Potential psychological benefits of nature enrichment through the reintroduction of the Eurasian beaver (*Castor fiber*) to Britain: A narrative literature review

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Abstract

Biodiversity is declining in the UK, which is considered one of the most nature-depleted parts of the world. The reestablishment of the Eurasian beaver (*Castor fiber*) has been posited as an effective means of facilitating a restoration of biodiversity in Britain, and following successful trials, nationwide reintroduction is being considered. This literature review considers the potential psychological benefits of such an initiative. Beavers could act as a 'super restorer', facilitating psychological as well as ecological restoration through a beneficial synergy of effects. Through their eco-engineering activities, beavers increase biodiversity at the landscape scale and facilitate habitat restoration and creation (creating a mosaic of green and blue space, and a sense of wilderness) all of which can increase the psychological well-being of visitors. Their creation of biodiverse natural settings offers the possibility of increased nature connectedness and nature-based psychological restoration amongst some of the human population of the UK. Beaver reintroduction may represent a partial antidote to 'shifting baseline syndrome' and beavers could act as a flagship species and become a totem of hope as eco-anxiety increases. Beavers can potentially have negative psychological impacts, and this will require appropriate planning, management and communication among stakeholders coupled with community-led initiatives to mitigate. Overall psychological benefits of beaver reintroduction likely exceed that of any other single species' reintroduction or conservation initiative of equivalent cost, and far outweigh the costs of their reintroduction and management.

Keywords: beavers, beaver reintroduction, biodiversity, nature connectedness, well-being

Introduction

Biodiversity is declining on both a global sale (Barnosky et al., 2011; Dirzo et al., 2014; IPBES, 2019) and in the UK (Hayhow et al., 2019), which is considered one of the most biodiversity-depleted parts of the world (Hayhow et al., 2016). Biodiversity has been defined as "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (United Nations 1992, p. 3). While much attention has been given to how biodiversity may contribute to human health through the provision of ecosystem services (Chivian & Bernstein, 2008; Mace et al., 2012; Marselle et al., 2021; Rook, 2013; Sala et al., 2009; Sandifer et al., 2015; Tilman, 2000), its effects on psychological health has received less attention. Biodiverse landscapes provide greater potential for 'nature connectedness' which has been defined as a "sustained awareness of the interrelatedness between one's self and the rest of nature" (Zylstra et al., 2014) or a sense of belonging to the wider natural world (Mayer & Frantz, 2004). One study estimated that globally, protected areas in nature benefit the mental health of visitors to a value of US $6 trillion per annum (Buckley et al., 2019).

At a time when eco-anxiety is increasing (Hickman, 2020; Pihkala, 2020), and 'shifting baseline syndrome' (a psychological phenomenon where generational amnesia results in people's perceptions of biodiversity loss being out of kilter with actual loss) promises inertia in the face of the degradation of our own habitat, the psychological impact of visiting areas in which biodiversity has been restored should not be overlooked. These places can offer hope that the erosion of our ecosystems can be reversed, with beavers having the ability to reverse the ecological degradation of landscapes affected by human activities through their eco-engineering ability, transforming land into a more 'wild' or 'natural' state at low cost (Law et al., 2017; Willby et al., 2018). While pro-conservation actions are likely to vary in terms of how much they influence visible biodiversity (Hamlin & Richardson, 2021), the reestablishment of keystone species such as the Eurasian beaver (*Castor fiber*) to the British landscape has been posited as having the potential of fostering a step change in the restoration of biodiversity (Willby et al., 2018). Keystone species such as the beaver (Janiszewski et al., 2014) have been defined as those possessing the ability to re-establish past ecological processes since altered or diminished by human activities (Crowley et al., 2017). For this reason, there are now beaver reintroductions taking place at a politically devolved level at differing stages in England, Scotland and Wales (Auster et al., 2020a; Gaywood, 2018), constituting the first reintroduction of an extinct British mammal species, a major conservation milestone (Gaywood, 2018).

While the potential environmental, ecological and hydrological benefits of beaver

reintroduction to Britain have received detailed scientific attention (for a comprehensive review, see Brazier et al., 2021), the potential psychological benefits that their presence may elicit has received less attention. Furthermore, ecopsychology has tended to focus on the human side of human-nature relationships, and a deeper, more comprehensive examination of the ecological aspects of this relationship is warranted (Sewall & Fleischne, 2019). This review examines the ecological engineering and biodiversity enhancing capacity of beavers, discussing the potential impacts this could have on levels of nature connectedness, psychological well-being and biodiversity education in the human population of the UK. Beaver reintroduction programmes have met with heated opposition from some landowners, and this review examines typical concerns about beaver induced damage, and offers some suggestions for mitigating these anxieties. This paper's focus on psychological impacts of beaver reintroduction to Britain is a necessary contribution to the current discourse, especially as emotions rather than scientific evidence hold greater influence in human-wildlife conflict decision-making (Hudenko, 2012).

