Appendix 5

Assessment of Likely Risks

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Date	5.07.2019
Date of next review	31.10.19

Assessment of risks arising from beavers in the River Otter

Introduction and purpose

This Beaver Management Strategy Framework is underpinned by a detailed assessment of the risks that arise from the activities of beavers in the River Otter. This full Risk Assessment is tabulated below (Appendix 5a).

This Risk Assessment builds on work carried out as part of the development of the River Otter Beaver Trial, which also included a Risk Assessment and Management Strategy. This provided an iterative framework for the resolution of complaints and management of conflicts for the five-year Trial period.

This revised Risk Assessment now incorporates and quantifies the conflicts that have been experienced during the Trial, as well as learning from other countries where beavers have been reintroduced. This process, which has been overseen by the ROBT Licencing Group and Steering Group, has helped to inform the development of this Beaver Management Strategy Framework.

The Risk Assessment now includes the principal risks associated with both an expanding wild beaver population in the River Otter, and those immediately adjacent catchments where recolonisation may naturally occur. Its scope is restricted to the risks and conflicts that can arise from the behaviour of beavers and does not reference the multitude of positive benefits that may also be derived from the same activity.

In managing any beaver conflicts, the potential benefits which arise must also be considered, and a final decision made with this holistic understanding of the pros and cons. For example, a beaver dam may submerge a fence-line reducing the lifespan of the posts and reduce available grazing land, but in doing so, may demonstrably reduce the flood risk to a community downstream. The associated management decisions will need to be made on case by case basis but be informed by empirical evidence such as that collated by the University of Exeter for the River Otter and beyond.

The Risk Assessment is presented as a table that arranges the risks by the behaviours of the beavers and the impacts that they can have. These risks are then complemented by information regarding:

- examples of impacts that have been experienced in the River Otter and elsewhere;
- the associated tried and tested mitigation options;
- the likelihood and severity of impacts are assessed; and
- the risk weighting based on a Red, Amber, Green scale.

Additional background information

Additional information and analysis is also provided here. This document should therefore be read alongside the full Risk Assessment (Appendix 5a). It is laid out under the following four headings:

1. Land-use and agriculture adjacent to the River Otter;
2. Dam Building and raising water levels;
3. Burrowing;
4. Feeding and tree felling.

1. Land-use and agriculture adjacent to the River Otter and tributaries

For the purposes of this strategy Devon Wildlife Trust commissioned Devon Biodiversity Records Centre to carry out a GIS based analysis of areas of potential conflict that may arise in the River Otter.

A 30m buffer has been overlain on either side of the watercourses within the catchment and the extent of different land-uses calculated (see example aerial photo right).

The results are shown in the table below (figure 5.2) and the key points are summarised as follows:

- There are 594km of watercourse within the catchment (including 124km of main river). A 30m buffer on either side creates a total area of 3,378ha.
- Within the catchment, 22% of the land-use within this buffer is in arable production, and this rises to 27% in the Tale tributary.
- The Budleigh and Knowle Brooks have significant areas of forestry plantation within their 30m buffer; 10% and 8% respectively.
- Throughout the catchment, 46km of public right of way are close to watercourses.
- Only 1% of the 30m buffer is orchard, in the Knowle Brook and Gissage areas.

