5. Evidence base

"The current upland landscape of Wales is largely unnatural, with a reduced biodiversity essentially due to a long history of agricultural management…Large scale changes in management are needed to prevent further loss and decline, extend the coverage of these valued habitats onto some of the heavily grazed acid grasslands and to restore the condition of the remaining sites." Jones 2007

The landscape and seascape within the Summit to Sea project area is a mosaic of differing habitat types from dune systems to plantation forests, from wet woodlands to improved pasture. However, all have been modified and adapted by historic human management that has left them fragmented and impoverished. Large areas of grassland have been "improved" and are heavily grazed by sheep, whilst vast tracts of upland heath and blanket bog were planted up in the 20th century with almost single species conifer plantations. On the marine side, Natural Resources Wales' condition assessment of the Pen Llyn y Sarnau marine Special Area of Conservation shows that more than 50% of the designated features within the SAC are in an "unfavourable" condition (Natural Resources Wales 2018).

The project proposes to unite the disparate elements of this endangered landscape in order to create a more unified, connected vision for restoration across the project area that will allow habitats to restore and species to disperse. This will be driven by natural processes and the creation of larger landscape units than currently exist to allow these processes to evolve at scale. The project will make use of tried and tested interventions to enable ecological processes to return to the land and sea, such as increasing habitat connectivity, peat-bog restoration, changing grazing patterns, alternative silvicultural systems and initiating a community-led marine protected area. The synergy of separate actions taking place at scale has the potential to initiate a gradual process of change that can restore resilience and dynamism to the habitats and communities of Mid Wales.

The context for the actions and interventions proposed by Summit to Sea is the decline in Wales' biodiversity and the impoverishment of ecosystems due to the accretion of impacts from historic landscape management practices. This context is established by the stark data presented in the State of Nature Wales report (2016), which states that Wales has a Biodiversity Intactness Index (BII) of 82.8% placing the country 49th from bottom in a group of 218 countries surveyed. There is a suggestion that BII values of less than 90% indicate that "ecosystems may have fallen below the point at which they can reliably meet society's needs."

"90% of lowland grassland has been "improved" since the 1930s resulting in the loss of the specialist wildlife that semi-natural grasslands support." State of Nature Wales report (2016).

"Between the 1940s and late 1980s, 44% of upland heathland (including dry heath and wet heath) was lost, mainly as a result of agricultural "improvement" and afforestation, predominantly with Sitka spruce and larch." State of Nature Wales report (2016).

The project and its proposed suite of interventions can also be situated in the international context of commitments that have been made to halt the loss of biodiversity world-wide and to restore the planet's degraded ecosystems.

"At the September 2014 United Nations Climate Summit…parties committed to restore a staggering 350 million hectares by 2030. The ambition affirms restoration's growing importance in environmental policy. These new commitments follow the 2010 Aichi Convention on Biological Diversity (to restore at least 15% of degraded ecosystems globally) and the 2011

Bonn Challenge (to restore 150 million hectares). Particularly when accompanied by policies to reduce further losses …restoration of such magnitude holds promise to address global environmental concerns." (Suding et al 2015).

Interventions: Reinstating ecological processes; Improving habitat connectivity; Changing grazing patterns; Peat bog restoration; Hydrological restoration; Woodland restoration; Irregular forestry (CCF); Species reintroduction.

Reinstating ecological processes

One of the main interventions underpinning the project is the reinstatement of dynamic physical and biological processes within degraded habitats. Many current land management practices perpetuate a pressure upon habitats which prevents ecological succession from taking place. For example, domination by a species monoculture weakens the action of ecological processes initiated by varied light levels, wind dynamics or hydrology. Improved grassland swards sown with a narrow range of species are clipped short by sheep grazing, and reseeded every few years preventing the process of more diverse species establishing or ecological succession from taking place. The pressure of grazing animals also compacts the soil and combines with the reduced root matrix to increase the downstream impacts of rain water run-off. Dense, un-thinned plantation forests prevent light getting to the forest floor, maintaining a barren needle litter below the canopy and not much else, although there can be some temporary biodiversity gains of early succession and scrub habitat species in the first years following clear felling.

