Renewed Coexistence:

Human dimensions of reintroducing the Eurasian beaver (*Castor fiber*) into England

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I certify that all material in this thesis which is not my own work has been identified and that any material that has previously been submitted and approved for the award of a degree by this or any other University has been acknowledged.

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Abstract

Coexistence is the adaptive but sustainable behaviour of humans and animals living together, which can be beneficial for humans. Conflicts can occur between humans and wildlife or among humans about wildlife which require effective and socially acceptable management solutions to achieve coexistence. Wildlife reintroduction is where species are returned to landscapes where they previously existed but are no longer present. A knowledge of how to anticipate and address conflicts in reintroduction scenarios would aid the development of sustainable solutions in this unique coexistence context, as would an understanding of how social benefits occur and can be maximised post-reintroduction. Further, understanding how reintroduction governance compares to the governance of coexistence with species that are already present would help aid the integration of reintroduced species into anthropogenic landscapes. In this thesis, these questions are addressed with a pragmatic, mixed-methods approach to investigating the human dimensions of Eurasian beaver (*Castor fiber*) reintroduction in England. Informed by a foundational nationwide attitudinal survey, the research consists of a series of studies: two of potential conflicts, two of social benefits, and one exploring the experiences of stakeholders involved in a reintroduction project. The thesis finds: 1) potential conflicts can be anticipated and addressed with early and appropriate engagement, and by seeking to understand social attitudes towards potential management solutions beyond just reintroduction itself; 2) social benefits occur naturally to some extent, but are greatest where there is active investment in the opportunities; 3) lessons from existing literature can be applied to governance of coexistence with reintroduced species, but key differences arise from the ‘future-thinking’ needed in reintroduction. The thesis concludes reintroduction is both an ecological and social

science, and defines ‘Renewed Coexistence’ as coexistence between a species which was formerly resident and humans in the locality today to whom the species is a ‘new’ presence.

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1. Introduction

Wildlife reintroduction is one form of wildlife translocation, where animals are moved between areas. Reintroduction is the act of translocating individuals of a species into an area in which it was formally present but is now locally extinct (Seddon et al., 2014). Reintroductions are distinct from species introductions (including of invasive species) as there must have been an historical presence of the species prior to the release, as defined by the presence of the prefix ‘re-‘ (Jørgensen, 2015).

In conservation communities, reintroduction is growing in popularity, often motivated by the potential to increase levels of biodiversity (Seddon, 1999; Taylor et al., 2017). This can be by means of establishing populations to support the specific species being reintroduced (such as the numerous red squirrel reintroductions in Europe (Lawton et al., 2015)), or it could support ecological communities more widely when the reintroduced species is a ‘keystone species’, one which is a fundamental component of ecosystem structure and function through trophic cascades (Mills et al., 1993; Paine, 1966, 1969). An example of this is the reintroduction of the grey wolf (*Canis lupus*) in Yellowstone National Park, USA, where the presence of wolf impacted on the population numbers and behaviour of elk (*Cervus canadensis*), in turn leading to the recovery of woody browse vegetation species especially in riparian zones, which then supported the return of the North American beaver (*Castor canadensis*), which built dams, positively impacting water resource management (Beschta & Ripple, 2016; Ripple & Beschta, 2012). Furthermore, motivations may be rooted in a sense of ethics, with some people holding a view that it is a ‘moral imperative’ to reintroduce species lost as a result of human activities (Lewis et al., 2017).

Whilst reintroductions hold potential for ecological restoration, there can also be impacts for people (Coz & Young, 2020; O’Rourke, 2014). As I will discuss throughout this opening chapter and the thesis, there could be beneficial or negative impacts for people and, in the case of the latter, there is potential for conflicts to arise between people *and* the reintroduced species, or among people *about* the reintroduced species and its management (Coz & Young, 2020; Madden, 2004; O’Rourke, 2014; Redpath et al., 2015). Conflicts hold implications for the success of reintroduction projects, maybe even preventing them altogether (Lopes-Fernandes & Frazão-Moreira, 2017; Sutton, 2015; Perring et al., 2015). As such, the International Union for Conservation of Nature and Species Survival Commission have published guidelines with several requirements that reintroduction projects should meet. Alongside an assessment of the ecological suitability of the reintroduction site, the guidelines state the need to understand the potential impacts of the reintroduction for the environment <u>and</u> for people (IUCN & SSC, 2013). These guidelines state that *“Any translocation will impact and be impacted by human interests. Social, economic and political factors must be integral to translocation feasibility and design”* (*pVIII*). Thus, the guidelines stipulate that an understanding of the human dimensions of reintroduction is required if a project is to be successful.

‘Human dimensions’ in wildlife research and management refers to an understanding of human beliefs or actions, impacts upon people, and the implications of human decision-making for wildlife policy and management (Decker & Chase, 1997; Enck et al., 2006; Manfredo et al., 2009).The human dimensions of reintroduction may relate to all of these factors, including potential benefits for society, arising conflicts, and the associated management implications of these factors (O’Rourke, 2014) (as is later discussed in this chapter).

This thesis will focus on the human dimensions of wildlife reintroduction, an interdisciplinary subject drawing particularly upon the disciplines of environmental social science and conservation science, and investigating relationships between humans and nature in the context of reintroduced species. Through the study of Eurasian beaver (*Castor fiber*) reintroduction in England, I will critically explore issues in the field: how potential conflicts can be anticipated or addressed; how arising benefits accrue and can be maximised; and lessons for the processes of reintroduction project governance and stakeholder engagement compared to the governance of coexistence with existing species.

Following this opening outline chapter, the main research chapters will consist of published papers, or papers that are currently undergoing peer review (a statement of contribution for these papers is given later in this outline chapter). Consequently, each chapter has a self-contained, bespoke literature review that is relevant to each paper’s focal subject. Thus, in this outline chapter, an introductory literature review of coexistence, human-wildlife conflicts, and the role that social science plays in these issues will frame the research context, with illustration of the implications of this knowledge for wildlife reintroduction projects. Following this, the study species reintroduction around which this research is centred is introduced: Eurasian beaver in England. I will then outline the structure of the remaining thesis including: the epistemological approach; descriptions of each chapter; and details of the research timeline.

2. Literature Review

2.1. Coexistence, Human-wildlife conflicts, and Human-human conflicts about wildlife

‘Coexistence’ between humans and wildlife is the sustainable but dynamic state in which humans and wildlife co-adapt to share the landscape (Carter & Linnell, 2016; Frank, 2016; Pooley et al., 2017a; Pooley et al., 2021). It is the ‘behaviour of living together’, requiring active governance of human interactions with wildlife (which can be either positive or negative) to satisfy the interests of both humans and wildlife, or to reach a compromise that allows both humans and wildlife to exist (Frank, 2016; Nyhus, 2016). ‘Coexistence’ can be peaceful and entail benefits, such as psychological benefits for wellbeing or recreational benefits through ecotourism (Nyhus, 2016).

Benefits for people that arise from coexistence with wildlife could be considered as ‘Ecosystem Services’ (ES). These are explicitly defined as the benefits that humans can derive from ecology and the environment (Costanza et al., 2017). ES are distinct from ‘natural capital’, which is defined as “‘the stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people’ (Lambooy et al., 2018; *The Natural Capital Protocol*, 2015), i.e. this is the stock that works with ecosystem processes to become ecosystem services, as opposed to the ecosystem services themselves.

ES benefits are primarily defined in four categories: provisioning, regulating, cultural and supporting services (Millennium Ecosystem Assessment, 2005), as detailed in Table 1. They have been widely accepted as a concept which bridges the gap between ecosystems and human well-being, helping to connect humans with nature (Daily et al., 2009) and incentivising conservation action (Naidoo et al., 2008).

Table 1. Types of ecosystem services (adapted from Millennium Ecosystem Assessment, 2005).

Type of Ecosystem Service	Definition	Examples
Provisioning Services	"Products obtained from ecosystems"	Food, water, fuelwood, biochemicals
Regulating Services	"Benefits obtained from regulation of ecosystem services"	Climate regulation, disease regulation, water purification, water regulation, pollination
Cultural Services	"Nonmaterial benefits obtained from ecosystems"	Recreation, Ecotourism, aesthetics, education, sense of place, sense of identity
Supporting Services	"Services necessary for the production of all other ecosystem services"	Soil formation, nutrient cycling

The Ecosystem Services framework is economics based, with services valued in financial terms (Farber et al., 2002; Liu et al., 2010). Valuation techniques include, for example, market methods where values are directly obtained from what people pay for a service, or contingent valuation methods where people are directly asked what they would be 'willing to pay' for a service (Liu et al., 2010). Proponents argue this helps to provide a common language with which to understand the environment (Daily et al., 2009), and it has contributed to its increasing utilisation in the development of environmental policy (Fisher et al., 2008; Pérez-Soba et al., 2018).

However, opponents may argue that the environment is not something that should be monetised as it is of 'greater worth' (Turnpenny & Russel, 2017). Economic values may fluctuate based on current market trends or may not reflect the importance of a service for the environment or for people, such as a sense of place amounting from the presence of biodiversity (Chan et al., 2012; Hausmann et al., 2016). In this thesis, when discussing benefits for people that may arise from beaver reintroduction, I will primarily define these using the terms ‘social benefit’ or ‘opportunity’, rather than as ecosystem services. This means that I refer to benefits using a similar definition to that of the ecosystem services framework (i.e. I refer to benefits for people arising from ecosystems - or in this case, beavers) but without the benefits being defined solely in economic terms.

Coexistence is at one end of a continuum, with conflicts between humans and wildlife occurring at the other; conflicts will need to be addressed if coexistence is to be achieved (Frank, 2016). ‘Human-wildlife conflict’ refers to negative interactions between humans and wildlife (Conover, 2002; Torres et al., 2018). The term can be controversial because some believe it to imply wildlife can be deliberately antagonistic (Peterson et al., 2010), but the term human-wildlife conflict is nonetheless widely used (Hill, 2015). In this thesis I define human-wildlife conflict as the negative interactions between humans and wildlife, without indicating wildlife or humans as ‘the antagonist’.

Human-wildlife conflicts occur in several forms, both real and perceived (Messmer, 2000). ‘Real’ conflicts can be seen where wildlife needs space and resources for sustenance, but often these compete with the interests of humans. Lions (*Panthera leo*) in Africa, for example, feed on meat to survive. Humans and lions may be in conflict when lions feed on livestock reared for human consumption (Blackburn et al., 2016). Perceived conflicts however are where humans believe there to be a conflict with wildlife which may not truly be occurring, such as in the case of the Zanzibar red colobus monkey (*Procolobys kirkii*). Here the species resides in agricultural areas where farmers perceived the monkeys to be feeding on the coconuts grown for harvest. However, it was found that the monkeys had no impact upon coconut harvests, and in fact may have a small positive effect (Siex & Struhsaker, 1999).

The literature is increasingly recognising that many human-wildlife conflicts are in fact conflicts among people, known as human-human conflicts about wildlife (Hill, 2015; Marshall et al., 2007; Redpath et al., 2015). Such conflicts may include social, political, cultural, economic, or legal intricacies (Madden, 2004). It is important to distinguish between human-human and human-wildlife conflicts to appropriately consider human-human dimensions in conflict management, rather than these dimensions being masked behind the banner of human-wildlife conflicts (Redpath et al., 2015).

Often, human-human conflicts manifest when different social groups have contradictory views upon how to respond to or manage wildlife (Marshall et al., 2007). A particular demonstration of this can be seen in the management of badgers (*Meles meles*) in the United Kingdom. *The Protection of Badgers Act* was introduced to protect badger welfare from the impacts of activities such as ‘badger baiting’ (HM Government, 1992). However, some believe that badgers are a vector for transmission of the disease *Bovine tuberculosis* (Bovine Tb) in cattle (Wilson et al., 2011). In cattle this disease can prove fatal and significantly affect a farmer’s income (Skuce et al., 2012). In response, the UK government has undertaken trial culls of badger populations (Enticott, 2015; McCulloch & Reiss, 2017). The culls have been received well in some farming communities (Maye et al., 2014), but other social groups oppose the culling trials on grounds of animal welfare, and cite scientific evidence indicating that culling does not reduce disease transmission and could increase transmission rates due to badger territoriality behaviour (Donnelly &

Woodroffe, 2015; McCulloch & Reiss, 2017). Thus, there are high conflict levels between social groups amounting from different views of the management of badgers and *Bovine tuberculosis* (Grant, 2009).

Conflicts among people may be defined as polarised or escalated (Crowley et al., 2017a). Polarised conflicts are where complex debates are framed as distinct arguments which oppose one another (Redpath et al., 2013). For example, human-wildlife conflict exists in the UK where grouse managers perceive raptors to reduce the size of harvests of red grouse (*Lagopus lagopus scoticus*), often resulting in the (now illegal) killing of hen harriers (*Circus cyaneus*). However, several government and non-government organisations oppose the killing of hen harriers on the grounds of wider conservation. The debate therefore holds opposing and polarised views on raptor conservation in a conflict among people (Redpath et al., 2013).

Escalated conflicts occur when conflicts intensify with increasing numbers of people engaging in the debate with further claims or opinions, causing a self-perpetuating, complicated, and potentially destructive situation to arise (Crowley et al., 2017a). Where these conflicts escalate, they can become increasingly difficult to resolve (Cusack et al., 2021). This is perhaps the case in the aforementioned debate surrounding the management of bovine Tb and badgers, as growing numbers of social groups and opinions have vastly increased the political sensitivity of the debate (Grant, 2009). This same example however also demonstrates polarity (McCulloch & Reiss, 2017), thus indicating that polarised and escalated conflicts can occur in the same situation, making for an ever more complicated situation to resolve.

2.2. Addressing conflicts for coexistence: The role of social science

Resolving current or potential conflicts can be a complex matter, but management strategies are needed to respond to and reduce human-wildlife and/or human-human conflict issues if coexistence between humans and wildlife is to be achieved and benefits garnered (Carter & Linnell, 2016; Frank, 2016; Messmer, 2000; Nyhus, 2016). As has been demonstrated however, disagreement over management strategies can lead to greater conflict, so the process of strategy development must occur in a manner which is careful not to lead to escalation; this will require a full consideration of the human dimensions (Cusack et al., 2021; Marshall et al., 2007; Zimmermann et al., 2020).

Stakeholder engagement is crucial to a successful management strategy - defined here as a social process of working together towards a collective solution (Green & Penning-Rowsell, 2010). There is much literature to support the importance of stakeholder engagement and environmental policy-makers are increasingly engaging with stakeholders in decision-making processes (Boiral & Heras-Saizarbitoria, 2017; Decker et al., 2016; Marshall et al., 2007; Redpath et al., 2013; Rust, 2017; Treves et al., 2009). By engaging with stakeholders effectively, key concerns can be better understood and appropriate decisions taken to attempt to address them; the most effective strategies are those which enable conversation with and between stakeholders, and problems are "shared as one" (Redpath et al., 2013). This is more likely to lead to consensus decisions on management, which are then more widely accepted and the potential for future conflicts is reduced (Rust, 2017; Treves et al., 2009). This can include reaching a consensus on the methods to be employed, and determining who should take responsibility for management, counteracting difficulties which could be faced through a lack of trust held in wildlife management bodies (Decker et al., 2014, 2016; Hill, 2015; Watkins et al., 2021). Engaging as early as is possible is likely to yield the best outcome (Treves et al., 2006). As has been described, conflicts can escalate with growing numbers of concerns and voices, leading to the conflict becoming ever more complex and thus more challenging to address (Crowley et al., 2017a; Cusack et al., 2021). As such, attempting to engage and address issues proactively has greater potential to alleviate such a situation before it occurs, rather than attempting to address them later.

Engagement with key stakeholders is not enough on its own. Stakeholder engagement such as this would be a top-down approach which tends to use policy-makers, those with scientific knowledge and key stakeholders in the management strategy development process.This may overlook the perceptions of and implications upon bodies within the general public (Cinque, 2015; Lute & Gore, 2014). Failure to consider these matters may mean that controversy will continue until strategies are consistent with societal values (Lute & Attari, 2017). For example, a sense of disengagement between publics and decision-making bodies may undermine the efforts made to reduce conflicts, potentially even escalating conflicts further by fostering distrust of decision-making bodies (Crowley et al., 2017a; Cusack et al., 2021; Manfredo et al., 2017; Watkins et al., 2021). Efforts to understand public perception can provide balance by sharing the ‘power’ in decision-making in a bottom-up approach (Lute & Gore, 2014) and leading to a strategy that is more likely to increase tolerance of wildlife and reduce potential future conflicts (Cinque, 2015; Crowley et al., 2017a; Cusack et al., 2021; Redpath et al., 2013; Treves et al., 2006).

To engage effectively with stakeholders and publics in the development of more socially acceptable management strategies, social science methods need to play an important role (Baruch-Mordo et al., 2009; Bennett et al., 2017). Often in conservation, the human dimensions can be overlooked, poor engagement practices can occur, and stakeholders/publics can develop greater distrust of management bodies (Blicharska et al., 2016; Frank et al., 2015). Engaging with the social sciences, however, can lead to a better understanding of social factors, leading to more robust and effective solutions (Bennett et al., 2017a, 2017b; Toomey et al., 2017). This could involve research into real or perceived impacts, particularly as it is often positive perceptions that lead to socially accepted conservation and wildlife management (Bennett, 2016). There is a large arsenal of methods in the social sciences that are applicable to the management of human-wildlife and human-human conflicts, but in the context of developing wildlife management plans it should be noted that a mixed-methods approach, or 'methodological triangulation', is best as it allows a diversity of perspectives to emerge (Bennett et al., 2017a, 2017b).

2.3. Wildlife reintroduction

In wildlife reintroductions, potential conflicts or benefits associated with the focal species would not yet be present but may occur after the reintroduction takes place. Conflicts that arise may lead to reintroduction failure, or conflicts may arise between groups over whether to reintroduce a species in the first place which, if not appropriately considered, could lead to barriers to a reintroduction taking place at all. For example, a proposal to reintroduce lynx (*Lynx lynx*) was rejected by the UK Government, in part, as Natural England advised that the project proposers had not undertaken a sufficient degree of engagement with concerned stakeholders (DEFRA, 2018). Consequently, it would be advantageous in reintroduction projects to anticipate and address conflicts that may arise at the earliest opportunity to minimise any potential for conflict escalation, or even the occurrence of conflicts at all – hence the recognition of a need to recognise the social implications in the IUCN Guidelines (IUCN & SSC, 2013). Management considerations will need to be proactive, determined at an early outset with *"a priori"* considerations of conflicts (Seddon et al., 2007), whilst accounting for adaptability to emerging and changing contexts (Decker et al., 2016). The principles discussed above must be applied to the management of reintroduction projects, and this can be achieved through the application of social science (e.g. by using social science methods to help understand stakeholder values or public perceptions). By doing so, conflicts could be minimised meaning a reintroduction is less likely to fail, then enabling coexistence. Thereafter, opportunities afforded by reintroductions can accrue, which may themselves require active input or governance to be fully realised (Frank, 2016; Madden, 2004; O'Rourke, 2014).

Recognition of the importance of the human dimensions of wildlife reintroduction is growing, and studies in this field are emerging. In a retrospective study of sea eagle (*Haliaeetus albicilla*) reintroduction in Ireland, the authors identified conflicts between groups with different views on the project, for example conservationists presented the eagles as a help for farmers as they would dispose of carrion, but sheep farmers perceived them as a threat to their farming interests through predation of lambs. The authors argued then for the early engagement of stakeholders in reintroduction projects as critical for reintroductions to succeed (O'Rourke, 2014). Similarly, a study of perspectives on pine marten (*Martes martes*) reintroduction in Wales identified and discussed diverse stakeholder perspectives, and argued that the acknowledgment of such perspectives could *"encourage a more democratic* *approach to conservation"* (Bavin et al., 2020*, p1127*; Pooley et al., 2017b; Redpath et al., 2013).

Studies such as those noted above are so far limited, but there is a need for a deeper understanding of the human dimensions of reintroductions as they grow in popularity and practice, identifying key features in the relationship between society and reintroductions. Three questions arise in particular:

1. How can potential conflicts that may arise from reintroduction be best anticipated and addressed?
2. Thereafter, how are potential social benefits of a reintroduction realised or maximised?
3. How does reintroduction governance compare to the governance of coexistence with a species already present in the landscape?

Answers to these three questions would prove informative for reintroduction projects, enabling projects to plan for conflict management and the maximisation of social benefits. But there are so far few studies which provide such answers. In this thesis I will seek to address this knowledge gap, through the study of the reintroduction of the Eurasian beaver in England. As is soon to be discussed, the Eurasian beaver has large-scale impacts on the landscape and human-beaver interactions are to be expected. The research I here present will examine the human dimensions of reintroducing Eurasian beaver into England. By doing so, I will respond to the three questions posed above, whilst demonstrating the importance of social science in wildlife reintroductions.

2.4. Research context: Eurasian beaver reintroduction in England

The Eurasian beaver and the closely related North American beaver are similar species of large, semi-aquatic rodents. Whilst the latter is native to North America, the Eurasian beaver was historically resident across most of Europe (and Russia) after the last ice age (Halley & Rosell, 2002). Historically, populations were dramatically reduced – including regional extinction in Great Britain – following hunting by humans for beaver fur, meat, and castoreum (Brazier, Puttock, et al., 2020; Gaywood, 2018; Halley et al., 2020). It is estimated that beavers were reduced to eight isolated populations with 1200 individuals at the start of the 20th century (Halley et al., 2012; Macdonald et al., 1995). Now, Eurasian beavers are present across much of their historical range (Figure 1) thanks to a combination of natural recolonisation and human-led reintroduction efforts in the last century (Halley et al., 2020).

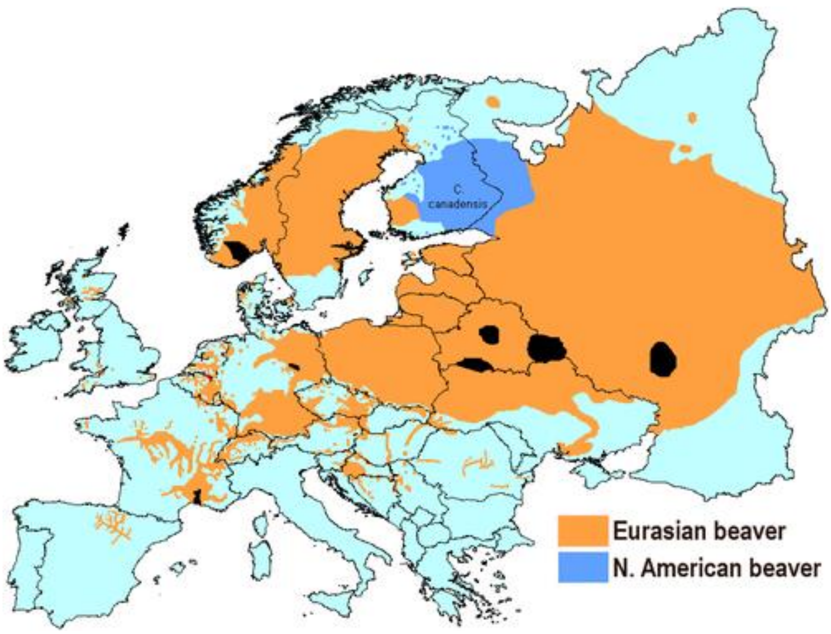

Figure 1. Distribution of beavers in Europe in 2020, with the black areas indicating the locations of the eight, isolated populations of beaver at the start of the 20th century. (Reproduced from original source: Halley et al., 2020)

Beavers are commonly referred to as 'ecosystem engineers' because their behaviours lead to significant changes in the landscape. Beavers are herbivorous and feed on riparian vegetation (as seen in Figure 2), and often fell trees (Figure 3). In shallower, marginal watercourses, beavers also use woody material to build dams, raising the water level behind and creating a beaver wetland (Brazier, Puttock, et al., 2020; Brown et al., 2018; Westbrook et al., 2020). This habitat creation serves beavers because they co-evolved alongside large predators and the aquatic lifestyle was safer than moving across land, but these behaviours also create a mosaic of habitats which supports biodiversity more widely, including waterbird species, terrestrial mammals, and aquatic invertebrates (Hood & Larson, 2014; Law et al., 2019; Nummi et al., 2019; Nummi & Holopainen, 2014; Stringer & Gaywood, 2016). Wildlife can also benefit from beaver-created habitat as refugia at times of wildfire (Fairfax & Whittle, 2020). An example of a beaver wetland can be seen in Figure 4. Biodiversity also benefits from improved levels of water quality downstream of beaver dams; the dams slow the flow of water which allows sediments to settle, and the dams then provide a natural filtration effect (Brazier, Puttock, et al., 2020; Puttock et al., 2017, 2018).

Figure 2. Eurasian beaver feeding on vegetation on the River Otter, England.

Figure 3. Example of a tree felled by Eurasian beaver in Bavaria, Germany.

Figure 4. A wetland created by beavers in Bavaria, Germany.

Where beavers live in anthropogenic environments, their landscape engineering behaviours interact with the landscape engineering behaviours of another species: humans. Where the two species exist together, two environmental engineers are resident in one shared landscape. Inevitably therefore, human-beaver interactions result.

In some cases, these interactions may be beneficial. Beaver dams (and channels dug by beaver) lead to increased water storage and the slowing of water flows through the landscape, thus reducing the peak flow rates and risk of flooding for human infrastructure downstream (Hood & Larson, 2015; Puttock et al., 2020) – a regulating ecosystem service (Table 1). This may be beneficial for human communities that are at risk of floods and are based downstream of beaver sites (Brazier, Puttock, et al., 2020). Water stored can also help to maintain base flows in periods of drought (Hood & Bayley, 2008; Brazier, Puttock et al., 2020; Fairfax & Small, 2017; Larsen et al., 2021). An example of a beaver dam is shown in Figure 5.

There is also evidence to suggest that beavers may serve as a focal species for wildlife tourism and associated economic benefits, a cultural ecosystem service (Table 1); there are examples of 'beaver safari' experiences or beaver information centres present in mainland Europe (Campbell et al., 2007; Rosell & Pedersen, 1999).

Figure 5. A large beaver dam in Bavaria, Germany.

There are also cases of human-beaver conflict. Within land management and agriculture, conflicts emerge where beavers dam watercourses, including drainage ditches, which are adjacent to productive land (see Figure 6 for an example). In these areas the land gets flooded or wetter, leading to lost income where it can no longer be used (Pilliod et al., 2018; Taylor & Singleton, 2014; Yarmey & Hood, 2020). Further, there are occasions where beavers may feed upon a farmer's crops if they are near to the watercourse, or land may be undermined by burrowing when beavers establish a lodge (an example of a beaver burrow can be seen in Figure 7, and a beaver lodge can be seen in Figure 8) (Mikulka et al., 2020; Swinnen et al., 2017; Verbeylon, 2003). These are similar conflicts to those which occur in the forestry sector, and the principles of flooding and burrowing can also conflict with infrastructure where, for example, beavers may cause flooding of a road or burrow into banks used for flood defences (Campbell-Palmer et al., 2015, p., 2016; Gurnell, 1998; Hood et al., 2018; Parker et al., 1999). Where these incidences occur, they can be viewed as 'real' conflicts for they relate to conflicts with wildlife which are actually taking place.

Figure 6. Flooded agricultural land on a floodplain, resulting from water stored behind a beaver dam in the River Otter catchment, England.

Figure 7. An example of an entrance to a beaver burrow, in an area drained of water following the removal of a beaver dam in Bavaria, Germany.

Figure 8. An example of a beaver lodge (in this case a North American beaver lodge in North Point State Park near Baltimore, USA).

In addition, some people are concerned of a possible conflict between beavers and fish or fishing (Kemp et al., 2012). On the one hand scientific evidence indicates that beavers increase habitat heterogeneity, thus supporting greater fish diversity, as well as improving water quality for fish and providing new areas in which to fish (Bouwes et al., 2016; Kemp et al., 2012; Smith & Mather, 2013). This is a motivation for some North American beaver reintroduction projects (or artificial re-creation of beaver-style dams or 'Beaver Dam Analogues') to support fish populations (Bouwes et al., 2016; Pilliod et al., 2018). On the other hand, there are accounts of conflict primarily resulting from the beaver's damming behaviour. Some people perceive beaver dams as an obstruction to migratory fish passages, particularly in commercially important species such as salmon or sea trout, or that beavers could impact both upon the health of fish species themselves by affecting fish spawning habitat or by providing conditions which favour invasive species (Kemp et al., 2012; Malison et al., 2015; Malison & Halley, 2020). Further conflicts with fisheries can ensue; in a Polish study, beavers were perceived to damage pond levées and lead to a decrease in fish farm yield (Kloskowski, 2011). As such, conflicts surrounding fish may be a mixture of 'real' and 'perceived' conflicts in a context-dependent manner.

Figure 9. A sea trout jumping up a beaver dam during an observation in November 2019 in the River Otter catchment, England. (This observation is detailed in Brazier, Elliott, et al., 2020, *p61*).

In Europe and North America, management strategies have been developed to prevent or respond to potential negative impacts of beavers. Practically, there are many techniques including, for example, the removal of problem dams, compensation for losses, fencing to protect trees, or translocation of beavers away from problem areas (Campbell-Palmer et al., 2016; Morzillo & Needham, 2015; Schwab & Schmidbauer, 2003). In legal terms, some countries may apply their own policies but, across the European Union (EU), the benchmark conservation policy within the EU is the '*Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora*', commonly cited as the '*Habitats Directive*' (Council of the European Union, 1992). The *Habitats Directive* lists species and habitats in different annexes, each of which requires a different level of protection. Currently, the Eurasian beaver is listed on two of these annexes:

> “Annexe II: Animal and plant species of community interest whose conservation requires the designation of special areas of conservation.
>
> Annexe IV: Animal and plant species of community interest in need of strict protection.”

Being listed on these annexes means that beavers are afforded strict legal protection in EU countries. Though there can be variation in how the law is applied, typically activities that involve the capturing or killing of beavers or the disturbance of breeding or resting areas are largely restricted (Council of the European Union, 1992; Pillai & Heptinstall, 2013).

Overall, where human-beaver interactions are concerned, beavers may provide both social benefits and challenges. Often, it is cited that the benefits of beaver activity may outweigh the costs (Brazier, Elliott, et al., 2020; Brazier, Puttock, et al., 2020; Campbell et al., 2007; Charnley et al., 2020; Gaywood et al., 2015; Gaywood, 2018; Gurnell et al., 2009; Hood et al., 2018; Jones et al., 2012; Tayside Beaver Study Group, 2015a). However, as I concluded in a passage on human-beaver interactions in a recent literature review of beaver impacts published by a team of beaver researchers at the University of Exeter (and attached to this thesis as Appendix 1), *“those people who experience the benefits may differ from those who experience the costs. […] Although it is often cited the potential benefits of beavers will outweigh the costs […], the costs that do occur may be attributed to a small number of people who derive little or no direct financial benefit”*. Hence, we as a team argue in the review that *“management strategies should consider the beneficiaries and the cost-bearers in a holistic manner”* (Brazier, Puttock, et al., 2020, *p16-19*).

Beaver-induced ecosystem services and conflicts with or about beaverwill be introduced alongside beavers when they are reintroduced to landscapes in which they are not yet present. As such, reintroduction projects will need to account for the challenges, as well as the potential for maximising the social benefits, highlighted in the IUCN guidelines: *“Human communities in or around a release area will have legitimate interests in any translocation. […] Consequently, translocation planning should accommodate the socioeconomic circumstances, community attitudes and values, motivations and expectations, behaviours and behavioural change, and the anticipated costs and benefits of the translocation.”* (IUCN & SSC, 2013, *p11*).

2.5. Beavers in Britain

At the time of writing, and similarly to projects that have occurred across Europe, beaver reintroduction is now taking place across Great Britain, with decision-making devolved to each of the nation governments.

In Scotland, the reintroduction process has occurred for over 20 years. Following initial research into the history of beavers in Scotland, a small population was released under license in Argyll for an official reintroduction trial (Gaywood, 2018; Gaywood et al., 2015). Concurrently, a population of beavers from an unknown source was found in the catchment of the River Tay. Scottish Natural Heritage established the Tayside Beaver Study Group in 2012 to examine the impacts that beavers were having in the area, with similar focuses to that of the official Scottish Beaver Trial (Coz & Young, 2020; Gaywood, 2018). The final reports from these projects were submitted to Scottish Natural Heritage in 2014/15 (Gaywood et al., 2015; Tayside Beaver Study Group, 2015b), and the Scottish beavers were legally protected as a European Protected Species in 2019, making this the first official mammal reintroduction in Great Britain (Gaywood, 2018; Scottish Government, 2019).

In England (where this thesis will focus), beaver reintroduction started in a similar fashion. A report was produced in 2009, commissioned by Natural England, which reviewed the ecology of beavers and considered the feasibility of their reintroduction into England (Gurnell et al., 2009).Later, in 2011, Devon Wildlife Trust released two beavers into a fenced enclosure with a scientific monitoring programmer to study their impacts on the site (Brazier, Elliott, et al., 2020; Devon Wildlife Trust, 2016). In 2015, the same Trust was granted a license (on behalf of the River Otter Beaver Trial and its many partners) to monitor a wild population in the catchment of the River Otter (Natural England, 2015). Similarly to those in Tayside, the beavers on the River Otter were from unknown origin (Crowley et al., 2017b). The licence that was issued required the Trial to monitor the social and ecological impacts throughout the project, which ran between 2015 and 2020. After the Trial's conclusion, a report of the science and evidence gathered through the Trial period was submitted to UK Government (Brazier, Elliott, et al., 2020) alongside beaver management strategy proposals (River Otter Beaver Trial, 2019). UK Government then announced that the River Otter beavers could remain permanently in August 2020, and also be allowed to migrate naturally beyond the boundaries of the River Otter catchment, with future consultations due on national approaches to reintroduction and management (UK Government, 2020). In parallel, the UK Government has granted licences for several fenced beaver projects, with examples in Cornwall (Cornwall Wildlife Trust, 2021), Yorkshire (Forestry England, 2021b), and the Forest of Dean (Forestry England, 2021a), as well as the first urban-based beaver project in England in Plymouth (Plymouth City Council, 2021).

In Wales, a feasibility survey took place in 2011 (Jones et al., 2012) and the Welsh Beaver Project was then established. This group, led by the Welsh Wildlife Trusts, was granted a licence by Natural Resources Wales to release beavers into a fenced enclosure at Cors Dyfi Nature Reserve, which they did in March 2021 (North Wales Wildlife Trust, 2021; Wildlife Trusts Wales, 2012).

As has been observed where beavers are present elsewhere, interactions with beaver populations are more likely as human land-use increases. As such, it can be expected that human-beaver interactions will occur with a new population of beavers in Britain. Addressing the human dimensions may minimise potential for the escalation of possible conflicts at an early stage and enable the benefits to be maximised (Brazier, Puttock, et al., 2020). In line with the IUCN/SSC guidelines, and as is recognised through the course of the main chapters of this thesis, attempts have been made to investigate the social implications of beaver reintroduction to Great Britain (Gaywood et al., 2015; Gurnell et al., 2009; Jones et al., 2012; Moran & Lewis, 2014; Scott Porter Research and Marketing Ltd, 1998; Tayside Beaver Study Group, 2015b, 2015a). Where human dimensions are concerned, these have primarily examined whether the public feels that beavers should be reintroduced and what are the perceived impacts of doing so, with some attempts at quantification of the socioeconomic impact where either the data were gathered, or where they could be inferred from cases in Europe.

Further study of the human dimensions would prove informative in beaver reintroduction decision-making. Knowledge of this kind is likely to enlighten projects which seek to reintroduce other species by identifying key lessons that can be integrated into project planning, thus influencing the long-term sustainability of wildlife reintroductions. Thereby, in this thesis thesis I will build on previous research by engaging with both key stakeholders and publics in a holistic manner (‘bottom-up’ and ‘top-down’) to critically explore issues associated with the human dimensions of reintroduction projects.

3. Approach to the Research

3.1. Epistemological Approach

In my thesis I will use a pragmatic approach to explore the human dimensions of reintroducing beavers to England (Dewey, 2008; Morgan, 2014). In this section I will first describe other philosophical approaches that pragmatism builds upon, before then introducing pragmatism itself and its relevance for this thesis.

In positivism, there is assumed to be ‘one truth’ which is reached through direct observation and objective measurement, using primarily deductive reasoning and quantitative methods (Park et al., 2020Where there is published conservation social science, it is common that it will have employed a positivist approach because it is often undertaken by conservationists with a natural sciences background, and it involves a methodological approach that is somewhat akin to those used in the natural sciences - through its focus upon the quantifiable and observable (Moon et al., 2014). A limitation however is that positivist research can be more restricted in its ability to identify meaning more deeply, or to unpick the motivations of people or social groups (Moon et al., 2014; Skogen et al., 2017).

Constructivism meanwhile views the world as something that is mentally constructed from the experiences of a human and their interactions with others, with theories generated from phenomena, primarily through inductive reasoning and qualitative research (Adom et al., 2016). Thus, constructivist approaches can recognise other ways of generating knowledge and can identify root causes that may not be necessarily directly observable. In Norway, a suite of research to explore conflicts between humans and wolves is synthesised in the book '*Wolf Conflicts*, *A Sociological Study*' by Ketil Skogen et al (2017). In this book, the authors make the argument for their adoption of a constructivist approach in that they highlight that [wolf] scientist conclusions can be "*challenged by other producers of knowledge"* (p12), here referring to knowledges that are constructed by other people based on their experiences or cultural backgrounds. The authors argue that recognising these different knowledges (that have not been constructed through science) allowed for the study of disputes between their understandings. The research presented then went on to employ intensive, qualitative methods that enabled the identification of new insights, such as that wolf conflicts may be in fact be less directly associated with the wolf but may instead resonate with wider societal issues such as divisions between different social classes or between rural and urban communities.

In this thesis I argue that a holistic study of human-wildlife interactions will require an approach that draws on both directly observable interactions and knowledges of human mental constructions of the situation, which is reflective of my own research journey that led me towards this PhD. I first studied *Zoology* for my undergraduate degree and learned methodological approaches that are more commonly associated the natural sciences, with their focus on understanding the observable and quantifiable. As my studies progressed, however, I recognised the role that understanding human values and motivations can play in conservation, such as identifying root causes of issues that may not be directly observable (Moon et al., 2017; Skogen et al., 2017). In light of this, I subsequently completed an interdisciplinary Masters course (*Conservation Science & Policy*) with the express aim of developing my understanding of the human dimensions and of methodologies that could be applied in the environmental social sciences. Although the integration of the social sciences so far remains limited in the conservation literature, the field is somewhat mirroring this path with growing recognition of the contribution that diverse approaches to social science can make (Bennett, 2016; Bennett et al., 2017a, 2017b; Moon et al., 2017).

The pragmatism paradigm, which is applied in this thesis, draws upon elements of both positivism and constructivism with the nature of the outside world and our conceptual understanding of it being ‘both sides of the same coin’ (Dewey, 2008; Morgan, 2014). Pragmatism places emphasis on the human experiences within a context, is not bound by a particular theory, and concentrates on beliefs that are more directly linked to actions - with theory that can inform practice (Morgan, 2014). In pragmatism, beliefs are seen to be subject to change based on actions, and mixed-method approaches are commonly utilised, dependent on the study context (Morgan, 2007, 2014). I judged that this paradigm most closely reflected my research outlook, with an openness to exploring the directly observable and human knowledges of a situation, with findings that could lead to actions that can help to address issues in the environment.

In this thesis, the research which I present forms a body of mixed methods research with findings that were directly linked to actions, with the knowledge that has been gained informing practice in and through the River Otter Beaver Trial. Alongside further research that was being undertaken by colleagues and external partners as part of the Trial (e.g. into areas such as beaver impacts on hydrology or biodiversity), my findings were expected to contribute towards addressing the research objectives outlined within the River Otter Beaver Trial's (ROBT) Monitoring Plan (Devon Wildlife Trust, 2017). Relevant objectives included: understanding social attitudes and stakeholder perceptions; understanding the impacts for land-use and agriculture; investigating impacts on eco-tourism; and characterising the River Otter fisheries and identifying any impacts upon them (see discussion below). These objectives concern matters that may be directly observable or perceived by individuals or social communities, thus I felt it required an approach that would be able to develop an understanding of these knowledges as *"both sides of the same coin"*. Further, my research needed to respond to the ROBT Monitoring Plan objectives in a way that would be broadly understandable for the external partners and political decision-makers, with outputs and theory informing practice. Thus, my use of a pragmatic epistemological approach facilitated research that could respond to the ROBT Monitoring Plan, whilst allowing the individuals and social communities to define the issues that mattered most in a way that was meaningful for them (Morgan, 2014).

As is soon to be described in section 4.1 (Chapter Descriptions), I used mixed methods (including qualitative and quantitative methods) which, as discussed above, is a trait associated with pragmatic research (Morgan, 2007). These methods respond to the study context in a manner that is useful to inform future practice, with each chapter discussing the (often practical) management implications that arise from the research. Mixed methods allowed my research to engage with a variety of social groups, including key stakeholders and wider publics (Bennett, 2016; Bennett et al., 2017a, 2017b), whilst enabling me to make methodological decisions that responded to practical or temporal limitations in the research programme.

3.2. An interdisciplinary thesis

As a collective, the papers which form the main chapters demonstrate the interdisciplinary nature of this PhD. As will become clear in each paper's introduction and literature review, they draw upon research from a range of disciplines, as outlined in Figure 10. Commonly through the chapters, the literature reviews draw upon work in the fields of wildlife reintroduction (from the discipline of conservation science), coexistence and human-wildlife conflict (from the disciplines of environmental social science and conservation science), as well as beaver ecology and an understanding of the impacts of beaver beaver upon the landscape (which also draws on the field of physical geography). In some chapters, additional literature is drawn upon as relevant towards those chapters specifically. Chapter 4 on angler perceptions includes literature on beaver-fish interactions (from the ecological and environmental social science disciplines), Chapter 5 on beaver tourism draws upon wildlife tourism literature (from environmental social science and conservation science), and Chapter 6 draws on natural flood management literature (from the physical geography discipline). Throughout all chapters, further literature is drawn upon to discuss the research methods used, which are embedded in environmental social science.

Overall, whilst rooted in environmental social science, this is collectively an interdisciplinary PhD drawing upon and contributing towards literature from the disciplines of Environmental Social Science and Conservation Science in particular, as well as Physical Geography and Ecology.

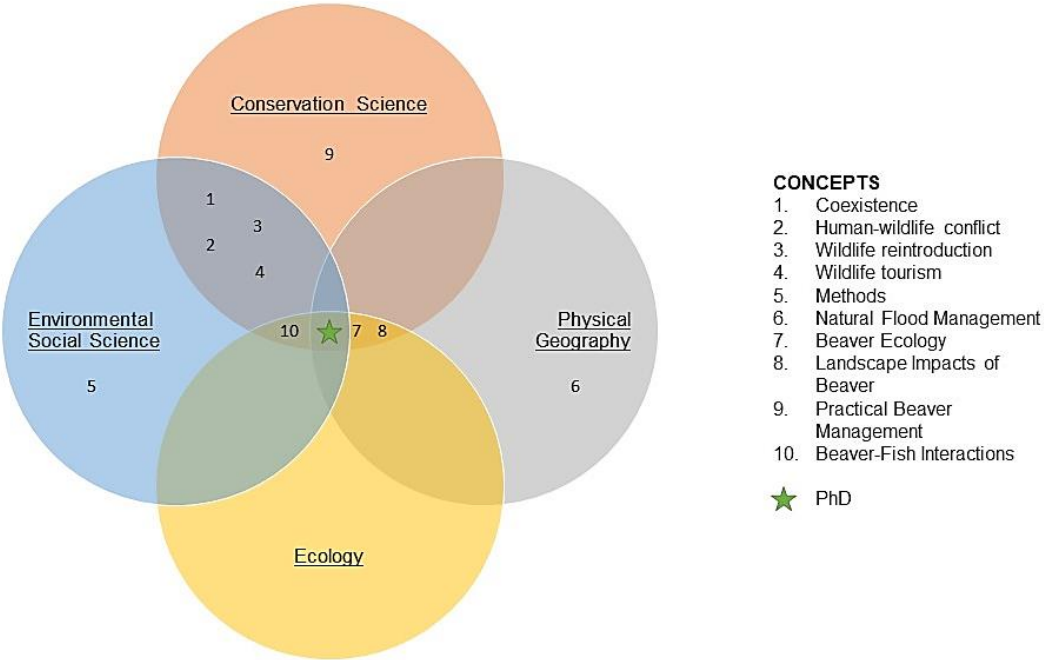

Figure 10. Visual illustration of the interdisciplinary nature of the PhD, highlighting where the literature has been drawn from in the disciplines of Environmental Social Science, Conservation Science, Physical Geography, and Ecology.

4. Thesis Structure

The primary research of my thesis is presented as six self-contained (though inter-related) papers/chapters that explore the human dimensions of beaver reintroduction, and the implications for wildlife reintroductions more broadly. I have described each in brief in section 4.1.

To form a holistic view of the subject, I designed the research programme to investigate a range of potential benefits and conflicts associated with beaver reintroduction using a mixed-methods approach, thus allowing diverse perspectives to emerge (Bennett, 2016; Bennett et al., 2017a, 2017b). To identify where these benefits or conflicts lay, my research was intellectually informed by the literature and co-created by the questions and answers from an exploratory nationwide attitudinal survey (which also forms the basis of chapter 2).

The first research paper in this thesis details the initial steps undertaken for this thesis; the undertaking of a nationwide, online attitudinal survey. I undertook this survey as an exploratory piece of work,covering a range of matters relating to beavers and their reintroduction into Great Britain. The questions and answers from this survey formed the foundational research which (alongside review of the wider literature) inspired my design of the remaining thesis. Notably, the survey study identified that there are polarised perspectives on beaver reintroduction in Great Britain, with certain groups more or less likely to be favourable towards reintroduction. As there is a potential for conflict between these polarised viewpoints it was recognised that, if this research programme is to contribute towards the understanding of human dimensions of beaver reintroduction whilst not escalating this potential, it would need to take a balanced approach with appropriate study of both potential benefits and conflicts that may arise from the reintroduction of beavers. Had the study focused solely on areas of conflict, attention would only focus on reducing negative interactions when coexistence also requires an understanding of how to encourage positive behaviours and enable social benefits to occur (Frank, 2016; Nyhus, 2016).

The human dimensions of beaver reintroduction are varied, with real or perceived impacts occurring in several different fields. To account for them all within one studentship would perhaps be impossible, so I determined that the most likely or greatest areas of social benefit or concern would be investigated. To meet this aim with a balanced approach, I designed the research programme to explore two areas of potential conflicts and two areas of potential social benefit (presented in turn in chapters 3-6). I identified these from evidence in the literature, participant responses to the nationwide questionnaire, and the objectives of the ROBT Monitoring Plan (Devon Wildlife Trust, 2017), which was drawn up via input from the wider ROBT Steering Group (which consisted of high level representation from a wide range of key stakeholder groups). The areas of conflict I discuss are those that occur directly between the impacts of beavers and agriculture, land or property (chapter 3), and the perspectives of anglers on the relationship between beavers and fish (chapter 4). The beneficial areas include the potential for beaver-related wildlife tourism (chapter 5) and a reduction in flood risk for downstream communities (chapter 6). I give more detailed insights into these dimensions of beaver reintroduction in the Chapter Descriptions, and within the focused literature reviews contained within each chapter, respectively.

In addition, I recognised that there are matters associated more specifically with the process of reintroduction and its governance, rather than the human dimensions of reintroduction in the longer term. As such, I include an additional chapter that investigates the lessons that can be learned from the experiences of stakeholders involved in Steering Groups for the River Otter Beaver Trial, and how reintroduction governance may be similar or different to the governance of coexistence with species already present in the landscape (chapter 7).

The main chapters within the PhD will begin with the foundational research of the nationwide survey, before then detailing the study of each potential conflict or benefit area in turn. Following this, I present the chapter focused upon the reintroduction process itself. This structure is visually illustrated in Figure 11.

At the end of the thesis, I give a synthesis of the key findings in chapter 8, which concludes what the implications are for the reintroductions of beavers and other species.

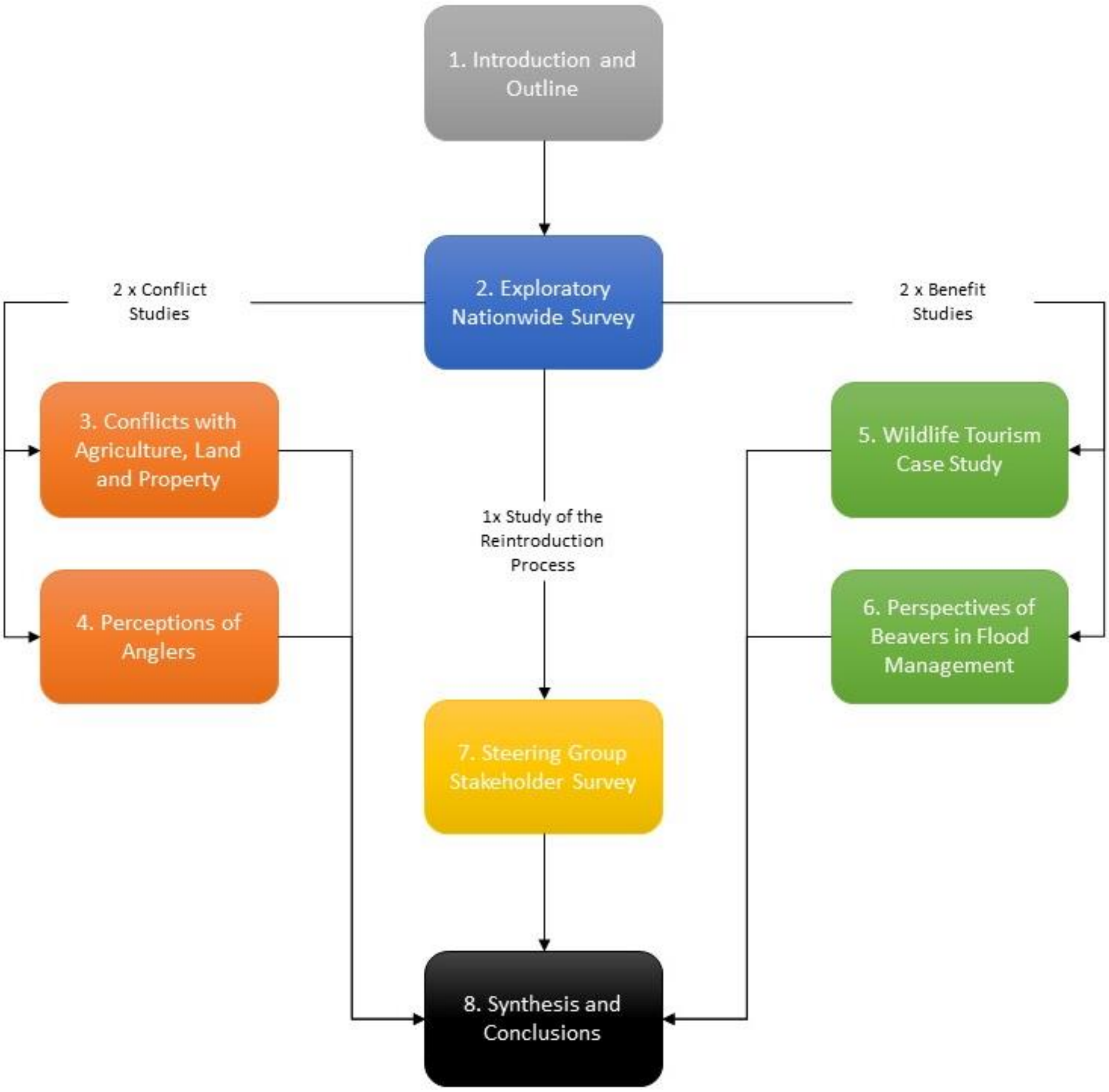

Figure 11. Visual illustration of the structure of the thesis.

4.1. Chapter Descriptions

In this section, I will describe each of the main chapters and the rationales for their respective approaches are summarised. In this section I will provide a general oversight including an introduction to the focus area and the methods. As the thesis is comprised of a series of self-contained papers however, a bespoke literature review and full methodological detail for each study (including limitations) is included within each chapter, respectively.

4.1.1. Chapter 2: An Exploratory Nationwide Survey

Paper Title: Unravelling perceptions of Eurasian beaver reintroduction in Great Britain

This chapter details the foundational research which informed the remainder of my PhD design, in the manner described above. I designed and undertaken the survey prior to the commencement of the PhD studentship when I was employed as a short-term Research Assistant, utilising knowledge from a literature review and small-scale interview study completed as assessments for my previous Masters course. I completed preliminary analysis of the survey within the Research Assistant timeframe and, following the onset of the PhD, I developed the manuscript and submitted it for peer review.

At the time of the survey data collection, I was employed on a short-term contract (funded by the NERC Knowledge Exchange program) with the remit of exploring the public perceptions of beaver reintroduction in Britain. To meet this brief, I chose the study method as an approach that could be rolled out within a short timeframe.

Further, as an online method, this survey had potential to provide the maximum number of people nationwide with the opportunity to participate, where direction interaction was not possible in the short timeframe.

I designed the survey to encompass a broad range of matters that related to beaver reintroduction, using my previous Masters study to inform the design. The questions covered matters related to beaver impacts, the potential management of beavers, and methods of public engagement. The responses received constituted a large sample (*n=2759*) with a range of opinions throughout. Hence, the findings of this study exemplified a potential for conflicts between people who held different and often polarised views of beaver reintroduction, particularly where there were differing views towards beaver management. Although at the time some participants may have lived in catchments where some of the first reintroduced beavers existed (such as in Argyll, Tayside or the River Otter catchment), for the majority of respondents this survey would have taken place prior to having any experience of living alongside the species – whereas the following studies that were undertaken during the early stages of reintroduction. Thus, this survey enabled potential conflict areas (such as disagreements over management) to be identified '*a priori'* and demonstrated the importance of considering the social implications of reintroduction at the earliest opportunity. I then used further findings from this survey to inform the subsequent research (identified as appropriate within the literature reviews contained within each chapter respectively).

4.1.2. Chapters 3 and 4: Two areas of conflict

4.1.2.1. Chapter 3: Conflicts with agriculture, land or property

Paper Title: Improving engagement in managing reintroduction conflicts: learning from beaver reintroduction

Where beavers are present elsewhere conflicts can occur between beavers and agriculture, property, or infrastructure. As examples, beavers may feed upon agricultural crops in the riparian zone (Mikulka et al., 2020); water held behind a beaver dam may spread onto productive agricultural land (Campbell-Palmer et al., 2016; Jensen et al., 2001; Morzillo & Needham, 2015); or beavers may fell commercially important trees (e.g. in an orchard) or trees that are of sentimental value (Campbell-Palmer et al., 2015). An array of practical mitigation techniques exists to manage conflicts, including protective fencing, the removal of beaver dams, compensation for losses, or the translocation of beavers away from conflict areas. A comprehensive overview of these techniques is available in *The Eurasian beaver management handbook* (Campbell-Palmer et al., 2016).

In beaver reintroduction, conflicts like these are likely to be introduced alongside the species and these situations would be new to the human communities at the reintroduction site as the species has not been resident in recent time. In the River Otter Beaver Trial there were conflicts of this nature observed, but as the beaver population was small there were few examples. Nonetheless, they echoed conflicts that have occurred elsewhere. When they occurred, Devon Wildlife Trust were responsible for engaging with the affected individuals and undertaking management actions when appropriate.

In chapter 3, I undertook a study that engaged with those individuals who had reported the real and direct conflicts with the reintroduced beavers. This provided the research opportunity to explore key factors in their experiences and the lessons that can be learned for the management of potential future conflicts in beaver reintroduction projects.

For this study, I required a methodological design that would be suitable for a small number of individuals whilst being adaptable to the different conflict situations. Semi-structured interviews facilitated the flexibility to adapt questions as appropriate to each conflict case and the experiences of the individuals involved. Interviews were also a straightforward form of data collection from the participants' point-of-view and was something that could be arranged around the individuals' convenience. This was of particular importance to facilitate the involvement of participating farmers, with interviews able to be arranged around their demanding schedules.

Qualitative thematic analysis then allowed me to explore the key themes that were common across the interview set from the participants' perspectives in a data-driven manner. The findings demonstrate five concepts to address in improved engagement practises for conflict management responses. These resulting themes were generated from the data themselves, yet it is notable that they align with the key points from chapter 2 which highlighted the need to consider engagement methods and attitudes to management in reintroduction projects if the risk of conflict escalation is to be minimised.

4.1.2.2. Chapter 4: Perspectives of anglers

Paper Title: Alternative perspectives of the angling community on Eurasian beaver *(Castor fiber)* reintroduction in the River Otter Beaver Trial

In the nationwide attitudinal survey in chapter 2, individuals who identified their occupation as within ‘Fisheries and Aquaculture’ were statistically less likely to have a more favourable view of the impacts upon beavers. A previous meta-analysis of the impacts of beavers and fish (which included interviews with experts in the field) found that, although a net beneficial impact for fish was reported, there were also suggestions of some negative impacts. In particular, these reported negative impacts regarded the movement of fish in response to the presence of beaver dams (Kemp et al., 2012). This is a topic in which research efforts are continuing (Bouwes et al., 2016; Bylak & Kukuła, 2018; Malison & Halley, 2020). However, having identified that people with interests in this area were less likely to hold favourable views on beavers, these more negative perceptions may mean there is a greater risk of conflict escalation with social groups who hold more positive viewpoints. As such, it would be advantageous to understand the perspectives of anglers in greater depth to then address them equitably in management decisions, if and where beaver reintroduction occurs.

Chapter 4 details my study of the perspectives of anglers within the catchment of the River Otter Beaver Trial. These anglers possess knowledge and experience of fishing practice and are some of the first to live and fish alongside the presence of beaver in England (in modern times). As such, they may have provided unique insights from where human-beaver interactions have occurred.

Q-Methodology seeks to elicit an understanding of the subjectivity in perspectives that exist. It uses a semi-qualitative procedure to provide a rich insight into these perspectives. It does not seek to examine the prevalence of viewpoints in a population, but to establish the existence of viewpoints and understand them. It can therefore be used when there is a small sample size, which I knew would be the case in this study because sampling was from a limited number of anglers in the river catchment. (In an economic profile of fishing in the catchment - Appendix 2 – I estimated that there were between 55 and 85 paying members of fishing syndicates in the catchment. These syndicates own or lease the rights to fish in the watercourse on behalf of their membership). In the chapter, I use this method to explore the perspectives of anglers in the River Otter catchment; three perspectives are identified and then described. The discussion then explores the management implications of these findings.

4.1.3. Chapters 5 and 6: Two areas of opportunity

4.1.3.1. Chapter 5: Wildlife Tourism

Paper Title: Wildlife tourism in reintroduction projects: Exploring social and economic benefits of beaver in local settings

Wildlife tourism is commonly cited as a benefit that may arise from reintroduction. This is also true for beavers, with the feasibility studies and reports on beaver reintroduction in Scotland, Wales and England all citing it as a potential benefit (Brazier, Elliott, et al., 2020; Gaywood et al., 2015; Gurnell et al., 2009; Jones et al., 2012; Moran & Lewis, 2014). Further, a report for the Wild Britain Initiative stated that the potential tourism *“benefits could be substantial”* (Campbell et al., 2007, *pl*).

However, there has until now been little academic study of how this manifests in reality following reintroduction. An understanding would identify whether this cited benefit is real or perceived, and be informative for reintroduction project planning; the IUCN reintroduction guidelines state that social and economic factors *"must be integral to translocation feasibility and design"* (IUCN & SSC, 2013*, pVIII*).

The River Otter Beaver Trial afforded me an opportunity to explore this human dimension of reintroduction. On the river near to the village of Otterton, a family of beavers established a territory that was easily viewable from a public footpath. Subsequently, there were reports of 'beaver-watchers' regularly gathering on the riverbank to view the beavers. The beavers were free to move about the river catchment with plenty of available habitat and a low beaver population density, so it could not have been foreseen where exactly the beavers would establish a lodge. However, when the beavers established one near to the village, this enabled me to study wildlife tourism in the community using methods that were reactive to these events.

I used mixed methods to explore this human dimension from different angles, giving a more holistic understanding of the occurring beaver tourism. First, footpath counters which the authority for *East Devon Area of Outstanding Natural Beauty* had installed on the riverside footpath enabled me to analyse footfall on the riverbank (and I thank the authority for the permissions to use this data in the research). Second, I held interviews with businesses in the village which facilitated my understanding of whether local business representatives felt there had been any economic benefits for their local businesses and how these had accrued. Third, a mail-return questionnaire of residents in the community provided an understanding of how beaver tourism was viewed among the local people and if there were other factors of importance related to this beaver tourism.

I conclude the study with insights into how wildlife tourism benefits may accrue in reintroduction projects, and what may be required for this opportunity to be maximised. The findings are informative for reintroduction practitioners, particularly where wildlife tourism is suggested as a potential benefit prior to a reintroduction taking place, as the findings could help to integrate potential tourism benefit into the feasibility and design of reintroduction projects.

4.1.3.2. Chapter 6: Flood Alleviation

Paper Title: Beavers and flood alleviation: Human perspectives from downstream communities

One of the most highly cited benefits of beavers for people is their potential role in providing natural flood management. When beavers build dams, usually in the upper and more marginal reaches of watercourses (Graham et al., 2020), water is held behind them and spreads sideways. This slows the flow of water through the landscape meaning, when there is a high rainfall event, the attenuation in flow rate results in a reduction in flood risk downstream (Brazier, Elliott, et al., 2020; Brazier, Puttock, et al., 2020; Puttock et al., 2020).

Although there is growing recognition of this fact, little attention has so far been paid to the understandings of the communities that live downstream of beavers who would be the beneficiaries. In Chapter 6 I therefore examine the perspectives that exist among communities living downstream and discusses the management implications.

In this study, I explore human perspectives on the potential role of beavers in flood management using Q-Methodology to elicit an understanding of the perspectives that exist among communities living downstream of three beaver sites in England (this is the same method as I described and used to understand angler perceptions in chapter 4). Unlike the other chapters, this study was undertaken outside of the River Otter Beaver Trial and downstream of three beaver projects elsewhere in England. This was primarily because these beaver sites were directly upstream of communities historically at risk of flooding, and these projects are in the public domain so there were no confidentiality issues to account for in sharing the location with participants. All sites are included in a recent multi-site study which demonstrated a flow attenuation impact from beavers (Puttock et al., 2020). (There was a fourth beaver site in the multi-site study by Puttock et al. which was within the River Otter Beaver Trial catchment. However, the beaver activity here was on private land and I did not have landowner permission to share details of the beavers' location with the downstream community.)

This is the first time that a study of attitudes towards beavers has focused upon the downstream community as the focal participants. I identify diverse perspectives that exhibit a range of value judgements. I explore these in detail, followed by my discussion of the implications for beavers and how, as flood managers, they compare to other natural flood management methods.

Due to the circumstances surrounding the COVID-19 pandemic at the time of data collection (including national restrictions), I collected the data remotely through online methods to remove any need for face-to-face interaction.

4.1.4. Chapter 7: Reintroduction Governance Process

Paper Title: A reintroduction trial ‘on trial’: Lessons from Steering Group stakeholders on a beaver reintroduction project in England

There are also human dimensions to consider associated with the reintroduction process itself. Matters of governance, project management, and stakeholder engagement that are relevant to the reintroduction process in the initial stages may be crucial to the success of a project, but may not be relevant in the long-term coexistence with the species when the reintroduction process itself is complete. It would be informative for practitioners to understand if and how this governance of reintroduction compares to the governance of coexistence with species already present in the landscape.

Some study of reintroduction practise has taken place, but this has primarily been focused upon practical and ecological processes. Perhaps this is reflective of the fact that the definitions of whether reintroduction has been a success tend to centre on matters such as survival of the released individuals or the establishment of a self-sustaining population (Armstrong & Seddon, 2008; Robert et al., 2015). There has so far been limited study of stakeholder and practitioner perspectives on the reintroduction processes in which they have been involved, and the lessons that can be learned from their experiences. This is despite the fact that, as already discussed and as identified in the IUCN Guidelines (IUCN & SSC, 2013), an understanding of social implications and stakeholder engagement is widely seen as a key part of the reintroduction process.

In the River Otter Beaver Trial, various organisations sat as members in the Trial Steering Groups, including practitioners, researchers, and key stakeholders. In chapter 7, the reflective views of these members of their experiences of the project are explored. These group members held varied interests which reflect many of the areas explored in the other chapters, but they had not yet participated in this human dimension research. Thus, this study provided the members of these groups with the opportunity to participate as well as the various publics who took part in the preceding chapters.

