pilot was to train the volunteers to become ‘community champions’ whose role in pilot 3 would be to engage with and support a community of concern in delivering citizen sensing to address the problem they faced. In the training the ‘community champions’ were trained in a variety of engagement methodologies, and through this process they worked with the research team to develop and test a set of engagement and technological tools that could be utilised in the third pilot. Early on in this process they identified issues and communities of concern across the city, and identified the community and issue they felt was most suitable and in need of addressing. This issue was a historical problem with noise pollution in a city plaza which was having a significant impact on the health and well-being of the plaza residents. The tools and methods that the community champions and research team co-developed therefore were geared towards understanding and

addressing the issue of noise pollution. The third pilot was kick started with a community event that invited the plaza residents to hear about the project and the intention for the collaboration, and then invited the residents to participate in a citizen sensing process with them. Many residents signed up and then the community champions and the research team supported them in collecting noise data from their homes. The residents used this data to raise awareness to the public, the press and the government about the excessive noise levels they were suffering in their community. The project received a lot of media attention and subsequently drew the government's attention, leading to improved dialogue between the residents and the government, and to the implementation of a number of policies and interventions to mitigate the noise problem. Whilst the problem is not completely solved, there has been a marked reduction in the noise within the plaza, and the community feel empowered in order to continue to try to change the situation.

8.1 Who's who in the Noise Pollution in the Plaza project

The narratives that make up this case study come from two researchers responsible for the delivery of the project, two volunteers who were trained and participated as community champions in the project, and one resident of the plaza who had been living with the noise pollution problem. The narrators are introduced in the Box 8.1 below. Also introduced in the figure below are other characters, organisations and projects that appear in the data. All personal and organisational names are pseudonymised. In order to make it easy to follow who is who through the case study chapter each pseudonym is followed by a tag referencing which actor type they are in the project. The tags are as follows: (Cit) = Citizen scientist; (Res) = Researcher; (PM) = Project manager; (RPM) = Researcher: Project manager.

Box. 8.1: Noise Pollution in the Plaza Case Study Characters and Organisations

Case Study Narrators

(The narrators are presented in the order they were interviewed).

Tanya (Cit) – was a non-national who had been residing in the country to carry out master's degree studies, she volunteered on the project as a community champion.

Sophie (RPM) – was a non-national who was a member of the research team for the overall research programme, she had moved to the country especially to take on the responsibility for the management and delivery of the pilot projects in Valdeeno, she is also the co-founder of the Delivering Real Action Initiative

Brendan (Cit) – was a non-national who was in the country to study for a master's degree, he volunteered on the project as a community champion.

Patrick (RPM) – was a national who worked at the Architectural Institute of Larsingia as a researcher and project manager, his was responsible for delivering the technological resourcing for the pilot projects.

Lizzie (Cit) – was a national and a resident of the plaza who participated in pilot 3 of the project.

Other characters

Neighbours – residents of the plaza.

Places

Valdeeno – country in which the project took place.

Larsingia – region in which the project took place.

Garda – city in which the project took place.

Projects

CitizenSensingAware – overall research programme looking to investigate methodologies for delivering co-created community technology development and citizen sensing.

CitizenTech – a technology development project developing a multi-purpose sensor that can be built and used by citizens for their own citizen sensing projects.

Organisations

Architectural Institute of Larsingia (AIL) – an architectural research institute who were partners on the CitizenSensingAware programme.

OpenTech Innovation Hub (OTIH) – an NGO running from within AIL that provides space and resources for citizens to develop their own technologies.

Delivering Real Action Initiative (DRAI) – an NGO working with policy-makers to deliver projects that have tangible action within communities.

8.2 Case Study Themes

8.2.1 Project structure and management

The project was organised around three pilots, which Sophie (RPM) saw as an opportunity to iterate knowledge and ideas from one to the other, testing tools and improving as they went. The first pilot trained the cohort of community champions and then worked towards the third and final pilot which was a citizen-led co-production. The first pilot was what Patrick (RPM) describes as a sandbox, so it was an opportunity to fail and test things and then improved, but the third pilot there was no room for failure as it was directly addressing a community issue. The methodology involved in the pilots was an eight-step methodology starting with scoping of the problem, then planning the sensing and then sensing. Each step in the methodology was delivered through two or three session and so the project involved a lot of time and effort from everyone involved, Patrick (RPM) explains that it wasn't an easy thing to deliver. Tanya (Cit) describes meeting up once or twice a week, and Brendan (Cit) explains how the engagement of the plaza community in the third pilot went on for months and months. There is a clear sense in the data that it was the research team that were decision making and guiding the process through which the community champions and the plaza residents engaged, with Sophie (RPM) having clear ideas from her expertise in these practices about how to approach the process. Interesting Brendan (Cit) occupied both the community champion and research team sides of the project, operating in both and so was able to see how discussions that took place in the community would then lead to decision-making around the project, in the research team.

8.2.2 Objectives

There was a strong focus on the delivery of action and change in the Noise Pollution in the Plaza project, although the conceptualisation of this as objectives was different for the plaza community compared to the research team. For the research team there was no specific problem or issue that they wanted to address, their research objectives were simply to address a problem of community concern. Of course for the plaza community however, there was a very specific issue that they wanted to create change around, that

being noise pollution, and they wanted to see a rapid and total solving of their problem. Lizzie highlights however that the Noise Pollution in the Plaza team never promised to create action and change for the community, but purely to equip them with the technology that could be used to influence change. Whilst Sophie (RPM) demonstrates a strong motivation towards successfully creating change, she does also talk a lot about managing the expectations of the community, ensuring that they didn't expect the Noise Pollution in the Plaza project to provide solutions. In fact Sophie (RPM) expresses a personal objective of wanting to see the project through to a successful conclusion, with a motivation and commitment to stick with the community until they saw some positive shift in circumstances. This concept manifested itself in the concepts of sustainability and failure, with Sophie (RPM) working towards developing sustainability in the project so that it could continue until some change had been achieved, but also expressing a lack of room for failure, this issue and problem was so impactful on the community that failure wasn't an option. Tanya (Cit) was of the belief that one of Sophie's (RPM) objectives was to demonstrate not only that there was a problem that needed to be addresses, but that they could solve that problem through the methodology of the project. Certainly this is paralled in some of Sophie's (RPM) and Patrick's (RPM) comments which highlight that from the research side of things the purpose of this project was to develop and validate a citizen sensing methodology that could be used by communities in order to address challenges and issues that they were facing.

8.2.3 Motivations

The data for motivations is dominated by content about the community champions' motivations for the project, and there motivations varied but seemed to be primarily driven by career interests in the project. Both Tanya (Cit) and Brendan (Cit) were living in Garda in order to carry out master's studies and both saw a parallel between their professional interests and the project, Tanya (Cit) was keen to learn as much she could from the project before returning to her home country, whilst Brendan (Cit) found that the project aligned with the interests he had for his master's dissertation and he felt that his could contribute skills to the project, in a valuable way. Interestingly Sophie (RPM) was also motivated by her career as the project offered her the opportunity to build on the work she

had conducted in her PhD. What was also recognised as a motivation for the community champions was the city itself. Most of the community champions were immigrants and their love and interest in the city and their willingness to understand the city and how it worked, meant that they were interested in participating in city-focused projects, but also as Patrick (RPM) identifies, projects like this gave them an opportunity to make connections with other people. Both Tanya (Cit) and Brendan (Cit) were also motivated to make a difference and saw this project as giving them the opportunity to deliver something tangible that had impact in real lives. The other motivations that are discussed are in relation to the plaza community who were of course motivated, as with the objectives, to address the noise problem, they were so angry at a deterioration in the problem and so tired of it that they had a strong commitment to the project, participating at every opportunity. Sophie (RPM) also expresses a motivation driven by the noise problem, but in terms of an emotional motivation, triggered by hearing stories of the negative impact that the problem was having on families, and she like the community champions felt compelled to do something to help.

8.2.4 Roles

The roles of the three groups of actors across the two pilots varied, but was highly collaborative. The researchers led, delivered and managed the project as a whole. They would meet on a weekly basis, separate to the citizen scientists, to discuss the challenges and needs of the project as they emerged, designing strategies and methods responsively, to facilitate either the community champions' engagement in the co-creation process, or the neighbours' engagement in the citizen sensing and action process. Whilst the researchers had separate responsibility for the delivery of the project as a whole, for the actual development of the citizen sensing methodology the researchers and community champions co-created this together. In some circumstances the researchers would lead on ideas, in other circumstances the community champions would lead. The researchers would do a lot of the groundwork and deliver much of the technical elements of the project, whilst the community champions' critical role was in thoroughly testing and suggesting adaptations and developments for the methodology. The researchers professional knowledge in both participatory processes, but technology were critical to

supporting the work, but the community champions were also equipped with much technical knowledge and expertise which supported the project too. Both the researchers and the community champions worked together to identify the problem that the third pilot should address. Whilst the researchers took responsibility for building the community for the project, taking much effort to support community building within and outwith the workshops and meetings, through socials and Whats App, the community champions were seen as the critical players in building the community and relationship with the neighbours for pilot 3. They were seen by the researchers as being much more accessible to the neighbours than the researchers were, and therefore better placed at building that relationship. By the end of pilot 1, the researchers had 'graduated' the community champions setting them on a equal footing, professionally, on the project. And so in pilot 3 the community champions role became much more about supporting the engagement of the neighbours in the project. Whilst the researchers would lead and facilitate the workshops, the community champions would directly support the neighbour in their engagement in these. The neighbours are discussed as having taken a key and independent role in trying to deliver action through the project, by independently setting up a twitter channel and communications, having meetings with the council and registering calls of the noise being too high with the police. The neighbours also fielded and engaged with a lot of media attention, as did Sophie (RPM).

8.2.5 Characteristics

Diversity of the actors

There were a number of characteristics that all of the project actors, ie. researchers, community champions and plaza community, shared. In particular as a collective they made a very professionally diverse group of people, with a wide range of technical and professional skills and expertise that could contribute to the benefit of the project. For example, one community champion was an audio engineer who was able to help Patrick (RPM) in training the citizen scientists how to read and understand the data. Whilst some individuals' expertise may not have been akin to the topics and processes of the project Tanya (Cit) explains that "nobody was left behind, we all had something to contribute". There was also a great demographic diversity within the team, with a wide range of ages,

but with the plaza community generally being older, and also with a wide variety of nationalities, Sophie (RPM), Brendan (Cit) and Tanya (Cit), as well as many other community champions were all from different countries, meaning that they didn't have a personal historical connection to the place, although there is a great sense of participation in the project out of a love for the city as an outside. The plaza community, on the other hand, were generally regional nationals who have a very strong sense of cultural heritage, many couldn't speak English and a few presented an animosity towards Sophie (RPM) for not being from Larsingia. Despite this Sophie (RPM) explains that this diversity was "powerful" and that "it was this really beautiful blend of cultures and expertise."

Commitment

Commitment is another characteristic that was discussed across all of the project actors. In particular Sophie (RPM) presented an impressively high level of commitment to the project emotionally, intellectually and personally, explaining that the stories from the plaza community left her taking the project as a "personal quest". She felt like she had to "stay here until something changed" and she put so much of her time and energy into the project that it occupied her every moment. The community champions and the plaza community, once their scepticism of the project had been allayed, also demonstrated a lot of commitment to the project, turning up and actively and enthusiastically contributing to the meetings and workshops throughout the project, in order to reach the goal. Finally, as a collective, the project actors as a team had a high level of resilience, in that when volunteers didn't show up or deliver what they suggested they would, the rest of the team didn't have too much problem adapting. Tanya (Cit) explains that one of the reasons for this was that "everybody was important, but nobody was indispensable."

Researchers communication skills

Their communication skills were also reported with Sophie (RPM) suggested as having communication skills that were impactful for engaging the citizen scientists, the government and the media, and Patrick (RPM) described as leading the workshop in the regional language in order to make them accessible to the plaza community.

Neighbours characteristics

The neighbours had a different set of characteristics, firstly, as Brendan (Cit) describes, the neighbours were inextricably linked to the issue, they couldn't just walk away from it at the end of the project, like the research team could. What is more their relationship to the problem had become so negative, and was so intense, and historical that they were "angry", "fighting", "stressed", "fed-up", had "depression", "crying", "tired" and "despondent". The problem was affecting them so much that their emotional attitude and state was very different compared to the other project actors. They are also described as not being connected as an organised and cohesive community at the beginning of the project, with some people connected through friendships, but not connected around the issue. Both Tanya (Cit) and Brendan (Cit) explain that the plaza community showed a lack of interest in the tech and a lack of understanding of how that tech could be useful, although in time this seems to have changed as the process of the project demonstrated itself.

Projects' characteristics

Finally the project itself had a set of characteristics described by Sophie (RPM). Firstly the project had a "very strong story" which evokes a sense of a clear and powerful message, but also a unity and solidarity around the message and the narrative that it had in its entirety. Secondly, Sophie (RPM) describes that the whole research programme had a huge generosity in that it published all of its methodologies and tools as open access and without individuals of the research programme team being individually named for their contributions, but named as a whole project, thereby relinquishing individual credit.

8.2.6 Engagement

Community champion and neighbours engagement

Engagement of both the neighbours and the community champions was extensive and intense. The community champions were recruited through professional and academic networks, as they engaged through social media or university with OpenTech Innovation Hub. Approximately 12-15 community champions engaged in the project overall, with numbers affected by a natural drop-off after the initial meetings when people decided they couldn't commit to the project, or between pilot 1 and 3 where the gap in engagement led

to fewer people returning to the project. Neighbours were introduced to the project either through the fact that a small number of community champions were residents of the plaza, or through the noise box intervention on the square, which Patrick (RPM) describes as building the pilot 3 community, or through the launch event at the beginning of pilot 3. Whilst the community champions engagement is described as reducing overall, the neighbours' engagement is described as increasing in number of people, time and effort, to the point that the neighbour community were more engaged in the project than the community champions, engaging with and discussing data on a daily basis. Whilst the community champions engagement was seen as less intensive than that neighbours community's engagement this is not to say that their engagement was not extensive, they attended meetings once or twice a week for several months, and Sophie (RPM) explains that they brought so much energy and enthusiasm to the project that sometimes she felt exhausted after meetings. It was impressed upon the community champions that as volunteers they were free to come and go as they pleased, contributing as much or as little as they wished and Brendan (Cit) certainly suggests that the amount that individuals contributed varied significantly with his own contribution being around 20 hours a week.

Factors limiting engagement

There were a number of limiting and enhancing factors that were reported with regards the engagement of the community champions and the neighbour community in the project. The limitations included the technology used within the project. A main driver for the project had been the problems that the CitizenTech project has been having with its sensing kits, and even though the kits were further developed through the CitizenSensingAware project they were still a barrier to engagement, particularly for the older plaza residents who needed support from the research team to engage with them. The seasonality of the noise pollution problem also affected the plaza community's engagement with the project, as they disengaged through the autumn and winter months and engagement had to be rebooted in the spring. The plaza community's engagement was also affected by their sensitivity towards impressions of progress, feeling happy and becoming increasingly engaged when progress seemed to be made, and then becoming despondent when they had a sense that it was not. Finally, language was a barrier to a

number of the plaza community members who were regional natives with a strong cultural identity and their own language, many were unable to understand English.

Factors enhancing engagement

One of the enhancing factors for engagement in the project was the amount of time and effort that the research team put into engagements. The researchers made numerous conscious adaptations and provisions in the project to increase accessibility and engagement, including arranging meetings in the evening so that those working or studying could attend, changing the meeting location to a venue closer to the plaza that was also more inviting, and using regional language in the face-to-face workshops and written communications. The research team also put a huge amount of effort into building and maintaining the community champion community, particularly through social engagements in addition to the project workshops. The project was made open for anyone to participate, and pilot 3 was launched with a very collaborative nature, explaining “this is what we can offer”, “this is what we think will work”, “let’s do something together.” Other things that were considered to be enhancing factors for engagement included the sense of ownership in the project, Sophie (RPM) describes how the community champions had ownership over the process and the plaza community had ownership over the problem which resulted in both parties having ownership over the result. The public interventions were widely discussed as having significant and positive impact on engagement of people who were external to the project. For example, the recreational users of the plaza were drawn into the discussing the noise pollution problem by the noise box intervention. This was also a key way for the plaza residents to be engaged, which as Patrick (RPM) describes led to the building of the pilot 3 community.

8.2.7 Relationships

Relationship between researchers and community champions

The relationship between the professional researchers and the community champions was highly collaborative. Both citizens and professionals brought a wide range of professional skills, expertise and perspectives, with citizens’ opinions being taken into consideration through the development of the project. Tanya (Cit) expresses a unity of

focus and determination to address the problem of noise. The professional researchers actively and explicitly recognised the value and contributions of the citizens, specifically positioning them as their equals through the Community Champion graduation process. In or to build this relationship with the citizens the researchers organised regular social gatherings for the citizens and researchers to meet and mingle.

Relationship between the neighbours and the researchers

There was a mixed relationship between the resident community and the researchers in this project. Whilst Sophie (RPM) presents a case of developing a significant commitment and dedication to the community, being open and available to them at any time, and building such a strong relationship with them that she knew their personal lives, the community did also present a lot of tension and conflict towards her and the research team. Their despondency at being able to change their situation could be a barrier to engagement and they were sometimes defensive towards the researchers about them not wasting their time. There was also some conflict around the cultural tensions of the region, with Sophie (RPM) challenged for not being a regional native. There was also a sense of an unrealistic expectation of the neighbours on the researchers. The researchers felt that the neighbours were willing to work with the researchers because they wanted the problem solving, but they wanted and expected the researchers to just be able to intervene with the council and solve the problem completely. Lizzie (Cit) however reveals that it was very clear to her that the researchers had not offered to provide a solution, but a tool that could influence change. She also reflects that they worked well together in discussing what different options and possibilities might be.

Neighbours relationship with the community champions

There are very few mentions of the relationship between the community champions and the neighbour community. Whilst Patrick (RPM) emphasises that is was the community champions that worked most closely with the neighbours and supported their engagement, Brendan (Cit) places emphasis on this being the role the researchers fulfilled. There is no indication in the data that the neighbours knew of the difference between the researchers and the community champions, or at least if they did, they difference wasn’t significant to them.

Neighbours relationship with government

Finally the neighbour communities' relationship with the government wasn't very positive. The neighbour community had been having a dialogue with the government, about the problem, for some time, and found that the government were not responsive to their plight. However, whilst working on the Noise Pollution in the Plaza project, they were also in parallel discussions with the government about the problem.

8.2.8 Value

Value of the actors

There was very little content in the data about the value of the different actors in the project, with most points made below only represented by one quote, and where there was data this was sometimes implicit rather than explicit. Essentially the community champions and the neighbour community both had value in the project in that they had a wide range of skills and expertise that could be used in the project to either develop critical infrastructures, such as Brendan (Cit) building the online on-boarding platform for the sensing kits, or in suggesting technical solutions for the noise problem, such as Lizzie (Cit) suggesting architectural technologies that could be implemented. In addition Sophie (RPM) explains how both the community champions and the neighbour community had immense energy and enthusiasm for the project, which not only gave her the confidence and support she needed to deliver success, but that meant the project could be delivered and with bigger achievements in a shorter space of time. Unique to the community champions was the role they played in engaging the neighbour community, which Patrick (RPM) describes as being critical to the success of the project. Whilst unique to the neighbour community was the fact that they brought the friction and the real problem to the project, which meant that the project was more meaningful to the community champions, but Patrick (RPM) reveals that it also meant that the methodology could be tested and therefore validated through a real world scenario. The value of the researchers came in their social and professional networks which not only led to the recruitment of the community champions, but also to the contribution of external experts who the citizen scientists expressed were highly valuable for developing understanding and ideas. Of course it was also the research teams, particularly Sophie's (RPM), expertise in

participatory methodologies that developed the methodology which led to the success of the project, but further to this Lizzie (Cit) highlights that Sophie's (RPM) communication skills and her ability organise ideas meant that she could impactfully communicate with the government and media.

Value of the project

The value of the project itself also emerged as a theme in the data and revealed itself as valuable in different ways for the three different stakeholder groups of the project, the research team, the community champions and the neighbour community. For the research team the project enabled them to develop and test a methodology for citizen sensing, through its application and validation in a real world scenario. For the community champions the project helped them with their career development, building new knowledge, developing new skills, developing their ideas about what they want to do with their careers, and supporting their job applications as something they can reference on their CVs. For the neighbour community the project had immense value as this was a type of initiative that as a community they would not have had the capacity to deliver themselves, the project and the research team gave them the structure, process, infrastructures, technology and organisation to deliver an initiative that the community wouldn't have had the knowledge, expertise, time or skills to deliver. Further to this the process then also enabled them to create action in their community, through the successful lobbying of government to the point that the government made investment in mitigations to reduce and then monitor the problem. A final point to add is the value that the media had on the project, Lizzie (Cit) highlights that it was the media's attention on the project that raised the profile of the issue the community were facing so that the government heard them.

8.2.9 The role and value of data and tech

Data and technology are words that seemed to have been used synonymously in the narratives, and actually the story told of the role and value of the two is the same story. Tanya (Cit), Sophie (RPM) and Brendan (Cit) all discussed that data and technology are useful tools for helping to create change and action, but not as solutions in their own right.

Tanya (Cit) specifically outlines that the data was limited in its ability to create behaviour change. Sophie (RPM) explains that what actually leads to change is people coming together and talking, and both she and Tanya (Cit) explain that you need to know how to use technology in a strategic and useful way, in order for it to have any value. There are a number of ideas about how technology and data are useful in these circumstances, but most dominantly in this particular case is the fact that the data was objective. Lizzie (Cit) emphasises that this gave the community objective evidence they could present to the police and government, rather than the communities' subjective complaints, which could have been rejected by the authorities. Lizzie (Cit) explains that these data were new weapons for the community, as their objectivity meant that the government and police had to respond. In this way the project created change for the community by providing them with something they hadn't had before. Lizzie (Cit) also explains that one of the powers of the data was that it galvanised the community, bringing them together to engage in dialogue with each other, because it was something they shared. A note of caution is offered by Sophie (RPM), however, who raises the fact that the data can be problematic to these processes because errors in the data can invite challenges and criticisms. In response to this risk in the Noise Pollution in the Plaza data Sophie (RPM) worked to shift the focus of the project into more social processes, bringing people together to acknowledge the problem and discuss solutions, thereby bypassing the opportunity for the data to be undermined.

8.2.10 Outcomes and successes of the project

Outcomes for the community

The project achieved a wide range of outcomes and impacts, most notably the change it managed to catalyse in the city plaza, but also a wide range of learning and personal outcomes for the actors. The most significant outcome of the project was implementation of several mitigations measures, by the municipal government, in the plaza. These changes were seen as a direct result of the project, and whilst they did not completely resolve the noise pollution problem, they significantly reduced it, achieving more than the communities' previous attempts. There were two outputs of the project which were critical to being able to create change, the first was the evidence that the project was able to

gather to demonstrate that the noise pollution was exceeding WHO guidelines. The second was the media attention that the project managed to attract, which raised the profile of the issue within the city and in turn put pressure on the government to respond to the situation. Another way in which the project enabled change was through creating a sense of empowerment in the neighbour community. Sophie (RPM) and Lizzie (Cit) explain how one neighbour said that the project had moved them as a community from being victims to being “powerful people”. Further change that took place through the project was the relationship building that it enabled strengthening and building relationships within the plaza community, bringing, as Lizzie (Cit) describes, the community closer together. There are differences of opinion however regarding the extent to which the research community are still engaged with the neighbours, with some suggesting there is still interaction and others bemoaning the absence of this.

Learning and professional outcomes

The project resulted in numerous learning, awareness raising, skill building, career development and research outcomes emerging from the project. Learning was a repeating theme within the data for the community champions and the neighbour community, who gained knowledge across a whole range of topics including data literacy, design thinking, programming, communications and science. Beyond intellectual knowledge there was also awareness raising impacts of the project, both amongst the citizen scientists that participated in the project and the wider community of recreational users of the plaza. Awareness raising is reported around the issue of noise itself, the availability of open access data, the ability of data to solve problems, and civil rights. Skill building was an impact of the project most particularly with the community champions, who whether choosing to work on tasks aligned with their existing skills base, or on something they had no experience of, developed or improved skills. Sophie (RPM) highlights things like communications, graphic design, programming and data collection as skill areas. Tanya (Cit) also raises that she learnt team working skills, which is something she had never had to do before. Leading on from this the project also had an impact on the community champions career development, either shaping their ideas of what they wanted to do, being an example of a project they had contributed to that they

could put on their CV, or else in the case of one community champion leading to a job with AIL. As a result of all of these learning and professional outcomes the projects also built a lasting professional community with the community champions continuing to work with Sophie (RPM) and Patrick (RPM) on other projects. From a research perspective the research outputs of the project emerged as successfully developing a validated citizen sensing methodology, for which there was in-depth documentation of the process and eventually the publication of a book of tools, from the project. In addition to this the citizen sensing kit was developed and improved upon and an on-boarding system had been developed to support this.

8.2.11 Weaknesses of the project

Weaknesses of the project were also orientated around four principle themes; the limitations and over extension of the scope of the project, the resource requirements of the project, the difficulties with the citizen sensing kits, and the lack of continued engagement with the community. The identification of the weaknesses associated with the scope of the project came purely from the community champions and neighbour interviewed for the case study. In a seemingly contradictory way the citizen scientists reflected both on the way in which the project sometimes tried to achieve too much in too little time, but also that the project engaged too small and specific a group of people, and that ideally it should have worked across a larger part of the city and throughout the whole year. In contrast the matters of resource challenges in the project were only discussed by Sophie (RPM) and Patrick (RPM). They both highlight how the resource requirements of projects of this nature are challenging, requiring significant financial, time and human resource investment. Sophie (RPM) raises the matter that the financial and resource costs of the project were way higher than was officially reported. Focussing specifically on technological resources, there were ongoing problems with the citizen sensing kit that was used in the project. Sophie (RPM), Patrick (RPM) and Brendan (Cit), discussed extensively how much development work had to be done in order to make the citizen sensing kits accessible to citizen scientists. However, despite much work and effort both Patrick (RPM), and most fervently Brendan (Cit), discuss how there were still challenges throughout the project in fixing bugs, making the kits, and the on-boarding of the kits

accessible. Finally is the issue of the on-going relationship between projects and communities. Both Brendan (Cit) and Sophie (RPM) expressed dissatisfaction and frustration that the community and relationships that had been built were not maintained beyond the end of the project.

8.2.12 Government response to the project and problem

The story of the relationship of the government to the problem and the project is in itself one of change. There had been a historic disinterest and lack of willingness from the government to do anything about the noise pollution problem, and initially there was a lack of trust and willingness to recognise the data that was being produced by the project. However, Patrick (RPM) reflects that the data provided to the government didn't need to be officially verified, but just needed to be meaningful. By demonstrating that noise levels were exceeding WHO guidelines and through the media attention that the project gained, the government started to become more open and willing to consider solutions. The community suggested a number of mitigations that could be implemented and the government adopted several of these. They also installed their own 'official' sensors in order to monitor the noise pollution levels and evaluate the success of the mitigation strategies.

8.2.13 Experiences

Neighbour communities' experience

The different project actors' experiences of the project were all wildly different. For the neighbour community their experience was largely described as an initial scepticism due to an uncertainty of whether to trust the researchers and whether the project would be a waste of their time. Through engagement with the project this was transformed into a huge commitment and satisfaction in the project, as the neighbours became convinced that the researchers and community champions were there to help, and they began to see the impact that the data they were collecting could have. The neighbours' satisfaction was further boosted by the outputs and impacts of the project, which managed to achieve more than any previous efforts, in two decades. Lizzie (Cit) exclaims "They were a miracle." They also gained through the project a significant amount of empowerment,

with one neighbour saying to Sophie (RPM), “I don’t feel like a victim anymore, I feel empowered.”

