Glen Affric, River Glass and Beauly Catchment Beaver Feasibility

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Executive Summary

- This report assessed the feasibility of beaver releases in Glen Affric, River Glass and upper River Beauly.
- Feasibility was assessed according to field survey findings along with habitat suitability and dam capacity modelling tools, according to methodology that has been widely implemented across sites throughout Britain.
- Beaver presence is evident in the upper Beauly though is restricted in range and likely only to comprise of a low number of animals. Breeding is likely to be occurring. Currently beavers can already colonise the areas surveyed bar Glen Affric.
- The majority of this area can be categorised as suitable to highly suitable for beaver presence, though field assessment highlight potential release considerations and further identify potential release areas.
- Dam capacity modelling indicates that the vast majority of the tributaries are unsuitable for damming and beavers are highly unlikely to maintain dams.
- Theoretically beaver release composition could be based; Glen Affric – two / three pairs; River Glass – two pairs; River Beauly two pairs. Note a pair may also compose any dependent young or a combination of singletons. Release of singletons would also encourage dispersal and mate choice pairing, which may encourage genetic diversity amongst current families / population more quickly.
- Potential conflict and management requirements are considered as low.
- Considering the area from a whole catchment and future colonisation potential, connectivity to other catchments is generally hampered by both topographical and artificial features.

Project Overview

This document has been prepared to support an application by Trees for Life, on behalf of a group of four local landowners, to NatureScot, for the feasibility of both releasing beavers into Glen Affric and augmenting existing beavers present on the upper River Beauly. Any released beavers would be translocated from conflict sites elsewhere in Scotland. If permitted, this project aims to achieve multiple goals including environmental benefits and to encourage the local community to engage with nature. The principal goals include;

- Act as a receptor site to provide alternative mitigation to lethal control.
- Augmentation of existing beavers present in low densities on the upper River Beauly.
- Demonstrate the importance of beaver activities in coexistence with wider land-uses including forestry, agriculture and tourism.
- Encourage the wider restoration and distribution of this native species.
- In biodiversity enhancement through the creation of a broad range of onsite habitats ranging from dam or pool complexes; the provision of more standing, fallen and submerged dead wood environments.
- Public engagement of local communities with nature, biodiversity and nature-based solutions/ ecosystem services.

Field surveys were undertaken between the 30th of May and 2nd of June by Dr Roisin Campbell-Palmer, Rob Needham and Sheelagh Mc Allister. These had two main aims; to assess habitat suitability and release potential; and map beaver activity. Site surveys have been further supported with the mapping of habitat suitability and modelling of potential beaver dam capacity.

Site Background

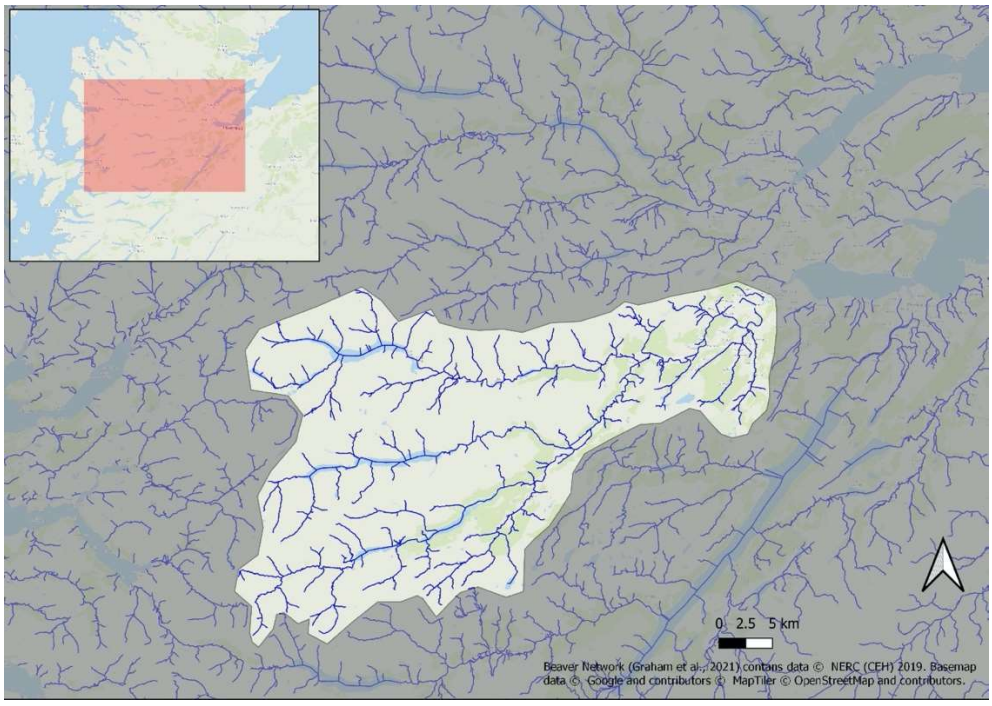


Figure 1. Area of interest map highlighting the main watercourses in Beauly catchment (source OS open river network).

Figure 1. Glen Affric, River Glass and upper River Beauly area of interest

Glen Affric is a Caledonian Forest Reserve of European importance, a National Scenic Area and a National Nature Reserve. Glen Affric is also a Site of Special Scientific Interest (SSSI), forming part of the Strathglass Complex Special Area of Conservation (SAC) and part of the Glen Affric to Strathconon Special Protection Area (SPA). The main fresh water bodies consist of the River Affric which runs through the length of the glen, passing through Loch Affric and Loch Beinn a' Mheadhoin (Loch Benevean). The hydrology of the glen is significantly affected by the Affric/Beauly hydroelectric scheme. The glen is lined by forest (including Caledonian pine, oak and birch), moorland and mountain habitats. There are sections of slower deeper water, though typically the water course is shallower with faster moving water and shorelines dominated by bedrock with thinner soil layers.

River Glass and River Beauly catchment – this is a large catchment draining ~1000km^2 including the Glass, Cannich and Affric, and the Farrar tributaries. For purposes of this study, the survey area includes the River Glass and upper River Beauly to the point of the Aigas dam and excludes the Farrar though this would be theoretically colonisable by existing and any released beavers. Much of this area consists of main channel river, meandering across a flat valley bottom, with any tributaries rising fairly immediately from surrounding higher slopes resulting in rocky, steep gradients with high flow velocities. The lower sections are deep and slow moving, with increasing earthen substrate, with upper regions shallower, faster moving and with shorelines more bedrock dominated with thinner soil layers. Middle to upper section of this stretch of the River Beauly also consists of large sections of predominantly sandy and smaller stone substrate including beach like features and steeper banks in varying phases of erosion. Noting water levels are regulated artificially, with regular let-outs which cause fluctuation over several feet over the course of a day. Significant hydroelectric dams exist which drastically influence water levels from Glen Affric to the firth of Beauly. Typically, the area beneath each dam is tree lined but solid bedrock. General land use is not urban, but includes a predominance of rough grazing along the main river stem, with commercial forestry and sporting estates situated mainly on the surrounding slopes. There are key fisheries interest throughout the length of this river system. Alder (*Alnus*

glutinosa) dominates throughout with pockets of dense willow and emergent vegetation, including reed beds, especially in backwaters and the limited number off-channel ponds.

It is highly likely that the presence of beavers could;

- Diversify the existing wet woodland habitats by increasing the availability of open water and encouraging a more complex fen-grassland environment in back waters and off-channel water bodies.

- Through a process of tree felling and subsequent browsing open the banks and water edge habitats to sunlight prompting vegetation regrowth.

- Increase wetland areas through the excavation of canals and dam creation which would in turn enhance the ability of the catchment's retention for surface and ground water.

- Create a greater abundance of standing, sunken and fallen deadwood habitats.

Status of Beavers in Scotland

Britain represents the very western extent of the Eurasian beaver range. Archaeological evidence of their former presence such as gnawed timber and bones in combinations with trade records, illustrations and other historic references, testifies to their former widespread occurrence throughout Britain (Coles, 2006; Manning et al., 2014). By the 15th century, the trade in Scottish beaver furs was no longer economically viable due to over-exploitation. While oral tradition recalls their presence in and around Lochaber until the late 1700's, there is no further mention of their presence after this time (Coles, 2006). The Eurasian beaver is therefore believed to have become generally extinct in Scotland, by the 16th century (Kitchener & Conroy, 1997).

The case for reintroducing the Eurasian beaver to Scotland has been debated for over 20 years. Beavers and beaver reintroduction issues are summarised in the Scottish Natural Heritage (SNH) 'Beavers in Scotland' report (Gaywood, 2015). In May 2009 five Norwegian beaver families were released into the Knapdale Forest of Argyll, as part of the officially sanctioned Scottish Beaver Trial (SBT). Although this official beaver trial concluded in 2014 by then beavers resulting from further unauthorised releases or escapes in the east of Scotland had extensively colonised the River Tay. In 2016, the Scottish Goverenment stated that they were minded to allow both populations to remain. In 2019, European Protected Species (EPS) was accorded to beaver populations in Knapdale, Argyll and the Tayside and Forth catchments which extended to any populations naturally colonising other areas from these core zones. The Scottish Government made it clear at that time that no further unauthorised releases would be tolerated or permitted and a NatureScot Beaver Mitigation Scheme was established to provide practical advice and support to landowners and interest groups. A management framework has been developed in which a range of beaver mitigation tools and interventions can be provisioned including tree protection and dam management. Under specific criteria landowners may apply for a licence for lethal control. In the first year of protection, 39 lethal control licences were issued and a reported 87 beavers were culled as a result. A cull of a further 115 was recorded in the second year of this schemes operation (NatureScot 2020, 2021). While government policy currently allows the translocation of beavers in Scotland within their current range the only recent applications to do so occurred as part of the population augmentation exercise for the Knapdale population and more recently to move two families into a series of pool systems at the Argaty Red Kite Centre, near Doune. This last project

represents the first successfully permitted translocation of beavers within a catchment where the species is otherwise free-living. Other unauthorised releases of beavers have also resulted in the establishment of populations in other parts of Scotland, England and Wales. While this wider restoration has generated much excitement in the nature conservation community (Brazier et al., 2020; Law et al., 2016, 2017; Stringer & Gaywood, 2016) certain land interest groups have expressed strong concerns regarding the species ability to modify landscapes in a manner unfavourable to their interests.

The NatureScot Beaver Mitigation Scheme was established to provide mitigation advice and support to various landowners and interest groups. A management framework has been developed in which a range of beaver mitigation tools and interventions can be provisioned including tree protection and dam management. Under specific criteria landowners may apply for a licence for lethal control. In the first year of protection, 39 lethal control licences were issued and a reported 87 animals dispatched, and a further 115 in the second year (NatureScot, 2020, 2021).

The nearest wild beaver populations too (outside of) the Beauly catchment would be the Tayside population (recent recorded distribution Figure X). A recent review completed for the Cairngorms National Park concluded that viable natural dispersal from Tayside into the Cairngorms was highly unlikely and that beaver restoration here would require proactive translocation (Campbell-Palmer, Brazier and Puttock, CNP commissioned report 2021). Therefore, it could be equally concluded that natural beaver spread from Tayside into the Beauly catchment was highly unlikely and require both successful colonisation of neighbouring catchments and subsequent significant population density increases to encourage inter-catchment scale colonisation.

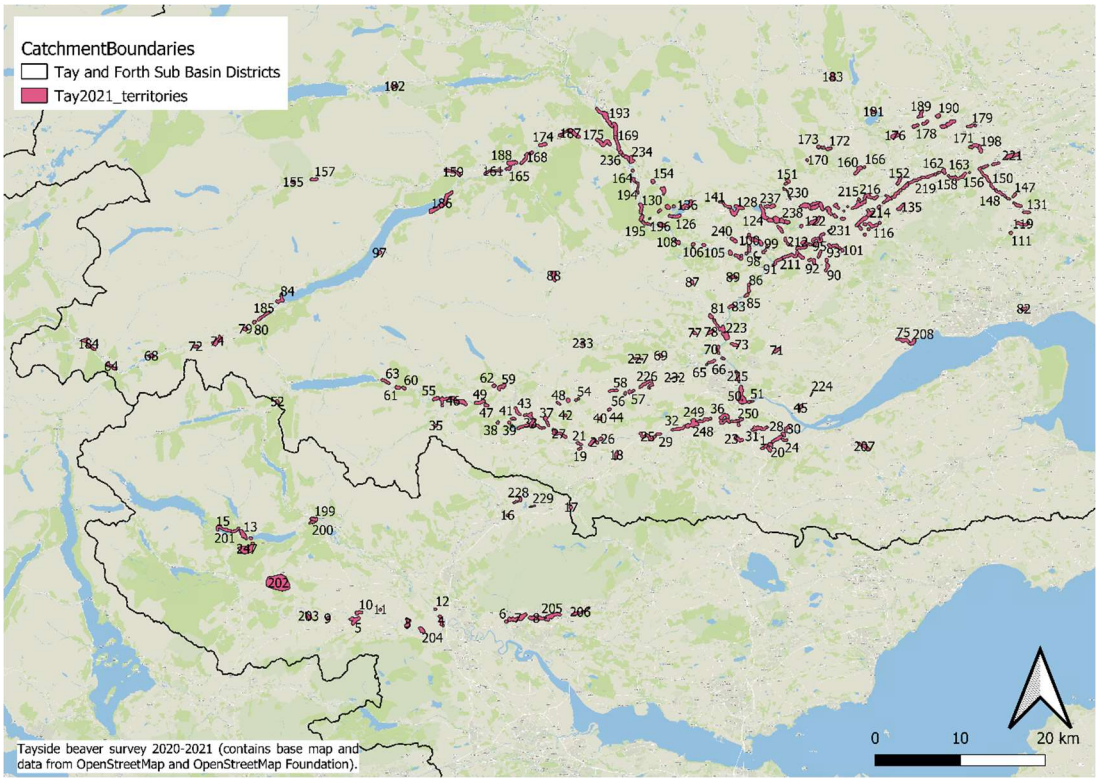


Figure 2. Nearest wild living beaver populations - Tay & Forth estimated territories 2021 (adapted from Campbell-Palmer et al., 2021).