The examples of over-grazed pasture and dense conifer plantation establish opposite ends of a spectrum of proposed restoration management. On one end is a reduction of management, the removal or reduction of grazing pressure and on the other is an increase in management needed to restructure and bring complexity to neglected (or unthinned) plantation habitats. The changes called for by the Summit to Sea project will be instigated through a mixture of reduced and increased management depending on the current land use, the potential for habitat restoration and the adjacency to more intact habitats within the landscape. The diagram on the right shows the degrees of intervention of different approaches to passive or active rewilding. It is expected that the Summit to Sea project will involve mixtures of interventions 3 and 4. All interventions are designed to allow ecological processes to re-establish in places where they have been impoverished or highly modified. Natural regeneration of seed banks currently suppressed by grazing or shading will be released by removal of grazing pressure, increased light and reinstated hydrological functions.

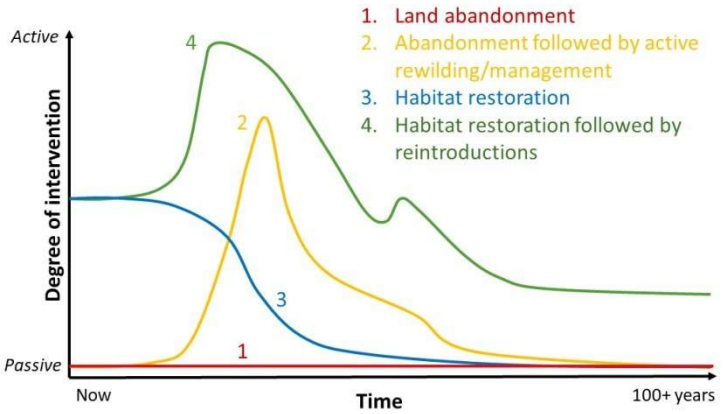

FIGURE SEQ FIGURE * ARABIC 1: DEGREES OF INTERVENTION OVER TIME IN 4 DIFFERENT MODELS OF REWILDING (FROM CARVER 2018 IN PETTEROLLI)

"Restoration consists of removing or modifying a specific disturbance, thereby allowing ecological processes to bring about an independent recovery" (Society for Ecological Restoration 2004).

"Ecosystems that are structurally and functionally diverse are more likely to be durable and capable of adapting to future challenges of climate change, introduced species, and land-use change and they can be sustained with a declining investment of human and financial capital over time. Involving people through multiple avenues—from participation to consumption of ecosystem services to cultural renewal—can promote public engagement and stewardship of local ecosystems." (Suding et al 2015).

"Assuming that high quality wilderness is a good proxy for the future of areas undergoing rewilding, our results suggest that rewilding efforts throughout Europe will enhance the capacity of ecosystems to supply regulating and cultural ecosystem services, such as carbon sequestration and recreation." (Pereira & Navarro 2015).

"Rewilding pursues the goal of restoring wild species interactions and their regulation of key ecosystem processes including nutrient and energy flows, vegetation succession and disturbances, drawing specific attention to the key roles of large-bodied species that are especially sensitive to the human appropriation of landscapes." (Fernández et al 2017)

Improving Habitat connectivity

There is evidence in the literature to show that the restoration of a resilient ecological infrastructure can only be meaningful on a large scale (Ockendon 2018, Adams 2016, Torres et al 2017). Fragmented, isolated habitats may be managed for a suite of particular species but these sites remain islands with little opportunity for species movement or gene flow. The Summit to Sea project area encompasses a number of sites and reserves that are owned and managed by environmental organisations committed to the project. National nature reserves, Sites of Special Scientific Interest, Special Areas of Conservation and ancient semi-natural woodlands are well represented from the upland elevation of the project area down through the lowlands and out to sea. However, these sites are currently isolated in the landscape, pockets of relative biodiversity within a matrix of agricultural land, forestry and infrastructure. Opportunities exist for connecting these sites up, strengthening the corridors and connecting habitats to create a larger area managed under the collective vision of the Summit to Sea partners. In some areas, sites only need small tracts of land to come into the project (via acquisition or owner buy-in) to create the connectivity. A focus of the project will be the unification such parcels of land to create larger tracts within which natural processes will be reinstated, driving a process of renewal and resilience building. Increasing habitat connectivity and landscape permeability to allow greater species movement is a well-researched and documented strategy for mitigating biodiversity loss and landscape fragmentation. What will emerge from the project area is a network of connected sites that will allow for species movement at different spatial scales.