Community champions’ experience

Whilst both community champions who were interviewed had taken a lot of enjoyment and satisfaction from the project, the level of satisfaction they experienced varied greatly. Tanya (Cit) thoroughly enjoyed the project, particularly through the way that it introduced her to new knowledge, skills and experiences. Brendan (Cit) on the other hand, despite having taken a lot of enjoyment and satisfaction from some of the social elements of the project, found a dissatisfaction with the quality of the technology that was utilised in the project, some inconsistency in the management of the project, and with the fact that the community were left by the organisations at the end of the project.

Researchers experience of the project

The researchers experience was different again and was mostly detailed by Sophie’s (RPM) experiences. Sophie (RPM) made a huge personal commitment to the project that involved emotional and professional dimensions, and she committed herself to the project to such an extent that it was “like a child” to her and sometimes left her exhausted. She expresses that she would never do a project in the same way again, simply because it was too intense to maintain. The project took a lot of emotional investment from Sophie (RPM), who not only experienced the emotional attachment to the community due to the impact of the problem on their lives, but also experienced animosity and some aggression from the some of the neighbours due to her nationality and their scepticism of the project. In parallel with Brendan’s (Cit) reflections, Sophie (RPM) was dissatisfied with having to have leave the community and the fact that the other organisations did too. On the positive side both Sophie (RPM) and Patrick (RPM) expressed a lot of satisfaction with the project based on its outcomes and impact, and Patrick (RPM) spoke specifically of his enjoyment working as a collective with the community champions.

8.3 Absences from the thematic analysis

Thematic analysis presented a number of codes related to the theme of ‘Theoretical notions of community, engagement, empowerment and change’. I have decided not to

present these ideas within the case study, as they reflect wider conceptual notions of practice, rather than what happened in the reality of this project.

8.4 Key Insights

8.4.1 Project managers being central and critical to the project

This project delivered a highly co-created process of citizen sensing methodology development with the community champions and then citizen sensing for action with the neighbour residents. The project provided a purposefully designed process through which each set of citizen scientists could engage. What is important to note here is that whilst there is a high level of co-creation and collaboration in the project, the design, management and facilitation of that process was carried out independently from the citizen scientists. This in many way reflects one of the comments that Patrick (RPM) made about the fact that volunteers, by their very nature of being volunteers, cannot be expected or relied upon to deliver the project. As a result employed staff need to take the responsibility for these aspects of the projects. Whilst the researchers and project managers are being paid to fulfil this role, in this case study Sophie's (RPM) narrative demonstrates the personal toll that this can take on individuals, particularly when the project looks to create action around a challenge the community are facing. This case study therefore highlights how the responsibility for these projects often needs to sit within the professional community, but also the pressure that that responsibility can bring.

8.4.2 Project continuity

This project created a significant action-orientated impact for the plaza community, leading to several tangible changes which did reduce the noise pollution problem. In this sense the project was a huge success both for the researchers, the community champions, and most importantly with regards the issue. However, the fact that the problem was not completely solved highlights an important point about these types of projects, which is spoken to across a number of the interviews. Projects of this nature are time-bound with researchers having to move on when the funding comes to an end. Brendan (Cit) raises this point in rather a stark way explaining that whilst the researchers can walk away at the end of the funded period, the community can't, they are stuck with

the problem. On this trend Tanya (Cit) discusses how she felt that so much more needed and could have been done and that it would have been valuable to expand this project to other communities across the city. The capacity and scope of funded projects of this nature, are however restricted. Where projects are looking to create change and impact, there is always a risk that that may not be achievable within the amount of time that the researchers can offer. This is a particular tension when we consider, as mentioned in section 8.4.1, that researchers hold the responsibility for delivering these projects and their outcomes.

8.4.3 Data and technology as a tool, not a solution

The way in which the process led to change is discussed through the project in terms of the data not being a solution that can directly deliver action, but instead acts as a tool through which change can be leverage. What the project demonstrates is that broader social processes are important to whether or not change and action happens, but also the role of government and policy-makers in this process. The process of the project was important for providing the community with a pathway through which they could more successfully engage in dialogue with the people that they needed to. The data was important and was significant in that it provided the community with objective and quantitative data that meant they could more meaningfully demonstrate the extent of the problem. This critical importance of this in the project must not be overlooked, but it wasn't enough on its own. Media was another important factor in the project, as this created the profile and the political pressure through which the government then felt pressure to respond. In addition, the existence of the project in its own right created dialogue and raised awareness about the problem, resulting in the production of mitigation suggestions for the government. In combination these social, as well as empirical drivers, coalesced and resulted in a government response. It is therefore important to recognise that the process of change and action is much more of a complex social negotiation, in which data can be a tool to catalyse, evidence and leverage some of that social movement, but cannot create change on its own.

8.4.4 Reflecting on the research questions

This case study provides understanding for both research questions of this thesis; 1) How does the concept of co-creation manifest in citizen science projects? And 2) What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate? Firstly, exploring the way in which co-creation manifests in projects of this nature, this case study reveals the important role that researcher: project managers play in making sure that these projects can happen, providing crucial organisational and management roles. This also demonstrates however, that the citizen scientists are absent from some of the governance of the projects, in that they participate in the research and action processes of the project, but do not necessarily have a broader role in the direction and delivery of the projects. There is also a tension that whilst the responsibility of the projects sits with the researcher: project managers, their ability to commit to the projects is time bound. In terms of how co-created citizen science projects deliver action this case study is important in revealing that projects may not be able to commit to seeing the problem through to salvation and that often communities' are left feeling that there is so much more than needs to be done. It also highlights that the change making process goes beyond the ability to create data, as data has to be negotiated with other social factors and influences. Co-created citizen science projects that look to create action and change therefore need to think about a much broader set of dynamics.

Part 3: Developing the contribution to knowledge

In part 2 of this thesis I have presented five empirical case studies of five different co-created citizen science projects. The case studies have been constructed through a thematic analysis of narrative interviews collected from a mixture of researcher, project manager and citizen scientist actors who participated in the projects. Each case study was significantly different from the next and all provided their own unique insights with regards the research questions of this thesis. A thematic analysis was conducted of the insights from across the five case studies in order to identify meta-themes for the research questions. In the up and coming discussion chapter (Chapter 9) I compare and contrast the insights from across the five case studies, structured around the meta-themes and in so doing develop two contributions to knowledge for the field of citizen science. These are followed by a series of recommendations for the field and a discussion of the limitations of the research. In the conclusion (Chapter 10), I then recount the journey of the whole thesis, highlighting the insights with regards both of the research questions, and the contributions to knowledge, before making recommendations for next steps.

9 Discussion

In the preceding chapters, comprising part 2 of this thesis, I have introduced and described the five case studies that were conducted as the foundation of this research. In this final chapter I compare and contrast the findings from across the five case studies presented in Chapters 4, 5, 6, 7, and 8, and in so doing develop two contributions to the field of citizen science, including speculative elements.

This research project looks to fulfil two aims. The first aim is to understand how co-created approaches to citizen science work; how the concept of co-creation manifests itself in citizen science and how different dimensions of the practice influence the ability to collaborate in a co-created manner. The second aim is to understand the relationship between the co-created process and the ability to deliver action outcomes, specifically for the communities that participate in the scientific research. In order to fulfil these two aims I look to answer the following two research questions:

1) How the concept of co-creation manifests itself in citizen science.

2) What is the link between the process of co-created citizen science and its ability to deliver action outcomes for the communities that participate?

A multiple case study approach was adopted for this thesis because of the highly situated contexts within which action-orientated projects exist. The resultant studies are therefore not directly comparable, presenting a challenge to generalise from one case to another. The methodological approach to this research is therefore one of looking for maximum variation in cases to understand the trends in practice that this diversity can reveal, rather than looking to determine absolute rules for practice. Looking across the case studies and examining the similarities and differences between the projects we can then learn about the dimensions around which practice is navigated. We therefore signpost the types of dynamics and facets of projects that need to be carefully considered when adopting co-created approaches to citizen science. In order to do this a thematic mind-mapping was conducted across the five case studies in order to reveal overarching themes that dominated the narratives. This method is described in Chapter 3, section 3.4.4 and the mind-maps are presented in Appendix 12. ‘Participation and Collaboration’, ‘Fostering

Positive Working Relationships' and the concept of 'Directions of Service' emerged as meta-themes that bring understanding to question 1 of this research and are presented below.

The insights that emerged from these three meta-themes are then synthesised to present my first contribution to knowledge; the consideration of the concept of mutuality and service in co-created citizen science practice (section 9.4). Following this I unpack the evidence around what facets of the approaches influenced and delivered the delivery of action outcomes in the projects, and who these outcomes served. Here I pick apart the influences and roles of science, the process of co-creation and different types of actors and agents in the project, and build towards the second contribution to knowledge presenting three models of co-creation and action (section 9.6). Finally, I draw conclusions about the link between the two contributions to knowledge, before summarising the key insights and learnings from across the discussion.

As done in the case study chapters (Chapters 4, 5, 6, 7, and 8), I use abbreviated tags after the use of researcher and participants' pseudonyms, to indicate what their role was in the citizen science projects. The tags are as follows: (Cit) = Citizen scientist; (Res) = Researcher; (PM) = Project manager; (RPM) = Researcher: Project manager.

9.1 Participation and collaboration

Concepts of participation and collaboration unsurprisingly emerged from the case studies as central and prominent meta-themes, as these are the very act that is carried out in citizen science projects and therefore speak directly to research question 1 of this thesis; 'How the concept of co-creation manifests itself in citizen science.' Here we look to understand the manifestation of co-creation by examining the roles and contributions that different actors made to the citizen science process and how the actors worked together around the research process and the governance of the projects.

9.1.1 Role and contribution of researchers and project managers

Whether formally employed as researchers or project managers these actors were central in delivering scientific and project management capacity to the projects, but they carried out these roles either through facilitating citizen scientists' engagement in their own

process, or providing a process through which citizen scientists could participate. Across all five case studies the researchers and project managers (referred to as 'researcher: project managers' for the rest of this document) played essentially the same role in the project, providing both scientific and technical expertise and guidance, and project managing the projects. For example, in Protecting Our Waterways (Chapter 5), Susie (PM) who is employed as a citizen science project officer has responsibility for both the development and management of the project and the management and delivery of the scientific process. This means that the researcher: project managers had to have a very wide-ranging skills set, much broader than might ordinarily be expected of either a researcher or a project manager. Their role was not only to ensure that the research process was carried out rigorously and with validity, but they were also responsible for recruitment, training, volunteer management, financing and resourcing, facilitation and communication. Where researcher: project managers didn't have the skills or technical expertise, external experts or other colleagues would be drafted in to support the work, such as in Noise Pollution in the Plaza (Chapter 8), where the project utilised the expertise of many different types of professional. The researcher: project managers' roles as both scientific experts and project managers were valuable to the projects because they fulfilled capacity gaps within the communities that were participating in the projects. Wilderman et al. (2004) define the professional partners of community science projects as "service providers" (Wilderman et al., 2004, pg. 1) because they are providing the technical and programmatic support that communities need. In Conserving Wolverine Populations (Chapter 7), the trappers were lacking in the scientific expertise they needed to create validity for their knowledge of the natural world, whilst in Noise Pollution in the Plaza (Chapter 8), Lizzie (Cit) discusses the difficulties communities have in being able to organise themselves and access the resources for these types of endeavours. This means that the researcher: project managers were of central and critical importance to the delivery of these projects. However, the way in which the researcher: project managers approached these roles was different across projects. In some cases, the researcher: project managers took the role of developing and providing a project and process in which the citizen scientists could participate, as was the case in Protecting Our Waterways and Healthy Household Water (Chapters 5 & 6). In other cases, the

researcher: project managers took the role of facilitating the citizen scientists' ability to conduct the research they wanted to carry out, as was the case in Conserving Wolverine Populations (Chapter 7) and the Large Carnivore Mitigation Programme mitigation project (Chapter 4).

9.1.2 Role and contribution of citizen scientists

Citizens' roles in these processes are intellectual, practical and social, but vary greatly depending on the way in which the project is being managed by the researchers' and project managers'. Citizens' knowledge was recognised as a significant contribution to the research projects, not just in terms of the knowledge they could bring about the local area, but also their professional knowledge and expertise. This parallels understandings in the broader participatory research literature about the value of 'lay' contributions (see (Irwin, 1995, Corburn, 2007, Turnhout et al., 2012, Mauser et al., 2013, Hoover, 2016). Citizens' knowledge not only expanded the researcher: project managers understanding of phenomena by offering alternative insight, but also had a significant impact on the research findings. In the Protecting Our Waterways (Chapter 5) case study the citizen scientists' knowledge about historic land use around the waterway, was able to explain some of the findings from the waterway monitoring. Practically, and again as widely established in the literature, citizen scientists significantly increase the capacity of research, by increasing human resource in terms of people hours and geographic distribution (Wiggins and Crowston, 2011, Miller-Rushing et al., 2012). In the Conserving Wolverine Populations case study (Chapter 7), Tim (RPM) had calculated that the trappers' voluntary contributions to the project were worth $300-500 thousand/ per year in human and travel resources, and also highlighted their access to remote locations. Beyond human resource the citizen scientists also had value in the social capital that they held, enabling them to encourage and motivate their communities to participate in the research, but also in the case of Healthy Household Water (Chapter 6) increasing the access to citizens as data sources. In this way citizen scientists participating in the project provided a crucial link between the communities and the research projects.

9.1.3 Collaboration around the research process

Collaboration between researcher: project managers and citizen scientists around the scientific process involved a mixture of shared or divided labour, and was influenced by whether the researcher: project managers had adopted a role of provision or facilitation of the research process. Co-created citizen science projects are defined as projects where the public are involved in most, if not all, stages of the scientific process (Bonney et al., 2009, Shirk et al., 2012). Projects were recruited as case studies for this research on the basis that they had endeavoured to realise this ambition. Certainly, for the four projects where the citizen science had achieved its objectives or reached a conclusion (Protecting Our Waterways, Healthy Household Water, Conserving Wolverine Populations and Noise Pollution in the Plaza) the citizen scientists were involved in method design, data collection, data interpretation and dissemination of findings to one extent or another. The only parts of the process where there wasn't participation of the citizen scientists, across these four projects, was in problem identification (for Protecting Our Waterways and Healthy Household Water) and data analysis (for Protecting Our Waterways and Conserving Wolverine Populations). Researcher: project managers contributed to all stages of the research process except for data collection. Where both researcher: project managers and citizen scientists contributed to the same part of the research process there were examples of both shared and divided labour. With regards shared labour, in the Conserving Wolverine Populations (Chapter 7) project both researcher: project managers and citizen scientists worked together on the design of the camera trap run poles. Whilst later on in the project labour was divided between the actors, with trappers holding responsibility for carrying out data collection and the researcher: project managers for the data analysis. This reflects the value that each actor was bringing to the collaboration in this project; the researcher: project managers brought the scientific expertise and the trappers brought the field expertise. The way in which actors worked together throughout the research process was also influenced by the philosophical role that researcher: project managers had adopted in terms of providing or facilitating the scientific process. Where researcher: project managers had adopted the role of providing the scientific process they would lead the direction of the process and invite and support the citizen scientists in participating in those processes, such was the case in Protecting Our Waterways (Chapter 5). Where researcher: project managers had

adopted the role of facilitating citizen scientists in carrying out their own research or innovation process, they would either involve the citizen scientists in discussions about what the process might look like, or else take their lead on ideas about the development of the process, as in Large Carnivore Mitigation Programmes mitigation project (Chapter 4). This has a significant impact on the amount of control that the citizen scientists have over the development of the research.

9.1.4 Collaboration around the governance of the projects

Citizen scientists' participation in governance and decision-making in the projects varied significantly from case study to case study, with some involved in decision-making about the structure and direction of the projects, and others only around day-to-day tasks. The distinction around which types of tasks that the citizen scientists do and don't participate in can be understood in terms of what Shirk et al. (2012) describe as the 'Activities' of the project, which is "the work that is necessary to design, establish and manage all aspects of a project," (Shirk et al., 2012, pg. 7) which the authors reinforce is different from the participation in the steps of the scientific process. For example, in Health Household Water whilst community researchers were involved in day-to-day decision-making about conducting the research interviews and the delivery of public engagement opportunities in their community, and the professional researchers were a part of the discussions around the direction of the research, it was the stakeholder clients who made the ultimate decisions about what the research would focus on and how it evolved. In Noise Pollution in the Plaza (Chapter 8) community champions were involved in decision-making about the development of the citizen sensing methodology and how it would be implemented within the community of concern, but the decision-making and the governance of the project as a whole was carried out independently of community champions, in separate meetings, amongst the researcher: project managers. Conserving Wolverine Populations (Chapter 7) appears to be the only case study where decision-making for the whole of the project was made collaboratively between the researcher: project managers and the citizen scientists, and in Protecting Our Waterways (Chapter 5) there is no evidence of citizen scientists participating in decision-making processes at all. This reveals that there were varying amounts of openness across the projects to the citizen scientists'

contributions to governance and decision-making, but also that openness varied across different parts of the same project. Wilderman et al. (2004) raise the issue of control in their examination of community science initiatives, producing a typology of community science based on dimensions of carrying out different tasks and decision-making across the research process. They suggest that processes where citizen scientists have least control are more appropriate for developing scientific knowledge, whilst processes where citizen scientists have lots of control are more appropriate for building capacity for knowledge being used to create action.

9.1.5 Summary of insights

In examining the nature of participation and collaboration across the five case studies examined, it is possible to shed light on research question 1 of this thesis; 'How the concept of co-creation manifests itself in citizen science.'

The findings reveal that even within the concept of co-created citizen science there is huge variation in how citizens are included within the research process. Project managers and scientists often 'hold the space' of these projects, either providing a process of research for citizen engagement, or else facilitating and enabling citizens to carry out the process for themselves. The way in which the project managers hold the space is critically influential for the ways in which citizens can and do participate in the research process, not just in terms of which parts of the process they participate in but also how and what they contribute. Where common conceptualisations of public participation in research can focus on training citizens to carry out the tasks that scientists might ordinarily do, evidence of division of labour across the case studies highlights the independent value of different actors and moves the conceptualisation of co-created citizen science towards ideas of mutually beneficial partnerships, where actors fill in the skill and knowledge gaps of one another. In addition to this the prominent focus on the participation of citizen scientists in stages of the research process overlooks other macro-structural elements of these processes (Wiggins and Crowston, 2011) and here we see governance as an important dimension of the practice of these processes, as is recognised by Wilderman et al. (2004).

Whether or not citizen scientists participate in the governance of the process is influenced by whether the project managers are facilitating the research process or providing a research process. This impacts participants' sense of ownership and their understanding of the project as a whole. These ideas encourage a deeper examination of the conceptualisation of co-creation in participatory research processes, leading us towards my first contribution to knowledge, that of the concept of mutuality and service in partnerships (Section 9.4). The concept of mutuality and service in this context asks us to consider the extent to which collaboration in research is a mutual endeavour or a relationship of service from one group of actors to another. Are all actors the intended beneficiaries of these processes and is the direction, delivery and governance of the process something that is mutually constructed, or else held by one actor more so than another? We will return to this question in section 9.4 and now move into an examination of insights around the relationships between actors, to deepen our understanding of the ways in which collaboration took place within these co-created citizen science projects.

9.2 Fostering Positive Working Relationships

Underpinning the ability of actors to collaborate within co-created citizen science projects is the nature of the relationships between the actors. Understanding around the nature of relationships is foundational for understanding research question 1 of this thesis, in that it helps us to understand why co-creation manifested in the ways that it did across the case studies. Here we examine how relationships were built across the case studies, what healthy and positive working relationships looked like between the actors, how the organisational structures and the formality of the relationships affected the ability to co-create research and the fact that the responsibility of all of this is held by the researcher: project managers in the projects.

9.2.1 Building relationships through co-creation

Relationship building and collaboration existed in a positive feedback loop, with trust as the key driver of that cycle. Across the five case studies there were different starting points for relationship building within the projects. In the Large Carnivore Mitigation Programme mitigation project (Chapter 4) and in the Conserving Wolverine Populations

(Chapter 7) project researcher: project managers already had established relationships with the communities and this seemed to put projects at an advantage, as there was already a certain level of trust and understanding between the actors. In contrast the Healthy Household Water project (Chapter 6) and Noise Pollution in the Plaza (Chapter 8) projects had to establish relationships with the communities from scratch and recruited paid community researchers and volunteer community champions, respectively, in order to bridge this gap. In the case of Noise Pollution in the Plaza (Chapter 8) and Protecting Our Waterways (Chapter 5) relationships had to be built from scratch not just between the researcher: project managers and the citizen scientists, but amongst the citizen scientists too. Trust was the most widely discussed factor seen as influential for building relationships, with communities' lack of trust in scientists, and in the government, as significant barriers for the researcher: project managers to overcome. In all but Protecting Our Waterways (Chapter 5) there was evidence of a lack of trust and a resulting scepticism from communities about the intentions of the researcher: project managers and the risks to the communities' well-being. This lack of trust was often the result of previous bad experiences and poor relationships with scientists and government institutions, and required a willingness from communities to set aside their misgivings and to see what would happen. It was then through positive experiences of dialogue and collaboration that trust could be built, which in turn would increase the depth of collaboration. In this way co-creation bred more co-creation. Community leaders, researchers and community champions were also seen as an important tool for developing that trust with the communities. Researchers considered that other citizen scientists were more accessible to the community and were therefore valuable vehicles of advocacy and trust building. However, Connor (Cit) did explain that he wasn't going to trust Ferendale Conservation Institute just because Kevin (Cit) did, they had to earn that trust from him through their interactions. Finally, time was also widely discussed as a critical factor for relationship building with Judy (PM) explaining that this was one of the failings of the Large Carnivore Mitigation Programme mapping project (Chapter 4), not taking enough time to build the trust and relationships with the community, and Tim (RPM) and Thomas (PM) recognising it as essential for success.

9.2.2 Positive working relationships

Partnerships across the projects were seen as positive and mutually beneficial, but conflicts and expectations still need to be negotiated as a part of these collaborations. Across all projects, the majority of narratives from researchers, project managers and citizen scientists painted stories of highly enjoyable, positive and beneficial collaboration and working relationships between the researcher: project managers and the citizen scientists. Three citizen scientists from across the five case studies had prominent strands of criticism running through their narratives, which were directed towards the researcher: project managers and orientated around criticisms of management and decision-making in the project, but even these individuals also had praise for the projects. The emphasis for what made the relationships positive was always orientated around what the researcher: project managers did. Positive characteristics discussed included the strength of their ability to listen to the community, their commitment to the community, their willingness to side with the community in public debate, their respect for the community and the value they placed in the communities' knowledge. Whilst the relationships between the researcher: project managers and citizen scientists in the projects were highly positive, supportive and constructive, this did not mean that there was an absence of conflict. There was evidence in a couple of the case studies of a need for negotiation between the researcher: project managers and the citizen scientists around conflicts and expectations of the projects. In the Conserving Wolverine Populations (Chapter 7) project conflict between the researcher: project managers and the trappers occasionally emerged regarding the direction and decision-making for the project. These conflicts seem to have been a healthy and constructive part of the co-creation process, as interviewees' reflections reveal an open and balanced negotiation between the different actors' knowledge systems. The actors' respects for one another and their commitment to working together ensured that they could amicably resolve their differences and continue to work together productively. There was also a need within some of the projects for negotiating expectations with the communities that were participating. In Healthy Household Water (Chapter 6) and Noise Pollution in the Plaza (Chapter 8) there were concerns and challenges in navigating the communities' expectations that the projects would provide them with solutions to their challenges. In both circumstances these issues were managed with regular reiteration to the community

about what the research intended to achieve and could offer, but the difference between what the research could offer and what the communities needed could be a source of tension.

9.2.3 Organisational structures of the projects

Organisation structures and the formality of relationships significantly influenced the ability to work collaboratively and the ways in which citizens contributed to the projects. Across the case studies the descriptions of how researcher: project managers and the citizen scientists collaborated with one another revealed different organisational structures across the projects. Healthy Household Water (Chapter 6) seems to have had a highly linear structure of management for the project, resulting in deliberation and decision-making moving up and down the chain rather than in open, collaborative discussions. As a result the research programme managers, the researchers and the community researchers all play the role of 'middle men' in the organisational structure. In contrast the other case studies had a variety of organisational structures that were more centralised with collaboration and decision-making taking place more collaboratively, to varying degrees. Across a number of case studies citizen scientists played a role as 'middle men' for the rest of the citizen community. In Conserving Wolverine Populations (Chapter 7) it was three trappers who represented the trapping community who were a part of the core research management team, with the rest of the community external from the co-creation of the research. In the case of Noise Pollution in the Plaza (Chapter 8), the research process was co-created with the community champions, who then acted as the bridge to bring the community into the project, so that they could participate in the co-creation of data and action. This demonstrates a gradation of centralised decision-making for different parts of the project, with the structure changing through time as the project evolved. The more centralised the organisational structure, the more collaborative the project was, but even within a centralised organisational structure governance and decision-making could be separate from citizen scientists.

Another way in which the organisational structure of the project affected collaboration was in the formality of the relationship between the researcher: project managers and the citizen scientists. The Healthy Household Water project (Chapter 6) brings an interesting

case of divergence to this thesis in that it employed community researchers in the project, rather than having volunteer citizen scientists as is most widely practiced in participatory research methodologies. In fact ECSA's exploration of the characteristics of citizen science argues that individuals who are regularly remunerated for their contributions to the research and become a part of the research team, are not in fact citizen scientists (European Citizen Science Association, 2020b). Being employed by the project creates a different contract of relationship between the researcher: project managers and the citizen scientists, as compared to volunteering. In scenarios of volunteering as was discussed frequently in Noise Pollution in the Plaza (Chapter 8), volunteers are free to come and go as they please and contribute as much or as little as they like, compared to examples like Healthy Household Water (Chapter 6) where employed community researchers had to fulfil the requirements of their contract, and carry out tasks as dictated by their employers. In this way employed citizen scientists are more reliable than volunteer citizen scientists, taking some of the pressure for project delivery off of the researcher: project managers. Yet the motivations of volunteer or employed citizen scientists differ, with employed citizen scientists primarily motivated by the financial opportunity and volunteer citizen scientists by more intrinsic motivations, such as altruism and learning. Differences in motivation and incentive have been shown to affect output quality in online citizen science tasks (Mao et al., 2013). The effect of incentive on contribution to the project could be seen in Lesley's (Cit) narrative where she describes how with her involvement being one of employment she would just do what was necessary to fulfil the requirements of the role, and how she found the collaborative intentions of the researcher: project managers frustrating, just wanting to be told what to do, rather than asked for their thoughts and opinions on what should be done. Jake (RPM) argues however, that there are ethical problems with having volunteers doing the work a researcher would be paid to do and that you can get a higher standard of work out of employees due to the recruitment and training process.

9.2.4 Responsibility for partnerships

Emphasis on the responsibility for the building, development and maintenance of relationships and collaboration is always focused on the researcher: project managers.