Site Assessment Methods

This feasibility work seeks to demonstrate the suitability of this area to act as a beaver release site along with some of the impacts and natural processes they could generate. These were assessed and documented using a combination of ground survey, experience, and knowledge along with the deployment of models developed at the University of Exeter to determine habitat suitability and beaver dam capacity.

Based on experience and knowledge of beaver ecology, a visual assessment of various key features including vegetation coverage, diversity and regenerative ability to determine long-term food resources, water permanence, extent and connectivity, capacity for wetland extension, bank structure and capacity to form shelter, and likely human-wildlife conflicts were ground truthed by Dr Roisin Campbell-Palmer.

Mapping and modelling work draws upon existing high-resolution datasets which describe:

- Habitat Suitability Modelling
- Dam Capacity Modelling
- Site designations

These datasets were mapped within a GIS framework and presented as outputs figures to visualise and compare the variability of existing hydro-geomorphological habitat.

The habitat suitability for any future beaver colonisation across the whole site was quantified using a Beaver Habitat Index (BHI) model developed by the team. BHI modelling details where vegetation availability creates suitable beaver habitat as determined via food and building resources. The BHI model not only provides a useful tool for designing effective, empirically based, restoration strategies but it also indicates where beaver presence might cause potential management conflict issues.

Additionally, Beaver Dam Capacity (BDC) modelling estimates the capacity of river systems to support dams at the reach-scale (c.a. 150m). The model also highlights reaches that are more likely to be dammed by beaver and estimates the number of beaver dams that could occur for a catchment at population carrying capacity. As such, this highly detailed tool would provide understanding of where dams are most likely to occur and in what densities, supporting future work on the conflicts and opportunities that might accrue from beaver presence. BDC outputs are extremely useful for informing management at catchment-scales in the long-term. Outputs will be provided as high resolution .pdfs for the study area and incorporated into reporting.

Beaver Feasibility – Modelling Work

Mapping of beaver habitat (beaver habitat index, BHI) and capacity for beavers to dam the current river network (beaver dam capacity, BDC) is presented. Model outputs can be used to inform surveys and subsequent recommendations and are included below for key areas of interest. Maps were prepared by Dr Alan Puttock for Dr Róisín Campbell-Palmer and Rob Needham to support the wider beaver project being considered in the Beauly catchment.

Beaver Habitat Suitability Modelling

The habitat suitability of the sites was assessed using beaver modelling tools developed by researchers at the University of Exeter (Graham et al., 2020).

Summary Description

Production of a continuous description of habitat suitability for beaver. First a vegetation suitability index is created using multiple high-resolution spatial datasets from Ordnance Survey, the Centre for Ecology and Hydrology (CEH) and Copernicus will be combined to provide detailed land cover/vegetation information which is classified based on empirical field observation of beaver habitat and preference. Vegetation suitability is combined with additional parameters describing stream networks and water bodies. Whilst beaver habitat suitability is primarily defined by vegetation suitability, beavers also require water for security and movement. Therefore, accessibility to water bodies (i.e., channels, ponds, and lakes) will also determine the viability of beaver occupancy and therefore are required to classify habitat accurately.

Outputs

This product provides a high-resolution (5m cell size) resource for describing habitat suitability for beaver. This dataset can allow the user to explore which landscapes were most (or least) suited to beaver reintroduction and also to understand where habitat enhancement might be useful to support future reintroduction.

Beaver Habitat Index (BHI) Model Summary

Vegetation is important for classifying beaver habitat (Hartman, 1996; John et al., 2010; Pinto et al., 2009; St-Pierre et al., 2017). It was therefore critical to establish a reliable Beaver Vegetation Index (BVI) using nationally available spatial datasets. No single dataset contained the detail required to depict all key vegetation types. Therefore, a composite dataset was created from The Centre for Ecology and Hydrology (CEH) 2019 land cover map (LCM) (Morton et al., 2020). This provides landcover classification at a resolution of 20m, derived from Sentinel 2 data using a random forest method. This dataset has been updated from the 2015 landcover map, used in previous modelling work (Graham et al., 2020). Copernicus 2018 10 m tree cover density (TCD) (Copernicus, 2020) provides a percent tree cover density estimate which is derived from sentinel 2A + B satellite imagery using a random forest classification system. This dataset has been updated from the Copernicus TCD 2015, used in prior modelling work. Additionally, The National Forest Inventory (NFI) Woodland Map (Forestry Commission, 2019) which includes woodland areas with an area > 0.5 ha and a minimum width > 20m. It is a partially derived from digitised Ordnance Survey (OS) MasterMap data but also includes additional woodland areas identified from other remotely sensed data sources. The (OS) VectorMap District (Ordnance Survey, 2021) is a digitised spatial vector product, from which we extract the surface water areas, which include larger river channels (c.a. >4 m wide) and still water bodies. This dataset and the NFI replaces the OS VectorMap Local data (Ordnance Survey, 2018b) used in Graham et al., (2020).

Vegetation datasets were assigned suitability values (zero to five). Zero values were assigned to areas of no vegetation i.e., buildings and values of five were assigned to favourable habitat i.e., deciduous woodland. Values were assigned based on a review of relevant literature (Haarberg & Rosell, 2006; Jenkins, 1979; Nolet et al., 1994; O'Connell et al., 2008), field observation and comparison with satellite imagery. Vector data were converted to raster format (resolution of 5 m). TCD data were resampled to 5m and aligned with converted vector layers. An inference system was used to combine these four raster datasets to create a vegetation index. The workflow prioritises the reliability followed by the highest value data.

Examples of highly suitable land (graded 5) include broad-leaf woodland, mixed woodland and shrub; examples of suitable vegetation (graded 4) include shrub and marsh; examples of moderately suitable (graded 3) include coniferous woodland, marsh, shrub and unimproved grassland; examples of barely suitable (graded 2) include reeds, shrub and heathland and boulders, neutral grassland; examples of unsuitable (graded 1) include heather, acid grassland, unimproved grass and boulders, bog; examples of no accessible vegetation (graded 0) include shingle and sand, buildings, rock, urban, freshwater and saltwater.

Whilst vegetation is a dominant factor in determining habitat suitability for beaver, so is proximity to a water body (Gurnell et al., 2008), with beavers being strong swimmers, using water bodies both to provide security, as a means of escaping predators and to access foraging areas. It is thought that most foraging occurs 10 m of a watercourse/body (Haarberg & Rosell, 2006), and rarely above 50 m (Stringer et al 2018). However, greater foraging distances have on occasion been observed and as in Macfarlane et al., 2015, 100m has been accepted as a maximum distance in which the vast majority of foraging occurs. Therefore, to determine suitable habitat for beaver incorporating both BVI vegetation suitability and water accessibility a 100m buffer was applied to water bodies. To do this the OS mastermap river network and OS vector in land water bodies were combined to get the best readily available national waterbody and water course coverage.

BHI use a scoring system of zero to five (Table 1). Scores of five represent vegetation that is highly suitable or preferred by beavers and that also lies within 100 m of a waterbody. Zero scores are given to areas that contain no vegetation or are greater than 100 m from a waterbody. It is important to note that the habitat model considers terrestrial habitat where foraging primarily occurs and that watercourses themselves are also scored zero. It is also important to note that all scores above 1 contain suitable vegetation.

Table 1. BHI value definitions. It is critical to note that all values above 1 are suitable for beaver.

BHI Values	Definition
0	Not suitable (no accessible
1	Not suitable (unsuitable vegetation)
2	Barely Suitable
3	Moderately Suitable
4	Suitable
5	Highly Suitable

Beaver Dam Capacity (BDC) Model Summary

The Beaver restoration assessment tool (BRAT) was developed in North America (Macfarlane et al., 2014, 2015) to determine the capacity for river systems to support Beaver dams. The BRAT model has been further deployed in a range of different river systems to aid both Beaver recolonisation and beaver dam analogue led restoration. The BRAT model not only provides an invaluable tool for designing effective, empirically based, restoration strategies but it also indicates where Beaver dams might be constructed and therefore where they may cause potential management/conflict issues. The BRAT model structures the framework of the model around the river network itself and using a fuzzy logic approach which builds in the considerable uncertainty that is associated with beaver habitat/dammable reaches. Furthermore, it provides a range of output values to predict the dam capacity which has implications for beaver preference towards a given location.

We have therefore used the BRAT framework to develop an optimised beaver dam capacity (BDC) model for Great Britain; and although many of the datasets used are specific to GB, these could readily be adapted to enable its use globally.

The BDC model estimates the capacity of river systems to support dams at the reach-scale (c.a. 150m). The model also highlights reaches that are more likely to be dammed by beaver and estimates the number of beaver dams that could occur for a catchment at population carrying capacity. As such, this highly detailed tool would provide understanding of where dams are most likely to occur and in what densities, supporting future work on the conflicts and opportunities that might accrue from beaver reintroduction.

The model infers the density of dams that can be supported by stream reaches (111.1m ± 52.5) across a catchment. Using low-cost and open-source datasets, the following attributes are calculated for each reach: (i) stream gradient, (ii) low (Q80) and high flow (Q2) stream power, (iii) bankfull width, (iv) stream order, and (v) the suitability of vegetation, within 10m and 40m of the bank, for beaver dam construction. These controlling variables are combined using a sequence of inference and fuzzy inference systems which follow an expert-defined rules system that allows for the considerable uncertainty often associated with these types of complex ecological processes.

Each reach was classified for damming capacity using five categories from none, defined as no capacity for damming to pervasive where a maximum capacity of 16-40 dams could theoretically be constructed in a km of channel. It is important to note that the model assumes both reach and catchment population carrying capacity for beaver. Therefore the maximum number of dams indicated in a category class is unlikely to occur in reality. A full list of BDC classifications is included in Table 2.

Table 2. BDC classifications and definitions.

BDC Classification	Definition
None	No capacity for damming
Rare	Max capacity for 0-1 dams/km
Occasional	Max capacity for 1-4 dams/km
Frequent	Max capacity for 5-15 dams/km
Pervasive	Max capacity for 16-40 dams/km

Beauly and Glen Affric

Beaver Habitat Summary

An overview of modelled beaver habitat is presented in Figures 3-9. Starting by presenting BHI results for the whole catchment, before focusing in on the Glen Affric area. From the overview map (Figure 3) an overall trend can be observed of a higher area of riparian habitat availability lower down in the catchment and in the floodplains of the larger rivers and a decrease in available habitat in upland areas.

Going upstream to Glen Affric, the lower sections of the River Affric and the River Glass downstream have wider valley bottoms and areas of high-quality beaver habitat that would support beaver territories. Upstream patches of habitat become more marginal around the lochs, but perhaps more critically hydropower dams would likely limit or significantly slow the natural spread of beaver into these areas.