The potential pool of participants was a small and finite number, based on the number of members who had sat on the relevant groups. Thus, I needed a method that was able to explore matters within this context. My method also needed to avoid any face-to-face contact in response to the COVID-19 pandemic situation; I undertook the study after the UK's pandemic restrictions were imposed, so I needed to respond to the fact that the potential participants may have had varied priorities at the time. I chose an online questionnaire with an extended data collection window. This meant that it could be completed by participants in their own time and safely from home. Furthermore, this responded to the method preference that was indicated by the participants; at a meeting of the River Otter Beaver Trial Steering Group prior to the pandemic, the members that were present indicated a preference for a survey-style approach due to the flexibility it afforded them around their other work commitments.

The questions were predominantly qualitative and open-ended, and I used an inductive qualitative thematic analysis of responses to identify learning that can be applied to future reintroduction projects in a data-driven manner. I hope that the findings will inform practitioners, stakeholders, and researchers to build upon an understanding of the engagement and governance processes involved in a reintroduction such as the River Otter Beaver Trial, in particular what the findings tell us about the governance of reintroduction projects compared to the governance of coexistence between humans and already present wildlife. I further hope this will lead to the application of this knowledge in practices which are more likely to foster trust and reduce potential for conflict between stakeholder groups in future projects. Accordingly, I also advocate in the paper for reflective evaluations as an essential component in future reintroduction projects to facilitate further knowledge-sharing and improved processes.

5. Statement of Contributions

I am the lead author on all six of the papers included in this thesis and confirm that I am the primary author, data collector, and conductor of analysis for all the included papers.

Chapters 2- 5 are all peer reviewed and published works, whilst Chapters 6 and 7 are currently undergoing the peer review process. In these, multiple authors are listed because Brazier, Barr, and (in the nationwide survey) Puttock provided academic supervision and commented on the papers after I had completed an initial draft.

In addition, I contributed to a literature review of beaver impacts that was conducted by members of the wider research group at the University of Exeter, as well as reports for the River Otter Beaver Trial. These are not included within the thesis directly but are relevant and cited in the text. Similarly, I authored two appendix reports for the River Otter Beaver Trial which are not included in the thesis but are cited in the text.

All relevant publications are listed below. All Supporting Information cited is freely available online on the journal sites.

Peer-reviewed publications arising from work undertaken for the thesis.

Auster, R.E., Puttock, A., & Brazier, R. 2020. Unravelling perceptions of Eurasian beaver reintroduction in Great Britain. *Area*, *52*(2), 364–375. https://doi.org/10.1111/area.12576

Auster, R.E., Barr, S., & Brazier, R. 2020. Improving engagement in managing reintroduction conflicts: learning from beaver reintroduction. *Journal of Environmental Planning and Management*, *64*(10), 1713-1734. https://doi.org/10.1080/09640568.2020.1837089

Auster, R. E., Barr, S., & Brazier, R. 2020. Alternative perspectives of the angling community on Eurasian beaver (Castor fiber) reintroduction in the River Otter Beaver Trial. *Journal of Environmental Planning and Management, 64*(7), 1252-1270. https://doi.org/10.1080/09640568.2020.1816933

Auster, R.E., Barr, S., & Brazier, R. 2020. Wildlife Tourism in Reintroduction Projects: Exploring Social and Economic Benefits of Beaver in Local Settings. *Journal for Nature Conservation*, *58*, 125920. https://doi.org/10.1016/j.jnc.2020.125920

Papers currently undergoing peer review and included in the thesis.

Auster, R.E., Barr, S. & Brazier, R. 2021. Beavers and Flood Alleviation: Human Perspectives from Downstream Communities. *In Review.*

Auster, R.E., Barr, S. & Brazier, R. 2021. Renewed Coexistence: Learning from Steering Group Stakeholders on a Beaver Reintroduction Project in England. *In Review.*

Appendices to the River Otter Beaver Trial: Science and Evidence Report authored by the student, not included in the thesis, but cited in the text.

Auster, R.E. 2020. *Appendix to the 'River Otter Beaver Trial' Science and Evidence Report: Beavers, Agriculture, and Land/Property-Owners Conflict Impacted by Beavers on the River Otter.* River Otter Beaver Trial. https://www.exeter.ac.uk/media/universityofexeter/research/microsites/creww/riverottertrial/appendix1/Beavers_and_Agriculture.pdf

Auster, R.E. 2020. *An Investigation into Fishing and its Economic Activity in the River Otter Catchment, and Reported Impacts of Eurasian Beaver (Castor fiber) Presence on Fishing, Prior to Spring 2019.* River Otter Beaver Trial. https://www.exeter.ac.uk/media/universityofexeter/research/microsites/creww/riverottertrial/appendix1/River_Otter_Fishing,_Economics_and_Beavers_(2019).pdf

Co-authored publications not included in the thesis, but which are cited in the text.

Brazier, R.E., Puttock, A.K., Graham, H.A., Auster, R.E., Davies, K. & Brown, C. 2020. Beaver: Nature's ecosystem engineers. *WIREs Water*, *8*(1), e1494. https://doi.org/10.1002/wat2.1494

Brazier, R. E., Elliott, M., Andison, E., Auster, R. E., Bridgewater, S., Burgess, P., Chant, J., Graham, H. A., Knott, E., Puttock, A. K., Sansum, P., & Vowles, A. (2020*).*

River Otter Beaver Trial: Science and Evidence Report. River Otter Beaver Trial. https://www.exeter.ac.uk/creww/research/beavertrial/

6. Ethics

In each paper I include details of the relevant study ethics. For each, I provided participants with details of the research and the use of the data prior to their participation. I have given the relevant research information (as provided for participants) as supplementary material for each publication. All participants were required to signify that they had read and agreed to the research information; they were required to give informed consent. Common to all the studies, I informed participants that participation was voluntary, and that they were not required to answer any or all questions if they chose not to do so. I also informed participants that their participation would be anonymised, with no identifiable data shared. For Chapter 3, I conducted verbal interviews. Here, I asked participants to give additional consent if they were happy for the interviews to be recorded for the purposes of transcription and analysis only.

Additionally, when any research output was published, I shared these back with the participants (where they had provided contact details for this purpose).

7. Research Timeline

As is evident from the preceding sections, I required a range of mixed methods for this research, I worked with various focal publics, and I examined different human dimensions of beaver reintroduction. Hence, a vital practical consideration in my methodological planning was the feasibility of achieving each study in parallel with each other and within the timeframe of the PhD programme. As such, I spread out the studies across the course of the studentship: I began the nationwide survey pre-PhD and submitted it for peer review in the first year of the PhD; I initiated three of the studies in the first half of the studentship; I completed the remaining two studies in the second half. The timeline of events presented in Figure 12 plots the PhD process and key stages of each study.

Following the nationwide survey which I undertook first (as it resulted from my pre-PhD Research Assistant role), the order in which I undertook the remaining studies was determined by a prioritisation of topics most pertinent to the culmination of the River Otter Beaver Trial. As my studentship was part-funded by Devon Wildlife Trust, and most of the research was conducted within the auspices of the Trial, it was anticipated by the partners that the research programme would contribute towards the Trial's Science & Evidence Report. (This included my participation in the Trial's Science & Evidence Forum throughout the period of study, which coincided with the Trial timeframe).

The River Otter Beaver Trial followed a Monitoring Plan which was developed to ensure progress towards the research and monitoring conditions of the Trial licence that had been issued by Natural England (Devon Wildlife Trust, 2017; Natural England, 2015). Key objectives in the plan which were relevant to my studentship included: understanding social attitudes and stakeholder perceptions; understanding the impacts for land-use and agriculture; investigating impacts on eco-tourism; and characterising the River Otter fisheries and identifying any impacts upon them. The studies I present in chapters 3, 4, and 5 respond to these areas, and so I prioritised these as the areas to focus upon first. As such, it was possible for me to report upon results from the nationwide survey and preliminary results from the chapters within the *ROBT Science & Evidence Report* (and appendices).

I conducted additional pieces for the *ROBT Science & Evidence Report* that are not included within this thesis but informed my intellectual understanding of the subject. These included working with River Otter fisheries and syndicates to profile the economic activity associated with fishing on the river and assessing the costs of beaver impacts to agriculture observed within the Trial using existing agricultural economic data. These findings were included within the main Science & Evidence Report, with full details included in additional appendix reports online. I have attached these appendix reports to this thesis as appendices 2 and 3.

Following the conclusion of the *ROBT Science & Evidence Report*, my remaining PhD gave time for the full manuscript write-ups and submission for peer review (and ultimately inclusion within this thesis). The remaining two areas of study were then feasible to carry out within the remaining time.

For the survey of Steering Group stakeholders presented in Chapter 7, this timing was ideal for it enabled the reflections of stakeholders to be explored at an appropriate time when the ROBT was still fresh in mind for participants, having just concluded. The study of perspectives on beavers and their role in flooding from communities downstream of beaver sites, presented in Chapter 6, would not have been possible within the ROBT as there were few dams built within the Trial time-frame and the majority of beaver territories were not in appropriate locations for such a study (asides from the one case where it would not have been possible for confidentiality reasons, as stated in the Chapter description section).

(To note, as these publications were developed during a situation that is rapidly changing, the status of beaver reintroduction is described slightly differently in each chapter. This reflects the status as it was at the times of the varied dates of publication).

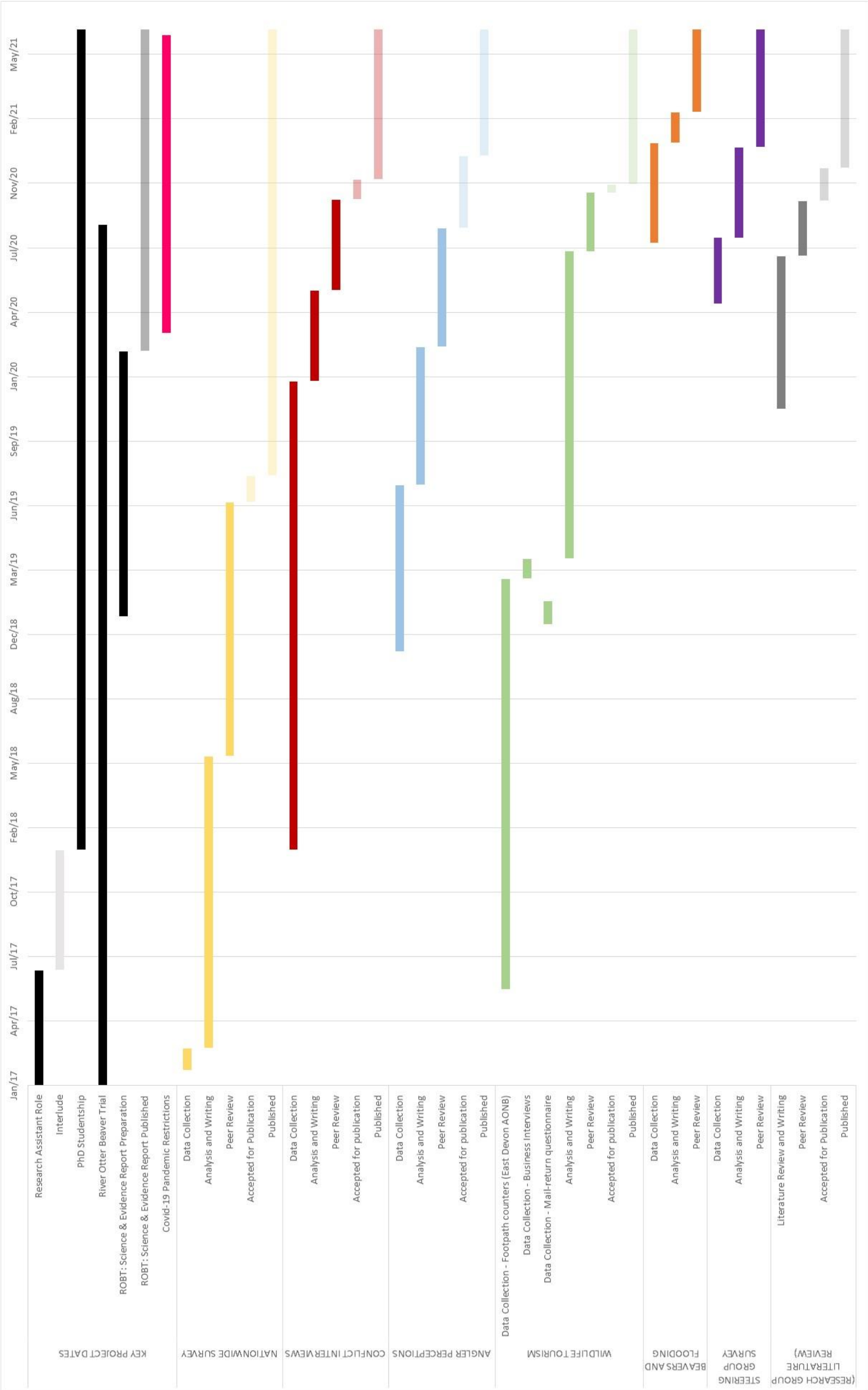

Figure 12. Gantt chart outlining the key stages of each of the studies contained within the thesis.

Chapter 2. Unravelling perceptions of Eurasian beaver reintroduction in Great Britain

The following paper forms the second chapter of this thesis. It is presented in published format, with all references included at the end of the chapter in publication format.

This paper details the nationwide attitude survey which forms the foundational research for the thesis.

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Statement of Contributions: I confirm that I am the primary author of this paper. I was responsible for designing the study, collecting, and analysing the data, and producing the text and figures. Puttock and Brazier supervised this work; they contributed ideas, manuscript edits, and proof-read the final text.

Full reference:

Auster, R.E., Puttock, A., & Brazier, R. 2020. Unravelling perceptions of Eurasian beaver reintroduction in Great Britain. *Area*, *52*(2), 364–375. https://doi.org/10.1111/area.12576

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REGULAR PAPER

WILEY AREA Royal Geographical Society with IBG Advancing geography and geographical learning

Unravelling perceptions of Eurasian beaver reintroduction in Great Britain

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International Union for the Conservation of Nature (IUCN) guidelines state that anticipated impacts must be considered in wildlife reintroduction, including the impacts on humans. Further, since reintroduction projects can be halted by resulting human–wildlife conflicts or human–human conflicts about wildlife, the perceptions of stakeholders and publics are of great importance. Eurasian beaver (*Castor fiber*) reintroduction is being debated in Great Britain at a devolved level. A decision has already been taken in Scotland to allow beavers already present to remain, while a number of reintroduction trials are taking place in England (both fenced and unfenced). There are also proposals for a reintroduction trial in Wales. We use a sub-set of results from a nationwide survey (n = 2,759) to identify four social areas that we propose decision-makers should consider in the debate: key stakeholder perceptions; engagement methods; attitudes towards legal protection and management responsibilities; and support for management techniques. In this paper, we investigate the complex social dimensions of wildlife reintroduction and we argue that emphasis should be placed on the need to recognise societal perceptions of potential management solutions, beyond perceptions of reintroduction itself. This is paramount in order to develop a management strategy that is more likely to garner social support and reduce potential future conflicts, should beaver reintroduction proceed.

KEYWORDS
Eurasian beaver, Great Britain, human–wildlife conflict, perceptions, reintroduction, survey

1 | INTRODUCTION

Conflicts between humans and wildlife – or "human–wildlife conflicts" – are increasing, particularly due to land use change associated with human population growth. These occur where wildlife is perceived to have undesirable impacts (e.g., economic loss or a decrease in well-being) (Nyhus, 2016). Often these are in fact human–human conflicts about wildlife, particularly when groups hold differing perceptions of management solutions (Marshall et al., 2007; Redpath et al., 2015). Human–human conflicts are often polarised, with complex debates framed as distinct opposing arguments (Redpath et al., 2013).

Wildlife reintroduction poses a unique conundrum for human–wildlife conflict theory. Reintroduction is an increasingly used conservation technique in which a species is returned to an environment in which it previously resided, often associated with ecological restoration or "rewilding" – the returning of managed land to "the wild" (Corlett, 2016). The unique conflict challenge in reintroduction (and wildlife translocations) is that conflicts are not necessarily yet present, but projects can be halted by resultant conflict issues (Hayward et al., 2007). Conflicts have consequences for decision-making about whether to reintroduce/translocate and how to manage projects. It is therefore important to identify and engage stakeholders early in the process (IUCN/SSC, 2013). If projects proceed, they may require management strategies to prevent conflicts arising later, depending on social and ecological contexts (Decker et al., 2015; Redpath et al., 2013).

Reintroduction of the Eurasian beaver (*Castor fiber*) – here-on referred to as beaver – is under debate in Great Britain (GB) with a number of projects underway. The species is estimated to have been resident until the 16th century, when hunted to extinction by humans. Similar events occurred in Europe and reintroduction has led to a self-sustaining population across most of the beavers' historical range (Halley & Rosell, 2003; Puttock et al., 2017).

Beavers are listed on Annex IV of the European Union (EU) "Habitats Directive" (Council of the EU, 1992). Annex IV requires member states to implement protective measures for listed species (if present) and to consider reintroducing formerly native species. Beaver reintroduction is now being considered in Great Britain (GB) (distinct from the UK as there is no evidence of beaver residence in Northern Ireland (Halley & Rosell, 2003)), with decision-making devolved to the Scottish, English, and Welsh governments.

Reintroduction considerations include environmental impacts of the beavers' role as "ecosystem engineers" (organisms which cause physical environmental changes that influence ecological community structures), including tree-felling and dam-building. Beaver behaviours may provide multiple ecosystem services, defined as benefits humans obtain from ecosystems (Gaywood, 2018; Millennium Ecosystem Assessment, 2005). In particular, beavers may provide a role in natural flood management by attenuating water flows in high rainfall events (Puttock et al., 2017). However, there are potential conflicts due to perceptions among social groups of (sometimes real) negative impacts of beaver-led landscape change, including the risk of flooding productive land or potential barriers to fish migration (Kemp et al., 2011; Morzillo & Needham, 2015). Hence, much of the debate is polarised and politically sensitive (Crowley et al., 2017).

Beaver reintroduction is at various stages across GB, with devolved decision-making responsibility. In Scotland, following a licensed trial in Mid-Argyll and assessment of a population of beavers in Tayside which established following an unlicensed release/escape (Scottish Natural Heritage, 2015), the Scottish Government announced that beavers are to be allowed to remain and that they will be listed as a European Protected Species (Gaywood, 2018; Scottish Government, 2019). In England, a population of unknown origin has been licensed for a reintroduction trial in Devon (Natural England, 2015) alongside a number of fenced projects, and the UK government has included reference to "providing opportunities for reintroduction of species such as beavers" in its 25-year environmental plan (for England) (HM Government, 2018, p. 57). For Wales, a feasibility study was conducted following which the "Welsh Beaver Project" was established to propose a Welsh trial (Jones et al., 2012).

International Union for the Conservation of Nature (IUCN) and Species Survival Commission (SSC) guidelines require reintroduction projects to consider anticipated impacts, including on humans (IUCN/SSC, 2013). Additionally, in Scotland the guidelines given in the "Scottish Code for Conservation Translocations" (which are based around the IUCN/SSC guidelines) must also be considered in reintroduction decisions (National Species Reintroduction Forum, 2014). In England, a reintroduction code is to be developed which may be applicable to reintroductions in the near future (HM Government, 2018, p. 61).

This paper aims to investigate complex social dynamics in beaver reintroduction and to build a consensus as to what knowledge is needed for decision-makers and society to comprehend the impacts of reintroducing beavers across GB. We draw on a sub-set of results from a nationwide online public attitudes survey to identify and outline four social factors that must be considered by decision-makers:

1. key stakeholder perceptions;
2. engagement methods;
3. attitudes towards legal protection and management responsibilities; and
4. support for management techniques.

We recognise the study of perceptions thus far. In Scotland, varied stakeholder engagement exercises were conducted over the past 20 years, including consultation most recently on species management (Gaywood, 2018; Scottish Beaver Trial, 2014, Scottish Government, 2017; Tayside Beaver Study Group, 2015a, 2015b). In England and Wales, interviews were held with stakeholder organisations for the feasibility studies (Gurnell et al., 2009; Jones et al., 2012) and stakeholder engagement is ongoing in the beaver trials. This paper builds on this work with an approach that accounts for perceptions among both stakeholders and the public. It aims to provide a deeper understanding beyond views on impacts, quantitatively comparing perceptions across the whole of GB for the first time. We explore opinions on engagement and potential beaver management and use findings to demonstrate how the four outlined factors are relevant for reintroductions.

2 | METHODS

As beavers are likely to naturally expand their range as populations grow (Halley et al., 2012), reintroduction will have consequences throughout GB. Therefore, a national-scale survey was undertaken to meet the research aims.

2.1 | Establishing questions

Following a literature review, we undertook an exploratory interview-based study in March–April 2016 in the catchment of the "River Otter Beaver Trial." This is the site of the English trial studying the "wild" beaver population that has established since 2007, and hence where human–beaver interactions have occurred (Crowley et al., 2017). Twelve purposively selected participants (covering the opinion spectrum recognised in the literature review) answered open-ended questions about beaver impacts and potential beaver management. We used thematic content analysis to identify themes to design the survey questions (see Data S1).

Questions were divided into five categories:

1. Knowledge of beaver ecology (detailed in section 3.3).
2. Perceptions of beaver impacts using Likert Scales – a bipolar scale in which respondents rate their answers (Allen & Seaman, 2007) – in an ordinal rating of "Very Negatively" (score 1) to "Very Positively" (score 5) on 8 impact themes.
3. Methods by which respondents felt comfortable to express views and whether they felt able to express them where it influences decision-makers.
4. Respondent views on the process of beaver reintroduction and potential beaver management.
5. Respondent details (occupation, geographical region, and the distance the respondent lives from a watercourse).

Questions were piloted internally (n = 20) to ensure clarity and bias avoidance.

2.2 | Sampling

We distributed the survey using the online platform "Typeform" (www.typeform.com) between 27 January and 1 March 2017, with the option for participants to request a paper copy.

We recruited participants with a "snowball" sample. This strategy identifies contacts with particular characteristics and invites them to recruit similar participants within their networks. New participants can in turn invite others, leading to a "snowballing" effect (Wasserman & Faust, 2007). A limitation is that numbers cannot be directly inferred to wider populations, but due to the topic's political sensitivity it was imperative to encompass a spectrum of views, including those of hard-to-reach groups (such as those who may be reluctant to volunteer due to political pressures or stigmas) that "snowballing" enables researchers to recruit (Sadler et al., 2010). Further, we aimed to examine attitudinal variance in response to background variables, rather than opinion prevalence.

"Snowballing" was achieved in two ways:

1. We invited 106 organisations/representatives that may have an interest in beaver reintroduction (purposively selected to cover the range of interest groups identified in preliminary work) to share the survey within their networks.
2. To capture the general public, we issued an impartial press release invitation through the University of Exeter Press Office, distancing us from media outlets. As far as we know, this appeared in 10 outlets.

We provided an optional prize draw as an incentive for participation, which took about 25 minutes.

2.3 | Analysis

In each analysis we excluded respondents who did not answer the required questions. We undertook statistical analyses using IBM SPSS Statistics 23 ×64 and R i386 3.3.2 software. Results were deemed significant when $p < 0.05$.

Ordinal logistic regression analysed whether respondent background variables influenced views on overall impacts of beaver reintroduction (response variable) relative to the other survey respondents, using overall scores of the ordered Likert-scale responses as identified in the methods (n = 2,272). For ordered independent variable (distance resident from a watercourse), the different categories were included within one model. For categorical independent variables (occupation, region), categories were compared to their dummy variables individually.

We used ordinal logistic regression to analyse overall impact scores (response variable) in response to the ordered independent variable of "Level of Knowledge" (n = 2,272), identified from answers to five multiple choice questions about beaver ecology (Data S2). Correct answers scored one point and total scores were assigned a "Level of Knowledge" category: 0 or 1 = "Little or No Knowledge" (n = 52); 2 or 3 = "Moderate Knowledge" (n = 503); 4 or 5 = "Strong Knowledge" (n = 1,717).

Analysis of variance (ANOVA) was utilised to test the relationship between overall impact scores and whether respondents supported the process of beaver reintroduction to GB (response variable) (n = 2,274). We then applied Pearson chi-square tests to assess relationships between whether respondents supported the process of beaver reintroduction to GB and the response variables: whether respondents felt able to express views where it influences decision-makers (n = 2,685); what level of legal protection should be applied if/where beavers are reintroduced ("Strong," "Limited," or "None") (n = 2,725).

Finally, we used chi-square tests of independence on multiple response sets to examine relationships between: methods by which respondents felt comfortable to express views and whether or not they felt able to express views where it influences decision-makers (n = 2,335); views on who should take responsibility for managing beavers in practice (if anybody) and the level of legal protection respondents felt should be applied if beavers are reintroduced (n = 2,597); support for management techniques, aligned with *The Eurasian Beaver Handbook* (Campbell-Palmer et al., 2016); and whether respondents supported the process of beaver reintroduction (n = 2,702). To note, multiple response questions challenge traditional Pearson chi-square tests as the data in a contingency table are not mutually exclusive. However, with adjustments a test can be used as an approximate test for marginal association (Thomas & Decady, 2004).

2.4 | Ethics

The study was approved by the University of Exeter's Ethics Committee.

3 | RESULTS

In total, 2,759 submissions were received (including one paper copy), 52.7% of those who started the survey online or requested a paper copy. (Respondent summary data in Data S3.)

3.1 | Key stakeholder perceptions

Table 1 shows the odds ratio results of the ordinal regression analyses. Odds ratios are measures of effect to compare respondents of a group to the other respondents (in each model as outlined in the methods). Table 1 shows that in all variables there were statistical significances indicating groups that could be identified as more/less likely to score in the next level on the overall Likert scales of views on beaver impacts (i.e., have a more positive view). A sum Nagelkerke Pseudo R^2 value of 0.109–0.130 was obtained.

When looking at overall views of impacts, respondent level of knowledge appeared to influence whether a respondent was more/less likely to score in the next category on the scale. Those with "Little or No Knowledge" or "Moderate Knowledge" were significantly less likely than those with "Strong Knowledge" to obtain an overall score in the next category on the scale (i.e., less likely to have a more positive view). Those with "Little or No Knowledge" were associated with an odds ratio of 0.59:1 (95% CI, 0.35–0.99, Wald $\chi^2_{(2)} = 4.055$, $p < 0.05$) and those with "Moderate Knowledge" were associated with an odds ratio of 0.56:1 (95% CI, 0.46–0.68, Wald $\chi^2_{(2)} = 36.965$, $p < 0.001$). "Strong Knowledge" was the reference category. A Nagelkerke Pseudo R^2 value of 0.019 was obtained.

Regarding respondents' support for the process of beaver reintroduction to GB, 99.36% of respondents who had a "Very Positive" (n = 1,094) view of the overall impacts of beavers supported the process, with the remaining 0.64% undecided. Of respondents who were "Somewhat Positive" (n = 848), 95.05% supported the process, 4.72% were undecided, and 0.24% did not support it.

Of those who had a "Somewhat Negative" view (n = 84), 83.33% did not support reintroduction, with 15.48% undecided and 1.19% supporting the process. Of respondents who had a "Very Negative" (n = 39) overall view of impacts, 100% did not support reintroduction. Where overall impact views were "Neutral" (n = 207), 46.86% supported

TABLE 1 Ordinal regression analysis results of overall impact scores presented as odds ratios, comparing categories relative to other survey participants. Full statistics are reported for statistically significant results.

Factor	Category	Odds ratio	Confidence interval: Lower bound	Confidence interval: Upper bound	Wald χ^2	Nagelkerke Pseudo-R^2
Region	Not resident in GB	1.56	0.89	2.71		
	North-West England	1.50[a]	1.00	2.23	3.906	0.002
	Yorkshire	1.37	0.37	2.07		
	East England	1.24	0.44	1.68		
	London	1.21	0.84	1.74		
	North-East England	1.05	0.57	1.93		
	East Wales	1.02	0.59	1.62		
	Highlands & Islands	1.00	0.65	1.53		
	South-East England	0.99	0.77	1.27		
	West Wales & The Valleys	0.96	0.60	1.53		
	West Midlands	0.93	0.68	1.27		
	South-West England	0.91	0.78	1.07		
	East Midlands	0.87	0.60	1.24		
	South-Western Scotland	0.79	0.40	1.55		
	North-Eastern Scotland	0.79	0.33	1.88		
	Eastern Scotland	0.62[b]	0.45	0.87	7.781	0.003
Occupation	Arts, sport & media	1.78[a]	1.07	2.94	4.985	0.002
	Community & social service	1.57	0.87	2.83		
	Environment, nature & wildlife	1.46[c]	1.22	1.74	17.151	0.009
	Sales	1.36	0.61	3.03		
	Tourism	1.31	0.46	3.78		
	Computer & mathematical	1.25	0.72	2.19		
	Forestry & woodland management	1.22	0.64	2.34		
	Education	1.18	0.91	1.53		
	Other	1.17	0.92	1.49		
	Healthcare	1.14	0.76	1.72		
	Hospitality	1.14	0.37	3.55		
	Business & finance	1.06	0.67	1.66		
	Student	1.01	0.74	1.37		
	Office & administrative support	0.99	0.69	1.41		
	Transport	0.89	0.31	2.59		
	Physical or Social Science	0.88	0.43	1.79		
	Production	0.68	0.22	2.03		
	Building & maintenance	0.67	0.32	1.40		
	Retired	0.59[c]	0.47	0.76	17.523	0.008
	Architecture, energy & engineering	0.59	0.34	1.01		
	Farming & agriculture	0.15[c]	0.10	0.22	93.236	0.037
	Fisheries & aquaculture	0.10[c]	0.05	0.22	35.896	0.015

(Continues)

TABLE 1 (Continued)

Factor	Category	Odds ratio	Confidence interval Lower bound	Confidence interval Upper bound	Wald χ^2	Nagelkerke Pseudo-R^2
Distance from watercourse	Property extends to/includes	0.71[a]	0.55	0.92	6.474	–
	<50 m	0.86	0.68	1.08		
	50–100 m	0.89	0.80	1.21		
	>100 m	Reference category			Model: 0.003	

[a]$p < 0.05$; [b]$p < 0.01$; [c]$p < 0.001$.

reintroduction, 17.87% did not, and 35.37% were undecided. These results were statistically significant ($F_{1,4} = 2{,}611.1$, $p < 0.001$, $r^2 = 0.5349$).

3.2 | Engagement methods

When asked whether respondents felt able to express views where it influences decision-makers, a higher number answered "No" ($n = 1{,}617$) than "Yes" ($n = 1{,}068$). There was a significant interaction between these answers and whether respondents supported the process of beaver reintroduction ($\chi^2 = 28.542$, $df = 2$, $p < 0.001$). Of those who supported the process ($n = 2{,}319$), 41.74% felt able to express views, whereas 58.26% did not. Of those who did not support the process ($n = 198$), 29.80% felt able to express views, whereas 70.20% did not. Of those who were "Undecided" ($n = 168$), 24.40% felt able to express views, whereas 75.60% did not.

We found a significant interaction between whether respondents felt able to express views where it influences decision-makers and the methods by which they would feel comfortable to express views ($\chi^2 = 555.090$, $df = 10$, $p < 0.001$). A higher percentage felt comfortable to use each method if they felt able to express views than if they did not (Figure 1). In both groups digital channels (social media, organisation website, email) and word of mouth were most selected. All methods (excluding "Other") were selected by >10% of respondents in each group.

3.3 | Attitudes towards legal protection and management responsibilities

Where respondents supported reintroduction ($n = 2{,}356$) the dominant view was that beavers should be given "Strong" legal protection (83.28%), followed by "Limited" (16.43%), then "None" (0.30%). Where respondents did not support reintroduction ($n = 199$) the dominant view was "None" (60.30%), followed by "Limited" (32.66%), then "Strong" (7.04%). "Undecided" respondents ($n = 170$) dominantly supported "Limited" legal protection (50.59%), followed by "Strong" (40.59%), then "None" (8.82%). These interactions were statistically significant ($\chi^2 = 1{,}555.1$, $df = 4$, $p < 0.001$).

We found a significant relationship between which bodies respondents felt should be responsible for management practice and the level of legal protection they felt should be applied if beavers are reintroduced ($\chi^2 = 1{,}741.036$, $df = 30$, $p < 0.001$). Among respondents who felt there should be "Strong" or "Limited" protection, the dominant view was that management practice was the responsibility of an environmental charity/organisation, followed by a government body. For respondents who felt there should be no legal protection, the dominant view was that responsibility should be with individuals/landowners, followed by a government body. "No Management Will Be Necessary" was least supported in all groups (excluding "Other") (Figure 2).

3.4 | Support for management techniques

We found a significant relationship between support for management techniques and whether respondents supported the process of beaver reintroduction ($\chi^2 = 1{,}741.036$, $df = 30$, $p < 0.001$). Respondents who supported reintroduction primarily supported education (to address misinformation or how to manage beavers), followed by paying landowners to host beavers on their land. Those who did not support reintroduction primarily supported compensation for losses, followed by population control by culling. Undecided respondents primarily supported education, followed by compensation for losses/tree protection. "No Management Will Be Necessary" was least supported in all groups (excluding "Other") (Figure 3).

4 | DISCUSSION

4.1 | Key stakeholder perceptions

Identifying stakeholders is important in policy decisions and herein it is shown that this must encompass the spectrum of views, including proponents and opponents. Table 1 demonstrates differences of statistical significance that could implicate differing levels of potential conflicts. In particular, and in line with literature from where beavers are present elsewhere (see Introduction), respondents whose occupations were in “Farming & Agriculture” or “Fisheries & Aquaculture” were significantly less likely to have a more positive view of beaver impacts, as were those who were “Retired,” respondents whose property extends up to/includes a watercourse, and residents of Eastern Scotland. Conversely, those whose occupation was in “Environment, Nature & Wildlife” or “Arts, Sport & Media” were significantly more likely to be more positive, as were residents of North-West England. Between these groups there is an increased risk of polarisation and conflict.

There were differences in respondent levels of knowledge. Those with “Strong Knowledge” were more likely to have a more positive view of beaver impacts. This implicates a need for education and addressing misinformation, and demonstrates that awareness of participant knowledge is necessary for informed decision-making, which would also have been true if the reverse trend had been found.

4.2 | Engagement methods

Perceptions need particular acknowledgement during research/trial phases of projects when beaver reintroduction impacts need full consideration (IUCN/SSC, 2013). All stakeholders and publics therefore need opportunities to express views where it may influence decision-makers. However, this research indicated the majority of respondents who answered

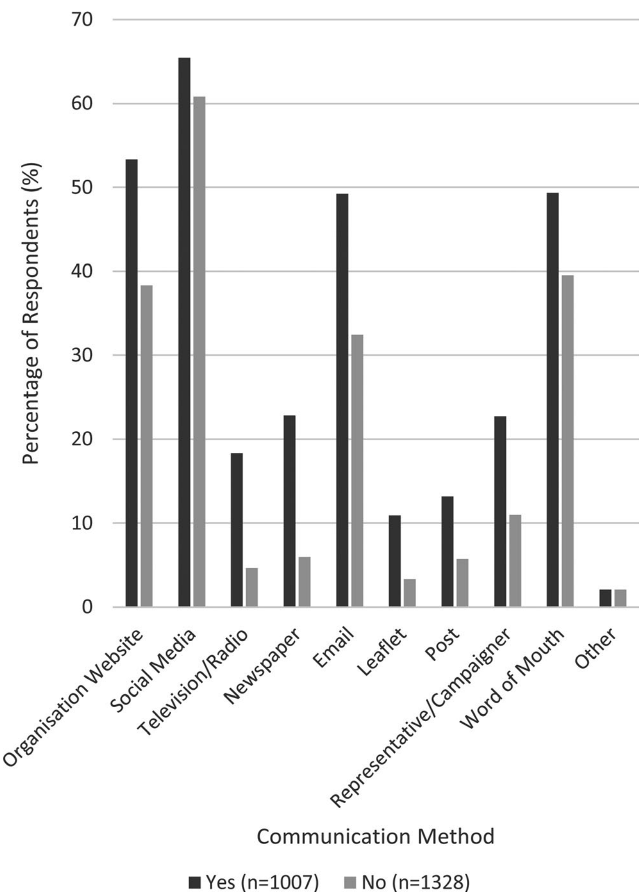

FIGURE 1 Percentage of respondents who felt comfortable expressing views through various communication channels as asked in a multiple response question, expressed in relation to whether respondents felt able to express views where it influences decision-makers – as denoted by the key.

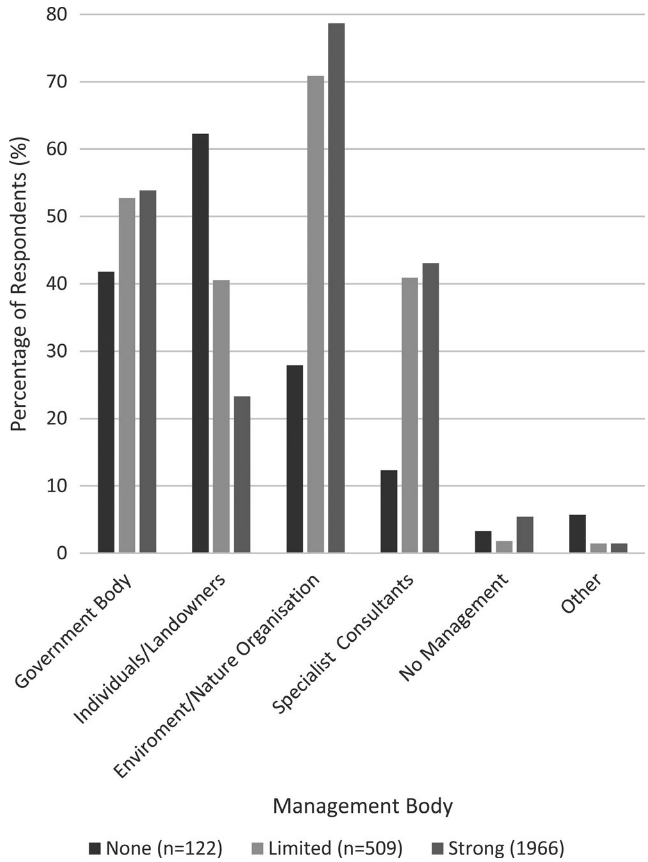

FIGURE 2 Respondents' views on who should take responsibility for management practice from a multiple response question, expressed in relation to the respondents' views on the level of legal protection that is required – as denoted by the key.

(60.22%) felt unable to do so. Although true in all groups, the margin was wider for those who did not support beaver reintroduction or were undecided than for those who did. The IUCN guidelines state that mechanisms for engagement "should be established well in advance of any release" (IUCN/SSC, 2013, p. 11) and that "participation in monitoring may be a practical means of engaging … and can be used to assess attitudes" (IUCN/SSC, 2013, p. 21). Thus, to meet the guidelines, the sense of inability to express opinions will need to be addressed throughout reintroduction processes. It should be noted, however, that methods and opportunities to engage will vary between projects. For example, there were numerous engagement studies before and during the Scottish Beaver Trial, but opportunities to engage pre-release were not present in the unlicensed release/escape in Tayside.

Furthermore, there were differences in specific methods whereby respondents felt comfortable to express views (Figure 1). While accounting for resource limitation, maximum opportunity will mean providing multiple channels for opinion expression. (To note, this survey was primarily online, which could have influenced this result, despite the paper copy option.) Due to the debate's complexities, it is likely that decisions will receive a mixture of support and opposition, particularly between groups identified as more/less likely to view beaver impacts positively, but greater support may be gathered if there is opportunity for view expression and decision-makers should provide evidence to demonstrate how opinions have been recognised.

4.3 | Attitudes towards legal protection and management responsibilities

In Scotland, a decision has been indicated on beaver reintroduction. In England and Wales, decisions are due after trial phases. The nature of these decisions are forward-thinking and, if beaver reintroductions progress, the question of species management needs early consideration. Indeed, results demonstrated support for some form of management; in Figures 2 and 3, fewest respondents supported "No Management."

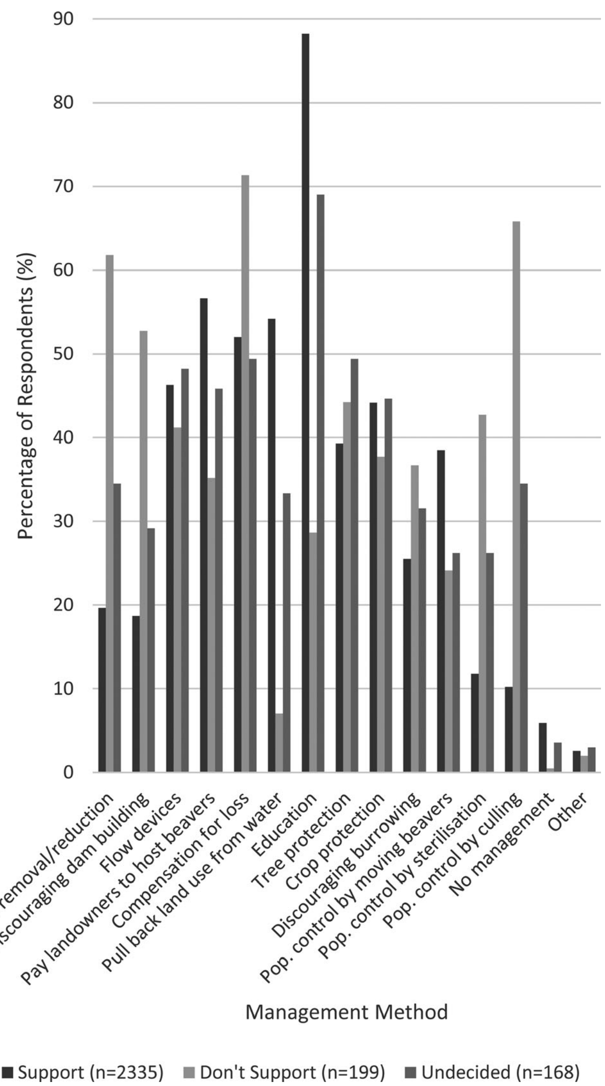

FIGURE 3 Respondents' support for management techniques expressed in relation to whether they support the process of beaver reintroduction to Great Britain – as denoted by the key.

There is opportunity to be proactive and collectively consider strategies from the outset, beginning with decisions on legal protection. These are devolved decisions so specific applications of legal protection will vary where differing policies apply. It is appropriate though to recognise that the application of one of these policies is currently uncertain; the future of the "Habitats Directive" (on which beavers are listed) in GB is unclear, due to recent moves to leave the EU ("Brexit"). It is likely that post-"Brexit" in 2020 (coinciding with the completion of the Devon trial) there will be better indication as to how European species protection policies will be applied across GB.

Regardless of these variables, and due to perceived beaver impacts, strategic decisions are needed on what management should occur – particularly by whom, as this will be affected by any level of legal protection applied, whether under current or new policies. This should be accessibly outlined at the earliest opportunity to manage expectations and reduce conflicts (Decker et al., 2015).

4.4 | Support for management techniques

Although consideration of the effectiveness and ecological implications of beaver management techniques is required, social aspects also need to be considered (Decker et al., 2015). Here there was variance in support for techniques (Figure 3). We argue that understanding these differences is critical to determining an approach most likely to garner public support, in particular between groups identified as having a more/less positive view of beaver impacts (section 4.4). While considering social and environmental contexts (Decker et al., 2015), emphasis needs to be placed on understanding attitudes towards management if selected techniques are to be deemed socially acceptable, rather than risk polarised human–human conflict.

4.5 | Research recommendation

Financial implications of management are an important consideration and for some a source of concern, as demonstrated by an anonymous quote received during this research: "if beavers stay in the future … then it's going to be a major cost for somebody to pick up." Research into the socio-economics of beaver reintroduction, both potential costs and benefits, has been undertaken to some degree, noting particularly the socio-economic reports on the Scottish Beaver Trial and Tayside Beaver population (Moran & Lewis, 2014; Scottish Natural Heritage, 2015, Tayside Beaver Study Group, 2015a, 2015b). Research is ongoing, particularly in England and Wales, where beaver reintroduction events are more recent. It is recommended that this research continues to give greater understanding of potential conflicts, as well as potential Ecosystem Service benefits. This will further help to identify whether perceived impacts are "real" (Messmer, 2000). However, it should be recognised that qualitative study is important also; economics are not of unanimous concern due to differences in ethical values, demonstrated by a survey participant: "Economics should not be a significant factor in wildlife conservation."

5 | CONCLUSIONS

By exploring four social areas of focus, this research has demonstrated significant social implications of beaver reintroduction needing full recognition (alongside ecological knowledge) in pragmatic decision-making. This study found differences between social groups that need accounting for in informed, socially acceptable decisions that prevent polarised conflicts from developing. This will require enabling stakeholders and the public opportunity to express opinions without judgement.

This paper argues particularly that decision-makers need to recognise perceptions about potential legal protection and beaver management techniques, beyond those simply of reintroduction itself. Wildlife management decisions are often made reactively to conflicts that occur, yet in reintroduction these decisions can be made proactively before conflicts arise. This task should be viewed as an opportunity for tackling challenges head-on while developing an optimal strategic approach, one that aims to support negatively affected parties while allowing opportunity to maximise potential benefits (Messmer, 2000). Although challenging, decisions that account for societal attitudes will be more likely to garner public support and reduce possible future human–wildlife and human–human conflicts.

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DATA ACCESSIBILITY

Due to ethical concerns resulting from the permissions given by participants for use of data in this research, supporting data cannot be made openly available. Data are held by the corresponding author.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Data S1. Finalised survey (including information for participants).

Data S2. Respondent answers to multiple choice beaver ecology questions.

Data S3. Summary respondent data.

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Chapter 3. Improving engagement in managing reintroduction conflicts: learning from beaver reintroduction

The following paper forms the third chapter of this thesis. It is presented in published format, with all references included at the end of the chapter in publication format.

This paper is the first of the two studies which investigate potential areas of conflict associated with beaver reintroduction. This paper details a thematic analysis of interviews conducted with individuals who reported conflicts with beavers in the River Otter Beaver Trial and identifies five key themes relating to the engagement with individuals who report conflicts with beavers.

(Further details of the conflict issues detailed in this paper are provided in the River Otter Beaver Trial Science & Evidence Report (https://www.exeter.ac.uk/creww/research/beavertrial/) and in an associated appendix which is also attached as Appendix 2 to this thesis.)

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Improving engagement in managing reintroduction conflicts: learning from beaver reintroduction

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Improving engagement in managing reintroduction conflicts: learning from beaver reintroduction

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Social factors hold implications for the success or failure of wildlife reintroductions. Potential conflict issues may prevent projects from proceeding or succeeding. The manner in which wildlife managers engage with affected people in conflict scenarios may prevent or contribute toward conflict escalation, so an understanding of how to improve engagement is required. We conducted interviews with individuals who reported conflicts with beavers (*Castor fiber*) within the case study of a reintroduction trial in England, called the 'River Otter Beaver Trial'. Using a qualitative thematic analysis, we identified five themes to be considered when engaging with affected people in beaver reintroduction conflicts: (1) *Proactive Engagement or a Fast Response*; (2) *Appropriate Communication*; (3) *Shared Decision-Making*; (4) *Sense that Humans are Responsible for Conflicts with Reintroduced Species*; (5) *A Need for Certainty*. We conclude that engagement with affected individuals will likely be improved, with reduced conflict potential, where these themes are addressed.

Keywords: Engagement; Eurasian beaver; human-wildlife conflict; human dimensions; thematic analysis; reintroduction

1. Introduction

Wildlife translocation is where individuals of a species are moved between areas (Seddon *et al.* 2014). Wildlife reintroduction is a form of translocation where a species is returned to an environment where it was previously resident but no longer exists, often to support species populations or for ecosystem restoration (Seddon, Armstrong, and Maloney 2007). Reintroduction is a growing field of interest (Seddon, Armstrong, and Maloney 2007; Seddon *et al.* 2014; Taylor *et al.* 2017) and guidelines are set out by the International Union for the Conservation of Nature, which stipulate factors that require consideration, including environmental conditions, ecological resource availability and social implications (Cheyne 2006; IUCN & SSC 2013).

Social factors, including 'human-wildlife conflicts', influence the outcome of reintroduction projects. Human-wildlife conflict refers to negative interactions between humans and wildlife, whether they are 'real' or 'perceived' (Messmer 2000; Torres, Oliveira, and Alves 2018). It is recognized these conflicts are often conflicts between people *about* wildlife rather than direct conflicts between people *and* wildlife (Madden 2004; Redpath, Bhatia, and Young 2015). Conflicts particularly occur where there are

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differing opinions about wildlife management (Madden 2004; Marshall, White, and Fischer 2007). For example, in England, there are conflicts between people with differing attitudes toward managing badgers (*Meles meles)* to reduce transmission of *Bovine tuberculosis* to domestic cattle, including debate about culling versus vaccination (Keenan *et al.* 2020). Ideally, conflicts should be addressed early to prevent them escalating and becoming more difficult to resolve (Seddon, Armstrong, and Maloney 2007; Reed 2008; Redpath *et al.* 2013; Clark, Workman, and Jung 2016; Crowley, Hinchliffe, and McDonald 2017a). In reintroductions, however, practical conflicts with a specific species do not yet exist as the animal is not yet present, though theoretical conflicts over the principles of reintroduction may occur prior to reintroduction. Conflicts should be anticipated proactively (Auster, Puttock, and Brazier 2020) as projects may be more likely to fail where conflicts are significant (IUCN & SSC 2013; Perring *et al.* 2015; Sutton 2015; Lopes-Fernandes and Frazão-Moreira 2017). For example, a proposal to reintroduce lynx (*Lynx lynx*) was rejected by the UK Government in 2018. In the justification for the decision, it was suggested that those proposing the project had not sufficiently engaged with key stakeholders. It was noted that the farming community had raised concerns of conflicts with lynx, yet "the farming community has not actively been involved and there is no evidence they accept the proposed measures or that they address the breadth of their concerns" (DEFRA 2018). As such, when conflicts with a reintroduced species occur there will need to be appropriate engagement with the affected individuals to reduce potential for conflict escalation. Thus, an understanding of what constitutes appropriate engagement is required.

In Great Britain, reintroduction of the Eurasian beaver (*Castor fiber*) is underway. The species was historically resident until hunted to extinction approximately 500 years ago (Macdonald *et al.* 1995; Halley, Rosell, and Saveljev 2012). Its reintroduction is being considered at a devolved government level. In Scotland, following a trial phase and monitoring of a free-living population on the River Tay, beavers were listed as a European Protected Species in May 2019 (Gaywood *et al.* 2015; Tayside Beaver Study Group 2015; Gaywood 2018; Scottish Government 2019). In England there are a number of enclosed beaver trials (behind a fence) and one official free-living trial – the River Otter Beaver Trial (ROBT). In August 2020, the UK Government announced that the River Otter beavers could legally remain and consultations on a national approach to further releases and management are expected later in the year (UK Government 2020). In Wales there is no formal reintroduction as yet but proposals have been put forward by the 'Welsh Beaver Project' (Wildlife Trusts Wales 2012).

Motivations for reintroducing beavers are rooted in a number of benefits resulting from 'ecosystem engineering' behaviors of dam-building and tree-felling, including: biodiversity increase (Stringer and Gaywood 2016; Law *et al.* 2019; Nummi *et al.* 2019); water flow attenuation (Puttock *et al.* 2017; Brown *et al.* 2018); water quality improvement (Puttock *et al.* 2017, 2018); and ecotourism opportunities (Campbell, Dutton, and Hughes 2007; Auster, Barr, and Brazier 2020). However, there are potential conflicts, with examples in Europe and also in America with the similar North American beaver (*Castor canadensis*). Conflicts may include: water behind a dam flooding agricultural land and/or roads or floodplain infrastructure (Jensen *et al.* 2001; Morzillo and Needham 2015; Campbell-Palmer *et al.* 2016); felling trees of social significance (Campbell-Palmer, Schwab, and Girling 2015, Campbell-Palmer *et al.* 2016); and burrow collapses in agricultural fields (Gurnell 1998; Campbell-Palmer *et al.* 2016). Management techniques exist to mitigate negative beaver impacts. These include direct measures (e.g. flow devices to lower water levels behind dams, or translocation of 'problem beavers') and indirect measures (e.g. compensation for damage, or payment of landowners to host beavers (Morzillo and Needham 2015; Campbell-Palmer *et al.* 2016; Wróbel and Krysztofiak-Kaniewska 2020). These conflicts result from the same beaver-induced landscape change that identifies them as ecosystem engineers, but here their activities may be at odds with human objectives for land or water use.

When conflicts occur, reintroduction practitioners will need to engage with affected individuals. The response from a wildlife manager needs to be appropriate from the stakeholders' point of view if conflict is to be reduced or avoided rather than escalated (Treves, Wallace, and White 2009; Decker *et al.* 2014, 2015, 2016). However, in a previous nationwide attitudinal survey which explored public perceptions of beaver reintroduction (Auster, Puttock, and Brazier 2020), the majority of respondents indicated they did not feel they could express their opinion where it may influence decision-making and 'engagement methods' were identified as one of four key elements that require consideration in reintroduction projects.

Our research aimed to build on this knowledge and develop an understanding of what constituted 'better' engagement practice from beaver managers in response to conflicts, from the perspectives of affected individuals. We used a traditional thematic analysis case study approach to identify the key themes for engagement. This qualitative technique employs a systematic approach toward coding textual data – in this case from interviews. It explores meaning in the codes and identifies key themes and the relationships between them (Vaismoradi *et al.* 2016; Castleberry and Nolen 2018). Using this technique, we sought to identify and understand key themes (or concepts) pertaining to engagement, the relationships between the themes, and the implications for improving engagement in beaver reintroduction conflict scenarios.

2. Methods

2.1. Study context

This study was undertaken within the catchment area of the ROBT, the base of the first licensed free-living population of beavers in England. The catchment of ca. 250 km^2 with 1190 km of riverbank is situated in Devon, south west England. It is largely rural with 50% of land use being improved grassland and 28% arable and horticulture. Settlements are small and dispersed (Brazier *et al.* 2020, 12).

Prior to 2015, a small group of free-living Eurasian beavers (of unknown origin) was discovered on the River Otter. Devon Wildlife Trust (DWT) was granted a license to monitor the beavers for 5 years following a locally-driven campaign and subject to health-screening (Natural England 2015; Crowley, Hinchliffe, and McDonald 2017b). The ROBT has monitored the beavers and collated evidence on their impacts, both positive and negative (Devon Wildlife Trust 2017). In 2015, there were two known breeding pairs of beavers in the lower river, rising to seven throughout the main river by 2019 (Brazier *et al.* 2020, 14). Where conflicts with beavers were reported, DWT Officers engaged with the affected individuals to determine appropriate management. ROBT findings were reported for UK Government in 2020, including details of the management undertaken by DWT where conflicts occurred and a proposed framework for managing beavers in the future (ROBT 2019; Brazier *et al.* 2020).

2.2. Participant recruitment

Purposeful participant recruitment is common within qualitative case study research as qualitative research values the understanding of a situation, thus selection criteria are based upon recruiting participants who provide useful insights (Sandelowski 1995; Guest, Bunce, and Johnson 2006; Trotter 2012). Herein, participants were purposefully selected as land- or property-owners/managers who reported a direct conflict with beavers and received a management response from DWT, within the duration period of data collection (January 2018 to December 2019).

As holders of the reintroduction license, DWT was responsible for management interventions so had access to individuals who reported direct conflicts with beavers. A partnership approach was used to invite participation, whereby DWT informed individuals of the study on our behalf when conflicts occurred. It was stated to participants that researchers were independent of DWT and interviews would be undertaken without the presence of a DWT member so participants could speak without influence. DWT informed the researcher when conflicts were reported.

There was a natural limit to the number of possible interviews based upon where conflicts with the beaver population occurred and the willingness of individuals to participate. In the data collection period there were seven incidents of reported conflicts with land-/property-use. One conflict case was reported by four neighboring landowners who were all invited to participate, to which one responded. Seven interviews were possible, with at least one participant from each conflict site (see section 3.1). At the participants' requests, there were four interviews in which there were multiple participants meaning thirteen individuals took part in total. When individuals engaged, study information was provided in advance of the interview (see section 2.4).

The participation of multiple individuals in four interviews occurred spontaneously at the participants' requests; thus it was ethically appropriate to accommodate their wishes as participation was voluntary. The method accounts for this naturally occurring variation as the study is exploratory, and group interviews allow for data to be gathered on interpretations of events that require group input (Frey and Fontana 1991; Frey 2004). These interviews consisted of a 'group' (either a couple or family) who experienced the conflict as a collective. In these interviews we followed the same interview procedure whilst ensuring all participants had opportunity to speak.

2.3. Interview process

Interviews were semi-structured in nature. Open-ended questions for participants were designed to explore: (1) beaver impacts experienced; (2) views on beaver reintroduction; (3) engagement with or by a ROBT member; (4) management interventions undertaken; (5) views *on* and advice *for* the future of beavers. Open-ended questions allowed participants to respond freely, setting the direction of discussion whilst allowing us to probe responses if appropriate. Thus, the interviews followed a flexible structure (McIntosh and Morse 2015). Each interview was approximately one hour in duration (range = 45–90 min). Where participants consented, we audio-recorded interviews for later analysis. One participant did not consent, so notes were taken (including verbatim quotes).

2.4. Ethics and consent

We provided participants with study information and statements on data use prior to interview. This included: clarity that participation was anonymous and voluntary; study funding details; clarification the study was impartial. We asked participants to give a signature of consent for participation and for the interview to be recorded (an example consent form is available as Supporting Information). To abide by data protection laws, participants' personal contact details were not shared with us directly but instead provided with ours. The study was approved by the University of Exeter Geography Department's Ethics Committee (application number: eCLESGeo000033).

2.5. Analysis

After each interview, we transcribed data verbatim from the recordings (except for the interview in which notes had been taken, including verbatim quotes). We produced a summary of each interview, with associated quotes as evidence, to aid our mental processing of the data. We shared these summaries with participants to provide opportunity for comment and ensure their perspectives were accurately reflected. This was the process of 'compiling' where data is transposed into a usable form (Castleberry and Nolen 2018).

We coded the data following each interview. This process, described by Castleberry and Nolen as 'disassembling', is where raw textual data are broken down into usable data by identifying similarities or differences between sections of text (Austin and Sutton 2014; Castleberry and Nolen 2018). In the first coding round we identified raw features within the data, generating codes from the data itself in a 'data-driven' process (Gibbs 2007). Preliminary codes were then subject to 'reassembling', where codes were arranged and put into context with one another (Castleberry and Nolen 2018). This enabled us to recognize nine 'intermediary codes' which, through a second round of 'reassembling' after data collection was complete, led to identification of five final themes (Appendix 1). Positive and negative reactions to management responses could be coded for within the same theme as concepts included factors contributing toward whether participants viewed management responses as more or less acceptable. The same textual passage could be coded for under multiple themes. We checked the validity of final themes by reviewing them against the data.

3. Results and discussion

3.1. Summary of participants

Interviews consisted of three with property-owners (seven participants), two with landowners (four participants), one with a tenant farmer (one participant) and one with a farm manager (one participant) (Table 1 and Supporting Information). There were nine male and four female participants. All participants were aged greater than thirty years old. Notes on practical management interventions undertaken by DWT at the times of interview are provided in Table 1, whilst management interventions since the interviews are reported in Brazier *et al.* (2020).

Table 1. Overview of interview participants, reported beaver conflicts and practical management undertaken by the time of interview.

Interview	Approximate time between beavers' arrival and interview	Number of participants	Participant description	Conflicts with beavers reported by respondents	Practical management interventions undertaken by DWT (at time of interview)
1	2 months	1	Property owner (Male)	• Dam in watercourse between four neighboring properties.[a] • Respondent reported removing dam once, which the beavers subsequently rebuilt.	• Dam removal
2	2 months	2 (A couple)	Landowners (1 Male, 1 Female)	• Dam in stream which runs through respondents' property. • Respondents reported removing the dam a few times, with the beavers having rebuilt it.	• Dam removal
3	4 months	4 (A family)	Property owners (1 Female, 3 Male)	• Felled wisteria of sentimental value • Felled Bramley apple tree in orchard	• Planted new Bramley apple tree • Protection of remaining apple trees with sand paint • About to trial electric fencing to keep beavers off property
4	1 month	2 (A couple)	Property owners (1 Female, 1 Male)	• Felled willow tree of sentimental value	• Protected remaining trees with fencing
5	18 months to two years	1	Farm Manager (Male)	• Wetting of fields used for a spring calving dairy herd by damming, close to the milking parlor	• Flow device installation • Considering options of dam removal or compensation
6	2 years	1	Tenant Farmer (Male)	• Flooded arable land behind a beaver dam. • Waterlogged cattle crossing • Felled poplar trees, with one falling onto fence	• Considering compensation for affected arable crop • Considering installation of a new cattle crossing • Protected remaining trees with fence • Some preemptive tree felling (for safety)
7	1 year	2	Landowners (1 Female, 1 Male)	• Waterlogged fence-line. • Gnawing of trees on neighboring land. • Tenant farmers' ram fell in collapsed beaver burrow	• Lowered water level with discussions ongoing. • Protective paint applied to affected trees. • Discussing ram impact.

Note: [a]No response to the interview invitation was received from the remaining three property-owners.

3.2. Study limitations and research recommendations

Rather than seeking to understand proportional representation of phenomena in society, we sought to understand the nature of a situation and perspectives of those involved. Our case study approach allowed for a deep, qualitative understanding of the situation (Firestone 1993; Crouch and McKenzie 2006; Flyvbjerg 2006; Gibbert, Ruigrok, and Wicki 2008; Tsang 2014). The small sample of interview participants (naturally limited by the low number of reported direct conflicts with the beaver population) helped to foster closer associations between researchers and participants (Crouch and McKenzie 2006) and enabled us to identify the key themes which we believe to be useful in conceptualizing how to engage with individuals in reintroduction-related conflicts in other reintroduction contexts. However, we recognize that a small number of interviews and a lack of randomization in participant recruitment limits the study's empirical generalisability to wider reintroduction contexts; we suggest further study to test our concepts in other species reintroduction scenarios.

3.3. Themes

We developed a set of five themes, from the affected peoples' points of view, which contribute toward improved engagement in reintroduction conflict management: (1) *Proactive Engagement or a Fast Response*; (2) *Appropriate Communication*; (3) *Shared Decision-Making*; (4) *Sense that Humans are Responsible for Conflicts with Reintroduced Species*; (5) *A Need for Certainty*. For each theme we use verbatim quotes to describe the concept and demonstrate their relevance through application of the wider literature. For ease of discussion, DWT representatives are referred to as 'managers'.

3.3.1. *Proactive engagement or a fast response*

Previous research has recognized how earlier responses to conflicts are more likely to prevent escalation, and an understanding of attitudes toward management may help reduce potential for conflicts in reintroductions (Reed 2008; Redpath *et al.* 2013; O'Rourke 2014; Crowley, Hinchliffe, and McDonald 2017a; Auster, Puttock, and Brazier 2020). A similar principle emerged here as a key factor in how participants viewed engagement in management responses. This was both in terms of whether there should be a management intervention prior to conflicts with beaver and the rapidity with which the issue was responded to.

The interview 1 participant felt strongly they did not have the opportunity to voice their concerns prior to beavers impacting their land:

> "I feel angry that there was no consultation. […] The Trial has been reactive rather than proactive." – *Interview 1*

The interview 2 participants, who live near to the interview 1 participant and whose own conflict experience (Table 1) occurred within the same beaver territory, agreed early engagement may have reduced the conflict level for the participant in interview 1:

> "If people like that [participant in interview 1] had been got involved earlier, before the beavers necessarily showed any signs of turning up on their land, it might have avoided some of the problems that we have now. […] If they'd known it ahead and they were prepared it might have been a slower boil to where you had them." – *Interview 2*

A participant in interview 3 described similar feelings that their apple tree issue (Table 1) should have been considered before it occurred:

> "Sometimes you think maybe they should have perhaps looked into it before it [apple tree] got bitten off. […] it's like shutting the door after the horse has bolted." – *Interview 3*

If possible it would be desirable to intervene in potential conflict scenarios prior to conflicts occurring. However, as resources in the environment or conservation sectors are limited (Walls 2018) it may be challenging, even impossible to engage with all riparian land/property-owners before any conflicts occur. This factor was recognized by a participant in interview 2:

> "I can understand the argument why it's difficult because of the resource constraints to be proactive with everybody, but I do believe it should be possible to identify the key people who have got houses along the river or stands of trees very close to the river and to have done something." – *Interview 2*

The participant has highlighted that strategic engagement may be a feasible approach when resources are limited. Regarding beavers, it has been shown that areas of suitable habitat and reaches capable of supporting dams can be modeled at large spatial scales (Macfarlane *et al.* 2017; Brazier *et al.* 2020). With this understanding, combined with a spatial description of land-use and at-risk infrastructure, developing further modeling or management strategies that identify those areas more likely to experience conflict is achievable (Brazier *et al.* 2020; Graham *et al.* 2020).