The fact that the researcher: project managers are providing the central and critical resources, management and delivery across the projects, and the fact that in most cases they are the only individuals employed on the projects, means that the responsibility of the projects sits with them. This responsibility seems to permeate into every aspect of the projects. Across the narrative interviews in the case studies whenever the nature and success of the relationship between the researcher: project managers and the citizen scientists was discussed it was always orientated around how the researcher: project managers behaved and what they did, demonstrating that the onus even for the nature and success of the relationships within the projects is placed upon these actors. So in reflection along with the content shared in sections 9.2.2 and 9.2.3 above there is a real emphasis on the professionals accommodating the citizen scientists, making the project accessible, managing the project and facilitating it, and being available to the community to support them. This parallels with the Voorberg et al. (2014) review of co-creation in social innovation literature which found that organisations engaging in co-creation projects with citizens were seen as responsible for both organisational and citizen barriers to co-creation. In the case studies of this thesis this reveals an imbalance in the partnership between researcher: project managers and citizens. Whilst there are many practical reasons for this imbalance in responsibility, such as human resource and power, where the adoption of co-creation is intended to created shared or citizen ownership and emancipation, these can be expected to be limited without shared responsibility. In Voorberg et al. (2014) paper they suggest that ownership and responsibility are synonymous and therefore without holding responsibility for processes or outcomes there cannot be ownership. That being said a lack of shared responsibility of the process does not undermine the quality of participation in such practices. From both researcher: project managers and citizen scientists there was evidence of substantial commitment to the projects and to the collaboration between the two actors. Further to this, there is evidence of layers of ownership throughout the projects, with citizen scientists in Protecting Our Waterways (Chapter 5) exhibiting strong ownership for the data they collected and as Sophie (RPM) describes in Noise Pollution in the Plaza (Chapter 8) the community champions ownership over the citizen sensing methodology and the neighbours

ownership of the problem, meant that both had a sense of ownership in the outcomes of the project.

9.2.5 Summary

We further build our understanding of research question 1, 'How the concept of co-creation manifests itself in citizen science,' through understanding how relationships between the actors were built, structured and appeared. The relationship between relationship-building and the ability to co-create the research was a cyclical process, with positive experiences of working together leading to an increase in trust and subsequently a deeper ability to work together and co-create the research. Across the case studies positive working relationships were built, but a natural part of co-creation and a marker of mutuality in co-creation was the fact that conflict arose. The way in which conflict was negotiated further influenced the strength of relationships. Further to this the organisational structures of the relationships between the actors, and whether the citizens contributed as volunteers or as employees also influenced the extent to which, and the way in which co-creation could take place, with linear structures and citizens as employees restricting the ability to negotiate and make mutual decisions around the direction of research processes. Interestingly, building on the idea of mutuality, it was the researchers and project managers who were seen as responsible and had the onus for ensuring relationships and collaboration were successful, thereby indicating a lack of mutuality in responsibility for the success of the projects. These insights lend further considerations to the concept of mutuality presented as my first contribution to knowledge in section 9.4, as its provides some indications of how notions of mutuality influence the nature of the co-created process, influencing the way in which actors relate and interact with one another and who has ownership and responsibility for the processes.

9.3 Directions of service in citizen science

The concept of service emerged implicitly across the datasets of the case studies from an observation that different groups of actors had different perceptions about who the projects were intended to serve, and what their role in delivering that service was. Understanding the direction in which actors were directing their energy, care and concern

in the projects, deepens our understanding of the relationships, the nature of the collaboration and the social contract that was developed between actors in the case studies. This further develops our understanding of research question 1 of the thesis; 'How the concept of co-creation manifests in citizen science projects,' but it also helps us to understand research question 2 of the thesis by shedding light on sub-question b); 'To what extent are action outcomes realised for the communities participating in citizen science projects?' because it helps to reveal the direction of effort and intention between the project actors and who was actually served by the outcomes of the research projects. Here we examine the origins and initiation of the projects, their objectives and beneficiaries, the actors' perceptions of who the projects were supposed to benefit, what outcomes were actually achieved and the conflicting perceptions about the process that was undertaken between actors.

9.3.1 Origins and initiation of citizen science projects

In most cases the projects were initiated by professional research institutions, rather than citizen scientists, which influenced sense of ownership for the projects. Except for in the case of Conserving Wolverine Populations (Chapter 7) where the trapping community approached Ferendale Conservation Institute to ask for support in delivering on their own science objectives, all other case study projects were initiated by professional organisations. This is in contrast to the academic literature which suggests that co-created approaches to citizen science are often initiated by communities (Haklay, 2017), although it should be noted that this trend within the case study sample for this research may be due to the recruitment process adopted in the methodology. In most cases these projects were driven by government agendas and funding with Protecting Our Waterways (Chapter 5) emerging directly out of governmental responses to public criticism of public bodies, Large Carnivore Mitigation Programme (Chapter 4) largely supported by government funding due to some political support to reduce large carnivore conflict, and the Noise Pollution in the Plaza (Chapter 8) and Healthy Household Water (Chapter 6) projects emerging from government funded research programmes, and therefore agendas. The Health Household Water project wasn't only funded through public funds but was also governed by governmental and corporate agendas who identified the

objectives and goals of the project. Even the Conserving Wolverine Populations project (Chapter 7) which was initiated by the trappers was funded through public budgets raised from natural resource management levies. The only other exception here is with the Large Carnivore Mitigation Programmes mapping project (Chapter 4), which as an NGO acquired funds from multiple funding streams both public and private. These factors were significant for the project for a number of reasons. Firstly, it meant that the ownership for the projects, Conserving Wolverine Populations (Chapter 7) excluded, started with the professional organisations that initiated the projects, not with the communities who were participating, thereby restricting their sense of influence and ownership over processes and outcomes. Secondly, it contributed to the sense of scepticism in communities who were distrustful of scientists and the government, as they lacked confidence that these types of actors would have a positive impact on their communities. Thirdly, it means that where projects might look to deliver emancipation for citizens the very starting point from which the projects are built is one where the power over the projects starts with those who are already powerful. These three factors could all be expected to undermine the ability for the projects to serve the needs of the communities that participate.

9.3.2 Objectives and beneficiaries of citizen science projects

Most of the case studies looked to create benefits for the communities involved, but the objectives for these communities were not always defined by the communities. Whilst all of the projects except Conserving Wolverine Populations (Chapter 7) were driven or enabled by government funding and agendas, they did all formally set out to deliver benefits for the communities who participated, except for Healthy Household Water (Chapter 6) which only formally intended to deliver knowledge outcomes for the stakeholder clients. In this way the power that professional institutions hold was in most instances intentionally utilised for the benefit of the communities. However, whether the identification of the objectives for the projects and the communities was carried out with the communities that participated varied depending on the projects, with some objectives identified independently of the communities. This is an interesting observation due to the fact that definitions of co-created approaches to citizen science often specify citizens' identification of the problem and research questions as a defining characteristic of these

approaches (Wilderman et al., 2004, Bonney et al., 2009, Sanders and Simons, 2009, Haklay, 2013), in addition Wiggins and Crowston (2011) identify this arrangement in action-orientated projects intended to address citizens' concerns. Whilst in Conserving Wolverine Populations (Chapter 7) and in the Large Carnivore Mitigation Programme (Chapter 4) researcher: project managers directly responded and worked with the communities to define the problem that they wanted to address, in Protecting Our Waterways (Chapter 5) and Noise Pollution in the Plaza (Chapter 8) the researcher: project managers identified these issues independently of the communities that they intended to work with. In Protecting Our Waterways (Chapter 5) the Natural Environment Agency picked a topic that previous projects had revealed was of interest to the community but without direct consultation of the community. Whilst in Noise Pollution in the Plaza (Chapter 8) the researcher: project managers worked with a largely migrant collective of community champions, with just a couple of representatives of the community of concern, to identifying the problem and the methodology for addressing the problem, before approaching the wider community that was affected. Again, as with the matter of the origins and initiation of the projects (section 9.3.1) the identification of the objectives of the project outside of the community reduces the sense of community ownership of the project. It also risks misrepresentation of the problem and as a result inappropriate research endeavours. However in the case of Protecting Our Waterways (Chapter 5) citizen scientists were recruited to the project after the problem had been defined, thereby the community of interest was self-selecting around the problem as defined by the Natural Environment Agency, and initial interactions involved negotiation driven by the community about what sites might be included in the monitoring. Furthermore there is some indication in the narratives from the Noise Pollution in the Plaza project (Chapter 8) that once the project was taken to the community in order to try to address the problem, the first engagements with the community were about discussing the definition of the problem thereby ensuring that the research would appropriately address their needs and concerns.

9.3.3 Delivering outcomes for communities

Communities benefitted from the projects across all five case studies, including significant progress being made on the matters of concern for communities in Large Carnivore Mitigation Programme (Chapter 4), Protecting Our Waterways (Chapter 5), Conserving Wolverine Populations (Chapter 7) and Noise Pollution in the Plaza (Chapter 8). Across the projects, regardless of what the intended objectives of the project were, and who the projects intended to deliver benefits for, all five projects delivered benefits for both the institutional partners and the communities involved. Benefits for researcher: project managers included the satisfaction of positive collaborative experiences with communities, the satisfaction of helping communities address their issues, an expansion of their knowledge and understanding of the natural and social world through the communities' alternative perspectives and experiences, meeting their own organisational, institutional and research objectives and learning new ways of conducting research. For the communities significant progress was made towards addressing their matters of concern. The Protecting Our Waterways (Chapter 5) project successfully ascertained the health status of the communities' local waterway, the Large Carnivore Mitigation Programme (Chapter 4) managed to significantly reduce carnivore conflict on ranches, the Noise Pollution in the Plaza project (Chapter 8) led to a reduction in noise pollution for the neighbour community and the Conserving Wolverine Populations (Chapter 7) project managed to scientifically validate trappers' knowledge of wolverine ecology. Whilst the projects were unable to fulfil the communities' objectives or interests in their entirety, with communities explaining that either the problem wasn't entirely solved or there was still more to be done, the communities did feel that the projects have had significant positive impact. In the case of the Healthy Household Water project (Chapter 6), even though the project didn't formally intend to deliver outcomes for the community, it still managed to do so directly and indirectly, by purposefully providing the community with the opportunity to have dialogue with the stakeholder clients who they had been keen to meet with, and unintentionally creating a greater sense of community and some changes in practice around private water supply management. In addition to directly addressing the communities concerns, all of the projects, Health Household Water included, led to community learning and an increased sense of community or community empowerment, thereby increasing the capacity of the communities to respond to and

engage with the challenges and concerns they were facing. Whilst this paints a picture of almost sweeping success in the projects' outcomes, citizens' satisfaction with the projects varied across and within projects. In all five case studies satisfaction in the outcomes of the project was strongly expressed by the citizen scientists, except for in the cases of Brendan (Cit) in Noise Pollution in the Plaza (Chapter 8) and Lesley (Cit) in Healthy Householder Water who had reservations about how much change had been enacted. Whilst Brendan (Cit) was disappointed in the lack of continued engagement with the community, Lesley (Cit) had had no expectations that the Healthy Household Water project (Chapter 6) would create any change and so wasn't disappointed when that was true. On a positive note, citizen scientists across the five case studies expressed a disappointment in the project ending, having enjoyed contributing to such an endeavour and feeling like there was still much work to do.

9.3.4 Citizen science, who's serving who?

The concept of providing a service emerged in multiple directions within projects, in some cases leading to contradictions about who projects were set up to benefit. Another interesting way to understand the way in which co-created citizen science manifested and whether the projects served the community or not, is to examine the different actors sense of who was serving who through the process. This is most commonly represented in explicit comments about how one set of actors were trying to help the other actors, or the focus they place on where their actions were supposed to have impact. In the Large Carnivore Mitigation Programme (Chapter 4) and the Noise Pollution in the Plaza project (Chapter 8) there was a clear sense from the researcher: project managers that they were there to serve the communities that were participating in the project. An added dimension within the Noise Pollution in the Plaza project (Chapter 8) was the community champions' sense of service towards both the neighbour community in helping them address their problem, and the researcher: project managers in helping them deliver the project. In both of these case studies the communities of concern were there to serve their own needs. In contrast however there were discrepancies in perceptions about who the projects were serving within the Protecting Our Waterways project (Chapter 5), and to a lesser extent in the Conserving Wolverine Populations project (Chapter 7). In the

Protecting Our Waterways project (Chapter 5) both the researcher: project managers saw the purpose of the project and their role as serving the needs of the community, whilst the citizen scientists saw the purpose of their role and the project to serve the scientific needs of the Natural Environment Agency. This scenario was echoed in the Conserving Wolverine Populations (Chapter 7) except with the nuance that those trappers involved in the core research management team who saw on the Ferendale Conservation Institute board saw the purpose of the project as serving the needs of the trappers, whilst other trappers believed the project to be serving the needs of the Ferendale Conservation Institute. Whilst in these cases there is no evidence of this creating any tension or disruption to the delivery of the projects, there is evidence that is did affect the way in which citizen scientists participated in the projects, resulting in their willingness to defer their own opinions, insights and interests in order to make way for the organisations'. However, within the Healthy Household Water (Chapter 6) project a multi-directional sense of service held by the researcher: project managers did lead to tension and conflict. Here there was evidence that the researcher: project managers desires to deliver opportunities and pursue lines of enquiry that were of interest and important to the community, led to conflict with the stakeholder clients who saw these programmatic interests as a risk to their own agendas. The stakeholder clients had such power over the research project that their interests were fulfilled rather than those of the community.

9.3.5 Perceptions of co-creation

Discrepancies in actors understanding about the nature of participation, collaboration, ownership and service within the projects raises questions about the success of some of the co-created processes. As mentioned in section 9.3.4 above there were contradictions in the perceptions that researcher: project managers and citizen scientists had about who the projects were intended to serve. In Protecting Our Waterways (Chapter 5) and in Conserving Wolverine Populations (Chapter 7) there were researcher: project managers and citizen scientists who both saw the project as serving the other actor group. So too were there contradictions in perceptions about the contributions that citizen scientists had made to the co-created process. For example, in the Protecting Our Waterways project (Chapter 5) whilst the researchers had made significant effort in designing an accessible

process in which the citizen scientists could genuinely participate in the interpretation of the research data, the citizen scientists did not recognise their own contribution in this way. They recognised that they had been involved in an activity that involved discussing the data and that they had presented these discussions to the scientists from the Natural Environment Agency, but they did not have a sense that this was a process of data interpretation or that it was a genuine contribution to the research process. They saw this process more as a public engagement opportunity. Building on from the reflections above (section 9.3.4) regarding the Conserving Wolverine Populations project (Chapter 7) where one of the trappers involved in the core management of the project viewed the project as owned by and serving the interests of Ferendale Conservation Institute, this trappers' understanding of the decision-making dynamics of the project was also skewed towards the researcher: project managers having control. He saw his role as sharing his knowledge and opinions, but that the researcher: project managers were the decision-makers; "…[Ferendale Conservation Insititute's] the boss, right? And we know that. And all we wanted to do was to give them our opinion, and whether they used it or not was their choice…" There was also some contradictions of understanding in the Noise Pollution in the Plaza project (Chapter 8), where Brendan (Cit) saw it that the researcher: project managers were the ones who would support the neighbour community in their difficulties with using the technology at home, whilst the researcher: project managers very firmly saw this as the community champions role and their value in the project. Whilst all of the case study projects worked very consciously and purposefully to collaborate and create shared ownership with the citizen scientists these differences in perception about the nature of contributions, governance and service in the projects, show that in some circumstances there has been a misalignment of understanding about the nature of partnership in the projects. Whilst this doesn't seem to have prevented the projects from achieving significant outcomes for the communities involved, it does highlight that there were some limitations to the communities' sense of ownership and validity in the projects. Citizen scientist's lack of awareness of their contribution to a co-created research process can be considered problematic on a number of levels, firstly, might the citizen scientists have behaved or interacted differently if they were aware that their contributions were genuine, secondly, can co-creation be considered successful if citizen scientists don't

have a sense of ownership over the process and outcomes, and thirdly, from a more philosophical vantage point, can co-creation be considered to have happened at all if one set of actors is unaware of their contribution to the process.

9.3.6 Summary

The examination of the concept of service from across the case studies starts to reveal insights in light of question 2 of this research: 'What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities who participate?' An interesting feature across the case studies is that they were initiated in all but one circumstance by research institutions, rather than by the communities. In the context of an exploration about how these projects might serve the communities that participated in them, the fact that the researcher: project managers in the partnership were the initiators and drivers of the project might be expected to reduce the potential to which the communities can be served. However, in all circumstances except for Healthy Household Water (Chapter 6) the researcher: project managers set out to purposefully deliver community-orientated objectives and succeeded in doing so. Interestingly again, in some scenarios, identification of the community-orientated objectives was done without the communities, with the communities having their own, separate, objectives and motivations for participation. Again this lack of mutuality and co-creation around objectives could be expected to lead to the projects not satisfactorily serving the communities, but there is no evidence of this being the case in the case studies. Where there was a lack of co-created objectives for the projects, however, the participating communities did not have a great sense of ownership over the projects, which in turn led to discrepancies between actors' perceptions about who the projects were intended to benefit. All this being said, in all five case studies benefits were achieved for all parties involved, including significant and satisfactory addressing of the communities interests and concerns, in all except the Healthy Household Water project (Chapter 6). So it seems that whilst initiation and objective setting influence the sense of ownership and service of communities, it does not influence the ability to deliver tangible action. However, at a more philosophical and fundamental level the extent of success in delivering a process of co-creation is brought into question where there is a lack of sense of ownership in the

communities, and discrepancies around perceptions of actor contribution and service. These discrepancies reveal an imbalance in the power sharing between the different actor groups, which is seen by many as a central tenet for more participatory research practices (Arnstein, 1969, Reason and Bradbury, 2012). These thoughts further add deliberation to the concept of mutuality of partnership in co-created citizen science, asking fundamental questions about which parts of these types of projects should be co-created and how. I now move on to introduce and discuss my first contribution to knowledge, the concept of mutuality and service.

9.4 Contribution to Knowledge 1: Mutuality and Service

The above explorations of insights from across the five case studies in relation to the concepts of participation, collaboration, relationships and service have helped to explore both research question 1 (How the concept of co-creation manifests itself in citizen science) and the sub-question 2.a) (To what extent are action outcomes realised for the communities participating in citizen science projects?). The research so far has revealed a great variation in the way in which co-creation manifests itself between actors in citizen science. Most significantly the case studies demonstrate that researcher: project managers can adopt different functional roles when offering programmatic support to communities, either facilitating, partnering or providing a process of research and engagement for the communities. The functional roles adopted by the researcher: project managers subsequently influence the citizen scientists' involvement in the governance of the projects. The research also provides examples of project initiation and problem identification being conducted by research institutions, which is contrary to suggestions in the literature that community science projects are initiated, and the focus defined by, citizen participants (Haklay, 2017). The researcher: project managers control over the initiation, problem identification and governance of the projects limits citizen scientists' sense of ownership over the project, but does not prevent projects from delivering benefits for them. The case studies also reveal that the partnership between researcher: project managers and citizen scientists can be built around a division of labour, rather than a shared delivery of contributions, and that the relationship between the two groups of actors works in a positive feedback loop with the ability to co-create the research. Finally,

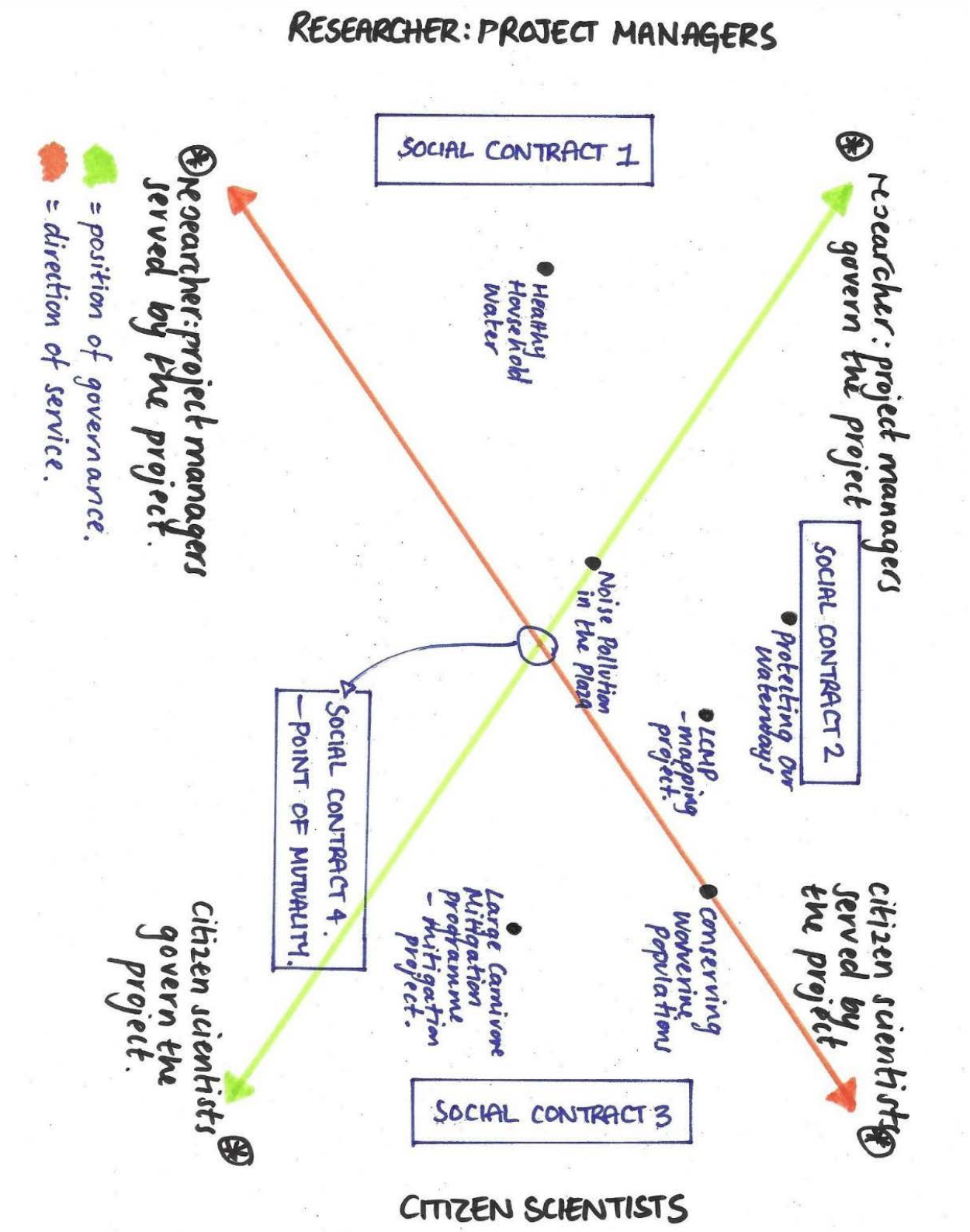
there was a notable imbalance in responsibility for the process of co-creation, with researcher: project managers being held responsible for both the organisations' and citizens' success in engagement. These insights from across the case studies drew me to question the existence of mutuality in co-created citizen science, predicated on the fact that there were differing senses of service and governance held by the actors across the projects, and what I saw as implicit notions of 'sharing' embedded within the concept of co-creation.

This bring us to my first contribution to knowledge, which rather than being concerned with citizens' participation in different stages of the scientific process, as many typologies are (Wiggins and Crowston, 2011), or the quality of participation in terms of excellence as Shirk et al. (2012) discuss, is instead concerned with the relational dynamics between the actors in processes of co-creation. Here I explore the variation of practices in co-creation in terms of the attributes of service and governance, discussing how these relational dynamics result in different social contracts between the researcher: project managers and the citizen scientists. I start by illustrating my conceptualisation of these dynamics as a 'Mutuality Saltire' where axes of service and governance intersect to reveal the extent to which projects are carried out with mutualism (section 9.4.1). I then go on to describe the way in which these relational dynamics lead to the existence of four different social contracts between the actors involved (sections 9.4.2 - 9.4.5), followed by an exploration of these ideas and their implications from the perspective of theoretical principles in the citizen science and participation literature (sections 9.4.6 – 9.4.9).

9.4.1 The 'Mutuality Saltire'

This research suggests that within the practice of co-created citizen science there are varying scales of service and governance between the researcher: project managers and the citizen scientists participating in the projects, and that this influences the amount of ownerships that actors have over the projects. Fig 9.1 illustrates a 'Mutuality Saltire' where two axes, one representing the direction of service and the other representing the access to governance, intersect to form a cross. These axes are orientated between researcher: project managers positioned on the left hand side of the saltire and citizen scientists positioned on the right hand side of the saltire, thereby representing a sliding

Fig. 9.1: The ‘Mutuality Saltire’.



X

Box. 9.1: Key of Social Contracts for Fig. 9.1

Social contract 1: In service of science (Section 9.4.2)

Project intended to benefit scientific institutions. Projects are designed and governed by the scientific institutions, with the citizens invited to support the endeavour through participation throughout the research process. The citizens are at service of the research institutions.

Social contract 2: Science-led citizen cause (Section 9.4.3)

Project intended to benefit communities. Scientific institutions provision a scientific process and govern the project in order to meet the objectives of the community. Citizens are invited to participate through the research process, facilitated and guided by the researchers. The researchers are at service of the citizen communities.

Social contract 3: Citizen-led citizen cause (Section 9.4.4)

Project intended to benefit communities. Citizen communities design and lead the scientific process and govern the broader project management, with the researchers providing programmatic assistance and technical expertise, as needed. The researchers are at service of the citizen communities.

Social contract 4: The point of mutuality (Section 9.4.5)

Projects seek to address objectives that meet the core needs and concerns of both the citizen communities and the research institutions. Both actor groups share the delivery and decision-making of the project and provide creative intellectual input throughout the research process. Neither party is at service of the other, with both receiving mutual benefit from the project.

scale between actors groups regarding who is being served and who is involved in the governance of the project. The saltire presents three segments that represent three different relational dynamics between the actors, which I refer to as social contracts and here I number them 1, 2 and 3. The point at which the two axes intersect I refer to as the 'point of mutuality', which represents a fourth relational dynamic and social contract 4.

Each of the case studies from this research have been mapped onto the saltire to tangibly illustrate how these different relational dynamics manifest, and to demonstrate the extent to which they exhibited mutuality. I now describe the characteristics of each social contract, discussing each in turn, along with which of the case study examples from this research, and examples that already exist within the academic literature, represent the social contracts.

9.4.2 Social contract 1: In service of science

In social contract 1 the primary goals of the research are intended to benefit the research institutions or government agencies that are involved in or funding the project. The citizen scientists' community may still gain benefits, but these are not the principle driver of the project and will not substantially address citizens' fundamental needs and concerns. Here the researcher: project managers have control over the governance of the project, both in terms of the scientific process and "the work that is necessary to design, establish and manage all aspects of a project" (Shirk et al., 2012) pg. 7). Citizen scientists may be consulted regarding different aspects of the project, but the decision-making power is held by the researcher: project managers. The researcher: project managers' high level of control over the project, and their position of leadership leads to a low sense of ownership amongst the citizen scientists who are participating. In designing and managing the project the researcher: project managers' relationship to the citizen scientists is, as discussed in section 9.1.1, one of providing a scientific research project for the citizen scientists to participate throughout. This social contract parallels with an instrumental philosophy of citizen science where science looks to deliver on its own needs, whilst providing science education opportunities for citizen scientists (Bonney et al., 2016b), out of an acknowledgement that it is necessary to give something back. With the projects' primary driver being to deliver outcomes for the research institutions and with the

researcher: project managers leading on the delivery and management of the project, the citizen scientists contribution to the project is one of service towards the researcher: project managers and the institutions they represent. In social contract 1 the contract is that citizen scientists will serve the needs of research institutions by offering their knowledge, skills and time, in exchange for some educational or experiential return. This is the same arrangement as is seen in contributory citizen science, except here the citizen scientists are participating throughout the whole research process, not just contributing data.