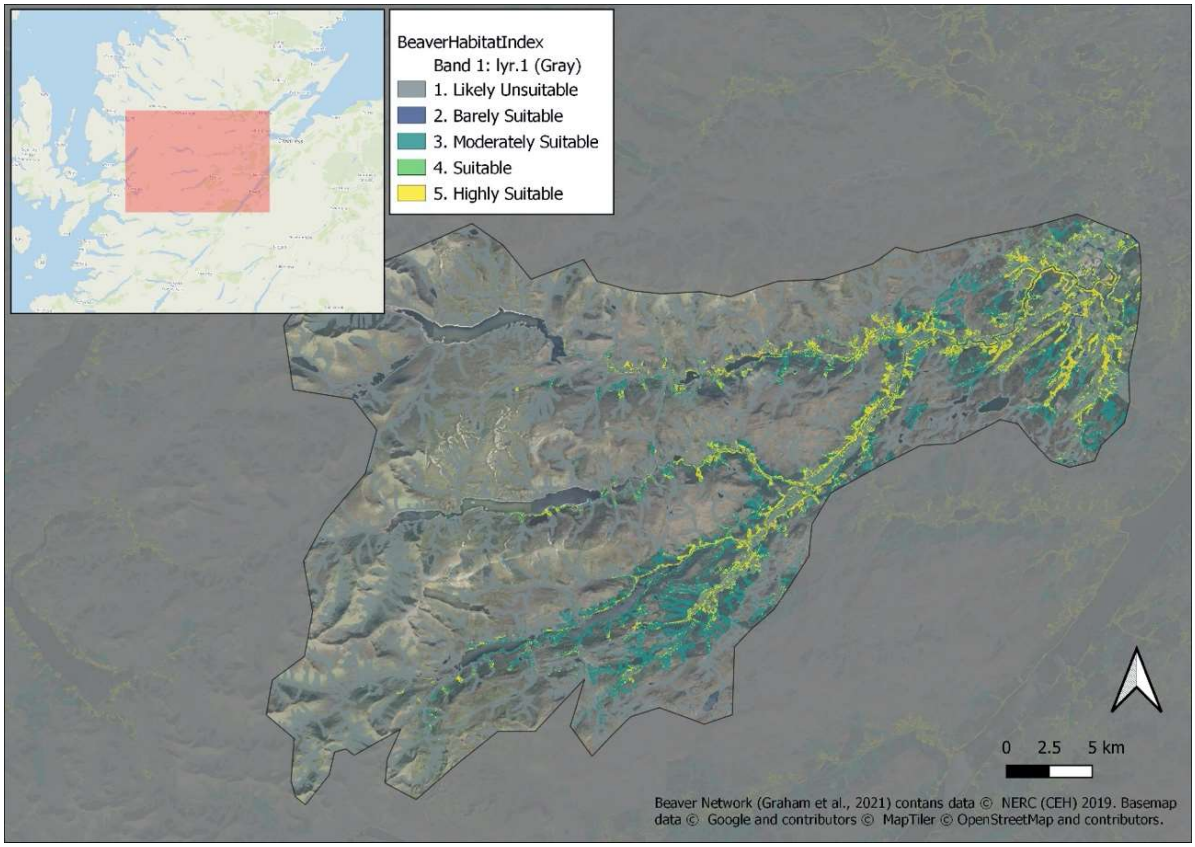


Figure 3. BHI for Beauly catchment (please note catchment boundary is approximate). Contains data derived from Ordnance Survey data © Crown Copyright 2007. Some features derived from digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH).

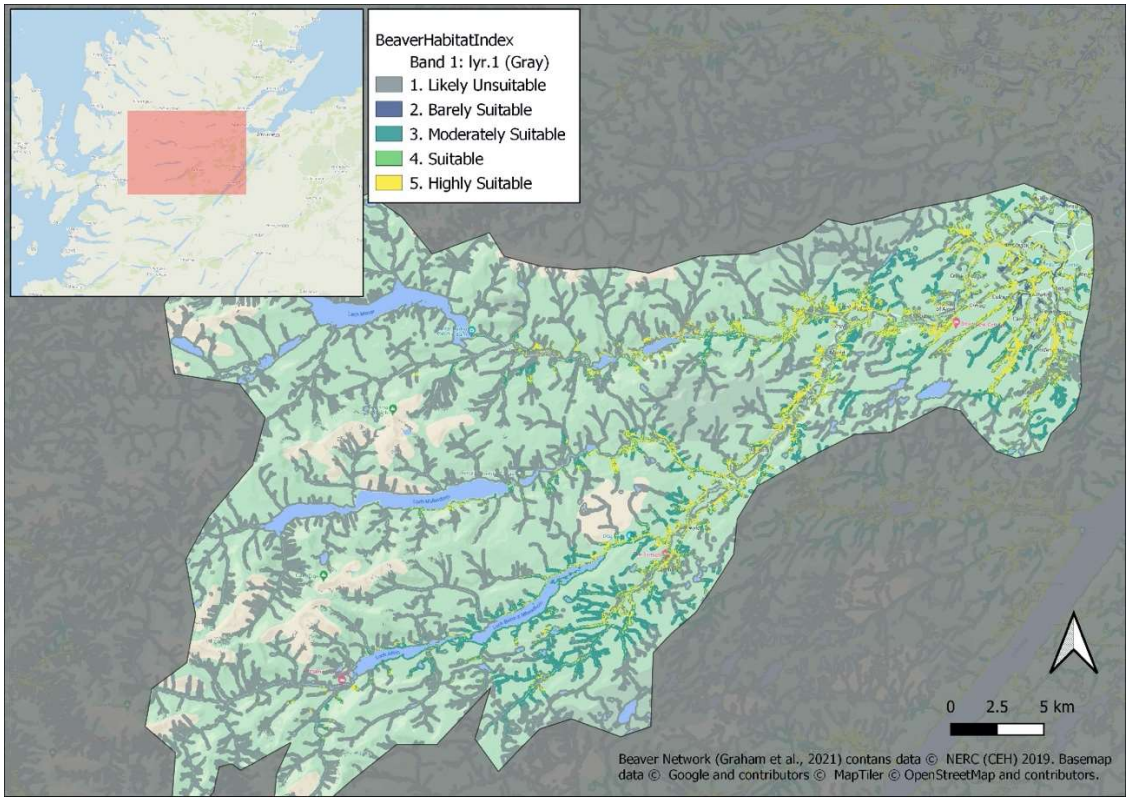


Figure 4. BHI for Beauly catchment (please note catchment boundary is approximate). Contains data derived from Ordnance Survey data © Crown Copyright 2007. Some features derived from digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH).

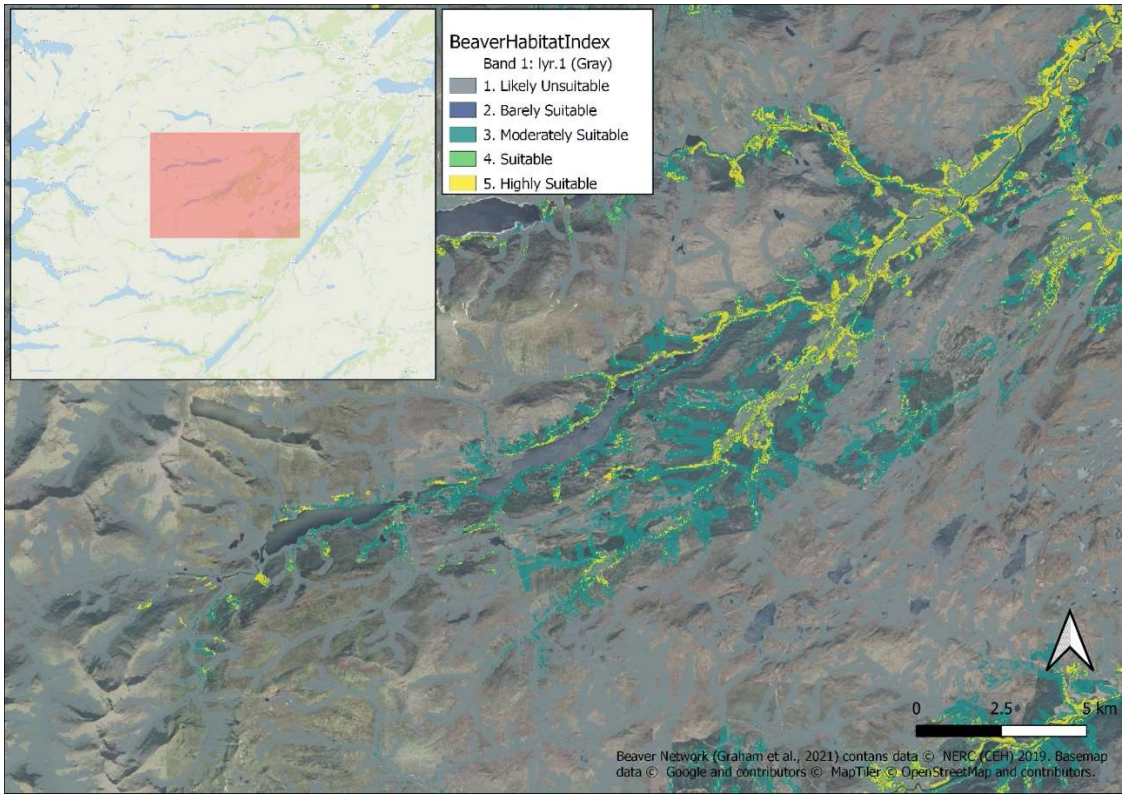


Figure 5. BHI for Glen Affric section of Beauly catchment). Contains data derived from Ordnance Survey data © Crown Copyright 2007. Some features derived from digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH).

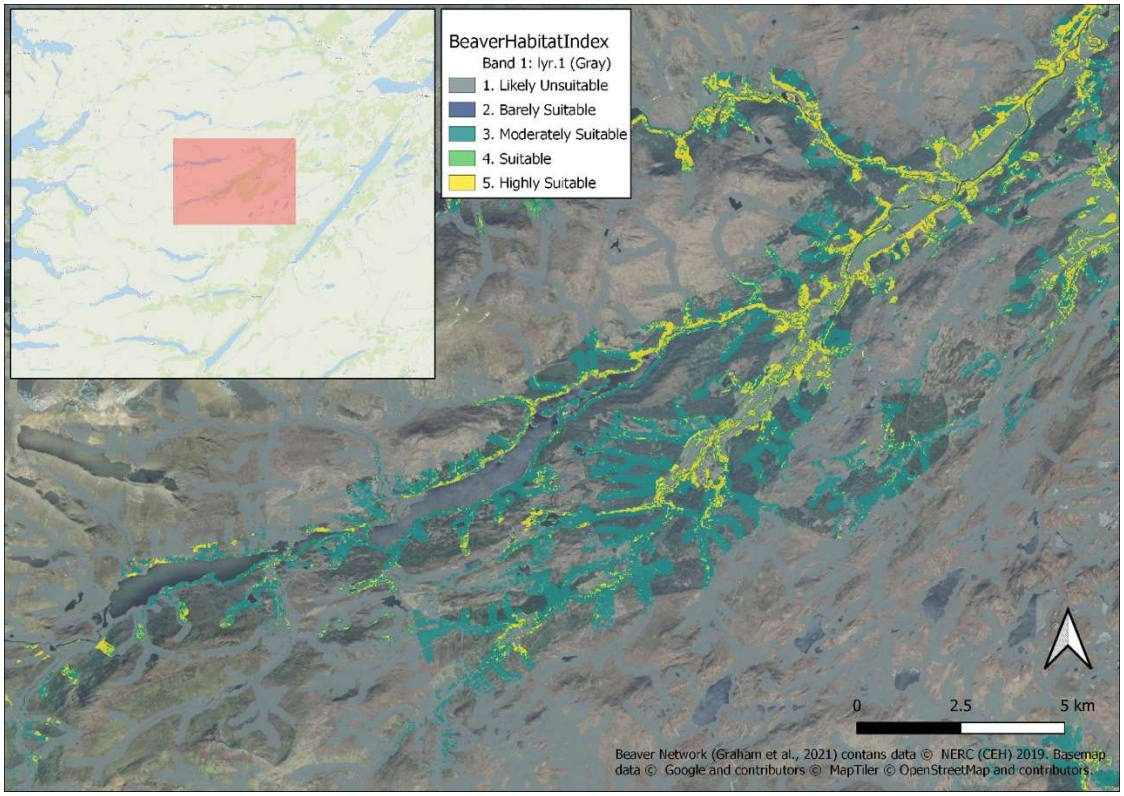


Figure 6. BHI zoomed in further to upper Glen Affric section of Beauly catchment). Contains data derived from Ordnance Survey data © Crown Copyright 2007. Some features derived from digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH).

Beaver Dam Capacity Summary

Beaver dam capacity results for the Beauly catchment are presented in Figure 12, with Figures 13 and 14 focusing on the Glen Affric area. The main large river systems show no dam capacity due to their size and power and upland areas of the catchment show only rare dam capacity both due to the flashy and steep nature of the streams but also the lack of suitable beaver habitat in these areas. Therefore, the majority of reaches that would support the creation of beaver dam sequences are concentrated in smaller streams in the lowland areas of the catchment near the river's mouth and in the valley bottoms. Recorded field signs show that currently beavers are focused on the main river where they neither can nor need to dam, however it is likely that over time as population densities increase beavers will expand their territorial range into areas where dam capacity is greater.