Beavers as ecosystem engineers

Beavers were hunted to extinction in Britain approximately 400-600 years ago (Kitchener & Conroy, 1997; Manning et al., 2014). They create wetland habitats, by building dams on smaller rivers and streams (Hartman & Tornlov, 2006). They also fell trees, build lodges, and excavate channels linking water sources to each other (Gurnell, 1998; Law et al., 2017; Willby et al., 2018). These wetland habitats support many different species (Law et al., 2019; Willby et al., 2018). Beavers may act as 'super restorers', having the capacity to facilitate psychological as well as ecological restoration through their ability to enhance biodiversity and alter and enrich ecosystems at the landscape level. Reintroduction of beavers to the wider British landscape could offer a valuable mental health increase, amongst those who learn about such initiatives and visit the reintroduction sites, which dwarfs the costs of their management, and likely far exceeds the psychological benefits of any other single species reintroduction or conservation initiative.

Freshwater habitats harbour disproportionally high levels of biodiversity, supporting up to 12% of the world's animal species, despite covering 1% of the Earth's surface (Collen et al., 2014; Gleick, 1998). With British wetland habitats having suffered a substantial decline (Everard, 1997; Wood et al., 2003), there is a growing interest in the potential of beavers as agents of wetland creation and rewilding (Brazier et al., 2021; Law et al., 2017, 2019; Willby et al., 2018). Rewilding has been defined as a multi-faceted conservation approach that attempts to restore historical ecosystems and species (Corlett, 2016), or the fluid and unscripted renewal of ecosystem function or processes with the associated benefits this can yield (Law et al., 2017).

Beaver created wetland habitats are heterogeneous and structurally complex in nature (Brazier et al., 2021; Sommer et al., 2019; Stringer & Gaywood, 2016; Wright et al., 2002) which allows them to support rich biodiversity (Smith & Mather, 2013; Willby et al., 2018). Beaver wetland habitats are capable of supporting greater biodiversity than anything humans can replicate (Willby et al., 2018), significantly increasing abundance of wildlife, including of plants (Law et al., 2014, 2017; Willby et al., 2018), invertebrates (Bush & Wissinger, 2016; Stringer & Gaywood, 2016; Willby et al., 2018) fish (Kemp et al., 2012), amphibians (Dalbeck et al., 2007, 2020), in addition to birds and mammals (Nummi et al., 2019; Nummi & Holopainen, 2014; Stringer & Gaywood, 2016). Importantly, this increase in biodiversity occurs at the landscape level (Rosell et al., 2005; Sommer et al., 2019; Willby et al., 2018; Wright et al., 2002).

Biodiversity and Nature Connectedness

Declining biodiversity has important implications for our connection to nature, or sense of belonging to a wider community of nature. Nature connectedness has been described as a basic psychological human need (Baxter & Pelletier, 2019) and is strongly associated with psychological well-being, including greater vitality (Capaldi et al., 2014; Cervinka et al., 2012; Ryan & Frederick, 1997), life satisfaction (Mayer & Frantz, 2004), life meaning (Cervinka et al., 2012; Nisbet et al., 2011) and feelings of worthwhileness (Fretwell & Greig, 2019; Martin et al., 2020). It also associated with higher psychological functioning (Sobko et al., 2018), resilience (Ingulli & Lindbloom, 2013), higher levels of self-reported personal growth (Pritchard et al., 2020) and lower levels of anxiety (Capaldi et al., 2014; Martyn & Brymer, 2016; Zelenski & Nisbet, 2014). It has also been linked to greater happiness and positive affect (Capaldi et al., 2014; Fretwell & Greig, 2019; Mayer et al., 2009; Nisbet et al., 2011; Pritchard et al., 2020; Zelenski & Nisbet, 2014). Nature connectedness also acts as an important mediator for some of the benefits to mood and cognition yielded by spending time in natural settings, while also being associated with greater contact with nature, which has further additive benefits to well-being (for a review, see Gandy et al., 2020). In addition, it is a strong psychological predictor of environmental concern and pro-environmental behaviours (Mackay & Schmitt, 2019; Martin et al., 2020; Schultz et al., 2004; Whitburn et al., 2020; Zylstra et al., 2014), the latter having also been associated with psychological well-being (Corral-Verdugo et al., 2013; Kaida & Kaida, 2016; Netuveli & Watts, 2020; Prati et al., 2017).