The Healthy Household Water project (Chapter 6) represents an example of social contract 1, in that it looked to deliver research insights for the stakeholder clients and not for the citizen community. In addition the stakeholder clients had complete control over the governance of the project. Citizen scientists were able to influence some of the decision making of the delivery of the research at the practical level, but they didn't make the decisions. Citizen scientists did receive benefits from the project, both intentional (public engagement opportunities with stakeholder clients as a give back to the community) and unintentional (changes in understanding and behaviour simply from engaging in dialogue around the project), but these benefits did not directly address the core needs of the community. Similarly, Jalbert (2016) describes the Three Rivers Quest (3RQ) programme in the U.S, that worked to amalgamate local-run watershed monitoring ventures. Whilst the watershed monitoring projects were all community run and delivered, the amalgamation of the projects through 3RQ created a relational dynamic that removed the governance and ownership of the data from the community, and controlled and used the data to serve its own priorities. The communities found that they were prevented from using the data towards locally-relevant action-orientated interventions. In this way the project shifted the power of the project from being decentralised and community driven, to being centralised and institution driven. In co-created citizen science projects that adopt a social contract like this science is looking to capitalise on the increased access to data that the citizen scientists can provided, as well as their local knowledge which can significantly influence interpretations and understandings of data (Corburn, 2007, Hoover, 2016). However, like with contributory citizen science approaches, this type of a social contract could be challenged for having neoliberal tendencies, through profiteering from

the voluntary contributions of the public, as discussed by Haklay (2017). Researcher: project managers need to take care to ensure that the sufficient and appropriate reward and value is returned to the citizen scientists who participate in the projects.

9.4.3 Social contract 2: Science-led citizen cause

In social contract 2 the projects are directed towards delivering outcomes for the community that are participating in the project, but the researcher: project managers have most control over the governance of the project. Here, like in social contract 1, the researcher: project managers are carrying out the work required to establish and manage the project (Shirk et al., 2012), but unlike social contract 1 they are doing so in service of the citizen scientists. In driving and leading the project the researcher: project managers' relationship to the citizen scientists is, as discussed in section 9.1.1, one of providing a scientific process for the citizen scientists to participate throughout, as instructed. Here the projects draw heavily on public engagement mentalities looking to purposively design a process which is accessible and enriching for citizen scientists. Here the social contract is that the researcher: project managers provision all aspects of a research project as a service for the community, in order for them to address a community concern. The citizen scientists simply have to participate throughout the scientific process and reap the rewards. Despite the fact that projects are set out to deliver benefit for the citizen scientists, their sense of ownership over these projects can be very low, due to their absence from the governance of the project. There can also be a presence of scepticism from the citizen scientists who don't understand why the research institutions would be making such investments at seemingly no benefit to themselves, leading to citizens' questioning of the scientists' true intentions.

Protecting Our Waterways (Chapter 5) is an example of a project that sits within the realms of social contract 2. In the Protecting Our Waterways project (Chapter 5) the researcher: project managers designed an engagement process that would enable the citizen scientists to participate in and contribute to several different stages of the scientific research process. The citizen scientists were a part of the research process but they were excluded from the governance of the project as a whole and therefore not aware of the decision-making and rationale behind many facets of the project. The project did

however successfully deliver on the citizen scientists' interests. The Large Carnivore Mitigation Programme (Chapter 4) mapping project is also an example of a project occupying the position of social contract 2 because it looked to deliver on the knowledge needs of the community, but several aspects of the governance and delivery of the project were handled by the researcher: project managers alone. That being said the Large Carnivore Mitigation Programme (Chapter 4) mapping project finds itself closer to the citizen scientists on the governance axis, because representatives of the local community were involved in decision-making for the focus, direction and closure of the project. A similar example from the literature is the 'Collaborative Science' program offered to the Virginia Master Naturalist's program, as described by Gray et al. (2015). The 'Collaborative Science' program provided a set of digital tools and resources to support the Master Naturalists in engaging in collaborative and co-created citizen science endeavours. The researchers designed and provisioned a structure for engaging in the development of research projects, and facilitated both the training and the engagement process itself. The projects were all developed in order to address issues, as identified by the naturalists, and the naturalists were provided with contact information for local experts who could further support their work.

Here along with in social contract 3 (described in section 9.4.4) the researcher: project managers are, as Wilderman et al. (2004) discuss in their community science typology, "service providers" (Wilderman et al., 2004, pg. 1) providing the scientific expertise and programmatic support needed by the community in order to deliver on their interests. However, here, unlike in social contract 3, the researcher: project managers are deciding how best those needs can be served, by having control over the design and management of the project as a whole. There are many practical reasons why this can be an appropriate and necessary way for co-created citizen science projects to operate; citizen scientists as volunteers are unlikely to be able to commit to such intensive processes as project design and management, they may also lack the confidence and some of the skills, experience or resources to contribute to such processes. However, this characteristic of social contract 2 could exist as a societal hangover of the 'deficit model' of public understanding of science, where there is an assumption that the 'lay' community are not equipped with the skills and knowledge to participate in such processes (Gregory

and Miller, 1998). Irwin (1995) argues that the public have a richness of knowledge and experience that is not recognised by scientific institutions. There are also challenges in this social contract in that the citizens may not participate in the identification and definition of the problem that is to be addressed. In the context of participatory theory this is highly problematic because the very idea and value behind 'science with the people, for the people' is that by participating in the identification and design of knowledge production processes the research can ensure a high relevance and an increased success for the communities (Irwin, 1995, Ashby, 2003, Turnhout et al., 2012).

9.4.4 Social contract 3: Citizen-led citizen cause

For social contract 3 the primary objective and purpose of the project is to deliver on a concern of the community, but in this social contract the citizen scientists lead the project having control over its governance, whilst the researcher: project managers role is to facilitate the citizen scientists in delivering scientific research by providing scientific expertise and programmatic support, as described in section 9.1.1. The project's focus on the community's needs and their control over the project means that they have a great sense of ownership over the project. In these scenarios the researcher: project managers are likely to contribute significantly to deliberations and discussions, but the citizen scientists make the decisions, either through their own sense of power and ownership or through the professionals holding back and making space for the citizens to do so. Whilst the citizen scientists' do have a great sense of ownership, the participation of the researchers is essential to the success of the project in that it fulfils some of the resource and science capital shortcomings of the citizen scientists. The researcher: project managers see themselves as at service to the citizen scientists and do not require benefits for themselves or their institutions in order to justify their contribution to the endeavour. In these cases the researcher: project managers are able to carry out this role because it is the core driver of their employment, providing a service to community entities.

The Large Carnivore Mitigation Programme mitigation project (Chapter 4) is an example of social contract 3, in that its entire purpose was to work directly with the community in order to address their conflict with large carnivores and it supported and facilitated the

community in leading and governing that process through which the change would be made. The researcher: project managers and their institutions did not receive any formal benefit or outcome from the project as their function was one of public service. In this project Thomas (PM) very purposefully employed engagement techniques that meant that the citizen scientists were in charge of the direction, innovation and decision-making for the project and the implementation of mitigations. Thomas (PM) and his colleagues facilitated these processes by providing the programmatic support required for the outcomes to be realised. The New York Sentinels programme, started in 2011, is a previously published example (Jalbert, 2016) of a co-created citizen science project that I would classify as an example of social contract 3. The New York Sentinels programme was established as a coalition of grassroots environmental advocacy groups carrying out baseline monitoring of watersheds. The programme is volunteer run and co-ordinated, both in terms of the scientific monitoring processes and the overall management of the programme, without outside experts brought in to assist the programme as and when required. That being said the programmes membership of the sierra club, later in its life, did begin to restrict the volunteers' governance and control over the project, shifting it closer toward social contract 2 on the mutuality saltire. In contrast to this Garcia and Brown (2009) describe a research project in a rural Colombian watershed where the communities' youth were involved in a participatory research project to address issues around access to clean water. In this project the collaboration was initially representative of social contract 2, in that the researchers governed and designed a project through which the youth could collaborate with them. The youth were heavily involved in the decision making around the research, but were facilitated in their engagement through the process. However, by the end of the project the relational dynamics had shifted to those akin to social contract 3, where the community had taken ownership for the governance of the project through locally-led action, and the professional researchers were there purely to provide training and technical support.

The involvement of the communities in driving and governing the projects is seen in participatory theory terms as highly appropriate as it actively shifts the power from, as Arnstein (1969) would describe it, the "powerholders" (Arnstein, 1969, pg. 216) to the "have-nots" (Arnstein, 1969, pg. 217). This process of emancipation is central to the

democratic theory behind much of the participatory research work out there (see (Arnstein, 1969, Irwin, 1995, Ashby, 2003, Reason and Bradbury, 2012, Chilvers and Kearnes, 2016). In this way social contract 3 could be seen as significantly embracing the ambition to balance power relations between science and society. However, reflecting on the opportunities that social contract 2 offers, it is important to consider Wilderman et al. (2004) comments that as the community take more control over the processes there is an increased need for organisational and technical support. Coupled with this need for more support from the researcher: project managers, is the matter that there is less opportunity for scientific outputs due to the focus on delivering community outcomes. In practical terms the research institutions offering these opportunities to the community need to have substantial resource and capacity, without much expectation for returns. Organisations whose purpose is to serve public needs, such as government institutions, are more likely to be aligned to this kind of work.

9.4.5 Social contract 4: The point of mutuality

Social contract 4 represents the point of mutuality on the saltire. Here the sense of service is dissipated by the equality of investment and benefit for both the citizen scientists and the researcher: project managers. Here instead of one actor or another seeing themselves as at service to the other, both sets of actors are united around a common goal that is mutually beneficial. The impact of the goals is something that addresses core and priority needs and concerns of both of the actors. Governance of the project is shared at all levels, with decision-making taking place with the genuine participation of both sets of actors, where both have the same level of influence over the decision-making process. The shared goals and shared governance leads to a collective ownership of the project and a sense of solidarity and equality in the endeavour. In this social contract because the decision-making and actors' contributions to the project are more equal there is more intellectual co-creation than in any of the other social contracts, with collective creativity permeating throughout the project (Sanders and Stappers, 2008, Sanders and Simons, 2009). The closer a case study is positioned to one of the axes, or to the point of mutuality, the more mutuality there is between the actors.

None of the case studies examined in this thesis would be considered as directly occupying the point of mutuality on the saltire, as none of the case studies had both a balance of service and of governance, thereby rendering this social contract as theoretical. Conserving Wolverine Populations (Chapter 7) and Noise Pollution in the Plaza (Chapter 8), however, both occupy central positions on the axes of governance and service, respectively, and are therefore useful examples to consider in relation to the concept of mutuality. Conserving Wolverine Populations (Chapter 7) is an example of a project in which the primary driver of all the actors was in the delivery of outcomes for the citizen scientists. Ferendale Conservation Institute saw the project as being the trappers' project with them offering technical, financial and organisational support to deliver on the trappers' objectives. However, the governance of the project was shared very equally amongst both groups of actors, with the objectives, philosophy and direction of the collaboration, the research itself and decision-making about the dissemination and sharing of the research outcomes being decided by both trapper representatives and the researcher: project managers as a single research management team. Hoover's (2016) case study describing Community Based Participatory Research around epidemiology in a Mohawk community in the U.S, would occupy a similar position to the Conserving Wolverine Populations case study described in Chapter 7. In this example the community initiated the project and then set the ground rules for the researchers' engagement with the community, maintaining power around decisions regarding what data would be collected, how, and how it would be used. The community were also employed as field researchers, thereby actively conducting the research themselves. Whilst at the same time the professional researchers held power over the analysis and distribution of the data and findings. In this way the governance of the project was somewhat shared between the two actors groups. However, rather than occupying social contract 4 in entirety, the Mohawk epidemiology project was almost entirely set up to deliver outcomes for the Mohawk community. The researchers were looking, to some extent, to advance their careers through the project, but the primary motivation and driver for the project was to deliver benefits for the community.

In contrast to the two examples in the paragraph above Noise Pollution in the Plaza (Chapter 8) comes much closer to delivering substantial outcomes for both parties

involved. It takes a position very close to the point of mutuality on the saltire because it serves both the needs of the researcher: project managers and the citizen scientists, whilst inviting citizen scientists to contribute to substantial amounts of the governance of the project. In terms of a mutuality of service the project sets out to deliver research outcomes for the researcher: project managers by setting out to develop and test a citizen sensing methodology, whilst also looking to directly impact on a matter of community concern. Interestingly the mutuality here isn't around the same outcome, but the process utilised serves both actors' core needs and interests. In terms of governance the researcher: project managers share a significant amount of decision-making with the community champions around the identification of the problem to be addressed, the design of the citizen sensing methodology and the innovation around the public interventions, but the researcher: project managers design the processes of engagement and make decisions about the direction of the project as a whole, independently of the citizen scientists.

An interesting case study published by Corburn (2007) demonstrates how the power over and purpose of a project can shift throughout its lifetime. Corburn (2007) describes a case in Brooklyn, New York, where the Environmental Protection (EPA) looked to conduct a "Cumulative Exposure Project" (Corburn, 2007, pg. 151) in a community who has some of the worst health records for the city, and who were exposed to some of the highest levels of environmental pollution. The EPA approached the community with their research objectives and methodologies, but very quickly the community intervened in the EPA's plans, highlighting environmental risks that the EPA were unaware of, and methodological challenges posed by the EPA's plans which would undermine the quality of the research. The EPA's responsiveness to the communities' compelling knowledge and insights shifted the project towards a participatory research endeavour with the community having increasing amounts of influence and involvement in the governance of the project, and shifting the objectives of the project to one's more relevant and pressing to the communities' needs and risks. The project therefore shifted from not being participatory research, towards a position of mutuality, with shared benefits for both actor groups, and increasingly shared governance as the project progressed.

Whilst much participatory theory discusses shifting power over to those without it, Ashby (2003) when discussing participatory theory in natural resource management research and development, refers to notions of “collective enterprise” and “joint management” evoking a sense of sharing and mutuality between actors. In a scenario where a project would occupy the point of mutuality on the saltire there would be a complete balance of power between the researcher: project managers and the citizen scientists, without one holding any more power over the process than the other. However, power is a highly pervasive thing that operates through a multitude of both conscious and subconscious factors. The complexity of power relations, which an exploration of is outside of the realms of this thesis, may make it impossible for a true balancing of power and arrival at an absolute point of mutuality, leaving it as a participatory utopian dream. That being said both Conserving Wolverine Populations (Chapter 7) and Noise Pollution in the Plaza (Chapter 8) demonstrate that certain levels of mutuality can be achieved, and the relational transformations that are achieved through progress towards mutuality set the foundations for more mutuality to be built. Certainly in the Conserving Wolverine Populations project (Chapter 7) a relational precedent has now been set that means that the trappers and researchers at Ferendale Conservation Institute continue to collaborate, drawing on each other’s expertise and strengths to continue to realise each other’s goals. The difference between this social contract and the other three social contracts is that here, there is an absence of a sense of service from one actor to another. This is a reframing of the social relationship between citizens and scientists in society, and is akin to what Ashby (2003) describes as a reframing of our relationships with nature where we are starting to dismantle the concepts of ‘other’ and reconstruct our sense of the same.

9.4.6 Trends in service and governance of co-created citizen science

Having provided suggestions of where each of the case studies, constructed for this research, would be positioned on the ‘Mutuality Saltire’, it is now interesting to reflect upon the distribution of these cases as they are mapped. Of the five case studies the two case studies that occupy the realms of social contract 1 and 3 are the two case studies that may not be strictly referred to as citizen science. Healthy Household Water (Chapter 6) was a social science research project, rather than a natural science researcher project

and involved the participation of paid community researchers as opposed to voluntary citizen scientists, and the mitigation project within the Large Carnivore Mitigation Programme (Chapter 4) did not involve the ranchers in a scientific process at all, but an innovation process. These two projects therefore sit at the boundaries of what might be considered citizen science. It is therefore interesting that they should represent the social contracts at either end of the service: governance spectrum. The remaining projects all occupy or sit at the boundary of social contract 2 and would all be confidently labelled as citizen science, focused on natural and physical sciences, and involving volunteers in a process of science. This suggests therefore that co-created citizen science processes, in the strictest sense, may be more inclined to adopt social contracts where the projects deliver on the core concerns of a community, but where the researcher: project managers lead, drive and manage the projects. Rather than being a symptom of practical or technical possibilities, I would argue that this is akin to Haklay's (2013) suggestion that citizen science challenges science's cultural capabilities. I say this because examples such as the Large Carnivore Mitigation Programme mitigation project (Chapter 4) and numerous cases in the participatory research literature demonstrate that relational dynamics such as those represented by social contract 3, where the communities lead and the professionals facilitate and support, are possible, see for example Ashby (2003). Instead it is likely to be that the more participatory citizen science practices become, the more scientific institutions are challenged to open their mind to the possibility of what citizens can offer professional and technical processes (Irwin, 1995).

Having explored the characteristics, opportunities and limitations of the four different social contracts across the 'Mutuality Saltire' I now summarise and highlight trends from across the saltire in its entirety. As paralleled by Wilderman et al. (2004), Bonney et al. (2009), Wiggins and Crowston (2011) and Shirk et al. (2012) the way in which citizens are involved in citizen science processes is influenced by the purpose and intended outcomes of the projects. I add to this argument that cultural and resource implications additionally influence the way in which citizens are invited to participate in citizen science. The more that a project moves towards the citizen scientists having governance over the project, the more resources are needed to facilitate this scenario (Wilderman et al., 2004). Yet, the more control the citizen scientists have over the governance of the project, the

more ownership they have over the project. Shirk et al. (2012) suggested that the more engagement that citizens had in the science the more ownership they had over the knowledge that was produce. I would argue that it is in fact the engagement in the governance of the process that influences citizens' ability to take ownership for the outcomes. In terms of service, the more a project sets out to deliver benefits for a community the more likely it will be able to do so, however the extent to which benefits are delivered for a community are influenced by how central the communities' objectives are as a driver for the project. Also it can be expected that the more communities have governance over the process that is intended to deliver outcomes for them, the more relevant and successful those outcomes will be (Irwin, 1995, Ashby, 2003, Turnhout et al., 2012). However the data here did not provide evidence to support this assertion. The more that projects are established as in service of the community the less opportunity there is for scientific outputs. It is also important to recognise that projects are not fixed in a static position on the mutuality saltire, but can be expected to shift along the dimensions throughout the life of the project. Certainly projects such as Protecting Our Waterways (Chapter 5) and Conserving Wolverine Populations (Chapter 7) described an increased openness to citizen scientists' inputs as researcher: project managers began to recognise the value of their knowledge and insights. Finally, there is a third dimension that influences the amount of mutualism in a citizen science project, which is too dynamic to map onto the mutuality scale, and that is the matter of perception. Differing perceptions of the relational dynamics between citizen scientists and researcher: project managers can be seen as another scale of mutuality. Where the citizen scientists and researcher: project managers perceptions of the relationships are in alignment, there is a more mutual understanding of the relationships, where they are significantly different as in Protecting Our Waterways (Chapter 5), there is less of a mutual understanding.

9.4.7 Implications for the conceptualisation of co-created citizen science

Wiggins and Crowston (2011) highlighted that most typologies focus on the extent to which citizen scientists participated in the scientific process, in order to delineate different types of citizen science, but that this was limited because it missed considerations of other macrostructural and organisational factors that might influence the way in which

citizen scientists participate and the outcomes that could be achieved. Shirk et al. (2012), when building on the typology of public participation in scientific research, also impressed that it wasn't enough to only think about the 'degree of participation', because 'quality of participation' was more influential in determining the outcomes of citizen science. I further contribute to this line of argument by suggesting that thinking about citizen science in terms of the extent to which citizen scientists participate is limited because even within a single model of citizen science, such as co-created, this research demonstrates that there is huge diversity in the way that public participation manifests, and that this diversity can be understood in terms of relationship dynamics. These relational dynamics, in turn, lead to a diversity of potential outcomes and benefactors, ranging from science-orientated to community-orientated. So where this has been considered a characteristic and trend associated across the typology of Public Participation in Scientific Research, with contributory citizen science best placed for delivering scientific outcomes and co-created citizen science best placed for delivering community outcomes (Bonney et al., 2009, Shirk et al., 2012) this research reveals that such trends exist within the practice of co-created citizen science too, depending on who the practice is applied to serve. More clearly expressed, the inclusion of citizen scientists in the whole of a scientific research process from question identification through to dissemination of findings, can be utilised to serve either the needs of science or the needs of communities.

This research reveals that one of the ways in which a focus on the extent of participation fails is through not explicitly considering and addressing matters of governance of the research. In Bonney et al. (2009) and Shirk et al. (2012) the notion of control is mentioned in relation to the typology of Public Participation in Scientific Research to highlight the fact that as citizens become increasingly involved in the scientific process they will not only have more influence over it, but also may have some opportunity to participate in decision-making. However a detailed dissection of the way in which governance might be shared between actors is outside of the realms of Bonney et al. (2009) and Shirk et al.'s (2012) work, and due to the light mention of control in relation to the typology the concept seems to have been lost behind a focus on which stages of the research process citizens participate in (pers obvs). Wilderman et al.'s (2004) typology of community science, which was a precursor to the Bonney et al. (2009) typology, explicitly utilised the notion

of control to determine the difference between approaches to community science. Here there is more of an explicit emphasis on who defines and designs the process through which the research will take place, but the emphasis of control is still focused on the scientific process and the conclusion in terms of typifying different practices of citizen science parallels the Bonney et al. (2009) typology of Contributory, Collaborative and Co-created citizen science. In my research here we see that the dynamics of governance have even more nuance influencing a diversity of modes of collaboration within the practice of co-created citizen science. These diversities of governance mean that just because a co-created approach has been adopted does not mean that it is necessarily highly participatory in nature, because citizen scientists can be involved throughout the process of scientific research without having very much influence over the direction and decision-making of that research at all.

9.4.8 Utilisation of the 'Mutuality Saltire'

Having established the dynamics of the 'Mutuality Saltire' and the implications that this has for our notions of co-created citizen science, I now discuss its utility suggesting that this contribution should not be adopted as another typology for categorising practice, but rather a framework for reflecting on relational dynamics and establishing social contracts between actors. As with the complexity of defining citizen science (Ceccaroni et al., 2017, Eitzel et al., 2017), so too do typologies suffer from being limited in their ability to accurately represent the diversity and nuances of practice. Whilst their limitations are recognised, due to the human satisfaction of neatly categorising natural and social phenomena in clearly defined boxes, we readily adopt typologies all the same. In doing so we can become overly focused on one set of dimensions of practice, losing consciousness of other facets, as with the focus on 'extent of participation' discussed above (section 9.4.7). I therefore do not offer this contribution to knowledge as a typology but as a framework that can be used to reflect upon and negotiate social contracts between citizen scientists and researcher: project managers. Further to this I would like to emphasis as Haklay (2018) does that there should be no value judgements placed on different positions of the saltire, as all have their different merits, weakness and utility. It should also be reiterated that few projects are likely to adopt one position on the saltire,

as throughout the life of a project dynamics shift and change. Equally, the position of a project on the saltire is highly subjective, based on the perceptions of different individuals who have either experienced, or in my case retrospectively examined, the case in question. These factors add further merit to the idea to utilise the saltire as a reflective framework, rather than a typology.

The saltire can be adopted as a tool for utilisation in the establishment of projects, as a discussion tool and point of negotiation between prospective partners looking to generate a shared understanding about what social contract they wish to establish with one another. Barreteau et al. (2010) describe how establishing a shared understanding of what is to be expected from a project before it even begins is highly important for ensuring success in partnership and advocacy and advancement for participatory practices. They offer a detailed and thorough framework for mapping the nature of the collaboration between partners throughout a participatory process that can be used to establish a shared understanding of what is to be expected at the beginning of a project, as well as to formatively evaluate the evolution of the project against those original expectations. In this way the 'Mutuality Saltire' can also be adopted as an evaluation or research tool, where project partners or researchers want to formatively or summatively assess where a project is operating along the dimensions of service and governance.

9.4.9 Summary

My first contribution to knowledge, directly responding to my first research question "How does co-creation manifest in citizen science?" establishes that within the practice of co-created citizen science there can be a great variety of partnerships between citizen scientists and researcher: project managers, determined by concepts of service and governance. Co-created citizen science projects can significantly serve either scientific or community interests and actors notions of service influence their motivations and expectations of what a project is going to deliver. Furthermore the concept of governance is not paid enough attention in the practice of citizen science and should be considered not just in terms of governance of the scientific process, but also governance of the projects as a whole, inclusive of all the 'activities' (Shirk et al., 2012) necessary for delivery a project. The extent to which citizen scientists contribute to the governance of a project

has a significant influence on their sense of ownership over the project, its outcomes and its benefits. This contribution to knowledge has established that different nuances of partnership will predominantly serve the interests of different actors, thereby developing insight for question 2 of this research 'What is the link between the co-created citizen science processes and the ability to deliver action outcomes for the communities that participate?' It has not, however, established the relationship between co-created practice and action outcomes themselves. So I now turn back to the case studies of this thesis to examine the relationship between different facets of the case study projects and their ability to deliver action outcomes.

9.5 Delivering action

In order to understand the second research question of this thesis, "What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?" the research look to unpick two sub questions; a) "What is the link between co-created citizen science processes and action outcomes?" b) "To what extent are action outcomes realised for the communities participating in the citizen science projects?" Question b) has already been established in sections 9.3.1 and 9.3.2 above, where I reveal how regardless of the relational dynamics, who initiated, or who the intended beneficiaries of the projects were, the citizen communities gained benefit from all five projects. However, where the projects were not intended to deliver benefits for the community, as in Health Household Water, the community's core concerns were not addressed. In the four other case studies substantial progress and change was made in addressing the interests and concerns of the communities. Whilst so far I have been able to ascertain the extent to which the communities had their concerns addressed by the project, I have not yet ascertained the link between the co-created citizen science process and the outcomes. Through this section of the discussion I draw together insights from across the case studies to explore the influence of different elements and actors in the co-created citizen science processes on the ability to deliver action outcomes. I start by returning to the definition of action, situating this in the context of the case studies, in order to appropriately frame the subsequent findings. I then explore the role of science, the role of co-creation, and the role of researcher: project managers,

citizen scientists and the government in achieving action through such projects. I finally consider a broader perspective of the impact of research interventions of any nature, on communities, before summarising the findings in relation to research question 2.

9.5.1 Defining the concept of action in the five case studies

I adopted an activism-orientated definition of action for the purposes of this research (Chapter 1, section 1.3.2) and found that in four out of the five case studies the co-created research projects had successfully resulted in positive change around a concern of the communities who were participating. The concept of action is an intangible concept with many different meanings for different people, but in the context of this research I adopted an activism-orientated definition due to my pursuit of this research being inspired by my prior experience as a citizen science practitioner and community activist. I therefore position my definition of action for this purpose as "doing something in order to have a positive impact or influence, or to make positive change, around a concern or problem." This definition absorbs a relatively wide range of potential outputs from citizen science providing that the outputs have a positive impact on the concern that is trying to be addressed. For example, knowledge-orientated outcomes which might ordinarily be considered as not action-orientated, are included in my definition of action if that knowledge creates positive change around an issue that the research is trying to address. Within the case studies this means that any outcomes that are produced as a result of the projects, that have a practical influence on the concern of the project, are considered action. In the case of Noise Pollution in the Plaza (Chapter 8) and the Large Carnivore Mitigation Programme (Chapter 4) the outcomes of the project were entirely tangible reductions in the noise pollution levels and large carnivore conflict incidences that the community were facing and are therefore considered action outcomes. In the case of Protecting Our Waterways (Chapter 5) and Conserving Wolverine Populations (Chapter 7) the outcomes were both knowledge-orientated, but in both cases these knowledge outcomes successfully fulfilled concerns that the project was focussed on; a lack of an environmental health assessment for the Protecting Our Waterways project (Chapter 5), and an absence of respect and recognition for the trappers' knowledge of wolverine ecology. The Healthy Household Water project (Chapter 6) is more complicated in that

the outcomes of the project were knowledge outcomes, through the establishment of an understanding of the relationship between communities and their private water supplies, but this knowledge did not change that relationship, but instead was taken to influence policy around private water supplies, but the case study is not able to reveal in what ways. Relying on the evidence that the case study provides I evaluate, in this case, that action outcomes were not delivered, however, action and change was delivered within the community in unintended ways, simply through the communities' dialogue around the project. I now examine from the data provided by the case studies what role different factors played in delivering these action-orientated outcomes.