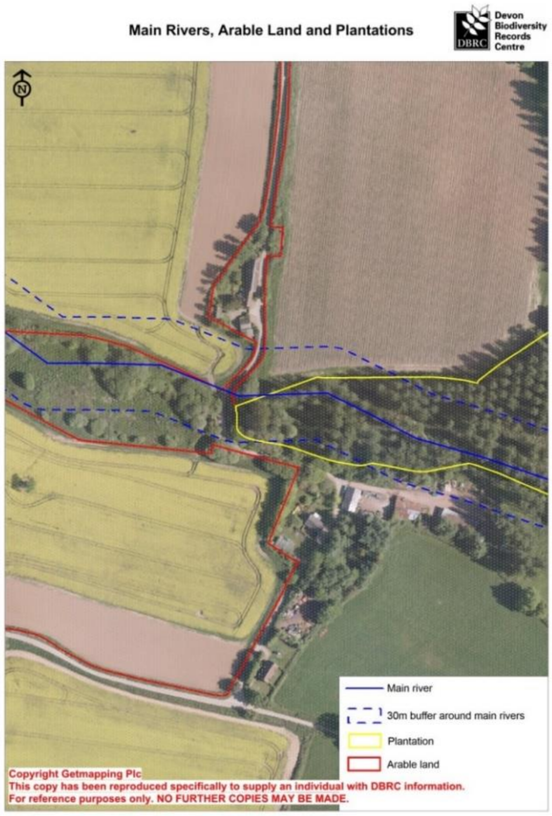


Figure 5.1 – Aerial photo of part of the river showing land-use within a 30m buffer

Figure 5.2 – Table showing breakdown of land-use within 30m buffer alongside the different River Otter sub-catchments.

Watercourse within River Otter catchment	Length of River (km)	Area of buffer (ha)	Length of PRoW (km)	Area of Orchard (ha)	%age of buffer	Area of Plantation (ha)	%age of buffer	Area of Arable (ha)	%age of buffer
Budleigh Brook	5.19	30.50	0.16	0.00	0%	3.05	10%	3.84	13%
Knowle Brook	5.02	30.07	0.59	0.19	1%	2.26	8%	0.79	3%
Love	8.77	51.81	0.96	0.08	0%	0.00	0%	6.62	13%
Otter	81.26	479.70	8.93	1.74	0%	8.01	2%	73.36	15%
Otter (Gissage)	3.45	20.46	0.00	0.14	1%	0.00	0%	4.71	23%
Tale	14.04	83.29	0.77	0.10	0%	0.13	0%	22.30	27%
Wolf	6.23	37.02	0.11	0.00	0%	0.00	0%	3.01	8%
Total Main Rivers	**123.96**	**732.85**	**11.52**	**2.25**	**0%**	**13.45**	**2%**	**114.63**	**16%**
Ordinary Watercourses	**470.46**	**2645.00**	**34.37**	**15.98**	**1%**	**68.72**	**3%**	**621.83**	**24%**
Total (all watercourses)	**594.42**	**3377.85**	**45.89**	**18.23**	**1%**	**82.17**	**2%**	**736.46**	**22%**

2. Dam building and changing water levels

The scale of beaver dams is highly variable ranging from a small collection of mud and sticks impounding a few square metres of water, through to series of large semi-permanent structures with the capacity to divert watercourses and raise water levels within floodplains.

Many of the potential conflicts and benefits arise from this aspect of beaver behaviour, and their status as a ‘keystone species’ is deeply interrelated with it. To maximise the multitude of benefits arising from beaver activity, dams should be retained wherever possible. This will be facilitated through awareness raising of the benefits that will accrue, through landowner advice and management support, and through the proposed provision of Environmental Land Management (ELM) scheme payments.

Beavers construct dams across watercourses to impound water, providing safety from predators and to attenuate fluctuating water levels. Dams are also constructed to raise water levels to submerge and provide protection to burrow entrances. Entry to beaver burrows and lodges is always secured from under the water level which ensures additional security.

Dams create open, deeper water enabling beavers to explore their territory and exploit the available food resources. Beavers create networks of impounded water with connecting channels (beaver canals) between areas of deeper water and extending out to sources of food. Beavers will utilise existing features in watercourses such as fallen trees, weirs, and culverts as ‘foundations’ from which to build dams.

As the number of beavers has increased during the first four years of the ROBT, the number of dams has also increased as beavers move out of the main river channels. Many dams are ephemeral; in place for short periods of time, before they are washed away. Others have become semi-permanent features of the riparian landscape. Their impacts are similarly varied depending on their location and the land-users that are affected.