A continued loss of biodiversity may be eroding the elements necessary to trigger and nurture nature connectedness (Thomashow, 1998), and have negative consequences for the human psyche (Kellert, 1997; Winter & Koger, 2004). One study found that the UK rated lowest for average nature connectedness out of 14

surveyed European nations (White et al., 2021). A diminished potential for everyday nature interactions and experiences, principally through reduced sensory contact with organisms inhabiting a shared physical space, has been referred to as an 'extinction of experience' (Cox et al., 2017a; Gaston & Soga, 2020; Pyle, 1993; Soga & Gaston, 2016). This has been posited as one of the core factors responsible for declining nature connectedness (Richardson et al., 2020), with diminishing contact with nature being fuelled by increasing urbanisation (Cox et al., 2017a; Cumming et al., 2014) and a loss of green space (Lin et al., 2015), with increasing numbers of people inhabiting nature-depleted environments (Fretwell & Greig, 2019; Soga & Gaston, 2016, 2020).

People with a strong sense of nature connectedness tend to seek out higher biodiversity (Shanahan et al., 2015) or environments of higher biophilic quality (Berto et al., 2018), but a reciprocal relationship applies, whereby encountering higher biodiversity or nature-rich environments may promote greater nature connectedness (Dornhoff et al., 2019; Hamlin & Richardson, 2021; Wyles et al., 2019). More biodiverse ecosystems may be more likely to provoke a sense of place attachment than more ecologically depleted or degraded settings (Horwitz et al., 2001), this being an aspect of nature connectedness (Zylstra, 2014). Higher ratings of nature connectedness are associated with greater and more holistic psychological benefits yielded by biodiversity (McGinlay et al., 2018), while enhancing the perceptual experiences and perceived restorative potential of natural landscapes (Tang et al., 2015).

Nature connectedness may be being eroded by shifting baseline syndrome, a psychological and sociological phenomenon whereby progressive environmental degradation and biodiversity loss at multiple scales over time results in accepted thresholds for environmental conditions being lowered successively over generations (Soga & Gaston, 2018). It constitutes a form of generational and personal environmental amnesia (Kahn, 2002; Papworth et al., 2009), where people's perceptions of change are out of kilter with actual changes occurring. Its consequences encompass an increase in societal tolerance to progressive environmental degradation; altered expectations about what is a desirable state of the environment worthy of protection; and policy makers setting inappropriate targets for environmental conservation, restoration and management. These in turn act as self-reinforcing feedback loops which further accelerate shifting baseline syndrome through progressive environmental degradation, making it a fundamental obstacle to addressing a wide range of global environmental issues (Soga & Gaston, 2018). While shifting baselines are predominantly discussed in a negative context, baselines can also be shifted positively; 'lifting baselines' (Roman et al., 2015). Several actions for halting or reversing negatively shifting baseline syndrome have been proposed which beaver reintroduction may help facilitate, including restoration of the

environment (including rewilding), reducing the extinction of experience, and education (Soga & Gaston, 2018). Species reintroduction has been posited as a potential means of reversing the extinction of experience, to help facilitate more contact with nature (Seddon & van Heezik, 2013) and natural areas of higher conservation value are more likely to promote engagement with the public (Miller, 2006). Boosting visible biodiversity (at least on a local level) through pro-nature conservation behaviours has been associated with enhanced nature connectedness, which itself is a predictor of such pro-nature behaviours (Hamlin & Richardson, 2021). This suggests that the feedback loops associated with shifting baseline syndrome are bidirectional, and enhancing landscape-level biodiversity may be an effective means of halting or reversing progressive negative shifting baseline syndrome and the environmental degradation and biodiversity loss associated with it.

A number of different pathways to enhance nature connectedness following contact with nature have been identified - these include contact (engagement with nature through the senses for pleasure) and appreciation of beauty (engagement with the aesthetic qualities of nature) (Lumber et al., 2017). A greater potential for immersive and sensorial (e.g. visual, auditory, olfactory) contact with nature, due to a greater diversity of form and colour (such as birds and flowers) of sound (including birdsong) and scents is more likely to occur in areas harbouring higher biodiversity and abundance of wildlife (Hamlin & Richardson, 2021). Such immersive interactions with natural elements have been described as the ultimate expression of biophilia (Kellert, 1997), and small humble habitats can be as important as larger protected areas in helping foster a sense of being fully and viscerally connected to the rest of life (Pyle, 2003). An appreciation for beauty and aesthetics in nature is also considered an important pathway to enhanced nature connectedness (Capaldi et al., 2017; Lumber et al., 2017; Richardson & McEwan, 2018; Zhang et al., 2014), with biodiversity having been linked to aesthetic value (Fischer & Young, 2007; Hoyle et al., 2017; Kiester, 1997; Lindemann-Matthies et al., 2010; Lindemann-Matthies & Marty, 2013; Novacek, 2008; Southon et al., 2017; Tribot et al., 2016). While unsustainable landscape change and simplification has been associated with a decline in nature connectedness (Riechers et al., 2020, 2021), more biodiverse landscapes of higher biophilic quality are likely to exhibit a richer sensorial tapestry, with important implications for nature connectedness amongst those who can access and have contact with such settings.