9.5.2 Role of science and data in delivering action

Science is a tool that can be utilised for action making but is not always a solution. The case studies revealed a number of different ways in which science and data supported the projects and the communities in addressing the community concerns, ultimately revealing that science was not always the solution to the problem in these projects, but, was often a tool through which change could be leveraged. Science and data were an important way of generating knowledge and evidence, but whether or not that knowledge resulted in action was often dependent on a broader range of socio-political factors. Where the answer to the problem was purely the establishment of knowledge, so for example with Protecting Our Waterways (Chapter 5) the community wanted to establish the environmental quality of their local waterway, then the collection of data was the solution to that problem as it filled the knowledge deficit. Here the role of data was one of understanding. Similarly, for Conserving Wolverine Populations (Chapter 7) the trappers concern was to demonstrate the limitations of scientific understanding of wolverine ecology, by establishing their own knowledge as accurate, and so it was scientific data that was the solution, as it provided the validity to the trappers' observations. Here the data was one of validation. However, where the focus was around changing something more tangible, such as reducing noise pollution in the case of Noise Pollution in the Plaza (Chapter 8), or, reducing large carnivore conflict in the case of the Large Carnivore Mitigation Programme (Chapter 4), then science and data could only be used as a tool. In both Noise Pollution in the Plaza and the Large Carnivore Mitigation

Programme (Chapter 4) mapping project the idea was that by collecting data that could quantifiably and objectively demonstrate the extent of problem, the communities would be in a position to leverage action and change with the government. In these circumstances the data needs to be accepted as valid and then negotiated with a number of other economic and political drivers, in order to create change. In these two circumstances the role of the data is one of objective and quantified evidence, which was used in an attempt to resolve disputes about the reality of the problem.

The case studies revealed two dominant reasons why science is limited in its ability to create change; firstly, due to its openness to criticism and disputes around the validity and accuracy of data and secondly due to the power of competing political and economic drivers. This brings us back round to the original conversations about the science:society relationship discussed in the literature review (Chapter 2, section 2.6) where I discussed how science's cultural position as the objective and reliable powerhouse of knowledge and societal solutions, in actual fact finds itself in many public disputes around the relevance and impact, once the findings make their way into the public sphere (Irwin, 1995, Ashby, 2003, Jasanoff, 2003, Turnhout et al., 2012, Chilvers and Kearnes, 2016). In civic society the acceptability and adoptability of scientific 'fact' is determined not by the rigour of the scientific method, but by the recognisability of those facts to the lived experience of the 'lay' public, and by the economic and political implications of the findings. Furthermore, even within the practice of science there is a limited ability for science to reveal truths, as different scientific studies can provide competing results around a scientific question or problem.

9.5.3 Role of co-creation in delivering action

Through the case studies co-creation has been found to deliver action outcomes either through the qualities of the process or through the outcomes of the process. In terms of qualities it was the ability of co-creation to integrate different knowledge systems and to build supportive working relationships that enabled the delivery of action outcomes in the case studies. In the Conserving Wolverine Populations project (Chapter 7) the amalgamation of scientific and lay expertise was able to validate the trappers' knowledge, and fulfilled the trappers' need for the recognition of a different understanding of wolverine

ecology. In Noise Pollution in the Plaza (Chapter 8) several different types of expertise were brought together through the diversity of volunteers participating and the mixture of internal and external professionals who contributed to the project. This diversity of knowledge and expertise meant the project could explore, suggest and enact a much wider range of solutions and interventions for the noise pollution problem. The ability to intertwine different knowledge systems and the capacity to deliver action is predicated on the ability to develop positive working relationships. In the Large Carnivore Mitigation Programme (Chapter 4) and Conserving Wolverine Populations (Chapter 7) whilst developing positive working relationships didn't directly lead to the outcomes of the project, it was highly influential in delivering success. In both cases mutual working relationships were fostered by a recognition, from both sides, of the value of the other partner and an ability to harness that value, leading to high quality innovation and research, which delivered impactful outcomes for the communities. In the case of Protecting Our Waterways (Chapter 5), improving the relationship between the Natural Environment Agency and the community was a core action objective of the project. Delivering a co-created process which involved developing positive working relationships was in itself a delivery of that outcome.

The social outcomes of co-creation also contributed to the ability to deliver action outcomes, both in terms of increasing the communities' sense of agency and in the way that it increased the relevance of the research processes to the communities'. Community agency was a critical part of whether or not action and change could be created around the issues that were challenging the communities. In fact a lack of community agency was often the reason why the problems existed in the first place. In both the Noise Pollution in the Plaza (Chapter 8) and Large Carnivore Mitigation Programme (Chapter 4) the community had a lack of agency in being able to tackle the problems they were facing because the government held the powers that influenced the problem. Furthermore the communities were not organised in a way that could adequately tackle the problem nor did they have sufficient social capital. Through the knowledge and management support provided by the researcher: project managers through the co-creation process, community agency was increased, providing them with tools and access to networks that meant they could either directly implement solutions,

or gain the leverage to push government to make the change. Co-creation also increased the relevance of the research processes and the subsequent outcomes to the communities. In Noise Pollution in the Plaza (Chapter 8) the fact that the citizen sensing methodology was co-created with the community champions ensured that the tools and methods utilised would be appropriate for the neighbour community, and thereby underpinned the success of the project.

9.5.4 Actors contributions to delivering action

Researchers, project managers and citizens' contributions to delivering action could only be understood in terms of what they contributed to the co-creation process. There are no anecdotes across the narrative interviews that suggest that an individual actor directly delivered an action outcome, instead all discussions about how different actors contributed are about how they contributed to the process of co-creation and partnership, and then how that subsequently delivered outcomes. Therefore the contribution that different actors made to the delivery of action was the contribution and value that they brought to the co-created process. In terms of the researcher: project managers this was the scientific expertise, the participatory methodologies and the organisational support (section 9.1.1). The value of these was critical in all the projects, since the researcher: project managers were often the leaders and drivers of the process (section 9.3.1 and 9.3.2) and central to the existence of the project at all. Very fundamentally in terms of the relationship between the researcher: project managers and the citizen scientists, the researcher: project managers fulfilled the gaps in capacity that the citizen scientists had, in order to address the problems they were facing. Interestingly, one of the contributions of the citizen scientists was also to increase capacity and resource, but rather than this being financial, technical or professional networks, it was in human resource capacity and connectedness to communities, increasing the scale and depth at which data could be collected (section 9.1.2). Furthermore, the citizen scientists' knowledge was seen as a highly valuable contribution to the research and innovation processes conducted by the projects, increasing the quality of the processes that were carried out and providing alternative understandings and perspectives that the scientific community would never arrive at. What this achieved was research processes that could more adequately

address the problem of focus and research outcomes that were more relevant and meaningful to real world situations. What these insights reflect is that within a co-created process the contributions of the different actors are complimentary, fulfilling the limitations and weaknesses of the other, in order to increase the quality of the research process and outcomes.

There are two other groups of actors that need to be mentioned here regarding their contribution to the ability to create action; the media and research clients. Firstly, the media were seen as very powerful agents for change within the Noise Pollution in the Plaza and the Conserving Wolverine Populations (Chapter 7) projects. In Noise Pollution in the Plaza the attention of the media to the project was seen as highly influential in putting pressure on the government to deliver change. In Conserving Wolverine Populations (Chapter 7) the media was also seen as a useful agent through which the trappers could improve their public relations profile, but whilst there was some positive press for the trappers there was also a frustration from the trappers at the media's limited interest in promoting their story. Secondly, the Healthy Household Water project (Chapter 6) presents an interesting scenario in that the stakeholder clients who governed the project and for whom the project was supposed to serve, prevented the ability for the project to address concerns and interests of the community, such as problems with landownership and a desire to be able to measure water quality at point of use, out of a concern around being involved in conflict.

9.5.5 Role of government in delivering action

There was a problematic relationship between the government and the projects in these case studies, in that the government had a critical influence on whether action could or couldn't be delivered, but were outside of the co-creation process. The starting point for exploring the role of government is to recognise that, in two of the case studies, government policy was seen as the source of the problems the community were facing. In the Large Carnivore Mitigation Programme (Chapter 4) a number of historic policy decisions had led to an increased population and presence of large carnivores and a reduced ability of the ranchers to manage the conflict themselves. Whilst in the case of Noise Pollution in the Plaza (Chapter 8) it was the historic lack of recognition and

response regarding the problem that had left the neighbours with decades of poor living conditions. Even where government wasn't seen as a source of the problem citizen scientists' attitudes towards the government were poor, holding the government with a lack of trust and a lot of scepticism. Interestingly, whilst the relationship between citizen communities and governments were poor, it was government funding that enabled the existence of each of the five projects, either through public funding issued to research and public agencies, or through specific funded research programmes that addressed policy interests (section 9.3.1). In fact, the Protecting Our Waterways project (Chapter 5) was set up as a direct response to public complaints about the inadequate services government agencies were providing. So whilst there was bad blood between the government and communities, the government had a hand in the ability of the communities to address problems and deliver outcomes. However, despite funding the projects and having the power, as policy-makers, to address the problems and challenges the community were facing, in all but the Noise Pollution in the Plaza (Chapter 8) project, there was no evidence of policy responses as a result of the projects. In Noise Pollution in the Plaza (Chapter 8) there was direct evidence of policy being written and implemented by the local council in order to mitigate noise pollution in the community, in fact this marked the significant success of the project. In the other four cases however, there was either an absence of government policy (as in Large Carnivore Mitigation Programme - Chapter 4), an absence of awareness of the governments' response (as in Healthy Household Water - Chapter 6), an assumption that the government would respond in a way that was favourable to the community (as in Conserving Wolverine Populations - Chapter 7) or an absence of comment about government responses at all (as in Protecting Our Waterways - Chapter 5). This highlights to me a very problematic relationship between the government and the projects, in that the governments demonstrate an interest in addressing problems faced by communities by providing funding, but do not engage closely enough with communities to be able to adequately support them. With the value and power that co-created processes offer there seems to be a missed opportunity that the government aren't a more integral part of these co-created processes.

9.5.6 Broader impacts of community research interventions in communities

Community research interventions, whatever manner they take, are vehicles for change in their own right, only limited by their longevity and philosophy of engagement. One of the observations that I made in Healthy Household Water (Chapter 6) and the Large Carnivore Mitigation Programme mapping project (Chapter 4) is that citizen science and even co-created citizen science processes are not necessary for creating action. In the cases of Health Household Water and the Large Carnivore Mitigation Programme mapping project (Chapter 4), the mere existence of the project was enough to stimulate action, in that the projects elicited dialogue within the community about the issues, challenges and solutions, and in turn increased awareness which led to behaviour change. Where the role of co-creation is discussed above (section 9.5.3) as contributing to the building of community and increases in social capital that can deliver action, we also see how productive dialogue alone can create action and change. Any sort of positive and constructive engagement between research institutions and communities therefore has the potential to influence change. What I also reflected across the case studies is the idea that co-created projects can be considered as processes of action, in their own right. The extensive inclusion of non-scientists and different knowledge systems in the process of knowledge making reflects a process of social change. These processes fundamentally change the relationships between science and society and build capacity within communities for self-governance and emancipation through empowerment and increased agency.

One of the notable limitations of the case study projects, for the communities, was the longevity and legacy of working with research institutions on fixed-term projects. The Conserving Wolverine Populations (Chapter 7) and Large Carnivore Mitigation Programme (Chapter 4) projects maintained a longer-term relationship with the communities they were working in, with active projects of more than five years. The Large Carnivore Mitigation Programme (Chapter 4) is still on-going and the trappers continue to work and collaborate with Ferendale Conservation Institute even after the Conserving Wolverine Populations (Chapter 7) project has finished. Noise Pollution in the Plaza (Chapter 8) also reflected that the project had led to extended professional networks where community champions had gone on to work for, or volunteer further with, organisations that had been involved in the project. However, there was a sense amongst

the citizen scientists that all five projects needed to be longer, or have a greater scope. Citizen scientists had more research questions they wanted to address, felt like the impact of the project could be beneficial to a wider range of communities if expanded, and/or had not yet seen a complete resolution of the problem they were facing. This provides an important reflection on the limitations that research projects have on working with communities. They often have a limited period of funding and therefore a limited opportunity to work with a community. Whilst communities are very aware of this reality, it does not negate from the fact that their research needs and interests cannot be fully satiated through the existing research funding culture.

9.5.7 Summary

By exploring the link between different facets of the case study projects and the action outcomes that were achieved through these projects, and drawing in insights from the exploration of service in section 9.3, we are provided with a number of insights around question 2 of this research: “What is the link between the process of citizen science and the ability to deliver action outcomes for communities?” This is explored through two separate sub questions: What is the link between co-created citizen science processes and action outcomes? And to what extent did the case study projects deliver action outcomes for the communities who participated? I found that, across case studies, outcomes were delivered for all actors groups, with the communities’ concerns significantly addressed in all but the Healthy Household Water case study (Chapter 6). It was found that the process of science was a useful tool that could provide understanding and objective quantification and validity of knowledge which in some cases would directly address community concerns, but when looking to create tangible change it was limited due to the need to navigate political and economic drivers. Co-creation was found to deliver action both through the characteristics of the process and the outcomes of the process, in that it led to an amalgamation of knowledge systems, positive working relationships between science and society, an increase in capacity for research and innovation, and it empowered communities by increasing their agency. Governments were found to be a key influencer of the ability to make change and yet largely absent from the co-creation process. Whilst providing the funding critical for delivering the five

projects presented in the case studies there seemed to be an absence of policy-making in response to the projects. Finally, the process of co-creation can be seen as an action in its own right, transforming the relationship between science and society and increasing the societal capacity to create action and change. The insights garnered around the ability to create action through co-created research processes bring us to my second contribution of knowledge which discusses three different relationships between co-created citizen science processes and the ability to create action, which I outline and discuss in section 9.6.

9.6 Contribution to Knowledge 2: Three pathways of co-creation and action

Section 9.5 above has established that co-created citizen science processes are able to deliver action outcomes in a number of different ways, either through their characteristics, their outcomes, or by the very act of co-creation itself. Here in the second contribution to knowledge I set these findings into a broader context of the utilisation of co-created citizen science processes, emphasising that where co-created research processes are adopted in order to deliver action outcomes, projects need to have an awareness of the pathways through which action can be affected, in order to ensure they appropriately utilise the approach. In doing so I offer three models of the relationship between co-creation and action that will help practitioners to appropriately utilise the process of co-creation. First I discuss the theoretical context and the gap in knowledge, to which this contribution is made, before introducing and describing the three models in turn, illustrating each with case study examples from this empirical research and the wider literature. I then discuss the influence of science and government on these processes, before discussing the implications for practice.

9.6.1 Understanding co-creation as an action-orientated tool for citizen science

The ability to deliver action-orientated outcomes is widely established within the academic literature as being most successfully delivered by co-created approaches to citizen science, and research processes that are more participatory in nature (Wilderman et al., 2004, Wilderman and Shirk, 2010, Ballard et al., 2018). Some scholars discuss this in terms of the fact that it is often highly participatory, grass-roots led, ‘community science’

or ‘participatory action research’ initiatives that emerge around environmental or social justice problems (Bonney et al., 2009, Wilderman and Shirk, 2010, Wiggins and Crowston, 2011, Haklay, 2013). Here citizens are taking science into their own hands in order to address the challenges that they are facing as a community, (Irwin, 1995, Haklay, 2013). This is as Wilderman et al. (2004) call it “science by the people” (Wilderman et al., 2004, pg. 2). Scholars suggest that co-created and more participatory approaches can deliver a wide range of action-orientated outcomes. For example, co-created projects lead to significant knowledge gains that are scientific, social and environmental (Bonney et al., 2009), they develop high levels of scientific literacy and skills compared to less participatory approaches (Bonney et al., 2009), they are associated with policy and decision-making (Shirk et al., 2012) as well as an increased capacity of communities to manage natural resources (Shirk et al., 2012). Co-created approaches are able to deliver more direct conservation outcomes, compared to contributory approaches that deliver more indirect knowledge-orientated outcomes (Ballard et al., 2018). They are also considered to have much community empowerment potential (Haklay, 2017). However, these inferences are often discussed with a lack of definitiveness, discussed in terms of ‘expected to’ and ‘may’ (see (Bonney et al., 2009, Ballard et al., 2018).

Within the discipline of citizen science there remains a lack of knowledge and understanding about the way in which co-created approaches to science lead to action outcomes. This lack of understanding is a result of a number of gaps in academic knowledge. Firstly, Science Communication Unit University of West England (2013) reported in their ‘Environmental Citizen Science’ report that there are very few examples of citizen science that are truly participatory and can demonstrate the way in which they influenced policy and decision-making processes. Mueller et al. (2011) further add that citizen science isn’t yet benefitting from deep participation of citizens, with Nascimento et al. (2018) explaining how citizen science projects remain largely institutionally driven. Secondly, Bonney et al. (2009), Wilderman and Shirk (2010) and Shirk et al. (2012) all establish that evaluation of citizen science is lacking, and that as a result there is a lack of measured outcomes for projects, with outcomes often inferred and assumed. Thirdly, the citizen science typologies offered by Wilderman et al. (2004), Bonney et al. (2009), Shirk et al. (2012) and Haklay (2013) all suggest that more participatory citizen science

processes are most aligned to the delivery of action-orientated goals, but are unable in the scope of these published articles to address how action is created through these more participatory processes. Shirk et al. (2012) specifically speaks to this challenge stating,

> *"with information on PPSR outcomes both limited and dispersed across field, little in the way of empirically based guidance has been available to inform strategic decisions about aligning goals, outcomes and trade-offs in the design and refinement of projects" (Shirk et al., 2012, pg. 2).*

This is seconded by Ballard et al. (2018) whose examination of conservation outcomes through citizen science highlighted a gap in knowledge around the pathways to conservation goals through citizen science processes, and the models that could deliver these pathways. I too have found within my own empirical literature review above (Chapter 2, section 2.3) that a sparse reporting of citizen science methods aligned with a wide range of purported opportunities of citizen science, without detailed evaluation of outcomes, makes it very difficult for scholars and practitioners to develop insights around the link between process and outcome. Nascimento et al. (2018), discussing citizen science in the context of policy-making, call for more research into the ways that citizen knowledge can be integrated into policy-making processes and the actual delivery of action. There exists, therefore, a noticeable gap in knowledge around how the mechanics of different citizen science approaches leads to the delivery of specific types of outcomes. Where this PhD research is interested in understanding the role of co-created citizen science in community action, I therefore look to fill this gap in knowledge by unpicking the link between different facets of co-created citizen science research processes and the action outcomes that they do, or do not, achieve.

9.6.2 Three pathways of action through co-creation

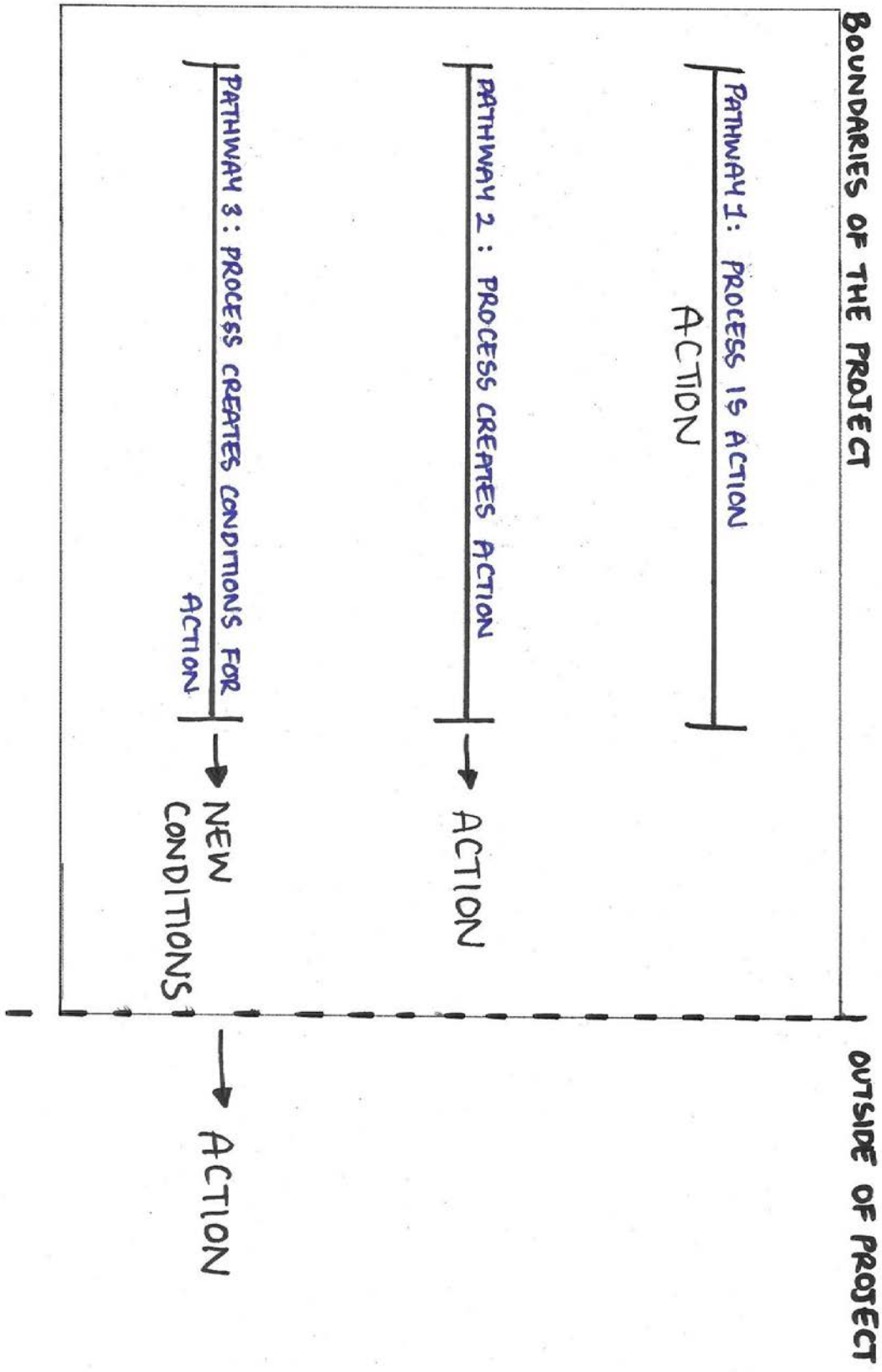
Through comparison and reflection of the five case studies examined in this PhD thesis, an understanding of the relationship between co-created citizen science processes and the ability to deliver action outcomes emerged. Firstly, it seems that the process of co-creation, irrespective of the process of science, is the pathway through which action is created. Science, as discussed above (section 9.5.2) can be limited in its ability to directly

deliver action and in some scenarios is simply a tool to leverage change, but not a solution to do so. The focal point of this contribution to knowledge is therefore the role of co-creation in delivering action, rather than co-created citizen science. The case studies represent three different relationships between processes of co-creation and the delivery of action (Fig 9.2). The first model represents co-created citizen science as the action outcome in its own right. The second model represents co-created citizen science as delivering an output that is an action. The third model represents co-created citizen science as delivering outputs that create the conditions through which action might be enacted. I now describe each of the models in more detail providing examples from the empirical case studies of this research and the wider literature.

9.6.3 Pathway 1: Co-creation is action

In a scenario where co-creation is action, the action outcome is predicated on the fact that the characteristics of a co-creation process are a positive social change in their own right. For example, co-creations' strength and necessity in creating close and positive working relationships and integrating different knowledge systems, within the context of power dynamics between science and society, demonstrates an achievement in social progress, and action, in its own right. Voorberg et al. (2014) found in their literature review of co-creation for social innovation that many projects didn't cite objectives for the project. They suggest that this implies a sense that the successful delivery of co-created approaches has significant value in its own right and is a sufficient goal for delivering social innovation. Within the case studies of this research we see this to be the case with Protecting Our Waterways (Chapter 5), which utilised a co-created citizen science project specifically to build strong relationships between the community and the Natural Environment Agency. In this way the process of co-creation in the Protecting Our

Fig. 9.2: Three pathways of action through co-creation



Waterways project (Chapter 5) was the delivery of action. Similarly in Garcia and Brown (2009) one of the objectives of the case study presented was to deliver participatory research. In this work looking to address access and use of water sources in rural Colombia, the researchers actively sought to establish collaborative working relationships with the community, as they knew that this would be critical for delivering action outcomes. In this way, co-creation was, in itself, an objective of the research.

9.6.4 Pathway 2: Co-creation creates action

As might more ordinarily be expected co-creation can directly deliver action-orientated outputs. Here the process of co-creation whether focused on a scientific process, an innovation process or some other creative process delivers distinct outputs which are themselves action. We see this being the case across the Large Carnivore Mitigation Programme (Chapter 4), Conserving Wolverine Populations (Chapter 7) and Protecting Our Waterways (Chapter 5). In the Large Carnivore Mitigation Programme (Chapter 4) mitigation project the co-created innovation process through which ranchers and government biologists participated led to the development and implementation of specific mitigation innovations on the ranches that prevented large carnivore damage on properties. In this way the innovation outputs were the action outcome of the project. In Conserving Wolverine Populations (Chapter 7) and Protecting Our Waterways (Chapter 5) projects the desire for action was to demonstrate a new understanding of an ecological status, the process of co-creation enabled the production of knowledge that satisfied a knowledge gap within society and so was able to directly address the concerns of the community. The delivery of action is therefore within the scope of the project's life. In both of these cases it is the direct outputs of the process of co-creation that are the change for the community, and in these scenarios co-creation stops once the outcome has been achieved.

In the co-created citizen science case study examples that I examined from the wider literature, Pathway 2 was the most common model of co-creation to action, represented. In the Garcia and Brown (2009) and Gray et al. (2015) case studies action outcomes were the intentional outcomes of the project and the research processes were designed to specifically deliver outcomes of a direct action-orientated nature. Whilst, in Corburn

(2007) where the original intention of the research had been to produce a health assessment of a community, the communities' commandeering of the research and the subsequent increasingly collaborative relationship between the researchers and the community, led to research findings that highlighted significant health risks in the community, and as a result an expansion of the research project to produce tangible collaborative action around the issues of concern. In this example the project evolved in such a way that the project expanded to take direct and tangible action on the issues that the research revealed.