A database of the dams has been compiled as part of the ROBT, and more information about the number, character and location of dams will be presented in the Science and Evidence report at the conclusion of the Trial.

Of the >80 dams constructed fewer than 10% have caused any conflict. These have however provided an invaluable test bed to trial different mitigation techniques. These have included the following measures:

- modelling of flood risks and installation of gauge boards to enable dam retention;
- complete and repeated removal by the landowner, with the support from ROBT;
- installation of a flow device; and
- notching to aid fish passage.

Spatial Risk Analysis of dam building

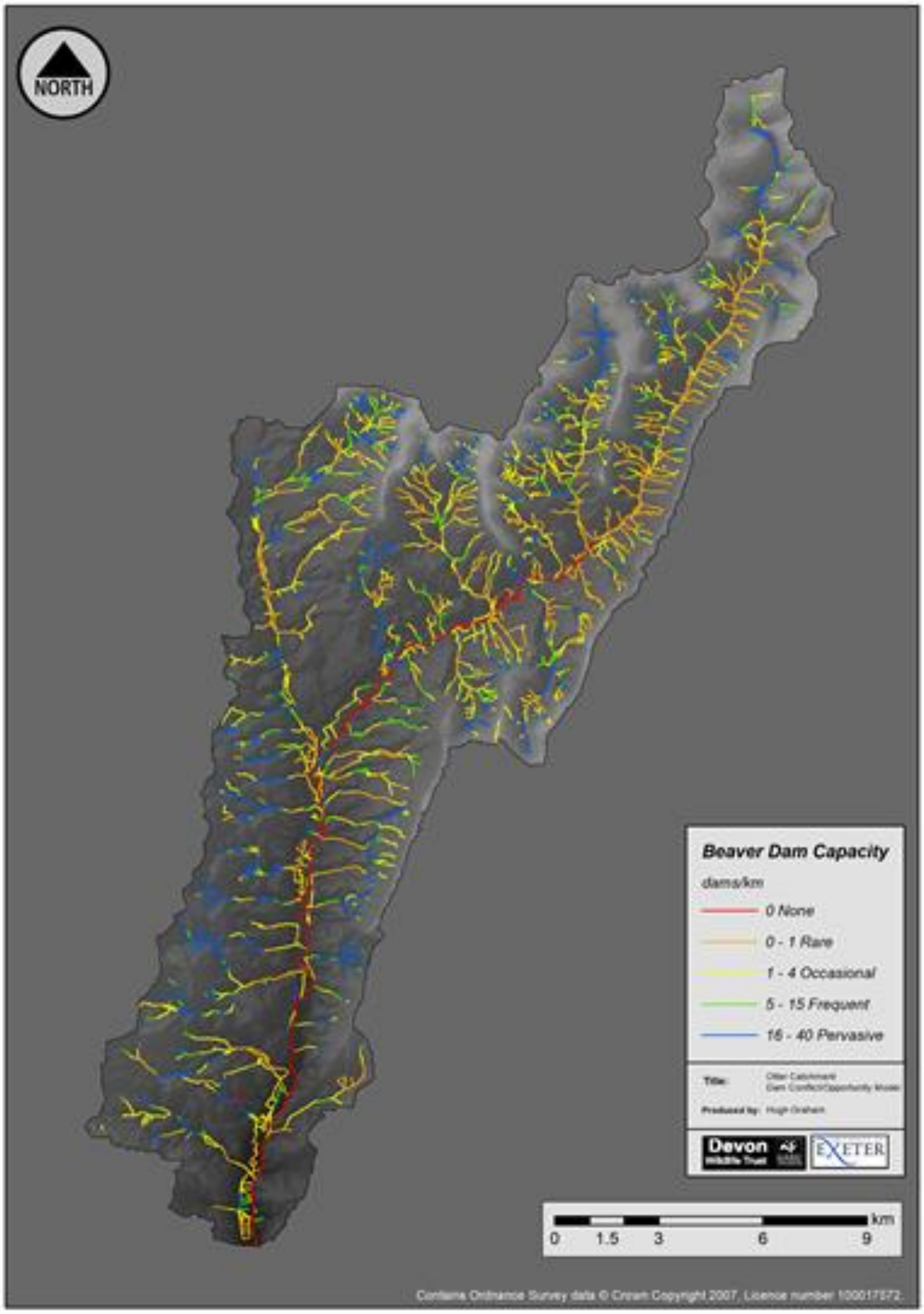
As part of the ROBT, the University of Exeter research scientists have developed and adapted a model to demonstrate which watercourses in the catchment have the capacity to support beaver dams. By combining this information with other datasets, it is possible to identify:

- those areas at greatest risk of conflict; and
- where beaver dams could be utilised to generate ecosystem service benefits, such as slowing flows and reducing flooding downstream.

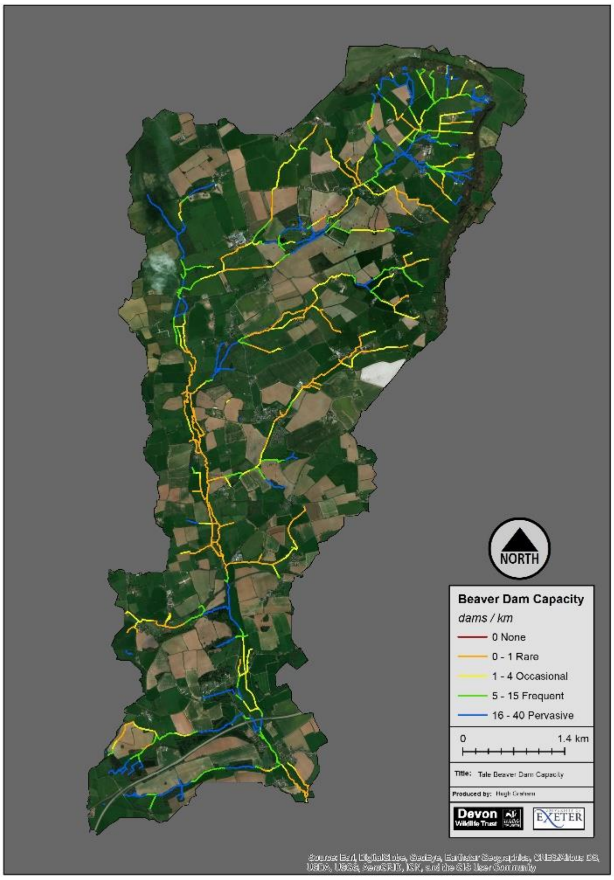
The **Beaver Dam Capacity (BDC)** model is constructed in Python 2.7 and utilises the ArcPy (from ArcGIS 10.5) geographic information system (GIS) module. A river network is split into <200m reaches. The surrounding vegetation suitability for beavers is determined for each reach, from a composite vegetation dataset. Hydraulic/hydrological characteristics are obtained from topographical data and a regional area-discharge rating. This information is then used to calculate the density of dams per kilometre that a given reach can support.

Figures 5.3 and 5.4 below show the capacity of the watercourses within the River Otter to support beaver dams. As well as being run and validated for the Otter catchment, it has also been applied to the Tay/Earn catchments in Scotland. Model performance has been found to be very reliable in correctly identifying the suitability of locations where dams have been constructed to date.

Figure 5.3 - Beaver Dam Capacity (BDC) model outputs for the River Otter catchment, showing the capacity of all watercourses within the River Otter catchment to support beaver dams. It is important to note that this model shows where beavers could build dams based on the physical environment, if they were living in these locations. The number and locations of beaver territories will influence where in the catchment, dams may be built.



Beaver Dam Capacity (BDC) modelling of the River Tale and Budleigh Brook tributaries.