In addition, a participant in interview 2 suggested education as a possible avenue to reduce conflict escalation potential.

> "I do think the communication piece is something the project needs to think carefully about and be proactive about educating people." – *Interview 2*

Such a suggestion will require further research, but it may be possible for communication/education to contribute, as this principle has been observed elsewhere. For example, there was a decreased likelihood that a black bear (*Ursus americanus*) was seen as a "conflict bear" amongst people who had participated in an education program in Massachusetts than amongst those who had not (Marley *et al.* 2017). This potential was referenced by a participant from interview 3.

> "It would probably be a bit better, if she [mother] could see these things [beavers] doing things she might end up liking them a bit more." – *Interview 3*

DWT actively undertook a programme of educational outreach within the ROBT, with 384 hosted events (e.g. guided walks and presentations) which engaged with an estimated 18,000 people (Brazier *et al.* 2020, 86). In the instances where it was not possible to address issues preemptively, however, the speed of response from DWT was found to have influenced participant views of management responses, with quicker responses viewed positively. This is demonstrated by comments from participants in interviews 3 and 4:

> "I've only got to send an email and he's here within, well it depends where he lives, but he's here within half an hour or so." – *Interview 3*

> - "I thought [DWT representative] was brilliant." - "It was a very fast response." - "Well he just came and said he would do it [protect remaining trees (Table 1)]." – *Interview 4*

Responding quickly is likely to reduce conflict potential, but one participant from interview 5 stated this should extend beyond initial engagement and conversation should be ongoing to avoid anybody experiencing a 'nasty surprise':

> "The sooner that the conversations could be had between the different parties, the better. And regular communication is critical so that no party suddenly gets a nasty surprise about something that's going on." – *Interview 5*

3.3.2. Appropriate communication

The way in which communication occurred was the second theme. Our analysis found a sympathetic approach was likely to be received positively. This is demonstrated by an exchange between the two interview 4 participants when explaining why they viewed DWT's engagement positively:

> - "I thought [DWT representative] was brilliant." […] - "Yes, he was sympathetic to the issue." – *Interview 4*

DWT was viewed to have shown willingness to listen to and take the respondents' concerns seriously, a key component of building trust. In a nationwide survey on beaver reintroduction the majority of respondents felt unable to express their opinion where it may influence decision-makers (Auster, Puttock, and Brazier 2020), but a feeling amongst stakeholders that concerns are being responded to by wildlife managers contribute toward addressing conflicts (Decker *et al.* 2016; Young *et al.* 2016). A willingness to listen is reflected in comments from three interview participants regarding how they had found the engagement with DWT to be appropriate:

> "We found them really friendly, helpful, interesting. They gave us time to talk through, answer our questions." – *Interview 2*

> "It's been good, fine. I've found that we've been able to work together with them [DWT] in a way that our views aren't overtaken by anything else." – *Interview 5*

> "It's surprised me actually, he [DWT representative] certainly seems to be taking it all very seriously." – *Interview 7*

A willingness to listen will help keep managers informed, and an understanding of stakeholder viewpoints will enable decision-making processes that allow stakeholders to trust their views are being considered (Decker *et al.* 2014; Young *et al.* 2016). There may be some challenges encountered when stakeholders hold particularly strong opinions that influence their willingness to listen to 'managers' in return. In interview 1, it was stated that they were unwilling to listen to information about beavers, resulting from their strong views and concern about damming in their local watercourse (Table 1).

> "I don't want to sit and listen to someone telling me about how great beavers are when I'm concerned about my land." – *Interview 1*

When it is possible to share information with stakeholders, it is important to manage expectations. Honest, transparent information is likely to maintain trust in management authorities (Marshall, White, and Fischer 2007; Smith 2011; Decker *et al.* 2016; Young *et al.* 2016), thus alleviating potential for worry if the actual situation then deviates from the information given. Such a situation was demonstrated in interview 6 regarding the growth in height of the main beaver dam and its relationship to the area of flooded land behind it (Table 1):

> "We were told that it [beaver dam] wouldn't be that big an area and it has developed. And the thing that worries me slightly is they are still going, they haven't seemed to steady up." – *Interview 6*

As the participant in interview 5 commented, "communication is always critical".

3.3.3. Shared decision-making

Stakeholder engagement is recognized as a key component in human-wildlife conflict decision-making, with the most effective strategies for tackling conflicts recognized as being those where conversations are held with and between stakeholders. Where problems are 'shared as one' they are more likely to lead to a consensus decision that is more likely to be accepted amongst the relevant parties (Treves, Wallace, and White 2009; Redpath *et al.* 2013; Rust 2017). Where stakeholders feel their interests have been considered in decision-making processes they are less likely to obstruct the implementation of decisions or reverse them as soon as possible, leading to reduced conflict potential (Madden and McQuinn 2014; Decker *et al.* 2015). DWT representatives aimed to share decision-making to address the objectives of both managers and participants, as often the participants did themselves, as evidenced in interviews 5, 6 and 7 (all interviewees of which had an association with farming (Table 1)):

> "We were really trying to find a way forward that meant the farm could continue to operate as a commercial business but in a way that was allowing the beaver to create a habitat." – *Interview 5*

> "We do have to be mindful that food production has to be protected and kept going, but obviously it is important that we have a balanced view of that with not only protecting our natural habitat but also enhancing it as well. So I think having the two together is really good." – *Interview 6*

> "Ideally you'd want a situation where it's compatible to have what we want but with the beavers creating the biodiversity and so on." – *Interview 7*

Conversely, strong tensions were observed with the discontented participant in interview 1 who did not feel they had been provided with an opportunity to have input:

> "It is a very unusual situation, to have this forced upon you." – *Interview 1*

Where people feel inadequately empowered, the risk of conflict escalation increases (Madden 2004), which is perhaps partly why the participant in interview 1 had such strong feelings. Where a sense of empowerment is achieved meanwhile, as may be realized by including both managers and stakeholders in decision-making, this would be more likely to lead to longer-term conflict solutions (Linnell *et al.* 2010; Redpath, Bhatia, and Young 2015; Dubois *et al.* 2017).

3.3.4. Sense that humans are responsible for conflicts with reintroduced species

We identified a sense amongst respondents that beavers were associated with "the people that put them there" [or allowed them to escape], rather than as a wild animal. We suggest this may be a factor unique to wildlife reintroduction and translocation (and unlike other human-wildlife interactions) as a direct link has been drawn between the 'new' presence of an animal and humans actively putting them there. This attitude is most clearly demonstrated by a participant in interview 4 who had erected posters in their village containing an image of their felled tree (Table 1):

> "I thought it [beaver reintroduction] was inappropriate. It's not a natural species. […] I was angry, angry. Well you've seen the poster, we don't blame the beavers because they're beavers, they're not human beings. It's the people who did it." – *Interview 4*

We found this theme influenced management expectations amongst individuals, with the view that those responsible for beaver presence should take responsibility for managing negative consequences, as shown by participants in interviews 1, 3 and 4:

> "The landowner shouldn't have to take responsibility. […] There shouldn't be an assumption that we will give up our time for free. It's been us who are walking up and down the riverbank and monitoring their activity." – *Interview 1*

> "So will the beaver people be responsible if I get flooded because of a dam?" -"If you could prove that caused it that's a no-brainer, they've got to pay up." – *Interview 3*

> "It's a question of responsibility. The people who put the beavers in the river in the first place were irresponsible, but who's going to take responsibility for dealing with problems that arise? And, by and large, experience suggests nobody is going to do that." – *Interview 4*

We believe this is the first instance of this link having been identified in wildlife reintroduction. However, a participant in interview 7 stated beavers were a 'wild animal', indicating the association is not necessarily unanimous amongst affected individuals.

"Beavers, I mean they're wild animals aren't they? So are they to blame?" – *Interview 7*

This indicates a need for managers to provide a sense for affected individuals that they, as managers, are taking some form of responsibility. However, further research will be required into how and when a reintroduced species may become 'normalized' as a wild animal. As the return of a wild animal is an objective of those undertaking reintroductions we suggest, beyond taking some responsibility to contribute toward conflict alleviation in the early reintroduction stages, perhaps managers should consider how they may facilitate normalization of a reintroduced species as 'wild' to address this link and allow management of the reintroduced species to be sustainable in the long term. This will interconnect with decisions upon future management strategy (particularly upon who may undertake management in practice under different scenarios of legal protection of the reintroduced species [Auster, Puttock, and Brazier 2020]) and allow an understanding of how long it might take for reintroduced species to be considered 'normally resident', above and beyond any legislation that might label them as such.

3.3.5. A need for certainty

Living alongside a reintroduced species will, for most people, be a new concept. Until recently, beavers have been absent from Britain for ca. 500 years so people in England today will not have experience of living alongside them (with the exception of migrants from where beavers reside elsewhere). This notion of beaver presence being 'new' could be argued to be a real example of the 'shifting baseline syndrome' in restoration ecology. This term refers to a change in societal perception of natural conditions over time, leading to acceptance of a 'normal' state of nature as one that has moved away from its original natural state (Pauly 1995; Vera 2010) – in this case acceptance amongst local people of a landscape in which beavers are absent. As a result, individuals may have been unlikely to have given thought to preventative measures or actions, as demonstrated by a participant from interview 4 regarding their felled tree (Table 1).

"We didn't need a cage for the old one [willow tree], so why would we need a cage for this one?" – *Interview 4*

We therefore identified a sense of uncertainty about what will happen with a reintroduced species and associated management going forwards, creating worry and opposition from a 'fear of the unknown'. We felt this to be the concept which most strongly resonated throughout the interviews. Participants from interviews 3, 4, 6 and 7 indicated how there are questions about the post-Trial situation and how this can lead to increased worry.

"What happens after 2020 then?" – *Interview 3*

"I wonder where it will end, is it [beaver population] going to explode? […] And to what extent do they [beavers] take over an area?" – *Interview 4*

"I'd hate for, you know, in the situation like that we've got with the badgers where they've protected the setts and the badgers, I would be pretty worried if they protected the dams and the beavers in a way that we couldn't manipulate their habitat somewhat.

> […] I'm sort of quite happy to see the beavers, but at the same time I'm really worried that if there became legislation that we couldn't have any, manipulate dam heights or anything like that, or in extreme cases move them from one site to relocate them, that would be a worry for me." – *Interview 6*

> "What happens if the trial finishes and they stop monitoring it, then whose responsibility is it then? […] It's very clear to me that, the trial ends […], and after then nobody knows what's going to happen." – *Interview 7*

This 'fear of the unknown' has been previously observed. Lynx in Macedonia is rarely seen and interactions with humans are scarce. For people, this lack of experience with lynx and lack of knowledge (and so their uncertainty) led to more negative perceptions of lynx (Lescureux *et al.* 2011). There is a similar principle here where individuals have had no previous experience of interaction with beavers, a species with which interactions with humans are commonplace in Europe (Campbell-Palmer *et al.* 2016). It would be desirable to avoid an increase in worry, particularly as where uncertainty exists emotions (rather than science) hold greater influence in human-wildlife conflict decision-making (Hudenko 2012).

We can conclude certainty is required in order to address these concerns. This particularly relates to certainty about what management will look like going forwards, as demonstrated by participants from interviews 1 and 6.

> "This doesn't seem to be forward thinking. There doesn't seem to be a management strategy." – *Interview 1*

> "I just want to know a little bit about what will happen with that [management] going forward. And, you know, whether we have to change some of our stewardship type schemes to accommodate what we are trying to achieve in the bigger picture here." – *Interview 6*

This need for certainty has been recently recognized in a study of beaver reintroduction processes in Scotland where their interviewees "called for more certainty and were anxious that guarantees could not be provided". The authors similarly suggest that implementing a management framework could help provide a sense of certainty (Coz and Young 2020). Together, these studies reinforce a previously recognized need to consider attitudes toward management early, with management decisions made as soon as possible and clearly communicated to provide as much certainty as is feasible (Marshall, White, and Fischer 2007; Redpath *et al.* 2013; Decker *et al.* 2016; Auster, Puttock, and Brazier 2020; ROBT 2019).

3.4. Relationships between themes

We look first at three concepts: *'Proactive Engagement or a Fast Response'; 'Appropriate Communication'; 'Shared Decision-Making'*. These have practical application in the approach to engaging with stakeholders, and to achieve a more positively viewed response we suggest these should appear in sequence.

'Proactive Engagement or a Fast Response' is about when to engage, so is naturally the first step. As referred to above, this can be through a strategic approach toward proactive engagement prior to conflict occurrence (including appropriate

information sharing and educational outreach), or where this is not possible this should be through engaging at the earliest opportunity when conflicts occur. In the ROBT, proactive engagement with educational outreach was practised where possible, but this could not reach all landowners in the 250 km^2 catchment. In these instances DWT aimed to provide a rapid response to conflict issues (Brazier *et al.* 2020).

'Appropriate Communication' should be applied from the first point of contact, so this concept needs to be addressed from the same moment as *'Proactive Engagement or a Fast Response'* (and throughout the remainder of the management response); first impressions count. As evidenced, a sympathetic approach showing a willingness to listen is more likely to foster trust and lead to stakeholders feeling able to engage (Decker *et al.* 2015; Young *et al.* 2016). It is once trust has been built and dialogue opened that *'Shared Decision-Making'* can take place, allowing for issues to be 'shared as one' (Redpath *et al.* 2013; Decker *et al.* 2015; Young *et al.* 2016).

The two remaining concepts are not so much practically applicable, but themes which underpin and influence the engagement that takes place. In the case of *'Sense that Humans are Responsible for Conflicts with Reintroduced Species'*, individuals who believe the humans who put an animal into the environment (i.e. undertake reintroduction) should take responsibility. Hence, the individuals concerned would expect greater responsibility to be taken by managers throughout the application of the practical concepts, (even though here DWT was not responsible for reintroducing beavers, but took upon themselves the responsibility of running the ROBT). This is reflected in anecdotal evidence from a fact-finding trip to Bavaria where we met a representative of a regional farming union. Beavers were reintroduced to Bavaria in the 1960s and are now widespread in the province. The state employs two beaver managers who oversee approximately 500 volunteer beaver consultants across the region (Schwab and Schmidbauer 2003; Campbell-Palmer, Schwab, and Girling 2015, Campbell-Palmer *et al.* 2016; ROBT 2019). When asked whether the farming union representative would recommend reintroducing beavers he said "no", but then stated "we are able to tolerate them [beavers] because there is someone willing to help us".

Thus, as discussed, reintroduction practitioners must consider how to facilitate the normalization of the animals as 'wild' rather than as a reintroduced species. This will have implications for the social sustainability of a reintroduction through decisions for longer-term management strategies. Where possible, this could include considerations on how to engender a sense of stewardship or investment in the reintroduced species, as this is likely to go beyond just fostering tolerance and support public participation processes, encouraging *Shared Decision-Making* in long-term planning and a further reduction in conflict potential (Lute and Gore 2014; Coz and Young 2020).

The view that humans should be responsible for the reintroduced species was not held unanimously; thus affected individuals had different expectations of the managers' response. We suggest to minimize conflict potential that the precautionary principle should be applied by reintroduction practitioners in showing willingness to take some form of responsibility for conflict management, until such time as the reintroduced animal is normalized as 'wild'.

We believe to have identified this as a key theme in engagement for the first time. As a new concept, we suggest this should be a focus for further research. In particular it would be useful for reintroduction practitioners to gain a deeper understanding of how reintroduced species can be (socially) normalized as 'wild' and how long that may take. This knowledge would assist decision-making processes for short and long

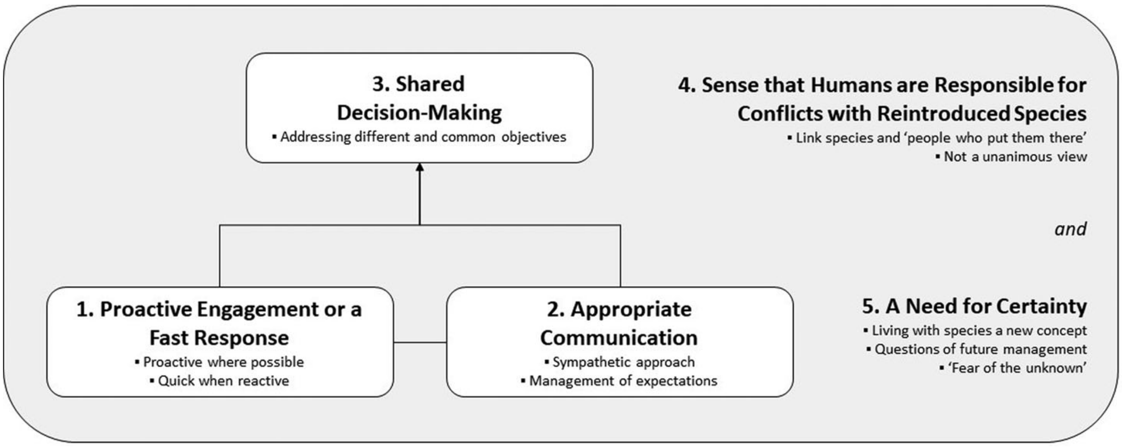

Figure 1. Outline of the relationships between the five themes, highlighting three practical concepts in sequence underpinned by two underlying themes.

term management strategies. We suggest it may be that the normalization of a reintroduced species as 'wild' could nest in part within *'Appropriate Communication'* as we identified the need to appropriately manage expectations, particularly in cases such as beavers where few peoples' views in Britain are currently informed by a full understanding of living alongside them (as discussed under *'A Need for Certainty*').

The second underlying concept is *'A Need for Certainty'*. Where there is greater uncertainty, emotions play a greater role in decision-making (Hudenko 2012) and we demonstrated the likelihood of increased worry amongst more uncertain individuals. Therefore the practical concepts – particularly *'Shared Decision*-Making' – are likely to be influenced by the affected individuals' emotions. More uncertain individuals are likely to allow emotion to play a greater role in their attitudes toward beaver management, influencing the degree to which it is feasible to undertake responses viewed as appropriate. Communications should provide a sense of certainty, which could be helped with early decisions regarding management strategies for reintroduced species, enabling information to be clearly communicated sooner – an approach advocated by Auster, Puttock, and Brazier (2020) and Coz and Young (2020).

The relationships between all five themes, with the three practically applicable and two underlying concepts, is illustrated in Figure 1.

4. Conclusion

We identified five themes of engagement in management responses to human-beaver conflict and made observations regarding these themes that, if followed, may positively influence responses to beaver reintroduction amongst affected individuals. This is vital for where affected people view engagement by wildlife managers positively there is likely to be greater trust in management authorities and less risk of conflict escalation (Burgess and Burgess 1996; Redpath *et al.* 2013; Decker *et al.* 2015, 2016). We believe the themes, identified as a direct result of engagement with people who reported conflicts with beavers (Figure 1), are informative for engaging with local people in a variety of reintroduction conflict contexts. We recommend continued case study research to test the prevalence of our key themes in further reintroductions of both beaver and other species.

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Supplemental data

Supplemental data for this article can be accessed here.

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Data availability statement

The evidenced summaries as shared with the participants are attached as Supporting Information, as well as an example of the ethical consent form for participation.

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Appendix 1. Summary of the coding process identifying the preliminary and intermediary codes and their relation to the five final themes

Theme	Intermediary codes	Preliminary codes	Secondary preliminary codes
Proactive Engagement or a Fast Response	Reactive engagement	Need to consider who may be affected Lack of consultation (Negative) Involve people likely to be affected earlier Fast response (Positive)	
	Strategic engagement	Should have considered issue before it happened Proactive/earlier communication better Resource limitation in engagement Education	
Appropriate Communication	Sympathetic approach (Positive)	Concern taken seriously (Positive)	Don't preach at but consider individuals' issue (Negative) Opportunity to speak (Positive)
		Need to listen to everybody	
	Expectation Management	Need to understand what is/isn't beavers More impactful than was told it would be (Negative)	
Shared Decision-Making	Understanding different objectives	Maintain farm operations Allow for beaver presence/benefits Feeling of having beavers forced upon them (negative) Lack of understanding of individuals' priorities (Negative)	
Sense that Humans are Responsible for Conflicts with Reintroduced Species	Managers responsible for beaver impacts	Fault of those who put beavers there Shouldn't be landowners' responsibility Beaver people responsible if property flooded Reintroduction viewed as irresponsible as feel no-one will take responsibility	
	Beavers are wild animals	Beavers not to blame	
A Need for Certainty	Beavers are a new concept	Didn't need to consider tree protection before	

(*Continued*)

Appendix (*Continued*).

Theme	Intermediary codes	Preliminary codes	Secondary preliminary codes
	Querying future management	Questioning post-Trial management	Questioning who will be responsible for management Questioning degree of beaver population growth Questioning stewardship schemes
		Need to be able to manage negative impacts	
		Worry about possible legislation	
		Lack of management strategy (negative)	

Chapter 4. Alternative perspectives of the angling community on Eurasian beaver (*Castor fiber*) reintroduction in the River Otter Beaver Trial

The following paper forms the fourth chapter of this thesis. It is presented in published format, with all references included at the end of the chapter in publication format.

This paper is the second of the two studies which investigate potential areas of conflict associated with beaver reintroduction. This paper details a Q-Methodology study of perspectives held among the angling community conducted in the River Otter Beaver Trial, and discusses the potential management implications.

(In this chapter, a reference is made to an economic profile of angling in the River Otter catchment that was produced as an appendix to the River Otter Beaver Trial Science & Evidence Report. This profile is also attached to this thesis as Appendix 3).

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Roger Edward Auster , Stewart Barr & Richard Brazier

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Alternative perspectives of the angling community on Eurasian beaver (*Castor fiber*) reintroduction in the River Otter Beaver Trial

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Eurasian beaver (*Castor fiber*) reintroduction is taking place in England with potential benefits for flood alleviation and biodiversity; however there is also opposition. One area of controversy relates to fish and fishing. A previous meta-analysis of research into beaver-fish relationships found perceived benefits of beavers amongst fish and beaver "experts" included increased fish abundance and productivity, whilst perceived negatives included impeded fish passage and reduced spawning habitat availability. We further this understanding using Q-Methodology (a social science technique) to reveal three nuanced and contrasting perspectives that exist amongst the angling community in the catchment of a trial reintroduction. Due to a conflict potential between groups, we suggest management themes to help reduce this where reintroduction occurs: open, cross-sectoral dialogue about research into beaver-fish relationships and management; a management strategy which supports ecosystem benefits whilst providing a sense of empowerment for individuals to respond to negative impacts.

Keywords: angling; Eurasian beaver; perceptions; Q-Methodology; reintroduction

1. Introduction

Ecological restoration projects are often driven by environmental scientific goals, but social attitudes are becoming increasingly recognized as important in whether projects are successful (Eden and Tunstall 2006; Martin 2017; Jellinek *et al*. 2019). As such, restoration projects (particularly river restoration projects) should be considered as both environmental and social (Eden and Tunstall 2006) so as to ensure that a consideration of how people understand the environment can be built into environmental policy (Eden 1996; Eden, Donaldson, and Walker 2006).

The reintroduction of formerly resident species of wildlife is a growing practice, sometimes undertaken to facilitate ecological restoration (Ewen and Armstrong 2007; Corlett 2016). It is recognized that social science should be integrated into reintroduction projects (Seddon, Armstrong, and Maloney 2007; Crowley, Hinchliffe, and McDonald 2017b) particularly as potential human-wildlife conflicts or conflicts between people over wildlife could occur or escalate if not properly considered (Auster, Puttock, and Brazier 2020). An understanding of the social implications of wildlife reintroduction is required according to guidelines set by the International

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Union for the Conservation of Nature (IUCN & SSC 2013) and it has been suggested that these considerations should also include social attitudes toward potential management of the reintroduced species (Auster, Puttock, and Brazier 2020), particularly as many conflicts between people over wildlife manifest where there are disagreements over management (Marshall, White, and Fischer 2007; Redpath, Bhatia, and Young 2015).

To gain an understanding of attitudes in reintroduction projects, it is vital to engage with publics and key stakeholders (Auster, Puttock, and Brazier 2020). Appropriate and transparent engagement will be more likely to give insights into how people interact and relate to the environment and democratize the decision-making process (Eden, Donaldson, and Walker 2006; Decker *et al*. 2016; Treves and Santiago-Ávila 2020). This would be more likely to lead to outcomes that are more socially acceptable, enabling stakeholders to feel that their views are valid, taken seriously and considered (Decker *et al*. 2014; Young *et al*. 2016). If a reintroduction then proceeds, this would be likely to foster greater trust in management authorities and reduce potential for later conflict escalation (Decker *et al*. 2016; Young *et al*. 2016).

The Eurasian beaver (*Castor fiber*) is being reintroduced to parts of Britain. It is a species of rodent which physically alters the landscape through dam-building and tree-felling activity (Stringer and Gaywood 2016). The species was historically resident in Great Britain until approximately 500 years ago when they were hunted to extinction by humans (Halley and Rosell 2003). Their reintroduction is now being considered at a devolved level: in Scotland, Eurasian beavers were listed as a European Protected Species in May 2019 (Scottish Government 2019); in England national consultations are due later in 2020 on the future of Eurasian beavers in the country, meanwhile the UK Government included a reference in their 25-year environmental plan to "providing opportunities for reintroduction of species such as beavers" (HM Government 2018, 57) and a small population is to be legally allowed to remain in Devon following a reintroduction trial (which is later discussed) (UK Government 2020); in Wales there is currently no official reintroduction project, although there are proposals being made by the "Welsh Beaver Project" following an earlier feasibility study (Jones *et al*. 2012).

Many of the motivations for reintroducing Eurasian beavers are due to a number of beneficial impacts, such as the slowing of peak water flows leading to a reduction in flooding downstream (Puttock *et al*. 2017; Brown *et al*. 2018) and the creation of complex and dynamic wetland habitats from their landscape alterations, leading to an increase in both terrestrial and aquatic biodiversity (Stringer and Gaywood 2016; Law, McLean, and Willby 2016; Law *et al*. 2017; Willby *et al*. 2018; Law *et al*. 2019; Nummi *et al*. 2019). However, there is also some opposition to their reintroduction with such narratives of controversy including debate about beaver-induced flooding of agricultural land; impacts upon trees of significance; responsibilities for and costs of beaver management; and the impacts of beaver activity upon fish and fishing activity (Kemp *et al*. 2012; Morzillo and Needham 2015; Campbell-Palmer *et al*. 2016; Crowley, Hinchliffe, and McDonald 2017b; Gaywood 2018; Auster, Puttock, and Brazier 2020). In this paper, we investigate the last of these – beaver reintroduction's effects on fish and fishing activity – from the perspectives of anglers.

Prior to this study, we undertook a nationwide questionnaire in 2017 which identified groups of respondents who were less likely to have a more positive view of the impacts of Eurasian beavers than the remainder of the respondent pool ($n = 2759$) and are consequently groups of people with whom there is an increased risk of conflicts between humans and beavers, or between humans about beavers. One of these groups was respondents who identified their occupation as being related to “Fisheries & Aquaculture”. Amongst this occupational group ($n = 34$), 44.12% indicated that they would not support beaver reintroduction to Great Britain, whilst 44.12% indicated that they would and 11.76% were undecided. Respondents who had heard about the survey through a fishing organization, thus implying a potential interest in fishing ($n = 90$), exhibited a division of opinion with a greater proportion opposed to reintroduction than amongst those whose occupation was related to “Fisheries & Aquaculture”; 65.55% of this group were opposed, whilst 22.22% were in favor and 12.22% were undecided (Auster, Puttock, and Brazier 2020). These findings indicate diverse perspectives amongst both those whose occupation was in the sector and those who have a potential interest in fishing.

We now seek to use a technique from the social sciences - known as “Q-Methodology” - to further our understanding in this new study, and describe the contrasting subjective viewpoints that exist amongst an angling community that has co-existed alongside beavers in an official reintroduction trial in England. We will first use relevant literature to provide the research context, before introducing and describing the Q-Method process. We will then outline the contrasting and nuanced perspectives that we identified amongst the respondent pool, before finally discussing what the implications of these may be for the management of potential future conflicts.

1.1. Context

The science of the ecological relationship between Eurasian beavers and fish is still under debate. A meta-analysis of research pertaining to the relationship between fish and both the Eurasian beaver and the similar North American beaver (*Castor canadensis*) was published in 2012. In the analysis of literature (88% of which had been conducted in North America) it was found that, whilst there is no consensus within the literature, the benefits of beaver reintroduction were cited more frequently than the costs, with “habitat heterogeneity, rearing and overwintering habitat and flow refuge, and invertebrate production” being the most frequently cited (and fisheries relevant) benefits (Kemp *et al*. 2012, 158). For example, beaver ponds in Poland were found to provide habitat for large brown trout (*Salmo trutta*) (Kukula and Bylak, 2010) and there are numerous river restoration projects in North America with the explicit intention of enhancing river health via beaver reintroductions so as to support better populations of Steelhead Salmon (Bouwes *et al*. 2016). However, there were also cited negative impacts, the most common of which were “impeded fish movement because of dams, siltation of spawning habitat and low oxygen levels in ponds” (Kemp *et al*. 2012, 158).

As the importance of integrating social science research into ecological sciences is becoming increasingly recognized (Redman, Grove, and Kuby 2004; Redpath, Bhatia, and Young 2015; Bennett *et al*. 2017), the meta-analysis study then went further by asking 49 North American and European experts to complete a questionnaire. From this, it was identified that the majority of these experts viewed beavers to have an overall positive impact on fish, particularly through influences upon abundance and productivity. However, perceived negative impacts were also recognized, particularly related to the movement of aquatic organisms in tributary streams and availability of spawning habitat (Kemp *et al*. 2012). These are similar to the reasons given by those who did not support the process of beaver reintroduction amongst respondents who identified their occupation as in "Fisheries & Aquaculture" in our nationwide survey; the majority of comments from this group related to concerns that beaver dams (or "semi-permeable barriers" (Bylak, Kukuła, and Mitka 2014)) may obstruct fish migration, particularly that of salmonids (Auster, Puttock, and Brazier 2020).

Since the time of publication of the meta-analysis, further research has been taking place upon the relationship between Eurasian beavers and fish in Great Britain. (From this point forwards, we now only discuss the Eurasian beaver which will henceforth be referred to as "beavers"). Prior to the Scottish Government's decision to protect beavers legally, a licensed reintroduction trial had taken place in Mid-Argyll (Gaywood 2018). As part of this project, a Beaver-Salmonid Working Group was established which consisted of multiple organizations. In their final report, the group concluded that beavers can have a positive effect on the production of some salmonid species, however ambiguity remained over their influence on Atlantic salmon due to their vulnerability to obstructed passage and reliance on "swift waters, which would be reduced by extensive beaver damming" (Beaver Salmonid Working Group 2015, 74). Therefore, although there is seemingly a net positive impact reported in some of the literature, there are still uncertainties and a lack of consensus about the potential relationship between beavers and fish.

Fishing is also a significant activity in England and Wales. In an economic evaluation report published by the Environment Agency in 2009 it was stated that there were over one-million licensed anglers in 2005 and that expenditure on freshwater angling supported £1billion of household income (the equivalent of 37,000 full-time jobs, with over 20,000 directly dependent on angling) (Mawle and Peirson 2009). The licensed "River Otter Beaver Trial", taking place in England, monitors and conducts research upon a free-living population of beavers in the catchment of the River Otter in Devon. Within the scope of the project, research must include impacts upon fish populations and fishing (amongst other areas including hydrology, agriculture and wider biodiversity) (Devon Wildlife Trust 2017). The full body of work has now been reported upon to UK Government (Brazier *et al.* 2020) alongside a proposed management framework (River Otter Beaver Trial 2019). UK Government announced on 6th August 2020 that the River Otter beavers may stay and spread naturally, with consultations led by Natural England on national management and further releases in England due later in 2020 (UK Government 2020).

If and where beavers are reintroduced, then subsequent decisions on management will need to consider perceptions held about beaver reintroduction. This is important (alongside an understanding of the ecological relationship between beavers and fish) if they are to reduce the potential for conflicts between people and beavers or between people about beavers (Auster, Puttock, and Brazier 2020). As such, we here provide a more detailed understanding of perspectives that exist amongst anglers who have lived alongside beaver presence in England. We focused upon anglers within the River Otter catchment as they are the first to have experienced fishing on an English river in which an official population of beavers is present and thus may also provide insights from where human-beaver interactions may have occurred, or indeed may occur as/if beaver populations become more widespread in years to come.

2. Methods

It was known that the pool from which participants were recruited would be limited as very few people in England have experienced living/fishing alongside this native animal (see Section 2.2), so a method was required which would be valid with a small number of participants. Q-Methodology is a technique used to explore the subjectivities of the research participants within a specific context (Eden, Donaldson, and Walker 2005). The method asks participants to arrange a number of statements into a matrix (see Section 2.3) and uses a factor analysis to provide a holistic understanding of viewpoints that exist amongst the respondent group (Eden, Donaldson, and Walker 2005; Watts and Stenner 2012, 4). It does not require large numbers of participants (and can even be undertaken with a sample of one) since, rather than explore the prevalence of viewpoints in a population, it seeks to establish the existence of viewpoints and understand them (Watts and Stenner 2012, 72), as is exactly the aim of this particular study.

2.1. Designing the Q-Set

This research method involves the sorting of a number of statements (see Section 2.3). This set of statements, otherwise known as the Q-Set, was designed to include the relationship between beavers and fish or fishing as well as other variables in order to explore how the views in these areas relate.

The statements were designed based upon findings from a previous nationwide questionnaire study, as outline above (Auster, Puttock, and Brazier 2020), a review of beaver reintroduction literature and the personal experiences of the researcher working within the field. As this study deals with opinion, the statements may or may not necessarily be factually correct, and they were designed to evoke a response of agreement or disagreement. 46 statements were written in order to ensure adequate coverage of the subject area whilst not having too many statements for the participants to sort. The final set of statements is represented in Table 1.

The statements were piloted by colleagues working within the subject field prior to the study to ensure there were no obvious omissions. Each study participant was also asked if there was anything missing at the end of their participation. All respondents stated that they felt that the key areas had been represented, although one respondent further added that they would have included a statement about the tradition of fishing.

2.2. Participants

The target pool of participants were people who identified as members of the fishing community within the catchment of the River Otter. This was determined as this is the boundary area of the "River Otter Beaver Trial" and, therefore, these are anglers who have experienced fishing upon a river alongside beaver presence. The majority of fishing activity in this catchment is for brown trout or sea trout (*Salmo trutta*), with the occasional salmon (*Salmo salar*) catch recorded. (Further details on fishing activity in this catchment are given in an appendix to the ROBT *Science and Evidence Report* – [Auster 2019]).

Purposive sampling (where recruitment criteria is based on individuals who will provide useful insights [Etikan, Musa, and Alkassim 2016]) was used to recruit as many members of this community as possible. The majority of the catchment's fishing rights are owned or leased by syndicates or a business. Those identified - three major syndicates and one business as described in Auster 2019 - were contacted to invite participation and to request the invitation was extended toward their members or other individuals of which they knew who had an interest in fishing on the River Otter. The total number of invites then shared further is unknown, but the number of possible

Table 1. List of statements and the factor arrays.

		Factor Arrays		
	Statements	Factor 1 – "Beaver-Accepting"	Factor 2 – "Beaver-Apprehensive"	Factor 3 – "Managed-Beaver"
1	There is a sufficient toolbox of beaver management techniques	2	−3	−2
2	Beavers would have a negative impact on agriculture	0	1	−1
3	Beavers are a native species in England	3	−1	3
4	Beaver activity would damage human infrastructure	−2	−1	−1
5	England would become overpopulated with beavers	−1	0	−2
6	Beaver activity would increase flood risk	−4	−2	−1
7	Beaver welfare would be at risk from riverbank users	1	0	−1
8	Bureaucratic processes would make it difficult to receive support for managing beavers	0	2	2
9	Beavers would increase river biodiversity	4	0	3
10	Beaver presence would mean I need to change where I fish	−3	1	−1
11	Beaver activity would contribute toward carbon storage	1	1	−1
12	Beaver dams would obstruct fish migration	−3	3	−2
13	Anglers contribute toward the conservation of nature	0	4	4
14	Beaver presence would increase opportunities for leisure activities	−1	−1	0
15	Beaver presence would lead to reduced fish size	−3	1	−3
16	Human physical health would increase from visiting beaver sites	−2	−1	1
17	Seeing beavers is a positive experience	3	0	2
18	Fishing does not improve physical health	−2	−4	−4
19	Beavers would negatively damage trees	0	1	0
20	Beaver activity would decrease the amount of sediment in rivers	−1	−1	3
21	Beaver activity would reduce riverbank erosion	2	−2	0
22	Beaver activity would improve water quality	2	0	2
23	Beavers are intimidating	−4	−1	−3
24	Legal protection of beavers would make it difficult to manage negative beaver impacts	−2	2	1
25	Legal protection of beaver habitats would protect river ecology	1	−2	0
26	Beavers lead to conflict between anglers and beaver-watchers	−3	2	0
27	Humans have affection for beavers	3	1	0

(*Continued*)

Table 1. (*Continued*).

	Statements	Factor Arrays		
		Factor 1 – "Beaver-Accepting"	Factor 2 – "Beaver-Apprehensive"	Factor 3 – "Managed-Beaver"
28	Fishing improves mental health	2	4	4
29	Beavers would create opportunities to engage people with nature	1	0	1
30	Human mental health would decrease due to the impacts of beavers	−4	−2	−4
31	Beavers would create fish spawning habitats	1	−4	3
32	Beavers should be in Great Britain	4	0	2
33	My quality of life relies upon fishing	1	4	4
34	Beavers would create new habitats for other wildlife	4	1	2
35	Beaver activity would reduce numbers of commercially important fish	−3	2	−3
36	It is clear who would be responsible for funding beaver management	−1	−4	−2
37	Beaver activity would lead to a greater diversity in fish	0	−3	1
38	Beaver activity would obstruct physical access to current fishing spots	−1	2	−2
39	Beaver presence would lead to a boost for local businesses	0	0	0
40	Beaver reintroduction would lead to other species reintroductions	2	−1	1
41	The science of the relationship between beavers and fish is unclear	0	3	−1
42	It is unclear who would be responsible for managing beaver impacts	0	2	1
43	Beaver activity would increase local esthetics	3	−2	0
44	Fishing does not contribute toward local business	1	−3	−4
45	Beavers would carry risky diseases	−4	−2	−3
46	Beavers would create new places to fish	−1	−3	1

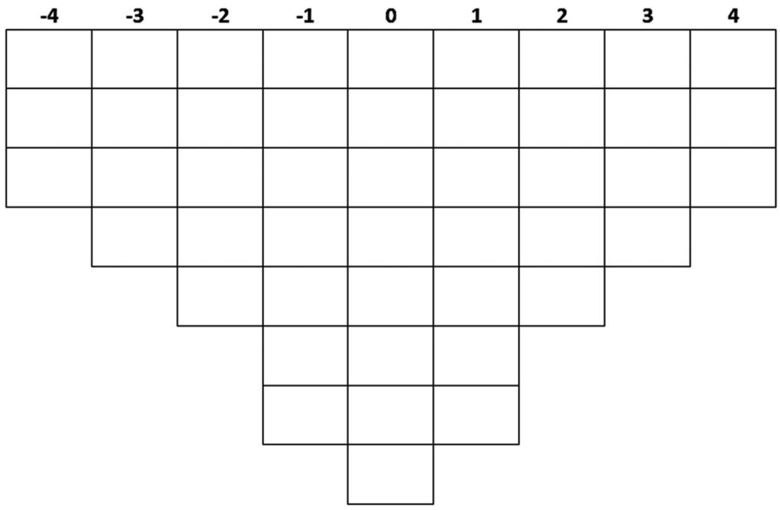

Figure 1. Example of the Q-Sort distribution matrix.

relevant paying syndicate members for the three syndicates is estimated to be between 55 and 85 (Auster 2019). There is one area of free fishing in the lower catchment area, but the research was not advertised in this location as the landowner did not wish it to indirectly advertise the fishing there. To participate (and abide by data protection laws by preventing sharing contact details of others) respondents were invited to voluntarily respond to the researcher's invitation. 11 respondents volunteered for the study from throughout the river catchment.

Prior to participation, all respondents were provided with statements regarding the study's ethics and data protection (provided here as Supplementary Information). Participants were required to agree to these statements and give written consent prior to participation.

2.3. Administering the Q-Sort

There were three stages to administering the Q-Sort which took place between 8th November 2018 and 23rd July 2019 (within the time frame of the "River Otter Beaver Trial"). First, participants were asked to sort statements into three piles: statements they agreed with, statements they disagreed with and statements that they were unsure about. The statements within each pile were recorded to aide later interpretation.

Second, respondents were asked to sort the statements into a matrix. This matrix essentially required participants to rank the statements between a score of 4 (statements which they most strongly agreed with) and a score of −4 (statements which they most strongly disagreed with). A fixed quasi-normal distribution matrix was provided for the sort, demonstrated in Figure 1, in order to facilitate the sorting process for the participants. As the distribution does not influence the end result, however (Watts and Stenner 2012, 78), participants were allowed to place statements outside of the matrix if they chose in order for it to be a comfortable process for the participants. Throughout the sorting process, any comments made by the participants about particular statements were recorded to aide interpretation.

Third, a discussion was held with the participants after the sorting process about their final configuration and any other points they would like to raise in order to aide interpretation of the results. The entire process took approximately one hour for each participant.

2.4. Statistical analysis

In Q-Method, the analysis looks at the configuration as a whole and how the statements relate to one another, rather than the placing of individual statements. The participants' statement configurations were analyzed using "PQMethod" software (Schmolk 2014). The perspectives shared by groups of people, known as factors, were extracted using a centroid factor analysis with Varimax rotation; this computerized rotation is mathematically superior to manual rotations and explains the maximum amount of variance, allowing us to derive and understand as many perspectives as possible from the group as a whole (Watts and Stenner 2012, 122–126; Nost, Robertson, and Lave 2019). As is often convention to provide objectivity, factors were retained if two or more participants significantly loaded onto (statistically correlated with) a factor and the Eigenvalue was greater than 1. Two factors were initially retained. However, a third factor with an Eigenvalue of lower than 1 was still retained as it represented a perspective recognizable to the researcher as "meaningful" from their experience of the Q-Study; eigenvalues guide decisions on which factors to retain but final decisions rest with the researcher (Watts and Stenner 2012, 105–107). From the weighted averages of the significantly loaded configurations, factor arrays were generated. Factor arrays are a single Q-Sort representative of the factor (Watts and Stenner 2012, 140). The factor arrays for the three retained factors are presented in Table 1. Four respondents were either confounded (loaded onto multiple factors) or did not statistically load onto any factors.

2.5. Interpretation

The factors (perspectives) were interpreted from the factor arrays and recorded comments from the participants whose Q-Sorts loaded onto (statistically correlated with) these factors. This included examining which statements were ranked at the highest or lowest positions as well as which statements were ranked higher or lower in each factor compared to their ranks within the other factors. As such, the entire configuration was reviewed with every statement engaged with at least once (Watts and Stenner 2012, Chapter 7).

3. Results

Throughout this section, we have referenced the relevant statements from the Q-Set when appropriate. These are represented in brackets with the formula S*XX* where "S" stands for "Statement" and "XX" represents the relevant statement number. We have also included demonstrative quotes from the participants where appropriate.

3.1. Factor 1 – "beaver-accepting"

This factor had an eigenvalue of 3.9971 and two respondents define this factor: participants 4 and 11.

The anglers loaded onto this factor viewed fishing as an opportunity to engage with nature and the wider ecosystem.

> "Fishing is a channel to get in touch with nature." (Participant 4)

There appeared to be a sense of responsibility to look after the environment and angling was viewed as an avenue to monitor the health of it. They felt that the majority of anglers contributed toward the conservation of nature (S13).

> Fishermen are those on the ground. Some say that we don't need fishermen but we do as they are the ones that see what's going on. (Participant 11)

> [Regarding Statement 13] Some do, others don't; others just fish. (Participant 11)

These anglers strongly agreed that beavers should be in Great Britain (S32), particularly due to potential benefits for biodiversity (S9) and habitat creation (S34).

> I have strong feelings about the potential for biodiversity increase. Beavers should be part of the landscape. (Participant 4)

They agreed more than the other factors that beavers would create new fish spawning habitats (S31) and that their presence would lead to a greater diversity of fish (S37). They also felt that beavers were not intimidating (S23) and agreed that seeing them was a positive experience (S17).

> Beavers on the Otter have hugely increased my pleasure in fishing. They are a privilege to see. (Participant 4)

These respondents were less concerned about possible negative impacts of beavers, including less agreement with statements referring to beavers leading to a reduction in fish size (S15) or leading to changes in where they fished (S10). These respondents were more uncertain as to whether beaver dams would obstruct fish migration (S12), but were less concerned about this than the anglers on the other factors and felt that, on the whole, beavers would be beneficial for fish.

> I feel strongly that, on the catchment-scale, beavers will be beneficial to fishing. (Participant 4)

These respondents agreed more that if there were negative impacts there is a sufficient toolbox of management techniques with which to be able to respond to them (S1) and if their fishing activity was negatively affected they would be more willing to accept it due to wider ecosystem benefits of beavers.

> I fish a lot. If there is some negative impact on fishing due to beavers, that is a price I am willing to pay. (Participant 4)

3.2. Factor 2 – "beaver-apprehensive"

This factor had an Eigenvalue of 1.2843 and two respondents define this factor: participants 1 and 2

The anglers loaded onto this factor were very passionate about their fishing activity and viewed it as an important tradition.

> I would include something about the tradition of fishing. (Participant 1)

They strongly agreed that their quality of life relied upon fishing (S33) and that the activity was beneficial toward both mental and physical health (S18, S28).

> I think it is worth adding that one syndicate member is recovering from cancer and has said that the prospect of fishing in future was one of the things that gave him the strength to cope and fight on. (Participant 1)

> Fishing gives me a great sense of freedom. (Participant 1)

These respondents also felt more strongly than anglers associated with other factors that anglers contributed toward the conservation of nature (S32).

Anglers of this factor were more skeptical about the possible benefits of beaver reintroduction compared to the other factors. In particular, respondents strongly disagreed that beavers create spawning habitats (S31), led to a greater diversity in fish (S37) or create new places to fish (S46) and strongly agreed that beaver dams would obstruct fish migration (S12).

> Pools behind dams are not good fishing spots. (Participant 1)

> Beavers might reduce habitats as well. (Participant 1)

> [Regarding Statement 12] This is the most important factor. (Participant 1)

These respondents were apprehensive about beaver reintroduction and nervous of its implications, and they agreed more so than the other factors that the science of the relationship between beavers and fish is unclear (S41).

> We are in a different situation to elsewhere. The impact on England's rivers is unknown. (Participant 1)

> It is opening a door without knowing what's coming through it. (Participant 1)

Beaver reintroduction was viewed as something that is likely to challenge their fishing activity and they were unwilling to accept that.

> I believe fishing has the right to continue. (Participant 1)

These participants agreed more than the others that there would be conflict between anglers and beaver-watchers (S26) and they felt that beavers or their impacts would require managing, but had reservations about what management may look like. Respondents of this factor agreed less than the others that there was a sufficient toolbox of management techniques (S1) and that it is clear who would be responsible for funding beaver management (S36), and agreed more than the other factors that legal protection of beavers would make it difficult to manage negative beaver impacts (S24).

> Who will manage the negative impacts? (Participant 1)

> We definitely need to be able to control them if they get too many. (Participant 2)

3.3. Factor 3 – "managed-beaver"

This factor had an Eigenvalue of 0.3577 and three respondents define this factor: participants 7, 9 and 10.

The respondents loaded onto this factor exhibited a hybridization of traits associated with the other two factors. Similar to Factor 2, these respondents strongly agreed that their quality of life relied upon fishing (S33) and felt strongly that it contributed toward their physical and mental health (S18, S28).

> [Regarding Statement 33] This is top of the list. (Participant 9)

However, this group agreed more than Factor 2 and more similarly to Factor 1 that beavers should be in Great Britain (S32) and that they would increase river biodiversity (S9).

> I consider them [beavers] a species which should be there. (Participant 7)

These respondents were less concerned about negative impacts on fishing, agreeing quite strongly that beavers would create habitat for fish spawning (S31) and disagreeing that they would reduce fish size (S15) or numbers of commercially important fish (S35), but they were uncertain about the potential impact of beaver dams upon fish migration (S12).

> I'd welcome research on fish migration. (Participant 10)

What characterized this factor was a favorable view upon beavers, but with a firm view on a need to be able to manage beavers. These respondents felt that bureaucratic processes would make it difficult to manage the negative impacts (S8) and that it is unclear who would be responsible for management funding (S36), but there was a feeling of a need to be in control, including the need to respond if there is a barrier to fish migration.

> The more [beavers] the merrier. Let them spread, provided there's some control of barriers for migrating fish. (Participant 7)

> It's our job to control nature as we don't have a choice. If we don't, we could end up with horrendous situations which we can't control. (Participant 7)

4. Discussion

Although members of the fishing community are often cited as having more negative views of beavers and their reintroduction than other people may hold, our research appears to indicate that opinion within the context of this specific community can in fact be much more nuanced and diverse. This is similar to how the national survey illustrated differences in whether respondents supported the process of beaver reintroduction amongst those who identified their occupation as within "Fisheries & Aquaculture" or had heard about the survey from a "Fishing Organization" (see Section 1) (Auster, Puttock, and Brazier 2020). With this Q-Method study we found the existence of three distinct perspectives, two of which appeared to contrast with one another and a third which exhibited some similarities with both of the other two. (It is also possible that further factors may emerge if the participant pool were to be expanded, to which the four respondents who did not load onto a factor may associate with.)

The "*beaver-accepting"* and "*beaver-apprehensive*" anglers in particular exhibited differences in their perspectives with little commonality between the factors, and notably they held different levels of agreement with the view that beavers should be in Great Britain (S32). Thus, there is a potential risk of conflict between these groups. This is exemplified in additional comments from respondents made during the post-Q-Sort interview. A *"beaver-accepting"* participant stated: "I find it very annoying that certain anglers have already made up their minds that beavers will have a negative impact on fishing. It's not a helpful position to take. I think there is probably, in fact, a strong core of anglers who are willing to accept beavers" (as is perhaps evidenced in Auster, Puttock, and Brazier 2020). Meanwhile, a *"beaver-apprehensive"* respondent stated: "Do-gooders can be antagonistic. They want to impose their own views. Activists would stop the removal of beavers if they could." Thus, subsequent decision-making will need to consider these perspectives in the development of a management strategy least likely to cause conflicts. Meanwhile, *"managed-beaver"* participants were observed to be accepting of the potential of beavers, however, they exemplified a need to feel that they (or someone) would be "in control".

Therefore, we suggest key elements of each perspective that will need to be taken forwards for consideration in management decisions where beavers are reintroduced: for *"beaver-accepting"* anglers, the potential opportunities that beavers may pose for biodiversity and ecosystems; for *"beaver-apprehensive"* anglers, the protection of the tradition, right and ability to fish; for *"managed-beaver"* anglers, the ability to manage potential negative impacts caused by beavers. To address these elements as a collective may be challenging, particularly as reintroduction projects bring together stakeholders with differing values who may present the nature of the interactions between people and the reintroduced species in a manner consistent with their respective agendas (Hill 2015). For example, the white-tailed sea eagle (*Haliaeetus albicilla*) was reintroduced to a national park in Ireland and there were observed tensions between farmers who perceived the eagles as a "threat" to rural living and feared predation upon lambs, and conservationists who emphasized the eagle's potential in ecotourism and its feeding on fish and carrion (O'Rourke 2014). However, we propose two particular themes which may go some way toward meeting this objective in the case of beaver reintroduction and angling in England, beyond continuing scientific research into the relationships between beavers and fish, if the reintroduction in England is to continue.

Firstly, we propose that information about the impacts of beaver reintroduction is accessible and that there is an open forum for discussion. This will enable anglers to gain a deeper understanding of the subject and learn from one another of their experiences. We include within this the sharing of scientific findings from ongoing research into the relationship between beavers and fish, as this will be important to address the concerns of the *"beaver-apprehensive"* anglers, who agreed more than the other factors that "the science of the relationship between beavers and fish is unclear" (S41). In particular, the ongoing research into beaver dams and fish migration (such as recent European discussions in Bylak and Kukuła 2018 and Malison and Halley 2020) will need to be communicated, as this was one of the particular aspects about which there was most uncertainty (S12). We further propose this should be accompanied with scientific information about the relationship between beavers and other variables such as biodiversity and ecosystems, as this will reassure the "*beaver-accepting*" anglers that the potential benefits of beavers are being recognized. Additionally, information about what support is available if there are negative impacts which may require management should also be accessible, which will be of particular interest to the *"managed-beaver"* anglers. Such an approach has similarly been advocated by Lynch *et al*. (2017) to address management and conservation issues in North American inland fisheries. Resulting from a "grand challenges" exercise with a group of disciplinary experts, they suggest that strategies to improve science-policy communication would provide greater involvement of the public and effective communication of science may help minimize the potential for conflict between social groups. They advise cross-sectoral communication and highlight the need for an understanding of both ecosystem processes and the management goals of the fisheries sector. They then propose the establishment of a centralized research data sharing framework to integrate cross-sectoral management and research efforts (Lynch *et al*. 2017).

However, it is important to recognize that the priorities in the identified factors are value-laden (e.g. the "beaver-accepting" group prioritized wider biodiversity, whereas the "beaver-apprehensive" group valued tradition and ability to fish). Value-laden conflicts can be difficult to overcome (O'Rourke 2014); an availability of information may not necessarily influence attitudes when values are held most deeply (Elliott 2019; Treves and Santiago-Ávila 2020), and information can be presented by individuals or groups in a way that is consistent with their own values, as observed in the case of the white-tailed sea eagles (O'Rourke 2014). As such, some disagreement may always be inevitable, but we believe that where it persists a recognition of how people understand and interpret the situation through the suggested discussion forum would help to facilitate decisions that can distinguish between evidence and ethical judgments, leading to more equitable outcomes (Stirling 2010; Crowley, Hinchliffe, and McDonald 2017a; Elliott 2019; Treves and Santiago-Ávila 2020).

This leads us to our second and arguably more important theme: we propose that management decisions will need to enable a sense of empowerment for individuals. Empowerment within wildlife management has been recognized in the human-wildlife conflict literature as a factor which may contribute toward long–term solutions for conflict resolution (Linnell *et al*. 2010; Redpath, Bhatia, and Young 2015; Dubois *et al*. 2017). In the context of beavers and anglers, the aforementioned communication may contribute toward this empowerment goal to some degree. Of particular note however, the *"beaver-apprehensive"* and the *"managed-beaver"* anglers (with whom the need to manage beavers particularly resonated) agreed that bureaucratic processes would make it difficult to manage negative beaver impacts (S8). Thus, we propose that a simplified route toward managing potential negative impacts of beavers with minimal bureaucracy or administrative procedures could provide a sense of empowerment and go some way to reducing potential conflicts. As an example, in Bavaria, two state-employed Beaver Managers oversee a trained team of volunteer Beaver Wardens who are spread throughout the state (and contactable through a central register). These wardens will rapidly respond to concerns raised and work with the affected parties to determine any necessary action to be taken (Campbell-Palmer *et al.* 2016, 112). However, the same management structure will also need to support the benefits for biodiversity and ecosystems in order to prevent the potential for conflicts with the *"beaver-accepting"* anglers and other non-angler groups who may similarly hold more positive views of the impacts of beavers. We suggest that the basis for such a management strategy exists in "*The Eurasian Beaver Handbook: Ecology and Management of Castor fiber"* (Campbell-Palmer *et al*. 2016) and that the pragmatic approaches therein should be reflected in any future beaver management framework.

5. Summary

In summary, we found that the perspectives held by anglers are diverse: for *"beaver-accepting"* anglers the potential biodiversity and ecosystem benefits were of high importance; for *"beaver-apprehensive"* anglers the tradition and health benefits of fishing were viewed as of high importance and beaver reintroduction was viewed as something which may affect the ability of fishing to continue; *"managed-beaver"* anglers exhibited a hybrid of these values, believing in the benefits of fishing for their quality of life whilst being supportive of beaver reintroduction, provided that there is the ability to manage potential negative impacts. As there is the potential for conflict between these groups where beaver reintroduction occurs, we propose that these perspectives will need to be factored into possible beaver management decisions. We suggest that an open dialogue about the scientific research about beavers and fish, their effects on the wider ecosystem and how beavers can be managed will go some way toward reducing the potential for future conflicts. We exemplify this approach ourselves by ensuring that all beaver research papers that we have produced are available open-access to all (Puttock *et al*. 2015; Puttock *et al*. 2017, Campbell-Palmer *et al*. 2018; Puttock *et al*. 2018, Auster, Puttock, and Brazier 2020; Graham *et al*. 2020). Even more-so, we argue that a management strategy which supports the possible biodiversity and ecosystem benefits of beaver reintroduction whilst providing a sense of empowerment to respond to possible negative impacts could help to reduce potential future conflict risks.

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The authors have no conflicts of interest to declare.

Supplemental data

Supplemental data for this article can be accessed here.

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Data availability statement

The completed participant Q-Sort configurations are available publicly in the University of Exeter CREWW GitHub repository, online at: https://github.com/exeter-creww/Participant-Q-Sort-Configurations_Auster-Brazier-Barr_Angling-Perceptions-and-Beavers (University of Exeter CREWW GitHub 2019).

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Chapter 5. Wildlife tourism in reintroduction projects: Exploring social and economic benefits of beaver in local settings

The following paper forms the fifth chapter of this thesis. It is presented in published format, with all references included at the end of the chapter in publication format.

This paper is the first of the two studies which investigate potential areas of social benefit associated with beaver reintroduction. This paper details a mixed methods case study of beaver tourism that arose in the River Otter Beaver Trial.

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Wildlife tourism in reintroduction projects: Exploring social and economic benefits of beaver in local settings

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Wildlife tourism

ABSTRACT

Wildlife reintroduction projects are required to account for social and economic factors. Wildlife tourism is often cited as a benefit of reintroduction, so an understanding of whether and how this manifests is required. Through a case study of a village in the catchment of a live reintroduction project (Eurasian beaver (*Castor fiber*) in England) we reveal how reintroduced species tourism has economic benefit for local business, but the scale of benefit is dependent upon business initiatives that take the opportunity (eg merchandise, marketing etc.). We suggest reintroduction practitioners should actively encourage local businesses to maximise opportunities, especially where tourism is cited as a reason to reintroduce. We recommend further research into whether benefits remain in the long-term, but speculate some value will persist. Finally, we recognise reintroduction-related wildlife tourism may interact with other local issues, but seeing a reintroduced species or signs of its activity can produce positive emotional responses.

1. Introduction

Wildlife reintroduction is a form of wildlife translocation. Reintroduction is a growing practice in conservation in which individuals of a species that were historically resident in a landscape are returned (Seddon, Armstrong, & Maloney, 2007). Reintroductions are motivated by a variety of reasons which can be ecologically driven (such as for ecological restoration) or economically driven (Carter, Foster, & Lock, 2017; Corlett, 2016; O'Rourke, 2014). Where reintroductions occur, they should abide by guidelines set by the *International Union for the Conservation of Nature*. These guidelines state that "Any translocation will impact and be impacted by human interests. Social, economic and political factors must be integral to translocation feasibility and design" (IUCN & SSC, 2013). As such, practitioners must account for social variables in wildlife reintroduction projects (Auster, Puttock, & Brazier, 2019; IUCN & SSC, 2013; Perring et al., 2015).

Wildlife tourism is often cited as a potential socio-economic benefit resulting from wildlife reintroductions. For example, the reintroduction of the white-tailed sea eagle (*Haliaeetus albicilla*) in Ireland was viewed favourably by tourism organisations who were broadly supportive of the project (O'Rourke, 2014). However tourism based on a reintroduced species may not be supported by others who may not hold a favourable view of the reintroduction (Hall, 2019). As wildlife tourism and its potential socioeconomic benefit for local communities is often cited as a motivation for reintroduction, an understanding of whether and how this actually occurs is required. Despite this need, there is so far little academic study of the wildlife tourism that results post-reintroduction. This therefore raises the question of whether the potential economic benefits of reintroduction cited pre-reintroduction are realised when the species is present and, if so, how do the opportunities manifest? Further, are there other implications of reintroduction-related wildlife tourism for local communities? As the IUCN Guidelines require an integration of social and economic factors in reintroduction project design (IUCN & SSC, 2013), addressing these research questions would enable practitioners to appropriately consider wildlife tourism potential when proposing and planning reintroduction projects.

In this paper we seek to address these questions by undertaking a case study of tourism associated with a reintroduced species in a live reintroduction project. We will first introduce the concept of wildlife tourism, and provide context surrounding our study species - the Eurasian beaver (*Castor fiber*). Following the presentation of our case study results, we will close by discussing the findings, and discover what the wider implications are for reintroduction (or translocation) projects.

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1.1. Wildlife tourism

Wildlife tourism (a form of ecotourism) is a growing trend globally in which humans interact with wildlife, whether it be flora or fauna (Higginbottom, 2004). The growth in wildlife tourism reflects an increase in people seeking experiences with wildlife both domestically and internationally (Curtin, 2010; Newsome & Rodger, 2013). Where wildlife tourism relates to animals (as will be the case in this study), humans interact with them in the wild or within enclosures (Higginbottom, 2004; Moorhouse, D'Cruze, & Macdonald, 2017; Skibins, Powell, & Hallo, 2013).

Wildlife tourism facilitates the engagement of people with nature and emotional responses (Curtin & Kragh, 2014), which research has argued leads to increased 'nature connectedness' – an individual's psychological sense of their relationship with nature (Martin et al., 2020). This in turn is claimed to result in a range of potential benefits: local businesses and communities can benefit from increased income resulting from visitors to the area (Higginbottom, 2004; Zimmerhackel, Kragt, Rogers, Ali, & Meekan, 2019); an increase in connectedness with nature can be beneficial for mental health, with numerous studies showing positive effects on an individual's well-being (Curtin, 2009; Lackey et al., 2019; Natural England, 2020); and encounters with wildlife can stimulate nature conservation behaviours in people (Apps, Dimmock, & Huveneers, 2018; Natural England, 2020; Newsome, Rodger, Pearce, & Chan, 2019).

Wildlife tourism is often centred upon 'charismatic species' (Curtin, 2010; Skibins et al., 2013) defined here as animals which are visually appealing to people, encouraging interest or sympathy (Ducarme, Luque, & Courchamp, 2013). For example, five mammals - the "Big Five" - are promoted as the ones to spot in Africa (Lindsey, Alexander, Mills, Romañach, & Woodroffe, 2007). A charismatic species focus is sometimes criticised for taxonomic bias (Clucas, McHugh, & Caro, 2008; Monsarrat & Kerley, 2018) but the focal species may be a 'flagship species' through which other wildlife and ecosystems are supported, either in the distribution of revenue generated (Lindsey et al., 2007; Meer, Badza, & Ndhlovu, 2016; Williams, Burgess, & Rahbek, 2000) or by conserving wider habitat (especially if the species is an 'ecosystem engineer', a species which modifies habitats and supports a wider ecosystem (C. G. Jones, Lawton, & Shachak, 1996; Nummi & Holopainen, 2014).

Not all wildlife tourism is driven by charisma as some is motivated by the intention to support or see wider biodiversity rather than charismatic species alone (Hausmann, Slotow, Fraser, & Minin, 2017). For example, tourist motivations to visit National Parks in Zimbabwe included "abundance of wildlife" and availability of both animal and plant species (Mutanga, Vengesayi, Chikuta, Muboko, & Gandiwa, 2017). Further, wildlife tourism can be motivated by experiencing wild landscapes, with the wildlife in context providing the "activity, drama and the focus" (Cloke & Perkins, 2005; Curtin, 2013).

1.2. Eurasian beaver (*Castor fiber*) in Great Britain

In Great Britain, the Eurasian beaver was historically resident until approximately 500 years ago, when they were extirpated by humans for fur, castoreum and meat (Halley & Rosell, 2003; Puttock, Graham, Cunliffe, Elliott, & Brazier, 2017). There are now reintroductions taking place at a politically devolved level; in Scotland beavers were formally recognised as a European Protected Species in 2019 (Gaywood, 2018; Scottish Government, 2019); in England, a free-living population of Eurasian beavers in Devon (in the south-west) has been monitored for five years and the UK Government announced in August 2020 they may permanently remain, with consultations on a national approach to beaver reintroduction due later in 2020 (UK Government, 2020); in Wales there are no formal reintroductions as yet, but the Wildlife Trusts of Wales have submitted proposals for monitored Trials (Wildlife Trusts Wales, 2012).