"The growing research effort investigating larger-scale ecological processes and connectivity (such as the needs of migratory species, the impacts of climate change on species' ranges, and the need to restore ecosystem function) is increasingly focusing attention on large or landscape-scale conservation and restoration." (N Ockendon et al 2018)

"It is increasingly recognized that ecological restoration demands conservation action beyond the borders of existing protected areas. This requires the coordination of land uses and management over a larger area, usually with a range of partners, which presents novel institutional challenges for conservation planners." (Adams et al 2016)

"Protected area networks, and other sites of key importance to biodiversity (such as BirdLife International's Important Bird Areas; BirdLife International 2004), can be viewed as very large islands in a mixed matrix. Even at such large spatial scales, improving the matrix can have demonstrable effects. For example, a study of large predatory mammals in North American

parks concluded that if matrix quality were to decline, the area of the parks would need to increase greatly if populations were to persist (Carroll et al. 2004)."

"Perhaps the most profound effect of climate change will be a redistribution of species' ranges as they track moving climate envelopes; such changes have already been observed and appear to follow patterns predicted by climate envelope models (Walther, Berger & Sykes 2005)"

Changing grazing patterns

One of the most significant anthropogenic impacts on the land within the project area it's long historical use for animal husbandry. This usage goes back hundreds of years. However, the over-grazing of the uplands has only reached a critical point over the last 50 years as policy instruments, such as the Common Agricultural Policy, drove farmers to farm in a manner which prioritised productivity over environmental stewardship. In the late 20th century, agricultural payments based on headage count drove stocking numbers up and severely affected the fragile plant communities of upland habitats. Stock levels have reduced significantly since headage payments ceased but are still high enough to severely restrict biodiversity and vegetation structure. Reducing the intensity of grazing as well as adapting the seasonality and the stock types are all tried and tested methods of instigating restoration of degraded, over-grazed habitats.

Removal of stock might be needed for certain habitats to begin to restore before applying a new grazing pattern. After a fallow period, hardy cattle and pony breeds can be introduced in low numbers. The more selective feeding habitats of these herbivores will allow the structural and species diversity of grassland and heathland to return. This form of "pulse grazing," needs careful management and observation in order that the stock remain on the land for the correct amount of time before being moved elsewhere.

"The removal of grazing stock appears to have had the greatest effect on this area, enabling those species that expand by vegetative growth (common cottongrasses and crowberry) to show small increases in cover." (Anderson 2011)

"Livestock grazing management, not banishment, should be considered a vital tool for restoration of degraded grazing lands, which have a historical trajectory of evolution with the presence of large herbivores. Degraded grazing lands that resulted from inappropriate grazing activities can be restored by grazing management when grazing activities have not irreversibly damaged their physical environment." (Papanastasis 2009)

"We propose an unequivocally process-oriented formulation of the "rewilding hypothesis" as a general guidance: that the large-scale restoration of apex consumers and large herbivores promotes self-regulation in community assemblages, and increases the complexity of ecological processes in ecosystems." (Fernández et al 2017)

Peat bog restoration

"The degradation of pristine peatland ecosystems causes a significant threat to the international goal of achieving a significant reduction in the current rate of biodiversity loss at the global, regional, and national levels." (SCBD 2006)

A large area of the upland elevation of the Summit to Sea project is blanket bog. Where this is degraded due to agricultural usage or plantation forest establishment there will be interventions to restore the habitat to its former bog status and reinstate or improve its hydrological functions. Where active peat bog status can be achieved, the raising of peat land water tables will be achieved through blocking of drainage channels. Where peat land is degraded to such an extent that restoration is impossible, other options will be explored such as the creation of bog woodland, a priority EU habitat.

Evidence to support the interventions described above comes from the academic literature (Aapala et al. 2008; Bradshaw 1990; Dobson et al. 1997; Haapalehto et al 2011; Vanha-Majamaa et al. 2007) and also a number of projects where restoration of degraded peat land has been carried out successfully across the UK and elsewhere in Europe. In upland England, The Sustainable catchment Management Programme (SCaMP, Anderson 2011) used measures such as "gully blocking and bare peat stabilisation with geojute and/or heather brash and/or a 'nurse crop' (fast germinating grass) seed application with lime and fertiliser" in order to successfully stabilise and rewet damaged blanket bog.

The Summit to Sea project area also includes areas of lowland raised bog managed by project partners. The project includes interventions to restore all peatland habitats especially the complex of lowland raised bogs across the Dyfi valley so that the iconic Cors Fochno raised bog is set within the restored landscape of smaller satellite bogs (see also Hydrological Restoration below).