It is noteworthy that while a few studies have found socioeconomic factors to be significantly more important predictors of well-being than biodiversity (Huynen et al., 2004; Sieswerda et al., 2001), one study found a positive relationship between nature connectedness and well-being that was nearly four times larger than the increase in well-being associated with higher socioeconomic status (Martin et al., 2020). This suggests that the probable influence of biodiversity on levels of nature

connectedness should not be overlooked. Aside from the effects of biodiversity on nature connectedness, a number of studies have found one or more positive associations between biodiversity (whether actual or perceived) and mental health and well-being (Adjei & Agyei, 2015; Cameron et al., 2020; Carrus et al., 2015; de Jong et al., 2012; Fuller et al., 2007; Gonçalves et al., 2021; Grahn & Stigsdotter, 2010; Hepburn et al., 2021; Luck et al., 2011; Marselle et al., 2016; Mavoa et al., 2019; Methorst et al., 2021; Rantakokko et al., 2018; Scopelliti et al., 2012; Southon et al., 2018; Wheeler et al., 2015; White et al., 2017; Wolf et al., 2017; Wood et al., 2018; Young et al., 2020). However in some instances, levels of perceived biodiversity may be a stronger predictor of well-being than actual biodiversity encountered (Dallimer et al., 2012; Schebella et al., 2019). In addition to actual or perceived biodiversity, total abundance of wildlife may also confer benefits to well-being (Cox et al. 2017b; Nordh & Ostby, 2013).

Psychologically restorative potential of beaver engineered landscapes

As well as potentially providing a sense of belonging to the web of life, beaver engineered landscapes offer a variety of soothing and restorative qualities, which can boost mental health in other ways. When beavers are introduced to a landscape, they create a habitat that includes a patchwork of green and blue space, including water bodies (Law et al., 2019; Puttock et al., 2018; Willby et al., 2018), and open marshland and meadow habitat (Willby et al., 2018; Wright et al., 2002) (see Figures 1 & 2). Wetlands have been associated with psychological restoration, enhancing mood and well-being (Pedersen et al., 2019), and relaxation, mental and emotional well-being, and reductions in stress and anxiety (Maund et al., 2019). Natural settings such as these can act as health-buffering 'equigenic environments', those that can disrupt the usual conversion of socioeconomic inequality to health inequality (Mitchell et al., 2015). This is suggestive that allowing the creation of and facilitating access to such settings may help address some of the health costs associated with inequality, without necessarily addressing the root causes (Braubach et al., 2017; Drabo, 2011; Kabisch, 2019).

Figure 1. Beaver engineered habitat. Mill Dam, Dunkeld, Perthshire. Dr Roisin Campbell-Palmer.

Figure 2. Beaver engineered wetland. Knapdale Forest, Argyll. SCOTLAND: The Big Picture.

One study found that the biodiversity associated with wetland environments was one of the most highly valued qualities they provide among members of the public surveyed (Carlsson et al., 2003). Beaver meadows support diverse plant communities (Law et al., 2014, 2017; Willby et al., 2018), with plant biodiversity being associated with human well-being (Adjei & Agyei, 2015; Fuller et al., 2007; Young et al., 2020). Plant biodiversity in beaver meadows helps promote bird biodiversity (Chandler et al., 2009), and these areas may be an important habitat for grassland birds on a landscape scale (Askins et al., 2007), and they have been found to support higher levels of songbird diversity than other riparian habitats (Aznar & Desrochers, 2008). This is notable, as bird biodiversity within people's vicinity has been strongly associated with life satisfaction across Europe, and the effect of bird species richness on life satisfaction was of a similar magnitude to that of income (Methorst et al., 2021). Bird biodiversity has been associated with well-being (Fuller et al., 2007; Hepburn et al., 2021; Southon et al., 2018), life satisfaction (Luck et al., 2011) and positive affect (Cameron et al., 2020; Wolf et al., 2017). Beaver eco-engineering also

increases the prevalence of some insect species highly valued by humans such as dragonflies (Batty, 2015; Schloemer et al., 2012; Stringer et al., 2015) which are appreciated for their colourful visual appearance and high visibility (Lemelin, 2007; Ngiam et al., 2017). Sensory engagement with and actively *noticing* nature has a much stronger association with nature connectedness than passively observing it (Richardson et al., 2021), with there likely being more potential for such active engagement with wildlife in beaver-enriched wetland habitats.