The Eurasian beaver (hereon referred to as 'beaver') is a semi-aquatic large mammal of the order *Rodentia*. They are 'ecosystem engineers' for they alter the landscape through tree-felling and dam-building behaviours, creating a mosaic of habitats that support a range of biodiversity. Supported species groups include birds, amphibians, aquatic invertebrates, bats and other terrestrial mammals (Nummi, Liao, Huet, Scarpulla, & Sundell, 2019; Dalbeck, Hachtel, & Campbell-Palmer, 2020; Law, Levanoni, Foster, Ecke, & Willby, 2019; Nummi & Holopainen, 2014; Nummi, Kattainen, Ulander, & Hahtola, 2011; Stringer & Gaywood, 2016). There is ongoing research into the relationship between beavers and fish (see Kemp, Worthington, Langford, Tree, & Gaywood, 2012 for a balanced review of pros and cons). The dam-building behaviours are often seen as beneficial for people as they lead to improved water quality and slow water flows in high rainfall events, reducing the potential for flooding (Puttock, Graham, Carless, & Brazier, 2018; Brazier et al., 2020; Brown et al., 2018; Graham et al., 2020; Puttock et al., 2017). There are also challenges associated with beavers which may require management by people including flooded agricultural land upstream of a beaver dam and the felling of trees of social significance (Brazier et al., 2020; Campbell-Palmer et al., 2016; Schwab & Schmidbauer, 2003).

In 2017 (prior to the study presented in this paper) we conducted a nationwide online survey of attitudes towards beaver reintroduction ($n = 2759$). This identified groups favourable towards and opposed to the process of beaver reintroduction in Britain, with the reasons given being largely reflective of the benefits and challenges cited above (Auster et al., 2019). When asked specifically about beaver impacts upon 'economics', the potential for beaver tourism was cited in some form by 47.99 % of respondents within their responses (though to varying extents with everything from a "minimal" to a "huge" benefit being referenced).

The beaver fulfils a number of criteria which would make it a prime candidate for a wildlife tourism focus. First, it is a large mammal that is considered a charismatic species with characteristics that appeal to people (Campbell, Dutton, & Hughes, 2007). Second, as 'ecosystem engineers' they actively create (or restore) diverse natural environments, which would appeal to wildlife tourists for whom biodiverse landscapes are of interest (Campbell et al., 2007; Hall, 2019). Third, in the process of beaver-induced landscape change, visible signs of activity are left (such as dam structures or felled trees) which are viewable when the animal itself may not be seen (Brazier et al., 2020). Fourth, they are 'predictable in activity or location' as they are territorial and (although largely nocturnal) they are often seen in daylight hours, especially in the summer months (Gaywood, Batty, & Galbraith, 2008; Reynolds & Braithwaite, 2001). Fifth, where they are introduced they would possess 'elements of rarity' (Reynolds & Braithwaite, 2001) in the early stages or 'super local-abundance' (Reynolds & Braithwaite, 2001) as they become more widespread (Halley & Rosell, 2002; 2003; Halley, Saveljev, & Rosell, 2020).

Beaver tourism activities presently exist in Europe. For example, there are initiatives such as 'beaver safaris', guided tours of beaver-modified landscapes and information centres (Campbell et al., 2007; Halley & Rosell, 2002; Rosell & Pedersen, 1999). Perhaps unsurprisingly therefore, feasibility studies and reintroduction project reports for all three nations in Great Britain have cited wildlife tourism as a potential socio-economic benefit resulting from beaver reintroduction (Brazier et al., 2020; Gaywood, 2018; Gurnell et al., 2009; Jones, Halley, Gow, Branscombe, & Aykroyd, 2012; Moran & Lewis, 2014).

Some study of 'beaver-tourism' potential in Great Britain has taken place. A report for the Wild Britain Initiative conducted by the University of Oxford in 2007 (prior to any official beaver reintroductions in Britain) undertook a scoping study of the potential economic benefit that could be garnered from beaver reintroduction. It concluded that "these benefits could be substantial" and a beaver release site may bring an estimated £2million a year into a local economy (Campbell et al., 2007). In Scotland, the Scottish Beaver Trial was a 5 year project which monitored a small reintroduced beaver population in Knapdale, Argyll from 2009 until 2014 (prior to the Scottish Government decision to legally protect Scottish beavers) (Gaywood, 2018). In the Trial's final socioeconomic monitoring report it was concluded that there was some evidence of increased turnover in local businesses, but that this was "modest". It also reported that "Local tourist and retail operators are generally favourable in their assessment of the local and regional added-value of the trial" (Moran & Lewis, 2014). The potential for beaver tourism ventures was also recognised by landowners surveyed by the Tayside Beaver Study Group, who collated evidence on the impacts of an unlicensed population of beavers on the River Tay (Tayside Beaver Study Group, 2015).

In this paper we seek to build upon this knowledge through the case study of a village community situated within the catchment of the River Otter Beaver Trial in South West England (see 'Study Setting'). We seek to understand how the presence of free-living reintroduced beavers on the River Otter near to the village and associated wildlife tourism has impacted upon local businesses and the community. We aim to find out if and how the suggested potential benefit for communities from wildlife tourism manifests. Finally, we will explore what lessons this experience can reveal which are transferable for a variety of wildlife tourism and reintroduction contexts (Tsang, 2014).

2. Study Setting

Our research occurred within the catchment of the River Otter, Devon (England) during the timeframe of the 'River Otter Beaver Trial' (ROBT). The village of Otterton, situated in the lower catchment, is small with a handful of businesses (see 'Interviews with local businesses' and Table 2 for business descriptions). The River Otter flows through the village from the North to the South.

In 2015, Devon Wildlife Trust was granted a licence (Natural England, 2015) to monitor a free-living population of beavers of unknown origin on the River Otter (Crowley, Hinchliffe, & McDonald, 2017). Over five years, Devon Wildlife Trust was responsible for monitoring and managing the beaver population with an array of external partners under the auspices of the 'River Otter Beaver Trial' (ROBT). An intensive program of scientific research and evidence gathering on both environmental and social factors (in accordance with the Trial's monitoring framework (Devon Wildlife Trust, 2017) took place over the course of five years until 2020 when the findings were published in the final 'Science and Evidence Report' (Brazier et al., 2020). This report, alongside a proposed management framework developed by a partnership of organisations (River Otter Beaver Trial, 2019), were presented to UK Government who announced in August 2020 that the River Otter beavers may remain (UK Government, 2020).

In 2017 a beaver pair established a lodge, located a short distance upstream (North) of the village. The beavers were in a location that was easily visible from a well-used riverbank footpath. The beavers did not build a dam construction as they were in the lower reaches of the main channel (beavers tend to only build permanent dam structures in upper and more marginal stretches of river (Graham et al., 2020). The beavers themselves were often active in daylight hours (usually evening or early morning) in the summer months, and produced feeding signs. The beavers often brought vegetation back to a small beach opposite the footpath to feed. By the summer of 2018, the beavers had moved away from this location to an area not publicly accessible.

3. Material and methods

As the beavers were free to roam throughout the river catchment (and as the population was small meaning there was plenty of available habitat), it was not foreseen that a lodge would be established just outside of the village. With that and the project timescale in mind, the methods selected for this investigation would need to be reactive to the events unfolding in the village. As such, this study undertook a mixed-methods approach. A mail-return questionnaire of village residents allowed for an understanding of how 'beaver-watching' and any association with visitors to the village were viewed amongst the community. Footpath counter data enabled an assessment of footpath use along the river, and face-to-face interviews with local businesses enabled insight into any potential economic impacts of 'beaver-watching'.

3.1. Community mail-return questionnaire

In order to understand how the beavers and related wildlife tourism were viewed amongst the local community, a paper questionnaire was delivered to 289 properties, the total which we identified to be within the village (the information for participants and full questionnaire is provided as **Supporting Information**). The questionnaire was supplied with a stamped, addressed envelope in order to submit responses. An optional opt-in prize draw (for a £20 voucher for a choice of stores) was offered as an additional incentive for participation. The survey was delivered on 20th December 2018 and respondents were asked to submit their answers by 10th January 2019, however submissions were accepted for a further two weeks in order to allow for late responses. 66 household responses were received; a response rate of 22.8 %.

This study uses a subset of results from the questionnaire. Within the

Table 2
Descriptions of participating businesses and interview findings.

Business ID	Description	Impact of beavers on visitor numbers to business	Impact of change in visitor numbers for business	Beaver-related initiatives undertaken	Possible other ideas or initiatives cited	Additional impacts cited
B1	Nature-focused visitor attraction, incorporating a working watermill, bakery, farm shop, restaurant, gallery and live music.	Increase Noted that increase is observed at certain times of year	Beneficial (increased custom)	Beaver Merchandise (eg coasters, cards, bronze figures) Beaver Beer – "Beaver Bitter" Beaver Event days Use of beavers in business marketing and promotion	Beaver interpretation, but hoped this would be provided by a beaver management authority	Successful bid for government funding to improve toilet facilities, with increase in visitors due to interest in beavers cited in the application Increased interest generally in River Otter area
B2	Community-owned shop for local people, run by volunteers with one paid manager.	Unsure (increase observed but not sure whether this is attributable to beavers)		Postcards featuring local photographer's beaver pictures	None, but cited interest in undertaking more	None
B3	Hospitality business incorporating hotel, public house and restaurant	Increase	Beneficial (increased custom)	None	Beaver focused walks	None

analysis for each question, respondents who did not answer the question were excluded. The relevant questions in this subset are presented in Table 1, alongside their respective focus.

3.2. Interviews with local businesses

The researcher identified five businesses within the village. Each was invited to participate in an interview to document their experiences and views of the beavers and beaver tourism; every business was invited at least twice. Three businesses agreed to participate. (Additionally, following the interviews and mail-return questionnaire, one business from outside the boundaries of the community was identified as of interest to interview. However, no response to the invitation was received from this business). The businesses are identified in this study by a code number which relates to the business description as given by themselves. These are outlined in the first two columns of Table 2. All businesses were established prior to the appearance of the beaver lodge in 2017.

The interview was of a semi-structured nature to ensure key areas were covered but to enable additional questioning if appropriate. Participating businesses were asked about:

- Their description and views of the beavers and their activity in the local vicinity, and whether there have been any direct impacts of this for the business.
- Whether there have been any changes in customer numbers and/or backgrounds which they related to the presence of beavers on the Otter.
- Whether they have undertaken or planned to undertake any business initiatives in response to the presence of beavers on the Otter.

Table 1
The subset of questions from the community mail-return questionnaire in relation to their respective focus.

Focus	Question	Notes
Community use of the river near to their village	"For which of the following reasons do you visit the River Otter near to Otterton?"	Respondents could select multiple answers from a list of tick-boxes.
	"Has the presence of beavers on the River Otter near to Otterton influenced your use of the river?"	Free comment box
Community experience and views of 'beaver-watching'	"Have you seen the beavers or signs of their activity on the river near to Otterton? If yes, please tell us how this made you feel."	Free comment box
	"As part of a 'beaver-watching' experience near to Otterton, would you be likely to spend money in any of the following business types?"	Respondents could tick multiple answers from the options, which were based on business types in the village: pub/restaurant; café; shop; other
Visitors to the village	"Since 2015, have you noticed a change in the number of visitors to Otterton?"	Respondents could tick one of the list of options.
	"Do you believe that the presence of beavers in the river near to Otterton has led to the change which you described?"	Respondents could choose between "Yes, completely", "Yes, in part" or "No".
	"Please use this space to tell us whether you believe there to be any impacts of visitors to Otterton and its residents. These can be positive, negative or neither positive nor negative."	Free comment box

Interviews took place in March 2019 and ranged between 30 and 60 min.

3.3. Riverbank footpath counters

The village resides within the designated *East Devon Area of Outstanding Natural Beauty* (AONB). In 2017, the AONB authority installed footpath counters on the riverside footpath near the beaver lodge near to the village. Two counters of particular interest for this study were installed either side of a road bridge over the river; one for the footpath leading north out of the village towards the lodge (North), and the second for the footpath leading south out of the village towards the sea (South). The AONB authority has granted permission for the use and analysis of their records for this research, for which the authors are very grateful.

The counters recorded one count each time an individual passed the counter. The data were available on a monthly basis from June 2017 until February 2019 (with the exception of October and November of 2018 due to a technical issue). The footpath counters recorded a total of 92,170 (North) and 206,593 (South) counts across the available months.

In 2017, the beavers were present on the river with a lodge in a location which was publicly visible from the footpath a short way north of the village. However, in 2018, the beavers moved to a location away from the footpath. Thus, in the data gathered, there were two comparable sets of four summer months when beavers are more likely to be seen (June through to September), including one summer of beaver presence near the footpath (2017) and one of beaver absence (2018). The differences in these months between the two years were statistically compared using a chi-square test of independence.

3.4. Ethics

All participants (in the mail-return questionnaire and the business interviews) were informed that participation was voluntary and anonymous, with written consent required for participation. Examples of the ethical information provided for respondents are available as supporting information. This study was approved by the University of Exeter Geography Department's Ethics Committee.

4. Results

In this section we will present results from the three methodological approaches. First, we present results regarding the contextual use of the River Otter amongst the community and how this may have been influenced by the presence of beavers from the community questionnaire. Second, perceptions of visitors from the community and the footpath counter data will allow for an examination of beaver influence on visitors and footpath use. We then provide results from the business interviews regarding economic influences of 'beaver-tourism'. Subsequently we return to the community questionnaire to understand any other implications of tourism for the community, and to gain an insight into the emotional responses that arise amongst residents when beavers or signs of their activity have been seen.

4.1. Community use of the River Otter

The local community use of the River Otter, as reported through the mail-return questionnaire, is shown in Fig. 1. The predominant activity was for walking (92.3 %), followed by viewing wildlife (64.6 %) and peace and quiet (40 %). The activity for which fewest respondents reported using the river was swimming (1.5 %). 6.2 % of respondents reported that they did not use the River Otter near to the village.

When asked whether the presence of beavers had influenced the respondents' use of the River Otter near to the village, 32 of the 55 respondents who provided an answer to the question (58.2 %) indicated that it had not. Of those who gave reasons, these cited that they used the

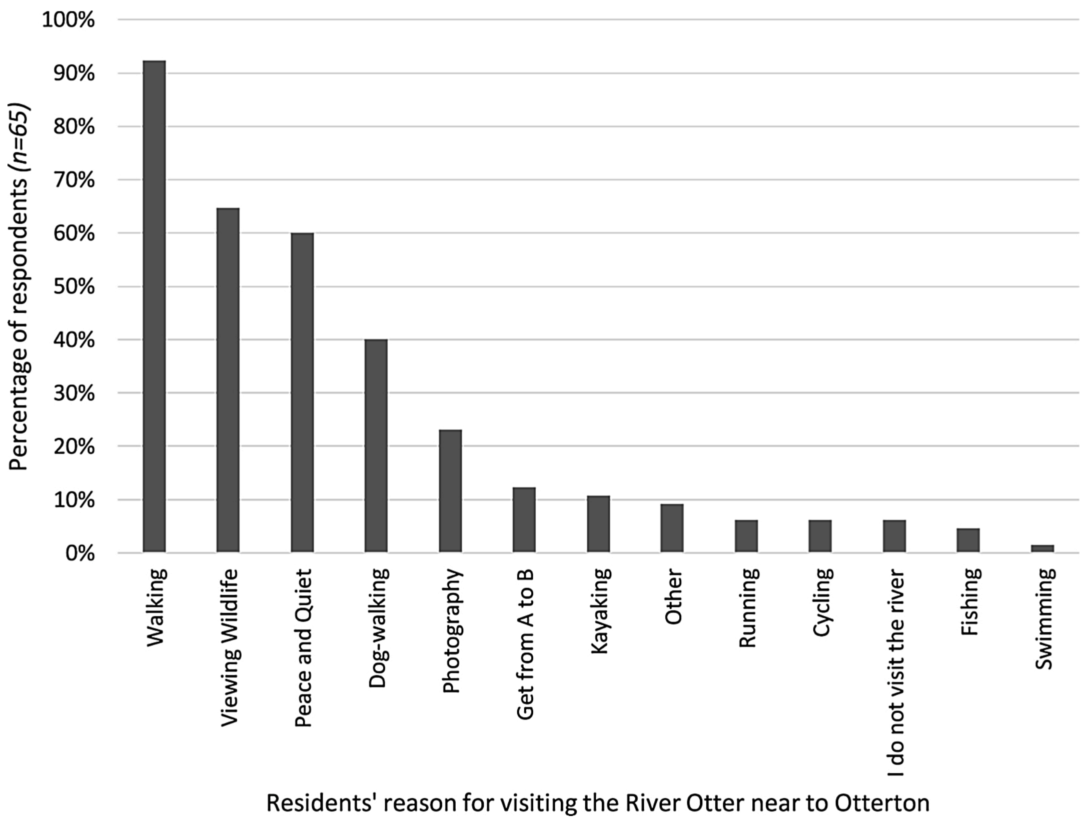

Fig. 1. Community use of the River Otter near to the village, as reported by respondents in the mail-return questionnaire.

river anyway, they were resident in the village, and that it had not changed the frequency of their river use. The remaining 23 respondents (41.8 %) indicated that the presence of beavers had influenced their use of the river. When reasons were given, these included (in no particular order): increasing time by the river; being more watchful for beavers on walks; aiming to see signs of beaver activity; aiming to see the beavers themselves; being more likely to take visitors; walking more in the evening; walking more in the early morning; and finding walks more enjoyable as there is more wildlife to see. However, there were also some negative reasons given, including (in no particular order): being more careful with dogs on walks; preventing their dogs from being able to swim in the river, walking different river stretches as some areas have now become too busy for them; and walking less frequently.

4.2. Visitors to otterton

4.2.1. Perception within the community

Of the 62 respondents who answered when asked in the mail-return questionnaire about whether they had observed a change in visitors numbers since 2015 (the start of the River Otter Beaver Trial), 7 respondents (11.3 %) indicated that they had felt there had been no change and 12 (19.4 %) indicated that they did not know.

43 respondents (69.4 %) indicated that they had observed a change in visitor numbers. 39 of those respondents (90.7 %) indicated this change to have been an increase, whilst none indicated that they felt there had been a decrease. 4 respondents (9.3 %) indicated the change had been variable.

Subsequently, respondents who had indicated that there had been a change were asked whether this was attributable to the presence of beavers on the river near to the village. 15 respondents (34.9 %) answered ‘Yes, completely’, 25 respondents (58.1 %) answered ‘Yes, in part’, and 3 respondents (7 %) answered ‘No’. Those who answered ‘Yes, in part’ or ‘No’ were given the opportunity to indicate what other factors may have led to the change in visitor numbers which they described, and reasons included: more people generally visiting the area; attractiveness of the local area and river; people trying to see other wildlife (including otters and birds); increase in holidays remaining in the UK (or ‘staycations’); development of a nearby holiday park; development of local businesses as attractions.

4.2.2. Footpath counter data

The footpath counter data for the months of June to September in 2017 (when the beavers were present on the river with a lodge in a location visible from the footpath a short way to the north of the village) and 2018 (when the beavers had moved away from the footpath) is presented in Table 3. Between the summers of 2017 and 2018, there was a reduction of 10,925 counts North and 15,506 South. Across all four months, there was a reduction in footpath counts for both the North and South counters. The differences in each of these months were statistically significant for both counters between 2017 and 2018 (North: $X^2_{(3)} = 885.6715$, $n = 52859$, $p < 0.00001$; South: $X^2_{(3)} = 729.1707$, $n = 104166$, $p < 0.01$).

4.3. Business perspective

A summary of the impacts of the presence of beavers as reported by

Table 3
Summary of footpath count data for both counters in the summers of 2017 and 2018. (Data provided courtesy of *East Devon AONB*).

Month	North counter			South counter		
	2017	**2018**	**Difference**	**2017**	**2018**	**Difference**
June	7090	6673	−417	14011	10599	−3412
July	9396	6020	−3376	15880	12673	−3207
August	10535	6423	−4112	19516	15962	−3554
September	4871	1851	−3020	10429	5096	−5333
Total	**31892**	**20967**	**−10,925**	**59836**	**44330**	**−15,506**

the local businesses is provided in Table 2, with all businesses indicating that the beavers led to an increase in revenue. The table details whether the business has seen a change in visitor numbers and the impact of this for the business, whether businesses had undertaken any beaver initiatives, other potential initiatives businesses cited that they may consider and any other reported additional impacts.

Overall, B1 reported a large scale benefit of beaver presence for their business predominantly from increased custom (including at beaver-focused events) and sales of beaver-related merchandise and products. This business also reported actively using the beaver presence within their business marketing and promotion.

> "We have stocked various beaver merchandise in the gallery. […] More recently this winter we've brought on three lines of beer made for us, and one of those beers is 'Beaver Bitter'. Now that's sold particularly well."

B2 reported a little benefit from beaver postcard sales but was unsure whether the increase in visitors they had experienced could be attributed towards the presence of beavers.

> "It's very hard to say because we we're gradually building our customer-base up at any rate so I suppose we didn't specifically know if people had come to see the beavers or whether they had just come to see the village. We do sell, we've got these pictures [points to beaver and otter pictures on wall] and we do sell postcards. We've got postcards of those two pictures."

B3 reported some benefit of increased custom from increased visitor numbers.

> "It does bring a bit of tourist trade down […] you do get people coming down and people who say through *booking.com* and stuff that 'we're coming to see the beavers'"

4.4. Other impacts of 'beaver-tourism' for the community

Respondents to the mail-return questionnaire were provided with an opportunity to reflect upon any additional impacts of visitors upon the village and its residents. Fifty-nine respondents provided an answer for this question.

Most prevalently, with 28 occurrences, respondents cited additional pressures on parking in the village due to an increase in visitor numbers. There were a further 19 references towards an increase in traffic or cars (including cases where these were linked to safety, congestion, speeding and noise pollution).

Other impacts cited included: damage to riverbanks and footpaths from increased foot traffic ($n = 7$, once also citing off-road cyclists); a potential benefit for local business ($n = 7$); an increase in litter (or plastic pollution) ($n = 5$); visitors getting angry at dog-walkers allowing dogs in the river ($n = 1$); dog-walkers encouraging dogs into the river ($n = 1$); a new interest for wildlife watchers and photographers ($n = 1$); a lack of toilets for visitors ($n = 1$); being "glad" of visitors coming to see beavers ($n = 1$); a potential for volunteer schemes and funding ($n = 1$).

4.5. Perceptions of seeing beavers or signs of their activity

Of the 62 respondents who answered the question in the mail-return questionnaire, 56 respondents (90.3 %) indicated that they had seen beavers or signs of their activity, with the remaining 6 respondents (9.7 %) indicating they had not.

Of those who had, 54 respondents then described how this had made them feel. The emotional and descriptive words were run through a word frequency analysis (with stemmed words). This method of content analysis seeks to quantify the frequency by which words are used (Stemler, 2000), in our case the frequency of emotion words used in responses to the question. This allows us to identify those which occurred most or least commonly amongst the group to give an indicative overview of the reported emotional responses to seeing beavers or signs of their activity.

The five most frequently used words were 'excited' (11 occurrences), 'interested' (9 occurrences), 'happy' (8 occurrences), 'pleased' (8 occurrences), and 'privileged' (4 occurrences).

There were however three occurrences of negative words. 'Concerned' and 'worried' appeared once each, with the respondents describing these as feelings experienced having seen what was perceived as "damage to trees". The word 'sad' occurred once where the respondent described seeing ""so many people 'viewing' the beavers and disturbing them".

An overview of the word frequency analysis is provided in Fig. 2, where the more frequently used emotion words appear in larger text.

5. Discussion

So, is there a wildlife tourism benefit for the community and how has this manifested? From our results, it is clear that the presence of beavers on the river near to this village has certainly had impacts for the local community which have largely been beneficial. Here we provide discussion of how beaver presence related to footfall and the benefits that were derived by local businesses. We will then look at indirect interactions between beaver-tourism and other local issues, and provide some indicative insight into the emotional responses to seeing beavers or signs of their activity.

5.1. An increase in footfall

Our data demonstrates that there is an association with increase in footpath usage and visitors to the village resulting from beaver presence. The data from the footpath counters showed a reduction in counts which correlated with when the beavers became absent near to the footpath (Table 3). It is important to recognise the limitation that there may have been other variables contributing towards this reduction in footpath counts which we cannot assess from our data, such as for example if there were unrelated local events or variations in the weather. However, other results presented in this paper lead us to suggest that beaver presence contributed towards riverbank footpath use: 93 % of mail-return questionnaire respondents related a perceived increase in visitor number to beaver presence (at least in part, with 34.9 % wholly attributing this to beaver presence); two of three business interviews attributed a perceived increase in visitors towards beaver presence (with the third reporting an increase which they were unsure whether it was due to beaver presence or not); residents in the local community - who predominantly use the river for walking or viewing wildlife (Fig. 1) - indicated that the presence of beavers had influenced their use of the River Otter near the village, with some citing that this was to view beavers or signs of their activity. (As an additional anecdotal note, the lead researcher often witnessed groups of beaver-watchers on the riverbank). Therefore, by triangulating these results we conclude it is likely that the number of people using the footpaths was significantly higher as a result of the presence of beavers near to the village.

5.2. Economic benefits exist but are greatest with business initiative

For the local businesses, the increase in footpath users they perceived was reported to have been economically beneficial in respect to an increase in revenue generated by increased customer numbers. All three businesses reported an increase in visitors leading to an increase in custom, although B2 was unsure whether this was attributable to beaver presence. This perceived impact is echoed in the community questionnaire as (although many respondents indicated that they would not spend money in local businesses due to their residency in the area) a proportion of respondents indicated that they would spend money in a range of local business types as part of a 'beaver-watching' experience,

Fig. 2. Overview of word frequency analysis of emotion words (including stemmed words) used by respondents to the mail-return questionnaire to indicate how they felt upon seeing beavers or signs of their activity.

including the main business types in the village. We propose therefore that the beaver-watching riverbank users provided some economic benefit for local businesses. This finding is similar to that reported by the Scottish Beaver Trial that local tourist and retail operators were generally favourable of the tourism-related value of the trial (Moran & Lewis, 2014).

Based upon the interview responses (Table 2), the business that reported the greatest benefit (B1) stated that they had profited well from sales of beaver-related merchandise and events, as well as the fact that they had incorporated beavers into their business marketing.

"It's become for us a unique selling point".

The benefits for this business even extended so far as to successfully be awarded funds to develop new toilet facilities on site as a result of an application which included reference towards increased visitor numbers due to 'beaver-watching'. As such, this business had actively sought to maximise the opportunities that were available due to beaver presence. Conversely, B2 had reported a lesser benefit as they had intentionally not undertaken many beaver-related initiatives as: "We try not to compete with [B1]", though they did indicate that they were considering the potential. As such, we suggest that the potential tourism benefit that may be derived from beaver presence will be greatest where businesses actively undertake initiatives to be able to maximise it (with the examples in this case study being beaver-related products, merchandise, events and marketing), and that the benefits from reintroduction will be more limited where this is not the case. Similarly, in the socioeconomic monitoring report from the Scottish Beaver Trial it was stated that the potential economic benefit reported by the Campbell analysis (Campbell et al., 2007) may be flawed as "companies may not actually offer tours" (Moran & Lewis, 2014). Further, a need to actively use initiatives to maximise the opportunity is perhaps reflected by the respondent from B1 who stated: "I think potentially what does need to happen is it needs to be upsold to visitors because people are genuinely interested", showing how this business has recognised the economic potential and, by using the phrase "upsold to visitors" they identified the benefit would be greater where there is business input to take advantage of it.

5.2.1. Business initiatives may account for temporal variation in animal activity

Bearing in mind the aforementioned assumption about the factors contributing towards the difference in footpath counter data, it is notable that when the beavers were absent there were fewer footpath users. It could therefore be assumed that there may be temporal variation in the impact of beavers for local businesses based upon when beavers (or signs of their activity) are present within a publicly visible vicinity; i.e. if there are no beavers to view then there will be fewer beaver-watchers undertaking expenditure in a local business. However, B1 indicated they had not seen much difference in the benefit for their business between when beavers were present or absent as they had used beavers in the business marketing in such a way as to say they are on the river, rather than based upon activity in the immediate vicinity:

"I would say that the majority of visitors wouldn't have a clue, without being disrespectful, whether [beaver activity's] increased or decreased. […] that's a marketing element on our part as well, as far as we're concerned beavers are on the River Otter […]. Whether they happen to be gnawing on a tree there or a mile upstream doesn't really affect us".

Again therefore, we suggest that business initiative here has actively unlocked the potential economic benefit arising from beaver tourism by incorporating beaver presence upon the river within their marketing, rather than passively relying upon beaver presence in the immediate vicinity to bring custom.

5.2.2. Are the economic benefits sustainable in the long-term? A focus for future research

At the time of this study, the free-living beaver population on the River Otter was small and local to the river. They are the first official free-living population within England and an element of the beaver tourism may therefore result from their new or 'novelty' value, particularly amongst visitors to the village. Indeed, the River Otter beavers have attracted national media coverage (Crowley et al., 2017) which B1 referenced had led to some increase in visitors' custom (and custom from the journalists themselves):

"When there was quite a lot of press at one point […] we did see higher numbers and certainly there was more people talking about it. […] There's been various TV people turn up here to be filmed out there."

Now that the beavers are to be allowed to remain, it would be an interesting point of further research to examine if this scale of benefit is to remain too, or whether the potential benefits will reduce over time and as the species becomes more widespread. This was a factor which was referred to by 29 people in responses to the aforementioned nationwide attitudinal questionnaire (Auster et al., 2019). We speculate that there may, at the time of writing, be some localised benefit attached to the 'newness' of beavers, as demonstrated by B3:

"Overall, where else can you go in the UK and say 'I've got beavers half a mile up the road'? Not many other places!"

It may be that the scale of benefit reduces over time, but for two reasons we believe there are reasonable grounds to assume that some benefit would still be observed as beavers become more widespread. The first is that, as we have identified, the degree of benefit is related to the initiatives undertaken by the businesses. As such, business initiatives may too be able to address a potential reduction in benefit over time. Indeed, this potential decrease in benefit was recognised by B1, but they were prepared for this and indicated that the beavers were part of a wider business ethos about engaging with nature.

"I suppose the problem would be that if there's beavers in everybody's back garden, the uniqueness of having them here will have less of a pull. […] as far as we're concerned that may be inevitable. […] But that wouldn't be something that we'd still not promote because of the nature of the business that we are […], so the whole sort of ethics of what we're about is quite in sync with nature."

The second reason is that wildlife tourism is a growing and important industry for the United Kingdom (Natural England, 2014). Between March 2018 and February 2019, it is estimated there were nearly 4 billion visits to the natural environment amongst the human population (1.7 visits per person per week), and 4 % of these visits were to view wildlife (other reasons include, for example, walking, dog-walking, eating or drinking, playing with children, running – amongst others) (Natural England, 2019). Wildlife tourism in the UK is often focused upon already widespread native species. For example, the grey seal (*Halichoerus grypus*) is common throughout Britain yet attracts large numbers of annual seal-watching tourists (Curtin, Richards, & Westcott, 2009). Thus, we suggest that a potential for beaver tourism would remain as they become more widespread (even if not quite to the same extent as at first in the localised reintroduction site). This is particularly due to their charisma and natural environment-creating behaviours which make them a prime candidate for wildlife tourism initiatives as discussed in the above (Campbell et al., 2007; Curtin, 2010; Hall, 2019; Newsome et al., 2019; Reynolds & Braithwaite, 2001), as well as the fact that beaver tourism is seen on the European continent where beavers already reside (Campbell et al., 2007; Macdonald et al., 1995; Rosell & Pedersen, 1999).

5.3. There can be interactions between wildlife tourism and local community issues

It is important to note however that, in the community questionnaire, there were other factors with which the increase in visitors were related that were less positively viewed. Predominantly these were an increase in traffic and parking issues in the village, which were often associated with other variables rather than the beavers. Hence, we believe it should be recognised that potential benefits in tourism can have indirect interactions with other local issues (Hall, 2019). In this case traffic issues were often related to other factors unrelated to beaver presence. We therefore suggest it is not necessarily the responsibility of reintroduction practitioners to tackle traffic issues directly, however where there are indirect relationships with such matters these may require attention when considering reintroduction-related business initiatives. An example of such consideration was observed in this case study as B1 undertook the development of new toilet facilities to respond to increased visitor numbers.

Similarly, it should be noted that potential tourism benefits may interact with potential conflicts elsewhere with a reintroduced species. In the case of beaver reintroduction, it has been recognised that those who benefit (eg. in tourism) may not necessarily be the same as those who incur the costs (eg. agricultural impact), and that addressing conflicts in a holistic management strategy may enable the maximisation of potential opportunities (Auster et al., 2019; Brazier et al., 2020; Gaywood, 2018). It is a possibility to consider that tourism beneficiaries could have a supporting role to play in conflict alleviation within such a holistic strategy. For one example, revenue generated through tourism could support the costs of coexistence with the wildlife species (Nyhus, 2016). If something on these lines were to occur in instances of reintroductions it will be important to ensure equitable outcomes for those involved, perhaps through localised management of coexistence compensation funds (Jordan, Smith, Appleby, Eeden, & Webster, 2020).

5.4. Positive emotions resulted from seeing the animal or signs of their activity

Finally, many residents indicated that they tried to see beavers and our data indicates that the presence of beavers on the River Otter near to the village was largely seen favourably amongst the community. 93 % of residents who answered the question indicated they had seen beavers or signs of their activity, and our word frequency analysis (Fig. 2) indicates that the majority of the reported feelings experienced as a result of this were positive. It is increasingly recognised that time spent viewing wildlife and engaging with nature evokes positive emotional responses (Curtin, 2010; Natural England, 2019), and emotional responses such as these have been widely demonstrated to be beneficial for the mental health of the observer (Grinde & Patil, 2009; Lackey et al., 2019; Martin et al., 2020; McMahan, 2018). As a result, positive emotions can be an effective way of increasing nature connectedness and enable people to learn about the environment (Martin et al., 2020; Natural England, 2020), which in turn can incentivise pro-environmental behaviours (Apps et al., 2018; Newsome et al., 2019). Our results indicate a positive emotional response to seeing the beavers or signs of their activity amongst the majority of local residents, thus it is likely that experiences of this kind may contribute towards benefits in mental health and nature connectedness for those individuals. Now the beavers are allowed to remain, such opportunities for people to see them or signs of their activity are likely to increase as they become more widespread.

6. Conclusions

We conclude there was an observed benefit for the local community resulting from beaver presence on the nearby river, and our findings have a number of implications that are transferable for other reintroduction and wildlife tourism contexts.

Economic benefits resulted from an increase in visitors to see beavers, spending money in local businesses. The economic benefit was greatest where businesses actively sought to maximise the opportunity. Hence - and whilst recognising the need for careful management to protect animal welfare (Moorhouse et al., 2017; Usui, 2019) - we suggest active encouragement by reintroduction practitioners for businesses to undertake initiatives relating to the reintroduced species (eg. merchandise, events and use in marketing, etc.). This will help realise and maximise reintroduction-related wildlife tourism opportunities, especially where reintroduction practitioners cite tourism potential as a motivator for the reintroduction to occur. Further, we suggest active uptake of this socio-economic opportunity through business initiatives may help to maintain benefits in the longer term as a species becomes more populous and widespread, even if not to the same scale of localised benefit as first seen at the reintroduction site; we recommend this as a field for further research.

However, we note there may need to be consideration of other potential local issues and challenges which may be contributed towards (whether directly or indirectly) in the uptake of the new wildlife tourism opportunity. These will require engagement with appropriate stakeholders if they are to be addressed (Hall, 2019).

Finally (and as is supported in the wider literature (Curtin, 2010; Lackey et al., 2019; Natural England, 2020), our findings suggest the new wildlife-watching opportunities resulting from the reintroduced species may invoke positive emotions amongst those who see the reintroduced species or signs of their activity. This may lead to benefits for mental health and an increase in connectedness with nature, which in turn can lead to those individuals undertaking pro-environmental behaviours.

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Declaration of Competing Interest

The authors have no competing interests to declare.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jnc.2020.125920.

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Chapter 6. Beavers and Flood Alleviation: Human perspectives from downstream communities

The following paper forms the sixth chapter of this thesis. It is presented in the format in which it has been submitted for review in accordance with the selected journal's guidelines, with all references included at the end of the chapter in publication format, followed by the Figure and Tables.

This paper is the second of the two studies which investigate potential areas of social benefit associated with beaver reintroduction. This paper details a Q-Methodology study of perspectives held among human communities living downstream of beaver sites of the role of beaver in Natural Flood Management.

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Beavers and Flood Alleviation: Human Perspectives from Downstream Communities

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Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Data Availability

The anonymised Q-Sort data is available at: https://github.com/exeter-creww/Auster-Barr-Brazier_Beavers-and-Flood-Alleviation_Q-Sort-Data

Abstract

Natural flood management (NFM) methods work with natural processes to achieve a reduction in flood risk, while often providing additional multiple benefits such as water quality improvement or habitat provision. Increasingly, the activity of an animal – beavers – is recognised to potentially provide flow attenuation, along with multiple benefits for the environment and society, but there can also be associated challenges. We use Q-Methodology to elicit and understand human perspectives of beavers and their potential role in flood management among communities living downstream of beavers at three sites in England (Cornwall, Yorkshire, and the Forest of Dean). This is the first time a study has focused on downstream communities as the primary stakeholders. We identify diverse perspectives that exhibit a range of value judgements. We suggest a catchment-based approach to beaver management and public engagement may facilitate deeper recognition of contextual perspectives in decision-making and enable knowledge dissemination with communities. Further, we examine the relationship between beavers and other NFM methods through these perspectives. In doing so we identify features that relate to the unique element of relying on decisions made by individuals of another species in beaver-related flood management, rather than human flood managers being the primary decision-makers.

Keywords

Eurasian beaver; flood risk; human dimensions; natural flood management; perceptions; public engagement; Q-Methodology; reintroduction

Introduction

In recent decades, reports of flooding and ensuing economic losses have increased globally (Kundzewicz et al., 2014), and notably in countries such as the UK, where flood events are projected to increase due to climate change (Dadson et al., 2017). Furthermore, hydrological catchments have been vastly altered by human activity, leading to increases in run-off and high-water flows (Brown et al., 2018; Hewett et al., 2020; Keesstra et al., 2018). Consequently, vast economic expense has been allocated towards intervention and response. For example, the UK Government allocated £815.4million for flood and coastal erosion risk management in England in 2019/20 (DEFRA, 2019).

Natural Flood Management (NFM) is where measures work with natural processes in the landscape (as opposed to conventional human engineered interventions) (Ellis et al., 2021; Lane, 2017). For example, natural features can be restored to re-establish ecological functions, such as in-channel woody debris to slow water flows (Short et al., 2019). NFM can occur on the catchment scale and alter flow regimes (Hewett et al., 2020), or can be a cost-effective approach locally (Wilkinson et al., 2014). NFM is often cited as a sustainable approach to flood management, with lower levels of ongoing management resource required (Keesstra et al., 2018; Lane, 2017) and delivering other multiple benefits such as water quality improvement and habitat restoration (Hewett et al., 2020; Keesstra et al., 2018; Thompson et al., 2018). Recognition of multiple benefits afforded by NFM has been growing in recent years, including by government bodies in the UK (Burgess-Gamble et al., 2017).

Public and stakeholder engagement and involvement is important in the delivery of conventional flood interventions or NFM (Maskrey et al., 2016; Short et al., 2019; Waylen et al., 2018). Without it, there can be barriers to implementation (Eden &

Tunstall, 2006; Waylen et al., 2018). Challenges include effectively communicating scientific knowledge or motivating publics to participate (Barr & Woodley, 2019; Buijs, 2009; Henderson, 2020; Waylen et al., 2018). When engagement is insufficient, controversy can arise, such as when publics disagree with scientists about the basis for decision-making (Barr & Woodley, 2019). However, successful engagement can lead to consensus solutions and local support (Wilkinson et al., 2014).

Recently, the activities of beavers have been suggested to play a role in NFM (Brazier et al., 2020b; Puttock et al., 2017, 2020; Westbrook et al., 2020). North American beaver (*Castor canadensis*) and Eurasian beaver (*Castor fiber*) are similar species of semi-aquatic rodents. They modify landscapes through unique tree-felling, dam-building, and burrowing behaviours (Brazier et al., 2020b; Larsen et al., 2021). Beaver dams push water sideways onto floodplains, thus storing water and reducing flow rates downstream in high rainfall events, contributing towards reduced fluvial flooding downstream (Puttock et al., 2020; Westbrook et al., 2020). By storing water, dams also help maintain base flows during drought (Brazier, et al., 2020b; Hood & Bayley, 2008).

In Eurasia, Eurasian beaver populations (herein referred to as beaver) were diminished by human hunting and landscape change, but have now recovered across much of their historical range from both natural spread and human-led reintroductions (Gaywood, 2018; Halley et al., 2020). In England, beavers were resident until approximately 500 years ago and are being reintroduced. Between 2015 and 2020, a free-living population was monitored on the River Otter in Devon (south-west England) in a reintroduction trial called the River Otter Beaver Trial (ROBT) (Brazier et al., 2020a; River Otter Beaver Trial, 2019). There are also several fenced reintroduction projects - three are described under ‘Study Sites’. Beaver reintroduction is devolved to UK nation governments; beavers are now legally protected in Scotland following a reintroduction trial (Coz & Young, 2020; Gaywood, 2018; Tayside Beaver Study Group, 2015a), and in Wales a beaver family were released under licence to an enclosure at Cors Dyfi Nature Reserve for a monitored project in March 2021 (Wildlife Trusts Wales, 2012).

In August 2020, UK Government announced the River Otter beavers may remain permanently, with consultations due on a national approach to reintroduction and management (UK Government, 2020). Science contributing towards this decision includes evidence of flow attenuation impact of beavers, which is of particular interest due to projected increases in UK flood risk (Brazier et al., 2020a; Dadson et al., 2017; Graham et al., 2020). Other factors include benefits for biodiversity (Law et al., 2019; Nummi & Holopainen, 2020; Stringer & Gaywood, 2016), water quality (Puttock et al., 2017, 2018), and wildlife tourism (Auster et al., 2020c; Campbell et al., 2007). However, there is potential for conflict with agriculture and land-ownership which will require a management framework to support those negatively affected (Auster et al., 2020b; Brazier et al., 2020b; Campbell-Palmer et al., 2016; NatureScot, 2021a; 2021b; River Otter Beaver Trial, 2019; Schwab & Schmidbauer, 2003; Ulicsni, et al., 2020). Additionally, there are diverse opinions regarding beaver impacts upon fish (Auster et al., 2020a). Research here continues, although existing literature suggests varied but net beneficial effects (Bouwes et al., 2016; Brazier et al., 2020b; Bylak & Kukuła, 2018; Kemp et al., 2012; Malison & Halley, 2020).

Considerations on impacts for society and engagement with publics are key in reintroductions, as recommended by the International Union for the Conservation of Nature (IUCN & SSC, 2013). Accordingly, such evidence was gathered for both the

ROBT and the preceding Scottish Beaver Trial (Brazier et al., 2020a; Devon Wildlife Trust, 2017; Gaywood, 2018; Jones & Campbell-Palmer, 2014). Research efforts engaged with various publics, including the general public nationwide (Auster et al., 2020d; Scott Porter Research and Marketing Ltd, 1998) and stakeholder groups such as: anglers (Auster et al., 2020a; Beaver Salmonid Working Group, 2015); local land/property-owners including those who reported conflicts with beavers (Auster et al., 2020b; Scottish Beaver Trial, 2007; Tayside Beaver Study Group, 2015b); and businesses and community residents that experienced beaver tourism (Auster et al., 2020c; Moran & Lewis, 2014). Perspectives of beavers and their role in flooding have been considered within these works; however, these studies had primary focuses elsewhere. As the potential role of beavers in NFM is influential, and as NFM requires public engagement, knowledge of community perspectives towards beavers as flood managers is required.

This study seeks to understand perspectives towards beavers and their role in NFM amongst some of the first communities to live downstream of beaver sites in modern-day England (where flow attenuation has been observed, Puttock et al., 2020). This is the first time a study has taken such a focus with the downstream community as focal stakeholders. As beaver presence in modern-day Britain is a new concept for many people, we employ an exploratory method designed to elicit an understanding of perspectives that exist within this context: Q-Methodology. We will first describe this technique and provide insight into the study sites. We then detail the perspectives we identified and discuss the implications of our findings for beavers and NFM.

Methods

Q-Methodology seeks to understand participant views within a context, using a systematic approach and semi-qualitative analytical procedure (Eden et al., 2005; Zabala & Pascual, 2016). Q originated in the psychological sciences and is increasingly used to explore discourses in environmental issues (Crowley et al., 2020; Ockwell, 2008; Zabala et al., 2018; Zabala & Pascual, 2016). It does not seek to understand prevalence of perspectives across society, but instead aims to develop deep understandings of subjectivities or shared viewpoints that exist (Auster et al., 2020a; Eden et al., 2005; Watts & Stenner, 2012). It can therefore be used with a small number of participants (Auster et al., 2020a; Watts & Stenner, 2012; Zabala et al., 2018). For respondents, the process involves sorting several statements (the “Q-Set”) and ranking them in relation to one another (producing a “Q-Sort”). In analysis, Q-sorts are compared to one another holistically and reduced to a few “factors” for interpretation. A factor is a representative response shared by multiple participants (Watts & Stenner, 2012; Zabala et al., 2018).

Q-Set Development

Statements were developed using a combination of researcher experience and literature review. The research team comprised of individuals experienced in the field of beaver reintroduction regarding human dimensions and hydrology. Two members recently worked on a literature review of beaver impacts on hydrology, geomorphology, and human-beaver interactions (Brazier et al., 2020b). The statements were developed with this knowledge.

The Q-set was limited to 34 statements to provide adequate topic coverage, whilst minimising the number of statements for participants to sort; we intended sorting to be interesting rather than onerous. Statements were written to elicit participant responses of agreement or disagreement to aid sorting procedure. Statements primarily focused upon beavers and flooding, but included other matters related to beaver reintroduction (such as impacts upon agriculture, fish, and tourism). Three internal colleagues - also with experience in beaver reintroduction and hydrology - reviewed the Q-Set for clarity and subject coverage prior to distribution. The final Q-set is represented in Table 1.

Participants

We recruited participants from communities living downstream of three beaver sites. These were fenced projects undertaken at least in part to attenuate flooding (Puttock et al., 2020).

Ladock

Ladock is a village in mid-Cornwall, south-west England. During the last census, there were 1513 residents (673 households) in the parish, with an average age of 40.4 years (Office for National Statistics, 2011a). Ladock has experienced multiple flood events, including three which flooded 13-20 properties in 1979, 1993 and 2012 (Cornwall Council, 2011, 2012).

In June 2017, a pair of beavers was released in an enclosure upstream in the Cornwall Beaver Project, led by Cornwall Wildlife Trust. By 2020, the beavers had created “7+ dams in addition to damming and raising the water level in a pre-existing pond’ (Puttock et al., 2020). For more information see Cornwall Wildlife Trust, 2021.

Sinnington

Sinnington is a village in Yorkshire, northern England. During the last census, there were 287 residents (164 households) in the parish, with an average age of 53.2 years (Office for National Statistics, 2011c). Sinnington has experienced historical flooding, including events in 1999, 2000 and 2007 (Environment Agency, 2007; North York Moors National Park Authority, 2017).

In April 2019, a beaver pair were released into an enclosure upstream in a project led by Forestry England. Prior to release, several timber bunds were placed across the channel for NFM. By 2020, there was no recorded interaction between beavers and the bunds, and the beavers had built 3 dams (Puttock et al., 2020). For more information see Forestry England, 2021b.

Lydbrook

Lydbrook is a village in the Forest of Dean in Gloucestershire, western England. During the last census, there were 2192 residents (1008 households) in the parish, with an average age of 42.4 years (Office for National Statistics, 2011b). Lydbrook has experienced multiple flood events, including in 2000, 2007 and 2012 (Environment Agency & Natural Resources Wales, 2015; Gloucestershire County Council, 2014).

In July 2018, a beaver pair was released into an enclosure upstream in a project led by Forestry England. The beavers were removed in May 2019 though their dams prevailed, and a new pair was released into the same enclosure in August 2019. By 2020, the beavers had created 3 dams (Puttock et al., 2020). For more information see Forestry England, 2021a.

Recruitment

In response to Covid-19 pandemic circumstances, participants were recruited remotely through online methods (avoiding face-to-face contact). We used purposive recruitment methods by contacting each Parish Council and community newsletters with a request to advertise the invitation, by requesting each of the beaver projects share the invitation within their networks, and by advertising the study in community Facebook pages. Data collection was open from August 3rd 2020 until 4th January 2021.

Thirty-nine community members participated, thirteen from each location (Table 2). There were 22 female and 14 male participants (three preferred not to specify gender). Of those who indicated their birth year, the average age was 59 (range 33-75).

All participants had seen beavers or signs of their activity on the television, internet or similar, and 27 had seen them in person, whether locally or elsewhere. Thirty participants had personally experienced the effects of flooding, with five in Ladock, eight in Sinnington and nine in Lydbrook having experienced it within those respective communities.

Q-Sort Process

Q-Sorting was undertaken online only (due to Covid-19 circumstances) using HTMLQ, an open-source software package (aproxima Gesellschaft für Markt- und Sozialforschung Weimar, 2014). Three internal colleagues piloted the study.

Participation took 24 minutes on average (range 7-79 minutes. 82% took <30 minutes). Upon opening the webpage, the study information was presented (Supporting Information). Notably, this highlighted the voluntary and anonymous nature of participation. Participants were informed that clicking 'Continue' would signify they had read and agreed to this information.

In Step 1, participants were presented with each Q-Set statement in turn (in randomised order) and required to sort them into three piles: Agree, Disagree or Neutral. This aided Step 2, where participants sorted statements into the Q-Sort matrix. Here, participants ranked statements in relation to one another between a score of +3 (statements most agreed with) and -3 (statements least agreed with). The matrix was of fixed, quasi-normal distribution to facilitate sorting (Figure 1). To help interpretation, Step 3 gave opportunity for participants to comment on why they agreed or disagreed with statements to which they assigned scores of +3 or -3. We then asked questions regarding respondents' backgrounds (Table 2) and gave opportunity to provide additional comments.

A Note for Future Researchers

We here note a technological limitation to assist future online Q-Methodology researchers. No technological issues were identified in piloting; however, late in data collection some participants reported software issues when using alternative devices (eg. Smartphones, tablets). These are more widely used now than when HTMLQ was developed. We recommend future HTMLQ studies highlight sorting should be completed on a desktop, or that there is investment in updating or developing open-access software packages, compatible with different devices.

Statistical Analysis

We used Ken-Q Analysis for statistical analysis (Banasick, 2019). Factors (shared perspectives) were extracted using centroid analysis and Varimax rotation. This standardised approach explains mathematically the maximum amount of variance in the data (Watts & Stenner, 2012, p122-126). As is often the convention, factors were retained when Eigenvalues were greater than one and at least two Q-Sorts significantly loaded onto (statistically correlated with) a factor (Watts & Stenner, 2012, p105-107). Confounded Q-Sorts (which load onto multiple factors) were excluded (Watts & Stenner, 2012, p143; Armatas, et al., 2014).

Six factors were extracted, explaining 68% of variance in the data (Table 3). (Q-Method is a data reduction technique and remaining variance is explained by factors which did not meet the above criteria to be retained (Watts & Stenner, 2012, p98-99)). Thirty-four Q-Sorts loaded onto the extracted factors. Factor arrays (single representative Q-Sorts) were generated using weighted average Z-scores, presented in Table 1.

Interpretation

We followed the systematic interpretation method suggested by Watts and Stenner (2012, Chapter 7). This evaluates: statements given highest or lowest scores; items sorted higher or lower than on other factors; a review of the remaining factor array for other important statements; comments of participants whose Q-Sorts loaded onto each factor. This interpretation method means each statement is engaged with at least once and allows statements of importance to be identified in a data-driven manner.

Identified Factors

Here, we outline the extracted factors. Throughout, we reference key statements in parentheses with the formula: (statement number, corresponding score in the composite sort). Where appropriate, illustrative participant comments are provided.

Factor 1 ("Pro-beaver, eco-centric")

Sixteen sorts loaded onto this factor, including five respondents from Ladock (Lad2, Lad5, Lad7, Lad12, Lad13), six from Sinnington (Sin1, Sin5, Sin7, Sin8, Sin10, Sin13), and five from Lydbrook (Lyd6, Lyd8, Lyd10, Lyd11, Lyd13). Thirteen participants had personal experience of flooding, and twelve had seen beavers or signs of their activity in person. The factor explained 25% of the variance.

This factor strongly agreed flood management measures should work with nature (2, +3) and help to restore natural environments (10, +3).

> *"I think it's imperative that flood management works with nature, particularly at this critical time of climate change."* -Lyd6

> *"any measures which work against nature do tend to create more problems for the environment than they solve. Flood management which can work with nature is a win-win situation."* -Lyd8

The factor agreed more than the others that flood management measures must also benefit wildlife (8, +2) and strongly agreed beavers would provide such a benefit (1, +3).

> *"*[Beaver] *habitats create a natural dam to slow the flow of water in heavy rains and floods, thereby retaining water and protecting other habitats. Their dams also clean the water and their wetland habitat is a beneficial addition to the environment as it attracts a variety of other wetland wildlife."* -Lyd6

The factor disagreed more than others that beavers would not build dams where flood management is needed (11, -2), and strongly disagreed with a preference for human engineered flood management techniques to natural methods (25, -3).

> *"Human methods have been seen to repeatedly fail, unless we learn from nature and mimic the natural world".* -Lyd6

> *"Human interventions should complement natural methods."* -Lyd11

The factor felt beavers should be in England (9, +2).

> *"Historically, [beavers] were part of our natural environment".* -Lad5

It believed beavers would help to reduce erosion (32, +2) and agreed more than other factors that beavers would improve water quality (28, +1). The factor was not worried beavers lived nearby (15, -3) and did not feel beavers would damage human infrastructure (23, -3).

> *"Simple land management steps could be taken to ensure successful co-habitation."* – Lad5

> *"I'm happy, even proud, to have beavers living close by."* – Lad7

It did not feel beavers would cause problems for agriculture (6, -2) and did not feel humans had altered the landscape too much for beavers (30, -1). The factor did not express strong feeling about the involvement of local communities in beaver management (13, 0) or potential for beaver tourism (29, 0), but these statements scored more negatively relative to their placement in other factors.

Factor 2 ("Anti-beaver, anthropocentric")

Five sorts loaded onto this factor, all of whom lived in Ladock (Lad3, Lad8, Lad9, Lad10, Lad11). Three participants had personal experience of flooding, and all had seen beavers or signs of their activity in person. The factor explained 13% of the variance.

This factor strongly felt human-built flood measures would be more reliable than beaver dams (17, +3) and that wild beavers would not build dams where flood management is required (11, +3).

> *"Man-made flood measures are predictable and work where they are required. Beavers are unpredictable. Beavers can flood river courses in the wrong areas, eg below/downstream from houses which can result in worse flooding."* -Lad10

Compared to other factors, it agreed more that beavers would damage human infrastructure (23, +1) and cause problems for agriculture (6, +1).

> *"If beavers dam up water courses downstream of properties they can cause flooding."* -Lad8

The factor felt it had knowledge of beavers (4, -2) but was worried beavers lived nearby (15, +2) and was not pleased there were beavers upstream of their property (7, -2).

> *"If they get out and find their way down [from] the village i am afraid [they] will build their dams there and the village will be flooded again."* -Lad11

The factor indicated it would not enjoy seeing beavers (22, -1) or visiting a beaver wetland (14, -1). Although thinking beavers may improve water quality (28, +1), the factor strongly disagreed that beavers were beneficial for the environment (34, -3) or for people (33, -3) overall. It did not feel beavers would benefit local businesses (18, -1) and strongly felt management costs would outweigh benefits of beavers (12, -3).

> *"They only benefit some people, not everyone. They should be contained in enclosures, but if not they must be managed to prevent damage, irrespective of the cost."* -Lad8

The factor thought beavers should not be allowed to roam wild (26, +2), and felt strongly that, if beavers were in an area, there should be support available for people who experience negative beaver impacts (31, +3).

> *"If the beavers flood the river downstream of the village it will negate all of the work the environment agency has done and will result in our houses being flooded again. Before* […] *the work we couldn't get insurance or sell our houses. We don't want to go back to that situation again. If it should happen because of beavers then we must be compensated for it."* -Lad11

The factor disagreed more than others that flood management measures should work with nature (2, -1) and preferred human engineered flood management techniques to natural methods (25, +2).

"It [human engineered techniques] is predictable." -Lad3

Factor 3

Three sorts loaded onto this factor, all of whom lived in Lydbrook (Lyd1, Lyd4, Lyd7). All had personal experience of flooding within Lydbrook and had seen beavers or signs of their activity in person. This factor explained 13% of the variance.

This was a bipolar factor - a factor whose loadings have both positive and inverse correlations with the composite sort (Watts & Stenner, 2012, p165). One Q-sort (Lyd7) positively correlated, and two (Lyd1, Lyd4) inversely correlated with the factor. These are "distinct but connected viewpoints" (Watts & Stenner, 2012, p166), so we provide separate 'twinned' interpretations (Watts & Stenner, 2012, p165-166).

Positive Correlation ("Pro-beaver, economy-focused")

The factor strongly agrees beavers would be good overall for the environment (34, +3).

"They are a keystone species." -Lyd7

It believed water stored behind beaver dams would be useful in periods of drought (3, +2) and beaver activity would improve water quality (28, +1). The factor strongly felt they would enjoy seeing beavers (22, +3) and there is a potential for beaver tourism (29, +3). It indicated it would enjoy visiting a beaver wetland (14, +2) and felt beavers may benefit local businesses (18, +1). The factor strongly disagreed that beavers would have a negative impact on fish (19, -3) or cause problems for agriculture (6, -2).

"They don't eat fish!" -Lyd7

The factor felt beavers should be in England (9, +2) and disagreed most out of all factors that beavers would need to be regularly monitored (27, -2). Similarly, the factor was less concerned than those loaded onto other factors that a wild beaver population would need to be managed (20, -1). The factor strongly felt humans could not build woody dams as well as beavers can (24, -3) and strongly disagreed with the statement that human-built flood measures are more reliable than beaver dams (17, -3).

"Human solutions to flooding are capital intensive and require ongoing maintenance." -Lyd7

Inverse Correlation ("Anti-beaver, impact-focused")

The inverse factor strongly felt human-built flood measures are more reliable than beaver dams (17, +3) and humans could build woody dams as well as beavers can (24, +3).

"Beaver dams will rot." -Lyd1

It strongly felt beavers were not good for the environment (34, -3) and believed more strongly than other factors that beavers would have a negative impact on fish (19, +3). The factor disagreed with the statements that beaver activity would improve water quality (28, -1) or water stored behind beaver dams would be useful in times of drought (3, -2).

[Regarding statement 19] *"Definitely, speaking to fisherman yes[t]erday. They don['t]t want them either especially as all the [Forest of Dean] po[n]ds are artificially stocked."* -Lyd1

It strongly disagreed there would be a potential for beaver tourism (29, -3) and indicated it would not enjoy seeing beavers (22, -3) or visiting a beaver wetland (14, -2). It did not think there would be a benefit for local businesses (18, -1) and felt more strongly than other factors that beavers would cause problems for agriculture (6, +1). The factor did not believe beavers should be in England (9, -2) and felt that, if beavers were present, they would need to be regularly monitored (27, +2) and a wild beaver population would need to be managed (20, +1).

"Seen the damage they do???? Wait til they escape. […] If you let them go there will be problems and then you'll be spending 20 years getting rid of them." -Lyd1

Factor 4 ("Anti-beaver, management-focused")

Two sorts loaded onto this factor, one from Ladock (Lad4) and one from Sinnington (Sin11). Neither had personal experience of flooding, and only Lad4 had seen beavers or signs of their activity in person. The factor explained 4% of the variance.

This factor strongly felt that a wild beaver population would need to be managed (20, +3) and beavers would need regular monitoring (27, +3).

"The only way my concerns would be in some way reduced would be if beavers were put on the general licence for control. The landowner should not have to apply for a licence to control beavers causing problems on their land." -Lad4

"If they are as destructive as I have heard them to be their numbers & effects will need monitoring." -Sin11

The factor agreed more than others that beavers may cause problems for agriculture (6, +1) or damage human infrastructure (23, +1). It believed beavers would not help to reduce erosion (32, -2), and did not believe their activity would improve water quality (28, -1) or benefit local business (18, -1). The factor disagreed more than other factors that beavers would benefit wildlife (1, -1) and agreed with the statement that beavers would have a negative impact on fish (19, +2). This factor strongly opposed beaver presence in England (9, -3) and did not think benefits would outweigh management costs (12, -2). It was not pleased by beaver presence upstream of their property (7, -2).

"England is too small, developed and overpopulated with humans to cohabit with a wild beaver population without a negative impact from tree felling and dam building." -Sin11

If beavers were to be in an area, the factor agreed more than most other factors that beavers should only be in enclosed areas rather than wild (26, +2).

"I think a wild beaver population would take a huge amount of management to constrain their activities where they (and they WILL) cause a problem to river flows, fish passage, tree damage, flooding etc. Once the genie is out of the bottle…" -Lad4

This factor felt local communities should be involved in beaver management (13, +2) and there was strong agreement that there should be support for people who experience negative beaver impacts (31, +3).

[Regarding statement 31] *"This goes without saying in my opinion!"* -Sin11

The factor did not think benefits of flood management must outweigh any management costs (5, -3) and disagreed more than other factors that they should help to restore natural environments (10, -2). However, it strongly disagreed with a preference for human engineered flood management techniques rather than natural methods (25, -3).

> *“Natural would seem better if appropriate.”* -Sin11

Factor 5 (“Pro-beaver, anthropocentric”)

Two Q-sorts loaded onto this factor, one from Sinnington (Sin3) and one from Lydbrook (Lyd3). Both had personal experience of flooding within their respective communities, but only Lyd3 had seen beavers or signs of their activity in person. The factor explained 6% of the variance.

The factor was the most pleased of all to have beavers upstream of their property (7, +3) and was not worried that beavers lived nearby (15, -3).

> *“I think it[’]s a great idea having beavers upstream and helping to slow the flow”.* -Lyd3

It did not agree beavers should be in enclosed areas rather than wild (26, -2) and felt beavers should be in England (9, +2). More-so than other factors, it believed beavers were good for people overall (33, +2) and the benefits of beaver outweighed management costs (12, +3).

> *“it[’]s a natural solution to the flood risk – can’t believe management costs would be prohibitory; seems like a worthwhile investment”.* -Sin3

The factor disagreed more than others that a wild beaver population would need to be managed (20, -1) but felt strongly that support should be available for people who may experience negative impacts of beavers (31, +3). Although agreeing more than other factors that humans could build woody dams as well as beavers can (24, +1), this factor strongly disagreed with the statement that human-built flood measures are more reliable than beaver dams (17, -3). It was not worried beaver dams may fail (16, -2) and did not feel beavers would damage human infrastructure (23, -2). Compared to other factors, this factor disagreed more that flood management measures must also benefit wildlife (8, -1), though it agreed flood management measures should work with nature (2, +2) and help to restore natural environments (10, +2). The factor strongly felt flood management benefits did not need to outweigh management costs (5, -3).

> *"Flood management is a key tool in mitigating some of the impacts of climate change. Within reason it costs what it costs".* -Lyd3

Factor 6 ("Pro-beaver, beaver-watchers")

Four sorts loaded onto this factor, two from Sinnington (Sin4, Sin6) and two from Lydbrook (Lyd2, Lyd9). Only Lyd9 had not had personal experience of flooding, but only Lyd9 had seen beavers or signs of their activity in person. The factor explained 9% of the variance.

The factor strongly agreed that it would enjoy seeing beavers (22, +3) and would find it enjoyable to visit a beaver wetland (14, +3).

> *"I enjoy seeing all wildlife in natural settings."* -Sin6

It was not at all worried beavers lived nearby (15, -3) and were pleased they lived upstream of their property (7, +2).