9.6.5 Pathway 3: Co-creation creates conditions for action

In the third pathway the process of co-creation creates outputs that increase the capacity, ability and potential for action and change, and so action is an indirect, and only potential, outcome of the co-creation process. Here the ability to create change and action is predicated on the social, capacity-building power that co-created processes have. In this scenario the indirect nature of the influence of the process on action means that the action is, unlike in pathway 1 and 2, outside of the life of the co-created project. It also means that action outcomes are not guaranteed and furthermore may not be measured. Noise Pollution in the Plaza (Chapter 8) delivered a process of co-creation which focused on both the production of scientific data and the co-creation of action and intervention campaigns. Through a process of co-created science and action the project was able to gather together a compelling dataset, media attention and numerous suggestions for mitigation interventions which provided sufficient political impetus for the local council to respond. The project created the conditions through which change would be enacted, but it was the responsiveness of the government to the projects outcomes that led to the reduction of noise pollution in the community. Another example is the Healthy Household Water project (Chapter 6) which did not directly deliver action outcomes for the community, but did increase their capacity for change. Here there was no intention to deliver action outcomes for the community, but the dialogue that the project created within the community led to an increased sense of community and an increased interaction between civic actors around the issues. In the wider literature Hoover (2016) and Jalbert (2016) both describe case studies where the purpose of the research was to provide

evidence of pollution incidence that might put pressure on industry and government to change policies and practices, but there was no specific design to directly deliver action outcomes as a part of the research process. In Hoover (2016), in particular, one of the outcomes of the project was the increased empowerment of the community, and their increased capacity to participate in research processes, which would support them in tackling other challenges in the future. In all of these case study scenarios the projects are creating new social dynamics and conditions which make the delivery of action more possible and more likely.

9.6.6 Trends across the three pathways of action through co-creation

Dynamics of the pathways to action

As we look at trends across the three pathways we start to gain a much deeper understanding of the relationship between co-creation and action making. As Shirk et al. (2012) establish it's important to pick appropriate methodologies that can deliver all of the desired outcomes. Whilst co-created citizen science has been established as being able to deliver action outcomes, it is important for project partners to know how those action outcomes are expected to be delivered. The three pathways help us to understand that action can be created in three different 'locations' of the projects; within the process itself, as a direct result of the process, or as an indirect result of the process. The nature of the objectives, and the context within which a project is operating, are key determinants of which pathway to action the co-created process offers. Where the desire to create action is orientated around something relational between two or more actors, such as in Protecting Our Waterways (Chapter 5), then Pathway 1 is appropriate. Where the ability to create action is within the power of the actors, but simply a process of creativity is required to deliver that action, then Pathway 2 can be utilised, as with Large Carnivore Mitigation Programme (Chapter 4) and Conserving Wolverine Populations (Chapter 7). Here that co-created process can be a science, innovation, design or other creative process. Where the ability to create action is outside of the realms of power that the actors have, then the focus needs to be on creating the conditions, or leverage, for change with those who hold the power. Here co-creation can be utilised as in Pathway 3, like Noise Pollution in the Plaza (Chapter 8) and Healthy Household Water (Chapter 6).

Taking care of the delivery of action is something that must be purposefully driven and orchestrated, rather than assumed and left to chance. A key difference between the three pathways for action is the inclusion of the action outcomes within or outwith the project's life. Where action is purposefully co-created, strategised and resourced within the project, there is more control over the delivery of the action and more likely to be success (Pathway 1 & 2). Where the action is not explicit in the project process, nor resourced and planned for and cannot therefore be directly co-created, as in Pathway 3, there is little guarantee for change. However, Noise Pollution in the Plaza (Chapter 8) presents a useful example of how change can be bolstered even within a Pathway 3 scenario, by co-creating other types of action within the scope of the project in order to catalyse the wider change. In Noise Pollution in the Plaza (Chapter 8) the project was purposefully designed to co-create action and social interventions, out of an awareness that collecting scientific data would simply not be enough to create change around the problem. In co-creating other types of action within the project, such as the Noise Box and the Public Assembly, the project took more control over creating the conditions for which change could be leveraged, thereby leaving less to chance and circumstance. Therefore, the more that co-creation of action can be built within the scope of the project, the more likely success can be achieved. Finally, it is important to highlight that a project may have multiple action objectives all of which require different pathways for delivery. This was the case in Protecting Our Waterways (Chapter 5), for example, where the organisational objective was to improve the relationship between the Natural Environment Agency and the community (Pathway 1) and the community objective was to fill a knowledge gap (Pathway 2). Where multiple action objectives exist for a project, careful attention needs to be paid to the pathways of each objective, in order for success.

The position of government in these models

As discussed in section 9.5.5 governments had a highly powerful and influential role in relation to the communities' ability to take action on the challenges they were facing. In some cases they were seen as contributing to the existence of the problem in the first place, but in all case studies they were the funders of the projects looking to address the problems, and as policy and decision-makers they intrinsically have the power to create

change. Interestingly, however, the policy-makers from government did not actively contribute to the co-creation processes and in all case except Noise Pollution in the Plaza (Chapter 8), it was not clear what policy-outcomes have been delivered as a result of the project. In relation to the 3 pathways of action through co-creation these case studies demonstrate that government, and by this I strictly mean policy-makers, were positioned outside of the action co-creation pathways. Policy-makers are only noticeable in the case studies of Noise Pollution in the Plaza (Chapter 8) and Healthy Household Water (Chapter 6), which both represent Pathway 3 projects, with action impacts outside of the co-creation process. In the same way that I suggest that bringing as much of the action creation activity into the co-creation process as possible, will result in more success, I would similarly argue that involving policy-makers in the co-creation process as much as possible would lead to increased ability to enact change. Further exploration of this matter is outside the scope of this thesis, but there is full and diverse literature on co-created policy-making that can be explored (see. (Bennett and Smith, 2007, Boivin et al., 2014, Phillips et al., 2010, Corburn, 2007, Accordino, 2013, Broner et al., 2001).

The role of science in these models

Above, in section 9.5.2, I established that science was often not a solution for creating action, but often a tool. This parallels with Wilderman et al. (2004) who discuss, around their community science typology, how science knowledge is sometimes a means rather than an ends for projects. In the case studies of this thesis I found that science is only the solution to the problem being faced where knowledge is the entity that needs to be changed or transformed. So in the case of Conserving Wolverine Populations (Chapter 7) there was a need to validate the trappers' knowledge and understanding of wolverine ecology, and similarly in the Protecting Our Waterways project (Chapter 5) there was the need to fill a knowledge gap about the environmental health of a waterway. In these circumstances science and data are the ends. Science as a solution therefore exists within Pathway 2 models of co-creation to action. In contrast in the case of Noise Pollution in the Plaza (Chapter 8), and the intention for data collected through the Large Carnivore Mitigation Programme mapping project (Chapter 4), science played a role as a means towards action. In these cases the science was collected with the intention of it providing

evidence that might create leverage at the decision-making table. Science as a tool therefore exists within Pathway 3 models of co-creation to action. Interestingly as the Large Carnivore Mitigation Programme mitigation programme (Chapter 4) demonstrates the process of co-creation does not need to be orientated around a science process, in order to create action. Any process of creativity could be co-created in order to create action. As a result where action needs to be created in communities, there should not be an assumption that a citizen science process needs to be adopted, instead a more critical reflection needs to be made about what type of outcomes need to be co-created.

9.6.7 Implications for citizen science practice

Where there has been a certain amount of assumption and a lack of understanding of the mechanisms regarding the relationship between co-created approaches to citizen science and action outcomes (established in section 9.6.1), here I establish that there are three different ways in which co-created processes can deliver action outcomes. The three pathways hold value in drawing practitioners' attention and cognizance to how the processes they adopt are reasonably able to achieve the outcomes that they intend. This awareness can help practitioners and the communities they work with to reflect and more purposefully utilise co-created approaches. However, there needs to be a thorough understanding of the problem that needs to be addressed and how action can influence the problem, in order for co-created approaches to be appropriately adopted.

One of the reasons that understanding these relationships is important is due to the development of social contracts between the actors and the need to build a shared understanding of how and to what extent the endeavour might be able to create action and change. This has an important role in developing trust and managing expectations between actors, but also in ensuring that actors contributions and efforts in the partnership are directed in the most meaningful and impactful ways. Further to this Barreteau et al. (2010) argue that when citizen participants don't know what to expect from a process, or when their expectations haven't been purposefully set, there is a risk of disappointment and disengagement. They advocate for mapping out the expected participatory process at the beginning of a project and continually evaluating and revising the map with the research participants, in order to establish and maintain a shared

understanding of the way in which outcomes will be delivered. They encourage that having a clearly articulated understanding of the trade-offs between the intended outcomes and the participatory process that is being adopted, is important for managing expectations.

9.6.8 Summary

My second contribution to knowledge speaks directly to the second research question of this thesis "What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?" The contribution establishes that there are three different relationships between co-created processes and the ability to deliver action. Processes of co-creation are either 1) action outcomes in their own right, as modelled by Pathway 1, 2) lead to the direct delivery of action outcomes as modelled by Pathway 2, or else 3) create the conditions through which action can be leveraged, as modelled by Pathway 3. Which of these pathways co-created processes deliver is dependent on the nature of the objectives and the context within which action is sought. In order to succeed in the delivery of action, action outcomes should be co-created as a part of the project as far, and as much, as possible, and powerful stakeholders such as policy-makers should be included in the co-creation process. The process of co-creation can be a scientific process, but this may not always be appropriate. Other creative processes such as innovation, as demonstrated by the Large Carnivore Mitigation Programme (Chapter 4), are sometimes more appropriate, and this needs to be considered carefully when embarking on a project. Finally, where science is an appropriate tool, attention needs to be paid to whether the process of co-created science will be a means, or an ends, for delivering action, and if the former, the importance of resourcing this objective.

9.7 The relationship between the two contributions to knowledge

9.7.1 The social contracts and pathways to action are independent of one another

Whilst the first contribution to knowledge is descriptive of nature of the co-creation process within the second contribution to knowledge, the different social contracts and pathways to action are independent of one another. The social contracts of the first

contribution to knowledge (section 9.4) represent the different relational dynamics taking place between the actors in the “Pathways to action” described in contribution to knowledge 2 (section 9.6). The theory of contribution to knowledge 1 therefore describes some of the mechanics of the theory of contribution to knowledge 2. However, there are no distinct relationships between the different social contracts and the pathways to action. Any of the social contract dynamics can be utilised to deliver any of the pathways to action.

Mapping the relationship between the social contracts and the pathways to action adopted in the empirical case studies of this research, and from the literature case study examples discussed throughout this chapter, demonstrates that there are no distinct relationships of association between social contracts and the pathways. Different social contracts can be used for several different pathways (see Table 9.1). For example the pursuit of Pathway 2: Co-creation creates action is delivered with the use of social contracts 2, 3 and 4.

There are two reasons why trying to make distinct associations between the social contracts and the pathways to action is ill-founded, on the one hand the dynamism of the projects and on the second the multi-purpose application of the projects. Firstly, the social contract that a project adopts can change within the life time of the project. For example, the Columbian watershed project described by Garcia and Brown (2009) started out by practicing participatory research in a social contract 2 dynamic, with the researchers leading the process for the needs of the community, and then shifted to a social contract 3 dynamic in the action phase, where the community led the project for their own processes, facilitated and supported by the researchers. Secondly, a project can have multiple objectives, which require or utilise multiple pathways to action. For example, Protecting Our Waterways (Chapter 5) sought both to create positive working relationships through a citizen science methodology (Pathway 1) and sought to deliver baseline data of the health of the waterway (Pathway 2). The dynamic and multifaceted nature of projects therefore means that looking for distinct associations is inappropriate and unhelpful, as one project can represent multiple social contracts and pathways.

Table 9.1: The relationship between social contracts and pathways to action for the empirical and literature case studies.

	Pathway 1: Co-creation is action	**Pathway 2:** Co-creation creates action	**Pathway 3:** Co-creation creates conditions for action
Social contract 1: In service of science			Three Rivers Quest (Jalbert, 2016) Healthy Household Water (Chapter 6)
Social contract 2: Science-led citizen cause	Protecting Our Waterways (Chapter 5)	Protecting Our Waterways (Chapter 5) Collaborative Science (Gray et al., 2015)	New York Sentinels (Jalbert, 2016)
Social contract 3: Citizen-led citizen science	Columbian watershed (Garcia and Brown, 2009)	Large Carnivore Mitigation Programme – mitigation project (Chapter 4)	New York Sentinels (Jalbert, 2016)
Social contract 4: The point of mutuality		Conserving Wolverines Populations (Chapter 7) Noise Pollution in the Plaza (Chapter 8) Brooklyn Community Exposures Assessment (Corburn, 2007)	Popular epidemiology in Mohawk community (Hoover, 2016)

9.7.2 *Expected trends in the relationship between social contracts and pathways to action*

Having said that looking for distinct associations between the social contracts and the pathways to action is inappropriate and unhelpful, there are a couple of observed and expected trends that are worth considering. Firstly, it is unsurprising to see that the case study examples that represent social contract 1 all have pathway 3 relationships with action (Table 9.1). In social contract 1 projects are being conducted in order to deliver benefits and outcomes for the research institutions who are leading the research. Research institutions do not commonly have direct, tangible, action outcomes as objectives of their work. They are more likely to indirectly influence action through publishing findings that are then adopted, or not, by policy makers or management agencies. This represents a pathway 3 relationship between co-creation and action. So where projects are delivered to meet the needs of research institutions, we are less likely to see pathway 1 and 2 processes for action being adopted.

Perhaps a more surprising trend present in Table 9.1 is the scarcity of examples of projects that look to deliver a pathway 1 relationship between co-creation and action. Only Protecting Our Waterways (Chapter 5) and the Columbian watershed project described by Garcia and Brown (2009) sought collaboration and relationship building as an explicit objective of their projects, and as a result chose, specifically, to adopt a participatory research approach. Voorberg et al. (2014) discuss how in the field of social innovation co-created practices are used as a goal in their own right, as they are seen as high value outcomes for society regardless of the summative outcomes of the process. In the examples I have presented here, this is less of the case, although the examples in this discussion have not been sampled specifically to address this question. A larger more purposive sample would need to be collected to identify whether this a significant trend. Interestingly, however, when examining the examples, provided in this thesis, which aimed to build collaborative relationships, we might expect them to have adopted more mutualistic approaches to co-creation, such as social contract 4, as social contract 4 represents a relational dynamic orientated around shared needs and endeavours. I speculate that the absence of this trend is partly due to the limited examples accessed

here, and partly due to a lack of awareness and know-how regarding participatory research practices.

Finally, it is interesting to look specifically at the fact that a wide range of social contracts have been utilised for the pursuit of pathway 2 relationships between co-creation and action. Where we find that the pursuit of action through a pathway 2 endeavour has been approached through social contracts 2, 3 and 4, we also find that all the empirical and literature-based case studies occupying these dynamics successfully achieved action outcomes for the participating communities. This demonstrates that success in delivering action does not rely on specific relational dynamics, but can be achieved through many different means. Although, we may speculate that the nature of the relational dynamics will affect the nature of the subsequent outcomes, with more participatory processes more able to deliver relevance and impact for communities, as suggested in the wider literature (Irwin, 1995, Ashby, 2003, Bonney et al., 2009, Shirk et al., 2012, Turnhout et al., 2012, Ballard et al., 2018). This PhD research has not, however, collected the relevant data to be able to make an assessment of the comparative success of the projects, and cannot therefore suggest whether one social contract might be more appropriate than another, in specific scenarios.

9.7.3 Implications of the independence between the two contributions to knowledge

The implication of the independence between the two contributions to knowledge is that different relational dynamics can be adopted for a variety of action-orientated endeavours and objectives. This means that regardless of the pathway to action that needs to be taken, there are a variety of approaches that can be adopted in order to pursue those action objectives. Rather than adopting specific social contracts because they are useful for delivering a specific pathway to action, instead social contracts can be chosen based on the resourcing and capacity that the actors have, as well as the social context and scenario in which the project is taking place. For example, where a project will be established to address a community problem, between a research institution which is well resourced and a community that has low capacity for delivering community projects, then social contract 2 can be adopted. Where a project will be established to deliver on a community objective and the community has high capacity to deliver a research process,

and the research institution in question has a mandate for delivering public services, then social contract 3 can be adopted.

What the independence between the two contributions to knowledge also demonstrates is that the academic preoccupation with determining the ideal methodological approaches for delivering specific outcomes, may be an ill-pursued. They dynamism and complexity of these highly-situated scenarios means that 'copy and paste' methodologies are not likely to be appropriate. Rather, what is needed, is practitioners with a more nuanced, experiential and intuitive understanding of social dynamics and action processes, in order to specifically craft and nurture processes that deliver action.

9.8 Summary and recommendations

9.8.1 Establishing the gap in knowledge

Scholarly work on citizen science practices have demonstrated that there are a broad range of ways in which citizen scientists can contribute to scientific practice (Wilderman et al., 2004, Bonney et al., 2009, Wiggins and Crowston, 2011, Shirk et al., 2012, Haklay, 2013). One of the most notable typologies offered delineates projects based on the extent to which the citizen scientists participate in the research process (Bonney et al., 2009, Shirk et al., 2012). This brought about a now well-established conceptualisation of contributory, collaborative and co-created approaches to citizen science, where in contributory citizen science the public purely participate in data collection, whilst in co-created citizen science they contribute throughout the whole process (Bonney et al., 2009, Shirk et al., 2012). What has also been established across the citizen science and the participatory research literature is that the more participatory a research approach is adopted the more likely the process will be able to deliver action outcomes and outcomes that are relevant, meaningful and impactful to the communities that participate (Irwin, 1995, Ashby, 2003, Bonney et al., 2009, Shirk et al., 2012, Turnhout et al., 2012, Ballard et al., 2018). What has not been established in the citizen science literature however is an understanding of how co-created approaches deliver action outcomes. With a diversity of interpretations of what a co-created approach to citizen science might look like and without an understanding about how the approach might deliver particular

outcomes, there is a risk that approaches could be inappropriately applied resulting in a failure to deliver on objectives.

This PhD thesis has therefore attempted to fill this gap in knowledge by looking to understand the diversity of co-created practice in citizen science and how this diversity delivers different action outcomes. Due to the predominance of an 'instrumental' philosophy of citizen science that utilises the process to serve the needs of science, this research was instead interested in understanding the influence of co-creation on delivering citizen science within the context of community action, looking to a more 'democratic' philosophy of citizen science. The research has pursued two aims. The first aim is to understand how co-created approaches to citizen science work; how the concept of co-creation manifests itself in citizen science and how different dimensions of the practice influence the ability to collaborate in a co-created manner. The second aim is to understand the relationship between the co-created process and the ability to deliver action outcomes, specifically for the communities that participate in the scientific research. In order to deliver these aims I looked to address two research questions; 1) How does the concept of co-creation manifest in citizen science projects? And 2) What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?

9.8.2 Research question 1: How does the concept of co-creation manifest in citizen science projects

Insights and comparisons drawn from across the five case studies in this research demonstrated a great diversity in the application of the concept of co-creation in citizen science and participatory research and innovation processes. The critical insights regarding the manifestation of co-creation in citizen science were around the relationships between the researcher: project managers and the citizen scientists involved in the projects, rather than in how the scientific process was delivered. The research suggests that researcher: project managers adopt different functional roles when working with the citizen scientists, either facilitating their own leadership of the process, partnering with them and mutually constructing and delivering the process, or else provisioning a process through which the citizen scientists can participate. The researcher: project managers,

rather than the citizen scientists, were in many cases the initiators of the projects and identified the problem that would be addressed. They were also often leading and driving the research projects and in so doing influenced the extent to which the citizen scientists could contribute to the governance of the projects. Whilst citizen scientists were often involved in decision-making for the scientific process of the research, they were less likely to be involved in the governance of the project as a whole. This significantly affected their sense of ownership over the projects; the less they were a part of governing a project, the less they felt like it was their project. However, there did not seem to be a link between the amount of citizen participation in the governance of a project and the ability of the project to successfully deliver action outcomes for the community. The ability of the researcher: project managers and the citizen scientists to work together in a co-created way was predicated on a positive feedback loop of relationship-building, where positive experiences of co-creation strengthened relationships between the actors, thereby increasing the depth in which co-creation could take place. Finally, there was a notable imbalance in responsibility for the process of co-creation, with researcher: project managers being held responsible for both the organisations' and citizens' success in engagement.

9.8.3 Research question 2: What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?

Research question 2 of this thesis was explored through two separate sub questions: a) What is the link between co-created citizen science processes and action outcomes? And b) To what extent did the case study projects deliver action outcomes for the communities who participated? Addressing question 2b) first, the case studies revealed that action outcomes were delivered in all five case studies and that communities concerns were significantly addressed in all but the Healthy Household Water case study (Chapter 6). The research did not, however, reveal insights about how the manner of the co-creation process ensured that the communities' interests were delivered. Regarding question 2a) a much fuller understanding of the link between co-created processes and the ability to deliver action was uncovered. Co-creation was found to deliver action both through the

characteristics of the process and the outcomes of the process, in that it led to an amalgamation of knowledge systems, positive working relationships between science and society, an increase in capacity for research and innovation, and it empowered communities by increasing their agency. It was also recognised that the process of co-creation can be seen as a mode of action in its own right, due to the way in which is can transform science: society relationships and increase the civic capacity for action and change. Science was identified as having two different functions in delivering action, either it was able to directly deliver action where action outcomes required knowledge outputs, or it was a useful tool that was able to provide objective quantification and validate knowledge, which in turn could leverage change. Science had a weakness, however, in that scientific evidence can be negated and critiqued and so is often negotiated with political and economic drivers. Finally, governments were found to be a key influencer of the ability to make change and yet largely absent from the co-creation process. Despite providing the funding critical for delivering the five projects presented in the case studies, there was little evidence of policy outcomes as a result of the projects.

9.8.4 Contribution to knowledge 1: Mutuality in service and governance

The knowledge generated by this research with regards the two research questions led to two separate contributions to knowledge, each of which are described here, in turn, before I reflect on the relationship between the two.

My first contribution to knowledge establishes that the relational dimensions of service and governance have a critical influence over the way in which citizen scientists and researcher: project managers work together around co-created citizen science projects. I offer a framework for understanding and negotiating the social contracts that are established between researcher: project managers and citizen scientists, in the form of a 'mutuality saltire' (Fig. 9.1). The 'mutuality saltire' establishes that the direction of service of a project, and the extent to which citizen scientists are involved in the governance of the project, represents four different social contracts between the researcher: project managers and the citizen scientists.

- In social contract 1 (the 'In service of science' social contract) the project is delivered to benefit the research institution, and the researcher: project managers

lead. Here the researcher: project managers provide a research process through which the citizen scientists can participate.

- In social contract 2 (the ‘Science-led citizen cause’ social contract) the project is for the benefit of the citizen scientists’ community, but is led by the researcher: project managers. Here again the researcher: project managers provide a process through which the citizen scientists participate and the citizen scientists are excluded from the governance of the project.
- In social contract 3 (the ‘Citizen-led citizen cause’ social contract) the project is for the citizen scientists’ community and they lead the research process, with the researcher: project managers facilitating their ability to deliver the research.
- In social contract 4 (the ‘Social contract of mutuality’) the benefit and governance of the project is shared equally between the two actors, which represents a point of mutuality.

The key insights that this contribution highlights is that co-created approaches to citizen science can be utilised to serve either research institutions’ or citizen communities’ needs. Further to this there are different extents to which citizen communities’ might be involved in the governance of co-created research projects, regardless of the intended beneficiary. In addition the extent to which the citizen scientists are involved in the governance of the project affects their sense of ownership over the project. These insights increase the nuance of understanding that exists around the concept of co-created citizen science, but can also be operationalised to assist in the establishment of relationships between researchers and citizen scientists (see Recommendation 9.7.7 below).

9.8.5 Contribution to knowledge 2: Three pathways for action through co-creation

Whilst my first contribution to knowledge addresses the manifestation of co-creation in citizen science, my second contribution addresses the way in which action can be delivered through co-created citizen science practices. The contribution establishes that there are three different relationships between co-created processes and the ability to deliver action. Processes of co-creation can deliver action through three different pathways.

Pathway 1) – co-creation is the action outcome.

Pathway 2) – co-creation directly delivers action outcomes.

Pathway 3) – co-creation creates the conditions through which action can be leveraged.

Whilst within Pathway 1 and 2 delivery of action is a part of the co-created project, in Pathway 3 the delivery of action is external to the co-created project and has, therefore, less guarantee. The more that the delivery of action can be included as a part of the co-created project, the more likely success can be achieved. Which of these co-creation pathways will deliver the intended action is dependent on the nature of the action objectives and the context within which action is sought. The role of science in these processes can either be a means (when utilised in pathway 3) or an ends (when utilised in pathway 2). But it needn't be a scientific process that is co-created, any number of creative processes can be utilised in delivery action. It's the process of co-creation that is key.

9.8.6 Relationship between the two contributions to knowledge

Where this research looked to understand the link between co-created citizen science processes and action outcomes, what has been discovered through the five empirical case studies is that there is no distinct relationship between the different types of social contract and the pathways of co-creation to action. Any number of social contracts can be adopted for any of the pathways to action, and still successfully deliver action outcomes for communities. This is due to the fact that these types of project are dynamic, multi-faceted and highly contextually situated. The selection of social contracts and pathways to action in co-created research projects, needs to be done responsively to the social, economic and political contexts of the problem being addressed.

9.8.7 Recommendations

In trying to build a better understanding of how co-created approaches to science research can be utilised to support communities' in taking action on the issues that matter to them, these contributions come together to provide a clearer understanding of some of the dimensions that need to be worked around in order to serve communities' needs. The contributions are connected in the fact that both can be utilised by prospective co-created

citizen science partners to map, negotiate and come to agreement on the expected pathway to achieving objectives and the way in which the partners will work together to deliver on the goals. They can be used as tools through which to deliberate around the best course of action, and subsequently evaluate the progress of the partnership. This starting point for partnership and collaboration is where I now make some recommendations.

9.8.8 Recommendation 1: establishing social contracts for co-creation

Co-created citizen science partnerships would benefit significantly by having open and frank discussions, between partners, before a project has even been initiated, about what the appropriate social contract would be. Most prominently, explicit deliberations should be held around who the project is intended to serve and who will be involved in governing the different elements of the project (Barreteau et al., 2010). Citizen scientists should be given free choice to choose the extent to which they participate, rather than having this dictated to them by the researchers involved (Robinson et al., 2018). Whilst concepts of service and governance are fundamental for establishing the power relationships between the actors, these need to be considered in the context of the resource potential of the two actor groups. What are the limitations of the researchers' and the communities' capacity to collaborate in different ways? A social contract should be agreed upon right from the start of a project, and it should be evaluated throughout the life of the project to ensure that all stakeholders feel that the social contract is being honoured (Barreteau et al., 2010).

9.8.9 Recommendation 2: Mapping pathways to action

In addition to identifying the social contract between the researchers and citizen scientists, it is also important to identify the expected pathway for delivering action. Taking the time to map out the way in which action is expected to be delivered, will provide a better understanding of the role and function that a co-created research process can play, in that journey. This will ensure the actors' expectations of the process are more in-line with reality. This is in contrast to assuming that a co-created process will deliver the intended action outcomes, without understanding how. It is also recommended that, as

far as possible, powerful stakeholders, such as policy-makers, are involved in the process of co-creation. However, caution must be applied here in that it will require a skilled facilitator to ensure that power dynamics can be balanced to deliver an equitable process of co-creation.