Memorable wildlife encounters can promote states of stillness and mindful absorption that can promote a deep sense of well-being that can transcend the initial encounter, resulting in feelings of spiritual fulfilment and psychological health benefits (Curtin, 2009). In addition, time spent being immersed in natural settings observing animal behaviour has been associated with eliciting flow states (Csikszentmihalyi, 1990), peak experiences (DeMares & Krycka, 1998), and feelings of wonderment (Bulbeck, 2005). Observations of beavers and their activity where they have been introduced into the wild in England is commonly associated with positive emotional reactions, generating pleasing feelings of excitement, interest and happiness. This suggests that beaver presence could help enhance nature connectedness and the mental health benefits of engaging with nature (Auster et al., 2020b).

Necessity of increasing public access to biodiverse landscapes

The potential benefits of contact with nature for mental well-being has been referred to as a 'forgotten ecosystem service' (Summers & Vivian, 2018), and it remains heavily underutilised and undervalued as a mental health intervention (Bratman et al., 2019; Maller et al., 2006). Given that there is a notable lack of wilderness areas characterised by natural dynamics in Britain, there is diminished potential for the public to engage in so-called 'quality nature experiences' (Gamborg & Sandøe, 2004). Public access to restorative green and blue space is highly variable across the UK (Barbosa et al., 2007; Public Health England, 2020), and for the potential benefits of beaver-created habitats to be maximised, access to them will need to be actively encouraged and facilitated. In some cases, a level of human intervention may be required to ensure that wetland habitat is accessible to people (Pederson et al., 2019). This is important, as visits to natural spaces once or more a week have been associated with greater well-being and pro-environmental behaviours (Martin et al., 2020), and 120 minutes of recreational nature contact a week has been associated with self-reported health and well-being benefits (White et al., 2019). Changes to how subsidies will be awarded to landowners following the UK's departure from the EU may facilitate greater opportunities for biodiversity enhancement and nature contact, through Environmental Land Management Schemes (ELMS). A greater emphasis will be placed on the delivery of 'public goods' such as ecosystem service

provision and improving public access to the countryside (Stokstad, 2020), although these initiatives are yet to be implemented.

Access to nature has been found to buffer children against the impact of stressful life events with little evidence of a ceiling effect or a saturation point pertaining to the benefits of contact with natural settings (Wells & Evans, 2003). This suggests that more nature-enriched landscapes (encompassing higher diversity and abundance of wildlife), may harbour greater potential psychological benefits. Accessible beaver-engineered landscapes offer a host of activities for children and adults alike, affording opportunities for birdwatching and other forms of non-consumptive recreation (Thompson et al., 2021). Such activities have been linked to improvements in mood, cognition and well-being, and reductions in anxiety and depression symptoms (Lackey et al., 2019), in addition to greater nature connectedness and positive environmental attitudes (Cooper et al., 2015; Rosa et al., 2019; Wells & Lekies, 2006; Wolsko & Lindberg, 2013). People who enjoy wildlife may seek out encounters in wildlife-rich beaver habitat (Kretser et al., 2009), but much of the population who live in urban environments and have been impoverished of nature contact may be less aware of the benefits of visiting beaver wetlands. Initiatives, incentives and campaigns may be required to generate awareness of beaver wetland habitats and increasing access to them will be important in some cases.

Beavers as a flagship species

Aside from their biodiversity enhancing and habitat creation activities, beavers themselves may act as a 'poster child' species that can facilitate appreciation of nature. They have the potential to act as a focal or flagship species (Lorimer, 2007), otherwise defined as a social-ecological keystone species, by which appreciation for them and their activities may act as a vehicle for greater ecological literacy, and help engender pro-conservation attitudes and behaviours (Kronenberg et al., 2017; Skibins et al., 2013). Beavers may be perceived as being aesthetically appealing (Gamborg & Sandøe, 2004; Ulicsni et al., 2020), and are considered an iconic and charismatic species (Brazier et al., 2021), with one study of perceptions of beavers in Hungary and Romania reporting that their presence was widely enjoyed, despite them often being considered a nuisance (Ulicsni et al., 2020). They can habituate to boat traffic and humans over time, so providing opportunities to encounter them (Asbirk, 1998) and with appropriate management can co-exist with humans in areas of high population density (Halley & Rosell, 2002).

Beavers could become a totem for reversing shifting baseline syndrome, a symbol of our shared commitment to lifting baselines. The presence of wild free-living beavers on the River Otter in Devon has been associated with a sense of pride among many community members (Crowley et al., 2017) and this pride could spread if

reintroduction occurs at the national level, and information about it is widely disseminated.

Educational opportunities provided by beaver reintroduction

Research conducted so far suggests that in order to maximise the potential psychological benefits that may come through contact with biodiversity, it will be necessary to encourage an active interest in it (McGinlay et al., 2018) and improve people's biodiversity literacy (Cox & Gaston, 2015; Southon et al., 2018), which the presence of beavers may help facilitate (Auster et al., 2020b). Biodiversity literacy can be defined as one's knowledge and understanding of the concept of biodiversity, in addition to behaviours that contribute to its preservation (Moss et al., 2014). However it is important to acknowledge that there may be educational challenges when engaging with individuals with strong anti-beaver sentiments, although early stakeholder engagement prior to reintroduction may be helpful in minimising strong negative feelings (O'Rourke, 2014). Commencing educational programmes directed towards a range of relevant stakeholders in advance of any reintroduction and continuing them in the long-term post-reintroduction monitoring phase may help mitigate strong feelings of opposition (Serfass et al., 2003).