> *"I obviously think it is marvellous that the beavers have been introduced* [upstream]*, and feel confident that they are providing a considerable level of protection from flooding."* -Sin6

Compared to others, this factor felt they knew less about beavers (4, +2) but felt strongly they are good for the environment (34, +3). It did not agree beavers would have a negative impact on fish (19, -2), nor that beavers would cause problems for agriculture (6, -2). It was not worried beavers would carry disease (21, -3).

> *"Never* [heard] *of this as a concern, and very unlikely to come into that close a contact."* -Lyd2

The factor was not worried that beaver dams would fail (16, -2) but did not think water stored behind beaver dams would be useful in times of drought (3, -3).

> *"very rare a drought"* -Sin4

The factor did not feel beavers would damage human infrastructure (23, -2) and disagreed more than others that there should be support for people who may experience negative beaver impacts (31, -1). It agreed more that there would be a benefit for local businesses (18, +1). This factor felt flood management should work with nature (2, +2) and, when compared to other factors, it agreed most that flood management benefits must outweigh any management costs (5, +1).

> *"ANY management of the environment should work with nature".* -Lyd9

Discussion

Using Q-Methodology, we identified a distinct set of perspectives pertaining to beavers and their potential role in NFM, amongst communities living downstream of beaver projects. In this discussion, we first explore the diversity in these perspectives and value judgements made by participants, then look at what the factors tell us about how beavers are perceived when compared to other NFM approaches. We will then investigate the practical management implications of our findings.

Varied perspectives and values

Factors 1, 5, 6 and the positive correlation of Factor 3 were all more favourable towards beavers and agreed with statement 9 ("I think beavers should be in England"). These factors also agreed with statement 7, indicating they were pleased beavers were upstream of their property (+1, +2, +3 and +2, respectively). However, prominent values in each factor varied. Factor 1 exhibited eco-centric values, with a broader perception that flood management measures should work with and for nature and wildlife and held trust in beavers as a flood management measure that would also achieve those environmental goals. Factor 5 agreed flood management should work with nature, but from a more anthropocentric perspective; greater emphasis was placed upon the benefits beavers could provide for people. This factor was pleased to have beavers upstream of their property and saw them as a *"worthwhile investment"* (Sin3).

In Factor 6, the role of beavers in flood alleviation seemed less important and emphasis was instead placed upon participants' enjoyment in the opportunities of seeing beavers and wildlife, with few concerns about negative impacts. The positively correlated interpretation of Factor 3 is similar, however here, the opportunity to see beavers is also linked to tourism potential and perceived benefits to local business; this factor placed value on potential economic benefits.

Factors 2, 4 and the inversely correlated interpretation of Factor 3 however were not favourable towards beavers, with disagreement scores given to statement 9. These participants also disagreed with statement 7, indicating they were not pleased with beaver presence upstream of their property. Again however, the foremost values varied. In Factor 2, emphasis was placed upon a preference for human-engineered flood techniques and a view that beavers would not benefit people or the environment. By reviewing the comments of participants whose Q-sorts loaded onto this factor, it is clear there is a perception that flood risk may increase if beavers were to move downstream. Thus, the factor places value on predictability and the level of human control that human engineered flood techniques would provide, with strong agreement they would be more reliable than beaver dams. Interestingly, all participants whose Q-sort loaded onto Factor 2 were residents in Ladock. Upon further review of the participants' comments, it is possible this may be associated with positive perceptions of human-led flood intervention measures previously implemented in their village; Lad3 and Lad11 both referenced works undertaken by the Environment Agency in Ladock. For example, referring to statement 25 with which Factor 2 exhibited agreement, Lad3 said *"[Human engineered flood management] is predictable. The work that [Environment Agency] have done locally [has] successfully prevented flooding. Beavers cannot be made to build dams where they are needed and they can create flooding if they build dams in the wrong place"*. Factor 4 also expressed the perception that beavers would have negative impacts and did not think these would be outweighed by potential benefits, but emphasis was placed upon potential management requirements, with statements they agreed most strongly with being those concerning needs for monitoring and management.

In the inversely correlated interpretation of Factor 3, potential negative impacts of beavers are again cited, particularly for fish and the environment alongside a preference for human-engineered flood management techniques. Greater emphasis is, however, placed upon disagreement with a potential for beaver tourism, and displeasure is expressed at the possibilities of seeing beavers or visiting a beaver wetland. By reviewing the comments of participants whose sorts loaded onto this factor, it appears this may be linked to wider opposition to species reintroductions, particularly from local contextual experiences of wild boar and pine marten in the Forest of Dean (for more on these reintroductions, please see Bavin et al., 2020 and O'Mahony, 2020). This is particularly so for Lyd1: "*Its heartbreaking that yet more species are being released. Horrible and heartbreaking to see the devastating effect on forest floor without yet more invasive species*. *Sickening.*"

Hence, we have highlighted that not only are there polarised viewpoints on beavers in flood management, but there is observable diversity in values held among communities. These may be associated with local contextual experience (as in Factor 3) but may also associate with different value judgements. For example, whilst both were favourable towards beavers and agreed flood management should work with nature, Factor 1 held eco-centric values on this being for the benefit of the environment whilst Factor 5 held the anthropocentric view of this being an opportunity for people. Consequently, we cannot assume the 'public perspective' is a singular nor that there are simplistic positions of support or opposition towards beavers as a flood management measure. Instead, a much deeper understanding is required that accounts for different perspectives and draws upon understandings of the relationships between beavers, the environment, and society.

Beavers compared to NFM methods

One notable difference between beavers and other NFM methods is clear. Although NFM works with natural processes, in human-modified riverscapes the decisions on where to undertake NFM interventions/restoration are undertaken by humans. With beavers, however, damming location is determined by individuals of another species (though it can be encouraged via placement of Beaver Dam Analogues - see discussion below). Outside enclosures, wild beavers tend to build dams in lower order, upper tributaries, and more marginal reaches of watercourses (Graham et al., 2020). Although these reaches are ideal to deliver flow attenuation benefits for human communities, the impact is delivered by non-human animals, which act without consideration towards flood prevention effects. This is unique in NFM, though might be considered the very definition of working with natural processes (Burgess-Gamble et al., 2017).

The literature recognises beaver presence may bring challenges in some contexts, for example, when water held behind a dam conflicts with agriculture (Auster et al., 2020b; Campbell-Palmer et al., 2015). When examining perspectives on beavers, concerns of negative beaver impacts are observed in factors with more negative opinions towards beavers. This is particularly so for Factor 2 which valued the predictability of human engineered techniques (even though they have not necessarily worked in previous flood years), with participant comments indicating a fear of beaver dams downstream of village infrastructure. Thus, to those with anti-beaver perspectives and anthropocentric values, a reliance on non-human decision-making may feel like surrendering some sense of control in flood management, and a reliance on beavers may seem of higher risk.

To others (e.g. factors 1, 5 and 6), beavers may be seen to provide a new opportunity in flood management, and recent evidence has demonstrated flow attenuation effects at all three study sites (Puttock et al., 2020). Such flow attenuation benefits are commonly seen to be beneficial for people and this was instrumental in the establishment of the three beaver projects in this study; the projects were intentionally developed upstream of communities historically at risk of flooding.

As referenced in the introduction, there is also a commonality between beavers and other NFM methods; beavers provide multiple benefits. In the identified perspectives, this was perceived among factors in both the anthropocentric and eco-centric sense. For example, Factor 1 strongly agreed beavers would benefit wildlife (an eco-centric view) while the positive correlation of Factor 3 strongly agreed there would be a potential for beaver tourism (an anthropocentric perspective). Thus, pro-beaver factors demonstrated agreement in their views that beaver activity may deliver other benefits, but with difference in the values placed upon where these benefits mattered most.

Management implications

Our research has demonstrated how a range of values can be brought to the table by the people in an area. To account for these practically in management of beaver projects and wild populations will require an approach which provides opportunity for localised engagement with communities and stakeholders (Ulicsni, et al., 2020). We argue this is supportive of a catchment-based approach, like that advocated in other NFM approaches (Dadson et al., 2017; Hewett et al., 2020).

This localised approach has been similarly endorsed in the ‘Beaver Management Strategy Framework’ put forward by the ROBT. To achieve this aim, the Framework recommends employment of a catchment-based Beaver Officer as a means of working with local communities and stakeholders to manage beavers and mitigate negative impacts (River Otter Beaver Trial, 2019). In an alternative strategy - though not strictly a catchment-based approach in this instance - beaver management in the state of Bavaria (Germany) is undertaken at a localised level by approximately 500 volunteer consultants located throughout the region, overseen by two state-employed Beaver Managers for all of Bavaria (70,550 km^2) (Schwab and Schmidbauer, 2003).

Further, we identified a perceived concern among some that beavers are unpredictable and may have negative impacts, dependent upon where dams are built. This was exemplified by Factor 2, which valued the predictability of human-engineered flood management methods. Asides from potential management interventions (see Campbell-Palmer et al., 2016 for a summary of techniques), an element of predictability can be applied to beaver populations. Alongside methods of surveying field signs to estimate present beaver population distributions (Campbell-Palmer et al., 2020), computerised models which assess beaver foraging habitat availability and the capacity for damming within watercourses are achievable (Graham et al., 2020; Macfarlane et al., 2017). Although a degree of uncertainty will remain based upon individual animal behaviours (which will need to be made clear), these models make possible a means of predicting likely future beaver impacts at the catchment scale. We suggest localised dissemination of this available knowledge within catchments may reduce predictability concerns and provide some reassurance for concerned individuals.

Additionally, we acknowledge the use of Beaver Dam Analogues (BDA's). These are human-made structures designed to mimic or reinforce natural beaver dams or their function (Pollock et al., 2017; Scamardo & Wohl, 2020). These have been installed to facilitate watercourse restoration in America, with evidence of BDA's being actively maintained by beaver; in a study of stream temperature alteration by natural and artificial beaver dams, 46 BDA's were maintained by North American beavers (Weber et al., 2017). It is also demonstrated that BDA's may assist the establishment of beaver territories by providing 'starter dams' (Beechie et al., 2010; Pollock et al., 2017). In future research, perhaps there is room to explore whether deployment of BDA's could be used to encourage beaver damming activity in locations that provide optimal flow attenuation benefits. Such an approach might address concerns around unpredictability and inspire more confidence in beaver-led flood defence, working with this animal to develop a 'right dam in the right place' strategy.

Conclusion

Beavers are unique in flood management as the only measure that relies upon the activity of non-human animals, rather than upon decisions taken by people. Where the two beaver species are native throughout Eurasia and North America, beavers provide a significant opportunity for natural flood management and climate change resilience (Puttock et al., 2020), but they also provide multiple benefits as well as challenges. This complexity is reflected in the perspectives of communities towards beavers as a flood management measure. To assume the public perspective as a singular would be overly simplistic when, in truth, a community can bring multiple values to the table. Through our research, we demonstrated links can be drawn with various matters in beaver reintroduction and both anthropocentric and eco-centric values.

We argue that more localised management and interaction with publics and stakeholders may facilitate communication between publics and managers, leading to a better understanding of such varied perspectives in each context. This may also facilitate the sharing of available knowledge on habitat modelling and beaver management, which may go some way to reducing a sense of unpredictability and concerns held by some. Future research should consider how the role of animals in natural flood management can be understood in the context of communicating other (non-animal) forms of flood management and the specific challenges that may arise.

In line with some other approaches to NFM, we support the principle of a catchment-scale management approach to beavers and public engagement if and where beaver populations exist as a genuine example of working with natural processes. Finally, we recommend further research into whether Beaver Dam Analogues could help to address concerns of unpredictability by encouraging beaver damming in locations that optimise the potential benefits of beavers in natural flood management whilst minimising the potential conflicts.

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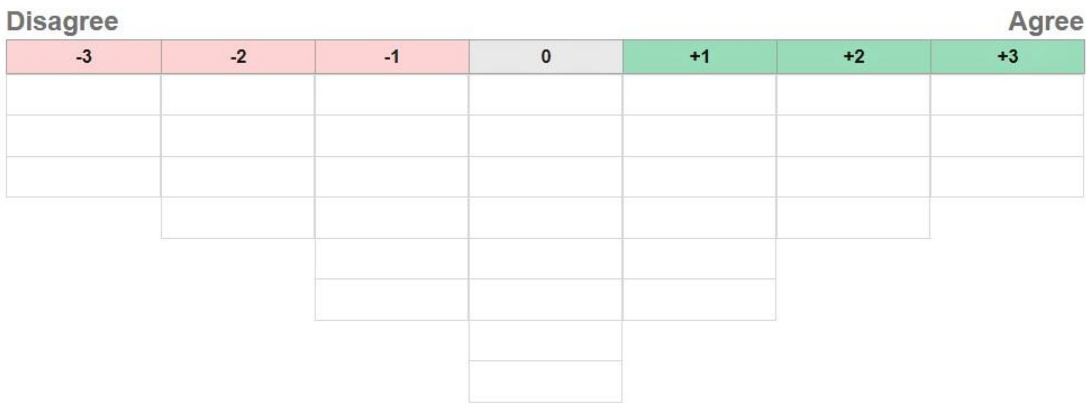
Figures

Figure 1. Example of the Q-Sort distribution matrix (as viewed by participants in HTMLQ).



Tables

Table 1. Statements in the Q-Set and the identified factor arrays (representative Q-Sorts).

	Statement	Factor						Z-Score variance
		1	2	3	4	5	6	
1	I think beavers would be beneficial for wildlife.	3	0	1	-1	1	0	0.583
2	I think flood management measures should work with nature.	3	-1	0	0	2	2	0.518
3	I think water stored behind beaver dams will be useful in times of drought.	0	0	2	0	-1	-3	0.727
4	I don't know much about beavers.	-1	-2	0	1	1	2	0.369
5	I think the benefits of flood management must outweigh any management costs.	0	0	0	-3	-3	1	0.652
6	I think beavers would cause problems for agriculture.	-2	1	-2	1	-1	-2	0.585
7	I am pleased that there are beavers upstream of my property.	1	-2	2	-2	3	2	1.131
8	I think flood management measures must also be beneficial for wildlife.	2	0	-1	1	-1	1	0.435
9	I think beavers should be in England.	2	-2	2	-3	2	1	1.401
10	I think flood management measures should help to restore natural environments.	3	0	0	-2	2	2	0.844
11	I think wild beavers will not build dams where we need to manage flooding.	-2	3	-1	0	0	-1	0.773
12	I think the benefits of beavers outweigh the costs of management.	1	-3	1	-2	3	-1	1.565
13	I think local communities should be involved in beaver management.	0	1	1	2	0	1	0.179
14	I would find it enjoyable to visit a beaver wetland.	2	-1	2	1	1	3	0.688
15	I am worried that beavers live near me.	-3	2	-1	1	-3	-3	1.455
16	I am worried beaver dams may fail.	-1	-1	0	0	-2	-2	0.147
17	I think human-built flood measures are more reliable than beaver dams.	-1	3	-3	-1	-3	-1	1.081
18	I think beavers would benefit local businesses.	0	-1	1	-1	0	1	0.249
19	I think beavers would have a negative impact on fish.	-2	-1	-3	2	-1	-2	0.785
20	I think that a wild beaver population would need to be managed.	0	1	-1	3	-1	0	1.001

21	I worry that beavers would carry disease.	-2	0	-2	-1	0	-3	0.374
22	I would enjoy seeing beavers.	1	-1	3	2	1	3	0.548
23	I am worried that beavers would damage human infrastructure (eg roads, bridges etc).	-3	1	-1	1	-2	-2	0.806
24	I think humans could build woody dams as well as beavers can.	-1	-2	-3	0	1	0	0.449
25	I prefer human engineered flood management techniques to natural methods.	-3	2	-2	-3	-2	0	1.115
26	I think beavers should only be in enclosed areas rather than wild.	-1	2	-1	2	-2	-1	0.964
27	I think beavers will need to be regularly monitored.	0	2	-2	3	0	0	0.907
28	I think beaver activity will improve water quality.	1	1	1	-1	1	0	0.393
29	I think there is a potential for beaver tourism.	0	1	3	0	0	1	0.221
30	I think humans have altered the landscape too much for beavers.	-1	0	0	-1	0	0	0.165
31	I think there should be support for people who may experience negative beaver impacts.	0	3	0	3	3	-1	0.844
32	I think beavers will help to reduce erosion.	2	0	0	-2	-1	-1	0.404
33	Overall, I think beavers are good for people.	1	-3	1	0	2	0	0.887
34	Overall, I think beavers are good for the environment.	1	-3	3	0	0	3	1.066

Table 2. Summary of participant details.

ID	Year of Birth	Gender	"I have visited my local Beaver Project"	"I have visited another Beaver Project"	"I have seen beavers or signs of their activity in another country"	"I have seen beavers or signs of their activity on the television, internet or similar"	"I have never seen beavers or signs of their activity in any way"	Have they personally experienced the effects of flooding?
Lad1	1967	Female	✗	✗	✗	✓		Here
Lad2	1961	Female	✓	✓	✗	✓	✗	Here and elsewhere
Lad3		Prefer not to say	✓	✗	✗	✓	✗	✗
Lad4	1979	Female	✓	✗	✓	✓	✗	✗
Lad5		Male	✓	✗	✗	✓	✗	Here
Lad6	1951	Male	✗	✗	✗	✓	✗	✗
Lad7	1953	Male	✓	✗	✗	✓	✗	Here
Lad8		Prefer not to say	✓	✗	✗	✓	✗	✗
Lad9		Male	✗	✓	✓	✓	✗	Elsewhere
Lad10		Female	✗	✗	✓	✓	✗	Elsewhere
Lad11		Female	✓	✗	✓	✓	✗	Here
Lad12	1953	Female	✓	✗	✓	✓	✗	Elsewhere
Lad13	1977	Female			✓	✓		✗
Sin1		Male	✓	✗	✗	✓	✗	Elsewhere
Sin2	1952	Male	✗	✗	✗	✓	✗	Here
Sin3	1953	Female	✗	✗	✗	✓	✗	Here
Sin4	1960	Female	✗	✗	✗	✓	✗	Here
Sin5	1966	Female	✗	✗	✗	✓	✓	Elsewhere
Sin6	1962	Female	✗	✗	✗	✓	✗	Here
Sin7	1953	Female	✓	✗	✓	✓	✗	Here

Sin8	1946	Female	✗	✗	✓	✓	✗	Elsewhere
Sin9	1969	Male	✗	✗	✓	✓	✗	Here
Sin10	1952	Female	✗	✗	✓	✓	✗	✗
Sin11	1963	Male	✗	✗	✗	✓		✗
Sin12	1960	Male	✓	✗	✓	✓	✗	Here
Sin13	1960	Female	✗	✗	✗	✓	✓	Here
Lyd1	1960	Prefer not to say	✓	✗	✗	✓	✗	Here
Lyd2	1988	Female	✗	✗	✗	✓		Here and elsewhere
Lyd3	1967	Female	✓	✗	✗	✓	✗	Here
Lyd4	1961	Female	✗	✗	✓	✓	✗	Here
Lyd5	1954	Female	✓	✗	✗	✓	✗	Elsewhere
Lyd6	1961	Male	✗	✗	✗	✓	✗	Here and elsewhere
Lyd7	1962	Female	✓	✗		✓		Here
Lyd8	1959	Male	✓	✗	✗	✓	✗	Here and elsewhere
Lyd9	1962	Female	✓	✗	✗	✓	✗	✗
Lyd10	1978	Female	✓	✗	✓		✗	✗
Lyd11	1958	Male	✗	✗	✗	✓	✗	Here
Lyd12	1969	Male	✓	✓	✓	✓	✗	Here and elsewhere
Lyd13	1956	Male	✗	✗	✓	✓	✗	Elsewhere

Table 3. Summary of factor loadings and the variance explained by each identified factor.

Factor	No. Sorts Loaded	% Variance Explained
1	16	25
2	5	13
3	3	13
4	2	4
5	2	6
6	4	9

Chapter 7. Renewed Coexistence: Learning from Steering Group stakeholders on a beaver reintroduction project in England

The following paper forms the sixth chapter of this thesis. It is presented in the format in which it has been submitted for review in accordance with the selected journal's guidelines, with all references included at the end of the chapter in publication format.

This paper focuses on the process of reintroduction and governance. The paper details the findings from a survey of River Otter Beaver Trial Steering Group stakeholders, examines how the governance of reintroduction compares with the governance of coexistence with species that are already present in the landscape, and defines the term 'Renewed Coexistence'.

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Status at time of thesis submission: Under review.

Statement of Contributions: I confirm that I am the primary author of this paper. I was responsible for designing the study, collecting, and analysing the data, and producing the text and figures. Barr and Brazier supervised this work; they contributed ideas, manuscript edits, and proof-read the final text.

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Renewed Coexistence: Learning from Steering Group Stakeholders on a Beaver Reintroduction Project in England

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Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Data Accessibility

All data generated or analysed during this study are included in this published article [and its supplementary information files]. The anonymised survey data is available in full (with participants’ details redacted) in the supplementary information.

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Abstract

1. Coexistence between humans and wildlife is adaptive and dynamic. To be achieved, it requires management of conflicts between humans and wildlife, or of conflicts between humans over wildlife management.

2. Species reintroductions are a growing in popularity. Example motivations include supporting species populations or the restoration of ecosystem function.

3. We seek to learn from the experiences of steering group members in a Eurasian beaver (*Castor fiber*) project in England, and identify how governance of issues in reintroduction may differ from the governance of coexistence with species that are already present in the landscape.

4. Using qualitative thematic analysis of an online survey, we identify a series of lessons in six key areas: *1) Project Governance; 2) Stakeholder Engagement; 3) Research and Monitoring Programme; 4) Strategy to Manage Arising Conflicts; 5) Public Engagement; 6) Broad Perspectives on Reintroduction Trials*.

5. We advocate for reflective evaluation as an essential component of reintroduction projects to enable knowledge-sharing from experiences, leading to improved practices.

6. Reflecting on our analysis, we identify and define ‘Renewed Coexistence’ - a new term that draws on pre-existing coexistence knowledge but identifies the unique elements that relate to governing coexistence with a reintroduced species.

Keywords

Beaver; *Castor fiber*; Coexistence; Ecological Restoration; Human dimensions; Reintroduction; Renewed Coexistence; Stakeholder engagement

1. Introduction

Coexistence between humans and wildlife ‘entails the behaviour of living together’ (Frank, 2015). It is defined as adaptive and dynamic, but sustainable (Carter & Linnell, 2016; König et al., 2020). Coexistence can be peaceful and beneficial, or it can be challenging; where interactions between humans and wildlife are more negative, human-wildlife conflicts can occur (Frank, 2015; Nyhus, 2016; Redpath et al., 2015). Conflicts may be real, or perceived by people (Bennett, 2016; Messmer, 2000). Management actions seek to prevent or mitigate conflicts and foster coexistence, but many human-wildlife conflicts are in truth human-human conflicts about wildlife or wildlife management (Marshall et al., 2007; Redpath et al., 2015).

Engagement with stakeholders is vital when addressing conflict issues and facilitating coexistence. Where appropriate engagement occurs, different perspectives can be better understood and integrated into management decisions (Coz & Young, 2020; Cusack et al., 2021; Zimmermann et al., 2020). Incorporating stakeholders as partners in planning and implementation is more likely to lead to equitable outcomes (Treves & Santiago-Ávila, 2020) with early engagement reducing potential for conflict escalation, when conflicts become increasingly difficult to resolve (Coz & Young, 2020; Crowley et al., 2017a; Cusack et al., 2021). Effective engagement involves trust between parties to facilitate open and transparent discussion (Decker et al., 2015, 2016; Manfredo et al., 2017), and when stakeholders feel their views have been listened to, decisions can be shared as a collective (Redpath et al., 2013, 2015). This leads to greater potential to minimise conflict and foster coexistence, then enabling associated ecological or social benefits to ensue (Nyhus, 2016).

Usually, coexistence refers to coexistence between humans and wildlife that is already present in the landscape. In wildlife reintroductions however, there is a ‘new’ coexistence for the humans in the locality with a species with which they are less likely to have prior experience.

Wildlife reintroduction is the process of returning a species to an area where it was previously present but is now extinct (Seddon et al., 2007). Reintroductions have recently been growing in popularity (Corlett, 2016). Motivations include boosting or supporting species populations, or facilitating restoration of ecosystem functioning (Seddon et al., 2014). For the latter, this is often associated with keystone species (which have disproportionately large effects on ecological community functioning (Hale & Koprowski, 2018)) or ecosystem engineers (those creating or modifying habitats which affect both themselves and other organisms (Byers et al., 2006)).

The International Union for the Conservation of Nature (IUCN) have developed guidelines for reintroduction projects (IUCN & SSC, 2013). These include ecological considerations e.g. assessments of habitats and resource availability (Carter et al., 2017; Seddon, 2015). They also recommend understanding social factors: “*…planning should accommodate the socioeconomic circumstances, community attitudes and values, motivations and expectations, behaviours and behavioural change, and the anticipated costs and benefits of the translocation*” (p11).

The need to account for human dimensions in reintroduction is increasingly recognised. In many projects, there is potential for conflict between people and reintroduced species, or between people about reintroduction and management (Auster et al., 2020d; Hiroyasu et al., 2019; O'Rourke, 2014). For example, although proposals for gray wolf (*Canis lupus*) reintroduction are favoured amongst the public in the western United States, some groups hold more negative views, e.g. farming and ranching groups whose economic interests may be affected by predation (Houston et al., 2010; Niemiec et al., 2020a; Sponarski et al., 2013; Williams et al., 2002). A study of attitudes towards wolf management in Colorado (where reintroduction is proposed) also found split opinions on acceptable management measures (Niemiec et al., 2020a).

If potential conflicts are not addressed, projects may fail (Auster et al., 2020b; Sutton, 2015).For example, proposals to reintroduce Eurasian lynx (*Lynx lynx*) to England were rejected, partly as UK Government felt the efforts to engage with stakeholders and reduce concerns were insufficient (DEFRA, 2018). In a previous nationwide survey exploring attitudes towards Eurasian beaver (*Castor fiber*) reintroduction in Great Britain, four social factors were identified to consider: "key stakeholder perceptions; engagement methods; attitudes towards legal protection and management responsibilities; and support for management techniques" (Auster et al., 2020d). The authors suggested, by addressing those factors proactively, conflict potential may be reduced. Thereafter, reintroduction will continue to be a social learning process for practitioners and communities, requiring ongoing communication to facilitate coexistence (Clark et al., 2016; König et al., 2020).

The process of reintroduction and the level of stakeholder involvement is central to long-term viability (Sutton, 2015). For example, Coz & Young (2020) reviewed

Eurasian beaver reintroduction in Scotland. The study included interviews with involved parties after the conclusion of a reintroduction trial in Argyll and monitoring of an unlicensed population in Tayside. The authors found the reintroduction process was the main driver of post-reintroduction conflict; participants expressed concerns about the unplanned release in Tayside. Some participants indicated conflicts had arisen from a lack of formal process, leading to a lack of trust between stakeholders (Coz & Young, 2020).

So far, there are limited examples of studies that relate to stakeholder engagement, conflict, and coexistence in the context of reintroductions. As they grow in popularity, there is a need to understand what may be similar or different in reintroduction, compared to fostering coexistence with species already present in the landscape. If a difference is identified, this knowledge would enable stakeholder perspectives to be better addressed, with coexistence between humans and the reintroduced species more likely to be fostered, if and where reintroductions take place.

In this study, we use an inductive thematic analysis of responses to a qualitative survey to record participant experiences of a reintroduction project. We aim to identify key factors that are informative for future reintroduction processes, discuss governance and stakeholder involvement in the context of reintroduction, and to identify what the implications of this may be for governing coexistence with reintroduced species compared to governing coexistence with a species that is already present in the landscape.

Structurally, the paper will first introduce Eurasian beavers, the focus of the reintroduction in question, before outlining the case study context. We will then describe methods and outline findings, demonstrating a series of lessons applicable for future reintroduction projects from the perspectives of practitioners, stakeholders and researchers involved. In our discussion we will examine what these findings tell us about coexistence within the context of reintroductions. Finally, this will lead us to define a new term in response to our findings, which we hope will frame the thinking around coexistence and its application in reintroduction projects: Renewed Coexistence.

1.1. Beavers in Great Britain

The Eurasian beaver (herein referred to as beavers) is a large mammal which lives in terrestrial aquatic environments. They are often referred to as ecosystem engineers or keystone species as they modify landscapes through dam-building and tree-felling behaviours (Campbell-Palmer et al., 2016; Stringer & Gaywood, 2016). Beaver behaviours create habitats which support wider biodiversity (Law et al., 2019; Nummi et al., 2011, 2019; Nummi & Holopainen, 2014, 2020; Stringer & Gaywood, 2016; Ward & Prior, 2020) and dams slow water flows through landscapes, reducing downstream flood risk and improving water quality (Brazier et al., 2020a, 2020b; Brown et al., 2018; Graham et al., 2020; Puttock et al., 2017, 2018). Additionally, beaver tourism may benefit local businesses (Auster et al., 2020c; Campbell et al., 2007).

Conflicts with beavers are observed where they are present in continental Europe, such as water stored behind a dam upon agricultural land, or felled trees of social significance (Auster et al., 2020b; Campbell-Palmer et al., 2016). Mitigation techniques exist, e.g. dam removal, flow devices through dams, protective fencing or compensation for damages (Campbell-Palmer et al., 2015, 2016; Morzillo &

Needham, 2015). There is also discussion about the relationship between beavers and fish, particularly salmonid migration (Auster et al., 2020a; Bylak & Kukuła, 2018; Kemp et al., 2012; Malison & Halley, 2020).

Beaver reintroduction is occurring in Great Britain at a nationally devolved level. Following a trial project in Argyll and monitoring of a population in Tayside, the Scottish Government legally protected beavers as a resident species (Coz & Young, 2020; Gaywood, 2018; Gaywood et al., 2015; Tayside Beaver Study Group, 2015). In England, a population in Devon was monitored in a reintroduction trial (see below) and there are several fenced projects. In August 2020, UK Government announced the Devon beavers will remain, with consultations on national approaches to reintroduction and management now due (UK Government, 2020). In Wales, the 'Welsh Beaver Project' released beavers under licence into an enclosure in March 2021 (North Wales Wildlife Trust, 2021).

1.2. Study Context: River Otter Beaver Trial

The River Otter Beaver Trial (ROBT) was a reintroduction trial in England between 2015 and 2020 in the catchment of the River Otter, Devon. The catchment is mostly rural with 50% of land use comprised of improved grassland, and 27% arable and horticulture. Only 5% is urban or suburban; human settlements are generally small and there are only three towns (Brazier et al., 2020a, p12).

Pre-2015, a small, free-living population of beavers was discovered in the catchment. The original population source was unknown. The beavers were to be removed but, following a locally-driven campaign, Devon Wildlife Trust (DWT) was granted a five-year licence to monitor the population (conditional on initial health-screening) (Crowley et al., 2017b; Natural England, 2015). The licence required evidence to be gathered on impacts across the five-years, deemed a 'Trial' phase. A Monitoring Plan was developed (Devon Wildlife Trust, 2017), with an Exit Strategy to terminate the project if triggers were met. The governance structure comprised of several groups with defined roles (Table 1)**.** Initially, organisations or individuals were invited to participate by Devon Wildlife Trust as the project leads, but others could be recommended or request to join these groups.

In 2020, findings were presented in the *Science & Evidence Report* (Brazier et al., 2020a)*.* A proposed *Post-2020 Beaver Management Strategy Framework* was also developed (River Otter Beaver Trial, 2019) in case the beavers could remain. These were presented to UK Government in February 2020. The following August, the beavers were permitted to remain permanently and disperse naturally (UK Government, 2020).

Table 1. Summary of the ROBT project governance structure.

Hierarchy Level	Group	Role	Members/Participants	Chair
1	**Licence Group**	To monitor compliance with the licence.	Statutory Agencies, Local Authorities, Trial partners	Natural England
2	**Project Management Group**	Responsible for day-to-day delivery and management of the Trial.	Partner organisations	Devon Wildlife Trust
2	**Steering Group**	To provide	High level	Devon

		oversight from key stakeholders and provide Project Management Group with scrutiny, advice and support. Key role to assess Exit Strategy triggers annually.	representation from wide range of key stakeholder groups	Wildlife Trust
3	**Beaver Management Strategy Framework Working Group**	Formed by Steering Group and tasked with development of *Post-2020 Beaver Management Strategy Framework*	Subset of SG members	Devon Wildlife Trust
3	**Science & Evidence Forum**	Oversee development and delivery of monitoring plan, in an objective and scientific manner. To publish *Science & Evidence Report*	Academic researchers and other stakeholders involved in monitoring and evidence gathering	University of Exeter

		summarising research findings.		
3	**Fisheries Advisory Forum**	Specialist group to advise ROBT in respect to fisheries interests.	Key national and local fisheries organisations and syndicates	Clinton Devon Estates
3	**Community and Education Forum**	Public information exchange.	Local community members, ROBT volunteers, landowners within Trial catchment	Devon County Councillor
3	*Internal DWT Communications Group*	*Coordinate communications and fundraising.*	*DWT*	

The ROBT was funded by donations and fundraising led by DWT and did not receive government funding. (Details are available in Brazier et al, 2020a (back cover)).

Throughout the ROBT, social research efforts engaged with community stakeholders, including:

- a broad nationwide survey of public attitudes to beaver reintroduction (Auster et al., 2020d).
- focused study with individuals who reported beaver conflicts with land/property (Auster et al., 2020b).
- investigation into beaver tourism and its reception amongst residents and businesses (Auster et al., 2020c).

- exploration of perspectives of beaver reintroduction among anglers in the River Otter catchment (Auster et al., 2020a).

2. Methods

We conducted an online survey of stakeholders involved in ROBT governance. Participants were questioned on a range of areas relating to the Trial, and a qualitative inductive thematic analysis enabled us to recognise key features in the responses. This method allowed us to conduct research in a safe, remote manner during the Covid-19 pandemic and national lockdown restrictions; participants may have had varying priorities and this enabled participation in their own time, from home.

2.1. Survey Design

We proposed the study to a SG meeting on 13th February 2020 (prior to covid-19 restrictions), at which SG members supported the proposal. Members indicated a preference for a questionnaire-based study to facilitate participation around work commitments. Proposed topic coverage was determined pragmatically and outlined to the SG in the meeting as a set of 'key questions' in the proposal presentation (Supporting Information). The proposals were approved, with additional comment that the questionnaire should also ask about risks involved in Steering Group participation.

We designed the survey in *Qualtrics* software. Questions were based around the key questions presented to the SG and their response. We piloted the survey internally to ensure balanced question framing and coverage. We anticipated participation would take up to thirty minutes. Questions (Supporting Information) were designed to ask respondents about: their ROBT involvement, including risk and challenges; perspectives on Trial governance; views on Trial successes or failures; whether participation was perceived as of value; lessons for the future; whether they would consider participating in future projects.

2.2. Participants and Survey Distribution

Originally, this study was proposed for Steering Group (SG) members only as key informants. This group comprised of a wide range of stakeholders with high levels of representation and knowledge of their organisational interests who had not had opportunity to participate in the earlier social studies (outlined in Study Context). At the 13th February 2020 meeting, SG members meeting requested the invitation be extended to the Beaver Management Strategy Framework Working Group (BMSF) and Science & Evidence Forum (S&E), thus including groups responsible for research, monitoring, and developing key document outputs (Brazier et al., 2020a; River Otter Beaver Trial, 2019). Hence, at the SG's request, we circulated the invitation to participating members of the three groups responsible for steering the ROBT and document outputs (SG, BMSF and S&E).

We sent the invitation on 30th April 2020, followed by two reminders. The survey closed on 10th August 2020. This included an extended deadline as we recognised possible impacts of the Covid-19 pandemic upon participants.

For data protection purposes, the invitation was email circulated on our behalf by DWT who had access to members' contact details. We were informed of a potential pool of 26 respondents. We received 19 responses (73%): fourteen SG, ten BMSF and nine S&E members (some participants sat on multiple groups, see Figure 1). Further participant details are given in Appendix 1.

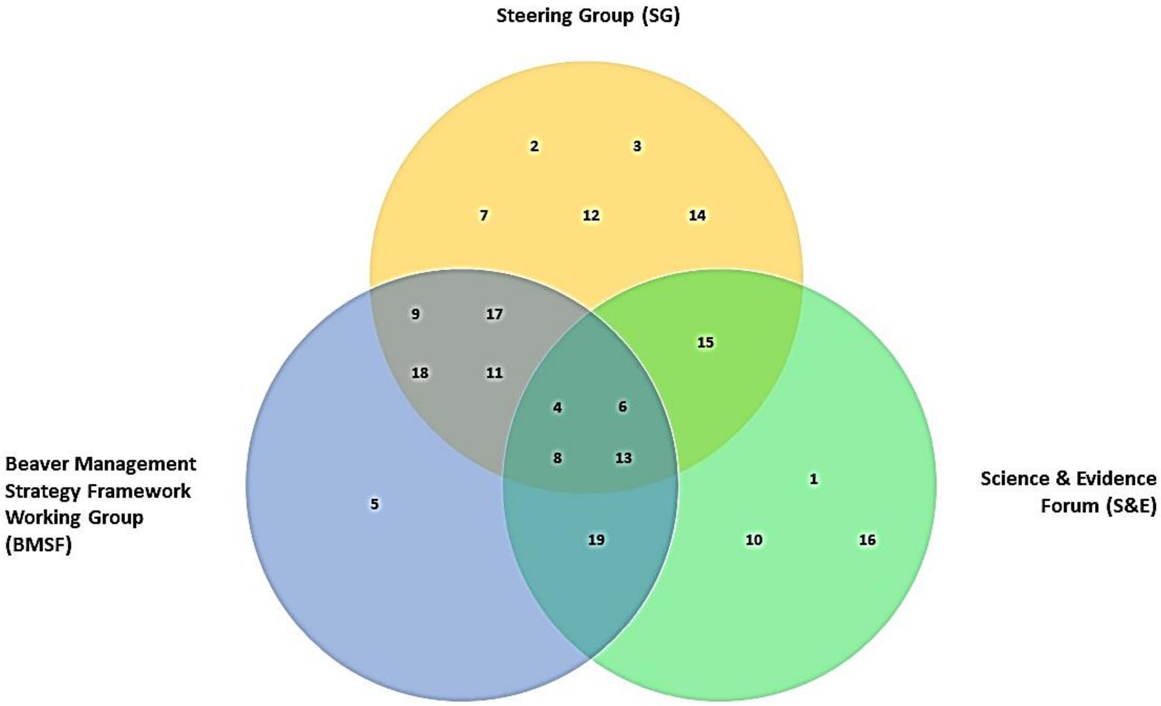

Figure 1. Illustration of the groups upon which participants sat, using assigned participant numbers.

Following the invitation, we received a participation request from an individual who had regularly engaged with the ROBT. Considering their Trial involvement, we accepted. However, the individual was not a member of the focal groups and, as other people outside of these groups did not have the same opportunity, their responses were not included in the primary analysis. Their responses are however made available in the data repository, identified as Participant 20.

Whilst this is a small number of participants, which could limit the empirical generalisability of our findings, the participants are key informants in the case study setting and represent members of the project Steering Group, which itself is argued to be cross-sectoral and thus representative of a wide range of stakeholders. Our qualitative method allowed us to provide an understanding of the processes in the situation and perspectives of those involved (Firestone, 1993; Tsang, 2013). We relate our results to existing literature and believe they provide a deep understanding that is informative for further reintroduction contexts.

2.3. Researcher Positionality

Researcher positionality was an important consideration; the lead author (who also led analysis) had been an S&E member and conducted previous research within the ROBT (detailed in the papers listed in the introduction, and Brazier et al., 2020a) so it was a possibility that the lead author's experiences, or views could have influenced study findings. Several factors were employed to minimise this potential and ensure objectivity:

- the study was developed in discussion with the first co-author (an academic, independent from the ROBT) and piloted with two colleagues who had no ROBT involvement;
- the lead author was excluded from participation;
- a 'Findings Report' of key points (Supporting Information) was shared with participants to comment between 27th November and 21st December 2020;
- anonymised participant responses are available in the data repository;
- the final text was subjected to peer review.

Furthermore, the thematic analysis used an inductive approach to coding data (see section 2.5). Although a researcher will always play an active role in reporting findings, this data-driven coding process meant resulting themes are strongly linked to the data, rather than driven by the researchers' theoretical interests or analytical preconceptions (Braun & Clarke, 2006).

Additionally, the second co-author sat in the groups so was excluded completely from survey design and had no input on analysis or findings (beyond opportunity provided for all participants to comment on the Findings Report). They contributed by checking study context details and reviewing structure and presentation of material. The funders had no study oversight.

2.4. Ethics

Prior to taking part, respondents were given details of the study and informed that participation would be voluntary and anonymous (the full information provided to participants is available in Supporting Information). All participants gave written consent by ticking a box to indicate that they had read and agreed to this information to participate; this box was a required field to proceed with the survey. In recognition of covid-19 pandemic circumstances, we emphasised the voluntary nature of participation. The study was approved by the University of Exeter Geography Ethics Committee, application number *eCLESGeo000033*.

2.5. Analysis

We used qualitative thematic analysis to identify key themes in the data, following the process described by Castleberry & Nolen (2018). This involved first coding survey transcripts - the disassembly of raw data into usable data (codes) by identifying features within the text. Codes were generated from the data. Text could be coded under multiple codes. We had an initial long-list of 272 codes.

We reviewed the long-list and identified similarities and differences to re-assemble codes - rearranging them into context with one another. This generated 22 preliminary themes. We subjected these to a second round of re-assembly to generate six overarching themes. Under these, 21 of the preliminary themes formed subthemes (Figure 2). The remaining preliminary theme (*Additional Beaver-Specific Points)* consists of extra points unique to beavers, so is summarised in Appendix 2.

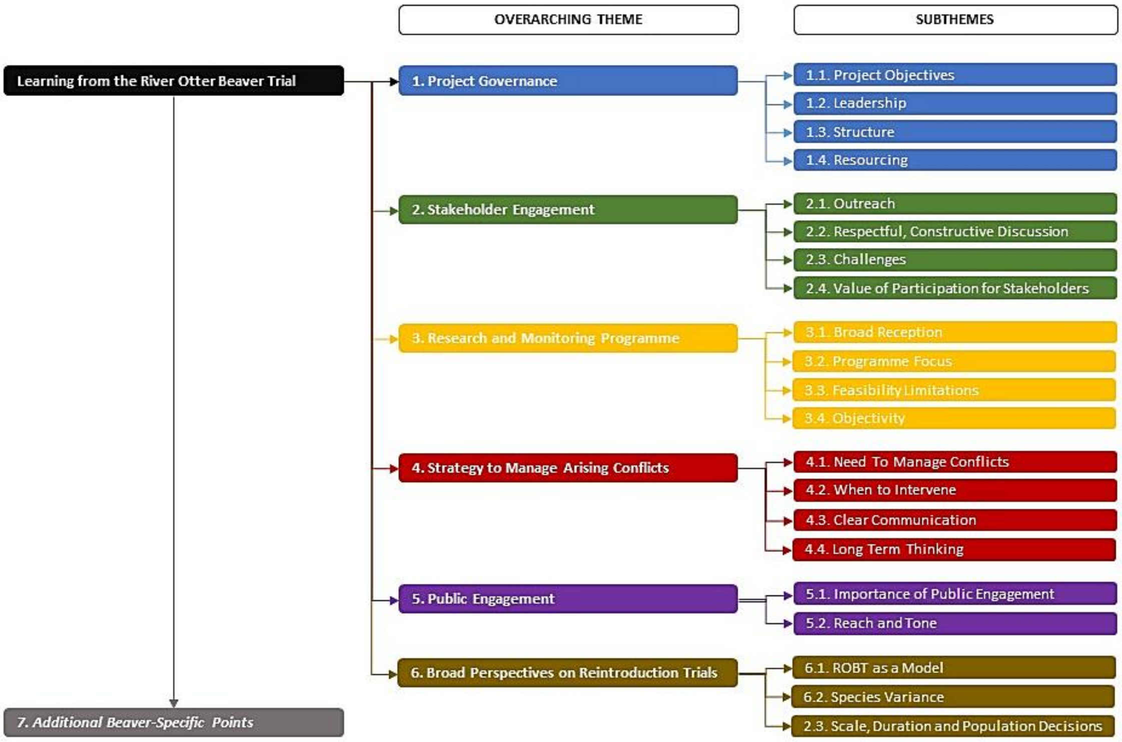

Figure 2. Summary of over-arching themes formed of their respective subthemes.

3. Identified Themes

We identified six overarching themes identifying lessons for future reintroduction projects: *1) Project Governance; 2) Stakeholder Engagement; 3) Research and Monitoring Programme; 4) Strategy to Manage Arising Conflicts; 5) Public Engagement; 6) Broad Perspectives on Reintroduction Trials*. Each is outlined in this section, using the participants' words and relevant literature.

We refer to participants using their participant numbers. I.e. P1 = Participant 1, P2 = Participant 2, etc.

3.1. Project Governance

First, participants identified a need for clearly defined objectives. Clear objectives facilitate successful planning and assessment (Ewen et al., 2014), but must recognise what is feasible within the project scope (see theme 6), with expectations managed accordingly. Objectives may require defined timescales to *"measure if the objectives are met"* (P8). P16 said future reintroductions need to consider "*The need for realistic expectations of what can be achieved during a relatively short trial reintroduction (perhaps particularly the expectations of various stakeholders)*." In the ROBT, P13 felt the "*focus [was] on the holistic understanding of beaver reintroduction - the bigger picture [rather] than just single interests which single organisations might ordinarily just focus upon*." Meanwhile, P11 felt there was a conservation focus, whilst not factoring in *"other land management changes in the areas and what these would have meant".*

Second, reintroduction projects require committed leadership, a point also recognised in a study of white-tailed sea eagle reintroduction in Ireland (Sutton, 2015). P4 stated "*Running a successful project requires huge focus and dedication far and above the normal 9-5 working practices*" and P2 cited "*The very strong lead provided by DWT and their unstinting commitment to the project*" as a success. Leadership will need to take an honest and transparent approach, recognising both benefits and conflicts. This approach to leadership can be important for building and maintaining trust between project leads and stakeholders (Auster et al., 2020b; Madden, 2004; Riley et al., 2018). For example, P4 indicated "*being open and honest about the conflicts that beavers can cause has helped with lots of stakeholder groups*." However, P17 believed that *"possible negative impacts on fish were somewhat glossed over"* which they cited as an *"example to warn against brushing issues like this aside, in terms of maintaining stakeholder engagement".*

One consideration put forward by participants towards an objective approach may be for independent chairing of governance groups; P9 and P11 believed the "*various groups should have had independent chairs*" (P11). If this is not possible, the transparency of leadership will increase in importance; there may always be factors which affect trust in wildlife managers but where stakeholders perceive greater transparency, trust levels are likely to increase (Riley et al., 2018). If concerns are not addressed and only extreme positive messaging is utilised, there is a risk of increased conflict and opposition (Niemiec et al., 2020b).

Third, the wider Trial structure (Table 1) received favourable comments. P16 stated "*I'm sure keeping these groups separate and limited greatly aided the overall coordination and management of the trial*" and P10 stated "*I believe the trial structure was appropriate and communication between groups was managed very well. There was enough cross over in terms of the same people sitting on different groups to ensure that concerns/questions were raised across all relevant groups*." However, some felt the structure was complicated, with P3 stating *"[the] framework could be simpler"* and P2 feeling *"There was a degree of overlap and duplication of effort*". Hence, we suggest reintroduction project governance frameworks (or group responsibilities) should be clearly defined to ensure aims can be met. This may include defining direct relationships between organisations; in one case here, a formal memorandum of understanding was agreed between the ROBT and P8's national organisation, which P8 found *"very helpful in defining roles and responsibilities".*

Fourth, defining responsibilities may reduce duplication of effort, increasing efficiency. This is important as "*Resource demands and commitments" (P7)* were highlighted as a challenge in governing the project, requiring *"personnel, time and money*" (P16). Any similar reintroduction should consider efficient resource use, with P18 stating the Trial could be "*streamlined*" (see theme 6). Costs of reintroduction can be high (Hilbers et al., 2019). Costs may include financial risks for project leads. In the ROBT, DWT held responsibility for costs of negative beaver impacts under licence conditions issued by Natural England. "*There have also been financial risks associated with the Trial - in particular the resources that had to be put aside for implementing the Exit Strategy, and for compensating for any significant impacts - which may need to have been covered by our insurance (eg Flooding of properties that [DWT] could have been responsible for under the licence)*" (P4). However, P3 believed costs should be viewed as a future investment, rather than purely as a costly process: "*One could argue it was very expensive but [this] probably has to be seen in terms of recovery of beavers across UK, or certainly lowland England, and not as a cost simply to recovery [on the] River Otter, or Devon and South west*."

3.2. Stakeholder Engagement

Identifying key stakeholders and understanding their perspectives is vital for reducing conflicts and fostering coexistence (Coz & Young, 2020; König et al., 2020; Redpath et al. 2013). Where failure to account occurs, conflicts could arise in reintroductions also (Auster et al., 2020d; IUCN & SSC, 2013; O'Rourke, 2014). In the ROBT, stakeholder engagement was seen by most as strong. When asked about Trial successes, thirteen participants cited stakeholder engagement or an element of it. For example, P2 said there were "*good opportunities for active participation / input by relevant stakeholders*" and P8 said meetings were well run, "*inviting full participation […] on every occasion*." Seven participants referred to invited stakeholders being of a broad range of interests, which was received positively. P7 said "*I believe there has been a good range of interests and organisations given the opportunity to be part of this project, covering landowner and business interests, environmental interests, social and community interests and, within that, a good suite of public, private, charitable and scientific bodies. It has felt well balanced*." Thus, there was "*opportunity for representation by key stakeholders*" (P2). Similarly to Coz & Young (2020), we suggest future reintroduction projects make similar concerted efforts to engage with the breadth of identified stakeholders.

Along with identifying stakeholders, engagement methods should be considered. It has been shown in the human-wildlife conflict literature that, where stakeholders feel their views or concerns are being taken seriously, trust between parties can be fostered (Auster et al., 2020b; Decker et al., 2016). This enables issues to be shared collectively, with conflicts addressed or prevented early (Auster et al., 2020b; Decker et al., 2016; Redpath et al., 2015; Redpath et al., 2013; Riley et al., 2018). In the ROBT, P19 cited successes in "*Listening, treating all concerns seriously, trust and* *good communication*". P13 referred to "*Excellent partnership working across a wide range of stakeholders who did not necessarily agree about the reintroduction of beavers*." Not all partners shared the same viewpoint, but it was reported they worked together to find solutions: "*one important point is that the successful operation of the Steering Group was the willingness of the individual participants to engage positively (i.e. highlighting relevant concerns as necessary, but in a manner which sought to resolve these in a mutually acceptable manner). There were tensions between various stakeholders involved in or affected by the Trial, but the Steering Group helped to manage these well*" (P2). Further, respectful discussion can enable different parties to learn from each other. For example, P3 stated there was "*Dissemination of much deeper understanding throughout group...from beaver ecology to farmers and fishermen for example, but also the reverse, from fishing concerns and preoccupations and local economic interests and constraints upwards to beaver enthusiasts and ecologists. All such groups benefit from this flow and counterflow of understanding*".

However, challenges can be encountered in stakeholder engagement. Here, four were reported:

- First, stakeholder participation. P4 stated "*there were a few organisations and individuals that didn't participate - despite being invited and wanting to be involved*" and P10 said "*It is disappointing that some groups who have raised concerns regarding the trial were invited to sit on groups but chose not to participate*". It may be that, despite outreach efforts, stakeholders do not fully engage. One participant's suggestion to address this to some degree was for participating organisations to be compelled "*to nominate seconds to ensure* *attendance at meetings*", and that the project should "*compel each organisation to speak openly at every meeting*" (P13).

- Second, there was a risk of "*partnership interactions and potential breakdown*" (P6) and that adopting a stance "*risks alienating some stakeholder groups*" (P4). In the ROBT, no participants reported any such breakdown.
- Third, some participants cited a potential reputational risk from participation. As examples, P19 reported a risk of "*the public automatically thinking we are anti-beaver because we are a landowner*" and P9 reported a "*risk of being seen to be 'pro-beaver' rather than having objective views based on empirical evidence*".
- Fourth, stakeholder resource use. P2 said "*there was an initial risk that our staff may need to devote considerable time to working with the Project Team and affected landowners*". However, here they stated participation did not require much of their time: "*there was only a very limited need for such input*". Regarding future reintroduction projects, P16 said "*Involvement needs to be adequately resourced*".

Despite challenges, participation in the ROBT was reported to be of value for those involved; we asked whether group members felt participation was of value for their respective organisations and all participants ticked 'Yes'. Reasoning included: "*strengthened stakeholder relations*" (P12); "*participation in discussions*" (P9); being "*better placed to field questions from local farmers*" (P5); "*bolstered […] membership (potential future financial support) and reputation for completing high quality conservation work*" (P15); "*having the opportunity to conduct research that has been co-created by a wide range of stakeholders*" (P13); opportunity to learn "*a lot about* *beavers and their ecology*" (P14) and being "*better informed and prepared to adapt our own strategies and operations, and advise others in future catchment management approaches*" (P7). These findings suggests that, if stakeholder engagement is effective in future projects, stakeholders may find participation in future projects to be of value also. All participants indicated a willingness to participate in future reintroduction Trials, particularly "*if [the] species was relevant to/impacted on*" (P12) their respective interests. P14 said they would take part "*to study and learn more and offer advice if helpful*". However, P9's willingness to participate was conditional "*provided the various criteria for objective trials […] are met*".

3.3. Research and Monitoring Programme

Reintroduction trials require a well-planned scientific research and monitoring programme to meet project objectives and IUCN Guidelines (Ewen et al., 2014; IUCN & SSC, 2013). Broadly, the ROBT's monitoring and research programme was viewed as a success; when asked about successes, twelve participants cited the science and/or monitoring programme, or the *Science & Evidence Report* (Brazier et al. 2020a). E.g. P16 stated "*I think the ultimate success of the trial has been the high quality of research that has been conducted. It has provided an evidence base for decision-making and highlighted areas where more work is needed*", and P13 felt "*the vast majority of organisations, indeed all of those who fully participated in the trial, will also have benefit from the research that we have undertaken and indeed have indicated such in response to the science and evidence report*".

In accordance with *Stakeholder Engagement* as discussed above, we suggest the research and monitoring programme should be co-created with stakeholders. Indeed, P13 said "*Having the opportunity to conduct research that has been co-created by a wide range of stakeholders has been a very positive experience*." By engaging stakeholders, questions or concerns are more likely to be addressed early. Greater stakeholder trust in the research may reduce conflict potential and early engagement during design stages may facilitate such trust between stakeholders and researchers (Riley et al., 2018).

Demonstrative objectivity will also facilitate trust. Here, P9 questioned the objectivity of research and felt there was "*bias towards beaver monitoring but poor collection of evidence on impacts on fisheries*". P1 (a researcher) suggested scientific peer review may be one avenue through which a demonstration of objectivity and rigour could be achieved. When asked about risks/challenges of Trial participation they said "*Maintaining scientific integrity and impartiality. Whilst our role as University researchers is to undertake independent research, our position as a main project partner has at times led some to question this. Have sought to address via peer review of results etc*."

With co-creation in mind, the research focus will need to give a "*holistic understanding*" (P13) of a reintroduction, beyond single interests of contributors. This is for the social and ecological consequences of a project to be sufficiently understood, as recommended by IUCN Guidelines. Additionally, the programme may need to be reactive to emerging issues and changing circumstances: "*Balancing the need for a clear programme of research with the value of being able to be reactive so research can focus on areas that emerge as being of key importance or lacking in existing evidence*" (P16).

However, there can be limitations. Three were evident in our findings:

- Financial resource limitations. P13 stated *"It has been challenging to undertake the wide range of research that stakeholders have demanded during the trial and particularly challenging to secure enough funding to deliver all aspects of the research program that were asked for by stakeholders, including other members of the steering group*." This sentiment was echoed by P10 who referenced that funding limitations led to strategic decisions on research prioritisation: "*With further funding there is of course additional research that would have been extremely valuable to undertake. However, even with the massive efforts […] to raise money it was still necessary to prioritise certain aspects of the research*". P13 suggested future projects could "*compel, in some manner, all members of the steering group to share their ideas early and to ensure that they are bought in to the program of research that addresses the aims of the trial. Ideally this will involve all groups bringing funding and/or resources to bear, as research across 5 years on a trial of this scale is very time consuming and very costly*."
- Practical limitations. P10 highlighted "*Monitoring beavers is very challenging due to the spatially and temporally variable nature of their impacts. Designing suitable monitoring frameworks can therefore be challenging and some studies had to be altered or abandoned due to changes to beaver activity. Therefore, not all of the desired investigations were completed*". A similar point was made by P2: "*a possible limitation of the project was (ironically) the lack of more problems. Although the beavers did create 'issues' in a number of locations which required active management to mitigate the potential consequences, which proved to be extremely instructive element of the Trial,*

it might have been better if there had been even more of these types of localised problem." Thus, there was a limit on research quantifying negative impacts based upon the number of negative impacts which occurred.

- Temporal limitations. P14 stated "*Many of the positive and negative impacts of beavers would not be seen until population numbers reach (initially overshoot) [ecological] carrying capacity*", which it would take some time to reach (Halley et al., 2020). This was recognised by P15: "*It has been a trial of the early phases of beavers recolonising a catchment*". This limitation can result from when a topic is raised within the timeframe of a project. E.g. P13 said within the ROBT it had been "*a challenge to work with certain stakeholders who either did not engage in the learning process at all or did so very late on in the trial, thus not leaving enough time to undertake research to answer their questions*".

Limitations may lead to outstanding research questions, as P16 suggested: "*it will not be possible to answer all the questions within the scope of such trials*". For example, there were outstanding research questions at the ROBT's conclusion about the relationship between beavers and fish: "*it is a shame that there couldn't have been a more definitive conclusion on the impact of beavers on migratory fish populations, which appears to remain as one of the points of contention. Although the Trial provided some good evidence on this issue, the work wasn't sufficiently comprehensive or of sufficient duration to enable a clear conclusion and consensus to be achieved"* (P2). It should be noted that where important questions remain unanswered, uncertainty may prevail. Uncertainty can lead to increased worry, making it likely that concerns escalate (Auster et al., 2020b; Hudenko, 2012). For example, P16 said "*Those with particular interests in these topics may well feel that* *a lack of information = failure*.” P16 then suggested “*What is important is that research continues where it is needed (and that this is well resourced)*". We suggest in the initial stages of reintroduction (alongside research planning) stakeholder expectations need to be managed regarding research feasibility, and stakeholders themselves may need to assess their expectations of what is feasible within the project scope and limits. If the reintroduced species is to remain in the longer term, addressing uncertainty with ongoing research into outstanding questions may help reduce worry and reduce conflict potential, particularly when associated with management that can adapt to emerging evidence (Hudenko, 2012; McCarthy & Possingham, 2007). Here, research into the relationship between beavers and fish (particularly fish migration) is likely needed to continue with open, cross-sectoral dialogue throughout (Auster et al., 2020a): *“I sense this is an area for further work and dialogue”* (P7).

In addition, P18 felt future projects should “*learn from other projects/experiences to build on knowledge, don’t reinvent the wheel, take more things as red [sic] with confidence* “(P18). This suggests that research could build upon prior knowledge, rather than cover topics addressed elsewhere. Indeed, P8 said in the ROBT it “*Sometimes felt like lessons and experience/expertise from Scotland were not being fully taken into account or utilised and potentially therefore re-inventing the wheel when this was not needed*.”

3.4. Strategy to Manage Arising Conflicts

Reintroduction projects should anticipate and seek to prevent or manage conflict issues, with proactive action likely to be received well (Auster et al., 2020b; Auster et al., 2020d; IUCN & SSC, 2013; Sutton, 2015). Reflecting this, our results indicated a need for projects to have a management plan for conflict scenarios. When asked about lessons for future reintroductions of beavers or other animals, twelve respondents referred to the *“importance of a management framework”* (P7). Here, this refers to the management of beavers and conflicts (as opposed to project management or research monitoring). E.g. P15 said “*Do not leave landowners to cope with reintroduced species on their own. Provide support*”, and P1 stated “*Most conflict or perceived conflict can be managed, but this does require a clear management plan*.”

Such a plan will require appropriate engagement with individuals who experience negative impacts (Auster et al., 2020b), as P2 recognised: “*such introductions are most successful if supported by a much wider approach which informs, support and engages all those potentially affected by it*”. In the ROBT, DWT held responsibility for management in accordance with the licence. It is important to recognise this incurred resource use for management measures (Brazier et al., 2020a). Future projects should be equally prepared to address conflict situations; "*Resources (personnel, time, money) need to be allocated for managing potential conflicts*" (P16).

Ideally, management actions would be undertaken proactively, addressing issues prior to occurrence (Auster et al., 2020d). In the ROBT, P12 stated they felt “*proactive action […] was successful in this case*”. This may be impossible for all potential conflict issues, in which case it is desirable to address issues quickly to minimise or prevent conflict escalation (Auster et al, 2020b; Seddon et al., 2007); P16 indicated “*manage[ment] needs to be reactive as many of the issues are likely unforeseen*”, and P2 cited a Trial success in "*The establishment and maintenance of a strong mitigation strategy, to deal with issues quickly and effectively as they* *arose*". These comments are supported by a previous study which interviewed individuals who reported conflicts with beavers in the ROBT; proactive action and fast responses were highlighted as positive among participants (Auster et al., 2020b).

Clear communication of a management plan can bolster community knowledge of available support. This may reduce conflict potential by providing certainty in management (Auster et al., 2020b). P10 said "*communication with all effected stakeholders and (as many as possible) landowners is key*". They stipulated "*If people know they can call on somebody to help if there are issues they are much more willing to take part and learn from the experience. In almost all cases, this was done extremely well during the ROBT*." Linked to this, project leads and those responsible for communication may need to consider their positionality when outlining available management support. Here, P11 said "*this has been led and managed from an organisation with a very particular slant […] linked to this has been the funding requirement. this has meant publicity and campaigns that have been pejorative and requiring the development of "beaver connection*"." The respondent felt "*this makes the conversation quite led and perhaps difficult with regard to "selling" the need for parts of the management hierarchy*."

When a species is to be reintroduced permanently, long-term thinking should structure the management strategy; the effectiveness of techniques together with attitudes to management should be considered (Auster et al., 2020d). In the ROBT, there was uncertainty among stakeholders about the management of negative beaver impacts in the long term. This increased uncertainty led to increased levels of worry (Auster et al., 2020b; Hudenko, 2012). For instance, P19 said "*We remain nervous as to the degree to which there will be support for beaver management post*

Trial." As above, not all long-term scenarios can be predicted so, as with coexistence of other species, we suggest adaptability must be included in management considerations (Failing et al., 2013; McCarthy & Possingham, 2007); P16 stated "*What is important is that […] the management of beavers is adaptive to the new evidence that emerges*".

Some long-term decisions may not be in the hands of project leads or stakeholders but with government or local authorities, e.g. decisions on the application of legislation. It is nonetheless possible for practitioners and stakeholders involved in projects to collaborate, share learning from experience, and provide informed recommendations. For example, in the ROBT a "*management plan [was] co-created by a broad spectrum of project partners*" (P1). These partners sat on the BMSF, formed by the SG (Table 1). The plan they developed – the '*Post-2020 Beaver Management Strategy Framework*' (ROBT, 2019) – was cited as a success by four participants. Collaboration and knowledge-sharing like this could occur across projects. P8 highlighted a need for *"consistency across projects"*. For instance "*each project doesn't need to reinvent the wheel"* as - if the species remains permanently - *"there will also be a need to have a national approach […] as animals transition into just "being there"."*

Additionally, "*the risk with anything new is that management systems and processes are overly complex and intensive*" (P6) when there is a desire for management to be "*simple and not heavily bound up in "red tape*" (P17). Indeed, in a previous nationwide questionnaire, several respondents indicated stronger levels of legal protection may make management of negative beaver impacts more difficult, (Auster et al., 2020d; Brazier et al., 2020a, p81). This will also require consideration as to how to "*normalise the species*" (P18) in a landscape (Auster et al., 2020b); "*although* *there is always room and need for more science and learning, any such project in the future […] has to be more orientated around management advice and interventions (where necessary) to help ensure as smooth a transition from beavers being seen as new to the landscape, to the wild, to the way rivers work, to a position where beavers are seen as being a natural part of all that*" (P7).

3.5. Public Engagement

Public engagement is critical in species reintroductions (IUCN & SSC, 2013), and "*social buy-in*" is important if a reintroduction is to be successful (Hiroyasu et al., 2019). In the ROBT, P1 claimed there was a "*High degree of public engagement and support*", and P4 said "*Doing lots of outreach work has been vitally important*".