9.8.10 Limitation 1: Anecdotal reporting of outcomes

One of the limitations of this research is that the empirical data collected is anecdotal data, collected as narrative interviews. The adoption of a narrative approach to the research was purposeful in that it looked to establish the diversity of understandings and perceptions around a project, in order to capture a fuller constructivist representation. Due to the causal dimensions of narratives, it also looked to establish causal links between what happened in the projects and the outcomes. Whilst this approach has provided rich and multifarious understandings of each of the case studies, enabling a deep understanding of the nature of the relationships and collaboration between the different actors and the contexts within which change was trying to be made, what it fails to do is provide more objective understandings of the outcomes and impacts of the projects. Bonney et al. (2009) highlight that one of the limitations of our understanding about outcomes of different models to citizen science is that there is a lack of empirical evaluation, and an over reliance on anecdote and assumption. Having collected multiple perspectives on the projects, we find multiple interpretations of the outcomes and impacts, and do not have a measured and quantifiable understanding of change. This means that the citizen science project outcomes reported in this thesis could be disputed, both from the research participants or external agents. However, this negates the significance and importance of constructivist epistemologies, which cannot claim in absolute terms what happened, but provide a richer understanding of how things happened in a project, because it explains why different actors behaved in the ways that they did. Understanding the multiple narratives of a project, helps us to understand the nuances of relational interactions and in turn the outcomes that are generated. Further to this a conscious choice was made not to include grey and peer-reviewed literature about the projects in the compilation of the case studies. Inclusion of these other published materials would have provided more formalised accounts and evidence of the

process and the outcomes used. There were, however, two important methodological reasons for not including these types of evidence. Firstly, including these texts would have undermined the anonymity of the projects, thereby breaking the privacy agreement made with some of the research participants. Secondly, these documents are ordinarily produced by the researcher: project manager actors in the projects, and would therefore place more emphasis on this voice and perspective. By choosing not to include these types of texts, my intention was to ensure that the representation of the case studies more firmly represented underrepresented voices (Shirk et al., 2012) and a more collective understanding of the events that took place.

9.8.11 Limitation 2: Replicability of the narrative interview methodology

A second limitation of this research is with regards the replicability of the narrative interview methodology. The narrative interview methodology adopted was a largely unstructured process which worked conscientiously to allow the research participants to guide, lead and navigate the content of the interview. Within this process a natural dialogue emerges between the interviewee and the interviewer. Without a structured set of questions, with the interviewee in control of the content, and further more with the combination of personalities of the interviewee and interviewer, it is not possible for the interview method to be replicated. Furthermore, there was limited replicability between the interviews within this study, with each being a completely unique conversation, with some descriptions of projects in one interview almost unrecognisable from the next. Whilst another researcher could adopt the same principles of the process and utilise the same narrative prompts and cue questions (Appendix 6), they are not likely to reproduce the content of the interviews collected here. As a result, it might be expected that the findings and interpretations of a similar study would draw different insights and conclusions. Whilst this is problematic in terms of validating this study in other places, it is, by its very nature, the merit and value of this research. A constructivist methodology embraces the unique, the situated and the personal, and recognises that there can be multiple interpretations of the same phenomena. The interview method adopted actively sought to capture this within the case studies, but as a whole this research acknowledges that other researchers may draw different conclusions and findings of the same projects.

The findings of this research should therefore be read and understood as a summation of a wealth of experiential knowledge and diverse perspectives, gathered together from research participants and then interpreted through my personal lens as a citizen science practitioner and a community activist. The findings should be explored not as absolute truth, but as a collective wisdom of experience, to ponder, consider and consult, in line with continued personal learning and practice, in the context of community science activism.

10 Conclusion

10.1 The theoretical staring point of this research

The relationship between science and society is changing, due to an 'age of participation' where the legitimacy and credibility of governing and elite institutions is being challenged (Irwin, 1995, Jasanoff, 2003, Chilvers and Kearnes, 2016). In this 'age of participation' institutions such as science are finding themselves under more and more pressure to open up their cultures and world to the critique and involvement of lay communities (Irwin, 1995, Ashby, 2003, Turnhout et al., 2012, Cooper, 2016, Chilvers and Kearnes, 2016). This shift is seen as necessary in order for global society to more adequately address the collective challenges that we face which require not only universal knowledge, but also contextualised and locally relevant solutions (Mauser et al., 2013, Irwin, 1995, Turnhout et al., 2012, Ashby, 2003). Citizen science, in its contemporary embodiment, is a part of this participatory turn where a growing recognition has been made at the value and opportunities that public participation in scientific research brings. However, the dominant trends in citizen science have an 'instrumental' philosophy that is orientated around utilising the capacity of citizens to deliver scientific outputs (Cooper and Lewenstein, 2016). The advances made to science through this application of citizen science have been significant and expanded the capacity of science beyond what would ordinarily be possible (Wiggins and Crowston, 2011, Miller-Rushing et al., 2012). What this approach fails to do however is make much more fundamental shifts in the power relations between science and society. An interest is now growing within the field of citizen science to pursue methods that deliver much deeper levels of participation and collaboration between scientists and 'lay' communities, in what is considered a 'democratic' philosophy in citizen science (Irwin, 1995, Mueller et al., 2011, Cooper, 2016, Cooper and Lewenstein, 2016, Chilvers and Kearnes, 2016).

10.2 Gap in knowledge

Where these more participatory approaches have been emerging, and where citizen science has been applied to a much broader range of scenarios and problems, citizen science scholars have made efforts to create typologies of practice, that can be used a

point of orientation and discussion when trying to deepen our understanding of how different approaches work. Scholarly work on citizen science practices have demonstrated that there are a broad range of ways in which citizen scientists can contribute to scientific practice (Wilderman et al., 2004, Bonney et al., 2009, Wiggins and Crowston, 2011, Shirk et al., 2012, Haklay, 2013). One of the most notable typologies offered delineates project based on the extent to which the citizen scientists participate in the research process (Bonney et al., 2009, Shirk et al., 2012). This brought about a now well-established conceptualisation of contributory, collaborative and co-created approaches to citizen science, where in contributory citizen science the public purely participate in data collection, whilst in co-created citizen science they contribute throughout the whole process (Bonney et al., 2009, Shirk et al., 2012). What has also been established across the citizen science and the participatory research literature is that the more participatory a research approach is adopted the more likely the process will be able to deliver action outcomes and outcomes that are relevant, meaningful and impactful to the communities that participate (Ashby, 2003, Corburn, 2007, Hoover, 2016). What has not been established in the citizen science literature, however, is an understanding of how co-created approaches deliver action outcomes. With a diversity of interpretations of what a co-created approach to citizen science might look like and without an understanding about how the approach might deliver particular outcomes, there is a risk that approaches could be inappropriately applied resulting in a failure to deliver on objectives.

10.3 Research aims and questions

This PhD thesis has therefore attempted to fill this gap in the citizen science literature, looking to develop understanding around the way in which different characteristics of co-created citizen science practice influence the ability to deliver action outcomes. An additional dimension to the research enquiry responds to the dominance of ‘instrumental’ orientations of citizen science, where citizen science is utilised in the pursuit of advancement of science. In order to address this imbalance in purpose this research looks to explore the notions of co-created citizen science for action within the context of community action. My research aim was to understand how communities faced with

problems might be assisted in taking action through a co-created citizen science process. In order to unpick this topic looked to address two research questions;

1) How does the concept of co-creation manifest in citizen science projects?
2) What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?
    a) What is the link between co-created citizen science processes and action outcomes?
    b) To what extent are action outcomes realised for the communities participating in the citizen science projects?

10.4 Research methodology

In order to address these two research questions a multiple-case study research design was adopted. This research design was chosen in order to contribute several detailed case studies of co-created citizen science to the literature, as there remains a lack of detailed examples of these types of processes. It was also chosen due to a lack of generalisability of single cases. By conducting a multiple-case study design the diversity of practices in co-created citizen science could be explored and broader trends, patterns and nuances in these types of practices could be identified. Five case studies were selected on the basis that they intended to deliver action outcomes, that they were also already complete and so could be studied retrospectively, and that the citizen scientists participated in most stages of the scientific process. Case studies were also purposefully chosen to capture maximum variability across cases. Data collection in order to compile the case studies was conducted through narrative interviews, with a mixture of researchers, project managers and citizen scientists for the projects being interviewed. The narrative methodology was built upon a constructivist epistemological standpoint that the only way to understand the reality of social phenomena is to understand it from the point of view of those who participated (Bryman, 2012). In this way, the only way to truly understand what happened in a co-created citizen science project, why, and how, was to collect multiple personal perspectives of the events that took place. Interviewees were recruited through the project managers and were either selected or self-selecting depending on the existing relationships between project managers and other participants.

Interviews were conducted in personal, by telephone, or by webcall, as was most accessible, in a relatively unstructured way, providing the interviewees with the freedom to tell their version of events on their own terms. Interviews were transcribed and then imported into NVivo software for coding and thematic analysis. Thematic analysis was conducted within cases in order to develop thorough case study descriptions for each project, and then across cases in order to synthesis the core insights for the research questions of this thesis.

10.5 Research question 1: How does the concept of co-creation manifest in citizen science projects?

Insights and comparisons drawn from across the five case studies in this research demonstrated a great diversity in the application of the concept of co-creation in citizen science and participatory research and innovation processes. The critical insights regarding the manifestation of co-creation in citizen science were around the relationships between the researcher: project managers and the citizen scientists involved in the projects, rather than in how the scientific process was delivered. The research suggests that researcher: project managers adopt different functional roles when working with the citizen scientists, either facilitating their own leadership of the process, partnering with them and mutually constructing and delivering the process, or else provisioning a process through which the citizen scientists can participate. The researcher: project managers, rather than the citizen scientists, were in many cases the initiators of the projects and identified the problem that would be addressed. They were also often leading and driving the research projects and in so doing influenced the extent to which the citizen scientists could contribute to the governance of the projects. Whilst citizen scientists were often involved in decision-making for the scientific process of the research, they were less likely to be involved in the governance of the project as a whole. This significantly affected their sense of ownership over the projects; the less they were a part of governing a project, the less they felt like it was their project. However, there did not seem to be a link between the amount of citizen participation in the governance of a project and the ability of the project to successfully deliver action outcomes for the community. The ability of the researcher: project managers and the citizen scientists to work together in a co-created

way was predicated on a positive feedback loop of relationship-building, where positive experiences of co-creation strengthened relationships between the actors, thereby increasing the depth in which co-creation could take place. Finally, there was a notable imbalance in responsibility for the process of co-creation, with researcher: project managers being held responsible for both the organisations' and citizens' success in engagement.

10.6 Research question 2: What is the link between the co-created citizen science process and the ability to deliver action outcomes for the communities that participate?

Research question 2 of this thesis was explored through two separate sub questions: a) What is the link between co-created citizen science processes and action outcomes? And b) To what extent did the case study projects deliver action outcomes for the communities who participated? Addressing question 2b) first, the case studies revealed that action outcomes were delivered in all five case studies and that communities concerns were significantly addressed in all but the Healthy Household Water case study. The research did not however reveal insights about how the manner of the co-creation process ensured that the communities' interests were delivered. Regarding question 2a) a much fuller understanding of the link between co-created processes and the ability to deliver action was uncovered. Co-creation was found to deliver action both through the characteristics of the process and the outcomes of the process, in that it led to an amalgamation of knowledge systems, positive working relationships between science and society, an increase in capacity for research and innovation and empowered communities by increasing their agency. It was also recognised that the process of co-creation can be seen as a mode of action in its own right, due to the way in which is can transform science: society relationships and increase the civic capacity for action and change. Science was identified as having two different functions in delivering action, either it was able to directly deliver action where action outcomes required knowledge outputs, or it was a useful tool that was able to provide objective quantification and validate knowledge which in turn could leverage change. Science had a weakness however in that scientific evidence can be negated and critiqued and so is often negotiated with political and economic drivers.

Finally governments were found to be a key influencer of the ability to make change and yet largely absent from the co-creation process. Despite providing the funding critical for delivering the five projects presented in the case studies, there was little evidence of policy outcomes as a result of the projects.

10.7 Contribution to Knowledge 1: Mutuality in service and governance

My first contribution to knowledge establishes that the relational dimensions of service and governance have a critical influence over the way in which citizen scientists and researcher: project managers work together around co-created citizen science projects. I offer a framework for understanding and negotiating the social contract that is established between the researcher: project managers and the citizen scientists, in the form of a 'mutuality saltire' (Fig. 9.1). The 'mutuality saltire' establishes that the direction of service of a project, and the extent to which citizen scientists are involved in the governance of the project, represents four different social contracts between the researcher: project managers and the citizen scientists.

- In social contract 1 the project is delivered to benefit the research institution and the researcher: project managers lead. Here the researcher: project managers provide a research process through which the citizen scientists can participate.
- In social contract 2 the project is for the benefit of the citizen scientists' community, but is led by the researcher: project managers. Here again the researcher: project managers provide a process through which the citizen scientists participate and the citizen scientists are excluded from the governance of the project.
- In social contract 3 the project is for the citizen scientists' community and they lead the research process, with the researcher: project managers facilitating their ability to deliver the research.
- In social contract 4 the benefit and governance of the project is shared equally between the two actors, which represents a point of mutuality.

The key insights that this contribution highlights is that co-created approaches to citizen science can be utilised to serve either research institutions' or citizen communities' needs. Further to this there are different extents to which citizen communities' might be involved

in the governance of co-created research projects, regardless of the intended beneficiary. The extent to which the citizen scientists are involved in the governance of the project affects their sense of ownership over the project. These insights increase the nuance of understanding that exists around the concept of co-created citizen science, but can also be operationalised to assist in the establishment of relationships between researchers and citizen scientists.

10.8 Contribution to Knowledge 2: Three pathways to action through co-creation

Whilst my first contribution to knowledge addresses the manifestation of co-creation in citizen science, my second contribution addresses the way in which action can be delivered through co-created citizen science practices. The contribution establishes that there are three different relationships between co-created processes and the ability to deliver action. Processes of co-creation can deliver action through three different pathways.

Pathway 1) – co-creation is the action outcomes.

Pathway 2) – co-creation directly delivers action outcomes.

Pathway 3) – co-creation creates the conditions through which action can be leveraged.

Whilst within Pathway 1 and 2 delivery of action is a part of the co-created project, in Pathway 3 the delivery of action is external to the co-created project and has, therefore, less guarantee. The more that the delivery of action can be included as a part of the co-created project, the more likely success can be achieved. Which of these co-creation pathways will deliver the intended action is dependent on the nature of the action objectives and the context within which action is sought. The role of science in these processes can either be a means (when utilised in pathway 3) or an ends (when utilised in pathway 2), but it needn't be a process of science that is co-created at all, any number of creative processes can be utilised in delivery action, it's the process of co-creation that is key.

10.9 Implications and significance of the contributions to knowledge

Where there has been a substantial lack of examples of more participatory approaches to citizen science in the literature and with that a lack of understanding of the dynamics of co-created approaches and the way in which they deliver their outcomes, the contributions to knowledge that I have offered through this thesis start to unpick the nuances of participation and collaboration and to understand the way in which co-creation delivers action. Where there was a normalised understanding that co-created approaches to citizen science were ordinarily initiated and driven by communities in order to deliver action for them , this thesis demonstrates that co-created approaches can be much more widely applied and with varying amounts of community control. This expands and diversifies our collective conceptualisation of the approach, opening up new opportunities and avenues for exploration in practice. Furthermore, having introduced notions of service and mutuality to the conceptualisation of co-created citizen science and reinforced the importance of governance, this work encourages a more critical and reflective attention to the manner in which relationships are built between researchers and citizens in these more intensive collaborations. This is fundamental in redressing the power relationships between science and society, fostering and nurturing the wider cultural shift taking place in the 'age of participation'. In more practical terms the concept of developing a social contract between researchers and citizens, whether formal or informal, encourages a more purposive designing of relationships rather than an assumptive adoption of normalised relational paradigms. The 'Mutuality Saltire' (Fig 9.1) presents a framework for deliberation and negotiation that can be used by researchers and citizen scientists to determine and agree on the social contract which is most suitable for their purposes and circumstances.

With regards the delivery of action, whilst this research failed to establish specific facets of co-created processes that needed to be attended to in order to deliver action, it did establish the different ways in which co-creation can be utilised for change-making, and the role that science plays within this. The established understanding that co-created approaches are better equipped at delivering action than contributory approaches are, without an understanding of how, potentially leads to a misguided and misappropriated

adoption of co-created approaches, with an assumption that if citizens are involved throughout the whole research process action happens at the end. Understanding that co-created citizen science processes can deliver action through three different pathways is significant because it means that co-created approaches can now be more purposefully adopted. It also encourages practitioners and communities to think more critically about the process of change-making and how co-created approaches might help to deliver that change, but what the limits of co-created citizen science are in doing so. This in practice leads to a more intelligent application and utilisation of the co-created approach to research. In addition to this the understanding that science can be utilised as a means (or in other terms, a tool) for creating action, or an ends (in other terms, a solution) for creating action, further develops our nuanced understanding of the application of co-created citizen science processes. In some cases the role of science is less central to creating action than might ordinarily be expected, and understanding this and reflecting on when this is the case, means that attention can be focused on the processes that are more influential. All in all the two contributions to knowledge, bring greater granularity into our understanding of the role of co-created citizen science in delivering action, and encourage more critical reflection and purposive design when adopting such approaches for change-making.

10.10 Suggestion for further research

Moving forward from this research there are two notable spaces which I would encourage researchers to pursue. This first is building on the identification of service, mutuality and governance as key notions for co-created partnerships. Here it would be valuable to understand the impact of the four different social contracts on the outcomes of projects. Do the four different social contracts deliver different types of outcomes, do they have different amounts of success, and in what terms? This would help to build a stronger understanding of value and limitations of the social contracts identified. The second suggestion is to build a better understanding of the direct involvement of policy-makers in co-created research processes. Gathering together and examining in detail what happens when researchers and citizen scientists directly collaborate with policy-makers, in a co-created way, in order to deliver action, would be highly valuable in helping to

develop understanding that could support more of this type of collaboration in the future. Policy-makers are a key stakeholder in many action and change stories, and knowing the power of co-created approaches to build relationships, integrate knowledge systems, and develop relevant and meaningful solutions, finding ways to build policy-makers into these types of collaborations would be very fruitful.

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Appendix 1: Participant Consent Form 1

Consent Form

Co-created Research for Community Action

Please read each of the following statements and tick the relevant box regarding whether or not you consent.

	Yes	No
I agree to the audio recording of my interview.		
I agree to the University of Dundee storing and making accessible to other researchers the anonymised transcript of my interview, and anonymised copy of my story timeline and my anonymised survey form, for at least 10 years.		
I agree to the use of anonymous extracts from my interview in conferences, academic and non-academic publications.		
I require that the name of the project I participated in be made anonymous.		
I require that the location of the project I participated in be made anonymous.		
I require that the names of the organisations, funding bodies and other projects that I discussed in my survey, story timeline and interview, be made anonymous.		
I understand that there is no compensation rewarded for my participation in this study.		
I understand that I can withdraw myself and my data from this research study, without explanation or penalty.		
I understand that I can withdraw myself and my data from this research study at any point up until data analysis commences.		

Please turn over to complete the consent form.

By signing below, you are indicating that you have read and understood the Participant Information Sheet, you have been given the opportunity to ask questions about the research project and that you agree to take part in this research study.

Participant's Signature _____

Participant's Name _____

Date _____

By signing below, the researcher is indicating that they promise to fulfil the conduct outlined in the Participant Information Sheet and in this consent form, and that they agree to contact you should any of those circumstances change.

Researcher's Signature _____

Researcher's Name _____

Date _____

Appendix 2: Participant Consent Form 2

Consent Form

Co-created Research for Community Action

Please read each of the following statements and tick the relevant box regarding whether or not you consent.

	Yes	No
I agree to the audio recording of my interview.		
I agree to the University of Dundee storing and making accessible to other researchers the anonymised transcript of my interview and anonymised copy of my story timeline, for at least 10 years.		
I agree to the use of anonymous extracts from my interview in conferences, academic and non-academic publications.		
I require that the name of the project I participated in be made anonymous.		
I require that the location of the project I participated in be made anonymous.		
I require that the names of the organisations, funding bodies and other projects that I discussed in my interview and story timeline be made anonymous.		
I understand that there is no compensation rewarded for my participation in this study.		
I understand that I can withdraw myself and my data from this research study, without explanation or penalty.		
I understand that I can withdraw myself and my data from this research study at any point up until data analysis commences.		

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Researcher's Signature _____

Researcher's Name _____

Date _____

Appendix 3: Participant Information Sheet 1

Participant Information Sheet

Co-created Research for Community Action

Invitation to take part in research study

You are invited to share your experiences of being involved in a science project that involves scientists and citizens working together extensively. By sharing your experiences you will support PhD research that is investigating how these types of projects work and how they support communities to make change happen.

This research is led by PhD Student Mrs Jade Gunnell of University of Dundee.

What is the purpose of this study?

The PhD research project is interested in science projects that involve scientists and citizens working together throughout a whole research project. This is called a co-created research process. The project you took part in has been chosen as an example of this way of working.

The ambition of this PhD is to identify whether co-created research processes can be used to support communities to take action on the issues that matter to them, and when and how such projects work best.

The findings of the PhD will be shared with researchers, project organisers and project participants through academic and non-academic articles, books and conferences. We hope the findings will be useful in improving and enhancing the way that co-created research projects are carried out.

By sharing your, positive and negative, experiences and opinions of participating in a co-created research project, you enable this study to capture the diversity and variety of these processes.

This will provide important and detailed insights into what makes these projects successful and unsuccessful.

What does participation involve?

This study involves the completion of one short survey, a story timeline and one story-telling interview. The survey will be conducted on a computer, and is made up of 13 questions, which should take no more than 15 minutes to complete. The story timeline is a designed worksheet that asks you to map out your project. You will be asked to spend 30 minutes completing this, before the interview, in preparation. You will be asked to send a digital copy (either a scan or a photograph) of the worksheet back to Mrs Jade Gunnell, before the interview. The interview will be conducted on the internet using video call software Appear.In (or any other software you have access to), or by telephone. Rather than being questions and answers, the interview will be an open discussion where you can share your story of your experience of co-created research. At the end of the interview you will be asked a couple of demographic questions, about your work, your education and your previous involvement in these types of projects. In total the video call will take 1 hour and 15 minutes, 15 minutes to allow for technical problems and to re-cover the information in this sheet, and then 1 hour for the interview itself. This call will be conducted at a time suitable to you.

What are the costs of participating and will I get paid?

There is no cost for participating in this study.

Participation in the study is completely voluntary, and there is no compensation or payment rewarded for taking part.

What are the risks of taking part?

There are no known risks for you in this study.

Can I withdraw from the study?

You can decide to stop participating in this study, without explanation or penalty.

You can withdraw your data from the research project at any point, up until data analysis has begun. Once data analysis has begun, we may not be able to identify and remove your specific contributions, as your data will have been anonymised and integrated with other data. You will be informed by email when data analysis begins.

To withdraw from this study you should email Mrs Jade Gunnell at the earliest opportunity. Contact details below.

How will me and my data be protected?

The data collected in this study will consist of your completed survey, your completed story timeline and an audio recording of your interview. Included in this data will be some personal data including your name, location, educational background, employment status, profession and links to other organisations and projects.

Your interview will be typed up as a word document, your story timeline will be saved as a pdf file and both these and your survey data will be anonymised, so that it is not possible to identify you as an individual. We will also anonymise the names of any individuals that you mention in the study. However, we will report the name and location of the project and organisations that you discuss, if you have given permission for us to do so. You are asked for your permission in the study consent form.

Your anonymised data, plus the original audio recording of your interview will be kept in a password protected data storage programme, authorised by the University of Dundee. Only Mrs Jade Gunnell and her supervisors Dr. Mel Woods and Prof. Ioan Fazey, will have access to this data. The original audio recording of your interview will be stored until September 2020, after which it will be destroyed.

With regards the rest of your anonymised data, we are required by our funding agency to make this data available to other researchers. This means that we will store the anonymised interview transcripts, anonymised story timeline and the anonymised survey data in the University of Dundee online archive. Here it will be accessible to any researcher from around the world, in order for them to assess the quality of this study, but also for their own research purposes. The data will be stored for ten years from the last time it was accessed.

Where data is reported at conferences or published in academic or non-academic articles and books, the data will be reported to the level of anonymity you have given permission for, in the consent form.

Whilst we will make your data anonymous so that you cannot be personally identified, we are only inviting three to five people from each project, to participate in this study. We believe that this situation means that it may be possible for your peers to identify your contributions to this study, in any published literature, if they know you were involved.

The University Research Ethics Committee of the University of Dundee has reviewed and approved this research study.

This research is funded by the Engineering and Physical Sciences Research Council (EPSRC).

Who should I contact about this study?

If you have any questions you can contact Mrs Jade Gunnell at j.l.gunnell@dundee.ac.uk, at any time before, during or after the study.

If you would like to be kept informed about the outcomes of the research, please contact Jade to be included on the mailing list.

Appendix 4: Participant Information Sheet 2

Participant Information Sheet

Co-created Research for Community Action

Invitation to take part in research study

You are invited to share your experiences of being involved in a science project that involves scientists and citizens working together extensively. By sharing your experiences you will support PhD research that is investigating how these types of projects work and how they support communities to make change happen.

This research is led by PhD Student Mrs Jade Gunnell of University of Dundee.

What is the purpose of this study?

The PhD research project is interested in science projects that involve scientists and citizens working together throughout a whole research project. This is called a co-created research process. The project you took part in has been chosen as an example of this way of working.

The ambition of this PhD is to identify whether co-created research processes can be used to support communities to take action on the issues that matter to them, and when and how such projects work best.

The findings of the PhD will be shared with researchers, project organisers and project participants through academic and non-academic articles, books and conferences. We hope the findings will be useful in improving and enhancing the way that co-created research projects are carried out.

By sharing your, positive and negative, experiences and opinions of participating in a co-created research project, you enable this study to capture the diversity and variety of these processes.

This will provide important and detailed insights into what makes these projects successful and unsuccessful.

What does participation involve?

This study involves the completion of a story timeline and one story-telling interview. The story timeline is a worksheet that asks you to map out your project. You will be asked to spend 30 minutes completing this, before the interview, in preparation. You will be asked to send a digital copy (either a scan or a photograph) of the worksheet back to Mrs Jade Gunnell, before the interview. The interview will be conducted on the internet using video call software Appear.In (or any other software you have access to), or by telephone. Rather than being questions and answers, the interview will be an open discussion where you can share your story of your experience of co-created research. At the end of the interview you will be asked a couple of demographic questions, about your work, your education and your previous involvement in these types of projects. In total the video call will take 1 hour and 15 minutes, 15 minutes to allow for technical problems and to discuss the information in this sheet, and then 1 hour for the interview itself. This call will be conducted at a time suitable to you.

What are the costs of participating and will I get paid?

There is no cost for participating in this study.

Participation in the study is completely voluntary, and there is no compensation or payment rewarded for taking part.

What are the risks of taking part?

There are no known risks for you in this study.

Can I withdraw from the study?

You can decide to stop participating in this study, without explanation or penalty.

You can withdraw your data from the research project at any point, up until data analysis has begun. Once data analysis has begun, we may not be able to identify and remove your specific contributions, as your data will have been anonymised and integrated with other data. You will be informed by email when data analysis begins.

To withdraw from this study you should email Mrs Jade Gunnell at the earliest opportunity. Contact details below.

How will me and my data be protected?

The data collected in this study will consist of your completed story timeline and an audio recording of your interview. Included in this data will be some personal data including your name, location, educational background, employment status, profession and links to other organisations and projects.

Your interview will be typed up as a word document, your story timeline will be saved as a pdf file and both of these will be anonymised, so that it is not possible to identify you as an individual. We will also anonymise the names of any individuals that you mention in the study. However, we will report the name and location of the project and organisations that you discuss, if you have given permission for us to do so. You are asked for your permission in the study consent form.