Beaver engineered habitats can be perceived as being 'messy' and 'untidy' (Ulicsni et al., 2020), and rewilding efforts may give rise to challenging aesthetic qualities, including landscapes perceived as unscenic and ugly (Prior & Brady, 2017). While ecologically healthy landscapes including wetlands may not be perceived as being attractive by everyone (Gobster et al., 2007), education on the ecological and environmental benefits associated with wilder landscapes and beaver-created habitats may help overcome this issue (Auster et al., 2021; Dramstad et al., 2006; Ulicsni et al., 2020). This could facilitate a more complex interpretation of such settings, incorporating values beyond neatness and aesthetics (Dramstad et al., 2006). Improving people's ecological knowledge could help people prioritise biodiversity over tidiness in a range of settings, including the current practice of mowing lawns and keeping gardens neat and tidy, instead of supporting wilder but more wildlife-rich spaces (Goddard et al., 2013; Qiu et al., 2013).

As a potential flagship species, beavers may act as a good animal ambassador for generating a wider interest in nature, particularly among children. Contact with nature in childhood appears to be a key predictor of nature connectedness in later life (Chawla, 2020; Fretwell & Greig, 2019; Rosa et al., 2018), so the importance of providing opportunities for engagement with nature during this period cannot be overstated (Dornhoff et al., 2019). Beaver reintroduction education could be of value as part of school programmes (Ulicsni et al., 2020). Declines in biodiversity have been linked to reduced opportunities for learning from nature (Scherson et al., 2018),

while greater biodiversity has been associated with greater learning opportunities among children (Beery & Jørgensen, 2018), and wilderness settings can provide ample educational opportunities (Miles, 1987). One study found that children tend to be more familiar with charismatic, appealing or exotic species than their local biodiversity, due to internet media content, indicating that environmental education should incorporate outdoor activities in local nature-based settings to develop children's connection to nature (Ballouard et al., 2011). Given that beavers are widely perceived as possessing these qualities, they may make an excellent candidate species for such environmental education programmes. A study evaluating participation in a programme of biodiversity-focused activities over the course of an academic year reported significant improvements in children's mood and well-being, while increasing feelings of nature connectedness over the duration of the programme (Harvey et al., 2020). One educational programme that fostered increases in nature connectedness among school children focused on water, and involved a direct multisensory nature encounter of a lake or stream and included identification of aquatic animals (Liefländer et al., 2012). A visit to a beaver wetland may provide an excellent basis for such a programme (Ulicsni et al., 2020) and large, conspicuous and colourful insects associated with beaver habitat such as dragonflies may make excellent subjects for nature-based educational programmes (Cannings, 2001).

Potential negative impacts of beaver reintroduction

Beavers may cause localised flooding through their damming and wetland creation. They also fell trees, and may consume crops, and cause bank and levee erosion, potentially resulting in loss of agricultural land (Brazier et al., 2021; Campbell-Palmer et al., 2016), and damage to fish farms (Kloskowski, 2011). People such as farmers (Crowley et al., 2017), and timber producers (Charnley et al., 2020) may have understandable concerns about the impacts of beaver reintroduction on their livelihoods. For such people, and their families and close communities, the idea of beaver reintroduction will likely bring negative psychological consequences such as anxiety and stress. In the US it has been observed that as beaver impacts increase, more intensive management of beavers, including dam removal and lethal control are increasingly favoured (Jonker et al., 2009; Morzillo & Needham, 2015; Siemer et al., 2013), likely stemming from growing anxieties over their impacts. The costs of beaver impacts tend to be borne by different people from those likely to benefit from beaver presence (Brazier et al., 2021; Gaywood, 2018). For UK beaver reintroduction to succeed, the fears and concerns of stakeholders will need to be understood, validated, compensated, and mitigated. An important issue is the sense of uncertainty associated with the longer term impacts of beaver reintroduction and their management, and this may generate anxiety and a 'fear of the unknown' (Auster et al., 2021). The dramatic impact of beaver eco-engineering may also have implications for people's sense of place (encompassing feelings of place attachment),

which may be impacted by ecological change (Horwitz et al., 2001), through their creation of a landscape that may be deemed unfamiliar or messy.