There were several reasons cited as to why. First, an opportunity to educate the public and address misunderstandings: "*a forum for clearing up issues as miss understandings [sic]*" (P12). This includes potential for education via the press, which P15 cited as a ROBT success: "*generating press interest and articles that show beavers can play a role in creating more flood resilient landscapes and create habitats for a wide range of biodiversity*". This may be important for "*attracting community support*" (P4), with engagement leading to education and influenced attitudes (Hiroyasu et al., 2019; Sampson et al., 2020).

The tone and framing of public engagement must be considered. Niemiec et al. (2020b) suggested that presenting extreme positive arguments, whilst not addressing concerns of opponents, is likely to lead to organised opposition. They suggest message framing should be more moderate. In the ROBT, and despite their organisation's stance in favour of beaver reintroduction, P4 felt a balanced approach to their engagement work had been beneficial: "*Our presentations are balanced* *rather than overly positive, which I think has helped*". This included "*being open and honest about the conflicts that beavers can cause*" (P4). P9 however felt their own "*main success has been to expose the issue of beaver re-introductions to a wider audience, offset[ting] the overwhelming pro-beaver position of most participants*".

Alongside ongoing research, public engagement should involve provision of knowledge surrounding management support to reduce uncertainty and address concerns (Auster et al., 2020b; Hiroyasu et al., 2019; Niemiec et al., 2020a, 2020b). P15 said "*Many landowners may be against reintroductions but attitudes can change over time if those landowners feel involved in the trial and feel that they […] have support if required*" (P15). In the longer term, such messaging may facilitate coexistence with reintroduced species; P6 cited "*Community engagement enabling people to learn to live alongside the animals once again*" as a ROBT success.

3.6. Broad Perspectives on Reintroduction Trials

Survey participants also provided broader comments on the process of reintroduction 'trials'. For some, the ROBT was perceived as a model to follow in future. For example, P10 said "*I believe the ROBT provides an excellent framework on which to design reintroduction programmes*" and P6 suggested future reintroduction trials should "*Follow a similar approach - there are few trials which end where all partners / members agree on success*." P14 felt the process provided "*evidence and understanding on whether reintroductions of a particular species could or should take place, and if so, how they should be carried out*" (P14).

Although participants were generally favourable of the principle of a reintroduction trial, further lessons could be learned. P11 believed *"[reintroduction trials] need to be* *developed but this was a very important first start*". Nonetheless (as discussed), there will still be room for more learning at the end of a trial phase. For example, P16 stated "*Trials such as this are invaluable for providing context specific evidence. The caveat is that it will not be possible to answer all the questions within the scope of such trials. The end of these kinds of trials does not indicate that no more research is required*."

Some participants had issue with how the trial began. P12 noted the beavers were already present prior to commencement and felt "*its not really a model for re-introduction as [it is] a model for how to deal with escaped and feral animals. if looking for how to do a introduction properly from the start it would not be the recommended approach to let the animal loose and then deal with it*." This was cited by P5: "*the dubious nature of how the beavers arrived is always a bone of contention amongst farmers*" - a notion also reported in Scotland resulting from the unlicensed beavers in Tayside (Coz & Young, 2020). Recognising the unplanned nature of introduction, Crowley et al. (2017b) suggested the ROBT was an opportunity for a "*wild experiment*", gaining experience in managing issues and "*finding ways to include affected and interested publics*".

Although reintroduction trials were broadly supported here, future trials may not need to echo the same scale for other species, particularly those that do not have landscape-scale impacts. P15 said "*For other species a trial reintroduction could be useful, other species may not require such work as they may have less of an impact of surrounding landscapes*." Similarly, P19 felt "*For other species [the need for a trial] depends on the potential ecological/economic impact*". They suggested a trial is "*Probably not necessary for species that are 'insignificant' in terms of impact […] BUT, you would still need good science behind it otherwise reintroduction [is] unlikely* *to be successful*". Indeed, P2 felt "*beavers are not like most other species which are subject to reintroduction programmes*". This is due to the scale of landscape change attributable to beavers; "*other species may not require such work as they may have less of an impact of surrounding landscapes*" (P15).

Respondents suggested population sizes may limit the ability to collect necessary evidence to meet trial objectives. For example, P14 suggested "*Many of the positive and negative impacts of beavers would not be seen until population numbers reach [..] carrying capacity*". Thus, depending on objectives defined at the outset, some research may require a larger population to exist for certain impacts to materialise and be studied. Accordingly, P18 believed a trial should have "*greater aspirations on numbers and scale*". However, P11 and P9, who held more concerns about the reintroduction, felt there needed to be a cautious approach with a *"clearly articulated "out" at the start of the project"* (P11) in case of negative consequences. Whilst a bigger population may enable further research, in the event of a decision not to formally reintroduce the species at a trial's conclusion, removal of the species from the landscape may become more challenging. This ability may be key in the engagement of some opposition groups; P9 stated they would participate in future reintroduction trials "*Only if the trials are truly objective and capable of being ended/reversed in the event of potential adverse impacts*". Consequently, there is likely to be trade-off required, and again expectation management of research feasibility among involved parties. (Additionally, related to population size, P18 felt there was a trial failure in "*not establishing a genetically diverse population*". Genetic diversity should be factored into population establishment (Campbell-Palmer et al., 2020; Halley, 2011)).

Similarly, decisions are needed on the duration of any trial. P16 referenced “*there is scope for [research] to continue for decades*”. If this were to occur however, this would be resource-intensive and potentially delay any decision on species reintroduction indefinitely. Again therefore, we suggest there will need to be some trade-off, with a decision taken on what trial duration is necessary, with “*realistic expectations of what can be achieved during a relatively short trial reintroduction (perhaps particularly the expectations of various stakeholders)*” (P16). Therefore, as discussed above, research may need to continue beyond the end of any trial, but trials may “*provide a starting point for decision making and management and this should be made clear to all stakeholders involved*” (P16).

Finally, some participants, although favourable towards trials, felt they risk resource-intensive processes which inhibit the potential of reintroductions. P18 believed reintroduction trials should “*not be overly cautious […] This type of trial set-up has a time and place but […] we are in danger this sets a precedence that conservation translocations require this level of investment every time, when other similar sectors have no such requirement or expectations thereof […] we need to be careful we aren’t holding up reintroductions as overly complicated and expensive and therefore subject to continued scrutiny*". P6 agreed: “*We are facing a climate and ecological crisis - species reintroductions need to be done well - but the barriers organisations face are often prohibitive and costly*."

4. Discussion

We have identified a series of themes from the points of view of stakeholders involved in steering a reintroduction project. In this section, we will discuss how this relates to previous study and examine what is different in reintroductions for conflict and coexistence issues. Prior to doing so however, we would like to advocate for reflective evaluation to be an essential part of future reintroductions. All reintroduction projects provide opportunities to learn from the process undertaken. Such learning may inform and improve the steering and expectations of future reintroduction projects. As reintroductions are a relatively recent and growing concept (Corlett, 2016), many participating groups will likely be 'learning-as-they-go'. Here we undertook a reflective evaluation of the ROBT with key informants and suggest the points made under the identified themes will prove informative in future reintroduction projects - for practitioners, stakeholders, and researchers alike. Undertaking evaluations such as these within other projects would enable knowledge gained through experience to be shared, affording the opportunity to apply knowledge in future project contexts. We would encourage this as a standard practice, including both when projects succeed and fail (Catalano et al., 2019).

In this analysis, there are points identified which reinforce the findings of research from pre-existing conflict and coexistence literature but in the reintroduction context, particularly about stakeholder engagement. In 2016, Decker et al. outlined ten 'Governance Principles for Wildlife Conservation in the 21st Century'. These include the incorporation of multiple, diverse perspectives in governance, as well as governance that is transparent and accountable. This is reflected in the participants' assessments of the ROBT, with thirteen participants citing stakeholder engagement as a key Trial success, but with a perception among some that leadership should have been independent to facilitate transparency. Trust building is essential for the resolution of conflict issues, which can be built through demonstrable efforts to recognise and respond to issues (Madden, 2004). Riley et al. (2018) examined trust in wildlife agencies and identified that trust was greater when personnel actions created a sense of fairness for stakeholder involvement. Extremely positive (or negative) messaging meanwhile may have the opposite effect, with a risk of more organised opposition and resulting conflict escalation (Cusack et al., 2021; Niemiec et al., 2020). There may always be issues affecting trust (Riley et al., 2018), but investment in trust-building and incorporating stakeholder viewpoints will mean it is more likely that conflicts can be negated and coexistence achieved for both reintroduced and already present species (Bennett et al., 2017; Coz & Young, 2020; Redpath et al., 2015; Riley et al., 2018).

As stated above, the relatively recent nature of reintroduction means many practitioners are likely to be 'learning-as-they-go'. We believe that the relatability between our findings and previous study can provide practitioners and stakeholders with reassurance that pre-existing knowledge from non-reintroduction-related experiences is applicable also within this emerging field. That said, by eliciting the views of the ROBT Steering Group stakeholders in a way that was meaningful for them, we have identified an important distinction between reintroduction and pre-existing research, regarding conflicts and coexistence.

Coexistence with a reintroduced species is a specific form of coexistence as humans in the locality have no prior experience of the historically present species. Hence, coexistence challenges in reintroduction begin from a different start-point; projects seeking to facilitate coexistence in response to conflict issues start from the point at which the issue exists in the present, whereas in reintroductions potential coexistence challenges are in the future (post-reintroduction). In our participants' responses, this sense of the future context is evident. Under theme 3, for example, participants identified outstanding research questions at the Trial end, particularly regarding interactions between beavers and fish. Research questions which remain unanswered can lead to a sense of uncertainty which in turn can lead to worry or concern about future consequences, influencing decision-making (Hudenko, 2012). In reintroductions, the decisions to be influenced by uncertainty can go beyond how best to coexist with a species to include whether or not to coexist with it in future at all, meaning uncertainty could trigger projects to be delayed or prevented altogether.

When a reintroduction does take place, theme 4 identified the importance of a planned management strategy to respond to conflicts if coexistence is to be achieved. Where management is developed to facilitate coexistence with present species they are reactive to challenges that exist and are able to engage with stakeholders who hold experience of those challenges (Frank, 2015; König et al., 2020; Madden, 2004). In reintroduction, conflicts with the species can only exist after the species is released. The participants here demonstrated concerns about the ability to address potential conflict issues and whether management would be *"bound up in red tape"* (P17). Such questions perhaps represent a fear of unknown future consequences, with uncertainty again contributing to concern. This represents the need for practitioners to engage with stakeholders at an early stage of a reintroduction project and consider potential options for management *a priori* (Auster et al., 2020d; Coz & Young, 2020; Seddon et al., 2007). In this instance, the Beaver Management Strategy Framework developed within the ROBT (River Otter Beaver Trial, 2019) was arguably an example of such a forward-thinking approach within the early stages of a reintroduction; it was developed between stakeholders to consider the management of the River Otter beavers post-2020, but ahead of the UK government decision to allow them to remain permanently from that year.

To encourage such future-orientated coexistence thinking in future reintroduction projects and research, we argue for the definition of a new term: 'Renewed Coexistence'. We define this as coexistence that is specifically associated with a reintroduced species, thereby one which was present in the landscape historically, but which is now a 'new' presence for the humans living in the locality, post-release. By building on the term 'coexistence', the new term recognises it is built upon pre-existing knowledge that coexistence is adaptive and dynamic to be sustainable, with conflict management where required (Carter & Linnell, 2016; Frank, 2015; König et al., 2020). With the application of 'Renewed', the 'newness' of the presence of the formerly resident species for humans in the landscape today is recognised, thus allowing for an appreciation of questions unique to the context, such as that discussed under theme 4 about how to normalise the sense that the species is a wild rather than reintroduced animal.

We argue that our definition of 'Renewed Coexistence' will provide the necessary emphasis for groups steering reintroduction projects to consider future coexistence challenges, engaging with affected stakeholders early to address uncertainty, and encouraging an *a priori* attention towards the management of potential future conflicts to achieve coexistence with reintroduced species, if and where reintroductions occur (Auster et al., 2020d; Coz & Young, 2020; Seddon et al., 2007).

5. Concluding Remarks

Reintroductions seek to establish a population of formerly resident species and garner benefits, such as the restoration of ecosystems or their functioning. By their nature, they are projects that think into the future and have implications for the long-term. Reflecting on an analysis of the experiences of stakeholders involved in steering a reintroduction project, we coined a new term to advocate for the consideration of future coexistence issues in similar vein: ‘Renewed Coexistence’. We trust our new term will encourage early and forward-thinking approaches to coexistence with reintroduced species, addressing potential conflicts *a priori* and reducing uncertainty. As advocated for in pre-existing coexistence literature, we believe ‘renewed coexistence’ is more likely to be achieved and sustained with effective project governance and early stakeholder engagement (Auster et al., 2020d; Coz & Young, 2020; Seddon et al., 2007). Finally, when reintroductions do take place, we believe this style of forward-thinking would lead to more effective conflict management and facilitate better integration of reintroduced species into anthropogenic landscapes.

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Chapter 8. Synthesis and Conclusions

'Human dimensions' research seeks to understand relationships between humans and nature, and the study of human-wildlife interactions explores the geographies of humans and wildlife; how they share space and interact (Decker & Chase, 1997; Enck et al, 2006; Frank, 2016; Frank et al., 2019). Human-wildlife interactions can be positive where there is coexistence (Frank, 2016; Nyhus, 2016), or they can be negative where there is conflict (Conover, 2002; Redpath et al., 2015; Torres et al., 2018). This thesis has been influenced by the concepts of the coexistence and conflict, in particular the conflict-to-coexistence continuum; this recent framework has built on the conflict and coexistence literature to recognise that these themes do not occur in isolation but are connected themes (Frank 2016; Frank 2019). This thesis draws upon this knowledge to investigate the human dimensions of beaver reintroduction in England.

My thesis has explored the relationship between humans and reintroduced beavers. Within this context I have investigated human knowledge and attitudes, and the impacts that have been observed and experienced; I have gained an understanding of the motivations and experiences of different actors pragmatically, by using mixed methods from the social sciences to allow diverse perspectives to emerge (Bennet et al., 2017a, 2017b; Morgan, 2014). By engaging with various focal stakeholder and public groups I have been able to provide an understanding of their various perspectives and experiences (Cinque, 2015; Lute & Gore, 2014).

Yet I have had to also apply an ecological understanding of beavers and the physical geography of their impacts on the landscape (these topics were further explored in detail by internal and external partners in the River Otter Beaver Trial - see Brazier et al., 2020). Drawing together these knowledges from different disciplines has enabled me to construct a holistic picture of the geographies of human-beaver interactions in a relationship which has been renewed, including the benefits and negative implications and their associated implications for the governance of renewed coexistence between humans and beavers in England.

Building on these findings, I have advanced the understanding of human-wildlife interactions by investigating a context that has until now received limited prior study; the geographies of renewed relationships between humans and reintroduced species. At the outset of this thesis, I highlighted three questions. Here, I now close the thesis with a synthesis that responds to these questions, using the research outcomes from each paper/chapter herein, before concluding with the contribution of Renewed Coexistence.

1. How can potential conflicts that may arise from reintroduction be best anticipated and addressed?

In the opening literature review of this thesis (section 2 of chapter 1), I identified that coexistence and conflicts exist in a continuum; conflicts between humans and wildlife or between humans about wildlife need to be addressed if coexistence is to be achievable (Frank, 2016; König et al., 2021; Nyhus, 2016). In reintroductions, conflicts either with the species or between people about management of the reintroduced species cannot exist until after a species is reintroduced meaning they can only occur in the 'future context' until reintroductions take place. Yet there can be disagreement between parties about whether to reintroduce a species in the first place (Auster, Puttock, et al., 2020; Coz & Young, 2020; O'Rourke, 2014), with concerns about possible future negative impacts potentially leading to any future coexistence with the species being delayed or prevented altogether, as in the case of the 2018 proposals to reintroduce lynx into England (DEFRA, 2018).

Early engagement with stakeholders in the development of management strategies is more likely to foster trust between parties and prevent conflicts from escalating (Decker et al., 2016; O'Rourke, 2014; Seddon et al., 2007), and the findings from my nationwide survey reported in chapter 2 (Auster, Puttock, et al., 2020) emphasise that, alongside key stakeholder views of potential impacts, attitudes to management should be considered prior to reintroduction to develop more socially acceptable strategies for management regarding the reintroduced species. For example, in the survey, different management techniques or levels of legal protection for beavers were favoured by participant groups who supported or opposed the process of reintroducing beavers into Great Britain; 83% of participants who supported the process of reintroducing beavers favoured a strong level of legal protection for beavers, whereas 60% of those who opposed beaver reintroduction favoured none. As is already recognised in the human-wildlife conflict literature, there is greater risk of polarisation and escalated human-human conflict when differing perspectives are not given appropriate recognition (Crowley et al., 2017; Cusack et al., 2021). In this case there is a risk of conflict over beaver management in the longer term, but there is opportunity to understand and respond to different perspectives proactively prior to reintroductions taking place in an attempt to prevent these from arising, unlike with other species which are already present in the landscape.

In chapter 3 (Auster, Barr, et al., 2020b) I focused more specifically upon the experiences of individuals who reported direct conflicts with beavers in the early stages of a reintroduction, with beavers being a recently reintroduced species in the River Otter Beaver Trial. From my interviews with these individuals, factors in the way in which engagement took place in the management response were shown to contribute towards the potential for conflict minimisation. From the affected individuals' points of view, five key themes were identified that related to the engagement responses: *(1) Proactive engagement or a fast response; (2) Appropriate communication; (3) Shared decision-making; (4) Sense that humans are responsible for conflicts with a reintroduced species; (5) A need for certainty*. As I suggested in chapter 2, these themes again demonstrate the importance of addressing potential conflicts proactively or acting on them quickly where proactive intervention may not be possible, and the significance of appropriate engagement with and support for affected individuals. Notably, the fifth theme (*A need for certainty*) focused on uncertainty among participants about future human-beaver conflicts, with uncertainty leading to participant worry about the management support that may or may not be available in the event that beavers were allowed to remain post-2020. As I discussed in the paper, this emphasises that decisions on future, long-term management support will need to be made early to tackle this uncertainty or worry about the feared future negative impacts of reintroduction and reduce potential for conflict escalation as the reintroduced species integrates into the human landscape.

In chapter 4 (Auster, Barr, et al., 2020a) I used Q-Methodology to provide a deeper understanding of the intricacies of the perspectives of members of the angling community - a group identified in chapter 2 as one that was less likely to hold a more positive view on beaver reintroduction and therefore one with whom there is likely to be a greater risk of conflict. I identified and detailed three distinct perspectives among anglers from the River Otter catchment (*‘beaver-accepting’, ‘beaver-apprehensive’, and ‘managed-beaver’*). In response to the finding that angler perspectives are nuanced and diverse, I discussed considerations for beaver management and suggested ways in which to respond to the potential for disagreement between these perspectives about beavers. These included a need for open, cross-sectoral dialogue about research into beaver-fish relationships and available management that are ongoing as reintroductions progress, as well as the development of a management strategy that supports ecosystem benefits (thereby responding to the *beaver-accepting*’ perspective) whilst providing a sense of empowerment for individuals to respond to negative impacts (responding to the concerns of the *‘beaver-apprehensive’* and *‘managed-beaver’* viewpoints).

Thus, I demonstrated in chapters 2 to 4 that public and stakeholder engagement early in reintroduction processes affords the ability to understand different perspectives in such a way that potential conflicts can be identified at the outset or early stages of a reintroduction project (Decker et al., 2016; Redpath et al., 2013; Treves & Santiago-Ávila, 2020). True efforts to engage with concerned parties can build trust and lead to reassurance that uncertainties regarding possible negative future scenarios are being considered, thus reducing the potential for worry and its associated influence on decision-making (Decker et al., 2016; Hudenko, 2012; Riley et al., 2018). Knowledge and acceptance of diverse perspectives in decision-making processes ahead of a reintroduction taking place, together with an understanding of social attitudes towards possible management solutions, could lead to more socially acceptable and equitable management actions that reduce potential for future conflicts or their escalation, and a situation that becomes increasingly difficult to resolve (Cusack et al., 2021).

2. How are potential social benefits of a reintroduction realised or maximised?

As I discussed in section 2 of chapter 1, benefits for people can arise from coexistence with wildlife (Nyhus, 2016). In my thesis, I investigated the tourism and natural flood management benefits arising from coexistence with a reintroduced species. These benefits could be viewed as 'new' benefits for the people in the area as they would not exist without the species having been reintroduced.

In chapter 5 (Auster, Barr, et al., 2020c), I demonstrated that economic benefits arose for local businesses in response to an increased number of riverbank users in response to the presence of beaver, as well as non-economic benefits observed in the form of positive emotional responses reported upon seeing signs of beaver or their activity (figure 2 in chapter 5). Hence, a benefit in beaver tourism was observed to have occurred, which could be considered as a cultural ecosystem service (table 1 in chapter 1). The economic benefit was greatest when a local business actively took initiative to maximise the business opportunity; by making the effort to invest in the presence of beavers (e.g. through beaver-related marketing or products) greater economic benefit was reported. Thus, although some benefit was observed to have occurred naturally (as reported by the other businesses), it was maximised when there was active investment in the opportunities presented by beaver reintroduction. As discussed in the paper, I recommend further research into whether the economic benefits persist over time as the species becomes more widespread in future, but I speculated in the chapter that some benefit will persist as a result of 1) business initiative to capitalise on the opportunity and 2) the fact that wildlife tourism is a growing industry in Britain.

The principle of investment in the potential social benefits of beaver reintroduction also emerged from my study in chapter 6 (Auster et al., 2021a) in which I identified a range of polarised perspectives that exist regarding beavers and their role in natural flood management (sometimes considered as a regulating ecosystem service) among communities living downstream of beaver sites. Among those favourable to beaver, there was a perception that beavers afford multiple benefits - similarly to other natural flood management methods (Ellis et al., 2021; Hewett et al., 2020; Keesstra et al., 2018; Thompson et al., 2018). But among those less favourable to beaver, a sense of uncertainty surrounding future beaver activity was identified to be held by some individuals who viewed beaver activity as more unpredictable than human-led flood management measures as the dam location is determined by a non-human animal; this is unique in natural flood management. Thus, I suggested management implications that included a localised or catchment-scale approach to management (perhaps including the employment of localised beaver officers), and the communication of habitat modelling outputs to provide some level of expectation of where damming could occur. These measures could seek to reduce conflict potential with concerned individuals, then enabling natural flood management benefits to accrue. Hence, conflict alleviation could be viewed here as an active investment in enabling the benefits for reducing flood risk to materialise; this is an example of the coexistence-conflict continuum (Frank, 2016). Further, I proposed further research into whether Beaver Dam Analogues (Beechie et al., 2010; Pollock et al., 2017; Scamardo & Wohl, 2020; Weber et al., 2017) could be used to encourage beaver damming activity in locations that are optimal for natural flood management benefits (see the discussion section in Chapter 6).

Although some level of benefit may naturally occur (for example, an increase in footpath counts in chapter 5 when beavers were present in the publicly visible location), I demonstrated in this thesis that the willingness to <u>actively invest</u> in the opportunities enables the potential benefits of a reintroduction to reach full potential. This principle is similarly recognised in the research group literature review (attached as Appendix 1) which highlighted that : *"to enable maximization of the opportunities from beaver reintroduction that are reviewed […] conflicts will need to be appropriately recognized. […] [Opportunities and conflicts] should be considered as one within a holistic approach"* (Brazier et al., 2020¸ *p18*).

3. How does reintroduction governance compare to the governance of coexistence with a species already present in the landscape?

In chapter 1 I introduced the concept of coexistence (section 2), defined as the "sustainable but dynamic state in which humans and wildlife co-adapt to share the landscape (Carter & Linnell, 2016; Frank, 2016; Pooley et al., 2017)". It involves active governance of conflict management if coexistence is to be achieved (Nyhus, 2016).

In Chapter 7 (Auster et al., 2021b), I examined the experiences of key stakeholders who sat on the Steering Groups within the River Otter Beaver Trial (those responsible for the governance of the reintroduction project) and discussed a series of lessons from their perspectives, using an inductive thematic analysis. From the results, it is notable that the key themes include stakeholder engagement, public engagement, and the need for a strategy to manage arising conflicts; the themes of engagement and conflict management are again prevalent, reflective of the findings I presented in chapters 2-4. Within engagement, and similarly to pre-existing coexistence and human-wildlife conflict literature, participants outlined how constructive, transparent, and early discussion between parties is more likely to foster trust and reduce the potential for conflict (Cusack et al., 2021; Decker et al., 2016; Redpath et al., 2013; Treves et al., 2006). In beaver management, the participants highlight that proactive and clearly communicated strategies hold greater potential to reduce conflict, and a subset of the main River Otter Beaver Trial Steering Group were tasked with thinking in a future-orientated manner in the development of proposals for beaver management post-2020 (River Otter Beaver Trial, 2019). This once again highlights the importance of proactive management consideration with effective stakeholder engagement (Coz & Young, 2020; Cusack et al., 2021), with the real-world example of the Beaver Management Strategy Framework proposals.

In the paper, I identified a ‘future-thinking’ mindset as a key difference between the governance of coexistence with a reintroduced species and with species that are already present in the landscape as humans in the locality today, as coexistence with a species and associated challenges are to be introduced into the landscape. This is reflective of the fact that proactive consideration of future scenarios was a concept that occurred repeatedly throughout the research studies within this thesis (such as the management of uncertainties or encouragement to maximise opportunities). Accordingly, I defined a new term that recognises this specific coexistence situation. ‘Renewed Coexistence’ draws on pre-existing study of coexistence (e.g. effective approaches to stakeholder engagement and trust-building (Frank, 2016; Nyhus, 2016; Treves & Santiago-Ávila, 2020)), whilst recognising questions that are unique to the reintroduction context (e.g. how to normalise the sense that a reintroduced species is wild rather than one put there by people [discussed in Chapter 3], or whether tourism benefits will change as the reintroduced species becomes more widespread [discussed in Chapter 5]). Renewed Coexistence characterises the unique coexistence that occurs as the reintroduced species transitions from one that is 'not present' in the landscape, to a 'new' presence for people in the area (at least until they are normalised for people as a wild animal in the landscape with the ongoing sustainable coexistence for later human generations thereafter), as is demonstrated visually in Figure 1.

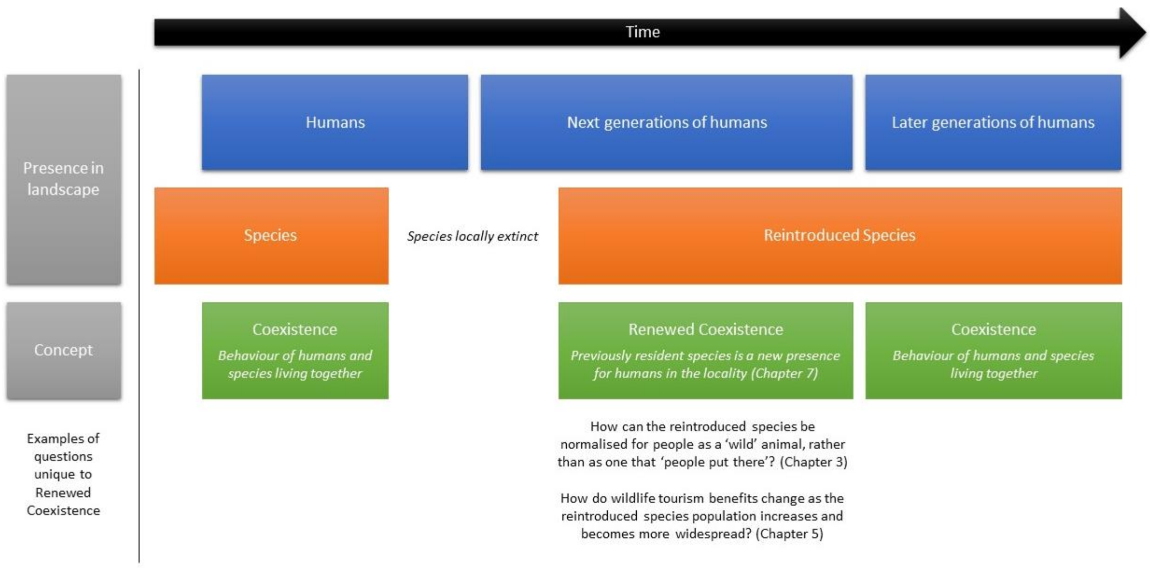

Figure 1. Conceptual diagram demonstrating the relationship between the concepts of Coexistence and Renewed Coexistence as time goes on; in Renewed Coexistence, the reintroduced species is a new presence for the people in the locality.

4. Conclusion

In this thesis I have shown that wildlife reintroductions require holistic understandings of both the ecological and human dimensions of returning formerly resident species to a landscape, reinforcing that which is stipulated within the IUCN Guidelines (IUCN & SSC, 2013). Consequently, I have demonstratedthat there is more than just a role for social science methods in wildlife reintroductions, but I have concluded that, as much as it is ecological, the evidence presented has revealed that wildlife reintroduction actually *IS* a social science in itself: the environmental social science of Renewed Coexistence. This is the behaviour of present-day humans and reintroduced species adapting to living together, with all the proactive conflict management and active investment in social benefits that this may entail.

As the range of pragmatic study in my thesis attests, mixed social science methods provide a deep knowledge of stakeholder and public attitudes, perceptions, experiences, and beliefs (Dewey, 2008; Morgan, 2014). With such efforts to consider the social aspects of wildlife reintroduction, a deeper understanding of the human dimensions can be gained. This knowledge can then be applied to engagement and management practices that are more likely to successfully foster Renewed Coexistence between humans and reintroduced species.

As I argued in chapter 7, defining ‘Renewed Coexistence’ draws attention to the human dimensions of reintroduction projects alongside the practicalities of reintroduction itself, providing the emphasis needed for reintroduction practitioners to consider future coexistence challenges as humans learn to live with the reintroduced species, thereby enhancing the likelihood of successful long-term integration of the reintroduced species into anthropogenic landscapes.

In the case of beaver in England, human-beaver interactions are likely to occur as their reintroduction entails the integration of a second landscape engineer (that may undo some of the positive and negative human landscape engineering that has prevailed since its extirpation) into anthropogenic settings. But with concerted and proactive actions to minimise the potential conflicts that could occur, there is an opportunity to obtain benefits for both human communities and biodiversity. Active investment will then enable social benefits to be maximised in the 'Renewed Coexistence' between humans and beavers in the modern English landscape.

APPENDIX 1.

Beaver: Nature's ecosystem engineers

The following paper forms the first appendix of this thesis. It is presented in published format, with all references included at the end of the chapter in publication format.

This paper is a literature review of beavers and their impacts. It is the result of a collaboration of researchers based at the University of Exeter who investigate various matters relating to beavers.

The researchers made equal contribution to this work. For me, this entailed writing Section 3.2 on Human-beaver interactions.

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OVERVIEW

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Beaver: Nature's ecosystem engineers

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Abstract
Beavers have the ability to modify ecosystems profoundly to meet their ecological needs, with significant associated hydrological, geomorphological, ecological, and societal impacts. To bring together understanding of the role that beavers may play in the management of water resources, freshwater, and terrestrial ecosystems, this article reviews the state-of-the-art scientific understanding of the beaver as the quintessential ecosystem engineer. This review has a European focus but examines key research considering both *Castor fiber*—the Eurasian beaver and *Castor canadensis*—its North American counterpart. In recent decades species reintroductions across Europe, concurrent with natural expansion of refugia populations has led to the return of *C. fiber* to much of its European range with recent reviews estimating that the *C. fiber* population in Europe numbers over 1.5 million individuals. As such, there is an increasing need for understanding of the impacts of beaver in intensively populated and managed, contemporary European landscapes. This review summarizes how beaver impact: (a) ecosystem structure and geomorphology, (b) hydrology and water resources, (c) water quality, (d) freshwater ecology, and (e) humans and society. It concludes by examining future considerations that may need to be resolved as beavers further expand in the northern hemisphere with an emphasis upon the ecosystem services that they can provide and the associated management that will be necessary to maximize the benefits and minimize conflicts.

This article is categorized under:
- Water and Life > Nature of Freshwater Ecosystems

KEYWORDS
beaver, catchment management, ecological restoration, ecosystem engineers, hydrology

1 | INTRODUCTION

Over millions of years, beavers (*Castoridae)* have developed the ability to modify ecosystems profoundly to meet their ecological needs. In doing so, they also provide valuable habitats for many other species that thrive in wetlands. They engineer ecosystems by building dams, which retain ponds, full of sediment, nutrients, plants, and wildlife. These dams slow the flow of water, reducing peak flows downstream (Puttock, Graham, Cunliffe, Elliott, & Brazier, 2017), storing and gently releasing water in times of drought (Hood & Bayley, 2008). Beavers excavate canals, laterally across floodplains, to access and transport food and building resources, enhancing floodplain connectivity, and geomorphic dynamism (Gorczyca, Krzemień, Sobucki, & Jarzyna, 2018; Pollock et al., 2014). They coppice trees, providing deadwood habitat and allowing sunlight to reach understory vegetation which in turn responds in abundance and diversity (Law, Gaywood, Jones, Ramsay, & Willby, 2017), providing rich habitat for insects, birds, bats, and amphibians (Dalbeck, Hachtel, & Campbell-Palmer, 2020; Stringer & Gaywood, 2016; Willby, Law, Levanoni, Foster, & Ecke, 2018). Beavers were once present throughout Europe, Asia, and North America in large numbers, managing water resources, working with natural processes, supporting the healthy functioning of freshwaters—the very definition of a keystone species.

Consider the potential implications of removing such an animal from our ecosystems. Large areas of stored surface water are lost, rivers flow faster, becoming flashy in times of flood and with lower baseflows in times of drought. Woody debris, carbon in water—an essential building block of life in ponds, streams, rivers, estuaries, and marine environments is reduced, undermining the food-chains that it supported. Wetlands dry up, wildlife move on, or are possibly lost from ecosystems entirely. During the Anthropocene, our catchments have largely become a product of human activity that realizes all of these implications, with associated additional pressures including; hydrological extremes, diffuse pollution, and soil erosion (Hewett, Wilkinson, Jonczyk, & Quinn, 2020). The natural disturbance and dynamic equilibrium maintained by beaver activity drives geomorphic and ecological complexity, in their absence, riparian ecosystems have taken on a simpler form both in terms of their structure and their function (Brown et al., 2018).

In the Northern hemisphere, beavers were hunted to near extinction and extirpated entirely in countries such as Great Britain (GB) about 400 years ago (Conroy & Kitchener, 1996). Thus, our living memory of what beaver-lands were like, is limited, in landscapes where natural recolonizations or reintroductions are now taking place. Our understanding of how *other* species co-existed with beavers, many of them dependent upon wetlands such as beaver ponds, is similarly limited. There is thus a requirement to understand the impact of beavers in contemporary ecosystems, particularly in landscapes that, since their extirpation, have been over-exploited, degraded, and altered by intensive farming and urban development.

To bring together understanding of the role that beavers may play in the management of water resources, freshwater, and terrestrial ecosystems, this paper reviews the state-of-the-art scientific understanding of the beaver as the quintessential ecosystem engineer. We focus upon research considering both *Castor fiber*—the Eurasian beaver and *Castor canadensis*—its North American counterpart, as they re-establish in ecosystems within which their numbers were decimated and are reintroduced or return to ecosystems from where they were extirpated, due to their high-value fur (for hats), castoreum (as a painkiller and perfume)—Nolet and Rosell (1998), and their scaly tail, which led the Catholic church to classify beavers as a fish—fit for consumption on Fridays and Saints days (Coles, 2006; Kitchener & Conroy, 1997; Manning et al., 2014).

The remaining two species of beaver are related to pre-historic *Castoridae* which included as many as 40 species, for example, the giant beaver (*C. Castorides spp*; Martin, 1969) and the terrestrial *C. Paleocastor spp*, famed for its spiralized burrows (Martin & Bennett, 1977). Today, the two extant species of beaver are genetically distinct with differing numbers of chromosomes (Kuehn, Schwab, Schroeder, & Rottmann, 2000). Despite their genetic and minor physiological differences, there are many similarities between the species. For example, they are visually similar and difficult to differentiate by sight alone (Kuehn et al., 2000). Until relatively recently, it was considered that the North American beaver had a tendency to build dams and lodges more frequently and of a greater size than the Eurasian beaver, but it has now been shown by Danilov and Fyodorov (2015) that, under the same environmental conditions, the building behavior of the two species does not differ.

In recent decades species reintroductions across Europe, followed by natural expansion has led to the return of *C. fiber* to much of its Eurasian range (Halley, Rosell, & Saveljev, 2012) with a recent review of national population studies, estimating that the *C. fiber* population in Europe numbers over 1.5 million individuals (Halley et al., 2012). As such, there is an increasing need for understanding of the impacts of beaver in intensively populated and managed modern European landscapes. This review focuses on Europe and *C. fiber* but draws on relevant research into *C. canadensis* in North America. The review summarizes how beaver impact: (a) ecosystem structure and geomorphology, (b) hydrology and water resources, (c) water quality, (d) freshwater ecology, and (e) humans and society. It concludes by examining future scenarios that may need to be considered as beavers expand in the northern hemisphere with an emphasis upon the ecosystem services that they can provide and the associated management that will be necessary to maximize the benefits and minimize conflicts.

2 | BEAVER IMPACT UPON THE ENVIRONMENT—CONTEMPORARY UNDERSTANDING

2.1 | Impacts of beaver upon geomorphology

2.1.1 | Overview

We take this opportunity to revisit Gurnell's (1998) review on the hydrogeomorphological effects of beaver, which provides an excellent foundation for our understanding. Beavers, as ecosystem engineers, have a marked influence upon the terrestrial and riverine environments that they occupy (Westbrook, Cooper, & Baker, 2011). Beavers are primary agents of zoogeomorphic processes; here we acknowledge their influence upon river form and process (Johnson et al., 2020) and discuss recent literature on the impacts of beaver on hydrogeomorphology.

2.1.2 | Canal and burrow excavation

Beavers are well known for their construction of impressive lodges, sometimes as tall as 3 m (Danilov & Fyodorov, 2015), but beavers, especially in river systems, typically excavate bank burrows in which to establish dwellings (Collen & Gibson, 2000; Rosell, Bozer, Collen, & Parker, 2005). Beavers often excavate multiple burrows in a single territory, which can contribute significant volumes of sediment to a watercourse (de Visscher, Nyssen, Pontzeele, Billi, & Frankl, 2014; Lamsodis & Ulevičius, 2012) and also create areas of weakness which can lead to localized erosion and, in some instances, the collapse of earthen flood embankments (Harvey, Henshaw, Brasington, & England, 2019).

Beavers commonly dig shallow channels, often referred to as canals, which extend laterally from beaver ponds. These structures enable beavers to access food and building resources more easily (Butler, 1991; Gurnell, 1998). Often developing into dense networks, these canals contribute significantly to the local hydrogeomorphology of floodplains, creating hydraulic roughness, tortuous flow paths, and complex topography in otherwise planar landscapes (Hood & Larson, 2015). Like burrows, these canals may act as a source of fine sediment (Lamsodis & Ulevičius, 2012; Puttock, Graham, Carless, & Brazier, 2018) or, in the event of significant overbank flows and floodplain inundation, sites of deposition. It is interesting to consider that early humans might have moved over (crossing channels on beaver dams) and through beaver landscapes crisscrossed by canals, observing beaver transporting woody building materials by water with ease, and subsequently learning to do so themselves (Coles, 2006).

2.1.3 | Woody debris contribution

Woody debris is a key driver of geomorphic complexity, has been shown to be a fundamental aspect of "natural" stream geomorphology and a critical habitat for aquatic life (Collen & Gibson, 2000; Gurnell, Piégay, Swanson, & Gregory, 2002; Harvey, Henshaw, Parker, & Sayer, 2018; Thompson et al., 2018; Wohl, 2014, 2015). Beaver increase the rate of both large and small woody material contribution to river systems (Gurnell et al., 2002). In small streams, the large woody material (for example felled trees) is less mobile and often remains in place, exerting a strong influence on geomorphic processes, increasing bed heterogeneity through promoting localized scour and deposition (Gurnell et al., 2002). The contribution of smaller woody fragments or cuttings has been shown to significantly increase willow (*Salix spp*) recruitment due to the provision of propagules, which can establish on gravel/sand bars (Levine & Meyer, 2019). This increases the stability of depositional features and promotes rates of aggradation and bed/bank stability.

2.1.4 | Dam building

Beavers have a preference for habitats with deep, slow-flowing water, to feel safe from predators (Collen & Gibson, 2000; Hartman & Tornlov, 2006; Swinnen, Rutten, Nyssen, & Leirs, 2019). Therefore, their dam-building activity is typically restricted to lower-order streams where stream power is limited (Graham et al., 2020; Gurnell, 1998; Macfarlane et al., 2015; Rosell et al., 2005) and water depths may not be sufficient (normally <0.7 m depth) for beaver movement and security. When dam building does occur, it increases the area of lentic (still freshwater) habitats in systems that are typically dominated by lotic (free-flowing freshwater) habitats (Hering, Gerhard, Kiel, Ehlert, & Pottgiesser, 2001). Damming typically reduces downstream connectivity, and conversely increase lateral connectivity, forcing water sideways into neighboring riparian land, inundating floodplains, and creating diverse wetland environments (Hood & Larson, 2015) as well as contributing to soil and groundwater recharge (Westbrook, Cooper, & Baker, 2006). Dams vary significantly in their size and structure depending on physical factors such as hydrology, topography, and building materials but also ecological factors (Graham et al., 2020). Hafen, Wheaton, Roper, Bailey, and Bouwes (2020) found that primary dams, that maintained a lodge pond, were significantly larger than secondary dams, which are used to improve mobility and the transport of woody material, concluding that beaver ecology, in addition to channel characteristics, exerts a primary control on dam size.

2.1.5 | Agents of erosion

Erosion often occurs at the base of dams, due to a localized increase in gradient and stream power (Gurnell, 1998; Lamsodis & Ulevičius, 2012). Woo and Waddington (1990) observed that flow across the dam crest may be concentrated in gaps, enhancing erosion of the stream bed and banks downstream of the dam, forming plunge pools, and widening the channel, respectively. Lamsodis and Ulevičius (2012) observed the geomorphic impacts of 242 dams in lowland agricultural streams in Lithuania; of which, 13 (5.4%) experienced scour around the periphery of the dam.

Beaver dams are also key sites for channel avulsion (Giriat, Gorczyca, & Sobucki, 2016; John & Klein, 2004), as shown in Figure 1. John and Klein's (2004) study investigated the geomorphic impacts of beaver dams on the upland valley floor of the third-order River Jossa (Spessart/Germany). Due to the creation of valley-wide dams, which extended beyond the confines of the bank, multi-thread channel networks developed across the floodplain. Newly created channels would deviate from the main stream channel, re-entering the river some way downstream. At the point where the newly created channel enters the stream, a difference in elevation results in the development of a knickpoint. This knickpoint then propagates upstream through head-cut erosion, eventually relocating the main stem of the channel.

2.1.6 | Agents of aggradation

Hydrogeomorphic changes, due to beaver engineering, are likely to have implications for stores and downstream fluxes of sediment and associated nutrients (Butler & Malanson, 1994; Lizarralde, Deferrari, Alvarez, & Escobar, 1996). Sediments mobilized and transported from upstream are deposited in beaver ponds, due to a decrease in velocity associated with a reduction in water surface gradient (Giriat et al., 2016) and consequently stream power (Butler & Malanson, 1994).

Pollock, Lewallen, Woodruff, Jordan, and Castro (2017) showed lower concentrations and loads of suspended sediment leaving a beaver site in contrast to those entering the site, while Puttock et al. (2018) showed that within the same site the beaver pond sequence was storing 100 t of sediment combined with an associated 16 t of carbon and 1 t of nitrogen. It is therefore suggested that beaver dams and ponds can create landscapes with depositional sediment regimes exerting a significant influence over channel sediment budgets, akin to the pre-anthropocene dam and woody debris that once played a vital role in the evolution of river networks and floodplains, through the storage of sediment and nutrients and creation of riparian wetland and woodland (Brown et al., 2018).

The large mass of sediment (over 70 kg per m^2 of ponded extent) being stored in a relatively small area (1.8 ha) reported by Puttock et al. (2018) represents similar levels of aggradation to those reported in studies, primarily from North America. Beaver dam sequences on low order streams have previously been shown to account for up to 87% of sediment storage at reach scales, while the removal of a sequence of beaver dams in Sandon Creek, British Colombia, leads to the mobilization of 648 m^3 of stored sediment (Butler & Malanson, 1994, 1995; Page et al., 2005). Butler and Malanson (1994, 1995), also reported sediment accumulation rates of 2–28 and 4–39 cm $year^{-1}$ for different beaver pond sequences in Glacier National Park, Montana. Values of sediment accumulation from North American beaver systems indicate the estimated average accumulation value of 5.4 cm $year^{-1}$ presented by Puttock et al. (2018) in Great Britain may be at the lower end of what is possible in bigger dam–pond complexes or systems with a more plentiful sediment supply. In one of the few other studies in European landscapes, de Visscher et al. (2014) studied sediment accumulation in two beaver pond sequences in the Chevral River, Belgium. de Visscher et al. (2014) estimated the total

FIGURE 1 Examples of dam construction and channel avulsion resulting from beaver dam construction from the River Otter catchment, England. Panel (a) shows an example where a divergent flow path has re-entered the main channel resulting in head-cut erosion. Panel (b) shows the type of multi-thread channel form that occurs downstream of dams in wide, low gradient floodplains. Panel (c) shows a beaver dam on a 4th order stretch of river. (Reproduced with permission from Photos © Hugh Graham and Alan Puttock)

sediment mass deposited in the dam sequences at 495.9 t. From the two pond sequences, average pond area was 200.4 m^2, average sediment depth 25.1 cm, and average sediment mass of 14.6 t, equating to a normalized mass of 72.65 kg of sediment deposited per m^2 of the pond. These values are very similar to the mean sediment depth of 27 cm and mean normalized mass of 71.40 kg m^2 reported from the intensively managed grassland catchment in the UK (Puttock et al., 2018).

The sediment data published also demonstrate that beaver ponds can exhibit high sediment accumulation rates in comparison with other wetland systems. As an example, in a review of sediment accumulation rates in freshwater wetlands (Johnston, 1991) a mean annual accumulation rate of 0.69 cm $year^{-1}$ was reported across 37 different wetland types, ranging from riparian forest to wet meadows. As with the biodiversity benefits of beaver ponds (see Willby et al., 2018 and Section 3 below) the high sediment accumulation rate of beaver ponds in relation to other freshwater wetlands, may reflect the highly dynamic nature of beaver systems, their constant evolution, and sustained maintenance (i.e., continuous dam-building).

The long-term fate of sediment will depend on the availability and composition of deposited sediment, the flow regime, and the preservation of dam structures (Butler & Malanson, 2005; de Visscher et al., 2014). Over many years, sediment may continue to accumulate until each pond fills completely and sediments are colonized by plants forming beaver meadows (Polvi & Wohl, 2012). However, beavers can also contribute to downstream sediment budgets; through the excavation of canal networks and bank burrows (de Visscher et al., 2014; Lamsodis & Ulevičius, 2012), in addition to the release of sediment following dam outburst floods (Curran & Cannatelli, 2014; Levine & Meyer, 2014). Beaver dam failure can result in releases of sediment (Polvi & Wohl, 2012) meaning that sediment storage in ponds can be transient (de Visscher et al., 2014). However, different sediment retention dynamics have been reported following dam collapse. For example, Giriat et al. (2016) found that there were very minimal losses of sediment from beaver ponds studied in Poland, following a dam collapse. Similarly, the majority of sediments were retained in ponds and subsequently stabilized following dam reconstruction (Curran & Cannatelli, 2014; Levine & Meyer, 2014) most likely reducing the downstream release of sediment from any single dam failure within the complex (Butler & Malanson, 2005; Puttock et al., 2018). While recent studies in North America involving extensive survey work have expanded knowledge of beaver dam persistence significantly (Hafen et al., 2020), including persistence during large rainstorm events (Westbrook, Ronnquist, & Bedard-Haughn, 2020), resilience, failure, and associated sediment dynamics are likely to be highly spatially and temporally variable. As identified in Section 2.2 for both hydrological, geomorphic, and associated sediment/water quality impacts a greater mechanistic understanding of dam failure is therefore still required.

Finally, high levels of nutrient-rich sediment have also been shown to result in further biogeomorphic alterations, that is, colonization by homogeneous patches of herbaceous or shrubby species, adding roughness to topography, reduced water velocities, and encouraging further deposition of sediments. Additionally, partial felling and submergence of woody debris disrupts flows and when felled in-channel, creates reinforcement for existing dam structures (Curran & Cannatelli, 2014).

2.1.7 | Impacts of dams on river profile

Beaver dams have two main effects on river profile; (a) long-profile is altered such that a stepped profile develops with sections of reduced gradient, that promote aggradation, upstream of dams separated by hydraulic jumps, created by flow over the dams, which initiates erosion. (b) Channel planform typically increases in complexity with many studies reporting; greater sinuosity, channel width, and the development of a multi-thread planform (Ives, 1942; John & Klein, 2004; Pollock et al., 2014; Wegener, Covino & Wohl, 2017). These increases in cross-profile complexity are driven by an increase in the heterogeneity of flow direction, which drives lateral flow, increasing bank erosion, channel widening, and subsequent localized deposition (Gorczyca et al., 2018).

2.1.8 | Agents of river restoration

In an undisturbed or near-pristine riverine system, the engineering behavior of beaver may simply maintain an evolving geomorphic structure, sustaining a state of dynamic equilibrium in river function. In degraded landscapes (which are much more common), where river planforms are incised, single thread, straightened, even dredged, and lacking in geomorphic diversity, beaver have a dramatic impact on channel planform at multiple scales. In North America, beaver dams and their human-constructed counterparts, known as beaver dam analogs, have been shown to restore degraded river systems (Pollock, Beechie, & Jordan, 2007), primarily through the aggradation of channel beds, leading to greater channel-floodplain connectivity (Macfarlane et al., 2015; Pollock et al., 2014).

Dams, however, are not rigid structures—they influence and are influenced by flow regimes (Johnston & Naiman, 1987) as is evidenced in Figure 2 (after Pollock et al., 2014). In narrow, incised channels, typical of degraded landscapes, beaver dams will capture some sediment but predominantly provide a foci for erosion. In these confined channels, unit stream power is high and therefore dams will frequently blow-out and erode laterally. The resultant effect is a widening of the channel, which leads to a concomitant decline in stream power, thus allowing for greater aggradation rates and less frequent blow-outs altering the sediment regime from net erosional to net depositional (Butler, 1995; Butler & Malanson, 2005). Over time, incised, straightened streams can be restored to complex multi-threaded channel systems that represent a return to the pre-anthropocene streams and rivers that were once common across north-west Europe (Brown et al., 2018). In Poland, beaver initiated geomorphic processes were shown to alter artificially homogenized river reaches and thus it has been suggested that they may have a substantial role to play in the renaturalization of river systems (Gorczyca et al., 2018).

2.1.9 | Summary of geomorphic impacts

- Beaver damming activity is mostly limited to ≤fifth-order streams as low stream power is favorable for dam-building and persistence, with a reduction in the frequency of blowouts.
- Beavers drive a transition in sediment dynamics from dominantly erosional to net depositional, while increasing the spatial variability of both erosional and depositional features.
- Geomorphic change due to beaver is often characterized by changes in channel planform, longitudinal profiles, water surface and channel bed slope, increased sinuosity, and enhanced floodplain connectivity and surface roughness.

2.1.10 | Gaps in geomorphic understanding

- At present, the majority of geomorphology-facing beaver research is from North America. Several studies from Europe indicate strong parallels between the geomorphic impacts between continents. However, geomorphic impacts are strongly influenced by local geography and therefore further monitoring is necessary to complement these findings.
- Research on the impacts of beaver on geomorphic processes is required at larger spatial extents and longer temporal scales. At present, most research focuses on site/reach scale observations, which must be continued in dialogue with long-term, catchment scale monitoring and modeling to build understanding at landscape scales.
- The effects of beaver activity on short-term sediment storage/mobilization due to bank-burrowing and canal excavation, has not yet been substantially investigated.

2.2 | Impacts of beaver upon hydrology

2.2.1 | Overview

There is an increased need to recognize the influence of biology upon river form and process (Johnson et al., 2020) and beavers as recognized ecosystem engineers are a key example of the ability of an animal to influence hydrological functioning. While other beaver engineered structures discussed in Section 2.1, such as burrows and canals, have a measurable impact (Grudzinski, Cummins, & Vang, 2019), the biggest (and most studied) hydrological impact of beavers results from their dam-building ability and the consequent impoundment of large volumes of water in ponds (Butler & Malanson, 1995; Hood & Bayley, 2008). Dam and pond features can alter hydrological regimes, both locally and downstream (Burchsted & Daniels, 2014; Polvi & Wohl, 2012). Beaver activity can reduce downstream hydrological connectivity, and conversely increase lateral connectivity, forcing water sideways into neighboring riparian land, inundating floodplains, and creating diverse wetland environments (Macfarlane et al., 2015), while also contributing to soil and groundwater recharge (Westbrook et al., 2006).

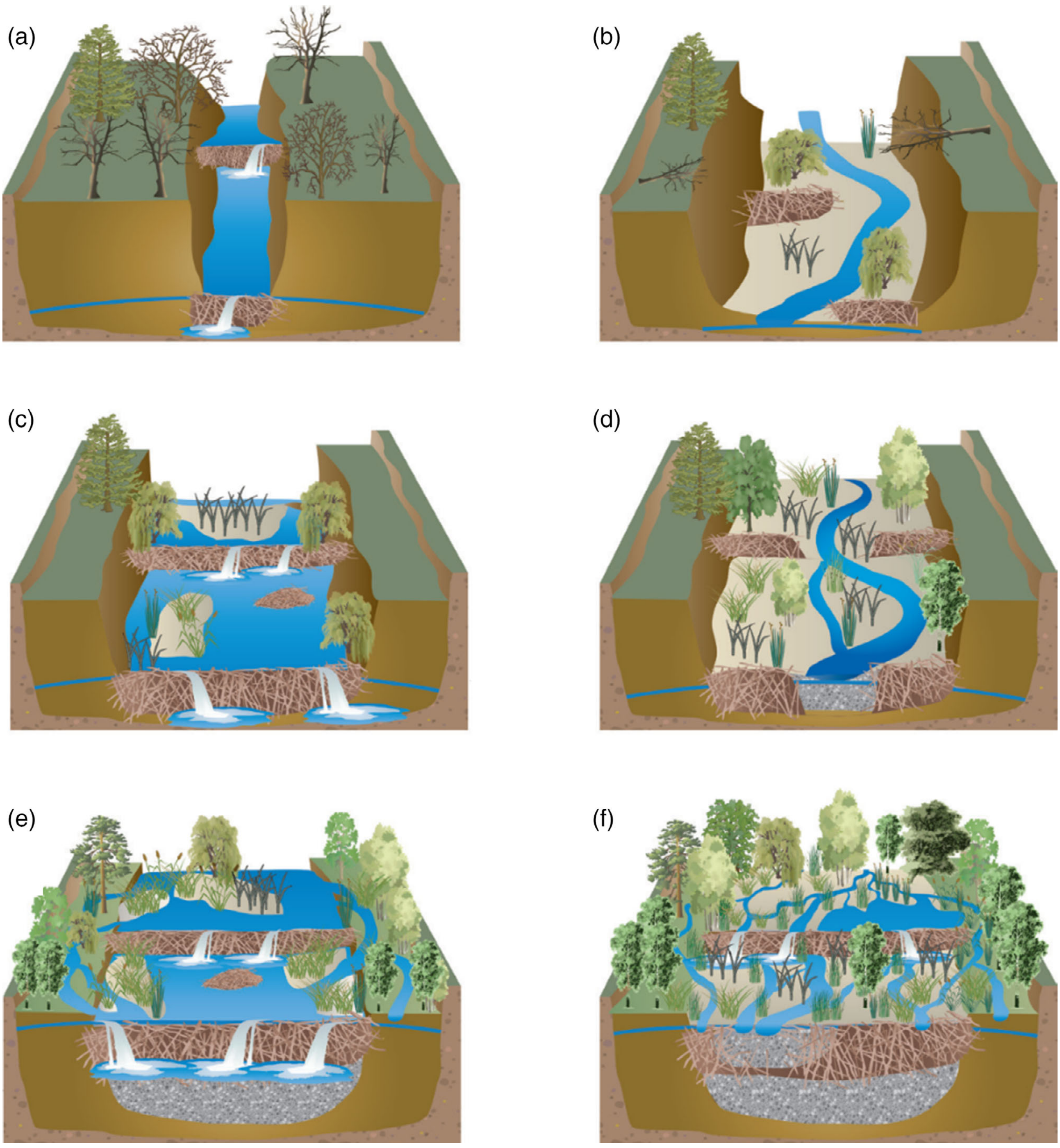

FIGURE 2 The influence of beaver activity on the geomorphology of incised streams: (a) low-flow damming of confined channels with high-flow blowouts causes overtopping, bank widening, and excavation of the channel bed; (b) sediment becomes more mobile and the channel reconfigures with vegetation establishment; (c) channel widening reduces high-flow peak stream power and this provides suitable conditions for wider, more stable dams; (d) sediment accumulates in ponds and raises the height of the channel with dams overtopped and small blow-outs occurring where dams are abandoned; (e) process repeats until dams are rebuilt, channel widens and the water table rises sufficiently to reconnect river channel to the floodplain; and (f) high heterogeneity occurs with vegetation and sediment communities establishing themselves, multi-threaded channels and ponds increase reserves of surface water and dams and dead wood reduce flows and provide wetland habitats. (Reproduced with permission from Pollock et al., 2014)

Multiple studies have identified beaver dam sequences and wetlands as a cause of flow attenuation—so-called "slowing the flow" (Green & Westbrook, 2009; Gurnell, 1998; Pollock et al., 2007). This impact has been attributed to the increase in water storage in beaver pond sequences, relative to undammed reaches (Westbrook et al., 2020), and increased hydrological roughness from the creation of dams and complex wetlands (Puttock et al., 2017), resulting in water being trapped or slowed as it moves through, over and around beaver dams. For example, Green and Westbrook (2009) found the removal of a sequence of beaver dams resulted in an 81% increase in flow velocity. The slow movement of water in beaver impacted sites is attributed to two main mechanisms: (a) increased water storage and (b) stream discontinuity and reduced longitudinal hydrological connectivity (Puttock et al., 2017). The increase in storage provided by beaver ponds and wetlands (Grygoruk & Nowak, 2014; Gurnell, 1998; Woo & Waddington, 1990) lengthens water retention times and reduces the velocity of the water. This in turn can increase the duration of the rising limb of the flood hydrograph which can reduce the peak discharge of floods (Burns & McDonnell, 1998; Green & Westbrook, 2009; Nyssen, Pontzeele, & Billi, 2011). Additionally, water stored in beaver ponds is released slowly as the porous dams gently leak both during and following rainfall, elevating stream base flows even during prolonged dry periods (Majerova, Neilson, Schmadel, Wheaton, & Snow, 2015; Puttock et al., 2017; Woo & Waddington, 1990), increasing environmental resilience to risks including drought and fire (Fairfax & Whittle, 2020).

Water levels in ponds vary significantly as a result of meteorological conditions both over long (i.e., seasonal) and short (i.e., inter-event) timeframes (Puttock et al., 2017; Westbrook et al., 2020). Consequently, seasonal variations in water storage have been observed (see Majerova et al., 2015 for example). It might be expected that the attenuating impact of flow due to storage will be less during wet periods. However, it has been proven that beaver activity still attenuates flow during large events. For example, see Nyssen et al. (2011) who conducted one of the few in-channel hydrological studies of Eurasian beaver; finding that flow attenuation was in fact greatest during largest events. In 2013, Westbrook et al. (2020) monitored the largest recorded flood in the Canadian Rocky Mountains west of Calgary, Alberta, challenging the commonly held assumption that dams fail during large floods (the majority fully or partially persisted) and showing that water storage offered by beaver dams (even failed ones) delayed downstream flood peaks. Therefore, it has been argued that the observed discontinuity or reduced downstream hydrological connectivity resulting from beaver dam-building activity—also shown by Butler and Malanson (2005), is a key reason for the flow attenuation impact persisting even for larger events during wetter periods (Puttock et al., 2017).

Of course, beaver dam construction is highly variable and depends on the existing habitat, building material availability, and channel characteristics (Collen & Gibson, 2000; Woo & Waddington, 1990). Woo and Waddington (1990) identified multiple ways in which dam structure will influence flow pathways and that streamflow can overtop or funnel through gaps in the dams, leak from the bottom of the dams or seep through the entire structure. While the impact of dam structure upon connectivity and therefore, flow velocity will differ (Hering et al., 2001; Woo & Waddington, 1990), all dams will increase channel/hydraulic roughness and therefore, deliver some flow attenuation effect, which can be most significant when a suite of dams in close proximity are constructed (for example see Puttock et al., 2017 case study). Thus, in addition to dam structural variations, it is important to note that the number of dams and their density will strongly influence any observed differences in hydrological function. Existing work has also discussed the importance of the number of dams in a reach, with beaver dams having the greatest impact on hydrology when they occur in a series (Beedle, 1991; Gurnell, 1998). Similarly, sequences of (non-beaver) debris dams in third order, Northern Indiana (USA) streams were found to increase the retention time of water by a factor of 1.5–1.7 (Ehrman & Lamberti, 1992). Ponds located in series provide both greater storage and greater roughness, resulting in a greater reduction in flow velocities as shown by Green and Westbrook (2009). In another study, pond sequences have been shown to reduce the peak flows of 2-year return floods by 14% whereas individual dams reduced flood peaks of similar events by only 5.3% (Beedle, 1991).

There are very few hydrological modeling studies into the impacts of beaver dam sequences upon flow regimes. In European landscapes, this perhaps reflects the fact that until recently there has been both a dearth of beaver dams themselves and also a lack of empirical understanding of the impact on hydrological functioning. In a notable exception, Neumayer, Teschemacher, Schloemer, Zahner, and Rieger (2020) undertook hydraulic modeling of beaver dam sequences and evaluated their impacts during flood events. Utilizing surveys of beaver dam cascades in Bavaria and 2D hydraulic modeling, Neumayer et al. (2020) predicted that during small flood events, beaver dams can deliver significant impacts upon peak flows (up to 13% reductions) and lag/translation times (up to 2.75 hr). But, Neumayer et al. (2020) also predicted that during larger floods (return period ≥2 years), the impact upon peak flows of a single dam sequence may be smaller (ca. 2%) and perhaps negligible at the catchment outlet. However, Neumayer et al. (2020) modeled the impacts of beaver dams on channels larger than those that other research has shown might support the greatest densities of dams (i.e., Graham et al., 2020 show that dams rarely persist on >fifth-order streams) and thus it is suggested that further modeling work is required into the downstream hydrological impacts of small streams with high dam densities. In addition, further research is required to understand what the cumulative catchment outlet effects might be if beavers return to being widespread and catchments contain multiple dam sequences (i.e., hundreds of dams) in all headwater streams.

2.2.2 | Summary of hydrological impacts

- Beavers can reduce longitudinal (downstream) connectivity, while simultaneously increasing lateral connectivity, pushing water sideways.
- Beavers can increase surface water storage within ponds and canals, while also elevating the water table and contributing to groundwater recharge.
- Beaver dam sequences and wetlands can attenuate flow during both high and low flow periods.

2.2.3 | Gaps in understanding: Hydrology

- A greater mechanistic understanding of the hydrological impacts of beaver dams and also critically sequences of beaver dams across scales and land uses to inform hydrological modeling, management, and policy decision making.
- Conditions of dam failure and consequences.
- Greater understanding of beaver landscape engineering upon low flow conditions and wetland maintenance during drought.

2.3 | Impacts of beaver upon water quality

The altered flow regimes and water storage capacity discussed in Section 2.2 can also modify sediment regimes and nutrient and chemical cycling in freshwater systems. As a consequence of reduced downstream connectivity and a change from lotic to lentic systems, beaver activity is believed to alter both local and downstream sediment dynamics, and water quality via both abiotic and biotic processes (Cirmo & Driscoll, 1996; Johnston, Pinay, Arens, & Naiman, 1995). It has been argued that two key mechanisms affect the difference in sediment dynamics of water quality observed in beaver systems: (a) slowing of flow resulting in the physical deposition of sediment (reviewed in Section 2.1) and associated nutrients/chemicals, (b) an increase in both ponded water and a local rise in water tables, results in an overall increase in wetness altering the biogeochemical cycling of nutrients (Puttock et al., 2017).