> *"The restoration of peatlands drained for forestry is implemented by damming or filling in the ditches with peat and the removal of trees grown after drainage. The aim of these actions is to initiate a process that will restore functional peatland ecosystems that can maintain viable populations of species characteristic to these habitats." (Haapalehto et al 2011)*

> *"A range of techniques may be used to raise the water table in peatlands e.g. blocking drainage ditches or gullies (using peat, rocks, plastic dams or wooden dams), planting flood-resistant vegetation in ditches to slow water flow, blocking underground channels or peat pipes, building raised embankments or berms (elongated mounds of peat or rows of straw bales) to retain water, inserting dams (e.g. straw bales) below the peat surface to slow subsurface drainage, switching off drainage pumps, or restoring inflows." (Taylor et al 2018).*

> *"Our results show that actively filling in and blocking ditches with peat is a useful measure to induce changes in water-table, peat elemental concentrations, and vegetation toward pristine target ecosystems." (Haapalehto et al 2011)*

> *"There was an indication that the water table under the re-vegetated ground was higher with reduced levels of perturbation after the restoration measures were applied than before, although the elevation in water table is not enough to secure active blanket bog yet." (Anderson 2011)*

> *"Although still low in terms of the water table requirements for good condition blanket bog, any increased wetness of the peat should positively affect the future development of the bog vegetation and ultimately increase medium-term resilience to drought and climate change. The recent gully blocking work appears to be having a positive effect in stabilising the peat surface and further reducing sediment delivery to streamflow." (Anderson 2011)*

Hydrological restoration

The UK's largest and most intact estuarine raised mire is included in the Cors Fochno Special Area of Conservation. The bog is under currently under restoration management to reverse and prevent drying out to point at which natural processes will be reinitiated.

Natural Resources Wales anticipates a significant step change in its 40+ year programme to restore the 650ha Cors Fochno raised bog. This is funded by a £4 million grant from the EU LIFE programme. The work will involve hydrological restoration, invasive species control and dissemination activities. A key focus will be restoration of the marginal or 'lagg' habitats around the edge of the raised bog leading to a more natural transition from the raised bog to surrounding land and allowing the raised bog to be more sustainable in the long term.

Much of the coastal land is below current sea levels as a result of historical drainage leading to peat shrinkage. This combined with increased storminess and sea level rise requires land to be protected

by a system of flood banks and leats. NRW's review of flood risk management in 2018 will create opportunities to fund potential managed retreat opportunities.

A key hydrological intervention is to rewild the Leri sub-catchment of the Dyfi through removal of Victorian woollen mill weirs to allow fish passage to the upper Leri, removal of invasive non-native species, restoration of peatland habitats in the upper catchment and the restoration of riparian ancient woodland. The Leri catchment has recently been responsible for devastating fluvial flooding of communities and is the best catchment to demonstrate the potential for natural flood risk management in the area.

Another hydrological intervention planned within the longer term project (subject to detailed feasibility studies) will be to allow the coastal habitats to adapt to climate change providing space for them to retreat alongside some managed realignment of the estuary with new habitats created to replace those lost to sea level rise.

> *"The enhancement, restoration or rewilding of European floodplains has huge potential for increasing biodiversity across Europe, and is probably the most cost-effective way of conserving iconic and key-stone species. But as pointed out by Schindler et al. (2016) it is also often the most challenging due to the multiplicity of organisations with interests and roles in floodplain governance and management." (Brown et al 2018).*

> *"There are many other birds that can benefit from rewilding of floodplains, including; waterfowl and waders, river corridor birds and birds of prey, and in several European countries this may be the key objective in restoration or rewilding schemes." (Brown et al 2018).*

> *"Whilst alteration of flow, sediment, organic matter and thermal regimes interact to reduce biological diversity and the ecological integrity of freshwater ecosystems – and thereby degrade the properties and ecological services most valued by humans – 'environmental flows' left in rivers, or restored to developed rivers, will sustain many ecological and societal values. The success of river protection and rehabilitation / restoration depends upon understanding and accurately modelling relationships between hydrological patterns, fluvial disturbance and ecological responses in rivers and flood- plains." (Arthington et al 2010).*

Woodland restoration (PAWS restoration and native woodland expansion)

The Summit to Sea landscape contains a good distribution of ancient woodland particularly along the steep-sided river valleys that run east-west, connecting the upland elevations with the coastal transition zone along the Avon Dyfi. However, many of these woodlands are categorised as plantations on ancient woodland sites or PAWS, meaning that the semi-natural broadleaf canopy cover has been removed and the site planted with a monoculture of non-native conifers. Many of these woodlands are neglected and have suffered from a lack of management interventions over the years. Alongside the neglect, landscape isolation and browsing pressure from stock ingress synergise to create very fragile woodland habitats in need of urgent restoration intervention. It has been demonstrated that a gradual approach to this process safeguards the remnant features many of the sites still retain from the pre-plantation semi-natural habitat (Brown et al 2015).