Importance of management strategies

There is the potential for conflict between different individuals with varying interests as a result of beaver reintroduction (Crowley et al., 2017). Communication between groups advocating and responsible for beaver reintroduction with landowners and local people likely to encounter them and their impacts is important to promote coexistence between humans and beavers (Auster et al., 2020a, 2021; Morzillo & Needham, 2015; Ulicsni et al., 2020). It is imperative that any reintroduction strategy be well planned, with different phases of consultation before reintroduction occurs. Several themes have been identified which may assist in engaging with those affected by beaver reintroduction conflicts. These include proactive engagement and a fast response time; appropriate communication; shared decision making; the need for certainty pertaining to the projected impacts of a reintroduced species and its associated management long-term; and the need for reintroduction managers to provide assurances and a sense of responsibility that those affected by beaver presence will be supported. This has played an important role in Bavaria where beavers were reintroduced half a century ago (Schwab & Schmidbauer, 2003), with farmers feeling that they are able to tolerate the beavers knowing there are people willing to help them manage their presence when necessary. In addition, the active facilitation of the normalisation of a reintroduced species as native and 'wild' is likely to be beneficial (Auster et al., 2021).

The importance of a well-planned management strategy is highlighted by the reintroduction of beavers to Scotland, where one resident population in Knapdale, Argyll resulted from a well-planned and science-led reintroduction, whereas another larger, expanding population in Tayside, Perthshire on intensively managed agricultural land resulted from accidental and/or illegal releases. The latter has resulted in major consequences to the debate around beaver reintroduction at the national scale. Level of conflict was found to be dependent on factors such as the reintroduction process, relationships between stakeholders and their perception of the wider landscape and their role in it, in addition to perceived issues of a lack of control and certainty around the reintroductions. To better mitigate these social conflicts around reintroduction, engagement with all actual and potential stakeholders in discussions on the long-term conservation plans at the landscape level is important in order to formulate an agreed-upon approach (Coz & Young, 2020).

Physical management strategies

Implementation of direct mitigation measures such as installation of wire tree guards or applying sand or latex-based paint to the bases of trees, or installation of flow devices into beaver dams, relocation of problem beavers and application of buffer strips around waterways can all significantly reduce the potential for human-beaver conflicts (Auster et al., 2020a; Campbell-Palmer et al., 2016; Schwab & Schmidbauer, 2003), with 95% of these conflicts occurring within 20 m from water (Schwab et al., 2014). Local interested community members could be recruited to implement some of these measures in a voluntary capacity.

One important avenue for mitigating the physical damage to land is through indirect measures such as financial compensation to those negatively affected, and payment of landowners hosting beavers on their land may also help reduce negative perceptions of them among those more heavily impacted by their presence (Campbell-Palmer et al., 2016). It is important that the costs and benefits of beaver presence are collectively shared, and that people bearing the brunt of beaver impacts are supported and compensated as and when necessary (Auster et al., 2021).

Emotional management strategies

In this review we have suggested three key ways in which beaver reintroduction could support positive psychological shifts for those who engage with these projects. These are the increased potential for nature connectedness and the sense of being part of a larger community of nature; opportunities for restorative and soothing visits to wetland areas; and the sense of hope and pride that can come from learning about beavers' radical biodiversity-increasing capacity which could contribute to a partial reversal of negatively shifting baseline syndrome. However, as noted by Brazier et al., 2021 and Gaywood, 2018, these benefits are likely to be experienced by different people from those likely to bear the costs of beaver presence. There is the potential for conflicts to arise between two polarised groups: landowners who suffer from beaver impacts and feel they do not benefit, and others who just benefit and do not suffer any negative impacts. Therefore, ahead of the implementation of beaver reintroduction plans at local sites, there will need to be some preparatory work at the community level, so that education and information can be effectively disseminated. This may serve to enhance community cohesion and promote understanding between the various stakeholders involved to help facilitate a positive community response to beavers' return. It should be noted that it is likely impossible to generate positive responses among all community members however.

Suggestions for community interventions ahead of beaver reintroductions

A project that could perhaps act as an example of the kind of community education approach that might be useful is the Frome community connector project, a scheme where hundreds of community members have been trained to signpost health and well-being services to other community members (Limb, 2020). In the same way that people in the Frome locality were trained as community health connectors, people in localities selected for beaver introduction could be trained as biodiversity connectors. This training could also include basic education about the potential benefits and drawbacks of beavers in that specific locality, and the psychological benefits of engaging with beaver reintroduction. They could also provide information to farmers and landowners about physical management strategies, link them up to community volunteers able to assist with those activities such as installing tree guards, and provide information about accessing financial compensation schemes. It would also be important to provide a means for farmers and landowners who have experience of managing land at scale to express their own opinions and share their knowledge with others. Facilitating open communication between all stakeholders so no groups or individuals are marginalised will be vital for building trust. For conversations with local residents, and local schools, the biodiversity connectors could offer short presentations about the psychological benefits of engaging with the beavers and provide information about how to access the wetlands when they are created, and set up projects centred on boosting nature connectedness and biodiversity awareness in the community. Like hugely popular Extinction Rebellion community groups, there is rich potential for the establishment of local groups to cater to those who are interested in these topics to meet regularly to socialise, share information and engage in many activities likely to help ensure the success of beaver reintroduction. However, for species reintroduction initiatives to be successful, it is important that such information be balanced, and consider the needs of those more vulnerable to negative impacts, as message framing in an overly positive fashion may lead to organised opposition (Niemiec et al., 2020).