2.3.1 | Impacts on nutrient cycling

When beaver dams inhibit the transport of fine sediments, large volumes of organic and inorganic compounds become stored within beaver ponds (Rosell et al., 2005), including; nitrogen, phosphorus, and particulate (bound) carbon (Lizarralde et al., 1996; Naiman, Pinay, Johnston, & Pastor, 1994). This change increases the volume of anoxic sediments and provides organic material to aid microbial respiration. Nutrients are temporarily immobilized in pond sediments and taken up by aquatic plants, periphyton, and phytoplankton. Increases in plant-available nitrogen, phosphorus, carbon, and increased light availability (due to canopy reduction) favor the growth of instream and riparian vegetation, thus further immobilizing nutrients within plant biomass that re-establishes local nutrient cycles (Rosell et al., 2005). In addition to the impacts of large volumes of sediment, the reduction in free-flowing water and increased decomposition has been shown to increase anaerobic conditions in both pond surface water and saturated soils (Ecke et al., 2017; Rozhkova-Timina, Popkov, Mitchell, & Kirpotin, 2018).

Lazar et al. (2015) show that beaver ponds have a denitrification impact while results from Puttock et al. (2017) showed Total Oxidized Nitrogen (TON) and Phosphate (PO_4-P) to be significantly lower in waters leaving a beaver impacted site compared with water quality entering. These reductions manifest both in terms of concentrations and loads of nutrients, suggesting that beaver activity at the site created conditions for the removal of diffuse pollutants from farmland upstream. Correll, Jordan, and Weller (2000) found that prior to dam construction, TON concentrations were significantly correlated with river discharge but after dam construction, no significant relationship was observed, although there was a correlation between discharge and nitrate (NO_3-N). Similarly, Maret, Parker, and Fannin (1987) identified reductions in Total Kjeldahl Nitrogen (TKN) downstream of beaver dams during high flows. It has also been shown that beaver ponds are particularly effective at NO_3-N retention (K. J. Devito, Dillon, & Lazerte, 1989). It is suggested, therefore, that in agriculturally dominated catchments where diffuse pollution rates are high, beaver ponds may be effective tools to manage N-related diffuse pollution problems from intensive agriculture upstream (Lazar et al., 2015).

Puttock et al. (2017) show that beaver ponds can also act as sinks for phosphorus associated with sediments, while Maret et al. (1987) identified that suspended sediment was the primary source of phosphorus found leaving a beaver pond; therefore, during conditions when more sediment is retained behind the dam than is released, total phosphorus retention will increase. In a study of a beaver impacted and non-beaver impacted catchment (Dillon, Molot, & Scheider, 1991), found total phosphorus export was higher in the non-impacted catchment suggesting that phosphorus was being stored somewhere within the catchment—most probably in the beaver ponds. Lizarralde et al. (1996) also reported that while phosphorus concentrations were significantly higher in riffle sediments, due to extensive wetland creation, total storage was highest in Patagonian beaver ponds. Previous studies have focused primarily on the relationship between discharge and phosphorus concentrations and yields leaving ponds, with inconclusive results. Devito et al. (1989) reported a strong positive correlation between phosphorus loads and stream discharge. However, Maret et al. (1987) report a negative correlation between phosphorus concentrations and discharge and Correll et al. (2000) report no correlation between nutrient flushing and stream discharge following dam construction. Climatic and seasonal changes (Devito & Dillon, 1993; Klotz, 2007) and organic matter availability (Klotz, 2007, 2013) have been shown to affect in-pond phosphorus-dynamics. With regard to downstream impact, the key consensus, that is supported by the correlation between suspended sediment and phosphate concentrations observed in Puttock et al. (2017) is that beaver ponds are effective at retaining phosphorus associated with high sediment loads (Devito et al., 1989; Maret et al., 1987).

Ecke et al. (2017) suggest age dependency as a factor in nitrogen and phosphorus dynamics, with older, more solid dams increasing retention compared to younger more leaky dams. In a review of beaver impacts upon nitrogen and phosphorus content in ponds and downstream, Rozhkova-Timina et al. (2018) cite contradictory information and study results as showing there is a strong contextual dependence and it is clear that further research into the controlling mechanisms of nutrient retention is required.

In contrast to the trends observed for nitrogen and phosphorus, multiple studies, that is, Puttock et al. (2017) and Cazzolla Gatti et al. (2018) found concentrations and loads of Dissolved Organic Carbon (DOC) increase due to beaver activity. This increase is attributed to enhanced sediment and nutrient storage in addition to the overall increase in wetland extent creating an environment rich in organic matter, as previously shown by Vecherskiy, Korotaeva, Kostina, Dobrovol'skaya, and Umarov (2011). Similarly, Law, McLean, and Willby (2016), using color as a proxy for DOC, observed increased concentrations below a series of beaver dams. Dams trap sediment-bound particulate carbon meaning that ponds can act as net stores of carbon (D. Correll et al., 2000; Lizarralde et al., 1996; Naiman, Melillo, & Hobbie, 1986). However, as a consequence of this overall increase in carbon availability, significant exports of DOC have been observed either downstream (D. Correll et al., 2000; Naiman et al., 1994) or in comparison with non-beaver impacted catchments (Błędzki, Bubier, Moulton, & Kyker-Snowman, 2011). Several authors have speculated that the cause of this DOC release relates to (a) incomplete decomposition processes making DOC more available for loss (Cirmo & Driscoll, 1996); (b) enhanced production during primary productivity; (c) a product of enhanced microbial respiration (D. Correll et al., 2000); and (d) retention of particulate organic carbon and litter entering the site and subsequent decomposition (Law et al., 2016). Based upon research in western Siberia, Cazzolla Gatti et al. (2018) argue that beaver activity simultaneously increases nutrient cycling and DOC availability at the same time as increasing carbon sequestration as carbon is accumulated in sediment and removed from the short-term carbon cycle.

pH has been shown to be a first-order control on DOC production and transport in other wetlands (Clark, Lane, Chapman, & Adamson, 2007; Grand-Clement et al., 2014). However, Cirmo and Driscoll (1996) found that a beaver impacted catchment contained higher levels of DOC both before and after $CaCO_3$ treatment (to reduce acidity) when compared with a non-impacted catchment, suggesting that pH plays a limited role in the production of DOC in beaver ponds. Puttock et al. (2017) showed pH to be marginally more alkaline in water leaving the site, which is in agreement with other studies showing more acidic waters in beaver ponds than immediately downstream (Cirmo & Driscoll, 1993; Cirmo & Driscoll, 1996; Margolis, Castro, & Raesly, 2001). However, whether these changes in pH were of a large enough magnitude to alter within site biogeochemical cycling is as yet unclear.

Increased water availability in beaver systems, in addition to a change in chemistry associated with a transformation from lotic to lentic waters, has also been ascribed by multiple studies to control increased leaching of heavy metals from soils and increased concentrations in waters downstream. Releases from pond or increases in downstream concentrations of calcium, iron, and magnesium (for example) were observed by Naiman et al. (1994) and C. A. Johnston et al. (1995), while Levanoni et al. (2015) and Margolis et al. (2001) also observed downstream increases in manganese and observed increasing methylmercury concentrations both downstream of beaver sites and in macroinvertebrates within beaver sites. In a meta-analysis review, Ecke et al. (2017) found young ponds to be a source for methylmercury in water, while old ponds were not, again highlighting that beaver systems are complex and dynamic with a high degree of context-dependence required to understand their impacts upon water quality.

2.3.2 | Summary of water quality impacts

- Beaver wetlands and dam sequences can change parts of freshwater ecosystems from lotic to lentic systems impacting upon sediment regimes and biogeochemical cycling.
- By slowing the flow of water, suspended sediment and associated nutrients are deposited, with ponds shown to be large sediment and nutrient stores.
- Increased water availability, raised water tables, and increased interaction with aquatic and riparian vegetation have all been shown to impact positively upon biogeochemical cycling and nutrient fluxes.

2.3.3 | Water quality gaps in understanding

- Sediment and nutrient dynamics within dam sequences as opposed to individual dams and ponds.
- A greater understanding is required of the contributing source of sediment and nutrients to beaver ponds.
- How long-term beaver dam sequences and wetland dynamics contribute to downstream water quality.
- How the impoundment of water, sediments, and associated nutrients in ponds affects biogeochemical cycling and resulting transfers of nutrients in both gaseous and dissolved forms to understand the contribution of beavers to overall nutrient budgets in both the carbon and nitrogen cycles.

3 | BEAVER IMPACTS UPON LIFE—CONTEMPORARY UNDERSTANDING

3.1 | Impacts of beaver upon aquatic ecology

Enhancement of natural processes, floodplain inundation, lateral connectivity, and structural heterogeneity in beaver-impacted environments creates a diverse mosaic of habitats. Such habitats are underpinned by greater provision of food, refuge, and colonizable niches, which form the cornerstone of species-rich and more biodiverse freshwater wetland ecosystems (Brazier et al., 2020; Campbell-Palmer et al., 2016; Gaywood et al., 2015; Gurnell, 1998; Rosell et al., 2005; Stringer & Gaywood, 2016). Readers are directed to three reviews on this topic: Stringer and Gaywood (2016), which provides a comprehensive overview of the impacts of beaver on multiple species, Dalbeck et al. (2020) which considers the impacts of beavers on amphibians in temperate European environments and Kemp, Worthington, Langford, Tree, and Gaywood (2012) which provides a valuable meta-analysis of the impacts of beaver on fish. This section builds on these reviews to summarize the findings of research into the impacts of beaver activity on aquatic plants, invertebrates, and fish. We focus on these groups as they are widely considered to be strong indicator species of freshwater health and function (Herman & Nejadhashemi, 2015; Law et al., 2019; Turley et al., 2016).

3.1.1 | Aquatic vegetation (macrophytes)

Beavers affect aquatic vegetation through direct and indirect mechanisms over a range of spatial and temporal scales (Rosell et al., 2005). Natural disturbances, including; herbivory, food caching, tree-felling (Campbell-Palmer et al., 2016; Harrington, Feber, Raynor, & Macdonald, 2015), and/or dam-induced extension of wetland area (Gurnell, 1998; Puttock et al., 2017) can aid macrophyte recruitment (Levine & Meyer, 2019), regenerate riparian areas (Jones, Gilvear, Willby, & Gaywood, 2009), and enhance plant biodiversity from the local to the landscape scale (Law, Bunnefeld, & Willby, 2014; Law, Jones, & Willby, 2014; Law, Levanoni, Foster, Ecke, & Willby, 2019; Willby et al., 2018). Canopy-opening and floodplain inundation creates wetland areas with reduced shading (Donkor & Fryxell, 2000; Johnston & Naiman, 1990), providing opportunities for shade-intolerant, opportunistic, and wetland plant species (Law et al., 2016, 2017; Law, Levanoni, et al., 2019; Marshall, Hobbs, & Cooper, 2013). Early successional shifts in newly created wetted zones promote emergent vegetation (Ray, Rebertus, & Ray, 2001), while transitional edges form around pond margins, characterized by rich, diverse, and structurally complex plant communities (McMaster & McMaster, 2001).

Over time, beaver wetland creation, maturation, and abandonment, can result in the siltation of ponds, creating novel habitats in marshy beaver meadows characterized by spatial variability in moisture-regimes which drives higher plant species richness (Polvi & Wohl, 2012; Ray et al., 2001; Wright, Flecker, & Jones, 2003; Wright, Jones, & Flecker, 2002). As beaver meadows mature, terrestrial succession often occurs, leading to herbaceous encroachment, typically comprising grasses, shrubs, and sedges, with studies showing evidence of an eventual return to open, forested, stream environments (Johnston, 2017; Little, Guntenspergen, & Allen, 2012; McMaster & McMaster, 2001; Naiman, Johnston, & Kelley, 1988; Pollock et al., 1995; Ray et al., 2001).

3.1.2 | Invertebrates and amphibians

Beaver increase the heterogeneity of stream depth, flow velocity, and benthic habitats such as silty substrates, woody material (Clifford, Wiley, & Casey, 1993; France, 1997; Rolauffs, Hering, & Lohse, 2001), and both submerged and emergent vegetation, which separately support unique invertebrate species and assemblages (Benke, Ward, & Richardson, 1999; Bush & Wissinger, 2016; Law, Levanoni, et al., 2019; Wissinger & Gallagher, 1999). Beaver ponds support more lentic species (Collen & Gibson, 2000; Margolis et al., 2001; Rosell et al., 2005) and typically demonstrate increased invertebrate abundance (Czerniawski & Sługocki, 2018; Osipov, Bashinskiy, & Podshivalina, 2018; Strzelec, Białek, & Spyra, 2018; Willby et al., 2018), biomass (Osipov et al., 2018) and/or density (McDowell & Naiman, 1986). Beaver ponds may harbor unique assemblages, dominated by collector-gatherers, shredders, and/or predators (Law et al., 2016; McDowell & Naiman, 1986; Robinson, Schweizer, Larsen, Schubert, & Siebers, 2020; Strzelec et al., 2018). However, diversity may be reduced due to the typically homogeneous benthic habitat within ponds resulting from increased fine sediment deposition (Descloux, Datry, & Usseglio-Polatera, 2014; Pulley, Goubet, Moser, Browning, & Collins, 2019). At broader scales, varying successional stages in beaver wetlands, as well as longitudinal variability in habitat type along with beaver dam-pond sequences (e.g., Margolis et al., 2001), increases the taxonomic, trophic, and/or β-diversity of aquatic invertebrate communities compared to environments lacking beaver modification. This is primarily due to the heterogeneity of habitat benefiting a range of both lotic and lentic species (Bush, Stenert, Maltchik, & Batzer, 2019; Law et al., 2016; Pollock et al., 2017; Willby et al., 2018). Furthermore, the storage of sediment and nutrients within beaver ponds improves water quality (Puttock et al., 2017) downstream and therefore enhances habitat for pollution-sensitive species (Rosell et al., 2005; Strzelec et al., 2018).

The gradual release of water from beaver ponds maintains flows during dry periods (Section 2.1), thereby increasing invertebrate resilience to drought by providing refuge pools and greater post-drought recolonization potential (Wild, 2011; Wissinger & Gallagher, 1999). High-head dams promote high velocity and turbulent water over, through, or around dams in side-channels, creating habitat suitable for lotic species, which can otherwise be rare in low-gradient stream reaches (Clifford et al., 1993; Law et al., 2016). In addition, cold hyporheic upwelling and lower stream temperatures downstream of high-head dams, and at depth in beaver ponds, has been shown to benefit the reproductive success of invertebrate species such as mayflies (Fuller & Peckarsky, 2011).

Beaver-engineered woody structures, such as dams and lodges, offer key invertebrate habitats resulting in greater abundance (France, 1997), biomass, density (McDowell & Naiman, 1986; Rolauffs et al., 2001), productivity, richness (France, 1997; Rolauffs et al., 2001), and diversity (Benke, Van Arsdall, Gillespie, & Parrish, 1984) compared to beaver ponds and free-flowing streams. Direct benefits for invertebrates arise from physical complexity, such as the interstices of dams, lodges, bank burrows, and canals, which offer spaces suitable for novel microhabitats (Hood & Larson, 2015; Willby et al., 2018), refuge from predators (Benke & Wallace, 2003), egg-laying (oviposition) sites (Gaywood et al., 2015), and emergent metamorphosis (Wallace, Grubaugh, & Whiles, 1993). These woody structures also provide attachment sites for filter-feeding organisms and foraging resources for species that feed on woody material (xylophagous) and those that feed on the epixylic biofilms which grow on woody surfaces (Godfrey, 2003; Hering et al., 2001; Strzelec et al., 2018). For example, deadwood-eating (saproxylic) beetles are known to occupy beaver-impacted habitats (Horák, Vávrová, & Chobot, 2010; Stringer & Gaywood, 2016). In addition, the retention of organic particulate matter in beaver ponds enhances foraging opportunities for aquatic invertebrates, particularly gatherers and shredders

(Johnston, 2014; Law et al., 2016; Wohl, 2013). Organic drift can also bring wider benefits within catchments, increasing the abundance and/or richness of invertebrates in areas both downstream (Redin & Sjöberg, 2013) and upstream (Rolauffs et al., 2001) of beaver-modified sites.

Dalbeck et al. (2020) conclude that beavers and their habitat creating activities can be pivotal determinants of amphibian species richness, particularly in the headwater streams. The creation of lentic zones in beaver modified wetlands is cited as an essential breeding habitat for amphibian species, but can also be important for entire life history requirements (Cunningham, Calhoun, & Glanz, 2007), with beaver ponds offering sites where reliable spawning and early metamorphosis can take place, in instances comprising exclusive ovipositional sites within wider wetlands (Dalbeck, Janssen, & Luise Völsgen, 2014). Beaver modifications, which increase lentic-rich habitat heterogeneity and/or raise light levels and solar radiation, warming patches of water, in turn, support healthier amphibian assemblages. Such improvements manifest via greater species-richness (Cunningham et al., 2007), diversity (Bashinskiy, 2014; Cunningham et al., 2007; Dalbeck, Lüscher, & Ohlhoff, 2007), colonization rates and abundance (Anderson, Paszkowski, & Hood, 2015; Dalbeck et al., 2014; Stevens, Paszkowski, & Foote, 2007), older-pond density (Stevens et al., 2007), size and productivity compared to unmodified habitats, with connectivity between ponds and through beaver canals reducing distances between breeding and foraging sites (Anderson et al., 2015). Woody complexes which form lodges and dams may also provide valuable habitat which amphibians can use for larval food provision and development (Tockner, Klaus, Baumgartner, & Ward, 2006), potential overwintering hibernation sites (Stevens et al., 2007) or cover from predators (Tockner et al., 2006), with cover options offering predatorial and larval protection by areas of shallow emergent-vegetated pond margins (Dalbeck et al., 2007; Vehkaoja & Nummi, 2015). Conversely, lotic obligate species may be negatively affected by beaver activity (Stringer & Gaywood, 2016), although studies have demonstrated the persistence and high abundance of stream-dependent species on the unimpounded reaches of beaver modified streams (e.g., Cunningham et al., 2007).

3.1.3 | Fish

Beavers and fish have cohabited for millennia (Malison & Halley, 2020) and have previously been shown to coexist positively (Kemp et al., 2012). As such, it is no surprise that beaver-induced habitat changes, particularly increased heterogeneity, can benefit fish populations (Figure 3). Documented benefits include increased: growth rates (Malison, Eby, & Stanford, 2015; Pollock, Heim, & Werner, 2003; Rosell & Parker, 1996), survival (Bouwes et al., 2016), biomass (Bashinskiy & Osipov, 2016), density (Bouwes et al., 2016; Wathen et al., 2019), productivity (Osipov et al., 2018; Pollock et al., 2003; Pollock, Pess, Beechie, & Montgomery, 2004), species richness (Snodgrass & Meffe, 1998), and diversity (Smith & Mather, 2013). Additional benefits to fish include the creation of juvenile rearing habitat (Johnson & Weiss, 2006; Leidholt-Bruner, Hibbs, & McComb, 1992; Pollock et al., 2004), overwintering habitat (Chisholm, Hubert, & Wesche, 1987; Cunjak, 1996; Malison et al., 2015), migratory respite (Virbickas, Stakėnas, & Steponėnas, 2015), enhanced spawning habitat (Bylak, Kukuła, & Mitka, 2014), greater invertebrate food availability (Rolauffs et al., 2001), and refugia from low-flows (Hägglund & Sjöberg, 1999), high discharge (Bouwes et al., 2016), temperature extremes (Wathen et al., 2019), and predation (Bylak et al., 2014). It is for these reasons, that recent approaches in the US have used beaver reintroduction to enhance habitat in support of salmonid reintroduction and/or conservation (Bouwes et al., 2016).

Due to the wide range of changes that beavers bring about, the benefits listed above will likely manifest for a variety of freshwater fish species through a wider understanding of these impacts is required as most research has focused upon interactions between beaver and salmonid species. Salmonids, particularly anadromous species (migrating from the sea to spawn in rivers) hold significant financial, cultural, and recreational value from a fisheries perspective (Butler, Radford, Riddington, & Laughton, 2009). Unfortunately, for a variety of reasons, which have nothing to do with beavers, populations of salmonid populations in Europe are in decline, and the two most abundant native salmonids, the Atlantic salmon (*Salmo solar*) and the Brown/Sea trout (*S. trutta*) are under threat (Forseth et al., 2017). Research in the US has largely shown that beaver reintroduction aids the recovery of salmonid populations (e.g., Bouwes et al., 2016; Wathen et al., 2019); however, despite the long-term coexistence of these species, the expansion and reintroduction of beavers across European landscapes, now substantially altered due to anthropogenic activity, has raised concerns regarding the potential impact that beaver activity may have on salmonid species (Malison & Halley, 2020).

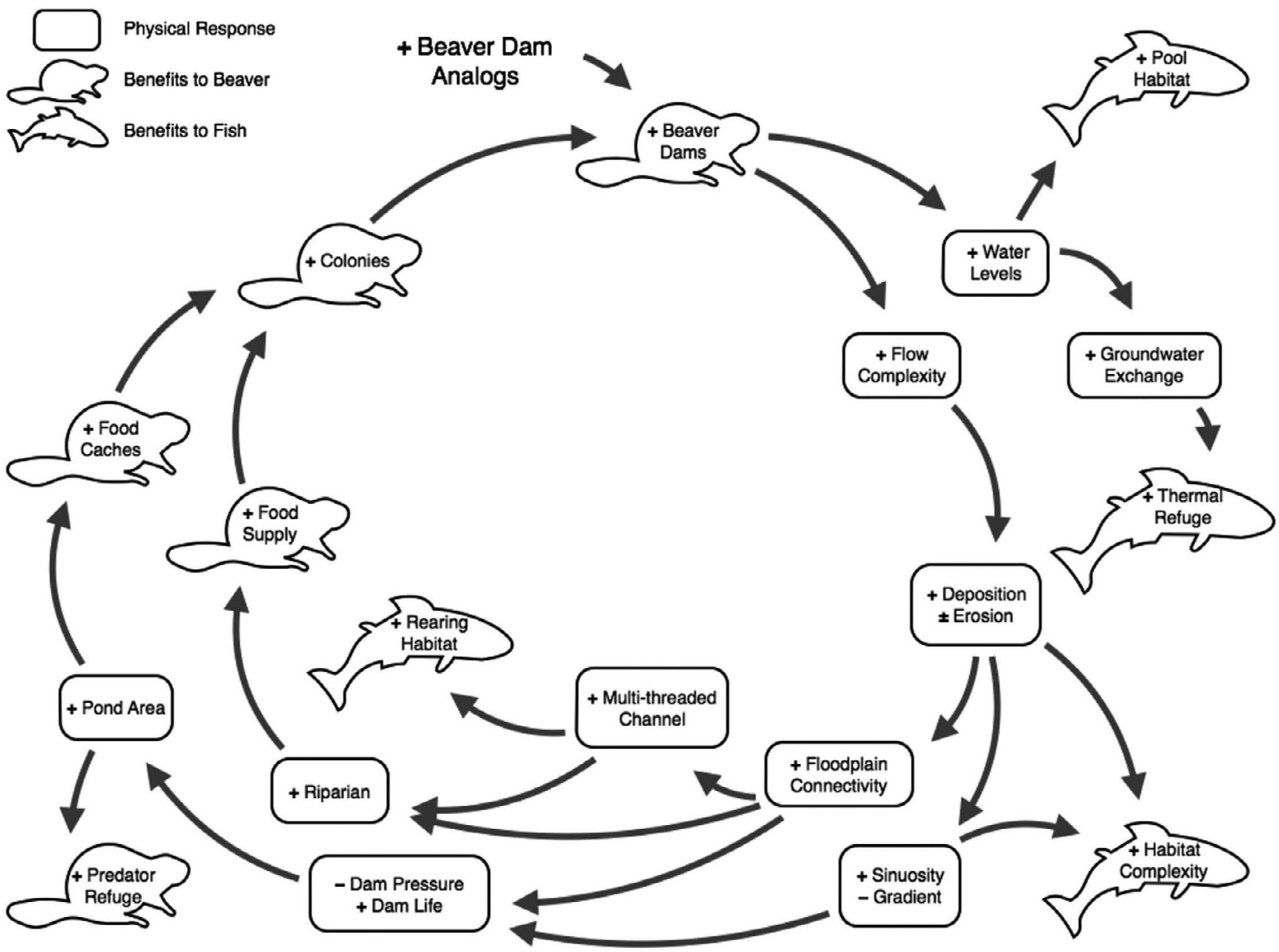

FIGURE 3 Flow Diagram of expected change following beaver return. (Reproduced with permission from Bouwes et al., 2016)

Two recent studies have investigated the impacts of beaver on salmonid habitat and populations in upland streams (Bylak & Kukuła, 2018; Malison & Halley, 2020). Both of these studies report increased habitat patchiness and heterogeneity in river systems that are typically dominated by fast-flowing habitat. Neither study found evidence to suggest that beaver dams prevented fish movement either upstream or downstream. However, Malison and Halley (2020) did find that the presence of beaver dams affected the frequency of movement between stream reaches, suggesting that either beaver dams may act to restrict daily home ranges of salmonids, or the increased local habitat complexity around beaver dams reduces the need for salmonids to travel greater distances. A conflicting finding of these studies is that of the use of ponds by salmonids. In agreement with numerous studies that found beaver ponds to provide valuable rearing habitat (Malison, Lorang, Whited, & Stanford, 2014; Weber et al., 2017) and habitat niches for different stages of salmonid life cycles (Bouwes et al., 2016; Wathen et al., 2019), Bylak and Kukuła (2018) observed that brown trout used different beaver-created habitats throughout their life stages. However, Malison and Halley (2020) reported that they did not observe beaver ponds being used as salmon rearing habitat. Both studies report either no significant effect of beaver on fish populations (Malison & Halley, 2020) or a positive impact on the community composition and patch dynamics (Bylak & Kukuła, 2018).

Virbickas et al. (2015) studied the impacts of beaver on two lowland Lithuanian streams. Unlike, the studies from upland streams, Virbickas et al. (2015) found evidence to suggest that beaver dam sequences do restrict upstream movement of salmonids with reaches below and between ponds being used but no salmonids or redds (spawning sites) being observed upstream of beaver dam complexes. While the presence of beavers did enhance community evenness upstream of dams, this effect was attributed to the exclusion of salmonids, which typically dominated fish communities downstream of dams.

The scale of such studies should be considered carefully in the context of mobile and dynamic species of fish. Bylak and Kukuła (2018) present data from the longest period of monitoring in Europe. They show that the response of fish to beaver activity enhances metacommunity resilience but consequently localized fish communities may alter for short periods of time. However, in these upland systems, high flows capable of "blowing out" dams are more frequent (Macfarlane et al., 2017) thus allowing unimpeded fish movement during these periods. In lowland systems, such as those investigated by Virbickas et al. (2015) the increased hydrological stability may result in a longer lasting separation of fish communities up and downstream of beaver dams. In low gradient systems, where spawning habitat is located solely in the upper reaches of a catchment, the presence of dams could potentially limit access to these reaches, affecting spawning success or resulting in the formation of new spawning habitat, such as the clean gravel bars which commonly form at the tail end of beaver ponds and immediately downstream of dams (Bouwes et al., 2016).

Further research on the impacts of fish across varied European landscapes is required. These studies should seek to understand the effect of beaver on fish communities at the catchment scale. It is well established that fish can navigate beaver dams (Bouwes et al., 2016; Bylak & Kukuła, 2018; Malison & Halley, 2020; Virbickas et al., 2015). However, a greater understanding is required to quantify the importance of any reduced longitudinal movement of fish alongside the known benefits including an increase in food availability and greater habitat diversity.

3.1.4 | Aquatic ecology summary

- Beaver activity extending wetland areas aids aquatic plant recruitment, abundance, and species diversity.
- Nutrient-rich beaver meadows result in mature beaver managed landscapes, contributing diverse plant life, and increasing patchiness in otherwise homogeneous (especially intensively farmed) landscapes.
- Heterogeneity of beaver habitat leads to greater diversity of invertebrates, benefitting both lotic, and lentic species.
- Slow release of water from beaver ponds elevates baseflow downstream supporting greater aquatic life, improving resilience especially in times of drought.
- A multitude of benefits accrue for fish due to beaver activity such as increased habitat heterogeneity and food availability.
- It is established that salmonid species can navigate beaver dams, though there is evidence that the presence of dams does alter the way they move within river networks. The impact of dams on salmonid movement is highly dependent on location and upstream movement may be reduced in low gradient, low energy systems.

3.1.5 | Aquatic ecology gaps in understanding

- Community level, catchment scale understanding of beaver interactions with fish of all species is required to determine whether the changes seen—returning freshwaters to something akin to pre-anthropocene conditions, are overall positive (as current literature suggests) or negative and thus requiring management interventions.
- The narrow, riparian landscapes of many European countries, wherein intensive agriculture encroaches on freshwaters, need further research into the impacts of beavers on both existing vegetation and that which may emerge if more space for water and beavers is made.
- Changes to the ecological status of freshwaters inhabited by beavers are inevitable and research to understand the impact on goals of the Water Framework Directive is needed, to contextualize what is meant by "good" ecological status now that beavers are present.

3.2 | Human–beaver interactions

The potential benefits and impacts of beaver reintroduction (outlined above for the environment) can also manifest for humans. Notably, flow attenuation resulting from beaver damming will be likely to reduce potential for flooding of properties downstream. There is a further socioeconomic benefit not as yet explored in this article; as beavers bring more wildlife to ecosystems, beaver lands can become a focus of wildlife tourism, where humans interact with wild animals or with animals in enclosures (Higginbottom, 2004; Moorhouse, D'Cruze, & Macdonald, 2017). Wildlife tourism is a growing global trend which can engage people with nature, with their experiences often contributing toward local communities, providing benefits for mental health and well-being, and incentivizing nature conservation behaviors

(Curtin, 2009; Curtin & Kragh, 2014; Higginbottom, 2004; Lackey et al., 2019; Newsome, Rodger, Pearce, & Chan, 2019; Skibins, Powell, & Hallo, 2013).

Much wildlife tourism is centered upon "charismatic species" (Curtin, 2010; Skibins et al., 2013), but some are motivated by the intention to support wider biodiversity rather than charismatic species alone (Hausmann, Slotow, Fraser, & Minin, 2017). Beavers are often considered charismatic and, as a keystone species, are associated with biodiverse landscapes, which they create and maintain. Thus, they exhibit both those traits that motivate wildlife tourism. Beaver tourism activities that currently exist in Europe include "beaver safaris", guided tours of beaver-modified landscapes, and information centers (Campbell, Dutton, & Hughes, 2007; Halley et al., 2012; Rosell & Pedersen, 1999). Beaver tourism and associated support for local communities is therefore often cited as one of the reasons for reintroduction where beavers are not yet present (Campbell et al., 2007; Gaywood, 2018; Gurnell et al., 2009; Jones, Halley, Gow, Branscombe, & Aykroyd, 2012; Moran & Lewis, 2014).

There are, however, a number of challenges experienced where beaver and humans interact. In Europe, these are observed mostly where beaver impacts interact with human interests within the riparian zone (Campbell-Palmer et al., 2016; Halley et al., 2012; Heidecke & Klenner-Fringes, 1992), particularly in upper and marginal reaches of watercourses where beaver will undertake the largest-scale habitat alteration (Graham et al., 2020; Halley et al., 2012). For example, where water is stored behind beaver dams, it may inundate land owned by humans which could lead to a financial cost, especially when associated with agriculture or forestry (Campbell-Palmer et al., 2016; Gaywood et al., 2015; Morzillo & Needham, 2015; Parker et al., 1999). Other notable impacts can include beaver burrow collapse and bank erosion in agricultural land (Campbell-Palmer et al., 2016; Gurnell, 1998), beaver grazing on arable crops (Campbell-Palmer et al., 2016, p.; McKinstry & Anderson, 1999), or the felling of particular trees of human importance (Campbell-Palmer et al., 2016; Campbell-Palmer, Schwab, & Girling, 2015). Perhaps not surprisingly, beaver are perceived more negatively by people where these conflicts occur (Enck et al., 1992; Jonker et al., 2010; McKinstry & Anderson, 1999; Payne & Peterson, 1986).

Practical management interventions exist that can be employed to address these factors, including dam removal, bank stability management, flow device installation (to lower water levels), tree protection, restoration of riparian zone as management, supported further by compensation or positive incentive payments (Campbell-Palmer et al., 2015; Campbell-Palmer et al., 2016; Morzillo & Needham, 2015; Pollock et al., 2017). To reduce the potential for further conflicts, however, particularly those that occur between people over species management (Marshall, White, & Fischer, 2007; Redpath, Bhatia, & Young, 2015), it is recognized that engaging with affected individuals and sharing in the decision-making processes for management of beaver is vital (Coz & Young, 2020; Decker et al., 2015, 2016; Redpath et al., 2015).

A recent study of local peoples' attitudes toward beaver in Romania and Hungary demonstrated that beaver was often viewed negatively when related to provisioning ecosystem services but positively regarding regulatory or cultural services. As such the study called for recognition of this complexity in perceptions to minimize conflicts, through "reciprocal learning" between conservationists and locals in adaptive management (Ulicsni, Babai, Juhász, Molnár, & Biró, 2020). For beaver, there are a number of management frameworks which seek to engage with affected parties across Europe in a variety of ways, for example: in Bavaria (Germany), regional authorities employ two beaver managers to oversee a network of volunteer beaver consultants throughout the region (Pillai & Heptinstall, 2013; Schwab & Schmidbauer, 2003); in the Netherlands, the government monitors the beaver population and provides management advice to landowners (Pillai & Heptinstall, 2013); in France, the state authorities provide an advisory service at a catchment scale (Campbell-Palmer et al., 2015; Campbell-Palmer et al., 2016; River Otter Beaver Trial, 2019). However, although engagement is a key component of management strategies, there are to date, few European studies describing attitudes towards beaver (Ulicsni et al., 2020).

The case is different in Great Britain where beaver is currently being reintroduced at a politically devolved level (with the reintroduction status at varying stages throughout the nations) as there have been a number of studies of attitudes towards the species. This may be because an understanding of social factors is a requirement of reintroduction according to the guidelines set by the International Union for the Conservation of Nature (IUCN & SSC, 2013); these guidelines were published in 2013 after many of the reintroduction projects in mainland Europe (Halley et al., 2012), and of course, these guidelines do not apply to established or naturally dispersing populations of beaver that were not therefore "reintroduced". Additionally, there is a recent increase in recognition in the literature that the human dimension of environmental projects is a key component of their success or failure (Bennett et al., 2017a, 2017b; Chan et al., 2007; IUCN & SSC, 2013; Redpath et al., 2015). For example, conflicts between humans and wildlife, or between humans about wildlife, may result in threats to species populations or the future success of any attempted species reintroduction (Dickman, 2017; Manfredo & Dayer, 2004; O'Rourke, 2014).

The British studies of attitudes may have limitations (most notably the ability to which they can be deemed representative of a wider population), but they have consistently demonstrated a majority in favor of beaver projects, ranging between 63 and 95.19% of respondents (Auster, Puttock, & Brazier, 2019). However, the intricacies of the social debate run deeper than a simple "for or against" question. A nationwide survey found an association between support for reintroduction and a positive view of potential impacts, and vice versa (Auster et al., 2019). The respondents from the occupational sectors of "Farming and Agriculture" or "Fisheries and Aquaculture" were less likely to have a favorable view of beaver impacts and were thus often (though not unanimously) opposed to beaver reintroduction, which is in line both with other studies conducted in Great Britain (Auster, Barr, & Brazier, 2020a; Crowley, Hinchcliffe, & McDonald, 2017; Gaywood, 2018; Lang, 2004; Scott Porter Research and Marketing Ltd, 1998) and the aforementioned conflict challenges which have been observed across mainland Europe.

Socially, when whomever gains or losses from beaver reintroduction is examined it is concluded that (in certain scenarios) those people who experience the benefits may differ from those who experience the costs (Brazier et al., 2020; Gaywood, 2018). Although it is often cited that the potential benefits of beavers will outweigh the costs (Brazier et al., 2020; Campbell et al., 2007; Gaywood, 2018; Gaywood et al., 2015; Gurnell et al., 2009; Jones et al., 2012; Tayside Beaver Study Group, 2015), the costs that do occur may be attributed to a small number of people who themselves derive little or no direct financial benefit. This distinction between potential beneficiaries and the negatively impacted parties is perhaps most easily demonstrated in the case of beaver damming, where a downstream community may benefit significantly from flood alleviation while the landowner upstream may experience flooding on their property. Thus, strategic management decisions will need to consider how to bridge this disconnect and address potential conflict issues while allowing for the potential opportunities for biodiversity, flow attenuation, water quality, and ecotourism to be maximized.

It is highlighted herein, that to enable maximization of the opportunities from beaver reintroduction that are reviewed above, these conflicts will need to be appropriately recognized; the best management strategies are those where issues are mutually addressed between wildlife management authorities and stakeholders (Auster, Barr, & Brazier, 2020b; Redpath et al., 2015; Rust, 2017; Treves, Wallace, & White, 2009). There are real opportunities resulting from beavers, as discussed above, but there are real conflict challenges to be addressed as well, and they should be considered as one within a holistic approach with a closed-loop between the beneficiaries and the negatively affected. Further, in the case of reintroduced beavers, such management considerations will need early attention if the potential for later conflicts is to be reduced, particularly as challenges may not yet exist but could occur post-introduction (Auster et al., 2019; Conover & Decker, 1991; Coz & Young, 2020).

Finally, holistic management strategies will need to incorporate effective communication to aid the reduction of potential conflict issues. In a case from Poland, beavers had been reported as of concern by fishery managers, who cited damage to pond levees. Some of the participants had received compensation for reported damage, but a number of fishery managers had undertaken both authorized and unauthorized beaver culls as the beavers were viewed as problematic. In this scenario, it was reported that "poor communication" by conservation bodies was a particular part of the problem, with a lack of information on management measures and unresponsiveness from government agencies being factors which were suggested to have exacerbated conflict (Kloskowski, 2011). However, the literature recognizes that, when stakeholders are appropriately engaged and communication is effective, trust can be fostered between stakeholders and the wildlife management authorities (Decker et al., 2015, 2016; Redpath et al., 2015; Rust, 2017; Treves et al., 2009). This in turn can enable an environment within which, as Redpath et al. remarked in 2013, wildlife management issues and decisions can be "shared as one" (Redpath et al., 2015).

3.2.1 | Summary of human–beaver interactions

- There are real opportunities for humans provided by beavers, as well as real potential conflicts between humans and the activity of beavers. The opportunities may be realized by different people to those who incur the costs in certain contexts.
- Effective management strategies should consider the beneficiaries and cost-bearers in a holistic manner, bridging the distinctions within a closed-loop management system.

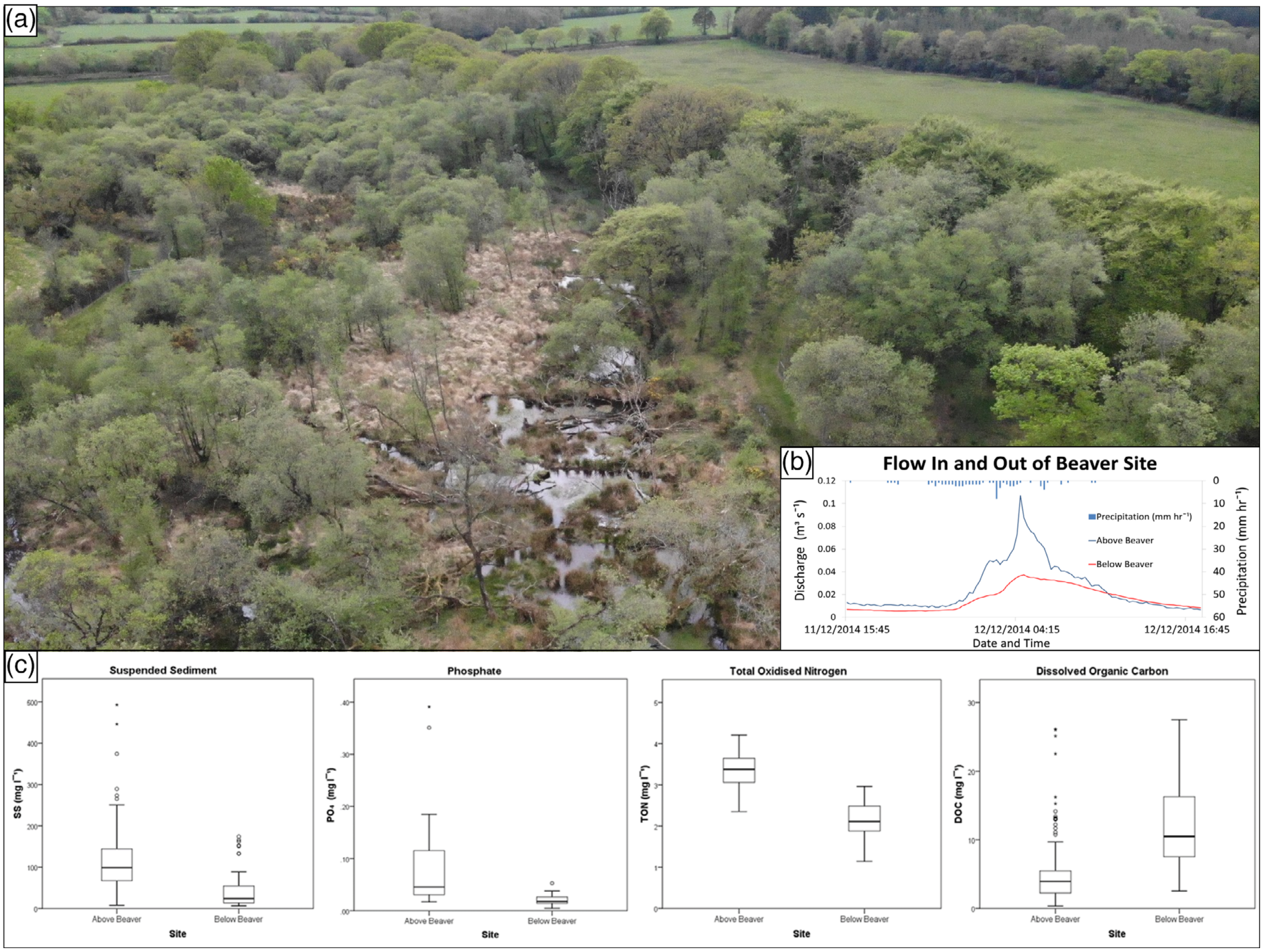

FIGURE 4 A summary figure for the Devon Beaver Project: (a) aerial photo showing the beaver wetland nestled amongst an agriculturally dominated landscape; (b) an example hydrograph showing the contrast in flow regime between water entering the site (blue) and water leaving the site (red); (b) summary water quality results from the site for each figure "Above Beaver" to the left is the concentration entering the site and "Below Beaver" to the right is concentration leaving the site. From left to right: suspended sediment, phosphate, total oxidized nitrogen, and dissolved organic carbon

- Management strategies require clear communication to gain trust between stakeholders and the wildlife management authority, thus providing an environment that is conducive toward addressing issues as a collective and reducing the potential for conflict between parties.

3.2.2 | Human–beaver gaps in understanding

- Where they are reintroduced, living with beavers (and associated management) will be a new concept. How do people learn and adapt to this change?
- In policy, what is the best approach for a closed-loop management framework that maximizes opportunities, for example, ecosystem service provision, while minimizing the potential for conflicts?
- What is the best way to disseminate information regarding approaches to management?

4 | CONCLUSION: FUTURE SCENARIOS AND CONSIDERATIONS

The beaver is clearly the very definition of a keystone species. The myriad ways in which it alters ecosystems to suit its own needs, which in turn supports other species around it, demonstrate its value in re-naturalizing the heavily

BOX Case study: Hydrology and water quality—Devon Beaver project

Puttock et al. (2017) undertook research at an enclosed and therefore controlled beaver reintroduction site in Devon, South West England. The site is situated on a first-order stream. In March 2011, a pair of Eurasian beavers were released into a 3 ha enclosure, dominated by mature willow and birch woodland, in addition to gorse scrub. Upstream, the site was fed by a 20 ha catchment area dominated by intensively-managed grassland. As illustrated in Figure 4, beaver activity at the site created a complex wetland, dominated by 13 ponds, dams, and canal networks (Puttock, Cunliffe, Anderson, & Brazier, 2015). Flow was monitored upstream and downstream of the beaver ponds.

Monitoring of the site between 2013 and 2016 showed that the 13 ponds covered >1,800 m^2 and stored >1 million liters of water. Across 59 rainfall-runoff storm events, the outflow below the beaver impacted site showed a more attenuated response relative to water entering the site. Events exhibited on average 34% lower total event discharges, 30% lower peak discharges, and 29% longer lag times below the beaver dam sequence, in contrast, to flow entering the site. Critically, Puttock et al. (2017) analyzed a sub-set of the largest flood events of greatest interest from a flood risk management perspective. Results showed the flow attenuation impact to persist. Additionally, while the inflow to the site was ephemeral, drying up during drought periods, the outflow from the site never dried up during the monitoring period, highlighting the ability of increased water storage in beaver wetland environments to maintain base flow in river systems.

Analysis was undertaken into sediment storage within the site and water quality entering and leaving the site. A site survey (Puttock et al., 2018) showed that ponds held over 100 t of sediment, 15 t of carbon, and 1 t of nitrogen. Pond size was shown to be the greatest control over storage, with larger ponds holding more sediment per unit area. Source estimates indicated that >70% of the sediment trapped in the ponds was from the upstream agriculturally dominated catchment. A summary of water quality results taken during rainfall-runoff events (see Puttock et al., 2017) showed that on average, compared to water entering the site, water downstream of the beaver dam sequence contained 3 times less sediment, 0.7 times less nitrogen, 5 times less phosphate, but twice the dissolved organic carbon content. Associated flow attenuation was shown to result in further reductions in total loads.

degraded environments that we inhabit and have created. The impacts of beaver reintroduction reviewed herein; to deliver changes to ecosystem structure and geomorphology, hydrology and water resources, water quality, freshwater ecology and humans, and society are profound. Beaver impacts are not always positive, at least from a human perspective, thus it remains critical that the knowledge gaps identified above are addressed as beaver populations grow, to ensure that improved understanding coupled with clear communication of beaver management can prevail.

Where beavers do deliver positive change, on balance benefits are shown to outweigh the costs associated with beaver reintroduction or management. It is unlikely that any other species, including humans, will deliver these changes, thus it would seem rational to conclude that beaver population expansion should be supported, wherever habitat is suitable and the species naturally occurred historically. Indeed, it is suggested that reintroducing beavers, is a genuine example of "working with natural processes" or implementing "nature-based solutions", which are both low cost and multi-faceted. As such, beaver reintroduction can underpin approaches to reverse the decline of species extinctions while also delivering ecosystem services, which may increase resilience to climate change and mitigate associated risks such as flooding and drought.

Of course, such an environmentally progressive approach needs to be implemented hand-in-hand with an appropriate management regime, ideally funded by Government, to capitalize on the environmental goods and services that beavers provide, and established as part of a national (or even international) strategy for the reintroduction of the beaver. Such management approaches have been normalized in places such as the German state of Bavaria, where beavers now deliver the wide range of ecosystem services reviewed above, with a pragmatic and flexible approach towards beaver management to support people who experience negative impacts while supporting a favorable conservation status of the species (Pillai & Heptinstall, 2013; Schwab & Schmidbauer, 2003). Other countries, including GB where beaver populations are in their infancy, but expanding, would do well to adopt similar management strategies (e.g., see the River Otter Beaver Trial, 2019) to ensure that successful reintroduction of beavers maximizes the environmental opportunities and minimizes the social conflicts that may manifest (Box 1).

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CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

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APPENDIX 2.

Appendix to the ‘River Otter Beaver Trial’ Science & Evidence Report: Beavers, Agriculture and Land/Property-Owners Conflict Impacted by Beavers on the River Otter

The following report forms the second appendix of this thesis. It is presented as it has been published online, with all references included at the end of the appendix.

This report, written by me, is an appendix to the River Otter Beaver Trial Science & Evidence Report, available from
https://www.exeter.ac.uk/creww/research/beavertrial/

The appendix details the costs of beaver impacts upon agriculture that were observed within the River Otter Beaver Trial and describes the standardised approach towards how they were assessed.

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Appendix to the 'River Otter Beaver Trial' Science & Evidence Report:

Beavers, Agriculture and Land/Property-Owners Conflict Impacted by Beavers on the River Otter

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Statement on Data Ownership

The data reported upon in this report which are from the nationwide attitudinal survey and interviews are owned by the research team at the University of Exeter, with thanks to all of the research participants.

The agricultural gross margin data sources described in this document are from two sources: data collated by *The Andersons Centre* for the *John Nix Pocketbook for Farm Management* (Redman, 2018) and by the *Organic Research Centre* for the *Organic Farm Management Handbook* (Lampkin *et al*, 2017). Further details on the data sources and justification for the use of them is provided within this report.

EXECUTIVE SUMMARY

- Where beavers are present elsewhere, there is the potential for conflicts with agricultural practice. This often results from the beavers' damming activity, and a number of beaver management techniques exist to try and address potential conflicts.
- A scientifically peer-reviewed nationwide attitudinal was conducted to explore the perceptions held about Eurasian beaver (*Castor fiber*) reintroduction in Great Britain, to which there were 2759 responses (Auster *et al,* 2019). A subset of results are presented in this report which explore the views of those who identified their occupation as within 'Farming & Agriculture' (*n=117*). In this report, these results are presented alongside results from other occupations for comparison.
    - It was observed that respondents who identified their occupation as within 'Farming & Agriculture' were statistically less likely to have a more positive view about the impacts of beavers than other respondents. By exploring the nationwide survey results in greater detail, the respondents from 'Farming & Agriculture' were found to have a diverse set of opinions about beaver impacts. Similarly, when asked whether respondents supported the process of reintroduction to Great Britain; 46.55% supported the process, 42.24% did not and 11.21% were undecided (*n=116*).
    - This diversity in opinion was also observed in respondents' views on the level of legal protection that should be applied should beavers be reintroduced; 32.17%% indicated that beavers should be given 'Strong' legal protection, 34.78% indicated that they felt beavers should be given 'limited legal protection' whilst 33.04% felt there should be none. Attitudes towards specific management techniques are also presented.
- The potential cost to agriculture is difficult to determine as a whole, however a standardised method of assessing the potential costs for agriculture through Gross Margins lost was

developed. This works using data from two sources: the *John Nix Pocketbook* and *Organic Farm Management Handbook.* This report describes the data sources and the approach taken, and recognises additional cost factors that will need to be considered.

- Cost assessments at two sites where beavers impacted upon agriculture within the Trial catchment area are described. The first was a backlog of water behind a beaver dam which prevented the sowing of organic potato seed over one acre and was estimated to have led to a gross margin loss of £2054.95 for this crop. The other was flooding to 0.89ha of grazing land for a spring-calving dairy herd, which without management intervention would have been estimated to lead a gross margin loss of £1565.51 over a year. There are additional variables which may contribute further costs to agriculture in these areas which are detailed, such as distance from a milking parlour or obstructed access gates.
- There are demonstrated costs upon agriculture resulting from the impacts of beavers, and these will need to be factored into future management decisions if beavers are to be formally reintroduced. These will need to be considered alongside the other impacts of beavers (whether positive and negative) and perceptions of wildlife management in the development of a strategy which would be more likely to reduce conflicts between humans and beavers or between humans about beavers (Auster *et al*, 2019).

Contents

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1. Introduction

Eurasian beaver (*Castor* fiber) reintroduction is being considered in Great Britain (here-on referred to as 'beaver'). There is the potential for conflicts with agricultural practice as this is observed where beavers are present elsewhere. This often results from the beavers' damming activity, and a number of beaver management techniques exist to try and address potential conflicts. Examples of such techniques can be seen in *The Eurasian Beaver Management Handbook* (Campbell-Palmer *et al.*, 2016).

The status of beavers in Great Britain is a devolved matter. In Scotland, the decision was made by the Scottish government to list beavers as a European Protected Species since May 2019. Alongside, a management framework has been announced which is available on the Scottish Government website: https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/protected-species/protected-species-z-guide/protected-species-beaver/management.

In Wales, no formal reintroduction project is currently taking place, although there are proposals being put forward by a group called 'The Welsh Beaver Project'.

In England, a decision is due in 2020 from the UK Government about the status of beavers. Although there are a number of projects, the results of the 'River Otter Beaver Trial' in East Devon will be considered within this decision-making process in particular. This is a licensed trial monitoring a free-living population of beavers.

This appendix to the 'River Otter Beaver Trial' Science & Evidence report will provide information on the study of the social and socio-economic aspects of beavers and agriculture which has taken place through the 'River Otter Beaver Trial'.

Firstly, a subset of results from a scientifically peer-reviewed nationwide attitude survey will be presented with a particular focus on exploring results from respondents who identified their occupation as within 'Farming & Agriculture'.

Second, two cases of beaver impacts upon agriculture are described, with further details available in the 'River Otter Beaver Trial' Science and Evidence report.

Finally, a standardised approach towards assessing the financial costs of beavers upon agriculture was developed. This approach is described in this report using the two cases of beaver impacts upon agriculture within the 'River Otter Beaver Trial'.

2. Nationwide Survey of Attitudes – 'Farming & Agriculture' Participant Responses

A peer-reviewed nationwide survey of attitudes towards beaver reintroduction was undertaken in 2017 (prior to the announcement in Scotland that beavers there were to be allowed to remain) (Auster *et al*, 2019). In this survey, respondents who identified their occupation as in 'Farming & Agriculture' were found to be statistically less likely to have a more positive view of the impacts of beavers than the remaining respondent pool.

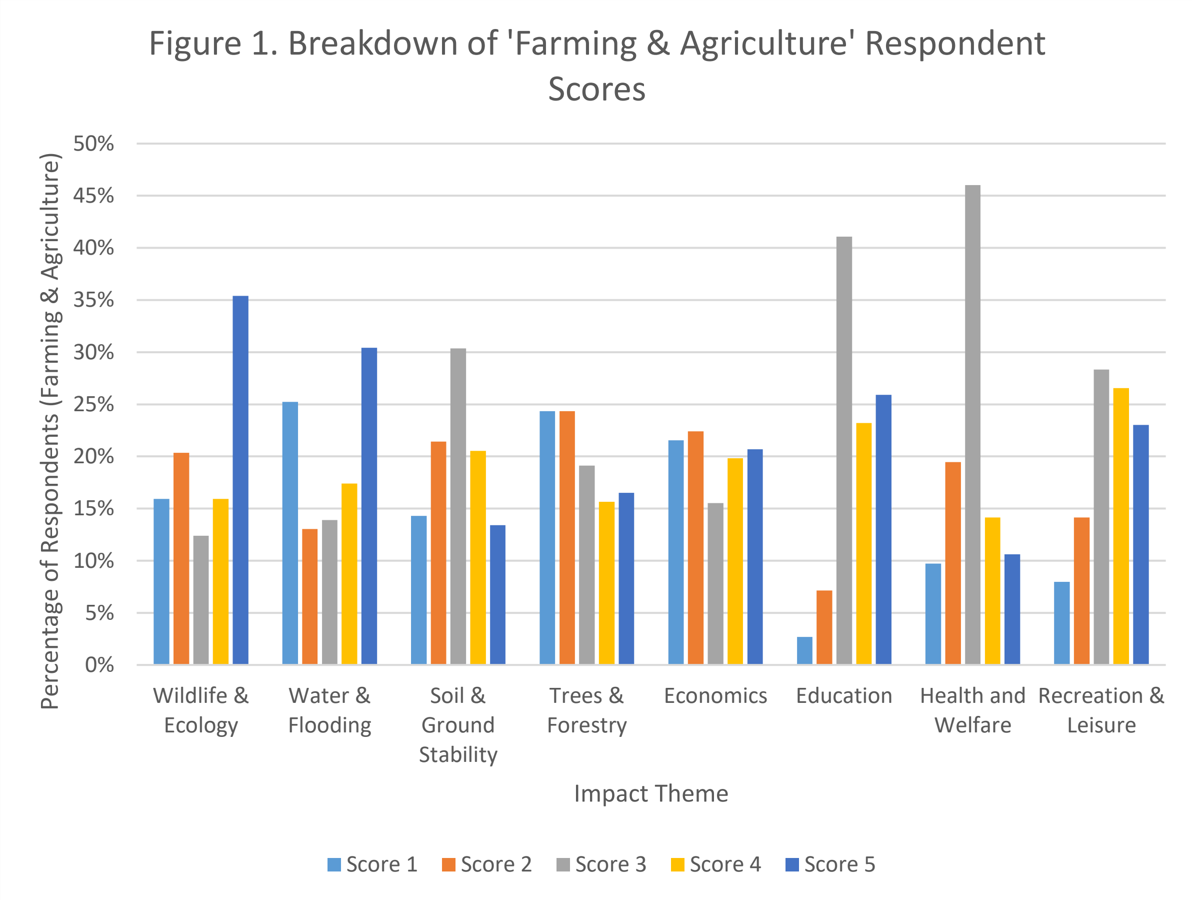
In each of eight impact theme areas, respondents were asked to score their view along a 5-point scale. A score of 1 = "Very Negative"; 2 = "Somewhat Negative"; 3 = "Neutral"; 4 = "Somewhat Positive"; 5 = "Very Positive". Broken down into the eight impact areas, the average scores given by the 117 respondents who identified as being from this occupation are here described.

(Following the scoring in each of these impact areas, respondents were given an opportunity to give a reason for their view which also allowed for an identification of their interpretation of the questions. An analysis of these comments amongst the entire respondent pool, broken down into whether respondents supported reintroduction or did not, is supplied in the ROBT Science & Evidence Report Appendix detailing the reasons for respondents' answers to the 2017 nationwide questionnaire).

Table 1 gives the average scores given by respondents who identified their occupation as in 'Farming & Agriculture) (*n=117*) when compared to the entire respondent pool overall (*n=2759*). Figure 1 then gives a further breakdown of the scores given by respondents as a percentage of those who identified their occupation as in 'Farming & Agriculture'.

Table 1

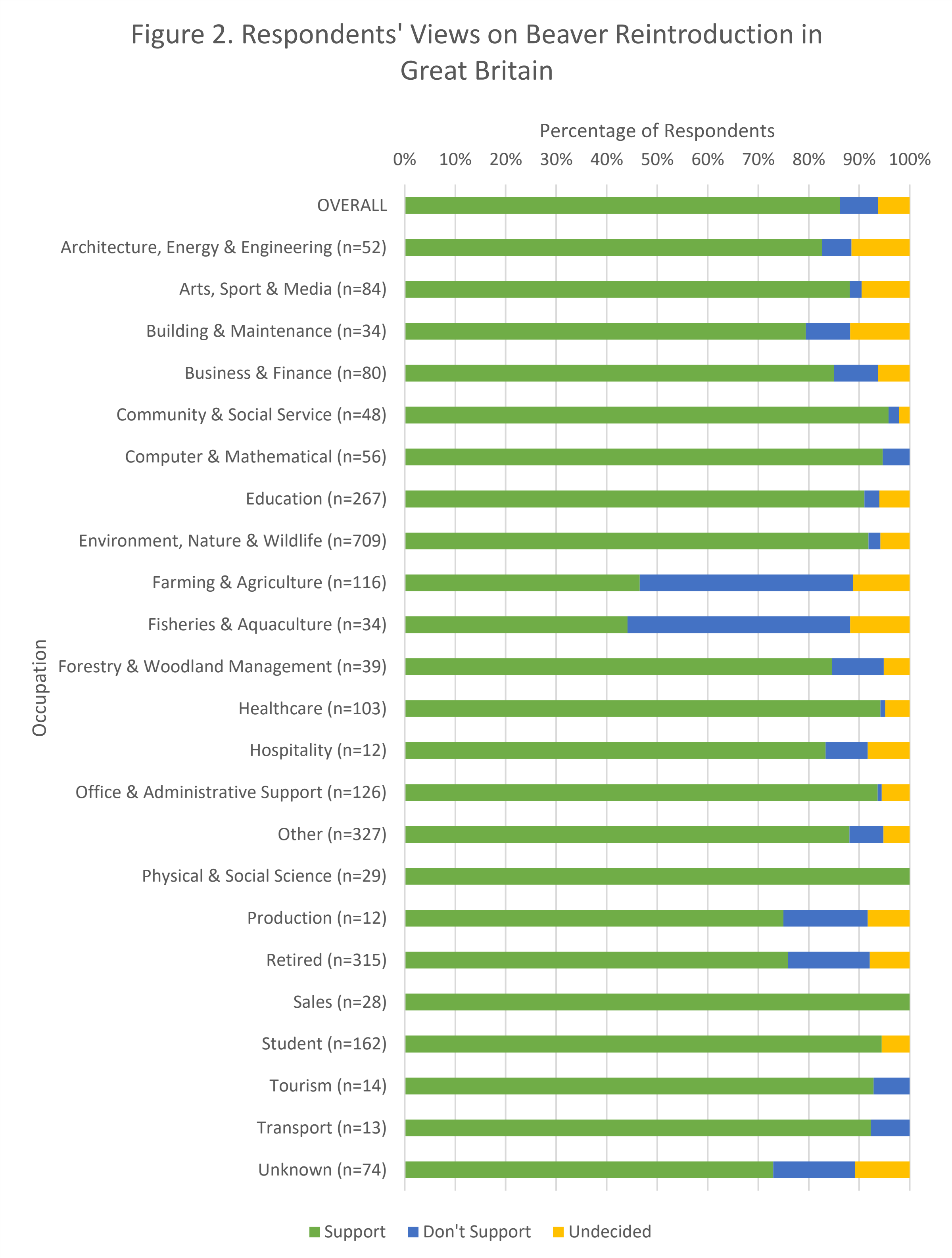
IMPACT THEME	AVERAGE SCORE			
	Farming & Agriculture		All Respondents	
	Average Score	Score Category (Rounded to nearest whole number)	Average Score	Score Category (Rounded to nearest whole number)
Wildlife & Ecology	3.35	Neutral	4.41	Somewhat Positive
Water & Flooding	3.15	Neutral	4.18	Somewhat Positive
Soil & Ground Stability	2.97	Neutral	3.64	Somewhat Positive
Trees & Forestry	2.76	Neutral	3.67	Somewhat Positive
Economics	2.96	Neutral	4.03	Somewhat Positive
Education	3.63	Somewhat Positive	4.3	Somewhat Positive
Health & Welfare	2.96	Neutral	3.67	Somewhat Positive
Recreation & Leisure	3.42	Neutral	4.23	Somewhat Positive



It would appear that within each of these impact areas there was an observed diversity of opinion amongst respondents whose occupation was in 'Farming & Agriculture', with respondents' attitude scores given right across the scale in each impact area. This is reflective of the diversity of opinion which was observed when respondents were asked whether they supported the process of beaver reintroduction to Great Britain. Respondents were presented with the options of 'Support', 'Don't Support' and 'Undecided'. 46.55% of respondents who identified their occupation as 'Farming & Agriculture' indicated that they supported the process, 42.24% indicated that they did not whilst 11.21% were undecided.

The results from this question are demonstrated in Figure 2 alongside a breakdown of other occupations in alphabetical order. In this graph, each *n* is reflective of those who provided an answer to the question; if respondents did not answer the question, they were excluded from the analysis. Overall, 2734 respondents indicated an answer (99.09% of all respondents).

(Following the question, respondents were asked for the main reason for their view. An analysis of these comments amongst the entire respondent pool, broken down into whether respondents supported reintroduction or did not, is supplied in the Appendix detailing the reasons for respondents' answers to the 2017 nationwide questionnaire).