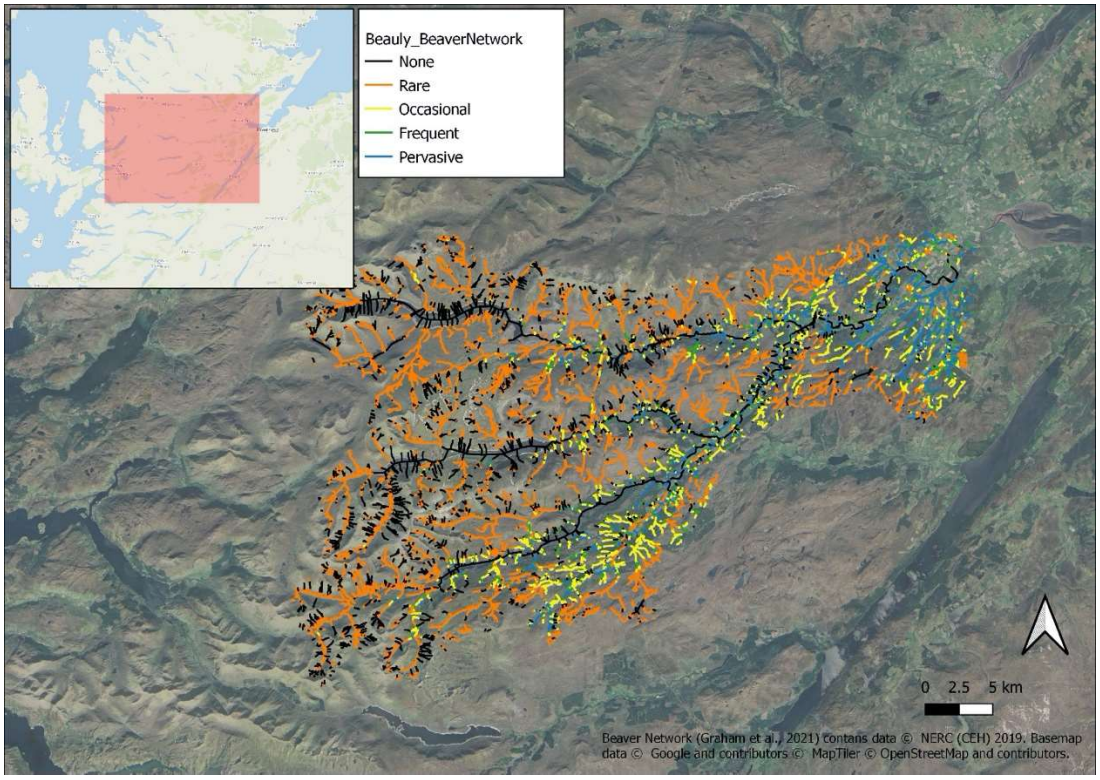


Figure 7. BDC for Beauly catchment, please note catchment boundary is approximate. Contains Ordnance Survey data © Crown Copyright 2007. Some features derived from digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH).

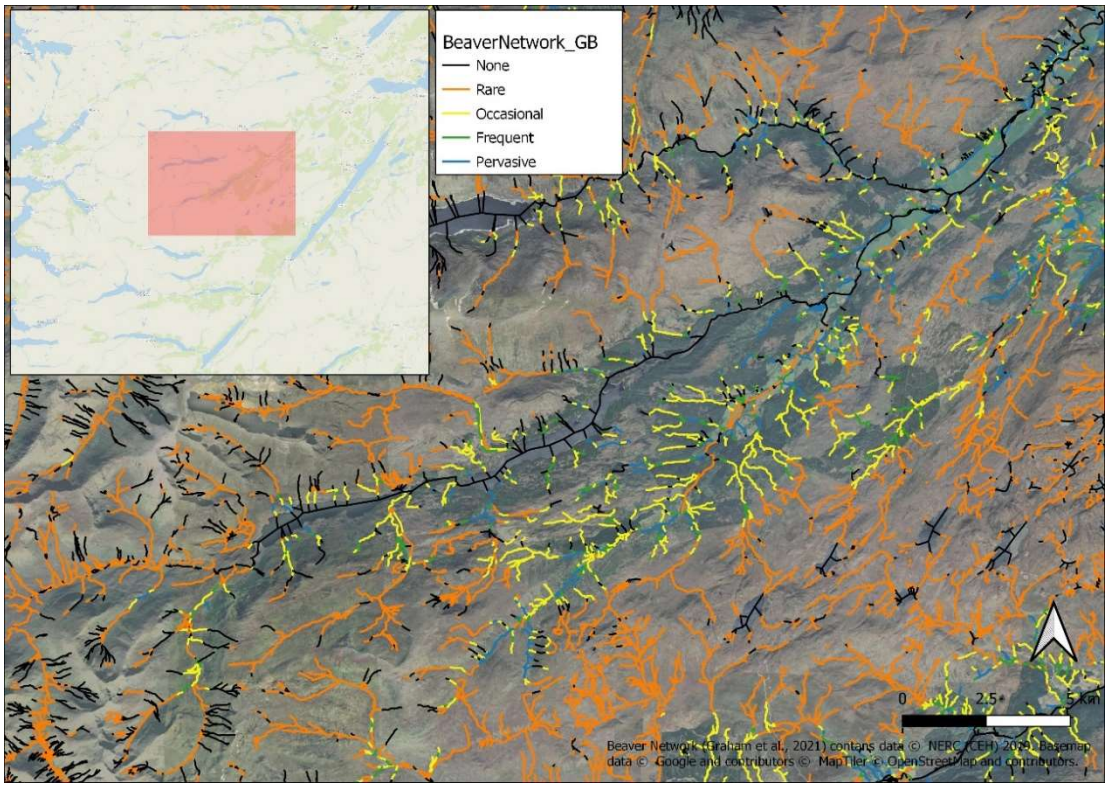


Figure 8. BDC for wider Glen Affric area of Beauly. Contains Ordnance Survey data © Crown Copyright 2007. Some features derived from digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH).

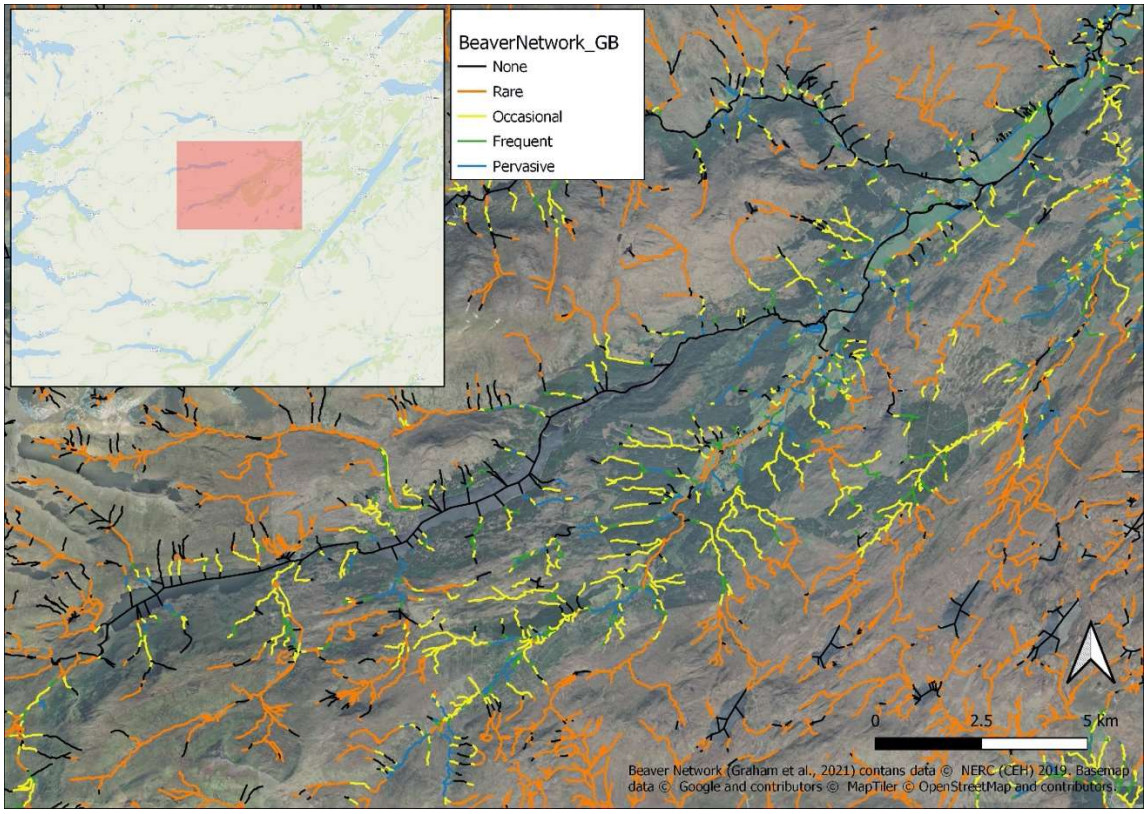


Figure 9. BDC zoomed in to upper Glen Affric area of Beauly catchment. Contains Ordnance Survey data © Crown Copyright 2007. Some features derived from digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH).

Caveats for Model Use

Use of Beaver Habitat Index (BHI)

BHI provides a resource for quantifying beaver forage suitability with national coverage. A high (10 m) spatial resolution can inform detailed local decision making. Examples of BHI presented in the results section overlaid on satellite imagery reflect its ability to provide a useful classification of beaver habitat, based upon a vegetation suitability ranking and access to water (including both river network and waterbodies such as ponds and lakes). However, it is critical to note that BHI is a model rather than an absolute reflection of reality and the below caveats should be considered when using the BHI model outputs.

- Remote sensing/mapping vegetation/landuse datasets are not to species level. However, beavers are generalists; foraging and utilising a wide range of vegetation so these more generalised datasets are appropriate. However, if more detailed information is required (i.e. protected plant species) supplementary local studies and data sets may prove beneficial.

- Each dataset is essentially a snapshot in time. Areas of vegetation removal or land use change may degrade vegetation suitability whilst conversely replanting and conservation schemes may improve vegetation suitability. However, a combination of datasets and methodology for ranking vegetation suitability minimise the risk of areas of suitable/unsuitable vegetation being missed currently.

- Some small channels i.e. agricultural ditches and ponds may be missing or outdated in the dataset meaning beavers could access or exist in such areas but not be correctly classified by BHI model as falling within 100m of a water body.
- Most literature cites 50 m as maximum foraging range of beaver (i.e. Stringer et al., 2018) however, to incorporate uncertainty, site development (i.e. beavers damming or canal building allowing them to extend their foraging range) and due to reports of further foraging we have adopted 100 m as shown by Macfarlane et al. (2017). There are extreme reports of beavers moving up to 250m from channel (Macfarlane et al., 2015) but this is thought to be incredibly rare and not applicable to a general widely deployed habitat model.
- BHI focused on vegetation suitability and distance to channel/waterbody as a computationally efficient model that can be deployed nationally. However, other local factors that will restrict access to water/vegetation particularly human infrastructure culverted/constrained sections walls/fences may locally limit beaver habitat suitability.
- Due to the above considerations, it is always recommended that if making important and detailed decisions at the local scale, supplementary site visits are undertaken.

Use of Beaver Dam Capacity (BDC)

The BDC model estimates the capacity of river systems to support dams at the reach-scale (c.a. 110m). The model also highlights reaches that are more likely to be dammed by beaver and estimates the number of beaver dams that could occur for a catchment at population carrying capacity. As such, this highly detailed tool would provide understanding of where dams are most likely to occur and in what densities, supporting future work on the conflicts and opportunities that might accrue from beaver reintroduction. However, as with BHI, it is important to remember BDC is a model and for all critical decisions, particularly at the local scale, understanding from modelling results should be supplemented by site visits. The following caveats in-particular should be considered for interpretation of BDC results:

- BDC is heavily dependent on the input channel network. In some areas, flow pathways can be complex and not always accurately represented by even detailed river network mapping. This is particularly the case in heavily modified urban environments (which is not an issue here).
- BDC modelling is a snapshot in time and will not reflect any subsequent alterations to channel networks.
- Flow conditions display a high degree of temporal variability, short term fluctuations due to rainfall events patterns and seasonal trends will alter the suitability of a channel for damming.
- A channel classed as having a rare capacity for damming, might see this capacity increase during drought periods, but conversely reduce to none during the wet/winter season.
- BDC does not consider the exact spatial distribution or configuration of dams, which is also likely to be heavily dependent on beaver population dynamics.

- BDC reflects the capacity of a given reach to support beaver dams (assuming catchment is at beaver population carrying capacity) rather than the actual number of dams that are likely to occur. In isolation, BDC cannot predict the likely number of dams in a catchment.