Given that the UK has the lowest tree cover in Europe (FAO, 2020), in some areas riparian tree planting may be necessary prior to the arrival of beavers (Nolet & Rosell, 1998). Engaging in such nature conservation activities can promote contact with nature and social interaction (Currie et al., 2016), and if led by local community groups, could enhance community cohesion, with increased acknowledgement and engagement with nature associated with prosocial attitudes and enhanced connectedness in a broad sense (Passmore & Holder, 2017).

Suggestions for community interventions following beaver reintroductions

In much of the UK, interested community members take on voluntary roles as river wardens through their local River Trusts (Parry et al., 2017), monitoring stretches of waterway for any changes or issues that may occur, with a reporting and support system in place to allow any issues that may arise to be dealt with promptly. In Bavaria, state-employed beaver managers oversee a trained team of voluntary beaver wardens, who serve a similar function to the river wardens, rapidly responding to any concerns raised, working with the affected parties to ensure the necessary action is taken (Campbell-Palmer et al., 2016, p. 112). Should beavers be introduced more widely into the British landscape, interested community members could potentially be recruited and trained as beaver wardens. The beaver wardens could be the same people as the biodiversity connectors, or these could be conceptualised as two distinct roles.

Post reintroduction, the beaver wardens might be able to offer individualised support to affected parties, for example if physical management strategies proved insufficient. Having a named, known, easily accessible person to talk to if and when problems emerge may soothe anxieties and prevent the need for an escalation of concern to the point that intensive management and dam or beaver removal are considered. Given the importance of emotions in dictating the outcome of human-wildlife conflicts (Hudenko, 2012), it may be helpful if these wardens are trained in sitting with and validating negative emotions, and non-violent communication skills would likely be very useful. The biodiversity connectors and beaver wardens could hold local meetings for those with concerns to attend and have their frustrations heard and validated, and solutions suggested. These are just a few suggestions that may be helpful in facilitating successful reintroduction initiatives, and there may be a variety of other potential options which are likely to vary with context. Further research is warranted to explore the effectiveness of communication, engagement and community-led interventions in species reintroduction initiatives.

Potential future directions

With a change in how subsidies are awarded to landowners following the UK's departure from the EU, with access to nature and provision of ecosystem services prioritised (Stokstad, 2020), there is the potential to develop an interconnected corridor of beaver inhabited waterways and wetlands throughout the British landscape. If buffer strips were implemented around these waterways, it would serve to markedly reduce human-beaver conflicts, benefit biodiversity and provide the space and opportunity for people to benefit from these environments, potentially through a network of public footpaths. Given the vast economic benefits associated

with visits to protected areas through their positive effects on mental health (Buckley et al., 2019), creating more opportunities for people to access and connect with nature in the UK in this manner could have significant societal benefits. Research could evaluate the potential of beaver-engineered habitats for fostering nature connectedness and well-being, opportunities for education and ecotherapy and for enhancing community cohesion, and qualitative research could shed light on some of the underlying mechanisms.

Conclusion

Through their unrivalled ability to restore ecologically degraded land and create rich wetland environments and enhance biodiversity at the landscape-level, beaver eco-engineering is likely to provide potential for enhancing nature connectedness while offering access to psychologically restorative landscapes to people. Through these combined positive impacts and the sense of hope, pride and potential for reversing shifting baseline syndrome beaver presence may yield in times of growing eco-anxiety, beavers may indeed be considered a 'super restorer'. While beaver reintroduction may be associated with negative psychological impacts, if reintroduction efforts are well-planned with a viable management strategy in place, clear communication and support provided to all involved stakeholders, and positive, socially connective community-led initiatives applied, potential issues that may arise are far from insurmountable. By embracing the complexity of beaver reintroduction, and the diversity of opinions it may trigger, we have an opportunity to practice the skill of connectedness: increasing connectedness amongst our communities, and fostering connectedness to our local natural ecosystems, with important implications for psychological well-being. In the words of Theodore Roszak, one of the founding fathers of the field of ecopsychology: "if the self is expanded to include the natural world, behaviour leading to destruction of the world will be experienced as self-destruction" (Roszak et al., 1995, p. 12). If this holds true, then surely the inverse applies: by restoring the planet's ecosystems of which all beings are a part, by extension we restore the well-being of ourselves.

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