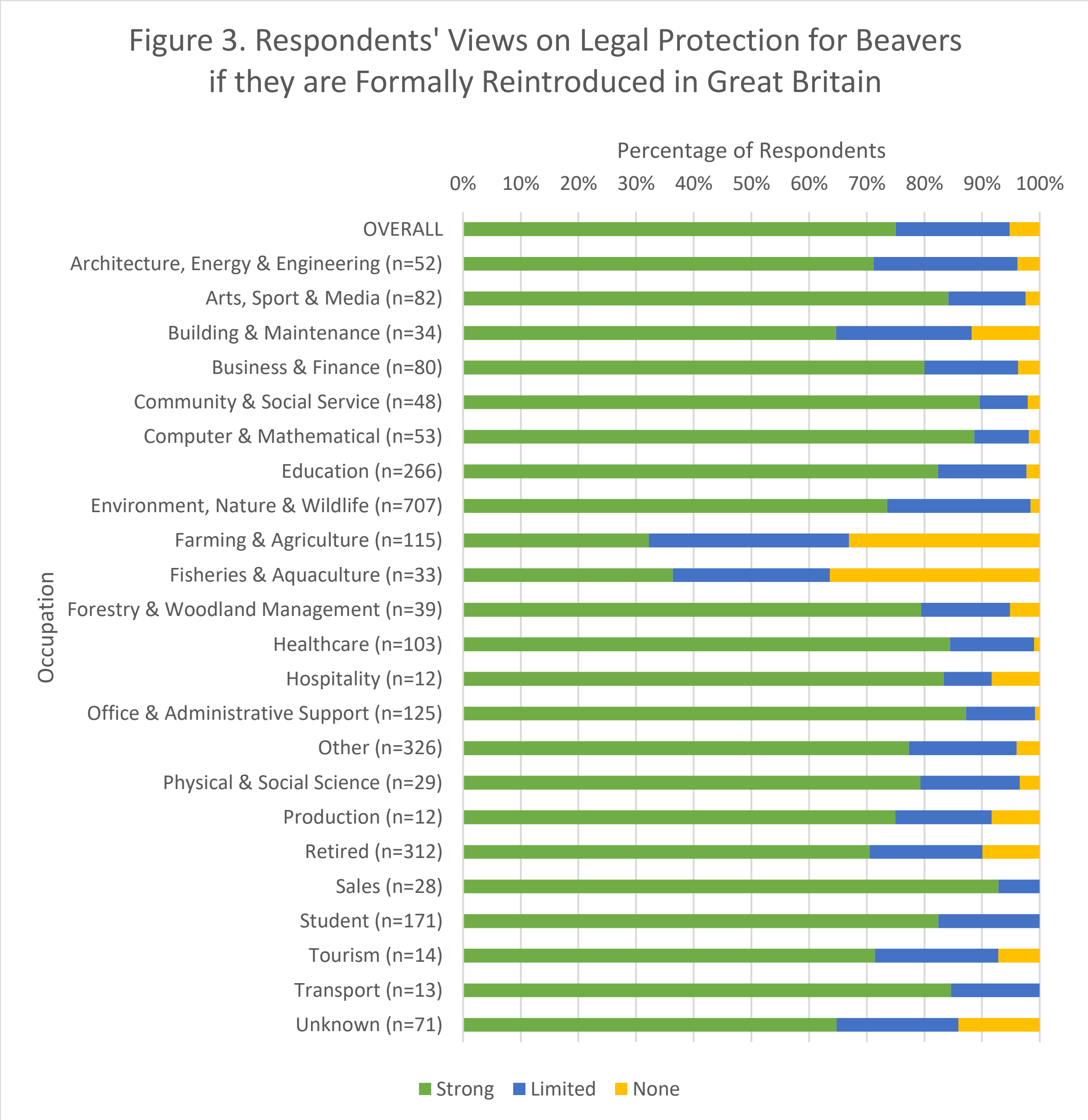


Similarly, there was a diversity of opinion which was observed when respondents were asked what level of legal protection should be applied to beavers should they officially be reintroduced. Respondents were presented with the options of 'Strong Legal Protection', 'Limited Legal Protection' and 'No Legal Protection'. 32.17%% of respondents who identified their occupation as 'Farming &

Agriculture' indicated that beavers should be given 'Strong' legal protection, 34.78% indicated that they felt beavers should be given 'limited legal protection' whilst 33.04% felt there should be no legal protection.

The results from this question are demonstrated in Figure 3 alongside a breakdown of other occupations, listed in alphabetical order. In this graph, each *n* is reflective of those who provided an answer to the question; if respondents did not answer the question, they were excluded from the analysis. Overall, 2725 respondents indicated an answer (98.77% of all respondents).

(Following the question, respondents were asked for the reason for their view. An analysis of these comments amongst the entire respondent pool, broken down into the differing levels of legal protection, is supplied in the Appendix detailing the reasons for respondents' answers to the 2017 nationwide questionnaire).



Respondents were also asked which beaver management techniques they would support if beavers were to be formally reintroduced from a list of techniques aligned with *The Eurasian Beaver Management Handbook* (Campbell-Palmer *et al.,* 2016). Respondents were able to select multiple answers and 2645 respondents answered the question (95.87% of the total respondent pool). Table 2 on the following page details the answers given in relation to the respondents' occupations (listed in alphabetical order). The green highlighted options indicate the most highly selected management technique for each occupation, and the pink highlighted options indicate the least selected option.

Table 2															
Occupation	**Dam removal**	**Discouraging dam building**	**Flow devices**	**Pay landowners to host beavers**	**Compensation for losses**	**Pull back land use from waterside**	**Education**	**Tree protection**	**Crop protection**	**Discouraging burrowing**	**Pop. control by moving beavers**	**Pop. control by sterilisation**	**Pop. control by culling**	**No management**	**Other**
Architecture, Energy & Engineering *(n=51)*	31.37	33.33	47.06	52.94	62.75	45.10	76.47	33.33	49.02	27.45	37.25	19.61	15.69	3.92	9.80
Arts, Sport & Media *(n=84)*	8.33	10.71	36.90	55.95	53.57	40.48	83.33	33.33	42.86	11.90	32.14	7.14	4.76	5.95	2.38
Building & Maintenance *(n=33)*	15.15	12.12	39.39	57.58	45.45	45.45	75.76	39.39	42.42	24.24	48.48	15.15	27.27	12.12	3.03
Business & Finance *(n=78)*	17.95	20.51	52.56	52.56	53.85	38.46	80.77	37.18	34.62	20.51	37.18	8.97	12.82	5.13	1.28
Community & Social Service *(n=46)*	13.04	13.04	50.00	56.52	60.87	43.48	80.43	32.61	45.65	19.57	39.13	10.87	2.17	6.52	2.17
Computer & Mathematical *(n=52)*	13.46	9.62	36.54	44.23	53.85	36.54	78.85	34.62	40.38	19.23	32.69	9.62	9.62	9.62	5.77
Education *(n=263)*	15.97	14.83	47.53	57.79	53.99	45.63	87.45	39.92	46.39	24.33	36.88	11.79	9.13	5.70	1.52
Environment, Nature & Wildlife *(n=702)*	32.62	30.06	50.43	59.54	51.14	64.25	90.03	44.30	47.44	35.33	40.60	15.53	18.66	5.56	2.56
Farming & Agriculture *(n=117)*	40.17	33.33	38.46	60.68	73.50	33.33	59.83	45.30	46.15	29.91	33.33	29.06	47.86	2.56	3.42
Fisheries & Aquaculture *(n=34)*	61.76	41.18	44.12	38.24	58.82	38.24	64.71	47.06	35.29	35.29	26.47	23.53	55.88	0.00	2.94
Forestry & Woodland Management *(n=39)*	38.46	33.33	53.85	61.54	43.59	66.67	92.31	43.59	53.85	30.77	46.15	15.38	33.33	0.00	2.56
Healthcare *(n=102)*	10.78	17.65	48.04	50.98	46.08	43.14	87.25	44.12	41.18	23.53	34.31	10.78	0.98	8.82	0.98
Hospitality *(n=12)*	25.00	25.00	33.33	58.33	75.00	41.67	75.00	41.67	33.33	16.67	16.67	8.33	16.67	0.00	0.00
Office & Administrative Support *(n=125)*	15.20	9.60	42.40	52.00	44.80	38.40	88.00	37.60	43.20	23.20	37.60	12.80	3.20	4.00	2.40
Other *(n=325)*	20.00	16.31	46.15	52.62	51.69	48.31	82.15	40.00	41.54	22.77	39.38	15.38	11.69	5.54	3.08
Physical & Social Science *(n=29)*	17.24	20.69	34.48	51.72	44.83	48.28	93.10	44.83	55.17	27.59	27.59	13.79	20.69	6.90	6.90
Production *(n=12)*	33.33	25.00	41.67	25.00	50.00	50.00	75.00	50.00	41.67	16.67	16.67	8.33	16.67	8.33	0.00
Retired *(n=314)*	21.34	22.29	43.31	44.59	55.73	44.59	70.06	34.39	31.21	24.84	28.03	19.11	18.79	3.82	2.87
Sales *(n=27)*	11.11	14.81	33.33	66.67	62.96	55.56	85.19	22.22	37.04	18.52	33.33	3.70	7.41	3.70	3.70
Student *(n=173)*	19.08	20.23	47.40	56.07	58.38	48.55	89.02	45.66	57.80	23.70	42.20	12.72	10.98	3.47	1.16
Tourism *(n=14)*	7.14	0.00	42.86	35.71	42.86	42.86	85.71	28.57	42.86	14.29	35.71	7.14	14.29	0.00	7.14
Transport *(n=13)*	15.38	7.69	38.46	53.85	53.85	53.85	92.31	30.77	46.15	15.38	15.38	15.38	0.00	7.69	0.00

3. Standardised Cost Assessment Approach

In order to be able to quantify the potential costs to agriculture resulting beaver damming activity, a standardised approach towards assessing costs was developed. The approach utilises the gross margin data from two existing data sources, to which an area of land affected can be applied to assess the potential gross margin lost from a flooded or waterlogged area. This section here will outline the data sources, the approach and the additional costs which may need to be considered.

3.1. Data Sources

The data used was taken from two sources, the *John Nix Pocketbook for Farm Management* (Redman, 2018) and the *Organic Farm Management Handbook* (Lampkin *et al.,* 2017). Both of these sources are issued regularly and so the most up-to-date data could be used as it became available.

3.1.1. John Nix Pocketbook for Farm Management

This is a data source used widely used in agricultural business planning and was used here as it is largely seen as an 'industry standard' data set (*Country Land and Business Association* representative, 2018, personal communication [verbal]; *Clinton Devon Estates* representative, 2018, personal communication [verbal]; *Woodland Valley Farm* representative, 2018, personal communication [verbal]). A new edition is released annually, with the 50th edition soon to be released for 2020.

The data available is based upon the 'Farm Business Survey' which the Pocketbook claims is "one of the most reliable sources of statistically robust farm data" (Redman, 2018, p5). This survey is carried out on behalf of *DEFRA* in England by a number of universities. In Wales, Aberystwyth University conducts this on behalf of the *Welsh Assesmbly*, and the *Scottish Rural College* conducts this in Scotland. In Northern Ireland, this is conducted by the *Department of Agriculture and Rural Development for Northern Ireland.*

Website: https://www.thepocketbook.co.uk/

3.1.2. Organic Farm Management Handbook

Organic farm data is not available in the *John Nix Pocketbook* which they state is because there is a specialist publication available (Redman, 2018, p135). This publication is named as the *Organic Farm Management Handbook* produced by the *Organic Research Centre*. Again this document is usually available on an annual basis, however due to uncertainties surrounding 'Brexit' the production of an issue since that issued in 2017 has been postponed (according to their website). The latest edition states that the "data have been derived from a number of different research reports and estimates of industry experts and have been reviewed by experienced organic advisors and producers" (Lampkin *et al*, 2017, p1).

Website:
http://www.organicresearchcentre.com/?go=Information%20and%20publications&page=Organic%20FM%20Handbook

3.2. Main Principle

The approach facilitates a standardised assessment of costs incurred from a lost area of productive land, such as the storage of water behind a beaver dam. As such, the area of land affected can be independently measured which (in the case studies described later) we have undertaken using a handheld GPS, then plotted using GIS software in order to calculate the area of affected land. This area can then be cross-referenced with the Gross Margin cost estimates in the data sources. Within the scope of the 'River Otter Beaver Trial', this was simplified by aggregating the data into a simple spreadsheet calculation tool for use within the Trial, called the 'Farming and Agriculture Beaver Cost Assessment Tool' (FABCAT).

3.3. Crop Types

The following table details the crops and organic crops for which there is provision to assess within these sources.

Crop Types (Redman, 2018)	Organic Crop Types (Lampkin *et al.*, 2017)
Apples - Cider	Apples (20yr Annual Average)
Apples - Culinary	Barley - Spring
Apples - Dessert	Barley - Winter
Barley - Spring Malting	Beetroot
Barley - Winter Feed	Cabbage - Red
Barley - Winter Malting	Cabbage - Savoy
Blackcurrants	Cabbage - Summer Pointed
Borage	Cabbage - White
Calabrese	Calabrese
Cauliflower	Carrots
Dry Bulb Onion	Cauliflower
Durum Wheat	Celery
Field Beans - Spring	Courgette
Field Beans - Winter	Dry Peas
Field Peas - Blue	Field Beans - Spring
Field Peas - Marrowfat	Field Beans - Winter
Grain Maize	Fodder Beet
Hemp	Leeks
Herbage Seeds - Intermediate Perennial	Lettuce
Herbage Seeds - Late Perennial	Lupins
Hops	Oats - Spring
Linseed - Spring	Oats - Winter
Linseed - Winter	Onions - Maincrop
Lupins	Parsnips
Millet	Pears (30yr Annual Average)
Oats - Naked	Potatoes - Early
Oats - Spring	Potatoes - Maincrop
Oats - Winter	Potatoes - Seed
Oilseed Rape - Spring	Rye
Oilseed Rape - Winter	Spelt Wheat
Pear	Strawberries (3yr Annual Average)

Poppy	Sweetcorn
Potatoes	Table Swede
Potatoes (Early)	Triticale
Raspberries	Wheat - Spring
Rye	Wheat - Winter
Soya	
Strawberries - Raised Bed	
Strawberries - Tabletop Ever-bearers	
Sugar Beet	
Triticale	
Vining Pea	
Wheat - Feed Winter	
Wheat - Milling Winter	
Wheat - Spring	

3.4. Livestock Types

The data provided for livestock types often was provided as a gross margin per forage hectare. However, this was not available for all the livestock options. In the instance that there is not data by this factor, the data was available as the gross margin per animal. In the instance that this is the data provided, the gross margin lost could be calculated by using the number of animals that could reasonably have used the lost area of agricultural land.

The following tables indicate the livestock and organic livestock types for which there is provision within the data sources.

Livestock Types (Redman, 2018)
Alpaca - Breeding & Fleece Production - after Forage
Alpaca - Breeding & Fleece Production - before Forage
Beef - Calf Rearing - Early Weaning - Bucker Rearing - 6 Months
Beef - Calf Rearing - Early Weaning - Bucket Rearing - 3 Months
Beef - Cereal Bull - Continental Cross Holstein/Fresian Bulls
Beef - Cereal Bull - Holstein Fresian Bulls
Beef - Finishing - Dairy Bred Store Cattle - Summer Finishing
Beef - Finishing - Dairy Bred Store Cattle - Winter Finishing
Beef - Finishing - Maize and Grass Silage - Dairy Cross Progeny - after Forage
Beef - Finishing - Maize and Grass Silage - Dairy Cross Progeny - before Forage
Beef - Finishing - Maize and Grass Silage - Suckler Progeny - after Forage
Beef - Finishing - Maize and Grass Silage - Suckler Progeny - before Forage
Beef - Finishing - Suckler Bred Store Cattle - Summer Finishing
Beef - Finishing - Suckler Bred Store Cattle - Winter Finishing
Beef - Store Cattle - Maintenance/Keeping of Young Dairy Store Cattle - Summer
Beef - Store Cattle - Maintenance/Keeping of Young Dairy Store Cattle - Winter
Beef - Suckler Cows - Single Suckling - Lowland - Autumn Calving
Beef - Suckler Cows - Single Suckling - Lowland - Spring Calving
Beef - Suckler Cows - Single Suckling - Upland - Autumn Calving

Beef - Suckler Cows - Single Suckling - Upland - Spring Calving
Dairy - Autumn Calving Holstein/Fresian - after Forage
Dairy - Autumn Calving Holstein/Fresian - before Forage
Dairy - Channel Islands - All Year Round - after Forage
Dairy - Channel Islands - All Year Round - before Forage
Dairy - Channel Islands - Autumn Calving - after Forage
Dairy - Channel Islands - Autumn Calving - before Forage
Dairy - Channel Islands - Spring Calving - after Forage
Dairy - Channel Islands - Spring Calving - before Forage
Dairy - Once a Day Milking - after Forage
Dairy - Once a Day Milking - before Forage
Dairy - Spring Calving Fresian - after Forage
Dairy - Spring Calving Fresian - before Forage
Dairy - Three Times a Day Milking - after Forage
Dairy - Three Times a Day Milking - before Forage
Dairy - Year-round Calving Holstein/Fresian - after Forage
Dairy - Year-round Calving Holstein/Fresian - before Forage
Dairy Follower - All Year Round
Dairy Follower - Autumn
Dairy Follower - Channel Islands - All Year Round - per Heifer reared
Dairy Follower - Channel Islands - Autumn - per Heifer reared
Dairy Follower - Channel Islands - Spring - per Heifer reared
Dairy Follower - Spring
Dairy Herd - Self Contained - Cows and Followers - All Year Round
Dairy Herd - Self Contained - Cows and Followers - Autumn
Dairy Herd - Self Contained - Cows and Followers - Spring
Egg Production - Enriched Cages - per Bird
Egg Production - Enriched Cages - per Dozen Eggs
Egg Production - Free Range - per Bird
Egg Production - Free Range - per Dozen Eggs
Goat Dairying - after Forage
Goat Dairying - before Forage
Goats - Angora - after Forage
Goats - Angora - before Forage
Meat Rabbit - per 150 Does
Meat Rabbit - per Doe
Ostrich - Laying Bird Trios
Ostrich - Slaughter Birds
Pigs - Breeding and Rearing (to 35kg liveweight) - per Pig
Pigs - Breeding and Rearing (to 35kg liveweight) - per Sow
Pigs - Combined Breeding, Rearing and Feeding - Bacon - GM for Pig
Pigs - Combined Breeding, Rearing and Feeding - Bacon - GM for Sow
Pigs - Combined Breeding, Rearing and Feeding - Cutter - GM for Pig
Pigs - Combined Breeding, Rearing and Feeding - Cutter - GM for Sow
Pigs - Combined Breeding, Rearing and Feeding - Pork - GM for Pig
Pigs - Combined Breeding, Rearing and Feeding - Pork - GM for Sow

Pigs - Feeding (Feeding from 35kg liveweight) - Bacon
Pigs - Feeding (Feeding from 35kg liveweight) - Cutter
Pigs - Feeding (Feeding from 35kg liveweight) - Pork
Poultry - Rearing Pullets
Poultry - Table - All Year Turkey
Poultry - Table - Broilers
Poultry - Table - Christmas Turkey - Heavy
Poultry - Table - Christmas Turkey - Light
Poultry - Table - Christmas Turkey - Medium
Poultry - Table - Goose
Poultry - Table - Large Roaster Chicken
Poultry - Table - Pekin Duck
Red Deer - Breeding & Finishing - after Forage
Red Deer - Breeding & Finishing - before Forage
Red Deer - Breeding & Selling Stores - after Forage
Red Deer - Breeding & Selling Stores - before Forage
Red Deer - Deer Park - after Forage
Red Deer - Deer Park - before Forage
Red Deer - Finishing Stag Calves - after Forage
Red Deer - Finishing Stag Calves - before Forage
Sheep - Finishing Store Lambs
Sheep - Rearing Ewe Lambs
Sheep - Spring Lambing - Lowland Spring Lambing - (selling lambs off grass)
Sheep - Spring Lambing - Upland Spring Lambing - (selling lambs off grass)
Sheep Dairying - after Forage
Sheep Dairying - before Forage
Wild Boar - 5 sows/ha

Organic Livestock Types (Lampkin *et al*, 2017)
Beef - Finishing - Spring-Born Stores (Finished at 22-26months) - After Forage
Beef - Finishing - Spring-Born Stores (Finished at 22-26months) - Before Forage
Beef - Suckler Cow - Lowland (Finishing at 24months) - After Forage
Beef - Suckler Cow - Lowland (Finishing at 24months) - Before Forage
Beef - Suckler Cow (Sold as Stores) - After Forage
Beef - Suckler Cow (Sold as Stores) - Before Forage
Dairy - Fresian/Holstein - All Year Round Calving - After Forage
Dairy - Fresian/Holstein - All Year Round Calving - Before Forage
Dairy - Fresian/Holstein - Spring Calving - After Forage
Dairy - Fresian/Holstein - Spring Calving - Before Forage
Dairy - Replacement Fresian/Holstein - After Forage
Dairy - Replacement Fresian/Holstein - Before Forage
Eggs - Laying Hens (Producer-Packer) - Before Forage
Pigs - Outdoor Breeding - After Forage
Pigs - Outdoor Breeding - Before Forage
Pigs - Outdoor Finishing - Baconers - Before Forage
Poultry - Table (Producer-Killed and Dressed)

Poultry - Turkey
Sheep - Lowland Breeding Ewes - After Forage
Sheep - Lowland Breeding Ewes - Before Forage
Sheep - Upland Breeding Ewes - After Forage
Sheep - Upland Breeding Ewes - Before Forage

3.5. Other Enterprise Data

A handful of other enterprises are included within the *John Nix Pocketbook*. These could be applied using the principles of the effects upon crops and livestock if necessary, but it is recognised that the business functioning behind coarse fishing and camping/caravan sites is different and therefore may require further consideration on a case-by-case basis.

Types of Enterprise (Redman, 2018)
Camping/Caravan Site (Net Margin)
Christmas Trees - per year (over 8 years)
Coarse Fishing (per Lake)
Perennial Energy Crops - Miscanthus
Perennial Energy Crops - Short Rotation Coppice

3.6. Variable Costs

There will be a number of variable costs which may not be factored into a Gross Margin cost estimate. For example these may include (but are not limited to): regional variations in market price; regional variations in financial support; staff costs due to pay rate; staff costs due to individual farm factors (such as the distance of a dairy herd from a milking parlour); costs of machinery repair, losses for landowners from reduced rent etc.

These are important factors which may be relevant in the potential assessment of costs related to beaver activity. For example, if an area of water is held back across an access point for livestock which may lead to a longer time taken to move them that would lead to an increased staff cost through the additional time taken in cattle movement. As the variance in these factors is high, these will need to be considered on a case-by-case basis.

There may also be variation in crop yields between farms. In the data sources there are often data for ‘Low’, ‘Average’ or ‘High’ performance levels. However, if it is established (on a case-by-case basis) that there is a significant deviation from the stated yield upon which the gross margin estimate is based, it is recommended that a gross margin estimate is sought from an independent consultant or other respected body.

3.7. A Note on Costs Already Incurred

The use of gross margin factors in the costs and income throughout the process. However, if an area of a productive field is inundated with water when some costs have already been incurred, these will in effect be additional financial losses above that of the gross margin.

For example, if seed has been purchased for an area of land which then becomes unsuitable for planting due to a backlog of water, the gross margin that would have resulted from the crop has been lost, as well as the money involved in the purchase of the then unusable seed.

3.8. Other Crops or Livestock Types

If a crop or livestock type occurs which is not included within the data sources, it is recommended that a gross margin estimate is sought from an independent consultant or other respected body.

3.9. Real-World Examples from the 'River Otter Beaver Trial'

There were two particular cases of beaver impact upon agriculture where the areas of land affected by water stored behind beaver dams were measured using GPS. Looking at the type of agriculture, the measured impacted areas were cross-referenced with the data sources to calculate an estimated cost resulting from beaver activity.

3.9.1. Case 1

The background of this case is described in the ROBT Science & Evidence Report (Case Study 2).

In this scenario, two cost estimates are provided. This is because there was a delay between the impact taking place and the site being measured. As such, there was disparity between the areas of land, so here the cost estimate was undertaken twice to reflect both measured areas. This is a lesson learned for the future if beavers are to be formally reintroduced; the area of affected land should be measured as soon as possible after being reported. In the management decisions undertaken within the Trial, the estimate used was Cost Estimate 1.

In the cost estimate tables, the average yield described by the data sources is reported. The farmer gave a yield estimation from the field which differs from this average. Therefore an adjusted value is also presented in which the gross margin value has been adjusted by the percentage difference in yields.

Cost Estimate 1

The farmer stated that as the tractors are GPS logged he was able to determine that an acre less of land was able to be planted than on the previous cycle.

Utilising this one acre value, the following estimates are made for the impact upon the 2019 potato crop. These values are an estimate of the Gross Margin which would have been made from the area of land in which the potatoes could not be planted.

Crop	Estimate Gross Margin Loss	Yield	*Yield Information Source*
First Early Potatoes	£1494.51	4.86 tonnes per acre	*Estimated Average Yield in Data Sources*
	£2615.38	8.5 tonnes per acre	*Farmer's Estimated 5 Year Historical Average (75% Increase on Data Sources)*
AVERAGE of the two estimate values: £2054.95			
Additional Cost: The farmer identified that 1 tonne of seed had been purchased to plant the 1 acre of flooded land. The *Organic Farm Management Handbook* estimates this cost to be **£600**.			

Should a similar area of 1 acre be flooded at the time of planting of the second cash crop in year five of the cycle, an estimate has been calculated for the potential impact upon the Gross Margin. As the farmer indicated they would usually plant barley, estimates for both spring and winter barley are provided.

Crop	Estimate Gross Margin Loss	Average Estimated Yield
Spring Barley	£227.43	1.29 t/acre
Winter Barley	£218.94	1.21 t/acre

Cost Estimate 2

The second estimate is as a result of a site visit. The visit occurred after the time of planting when the flooded area had dried out. The area of land in which the potatoes could not have been planted was estimated using points plotted with a handheld GPS system. The coordinates were taken from the line where potatoes had been planted to within an approximate tractor's width of the field boundary (the area in which a tractor would need to turn around).

The coordinates were plotted in ArcMap software to produce the following image (*satellite imagery from Google*). The area shaded in blue indicates the area estimated in which potatoes could not be planted.

This approximated area equates to 0.6626 acres, as demonstrated in Figure 7.

Figure 7.

Utilising the value of 0.6626 acres, the following estimates are made for the impact upon the 2019 potato crop. These values are an estimate of the Gross Margin which would have been made from the area of land in which the potatoes could not be planted.

Crop	Estimate Gross Margin Loss	Yield	*Yield Information Source*
First Early Potatoes	£990.32	4.86 tonnes per acre	*Estimated Average Yield*
	£1733.07	8.5 tonnes per acre	*Farmer's Estimated 5 Year Historical Average (75% Increase on Data Sources)*
Average of the estimate values: £1361.70			
Additional Cost: The farmer identified that 1 tonne of seed had been purchased to plant the 1 acre of flooded land. With an adjustment to the 0.6626 acre value, the Organic Farm Management Handbook estimates this cost to be £397.56.			

Should a similar area of 0.6626 acres be flooded at the time of planting of the second cash crop in year five of the cycle, an estimate has been calculated for the potential impact upon the Gross Margin. As the farmer indicated they would usually plant barley, estimates for both spring and winter barley are provided.

Crop	Estimate Gross Margin Loss	Average Estimated Yield
Spring Barley	£150.71	1.29 t/acre
Winter Barley	£145.08	1.21 t/acre

3.9.2. Case 2

The background of this case is described in the ROBT Science & Evidence Report (Case Study 1).

Since the time of interview, the height of beaver dams was reduced in a management intervention. The estimated flooded area of land prior to this intervention, measured using a GPS device, was calculated as 0.89hectares. Following the intervention, the area flooded equates to 0.05hectares.

The estimated gross margin costs for a year were estimated. The 'pre-management' figure is an estimate of the gross margin cost over the course of a year had no intervention taken place, and the 'post-management' figure is an estimate of the gross margin cost over a year having had the intervention.

Livestock Type	Pre/Post-Management Intervention?	Area Affected	Estimate Gross Margin Loss
Dairy Herd - Self Contained - Cows and Followers – Spring Calving	Pre-Management	0.89ha	£1565.51
	Post-Management	0.054ha	£94.99

There were some potential secondary costs reported. In this instance, the cattle were twice-a-day milking but the flooding had obstructed an access point used for moving the cattle. As such, the time required to move cattle increased and there are other additional elements that were reported, such as increased lameness in cattle from walking further and increased wear to an access track, and additional staff time in moving cattle. Due to these additional costs, the management intervention of reducing dam height was utilised. These potential secondary costs would vary on a case-by-case basis and it is therefore recommended that an independent assessment is sought from an independent consultant or other respected body in possible future scenarios.

4. A Note on Upcoming Research

In the 'River Otter Beaver Trial', individuals who had reported beaver impacts of concern or conflict were interviewed by a PhD researcher at the University of Exeter. These interviews have been analysed and (at the time of writing) a manuscript is in production. Following the process of scientific peer review, the paper will be uploaded as a further appendix document for the 'River Otter Beaver Trial' Science & Evidence Report.

5. Concluding Remarks

- There are demonstrated costs upon agriculture resulting from the impacts of beavers, and these will need to be fully factored into future management decisions if beavers are to be formally reintroduced.
- This is one of area of a number of potential impacts (whether positive or negative) amounting from beaver reintroduction (see the 'River Otter Beaver Trial' Science & Evidence Report). These will need to be considered collectively in decision-making processes as they are not necessarily able to be considered in isolation. For a particular example, evidence suggests that there may be a potential benefit in attenuating flooding for properties downstream of a beaver dam (Puttock *et al*., 2017), though this may be associated with a cost for agriculture upstream of the dam should water backlog onto productive agricultural land.
- As well as the observed economic and ecological considerations, perceptions of wildlife management will need to be considered in the development of a management strategy which would be more likely to reduce conflicts between humans and beavers or between humans about beavers - if they are to be formally reintroduced (Auster *et al*, 2019).

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APPENDIX 3.

Appendix to the ‘River Otter Beaver Trial’ Science & Evidence Report: An Investigation into Fishing and its Economic Activity in the River Otter Catchment, and Reported Impacts of Eurasian Beaver (*Castor fiber*) Presence on Fishing, Prior to Spring 2019

The following report forms the third appendix of this thesis. It is presented as it has been published online, with all references included at the end of the appendix.

This report, written by me, is an appendix to the River Otter Beaver Trial Science & Evidence Report, available from https://www.exeter.ac.uk/creww/research/beavertrial/

The appendix details the findings of an evaluation of the economics of recreational fishing in the River Otter catchment, including fishing licence sales; fishing rents/rights; syndicate memberships; day/guest fishing tickets; fishing effort; fish stocking; insurance; individual angler expenses; capital value of fishing rights and other factors.

First published: February 2020

Appendix to the 'River Otter Beaver Trial' Science & Evidence Report:

An Investigation into Fishing and its Economic Activity in the River Otter Catchment, and Reported Impacts of Eurasian Beaver (*Castor fiber*) Presence on Fishing, Prior to Spring 2019

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The author of this report would like to extend their gratitude to the members of the 'River Otter Fisheries Association', the Syndicates/Clubs/Fisheries of the River Otter catchment and individual anglers for their contributions towards this work.

EXECUTIVE SUMMARY

- This report seeks to profile fishing activity within the River Otter, explore the economic factors and detail the reported impacts of Eurasian beaver (*Castor fiber*) reintroduction seen up until the time of writing (Spring 2019).
- Further to this report, other research looks at both perceptions and the ecological effects of Eurasian beaver reintroduction; as such these areas are **not** the focus of this piece of work.
- Fishing in the River Otter catchment is largely recreational brown trout or sea trout, with a limited amount of coarse fishing.
- Engagement with fisheries and syndicates throughout the catchment and publicly accessible data held by the *Environment Agency* are used to examine key economic focal areas including: fishing licence sales; fishing rents/rights; syndicate memberships; day/guest fishing tickets; fishing effort; fish stocking; insurance; individual angler expenses; capital value of fishing rights and other factors.
- It is identified that a true total economic value of fishing within the catchment is difficult to obtain due to a number of limitations which are described. However, it is assumed that the annual figure is likely to be at least a six-figure sum, as well as the capital value held in fishing rights. The flows between the different economic aspects of fishing are described.
- The impacts of beavers on fishing within the River Otter catchment that were reported up until the point of writing are outlined. These are so far limited and have occurred both directly as a result of beaver activity and indirectly through interactions between fishing and 'beaver-watching' activities.
- The research presented within this report enables the identification of the method by which the economic variables in fishing may be effected if beavers were found later to impact on recreational fishing activity, either positively or negatively. This is identified by first influencing an individual anglers' activity, which in turn could impact on factors such as syndicates, riparian rights holders, insurance companies and businesses.

Contents

1. Introduction and Data Sources

The River Otter catchment in East Devon and Somerset is subject to a licensed Trial reintroduction of Eurasian beavers (*Castor fiber*) until 2020, having begun in 2015. Detailed within the licence agreement issued by *Natural England* are the needs for research into the activity of fishing in the catchment and the potential impacts of Eurasian beavers (hereon referred to as 'beavers') upon it. Fishing within the River Otter catchment area is largely recreational brown trout or sea trout fishing, with a small amount of coarse fishing.

The scope of this report is to independently and impartially profile the current fishing activity within the River Otter and explore the economic factors involved, prior to then detailing the impacts of Eurasian beaver (*Castor fiber*) reintroduction which have been reported up until the time of writing (Spring 2019). This report does **not** seek to detail the potential attitudinal or ecological aspects of beaver reintroduction as there is further research within the 'River Otter Beaver Trial' and elsewhere.

The data that is drawn upon within this report comes predominantly three sources. The first is publicly available data held by the *Environment Agency*. Where this data is used, they are explicitly stated and a reference list is provided at the end of the report. Second, the researcher has engaged with identified representatives of fishing syndicates/clubs/fisheries throughout the catchment where possible (an overview of these is provided later in the report). Finally, some details have been provided by up to eleven individual anglers from within the catchment. This is specified on each occasion, and engagement occurred either through a face-to-face interview or through email communication.

All respondent identities and personal data are treated as confidential, as such contributions have been made anonymously. At times, data was provided which was identified by the contributor as commercially sensitive. Where this is the case, the information itself is not reported so as to remain confidential, but it is specified as to which factor this data would contribute to. Finally, the ethical statements through which this work was conducted and to which respondents agreed is provided in Appendix 1.

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2. Fishing Licence Sales in the Otter Catchment

The *Environment Agency* (EA) sells two types of fishing licence: 'Salmon and Sea Trout' and 'Non-Migratory Brown Trout and Coarse Fishing'. In this section, the average sale numbers and values of these licences between 2010 and 2016 are presented.

It is important to recognise that the sales of licences within the catchment is unlikely to be directly reflective of the number of anglers who fish in the Otter catchment as licence-holders may fish in different catchments, and licence-holders outside of the catchment may fish in the Otter. The licence sales are however a significant economic factor which should be recognised.

The data indicating the number of licences sold is available annually from the *Environment Agency* by *Environment Agency* area, in this case the South West. It is not however readily available by river catchment. Therefore, to obtain data for the River Otter catchment, data was obtained through a Freedom of Information request for postcode districts EX9, EX10, EX11, EX14 and TA20[1]. This data is only retrievable until 2016 as, from 2017 onwards, the author was informed that it is not possible to obtain licence sales figures for postcode districts due to a change in the recording system at the *Environment Agency*. Thus, the estimates for the catchment by these postcode districts is only available between 2010 and 2016. Using the figures from between these years the average estimates are calculated.

The proportion of sales in the South West are also presented here, calculated using figures from the *Environment Agency* 'Annual Salmon and Freshwater Fisheries Statistics for England and Wales Reports'[2]. These are available from 2010 onwards, with the latest available being for 2017. (South West licence sales data is available in Appendix 2.)

2.1. No. Licences Sold

TABLE 1. OTTER CATCHMENT – SALMON AND SEA TROUT FISHING LICENCE SALES[1]								
Licence Type	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**AVERAGE**
Disabled Concession – Full Annual	0	0	0	1	1	1	2	**1**
Full Licence – 1 Day	11	13	21	14	12	8	12	**14**
Full Licence – 8 Day	7	4	0	8	2	0	1	**3**
Full Licence – Full Annual	44	47	48	51	47	38	41	**47**
Junior Concession – Full Annual	13	6	6	9	7	3	4	**7**
Senior Concession – Full Annual	25	27	25	24	32	30	35	**27**
TOTAL	**102**	**98**	**100**	**108**	**102**	**82**	**96**	**98.29**
% of Sales in South West[2]	***2.507***	***2.365***	***2.459***	***2.866***	***2.798***	***2.218***	***2.710***	***2.590***

TABLE 2. OTTER CATCHMENT – TROUT AND COARSE FISHING LICENCE SALES[1]								
Licence Type	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**AVERAGE**
Disabled Concession – Full Annual	46	41	34	31	31	29	26	**34**
Full Licence – 1 Day	288	303	265	254	252	319	298	**282**
Full Licence – 8 Day	63	65	36	66	49	56	58	**56**
Full Licence – Full Annual	658	664	598	544	527	526	526	**594**
Junior Concession – Full Annual	153	149	115	92	72	61	48	**104**
Senior Concession – Full Annual	184	192	211	218	218	219	208	**203**
TOTAL	**1392**	**1414**	**1259**	**1205**	**1149**	**1210**	**1164**	**1256.14**
% of Sales in South West[2]	***1.380***	***1.410***	***1.416***	***1.359***	***1.301***	***1.357***	***1.330***	***1.284***

2.2. Value of Licences Sold

The values of each licence type sold across all of these years were as detailed in Table 3[2].

TABLE 3. VALUE OF FISHING LICENCES		
Licence Type	**Salmon & Sea Trout**	**Trout and Coarse**
Disabled Concession - Full Annual	£48.00	£18.00
Full Licence - 1 Day	£8.00	£3.75
Full Licence - 8 Day	£23.00	£10.00
Full Licence - Full Annual	£72.00	£27.00
Junior Concession - Full Annual	£5.00	£5.00
Senior Concession - Full Annual	£48.00	£18.00

If these values are applied to and multiplied by the sales frequencies, the total values in the Otter catchment per year for all licence types are then as follows in Table 4, or as follows in Table 5 when the sales values are adjusted to account for inflation between each respective year and 2018.

TABLE 4. OTTER ESTIMATED VALUE OF LICENCES SOLD

2010	2011	2012	2013	2014	2015	2016	AVERAGE
£29,063.00	£29,559.25	£27,338.75	£26,445.50	£25,651.00	£25,030.25	£25,218.50	**£26,902.32**

TABLE 5. OTTER ESTIMATED VALUE OF LICENCES SOLD ACCOUNTING FOR INFLATION UNTIL 2018

2010	2011	2012	2013	2014	2015	2016	AVERAGE
£38,509.01	£34,787.40	£34,276.61	£30,770.93	£29,085.96	£27,923.76	£26,781.50	**£31,733.60**

2.3. Licence Data Conclusions

From these figures, the sales from within the Otter catchment accounted for an average of 2.59% of Salmon and Sea Trout licence sales in the South West (98.29 sales), and 1.284% of Trout and Coarse licence sales in the South West (1256.14 sales).

The average value of licences sold in the Otter catchment was £26,902.32. Accounting for inflation until 2018, the average value of licences sold per year was £31,733.60.

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3. Fishery and Syndicate Details

During the course of this work, four major fisheries and syndicates were identified as active within the River Otter catchment, as well as a number of smaller syndicates or individually rented stretches in the middle reaches. It was possible to engage with the four major fisheries in the course of this research.

At the headwaters of the River Otter, Otterhead Lakes fishing falls under *Taunton Fly Fishers* as one of six of their beats (the remaining five beats are outside of the Otter catchment). This operates on a membership basis. *Deer Park Country House* operates a fishery with four beats in the middle reach of the river. This operates by the sales of day tickets. Neighbouring the Country House both up- and downstream, the next fishery is the *Otter Fly Fishers Association* which runs on a membership basis, as do the syndicates operating furthest down the catchment on the four beats owned by *Clinton Devon Estates*. This section of the report is the result of engagement with at least one representative of each of these four bodies.

The lowest reach of the River Otter is free for members of the public to fish as a philanthropic gesture by its owners *Clinton Devon Estates.* Additionally, the compiler of this report heard of small amounts of fishing activity on the River Tale (a tributary of the River Otter within the catchment) and of a small syndicate in the middle reaches of the catchment, but was unable to identify appropriate contacts with which to engage. These are therefore not referenced from this point forth, but it is important to note that there is likely to be further economic contributions from these areas.

3.1. Rent/Rights Estimate

Three fisheries/syndicates identified that they rented the rights to fish particular reaches of the River Otter. The values were identified as commercially sensitive and therefore are confidential data. This information cannot therefore be reported upon here in detail, however the value of each rental sum paid was a four-figure value. On one occasion, a representative further specified that fishing rights were obtained in return for access to a number of days fishing on other beats.

The lowest reach of the river is owned by *Clinton Devon Estates* and is open for members of the public to fish for free (provided they hold a valid licence).

3.2. Memberships

Of the fisheries/syndicates which offered memberships, there are approximately 55 paying members. At Otterhead Lakes, the fishing is managed by a syndicate which also manages five further fiver fishing beats outside of the Otter catchment. It was estimated by the representative of this syndicate that Otterhead Lakes is used by approximately 20-30 of its syndicate members.

The value estimate of members' fees was estimated by multiplying the number of paying members by the value of a full adult membership price at the respective syndicates. (For Otterhead Lakes, this multiplied 20 and 30 by the syndicate membership price, then the obtained value was divided by 6 to reflect the fact that the Lakes are one of six beats). The resultant value estimate for memberships alone was therefore £9625-9775.

At *Deer Park Country House*, the access to fishing is administered through the sale of day tickets rather than through memberships. The number of day tickets sold was not quoted so a quantified value estimate is unavailable (see Section 3.3 for notes on pricing.)

Also of note, one fishery/syndicate identified that they also have 4 non-paying lifelong members, and two syndicates identified that they also charge joining fees for new members.

3.3. Day/Guest Tickets

Two fisheries/syndicates identified that they allowed members to bring guests. One indicated that this was free to do, and the other charges £2 a day (the number of guest tickets sold was not available). None of the three syndicates sold day tickets to the general public.

At *Deer Park Country House*, day tickets are charged at £35 a day (the number of tickets sold was unavailable). Season tickets are also available, yet the price was identified as commercially sensitive and is therefore confidential.

3.4. Effort Data

3.4.1. Effort Reported By Syndicates/Fisheries

Two syndicates identified that they do not collect effort data or were unwilling to share the information that they did have. The reasons cited for this were: a lack of trust in returns; that some anglers won't share details of where they fish; that some anglers are not bothered to complete returns; inaccuracy of reporting - including the difference in reporting of fish size between kept and returned fish (due to speed of measurements) and that the effort of chasing return forms was too high when the administrative tasks were undertaken on a voluntary basis.

Deer Park Country House did however state that a record book is kept, into which it was estimated about 60% of anglers complete. The author of this report however was unable to view the information.

Of note, brown trout and sea trout were cited by respondents to generally be in decline. One noted that the fish in the past year have been smaller than usual, cited as being possibly due to environmental conditions or perhaps due to dominant trout holding the area. One representative cited that they can block the use of certain beats when they believe it needs to recover from environmental disturbance.

3.4.2. Environment Agency Effort Data

3.4.2.1. Number of Fishing Days

An estimate has been calculated for the number of days fished in the River Otter catchment utilising data held by the *Environment Agency*.

Although it is not a requirement for Non-migratory Brown Trout licences, Salmon & Sea Trout licence holders are legally obligated to submit an annual return detailing their fishing effort including: number of days fished, where they fished and what was caught and returned. It is important to note that fewer returns are received than the number of licences issued and that the data may possibly suffer from the limitations which were identified by the syndicates/fisheries as outlined above in Section 3.4.1. However, these are the best available data at present and it is this data that is used in this section[2].

The data available in the *Environment Agency* reports between 2010 and 2017[2] for the number of days fished for Salmon & Sea Trout in the River Otter and in the South West are presented in Table 6. (The number of returns with effort data is reported in Appendix 3).

TABLE 6. REPORTED NO. DAYS FISHED FOR SALMON & SEA TROUT[2]

REGION	2010	2011	2012	2013	2014	2015	2016	2017	Average
River Otter	283	363	151	179	275	237	233	175	237
% of South West Days Fished in River Otter	*1.22%*	*1.51%*	*0.74%*	*0.97%*	*1.7%*	*1.31%*	*1.51%*	*0.99%*	*1.24%*
South West	23206	24008	20482	18385	16221	18129	15418	17717	19195.75

Note: It is possible that licence-holders who did not submit their returns may fish for a further number of days.

This data is not available for the fishing of brown trout and coarse fish. However, in 2005 the *Environment Agency* released the most up-to-date of its *'Economic Evaluation of Inland Fisheries'* Reports[3]. This report used the results of a telephone (*n=3000*) and internet survey (*n=4000*) of fishing licence holders. This report uses their results to estimate the number of days that were fished across England and Wales (See Appendix A[3] within the report).

The figures estimated for the South West region are presented in Table 7 below, alongside the percentage increase in days between Salmon & Sea Trout fishing and fishing for Brown Trout and Coarse Fish. (The report is broken down into the Environment Agency regions, therefore the figures are not available specifically for the River Otter.)

TABLE 7. ESTIMATED NO. DAYS FISHED FOR DIFFERENT FISH TYPES IN SOUTH WEST[3]			
FISHING TYPE	Salmon & Sea Trout	Brown Trout	Coarse Fish
No. Days Fished	43,000	455,000	2,182,000
% Increase in number of days from fishing for Salmon & Sea Trout	-	958.12%	4974.42

To estimate the number of days fished for brown trout in the River Otter catchment, the number of days reported for Salmon & Sea Trout fishing[2] detailed above were adjusted by the percentage increases in number of days calculated from the '*Economic Evaluation of Inland Fisheries*' report[3]. The number of estimated days' effort in the River Otter are therefore as follows in Table 8. We have not calculated the number of days in the same manner for coarse fishing as this activity is limited within the River Otter catchment and such a calculation would be likely to misrepresent the level of coarse fishing activity in the area.

TABLE 8. ESTIMATED NO. DAYS FISHED IN THE RIVER OTTER[2,3]									
FISHING TYPE	2010	2011	2012	2013	2014	2015	2016	2017	Average
Salmon & Sea Trout	283	363	151	179	275	237	233	175	237
Brown Trout	2711.48	3477.98	1446.76	1715.04	2634.83	2270.74	2232.42	1676.71	2270.74
TOTAL	2994.48	3840.98	1597.76	1894.04	2909.83	2507.74	2465.42	1851.71	2507.74
Note: It is possible that licence-holders who did not submit their returns may fish for a further number of days.									

Further, the 2005 report estimates the proportion of days spent fishing by residents and visitors for the three types of fishing as detailed in Table 9.

TABLE 9. ESTIMATES OF PROPORTION NO. DAYS FISHED BY RESIDENTS AND VISITORS[3]		
FISHING TYPE	Residents	Visitors
Salmon & Sea Trout	86%	14%
Brown Trout	73%	27%
Coarse Fish	76%	24%

If these proportions are applied to the estimated number of days in Table 8, the average estimated number of days fished by residents and visitors between 2010 and 2017 (excluding coarse fishing for reasons outlined above) are thus as detailed in Table 10.

TABLE 10. AVERAGE ESTIMATE NO. DAYS FISHED BY RESIDENTS AND VISITORS IN RIVER OTTER[2,3]		
FISHING TYPE	Residents	Visitors
Salmon & Sea Trout	203.82	33.18
Brown Trout	1657.64	613.10
TOTAL	1861.46	646.28

3.4.2.2. Estimated Value of Visitor Fishing Days

The 2005 '*Economic Evaluation of Inland Fisheries'* report[3] deduces from its results that, in the South West, the average expenditure on a visitors' fishing day in the region was £176 for Salmon & Sea Trout and £40 for Brown Trout (and £36 for Coarse Fish). With this value applied to the estimated number of visitors' days fished from Table 10, the estimated values of visitor expenditure in the River Otter between 2010 and 2017 are presented in Table 11, which also presents the values when adjusted to account for inflation from 2005 (when the *Environment Agency* report was published) and 2018 (£256.69, £58.67 respectively).

TABLE 11. ESTIMATED VALUES OF VISITING ANGLING EXPENDITURE[2,3]

FISHING TYPE	Estimated Value	Estimated Value Adjusted for Inflation until 2018
Salmon & Sea Trout	£5837.92	£8516.97
Brown Trout	£24,524.00	£35,970.58
TOTAL	£30,361.92	£44,487.55

As stated above, we have not calculated figures for coarse fishing in the same manner. However, it should be noted that there may be a slight additional value from limited coarse fishing activity.

3.4.4.3. Reported Catch

The *Environment Agency* annual reports[2] detail the Salmon & Sea Trout catches reported within the River Otter. The data is presented in Table 12. (This information is not available for Brown Trout and Coarse Fish as it is only a legal requirement to submit a return for the Salmon & Sea Trout licences.) The number of returns containing effort data is reported in Appendix 3.

TABLE 12. REPORTED SALMONID CATCH IN THE RIVER OTTER[2]

YEAR	SALMON ROD CATCHES (All Released)	SEA TROUT CAUGHT (Releases in Brackets)	TOTAL REPORTED SALMONID CATCH
2010	-	91 *(66)*	91
2011	-	123 *(101)*	123
2012	-	27 *(24)*	27
2013	2	113 *(103)*	115
2014	-	152 *(104)*	152
2015	-	60 *(49)*	60
2016	-	79 *(73)*	79
2017	1	60 *(56)*	61

3.5. Stocking

All fisheries/syndicates that were engaged with reported that they no longer stock fish, except one which stated that it is reducing the number of fish stocked (see Section 7). Of those that had stopped stocking, the motivations for doing so were described differently. One cited the reason as being due to rising costs and that its members questioned whether there was still a need to undertake stocking. This organisation previously stocked 200-300 triploid brown trout annually until 2014. Another, which stocked approximately 100 triploid brown trout in the previous three years, will no longer stock from 2019 as the committee view is that there should be a 'wild fishery'. Another stated that they do not stock in order to "encourage the growth of locally spawned trout".

Finally, the last organisation stocked fish until Spring 2017, with the number stocked having been reduced over time due to rising costs. The reason for stopping was as the fishery's work was to now focus upon improving habitats and biodiversity in line with the wider business ethos and to provide "more wild fishing". The fishery/syndicate which still stocks inputs 1lb sterile brown trout from a fishery in Dorset. They and one of the smaller syndicates collectively stocked 300 in 2017 at a cost to the syndicates of £1200, and in 2018, 200 were stocked at a cost of £840.

3.6. Insurance

All fisheries/syndicates indicated that they paid a cost for insurance. Two confirmed the value as a three-figure sum. One identified that the insurance price was included in *Angling Trust* membership through *Fish Legal*, through which the price is dependent upon the number of members within a syndicate.

3.7. Other Economic Factors

One organisation indicated that it auctioned 2 days' worth of fishing a year for a *Salmon and Trout Conservation* auction, raising approximately £150 each.

Deer Park Country House previously ran 'Stay and Fish' packages and fishing masterclasses. These are currently not in operation, but are in consideration for the future.

3.8. Additional Notes

One representative stated that their operation is running at the "everybody is happy" level, but it could increase its economic potential through the building of fishing huts etc.

One fishery representative believed it important to recognise the mental health benefits that they believed fishing provided within this work. This included the act of fishing itself, as well as during the time spent making new flies. They reportedly quoted one particular angler who had previously suffered with cancer who stated that "the prospect of fishing in future was one of the things that gave him the strength to cope and fight on".

4. Individual Angler Expenses

A number of factors were also identified at the level of individual anglers following discussion with eight members of the angling community within the catchment. Table 13 aims to provide an indicative insight as to the types of economic factors which were cited by respondents:

TABLE 13. INDIVIDUAL EXPENDITURES REPORTED BY ANGLERS	
Economic Factor	**Details**
Gear/Equipment (Including Flies/Tackle)	Broadly, these were cited as 'one-off' purchases, ranging between £400-700 per year to include baits, ties and tackle. One respondent identified that this may be higher if they needed to purchase more expensive equipment such as a new rod or pair of waders for example, likely to be on a less-than-annual basis. Respondents stated that gear may be bought either in a local shop or purchased online. Three anglers identified that they made these purchases in nearby Exeter.
Local Hospitality Establishments	Food or Drink purchases after fishing. Amongst the eight anglers spoken to, this was less regular as most would travel to fish from a nearby home and head back there afterwards.
Local Shops	Snack food and drinks for a fishing trip, cited by two respondents as approximately £5 a trip.
Transport/Fuel To and From Fishing	This is a variable cost dependent upon the distance a respondent travels. The syndicates identified that most anglers within the Otter catchment lived reasonably locally, but with a small number traveling from further afield.
Fishing Holidays	Two River Otter anglers identified that they undertake significant expenditure on fishing holidays away from the Otter catchment.
Fishing Guiding/Teaching	One angler identified himself as a fishing guide/teacher. They stated that this was paid but occasional as they were retired. The number of guides/teachers in the catchment is unknown.

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5. Capital Value of Fishing Rights

As well as the economic transfers outlined above which will occur annually (or are expected to occur regularly), further value is held in capital through the ownership of fishing rights.

The Secretary of the *River Otter Fisheries Association* calculated an estimate of the total capital value based upon historical sales of fishing rights. This was based upon three values for what may be termed the upper, middle or lower reaches of the catchment. The River Otter Beaver Trial 'Fisheries Forum' were presented with these estimates and agreed that they were appropriate figures. These estimates are thus outlined in Table 14.

(To note, the figures do not include the capital value of the fishing rights at Otterhead Lakes or the River Tale.)

TABLE 14. ESTIMATED CAPITAL VALUE OF FISHING RIGHTS			
STRETCH OF 'FISH-ABLE' RIVER	Estimated Figure Per Yard - Double Bank (Based on historical sales)	Stretch Length	Estimated Value of Stretch (Estimated Figure x Stretch Length)
Upper	£20	7655yds (7km)	£153,100
Middle	£50	15,310yds (14km)	£765,500
Lower	£100	15,310yds (14km)	£1,531,000
TOTAL	-	38,275yds (35km)	£2,449,600

The Secretary added that it could be assumed that up to 20% of each stretch would be 'unfishable' (due to built-up areas and other obstructions). Therefore the estimated capital value held in fishing rights for the main part of the River Otter can be adjusted to **£2million**.

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6. Economic Value of the Catchment

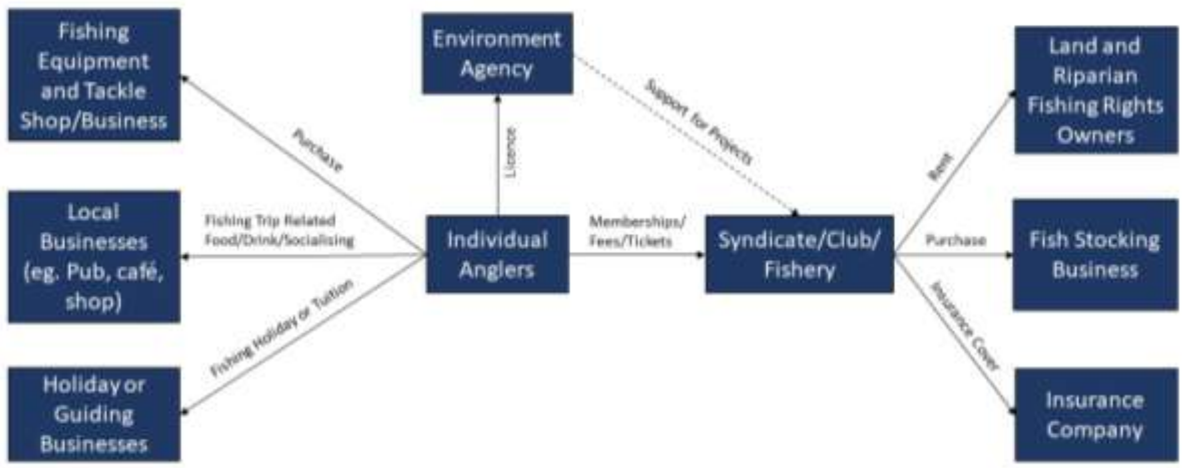
This study initially set out to gain an understanding of the total economic value of fishing within the River Otter catchment area. However, a number of challenges have been identified that limit the ability of identifying the true value:

- Some information was withheld by fishing syndicate representatives. This was primarily stated as being due to the commercial sensitivity of the information and the intention of keeping the information confidential from other syndicates nearby.
- For some information, the data obtained was incomplete (for example, sales numbers of day or guest tickets in the catchment). Further, appropriate contacts could not be identified for some of the reported fishing such as in the River Tale or another small syndicate.
- This study could not question all anglers within the catchment about their economic activities. Partly, this is due to the ability to identify anglers and the importance of data protection from relevant organisations, or from the willingness to engage of potential participants.
- Where anglers could be questioned, there were limitations borne of a lack of information recording or other challenges, such as those also quoted by syndicates in chasing effort data (varied quality and accuracy of records or high effort in following a line of enquiry).
- Also of note, this study received good engagement from fishery committee members, for which the author is very grateful. In other similar studies however, it may be that data is unavailable dependent upon the willingness-to-participate of respective participants.

As such, the true value of fishing activity in the River Otter catchment cannot be identified fully accurately. From the information gained in this research however, it is reasonable to assume that the annual value could be at least a six-figure value, as well as the capital value held in fishing rights.

However, an understanding of the key economic areas has been obtained which provides a useful profile of the annual activity within the catchment. Through this information, it has been possible to understand particular economic variables, and indeed of how economics flow within this catchment each year. Figure 1 presented here is a flow diagram demonstrating the annual economic transfers identified in this work. Each arrow is representative of financial flow.

Figure 1. Flow diagram of the annual economic transfers identified within the River Otter catchment.



7. Reported Beaver-Related Incidents Related to Fishing

This section reports upon impacts of beavers which have been observed within the Otter catchment by respondents to the Syndicate/Fishery research and individual anglers. To preserve representative identities, all fisheries/syndicates are referred to here as a 'fishery'.

This section states only observed impacts. Further research into perceptions of the potential impacts of beaver reintroduction in the catchment in relation to fishing is ongoing in a Q-Methodological study (the results of which will be attached as an appendix to the *'River Otter Beaver Trial' Science & Evidence Report* following scientific peer review). Similarly, research into the ecological relationships between beavers and fish has taken place in the 'River Otter Beaver Trial' and elsewhere.

1) One fishery reported that there had been antagonistic behaviour and disturbance caused by people attempting to watch beavers on the riverbank. It was stated that numbers of visitors on the riverbank at any one time could exceed twenty people trying to watch beavers and that there had been incidents where members of the public had shouted at the anglers in the water. This includes one stated incident where an angler was reported to have been told by a member of the public to "stop fishing to protect the beavers". It was reported that the fishery had lost four paying members as a result, causing the fishery to have to replace them.

2) One fishery representative identified that two of the 'Beavers Live Here' signs (erected by the Wildlife Trust) had been damaged. One in particular had the line which asked members of the public to respect the rights of fishing in the river scratched out which the representative stated was "antagonistic behaviour towards the angling community" (see Figure 2). In response, the fishery estimated that approximately 40% of the beat had become unfishable due to the presence of beavers leading to 'beaver-watchers' disturbing their activity. This led to negotiation with the Estate which leases the fishing rights who reduced the rent in response by £200 in 2018.

Figure 2. The damaged sign on the River Otter.

3) The fishery which reported that it had had its area reduced by 40% in point 2 stated that this had led to the further decision to reduce the number of fish stocked in its reaches as, with reduced fishing availability, the representative reported that its members had questioned "is it worth it?".

4) A concern was expressed by a fishery representative who stated that "a number of 'beaver-watchers' have left litter on the riverbank".

5) A fishery representative reported that there had been some disturbance by 'beaver-watchers' in the evenings. However, they stated this had been limited and expressed their view that this impact would become less commonplace if beavers became more widespread as "currently they are a novelty".

6) One fishery representative stated that "impacts from the beavers had been limited as they are not really in our stretch."

7) One of the fishery representatives identified that there had been many signs of beaver activity within their beats, however they stated that there were no impacts of concern.

8) One of the fishery representatives reported that there had been some interest in the beavers amongst anglers in their stretch.

9) One of the fisheries stated that they had become used to beaver presence having known they were there since before the Trial began.

10) One angler expressed that a beaver-felled tree had obstructed the angler's ability to wade in the water: "This falling tree makes it difficult to wade up that stretch of river."

11) One angler stated that beavers are not necessarily effected by fishing following a sighting of one during a fishing experience: "I saw one before they were known about and there was no reaction from the beaver to my presence. (It would have been nice to have known that it was a beaver at the time though!)"

12) It was reported by one fishery representative that they had lost a member who felt intimidated by beavers and so moved to fish in another river catchment to avoid them.

13) One angler stated that they had seen a beaver whilst fishing in the water and that it had, in their view, "improved my [angler's] fishing experience".

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8. Beavers and Fishing Economics

Within the scope of the 'River Otter Beaver Trial' there have been limited observed relationships between beavers and fishing thus far, however research is ongoing into the potential impacts that there may be of reintroducing beavers upon fishing. This report has however been able to provide an indication of the potential mechanism by which beavers could impact upon the economic factors in recreational fishing, if there are any impacts to be observed, whether positive or negative.

> **Step 1**. Whether positively or negatively, it is most likely that the beavers would impact upon an individual anglers' fishing experience in the first instance, as has so far been the case in the impacts outlined in Section 7. These impacts could be direct, such as the felled tree in the river, or indirect, such as the presence of 'beaver-watchers' causing disturbance.

> **Step 2**. Should this then alter an anglers' fishing activity in either a positive or negative manner and lead to a change in their fishing activity, this could alter the financial contributions of the angler towards the other areas as described in Figure 1 (such as the *Environment Agency* [if they stop fishing altogether and no longer purchase a licence], fishing equipment/tackle shops, local businesses, holiday businesses and/or syndicate/club/fisheries [such by revoking membership, as reported to have occurred within one of the syndicates within the Otter catchment]. In the case of the latter, this would then by extension alter the economic contributions towards the fishing rights owners [as has once been reported in the Otter catchment], fish stocking businesses [also once reported in the Otter catchment] and/or insurance companies.)

As yet however, the potential impacts (if any) and the scale of those is uncertain. Further research into the perceptions held amongst anglers about the potential relationship between beavers, fishing and other factors in the River Otter catchment is ongoing, as is research into the ecological relationship between beavers and fishing.

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APPENDIX 1 – Ethical Statements

All respondents to this work were provided with the following statements in writing prior to making their contributions to this work.

- Taking part is entirely voluntary, and you may choose to withdraw at any time.
- Participation is anonymous and you will not be expected to provide any personal information. However if you choose to do so, this will be treated as confidential and not be used in a way that would allow for the identification of your individual participation.
- Should any data that you provide be identified as commercially sensitive by you, this will be treated as confidential and not shared elsewhere unless with your prior written permission.
- Data will be stored securely and anonymously at the University of Exeter and then, if appropriate, at the UK Data Archive, in order to make it available to other researchers in line with current data sharing practices. If data is not used, it will be held by the researcher for up to five years.
- This study is funded by the University of Exeter, Devon & Cornwall Wildlife Trusts and Plymouth City Council.

APPENDIX 2 – South West Licence Sales Data[2]

SOUTH WEST – SALMON & SEA TROUT LICENCE SALES ***(EA Fisheries Statistics Reports)***

Licence	Licence Duration	2010	2011	2012	2013	2014	2015	2016	Average
Concession (Disabled and Senior)	Full Annual	886	935	984	1049	1095	1130	1153	**1033**
Full Licence	1 Day Licence	870	911	817	661	588	728	671	**749**
Full Licence	8 Day Licence	211	199	215	209	179	192	186	**199**
Full Licence	Full Annual	1787	1786	1730	1581	1554	1468	1409	**1616**
Junior Concession	Full Annual	314	312	320	268	229	179	124	**249**
TOTAL		**4068**	**4143**	**4066**	**3768**	**3645**	**3697**	**3543**	**3847**

SOUTH WEST – BROWN TROUT & COARSE LICENCE SALES ***(EA Fisheries Statistics Reports)***

Licence	Licence Duration	2010	2011	2012	2013	2014	2015	2016	Average
Concession (Disabled and Senior)	Full Annual	12169	12555	12910	13626	14165	14892	15270	**13655**
Full Licence	1 Day Licence	30401	31658	25899	26903	27114	27706	27218	**28128**
Full Licence	8 Day Licence	3631	3878	3565	3496	3503	3591	3666	**3619**
Full Licence	Full Annual	46684	44930	40806	39604	39194	38960	37957	**41162**
Junior Concession	Full Annual	8019	7240	5758	5060	4367	3995	3426	**5409**
TOTAL		**100904**	**100261**	**88938**	**88689**	**88343**	**89144**	**87537**	**91974**

APPENDIX 3 – Salmon & Sea Trout Licence Returns Containing Effort Data on the River Otter[2]

YEAR	2010	2011	2012	2013	2014	2015	2016	2018
No. Returns with Effort Data[2]	32	37	24	22	23	26	31	22

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