Beaver Feasibility - Field Site Assessments

Methods for identifying the suitability and key habitat characteristics for beavers have been widely studied and published (including Allen 1983; Bergman et al., 2018; Dittbrenner et al., 2018; Halley et al., 2009; Hood, 2020; Macdonald et al.,1997). The main features to consider in any site assessment for beavers are:

- The initial composition and structure of the vegetation within ~30 m of the water's edge
- The distribution and abundance of palatable riparian trees
- The character of the riparian edge habitat
- The hydrology of the water bodies available to the beavers, including flow speeds, level stability and shoreline features
- Water management and where beavers may cause conflict i.e. flood banks/low-lying farmland/agricultural drainage
- Topography – gradient of land, substrate type, valley shape
- Associated land-use – disturbance and land-management practices, infrastructure, water use
- Presence and distribution of any existing beavers, particularly to identify vacant suitable habitat and connectivity

Sampling points

In addition to undertaking a beaver field sign survey, recording field signs while assessing general habitat, additional feasibility sampling points were taken along Glen Affric and River Beauly (Figures 10 and 11).

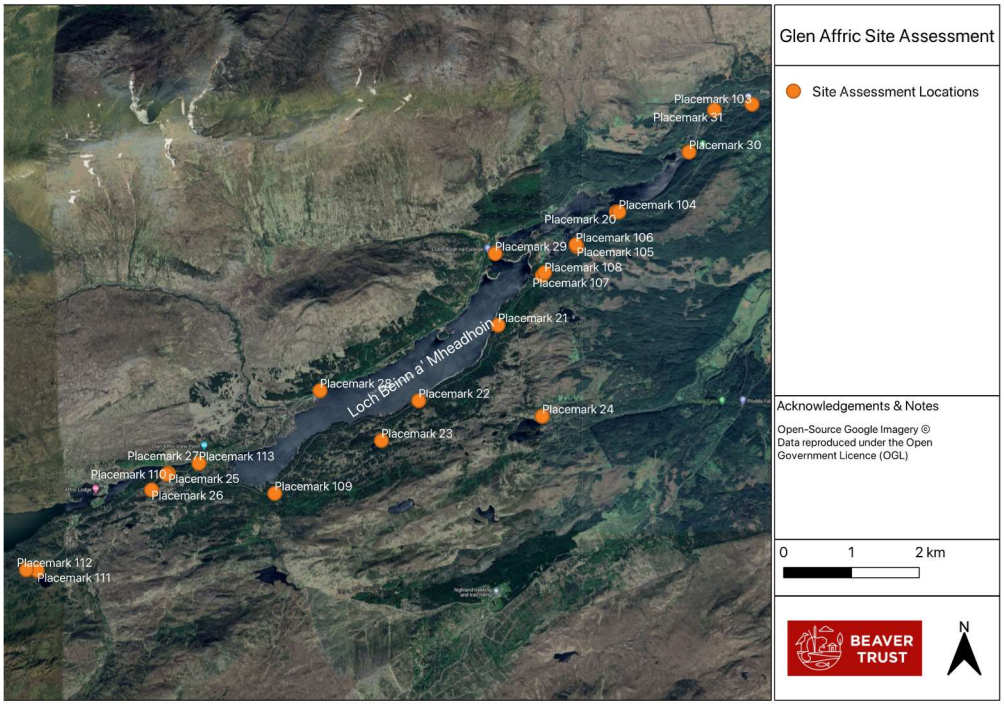


Figure 10. Main visual sampling points associated with Glen Affric.

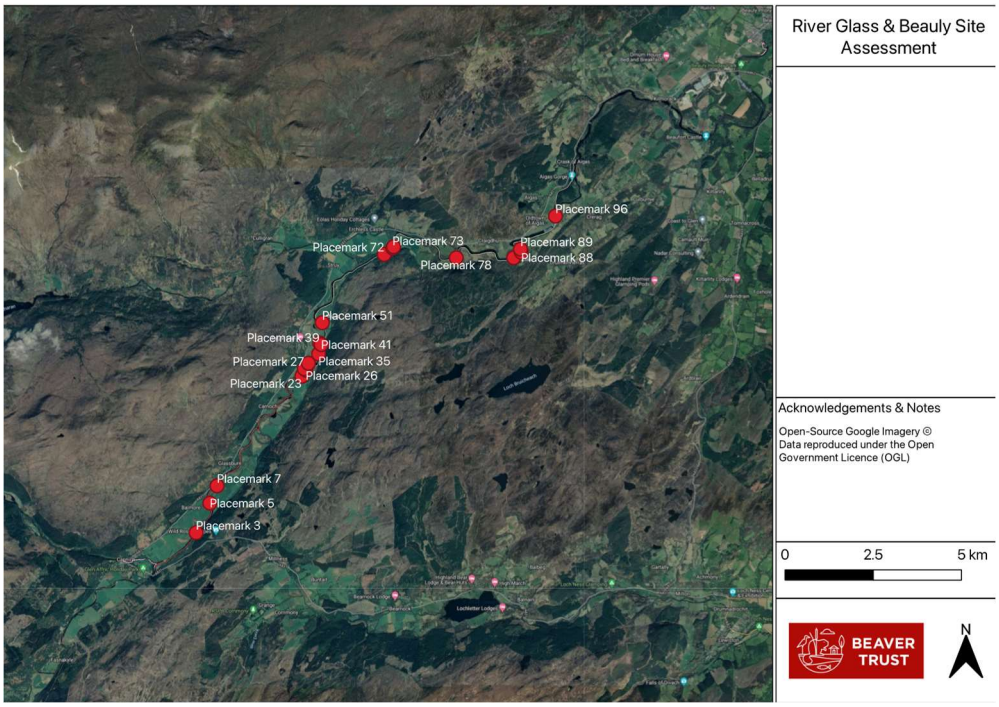


Figure 11. Main visual sampling points associated with River Beauly in addition to beaver field sign survey.

Beaver Field Sign-Survey Upper Beauly

Beavers live in family groups, occupying water courses in a linear fashion, defending resources within an active territory, leaving distinctive field signs which can be mapped to determine presence, habitat use and population density. Accurate population counts are difficult to achieve, mapping active territories is an effective measure of population development, range and size. Territory size varies greatly, for example ranged from 1.1 to 6.8 km of bank length (average 3.7±1.7 km) in Norway based on pair cohesion studies (McClanahan et al. 2020). Overlap between territories are minimal (0.5-2.2%)

and typically influenced by population density, habitat type and resource availability (Bloomquist et al. 2012; Herr & Rosell 2004; Mayer et al. 2020). In newly colonising populations, with poorer habitat quality, beaver territories are larger and more widely spaced. As beaver populations grow, infilling between the highest quality territories occurs and their highly adaptive, habitat modification abilities see them utilise less favourable habitats. At higher population densities areas of 'no man's land' between territories are likely to decrease although it is rare to find two lodges from different family groups closer than 400 m. Therefore, at a landscape scale the distribution of beaver territories is often highly discontinuous (Schulte 1998). Early colonisation of new habitat/ areas is often slow and represented by low numbers of pioneer individuals. As mating opportunities increase, new territories become established and population density increases. In expanding beaver populations, active territories tend to be further apart as family units select the highest quality habitat (Nolet & Rosell 1994), but as population density increases infilling occurs, territories come closer together and territorial behaviours (including aggression and scent marking) increase (Hartman 1995; Rosell 2002). The size and numbers of beaver territories depends on a number of factors including the density of beaver populations, habitat quality, the number of family members and their settlement pattern (Campbell et al. 2005).

A gross recording of beaver field signs was undertaken, based on previous and widely used field survey techniques and classifications employed regularly by this team. Noting given the time of year and high-water level on day of the survey not all field signs would have been recorded, with burrows especially being hard to detect and very under reported. Understory vegetation was also well developed, however the survey focused on visible woody field signs especially and we are confident the main areas of current beaver activity were captured.

Field signs were generally classified as;

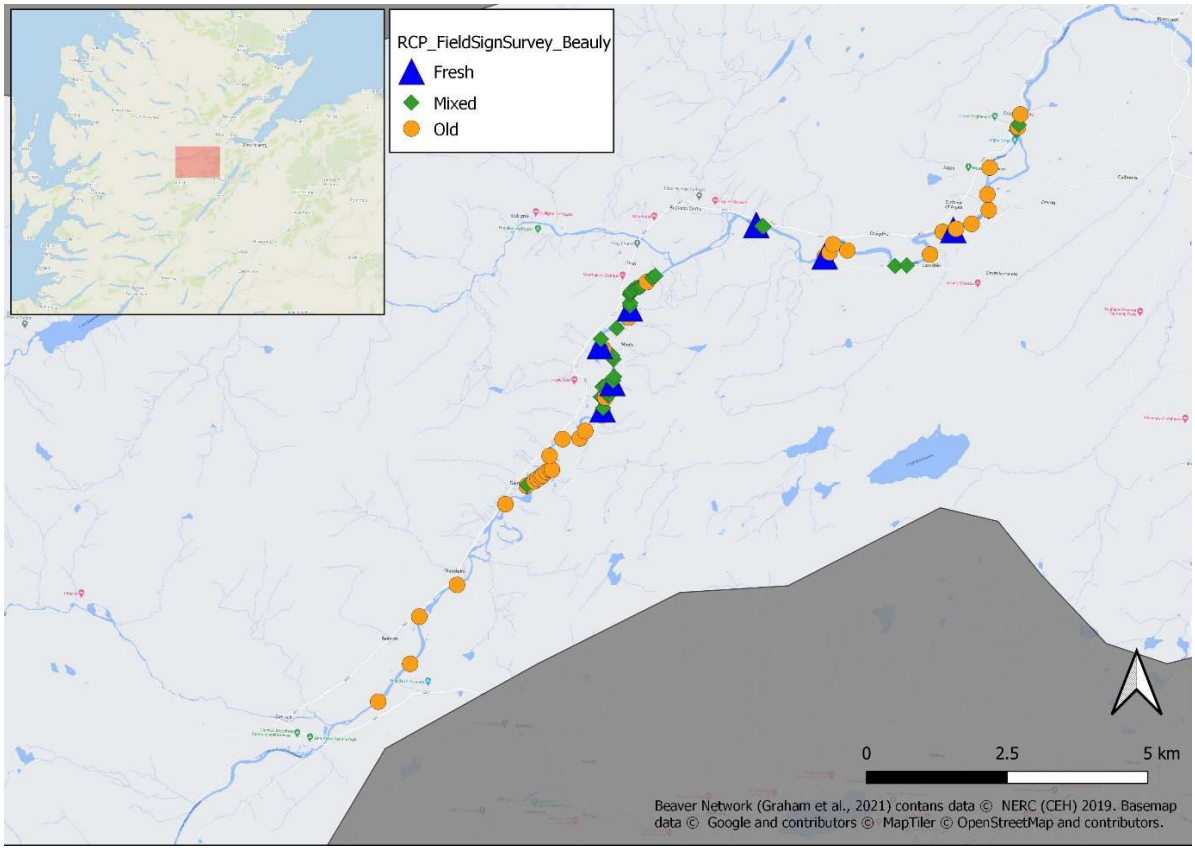
- Fresh or active – included very recent activity such as gnawing or cutting of woody vegetation within the last month up to 2 months. Based on degree of woody stem discolouration and drying out, present of leaves, any foraging on herbacious vegetation etc. Active typically represents field signs such as feeding stations, shelter structures or maintained dams, in which recent beaver behaviour can be clearly observed including active lodges, fresh digging and/or scent marking for example.
- Old or inactive – no evidence of any fresh activity in the immediate area. old woody feeding signs in which cuts were weathered, woody stems were obvious discoloured and dry in appearance and coppice may be present. For ease this definitely included signs from the previous year or longer. Inactive typically represented obvious beaver field signs such as shelter structures that were evidently no longer occupied.
- Mixed – were signs and areas in which both fresh and old field signs and/or activity were present in the same immediate area. This typically included for example, fresh feeding on top of old feeding and was taken as evidence of an active territory.