The Woodland Trust has been working to survey the PAW sites within the Summit to Sea project area and wider afield as part of the Ancient Woodland Restoration project. WT advocates the use of continuous cover forestry principles in the restoration of ancient woodlands and the transformation of the forest to an irregular structure. Gradual thinning of the conifer canopy retains woodland ecological conditions whilst allowing light levels to increase slowly, initiating natural regeneration of site native broadleaves, safe guarding ground flora hotspots and ensuring the survival of remnant broadleaf standards. Transformation to an irregular structure increases age class and species

complexity within stands, building wind firmness over time and strengthening the resilience of woodland habitats.

Restoration of the PAWS within the Summit to Sea landscape will prevent the loss of these vital woodland habitats and associated species. Combined with the establishment of new native woodlands through afforestation or natural regeneration, restoration will enable a network of woodland habitat to connect through the project area, establishing greater habitat permeability.

> *"…taken as a whole our results suggest that as woodland specialists and Ancient Woodland Indicator (AWI) plants are found in PAWS, and these are a conservation priority, at the very least an important part of the ancient woodland flora community would be better served by a restoration approach that is focused less on conifer removal and more on the moderation of light and shade levels. This is an important finding for PAWS management, because it supports the case for gradual restoration as a default approach for those stands that have remnant populations of woodland specialist species." (Brown et al 2015)*

> *"The biodiversity value of production forests is substantially lower than that of natural forests. This is related to differences in hydrology, stand age and amounts of old trees and deadwood. Using a predictive model framework we show that restoring hydrology and old-growth characteristics in a forest formerly managed for timber extraction results in changes to forest composition and structure, ultimately increasing its biodiversity value." (Mazziotta et al 2016)*

Irregular forestry (Continuous cover forestry - CCF)

The economic models underpinning much of the upland forestry within the project area use the clearfell and restock management system, whereby stands of conifer are felled in entirety when they have reached the end of a rotation period based on the growing vigour of the stock and the capacity of the site. Forest sites are then restocked and left to mature, often with little or no thinning, for a subsequent rotation period. This model is used on much of the public forest estate and also by the large forest agencies operating in the area. This economic model does create a return and feeds the soft wood supply chain for low grade timber products such as fence posts and paper pulp. However, the clearfell/restock model often relies on single age, single species stands of non-native conifers. Continuous Cover Forestry (CCF) is a system of management which aims at creating complex, irregular forest structures and retaining forest conditions on a site for perpetuity. It can be contrasted with the clearfell system, through which all the above ground biomass is removed in one operation at the end of a rotation period and the site is then restocked with new trees. The continuity of forest structure under CCF has a number of benefits, namely: increased resilience through age class and species diversity, reduction in compaction of forest soils, reliance on natural regeneration rather than costly restocking and gradual improvement of onsite tree genetics, and increased biodiversity.

Gradually increasing irregularity and structural complexity in forest stands in the project area will have a number of benefits. It will create more habitat niches for a greater number of species by breaking up the simplicity of monoculture plantation stands. It will allow space for the regeneration of native broadleaf species within single species conifer stands. It will protect forest soils by reducing their exposure through clearfell operations. It will also allow for management towards old growth features which in the long term will benefit woodland specialist species. Lastly, it will allow for the establishment of long wooded habitat corridors if adopted on a large scale across continuous forest blocks.