Your anonymised data, plus the original audio recording of your interview will be kept in a password protected data storage programme, authorised by the University of Dundee. Only Mrs Jade Gunnell and her supervisors Dr. Mel Woods and Prof. Ioan Fazey, will have access to this data. The original audio recording of your interview will be stored until September 2020, after which it will be destroyed.

With regards the rest of your anonymised data, we are required by our funding agency to make this data available to other researchers. This means that we will store the anonymised interview

transcripts and the anonymised story timeline in the University of Dundee online archive. Here it will be accessible to any researcher from around the world, in order for them to assess the quality of this study, but also for their own research purposes. The data will be stored for ten years from the last time it was accessed.

Where data is reported at conferences or published in academic or non-academic articles and books, the data will be reported to the level of anonymity you have given permission for, in the consent form.

Whilst we will make your data anonymous so that you cannot be personally identified, we are only inviting three to five people from each project, to participate in this study. We believe that this situation means that it may be possible for your peers to identify your contributions to this study, in any published literature, if they know you were involved.

The University Research Ethics Committee of the University of Dundee has reviewed and approved this research study.

This research is funded by the Engineering and Physical Sciences Research Council (EPSRC).

Who should I contact about this study?

If you have any questions you can contact Mrs Jade Gunnell at j.l.gunnell@dundee.ac.uk, at any time before, during or after the study.

If you would like to be kept informed about the outcomes of the research, please contact Jade to be included on the mailing list.

Appendix 5: Story Timeline Tool

Co-created Research for Community Action

Story Timeline

I would like you to tell me your story of the project you participated in.

Starting with the goals of the project and finishing with the outcomes, I'd like you to tell your story of **what happened and how this led to the outcomes.**

Over the page you will find a couple of questions and a story timeline.

- Please take around 30 minutes in the week before the interview to map out your story of the project on the story timeline.
- Scan or photograph the story timeline and email it to me, before the interview and keep the original copy for yourself.

You **do not** need to provide a **detailed account** of the project on the story timeline. Simply **record** some notes in any format (**bullet points, words, drawings, doodles**), that will act as reminders during the interview. *But please write in BLOCK CAPITALS.*

ACTIVITIES
What happened?

PEOPLE
Who was involved and how did they work together?

SUCCESSES & FAILURES
What worked and what didn't work?

REFLECTIONS
What did you think and feel?

Four prompts (above) have been provided for you to think about as you construct your story, but this is **your story**, so only use them if and when you find them relevant. The focus of your story should be **your perspective on what was important** about the project and how it achieved its outcomes, as well as your experiences of the project both good and bad.

The interview

- For the interview, we will meet online for 1 hour and 15 minutes.
- The interview itself will be 1 hour long.
- During the interview you can use your story timeline to help you tell your story.
- The extra 15 minutes are to provide time for any technical issues and for us to re-cover the participant information sheet and consent form.

What were the goals of the project overall?....

What were your personal goals for the project?....

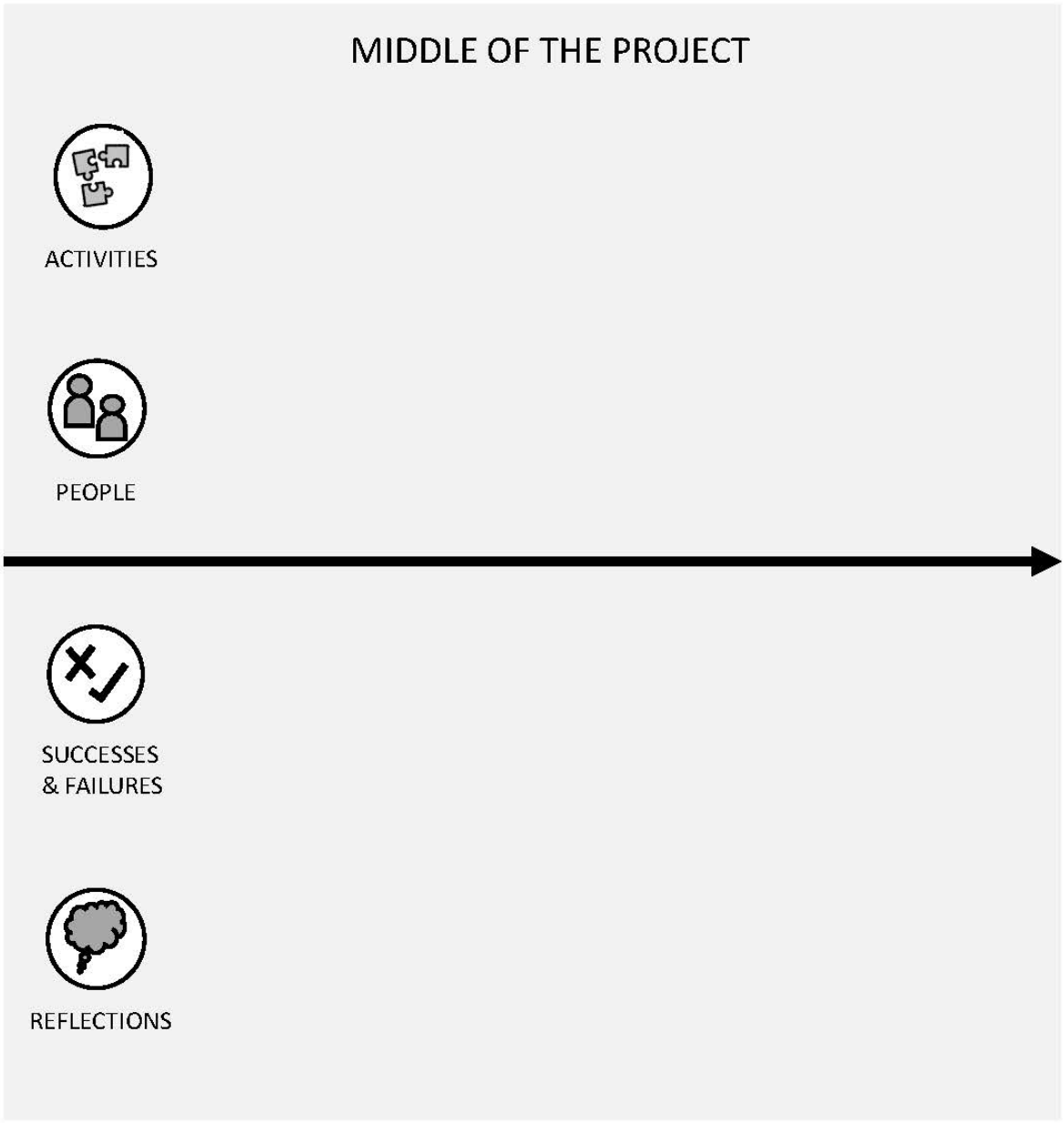
BEGINNING OF THE PROJECT

ACTIVITIES

PEOPLE

SUCCESSES
& FAILURES

REFLECTIONS



Not sure what to do? Looking for some help?
Feel free to get in touch: j.l.cawthray@dundee.ac.uk

END OF THE PROJECT

ACTIVITIES

PEOPLE

SUCCESSES
& FAILURES

REFLECTIONS

What were outcomes of the project overall?....

To what extent were your personal goals met through the project?....

What has happened since?

Appendix 6: Interview Schedule

Interview Schedule

Co-created Research for Community Action

Topics checklist:

Please note: This following list will act as a checklist to ensure that all topics are covered during the narrative interview. These statements are not suggestions of phrasing for the interview, as the language and terminology is in appropriate. I will use the participants own language and phrasing to encourage dialogue around topics that are not covered in their narrative.

How the project came about.

How the participant became involved in the project.

Why the participant wanted to become involved.

The participant's ambitions for the project.

The stages of the project.

The participant's involvement in the project.

The participant's experiences of working with scientists/citizens.

The participants experiences of the co-created process.

The external factors that affected the project.

The outcomes of the project.

How satisfied the participants were with the outcomes of the project.

Narrative prompts:

- Tell me how the project came about.
- Tell me how you got involved in the project.
- Tell me what happened at the beginning of the project.
- How did things progress from there?
- What happened next?

- What happened when….?
- Tell me about a time when….?
- What do you think would have happened if….?
- Can you say more about that?
- Can you say more about….?
- Can you say more about your experience of….?
- What happened in the end?
- What were the critical moments/events in the project?
- What do you mean by….?
- Do you mean that….?
- Who was involved….?

Post interview demographic questions:

Please note: The following questions will be asked at the end of the narrative interview, and only where they have not been covered within the interview.

With regards employment, are you full-time employed, self-employed, retired, home mum/dad or in some other situation?

What is/was your profession?

What is your highest level of education?

What topic is your highest level of education in?

What is your highest level of science education?

Which organisation were you involved in that brought you to the project?

What was your role in that organisation?

Were you employed on this project, or a volunteer?

Can you tell me when it was that you got involved in the project? [Month &/ Year]

When did you leave the project? [Month &/Year]

Have you been involved in citizen science/ participatory research before?

What was the project?

What was your involvement in the project?

Appendix 7: Codebook – Large Carnivore Mitigation Programme

(Codebook presented to two levels of granularity).

BACKGROUND INFO & CONTEXT	6	54
Debate around appropriate allocation of funds	1	1
Project scope	3	8
Project situated in a on-going dynamic context	6	18
The impact of the large carnivore conflict on the community	6	20
Weaknesses of compensation scheme	3	7
COMMUNITY RELATIONSHIPS WITH REST OF SOCIETY	6	96
Community relationship with government	6	31
Community relationship with scientists	1	1
Social conflict	6	28
The lack of support for ranching community	4	8
Understanding and valuing the community	6	28
COMMUNITY TACKLING THE LARGE CARNIVORE ISSUE	6	83
Community capital	4	11
Community priorities	1	1
COMMUNITY RELATIONSHIP WITH ASSOCIATION A	1	2
Community's management of issue	6	29
Community's management of project	5	34
Inspiration from other projects	3	5
Pride and ego as a barrier to participation	1	1
FAILURES OF MAPPING PROJECT	5	20
Agreement to close down project that wasn't delivering results	1	1
Community relationship with institute A	2	4

Funding restrictions for delivering programming	1	4
Going to community to collect data	1	1
Mapping project ended due to low participation	1	1
Maybe there wasn't a need for these guys to collect their own information	1	1
Sharing excess funds to help other programmes	1	1
Timing is critical	1	1
Understanding the value of science	1	1
We did things in the wrong order	1	1
PROJECT OBJECTIVES	2	12
Change management practices	1	1
Developing respect across multiple perspectives of issue	1	1
Educating ranching community	1	2
Empowering community with their own data	1	2
For ranchers and wildlife to live comfortably together	1	1
Opening up people's perspectives	1	2
Ranchers access to funding for mitigation	1	1
Trying to increase community's awareness of perceptions vs reality	1	1
PROJECT OUTCOMES	6	47
Bringing funds into the community	1	1
Knowledge and understanding	5	8
Project influenced other work	2	3
Reducation in large carnivore conflict	4	11
Relationships	3	5
Success	2	4
The impact of SciG's work	5	13
The need for evaluation	1	1

Trail cam camera network outlasted the project and continues	1	1
SCIENTISTS AND COMMUNITY WORKING TOGETHER	6	340
Building and maintaining relationships and partnerships	6	143
Community's role	1	3
Ranchers qualities	3	16
Scientists qualities and conduct	5	112
Scientists role	5	53
THE ROLE AND VALUE OF SCIENCE	6	38
Data can make things worse if in wrong hands	1	1
Importance of science	2	2
Previous population estimates weren't solid	1	1
Revealing truths	6	27
The role of data	2	5
THE ROLE OF GOVERNMENT AND POLICY	5	27
Community request to government for different management consideration	1	1
Government's capacity to manage problem	2	2
The role of policy	4	24

Appendix 8: Codebook – Protecting Our Waterways

(Codebook presented to two levels of granularity).

CITIZEN DEMOGRAPHICS	2	4
CRITICAL INCIDENCES	5	16
Citizens' share local industrial knowledge X	1	1
Dwarf galaxias	5	8
Project drivers	2	7
ENABLING CITIZEN SCIENCE	3	4
MOTIVATIONS	5	32
OBJECTIVES	4	12
OUTCOMES	5	77
Change in attitudes	2	2
Engagement	2	3
Learning	4	12
Project success	2	2
Satisfaction and experience	5	36
PARTICIPATION AND COLLABORATION	5	240
Citizen autonomy	4	9
Citizen validity	5	21
Commitment	5	16
Communication	5	49
Community interest	1	1
Enabling citizen participation	5	30
Governance of process and project	5	22
Meeting expectations	1	3

Ownership	2	3
RELATIONSHIPS	5	60
Citizen-citizen relationships	4	8
Citizen-organisation relationships	5	37
Citizen-scientist relationships	4	8
Organisation-organisation relationships	1	2
Social connections	4	5
SCIENCE COMPREHENSION	5	31
SCOPE OF PROJECT	4	8
THE VALUE AND ROLE OF ACTORS	5	61
The value and role of citizens	5	40
The value and role of the environment authority	5	21
THE VALUE OF CITIZEN SCIENCE	3	10

Appendix 9: Codebook – Healthy Household Water

(Codebook presented to two levels of granularity).

CHARACTERISTICS	5	62
Academic research programme staff characteristics	1	2
Community characteristics	5	28
Community researcher characteristics	3	16
Professional researcher characteristics	2	7
Stakeholder clients characteristics	2	9
CITIZENS EMPLOYED AS COMMUNITY RESEARCHERS	5	31
Community researcher recruitment	5	12
Community researchers confidence about taking on the role	1	4
Employee and line management from different organisations	2	3
Hours and pay	4	9
Reasons for paying community researchers	2	3
COMMUNITY RESEARCHERS AS THE STRENGTH OF THE PROJECT	5	38
Access to the community	5	11
Local knowledge	4	11
More useful as an expert	1	1
Research outputs better	3	6
Strength of the project	3	5
Trade offs of a community researcher approach	1	2
Willingness to have community researchers on steering group	1	1
EVENTS AND ACTIVITIES	5	39
Closing event	3	6
Community events	5	18

Community researchers participation in other project workshops	1	3
Consultation with key stakeholder bodies about biggest priorities	1	2
Training community researchers	3	6
Water testing with communities	2	4
EXPERIENCES AND REACTIONS TO PROJECT	5	37
Community researcher experiences of the project	2	20
Community response to project	3	11
Frustration for research staff	2	3
Researchers awareness of poor water quallity	1	2
Stakeholder clients reactions to the project	1	1
GOVERNANCE AND MANAGEMENT OF THE PROJECT	4	41
Changes in management	1	1
Decision-making	4	15
Management at research programme level	3	15
Researchers' collaboration with each other.	2	9
OBJECTIVES	5	39
Assessing new technologies	1	1
Better understanding of communities and their private water supplies	5	7
Creating dialogue and communication	2	2
Delivering research for stakeholder clients	4	8
Inform National Campaign on Water Quality	1	1
Project drivers	3	14
Providing solutions for communities	2	4
Solutions	1	1
OUTCOMES	5	56
Action or change	5	10

Community engagement	3	8
Knowledge	4	17
Lack of awareness of outcomes	3	4
Ongoing relationships	3	11
Perception of success in the project	4	6
PROJECT SCAFFOLDING	5	115
Project structure	5	31
Research approach	4	13
The context	5	71
RELATIONSHIPS AND INTERACTIONS	5	125
Academic research programme relationships	1	10
Community relationships	5	20
Community researcher relationships	5	62
Professional researchers relationships	3	33
ROLES	5	111
Academic Research Programme Role	1	14
Community Researchers Role	5	57
Professional Researchers Role	5	26
Stakeholder Client Role	5	14
TAKING ACTION	5	27
Community do not see a problem with their water quality	2	3
Enabling change	3	11
Providing the community with solutions	3	13
WEAKNESSES OF THE PROJECT	5	28
Community researchers lack of clarity in project	2	11
Impact of powerful actors on the research	2	8

Lack of momentum within the community around the issue	1	2
Limited impact around issue	1	2
Professional researchers constrained too much	1	3
Time is a limiting factor for projects	1	2

Appendix 10: Codebook – Conserving Wolverine Populations

(Codebook presented to two levels of granularity).

CONTEXT	6	80
Conservation partners relationship with government	1	2
Government not motivated to respond to positive wolverine data	1	1
Social network support	1	1
Television broadcaster not willing to promote trappers	1	3
This project is part of an evolution of stakeholder engagement for conservation partner	1	1
Trapper culture	1	2
Trappers public relations	5	9
Trappers relationship with science	6	36
Wolverine conservation and management	5	24
Wolverine research	1	1
OUTCOMES	6	181
Assessment of the project	3	13
Communications	2	2
Conservation	1	1
Engagement	4	9
Knowledge	6	23
Policy	3	7
Relationships	6	35
Science outcomes	6	15
The science	5	36
Trappers experience of the programme	6	40
RADIO COLLARING PROJECT RUNS IN PARALLEL	4	40

PhD student qualities	3	5
Recruiting a grad student to carry out research	1	1
Research student worked in consort with trappers and conservation partner	1	1
Trappers contribute to additional project in parallel	3	4
University - conservation partner conflict	2	20
University scientist qualities	1	2
University scientists role	1	7
SCIENTISTS AND TRAPPERS COLLABORATION	6	635
COLLABORATIVE INFRASTRUCTURES	6	305
Collaborative philosophy	6	44
Objectives	6	42
Ownership	4	11
Project meetings	3	6
Resources	5	18
Roles	6	179
These projects can be successful if you take the right approach	1	2
INTERACTIONS	6	195
Being right and wrong	2	4
Building Trust	5	13
Checking that trappers are happy with the findings	1	2
Communication	5	15
Conservation partner wanted the project to be trapper driven	1	1
Consultation	2	2
Decision-making	2	6
Disagreements	4	13
Face to face interactions	1	1

Leadership	4	17
Listening	2	4
Negotiation and persuasion	2	4
Relationships	6	102
Respect	1	1
Scientists engaging in trappers space	2	3
Support	2	5
Trapper initiation	1	1
Trappers wanted Conservation Partner out in the field	1	1
QUALITIES - CHARACTER TRAITS	6	135
Characteristics and qualities of trappers	6	62
Characteristics of conservation partner scientists	6	39
Commonalities	3	7
Motivations	6	26
THE FUTURE	5	13
Hopeful that research will contribute to wolverine population reassessment	1	1
Opportunities	3	6
So much progress, but so much more to do	2	5
We're going to ride the wave of this forever	1	1
PROJECT ACTIVITIES AND STRUCTURE	6	103
Activities	6	52
Continued collecting data beyond University students PhD	1	1
Final years	2	3
First years	1	1
Long programme	2	4
Pilot year	2	2

Project end	3	3
Project evolved through an iterative process	3	7
Project initiation	2	6
Project set-up	1	1
Project wrap up	2	5
Run for a couple of years	1	2
Scale of the project	5	8
The partners	2	5

Appendix 11: Codebook – Noise Pollution in the Plaza

(Codebook presented to two levels of granularity).

ACTIVITIES AND ROLES	5	177
Awareness raising	3	4
Citizen sensing	3	6
Community building	2	4
Community champion roles	2	3
Creating community champions	3	5
Data analysis	4	8
Documentary making	2	4
External contributions	3	5
Identifying the problem	3	9
If you have political contacts you should use them	1	1
Media engagement	5	5
Meetings	3	5
Pilot projects	3	18
Project management	4	22
Public interventions	5	14
Recruitment	2	2
Supporting engagement	3	20
Taking action	4	12
Tech and tool development and management	5	28
The role of [Civic Organisation]	1	2

CHARACTERISTICS	5	79
Community champion characteristics	4	27
Government characteristics	1	1
Neighbours characteristics	5	22
Project characteristics	1	2
Project team characteristics	3	6
Researcher characteristics	4	21
ENGAGEMENT	5	98
Community champion engagement	4	38
Factors affecting engagement	4	14
Neighbours engagement	5	35
Recreational community engagement	1	1
Researchers engagement	2	7
When someone's heart is devoted to a project there's all this magic and love	1	1
EXPERIENCES	5	107
Collective experience	3	4
Community champion experiences	3	41
Neighbours experiences	5	35
Researcher experiences	4	27
MOTIVATIONS	4	19
Career	4	7
Community champion motivations different from neighbour motivations	1	1
Make social connections	1	1

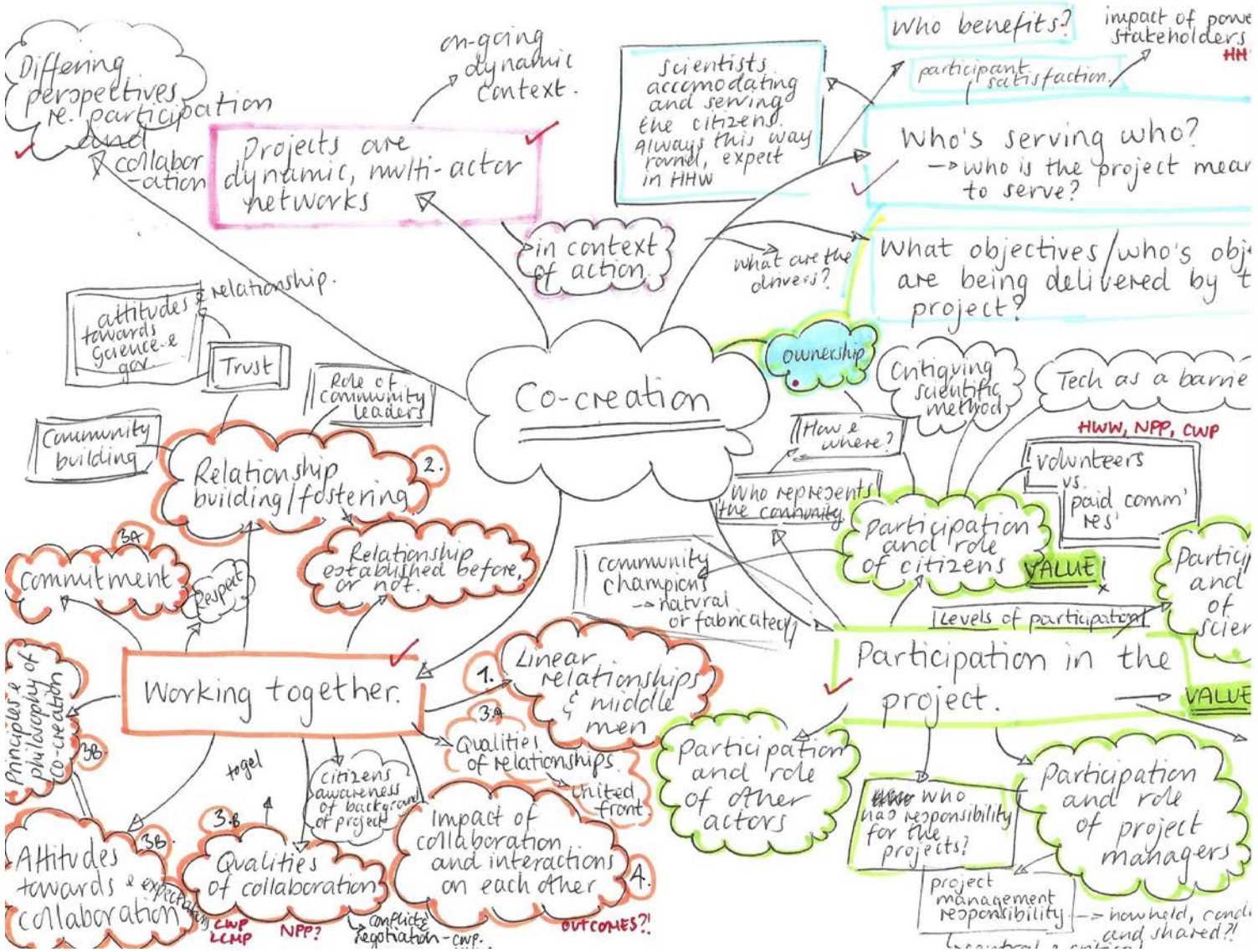
Making a difference	2	2
The city	2	2
The noise issue	3	3
The project	3	3
OPPORTUNITIES	5	11
Alignment of issue and technological capabilities	1	1
Broaden scope	1	2
Creating a complete product methodology	1	3
Developing social networks	3	3
Not a cookie cutter approach for this	1	1
Slow thing down	1	1
THEORETICAL NOTIONS OF COMMUNITY, ENGAGEMENT, EMPOWERMENT AND CHANGE	4	37
Creating change	2	11
Dialogue and co-creation was needed because the community were angry	1	1
Don't put words in participants mouths	1	1
Faster you can produce meaningful data the better	1	2
Get everyone to acknowledge the problem and move beyond conversations about the data	1	1
Need to create trust	1	1
Not about quantity of sensors but communities and methodology	1	1
Overcoming conflict	1	2
Power of bringing together different people who feel sense of ownership over different parts of the project.	1	1

The process was emergent	1	1
GOVERNMENT RESPONSE TO THE PROJECT AND THE PROBLEM	5	29
Government only expect experts to access and utilise their data	1	1
Organise meetings	1	1
Political balance not wanting to repress people	1	1
Priorities	2	2
Taking action	2	12
Trust in data	3	8
Trying to win votes	1	2
OBJECTIVES OF THE PROJECT	5	15
Better understand opportunities for utilisation of [public invention centres]	1	1
Create action and change	4	9
Develop a methodology of citizen sensing	2	2
Reach a successful conclusion	1	2
Testing replicability across research partners	1	1
OUTCOMES	5	140
Career development	4	5
Change	5	28
Empowerment	4	8
Endings	3	5
Evidence	2	2
Knowledge, awareness raising, skill building	5	19
Legacy	3	4

Media attention	2	2
Outputs	4	6
Post project	2	2
Post project engagement legacy	3	7
Project manager got the results she wanted	1	1
Relationships	3	6
Successes	4	16
Weaknesses	5	23
What the project didn't achieve	2	2
Who benefits from the project	3	4
PROJECT STRUCTURE & MANAGEMENT	4	28
Governance of project	3	3
Pilot projects	3	12
Project conducted in regional language	1	1
Project run from [co-working space] near [plaza]	1	1
Resources	4	8
Time	3	3
RELATIONSHIPS	5	39
Between researchers	1	2
Community champion and neighbours relationship	1	1
Community champions worked together based on professional skills and interest	1	1
Neighbours and researchers	4	20
Neighbours relationship with government	1	7
Researcher and citizen collaboration	3	8

ROLE OF DATA AND TECH	5	24
The role and value of data	5	17
The role and value of technology	2	6
THE BROADER CONTEXT OF THE PROBLEM	5	37
Citizens didn't know about availability of open access data	1	1
Different ideas of what's causing the problem	1	1
Government response to the problem	3	3
Impact of the problem	3	9
Plaza usage	2	2
Scale of the problem	5	15
Source of the problem	2	5
Younger people able to mitigate the challenges	1	1
VALUE	5	29
The value of community champions	3	10
The value of external experts	1	2
The value of neighbours	4	7
The value of researchers	2	4
The value of the media	1	1
The value of the project	3	5

Appendix 12: Cross case study thematic mapping




revealing truth
Outcomes
Role of science data & tech
role and value of diff" actors
role of gov.
addressed in ownership & service section
Co-creation
Need to define what is the action for each project
Delivering Action
project conti and legac
Extent community is served
Are communities objectives met?
addressed in ownership and service section
role of co-creation
Community agency
Barriers to action & change
community use other/additional avenues for tackling their problems
role of engagement