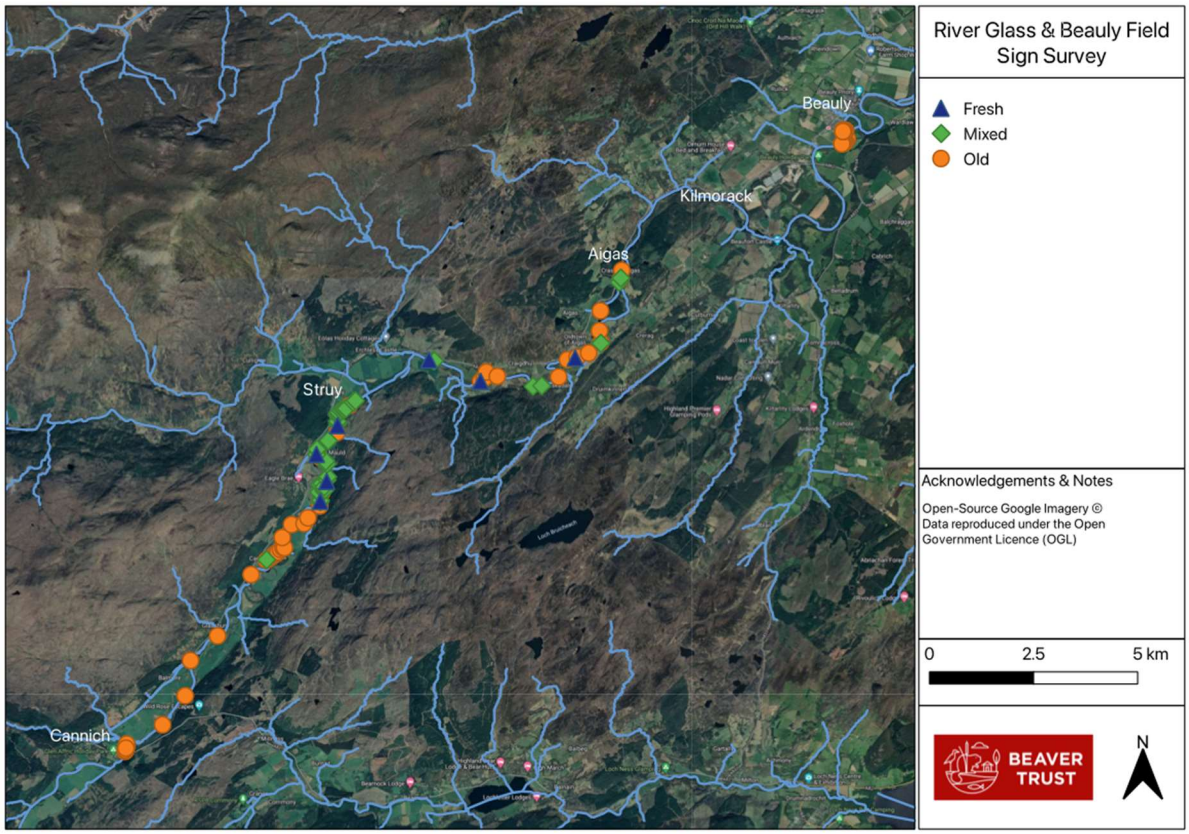
Figures 12 & 13. Freshly cut stems.

Figures 14-16. Woody stem feeding ranging from oldest to freshest but all this years feeding. With multiple field signs clustered nearby.


Figures 17 &18. Mixed age feeding, including fresh feeding on coppice of a mature tree felled several years previously.


Figures 19 & 20. Mixed age lodges, abandoned and partially collapsing (left), and active with fresh feeding and food cache still evident (right).





Figures 21 and 22. Recorded beaver field signs in Summer 2022 in the Beauly catchment and their age.

Reported observations, previous surveys and trapping events have all documented beaver presence on the upper Beauly at least from 2015, though beaver coppice willow could be aged from ~8 years around the same time (pers. comms. R. Campbell-Palmer, A. McDonnell).

From the field sign survey that was undertaken as the wider body of work it can be seen that both current and old beaver field signs are focused in the area between Cannich and Aigas. This distribution will have been restricted by anthropogenic infrastructure such as the Aigas dam but also shows the concentration of beaver in areas of good riparian habitat on the main river system rather than having to seek out more marginal areas as populations increase.

The density of field signs, presence of mixed age field signs and spatial clusters of beaver activity are assumed to relate to estimated active territories (Campbell-Palmer et al., 2018, 2020). For purpose of this study and given the suspected low number of animals and spatial distribution of fresh signs, suspected territories have been judged based on visual assessment of mapping and range of signs recorded. From this it can be realistically suspected that at least one active family territory is present with breeding suspected, with potentially another establishing further down-stream or equally likely older related offspring living around the boundary. Either way these are likely to all be related and could be one larger family with a large territory given lack of competition for resources and high animal densities.

Habitat Suitability with Potential Release Areas – Glen Affric

Both the field survey and vegetation index mapping demonstrate that there is a suitable habitat especially along the southern shore of Loch Beinn a Mheadhoin and upper River Affric (Figure 6, 22-25). Mixed woodland lines this loch and the River Affric throughout, including loch bays deep with birch and good understorey. Smaller Lochans such as Coire Loch also offer areas of expansive mixed vegetation and may function as release points, noting animals may disperse into the main loch body.

Moving into Loch Affric, the habitat quality does decline mainly as vegetation cover becomes sparser, both in coverage and density. This loch is fringed by open heath, with deer grazing a significant feature. Many patches of woodland are deer fenced, with the loch inflow and majority of the northern shore devoid of tree cover. Significant planting effort has occurred along the length of the southern shore and along some of the burns flowing into the loch. Young birch, rowan and aspen line these burns and some bays, however much of this planting is some distance from the shoreline. The burns are relatively steep although could be accessed by beavers and given the high-quality food in comparison to the rest of the loch this would be likely. There are potential damming sites along the burns, however the likelihood of beavers doing so, and maintaining such dams over the winter/spring period, especially at low population density, is questionable. Shorelines are predominantly bedrock which is steep and inaccessible in parts, though well wooded bays exist with more accumulated sediment which may support burrowing. Beavers are strong and capable burrowers and will readily create burrows and lodges in banks with modifiable substrate but they are also capable of forming lodges based around crevices in rocks and building structures outwards. It is presumed they would readily discover suitable locations throughout the site for lodge and burrow creation. Water level fluctuations around these structures would be a bigger issue than ability to find sites for lodge creation.

Both Loch Affric and Loch Beinn a Mheadhoin could act as release points, for a pair or family unit each, or a combination of singletons most likely based on establishing 3 pairs. Note small lochans associated with the lochs, namely Loch Salach a' Ghiubhais could act as a release point during late spring to late

summer releases to ensure there is enough vegetation available for them to either establish or disperse into the main loch below without being immediately released 'on top' of unknown individuals. Following establishment, it is highly likely beavers would occupy the shoreline areas of the loch, focusing activities in well wooded and more sheltered bay areas. Shelters would be created in steeper banks which offered either earthen sections and/or crevices in rocks or under tree roots. Most activities would be visible along the shoreline, and most likely within 30m of the shoreline and likely to be most visible as felled trees.

Figures 23 & 24. River Affric predominant bedrock banks restricting burrowing, though pockets of earthen banks are present and could be utilised, with lodge building more likely. Sections of deeper water present with dense mixed woodland lining river.

Figures 25 & 26. General bankside vegetation Loch Beinn a Mheadhoin – mixed broadleaf with diverse understory during present during late spring and summer.

Figures 27 - 29. Shoreline associated with both lochs, noting stoney banks exposed regularly at low water, this will undoubtedly influence shelter construction and habitat use around the shoreline. Beaver activity is likely to be concentrated in bays which are easier to access.

Figures 30.

Figure 31. Loch Affric would represent the upper point of any beaver release, for a pair or small family group. Any release should occur in a wooded bay with vehicle access.

Figure 32. Loch Salach a' Ghiubhais draining to Loch Affric could be planted up and act as a release site for a pair or singletons, especially in spring/ summer months to allow for acclimatisation and ensure unknown beavers are not released in close vicinity to each other, though deer grazing on both any planted trees and beaver coppice are likely to be significant practical considerations for permanent colonisation.

Potential challenges to beaver restoration and long-term colonisation are most likely to include water level management, with sudden and or prolonged drawdowns by SSE a concern. Water levels are typically maintained to ensure fairly constant levels though fluctuations can be significant, resulting in large sections of exposed bedrock along the shoreline. Any beaver shelters could readily become exposed but this may also influence access to forage and restrict area available for suitable for shelter creation. Pre-release talks with SSE on the potential graduated drawdowns and avoidance of significant fluctuations throughout the year would seem prudent.

It is evident that riparian woodland cover varies between the two lochs, with Loch Affric being much more sparser and visually less diverse. Consideration of winter food availability, especially during prolonged winters with snow coverage. An additional consideration is deer impacts, especially on beaver coppice, as they typically selective feed on these. Such competition could have a limiting factor especially in Loch Affric and smaller associated lochs which could otherwise function as potential release sites. Deer competition seems less of an issue in associated with Loch Beinn a Mheadhoin, though this should be monitored.

Potential sources of conflict with beaver presence appear low overall, with any monitoring efforts and mitigation fairly targeted and reactive. Nationally scarce lichens are a noted SSSI feature in Glen Affric (including *Bryoria furcellata*, *B. capillaris* and *Calicium parvum)*. Current lichen populations or mapping are unknown for this report though areas with species of concern within tangible foraging range of beavers should be monitored and stands fenced off if of real concern. Though it should be noted beaver foraging range, especially given shoreline gradient in many parts will be fairly restricted, with habitat suitability maps providing an indication of maximum likely range. There may be concerns over rarer

tree species or important stands such as Aspen, which again could be mapped to determine within likely foraging range and mitigation need assessed. It should be noted any deer fencing in the riparian zone may not be effective against beaver foraging and should be checked as growth inside may be especially attractive to beavers. Fencing could be readily improved retrospectively to exclude beavers if required.

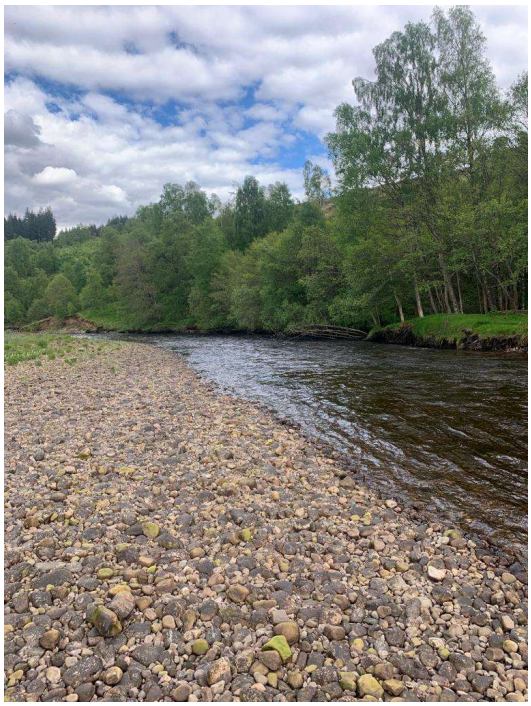
The vast majority of access roads, public paths and any infrastructure (such as bridges) are located a significant distance and/or alleviation from the water course. Therefore, realistically potential conflicts such as tree felling onto structures, restricting access, burrowing or damming activities leading to the f undermining or flooding of access are highly unlikely. Bridge areas and water side paths for example typically site well above the water course and/or have limited trees immediately likely to cause impacts, with structures in bedrock. Any areas of concern could be further mapped and risk assessed, most likely focusing on trees with preventative mitigation such as tree guard application or tree coppicing put in place. But to emphasis this seems low risk and could be readily reactive to beaver habitat use post-release.

It should be noted that the numerous small tributaries feeding both these lochs are steep gradient, flashy and shallow, therefore the capacity for damming is very low – with the vast majority scoring none, rare or occasional. Concerns over migratory fish impacts can therefore be confirmed as non-existent to low. More southern tributaries would have capacity for damming, this is increasingly likely as populations rise and/or if water level fluctuations encourage beavers to create more stable water level environments away from the main loch shoreline. The impacts of any damming in such water courses could be monitored for impacts on migratory fish though it should be noted that on such narrow and steeper tributaries and given these are lined with native woodland, water will typically work its way around any dam and cut new by-pass channels. Clarification on fish records and populations in this section worth further investigation.

Habitat Suitability with Potential Release Areas – River Glass and Beauly

This stretch of catchment includes the River Affric, River Cannich, River Glass and upper River Beauly to the Aigas dam, including the mouths of tributaries entering the main stem of these (noting the River Farrar was not included though quick visual assessment suggests suitable habitat present in lower section at least). Both the habitat suitability modelling and field sign survey confirm that habitat on the whole and throughout this catchment ranges from suitable to highly suitable for beaver occupation. These rivers were fairly consistently wooded along their courses, with lower stretches including reed beds and areas of wetland. Alder is the dominant species, especially in the upper regions of the Glass and Beauly, with some Alder die back reported. However, this is not a favoured species by beavers though they will utilise especially if other species lacking. In areas of mixed woodland including willow, rowan, birch with some oak. Current beaver activity does focus on willow areas. In many areas understory vegetation is also diverse where grazing doesn't occur including reeds, grasses, bracken, iris, brambles etc – all of which beavers will readily forage on. Bank structure ranges from bedrock, stones, sand to earthen. This will influence beaver distribution, with animals most likely to select earthen and wooded sections first. Hydrology, especially water level fluctuations and peak flow rates should be considered as these will also likely influence distribution and habitat use. For example, some beaver territories on the River Tay and Earn in which water level fluctuations can vary rapidly by several feet display adaptive behaviours and activities. These include lodges and burrows built higher and/or

dug further back to compensate and to allow retreat into upper sections of shelter with rising water levels. It is predicted similar adaptive behaviours would occur, though beavers do prefer areas with more stable water levels. Though even on days of survey it was evident dam drawdowns did fairly quickly raise water levels noticeably by a few feet but these subsided fairly quickly. These features are controlled by SSE water management regimes, further engagement may be useful to determine if extreme fluctuations are a likely concern. Noting vegetation growth lines and observed high and low water levels during survey suggest lower conditions expose both gravel and sand beach like shorelines in parts, whilst higher levels stay within channel and so present much less challenging conditions in comparison to Glen Affric.