> *"Improving the sustainability of forests has become a key feature of international forest policy. One direction that this has taken is through the transformation of predominately even-aged stands into uneven-aged, mixed-species structures. Maintaining structural diversity at the level of the stand is seen as highly advantageous through the delivery of a wide range of*

management objectives including enhancing biodiversity (O'Hara, 1998) and increasing resilience to potential climate change." (Cameron and Prentice 2016)

"Because CCF provides a cost-efficient option to manage forests for multiple purposes it could be applied in multi-use landscapes. Moreover, because CCF has the potential to maintain habitat connectivity (Pukkala et al., 2012) and may better provide corridors and stepping stones for species living in protected areas, it may well promote species persistence in managed landscapes if augmented with adequate levels of set-asides…Our results indicate that continuous cover forestry has greater potential than rotation forest management to maintain multifunctional forests." (Peura et al 2018)

"Increasing forest harvest level to the maximum economically sustainable harvest had a negative effect on the habitat suitability index, bilberry yield, deadwood diversity and carbon storage. It resulted in a loss in variation among landscapes in their conservation capacity and the ability to provide ecosystem services. Multi-objective optimization results showed that combining different forest management regimes alleviated the negative effects of increasing harvest levels to biodiversity and non-wood ecosystem services. The results indicate that careful landscape level forest management planning is crucial to minimize the ecological costs of increasing harvest levels." (Eyvindson et al 2018).

Species reintroduction

On the spectrum of rewilding/ecological restoration projects internationally, the Summit to Sea project has more of an emphasis on creating space for natural processes to drive ecological change and restoration rather than initiating trophic cascades through the reintroduction of apex predators as in Yellowstone National Park. However, over the last three years, there has been a very successful pine marten reintroduction project lead by project partners, the Vincent Wildlife Trust (VWT). This project has taken place within the Summit to Sea area and provides an example of how community engagement and strategic introduction of individual animals from other areas can lead to the reinstatement of missing or very sparse populations. There have been two successful translocations from diverse pine marten populations in Scotland leading to a healthy, breeding population of around 60 pine marten in Mid Wales. VWT have been closely involved in the community engagement group tasked with developing this aspect of the Summit to Sea project. The project could involve the reintroduction of a selection of missing terrestrial species (beaver or red squirrel for example) and marine species (crawfish and native oyster) after adequate feasibility studies and consultation. The case of beaver reintroduction is used here as an example of the importance of planned and phased species reintroduction as a project intervention.

Beavers are a good case in point as their presence within a landscape can create a significant impact on ecosystem function. Beavers are thought of as ecosystem engineers due to their propensity to modify river systems and riparian zones through the building of dams, initiating the build-up of large bodies of water in the landscape. These re-wetted areas create much needed wetland habitat with a positive impact on biodiversity and hydrological functions in the surrounding landscape. There have been two successful controlled reintroduction projects in the UK, in England and Scotland, but so far Wales, which in the 16th century was the last place to host a wild beaver population on the Teifi river, has not yet seen the reintroduction of this important ecological engineer. The Welsh Beaver Project, coordinated by the Wildlife Trusts Wales, is investigating the feasibility of bringing wild beavers back to Wales.

"In addition to reported biodiversity benefits (Correll et al., 2000), it has been suggested that beavers could play a key role in the provision of environmental ecosystem services (EES) and as a nature based solution for the management of our river catchments." (Puttock et al 2017).

"Hence by far the most important species reintroduction in European rewilding schemes, in terms of impacts upon the structure and function of streams and rivers has been the European beaver. There have been at least 150 reintroductions of beavers in 24 European countries (BACE (Beaver Advisory Committee for England), 2017) including; Litovelské Pomoravi (Czech Republic, 1991), Millingerwaard, part of Gelderse Poort (Netherlands, 2014), central and southern Germany, the Brittany Alps, and the Loire (Dewas et al., 2011), Knapdale and Tayside (Scotland, 2009, Gaywood, 2017) and Devon (England, Puttock et al., 2017). As a result, the population which fell to not>1200 individuals divided in 8 isolated population across Europe (Liarsou, 2013) has now dramatically increased." (Brown et al 2018).

"recent efforts and indeed recent research papers on indigenous beaver populations have recognised the multiple environmental benefits that beaver reintroduction might deliver to riverine ecosystems (John and Klein, 2004; Gaywood, 2017; Puttock et al., 2017; Law et al., 2016, Wegener et al., 2017). Ecosystem services that respond positively to beaver reintroduction include; flood attenuation, sediment and carbon storage, water quality improvements and increased biodiversity (Hering et al., 2001)." (Brown et al 2018).

"The first step in any reintroduction programme is to identify favourable areas for a species and the connectivity between those areas. This is required to optimize the success of reintroduction and the establishment and dispersal of the introduced population." (Torres et al 2017).

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