Figures 33 & 34. River Glass near has good stretches of suitable to highly suitable habitat, including mixed woodland, shoreline is stoney in parts but also has good sections of shallow earthen banks.

Figures 35 & 36. Large sections of the River Glass and upper Beauly (upstream of Agias Dam) provide highly suitable habitat – both in relation to forage diversity and availability, suitable banks with slower and deeper water. Mixed woodland is present, with commercial plantation typically situated away from the water. The majority of land-use is also set back from the water with rough grazing the main agriculture practice. Fish beats consistently line the river bank which in general have little public or vehicle access.

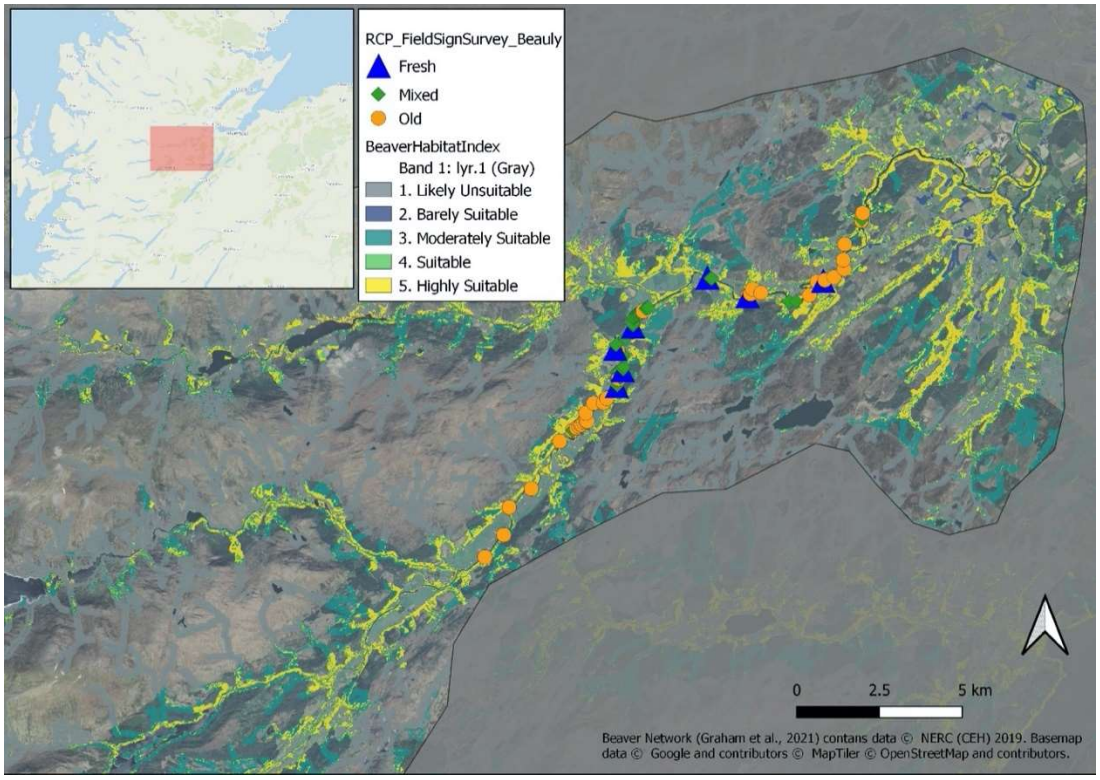


Figure 37. Catchment scale overview showing recorded field signs for Beauly relative to modelled location of beaver habitat. Noting that current beaver activity is focused in areas categorised as highly suitable but also current colonisation is downstream with much highly suitable habitat unoccupied.

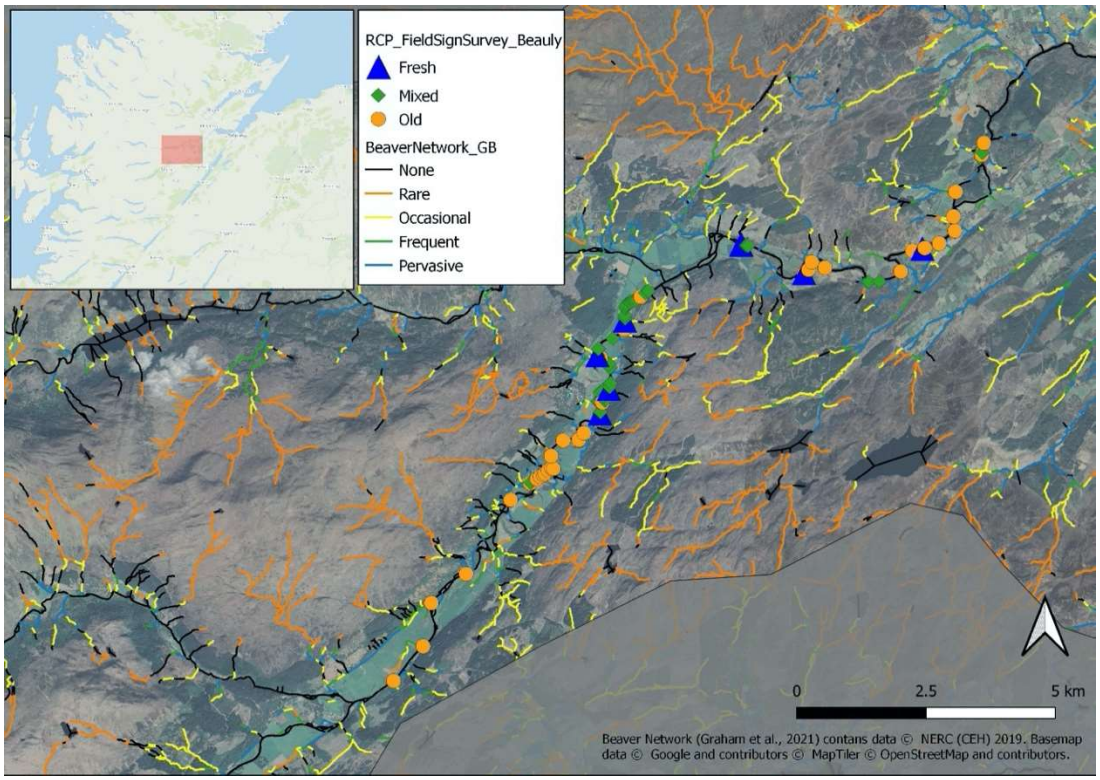


Figure 28. BDC in the Beauly relative to recorded field signs. Contains Ordnance Survey data © Crown Copyright 2007. Some features derived from digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH). Noting the vast majority of tributaries categorised as unsuitable for beaver damming. Any future damming is more likely to occur over the long term in areas just off the main Beauly stem already occupied by beavers or in the lower River Cannich which beavers can currently access.

The dominant land-use associated with the River Glass and Beauly, next to woodland /wetland areas, is rough grazing (sheep and cattle) and fishing beats. Both of these interests could experience limited beaver impacts, mostly likely as inappropriate tree felling and unwanted burrowing to undermine banksides or tree roots. Bank erosion is occurring naturally and is evidently more obvious in grazed areas and banks with little vegetation cover. Beaver activities could of course accelerate this process in limited areas, although beavers will naturally favour wooded banks for burrowing and these are more resistant to being undermined due to the binding effects of root systems. Wider riparian restoration would not only serve to reduce potential beaver impacts in these areas but also serve to deliver multiple wider benefits e.g. sediment retention, bank stability and biodiversity. Such banks would also benefit greatly from livestock exclusion. As project partners, TfL could be well positioned to collaborate and assist landowners to increase bank resilience whilst reduce beaver conflicts.

Figure 39. Streches of the Beauly especially have think tree cover, typically Alder dominated in which rough grazing occurs immediately behind, and typical which livestock have access. They still provide suitable foraging for beavers, though tree felling in these sections may generate very localised conflict through both visual impact of loss of trees but also potentially associated with erosion. Though it should be noted many of these trees are in a process of falling into the water course with no potential of regeneration due to livestock grazing.

There is very limited property or infrastructure (bar hydro dams) directly associated with this catchment section. No likely impacts of beaver activity on property are presumed based on both distance and height above river courses. Given proximity of some gardens and /or broadleaf planting lining small sections of the Glass and Beauly, some foraging may occur with protection of ornamental trees required in time. It should be noted an active beaver territory has existed for several years in close proximity to two/three properties feeding largely on willow present there. Reports of beavers feeding near gardens in Cannich have been reported. To these authors knowledge these have not been extensive or reported as conflicts. A property with previous beaver activity did experience tree feeling conflict. Regular

engagement with any properties having concerns or at risk of losing trees of value should be engaged and supported. Given the limited number, this is expected to be manageable. The field survey did not determine many obvious amenities that could be impacted such as electric power lines or septic tanks. Small sections of road, namely the A831 and the Eskadale road do run in very close proximity (within foraging range) of beavers. Given the long-term presence of beaver activity in the areas, road height, and bank slope associated with wooded sections, any tree felling should result in trees falling river rather than road side. Very limited areas of wooded back waters in close proximity to the Eskadale road, in which beavers are currently active, should be monitored should beavers begin to cross the road to forage and reactive mitigation implemented. Note in comparison to Tayside such areas of potential concern are negligible, e.g. A923 running alongside large sections of Loch of Craiglush, Loch Clunie, Lunan burn and Rae Loch, all with many years of beaver activities. Over time, the most likely beaver and road concerns would be dispersing animals attempting to navigate hydroelectric dams, which again could be mitigated with short sections of fencing to funnel animals away from the road and potentially back into the river beneath.

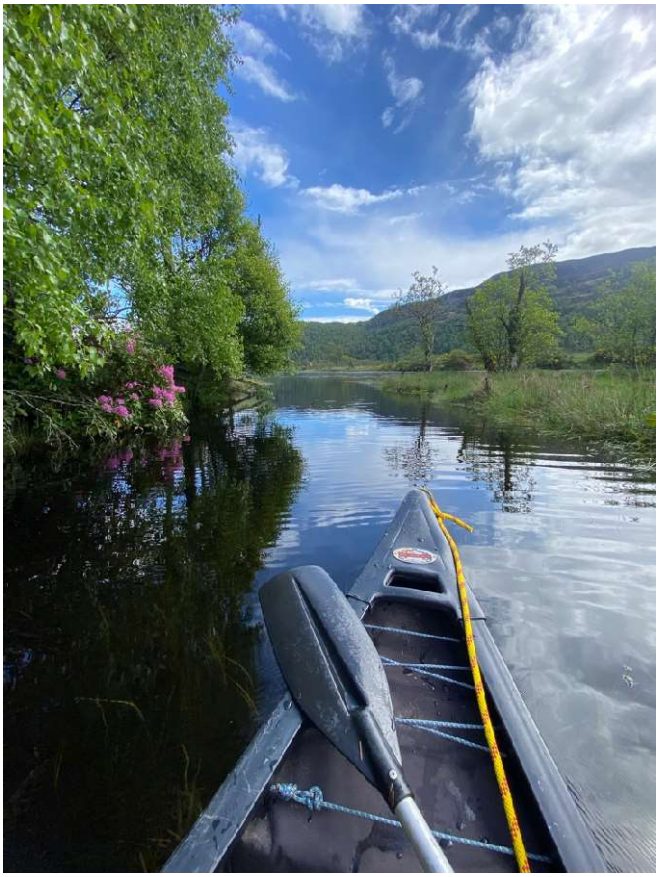


Figure 40. Beaver activity (past and current) tend to be associated with sections of the main river stem with back waters and ox-bows, one of which has been subject to previous reported conflicts. Based on tree felling.


Figures 41 & 42. Backwaters downstream of the mouth of the River Farrar and Erchless Burn, and downstream from the very active beaver territory around Struy, could offer a release point for singletons or a pair, providing suitable areas and space for retreat but may also encourage mixing and increase genetic diversity over time. It would also seem prudent to release a pair / singletons upstream of the current activity. Habitat wise, the wetlands associated upstream of Carnoch wood would offer a suitable release area but also enable animals to move away from each other. Note the water course at both is wide and deep also allowing animals to move away from each other whilst still being able to move into unoccupied or infrequently utilised (based on age but also density of field signs).

Release Considerations

Potential Release Areas and Animal Composition

There are many considerations for release areas selection outside of the scope of this report such as land owner permission, vehicle access to water course etc. Therefore, the release areas here are proposed based on suitable habitat and current absence, or very low levels of beaver activity. It should be emphasised that any release into a linear river system is highly likely to see fairly rapid dispersal and wider exploration of the water course. This should not be considered as a negative, with habitat selection by the animals themselves an important part of long-term colonisation success. In addition, the beavers currently in the system are suspected to be closely related, so some level of mixing and disruption may be highly positive for genetic health. Saying that, direct release into active beaver territories presents a welfare challenge to both the released and resident animals and should be avoided. Any released animals are likely to move, especially downstream, and are likely to interact with resident beavers, a fact which is out of human control. Therefore consideration should be given to the relocation of family units into any lochs or larger backwater areas to try and encourage families remaining together and finding each other post-release, while greater consideration of either established pairs without dependent offspring and singleton adults/sub-adults (~2 years plus) being released directly into river sections (these could be over several releases) and being allowed to disperse at will. Note that if beavers are proven to leave a release point between release events then this site could be used again. In order to successfully establish a healthy and robust beaver population, capable of long-term survival then founders should be taken from several trapping sites and across a number of rivers, but also be realistic in numbers to allow for either dispersal, fatalities and to enable pairing and breeding, whilst also avoiding 'over stocking' and immediate territorial disputes.

Therefore, the following release areas and potential animal release compositions are proposed;

Area	Singleton	Pair	Family unit	Status
Loch Affric		Yes	Yes	Vacant
Loch Beinn a' Mheadhoin			Yes	Vacant
Associated lochans (potentially 2)	Yes	Yes		Vacant
Abhainn Deabhag	Yes	Yes		Vacant
Lower River Affric	Yes	Yes		Vacant
Lower Farrar / River Glass around	Yes	Yes	Potentially	Vacant – limited old field sign
Erchless burn	Yes	Yes		
River Beauly around Knocknashalavag or Eskadale or Carnoch Wood	Yes	Yes		Beaver activity – some fresh with mainly old signs noting meeting likely but space to move, and sub-adults likely present
Total potential number based on pairs (excluding any dependent young)				~ 12-16 animals across potentially a min. of 5 release points

Potential Conflict and Mitigation Considerations

A gross assessment of potential conflict issues was made, this involves a level of subjectivity, based on experience of beaver activities and neighbouring land-use, especially as population densities increase. Note no obvious management impacts due to existing beaver presence were observed during the field survey. However, these authors are aware of previous reported tree felling conflicts, though fairly limited in extent, these most likely contributed to the implementation of wider calls for trap and removal given the ScotGov stance on not tolerating unlicensed beavers outside of the Tayside catchment and Knapdale project. As far as these authors are aware no conflicts have been raised since. Though beaver presence, especially in off-channel ponds or private ox-bows may conflict with some landowners, especially as these areas may have specific usage such as garden areas, plantations or duck ponds, in which beaver presence may not be welcomed. Such sites may require mitigation such as tree protection which could be readily implemented as required.

It is highly likely that beaver activity will be relatively limited to the immediate river shoreline, therefore tree felling and burrowing could be the most likely potential conflict to a small number of land owners, though very localised. There are few public paths or vehicle access routes along the river bank, so undermining due to burrowing or restricted access due to tree felling is highly unlikely. Some fishing beats do have limited boardwalks and worn paths to access banks which have the potential to be impacted at some point. These are likely to be continually monitored given regular use so mitigation could be reactive such as tree protection or coppicing, wooden board walk protection with metal mesh protection or burrow infilling if and as required. Support with such mitigation requirements seems sensible and could go a long way to reduce potential conflict.

It is likely given the significant fisheries interest in this area and various existing management regimes especially for salmon, that concerns may be raised by this sector that beaver damming may impede both upstream and downstream migration. Damming is unlikely to be a significant issue with limited water courses physically capable of enabling dam construction with most damming likely to occur in

the tributaries of the lower reach below both the Aigas and Kilmorack dams. The upper reaches of the River Affric and Glass are comprised of numerous tributaries which appear overall mostly unsuitable for damming by beavers, either being un-dammable or the likelihood of dam construction is rare. There are however a number of smaller sections where dams might be constructed. The Abhainn Deabhag, which flows through Tomich and joins the River Affric upstream of Cannich to become the River Glass, has a much greater chance of dam construction occurring over time. Given the topography of the tributaries, with steep gradients and rocky beds, dam construction is unlikely to be a major issue within the catchment and is unlikely to prove a significant issue when it comes to fish passage. It would however be advantageous to discuss this with Beauly Fisheries Board and obtain up to date salmonid records for the area to identify key spawning tributaries and areas of high concern and cross referenced with both the beaver dam capacity and habitat suitability modelling.

In the upper/middle reaches of the Beauly where beavers are currently present, the topography of the tributaries makes damming unlikely in this area and where damming might be possible, the habitat availability is poor, again making damming an unlikely significant management issue (Figures (BDC & HIS). It is likely, given the significant fisheries interest in this area and various existing management in place especially for salmon, that concerns may be raised by this sector that beaver damming may impede both upstream and downstream migration. Recent research from Norway found that beaver damming did not negatively impact the juvenile stage of salmon and trout populations as dams did not block the movement of salmonids (Malison and Halley, 2020). In Oregon USA, following the installation of beaver dam analogues, scientists observed significant increases in density, survival and production of juvenile steelhead without impacting upstream and downstream migrations (Bouwes et al., 2016). Despite this knowledge and due to the density of anthropogenic structures already in place on the river Glass and Beauly it may be prudent to communicate with the Beauly Fisheries Board to discuss their concerns.

Potentially the most significant impact over time could be associated with bank erosion on the main Beauly stem. This would be very limited to banks with certain characteristics which could be readily mapped and vulnerability assessed. Though it is important to recognise in any such assessment both the likelihood of beaver use (e.g. are they suitable for shelter construction, do they offer attractive forage), along with current erosion processes (e.g. sandy banks, lack of vegetation, livestock poaching). Certainly, with such features beaver burrowing could exacerbate erosion rates, but it is evident that this process is already occurring on the river. Replanting sections of bank and excluding livestock would help to build bank resilience against erosion.

Figures 43 - 45. Certain sections of the main Beauly river stem are already exposed and subject to erosion, predominantly associated with livestock grazed and access to banks. Such banks may be attractive to beaver burrowing and would be easy to construct, however, the attractiveness of the banks to beavers is also highly likely to be influenced with accessible vegetation. Open heavily grazed banks with few other features are likely to be utilised less often than those with suitable forage, which in turn may be more resilient to burrowing.

The anticipation of potential conflict does not negate or dismiss the possibility that such beaver activity could be perceived to have benefits to others, i.e. a beaver dam, resulting in localised flooding on private land may be recorded as a high management impact. However, as shown in numerous studies (see Brazier et al. 2020 for a recent review) this same dam may bring significant biodiversity and hydrological benefits. Weighing up the costs vs. benefits of individual beaver impacts is important but is beyond the scope of this study.

Further Potential Release Areas and Colonisation Scenarios

Middle Beauly – referring to the stretch between Kilmorack and Aigas Dams. Note this section of the main river stem appears currently free of beaver activity (noting survey undertaken in 2017 by RCP and KW, and 2022 by NatureScot), though beaver presence exists up-and downstream of these points. This may be considered as a reflection of potential beaver escapees rather than completely due to inaccessibility which may change in relation to population density pressure, largely upstream. Aigas dam may be navigable should dispersing beavers in time circumnavigate the dam especially via the road. This river section is heavily wooded throughout, with a deep buffer of riparian vegetation. The water is slow moving and deep, though water levels fluctuation would need to be scrutinised in more detail, superficially they appear more stable. Banksides are steep and dominated with bedrock and looser stones. There are few tributaries entering this section, with any that do fairly immediately forming steep water falls, with less suitable habitat upstream, with further beaver colonisation unlikely. Direct release into here may in effect form a largely enclosed population given the more likely difficult upstream dispersal, and with downstream dispersal likely to be hampered by another significant hydro dam at Kilmorack. These hydro-electric dams have a fish ladder and a fish lift between them, both of which are fairly formidable barriers to any dispersing animals further likely encouraging beavers to use the road to circumnavigate these structures. Therefore, future mitigation fencing to funnel animals around the dam may be a serious consideration.

Lower Beauly – referring to the stretch between Kilmorack and Beauly Firth. Note this section of the main river stem has known beaver presence, particularly associated with the river around Beauly. The river varies in this section but is generally wide and well wooded, with increased fishing interest and more urban areas than in the rest of this catchment. The river ranges from wide and shallow, with more rocky banks to slow, deeper water with extensive reed beds. Rough grazing is also present in sections, along with private estate managed woodlands and public paths. More tributaries offering potential beaver habitat are present and could be readily colonised, including supporting more damming activity than those in the upper Beauly. Mixed broadleaf, including willow with reed systems are present throughout. Potential for conflict could increase with rising beaver densities but this is not predicted to be extensive, and could be mitigated with appropriate resources and application. Beaver presence could ddemonstrate the importance of beaver activities in creating sustainable landscapes which deliver ecosystem services including water storage, reducing flood events, improving water quality and retain silt discharges, if tolerated.

River Farrar and associated lochs – this is a significant tributary to the north of the River Glass and Beauly, which seems partially wooded, though livestock grazing is a reported issue along with low water flow/drying out of some minor burns (Beauly Fisheries Board). Many of the more significant burns in this system are very stoney, predominantly rough grass land, rising steeply and generally unsupportive of wider beaver colonisation. Any future livestock exclusion fencing, deer control and riparian tree replanting programme may increase some potential beaver colonisation range in time. Habitat initially appears better in the lower River Farrar but habitat suitability and OS mapping suggest tree cover becomes increasingly patchy though there may be suitable patches of mixed woodland habitat with more stable water. Three lochs are present, Loch Monar, Loch Beannacharan and Loch a'Mhuilidh, these may be investigated by dispersers in time but habitat suitability is low so long-term colonisation seems unlikely. Deer grazing is likely to be an ongoing consideration.

Long-term Population Considerations

Considering the area from a whole catchment and future colonisation potential, connectivity to other catchments is generally hampered by both topographical and artificial features. Any beaver populations are very likely to be restricted in time with inter catchment dispersal potential fairly low, noting that much larger populations could be supported over many years before this becomes a consideration. Neighbouring catchments include the Ness to the south and the Conon to the north and dispersal is highly likely to be significantly restricted due to two typical upper catchment habitats such as very steep gradients, bedrock dominated and shallow fast flowing tributaries emerging in upland environments with limited connectivity, rougher terrain and extent of unsuitable but typically upland habitat. Vegetation wise, these are fairly barren, heavily deer grazed and offer little suitable habitat. Though if traversed, could enable beavers to enter. The most likely route for any dispersers, especially with increasing population pressure, would be via some of the southern tributaries of the River Beauly, especially via the lower Beauly and into the Ness catchments, there may be chance of dispersal via southern burns of Benevean in time in theory too.

If beavers do reach the sea then dispersal along coastal stretches is viable, especially over shorter distances and where tidal energies are generally lower.

Conclusions

Overall habitat suitability is presented across both Glen Affric and upper River Beauly, with beaver presence already demonstrating preferred habitat. Beaver restoration would not be without its challenges, with probably the most significant consideration being future population spread and connectivity. There is no doubt both natural and artificial features will influence dispersal potential and in time likely to force dispersers to access steep tributaries or attempt to traverse significant hydrological dams (which could bring them into conflict with roads, though this could be mitigated with fencing). Saying that the extent of suitable habitat could ensure a viable translocation option for several pairs and families groups otherwise subject to lethal control, in addition to the multitude of positive biodiversity benefits and ecological services. Potential conflict appears low given river characteristics and riparian land use. Further stakeholder engagement would be essential to highlight any concerns further and develop accessible mitigation if and as required. Such mitigation is likely to be largely associated with tree protection and potentially burrowing impacts – though these are likely to be very localised issues and highly dependent on landowner. Given that beavers could have been present in this area for ~10 years the reported impacts and conflicts are very low. This may be representative of small numbers, stakeholder acceptance of presence and/or lack of conflicts in practice. Impacts of other large herbivores (deer and livestock) should also be considered as these may significantly impact on tree regeneration. While Fishing interests may be cautious over beaver releases, damming and impacts on migratory fish species are not likely to be significant. However, further discussions on the likelihood of damming, with modelling a useful tool to highlight sensitive areas, would be very worthwhile. Though outside the scope of this study, successful restoration and positive stakeholder engagement could act as a model for further future releases in the rest of the Beauly river and link existing animals in the lower catchment.

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