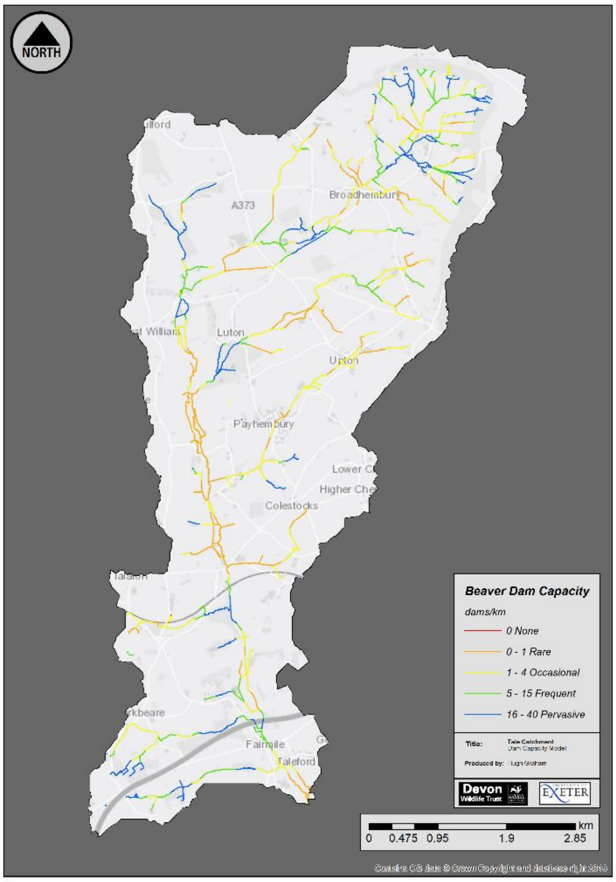
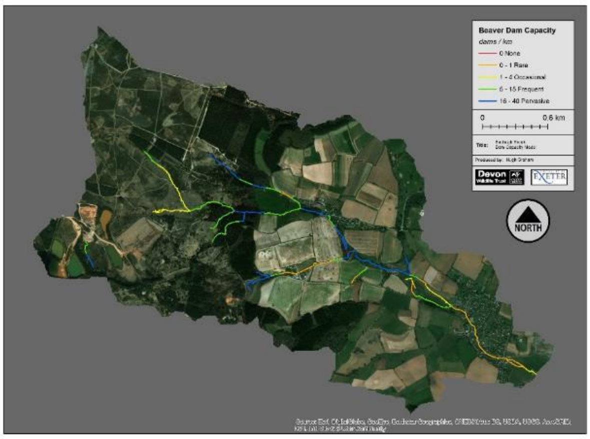
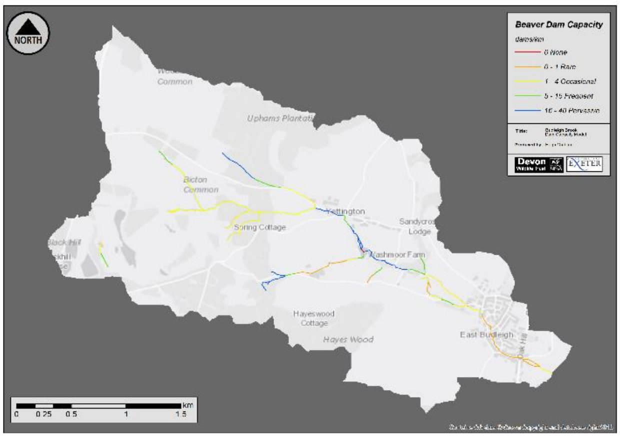


Figure 5.4 - These paired maps show the dam capacity of all watercourses within the Tale tributary (above) and Budleigh Brook (below), both part of the River Otter catchment. The results of the model are displayed on the aerial photos of the catchment (left) showing current land-use, and on an OS basemap (right). (© Crown Copyright and database rights 2012. Ordnance Survey Licence number 100022021).

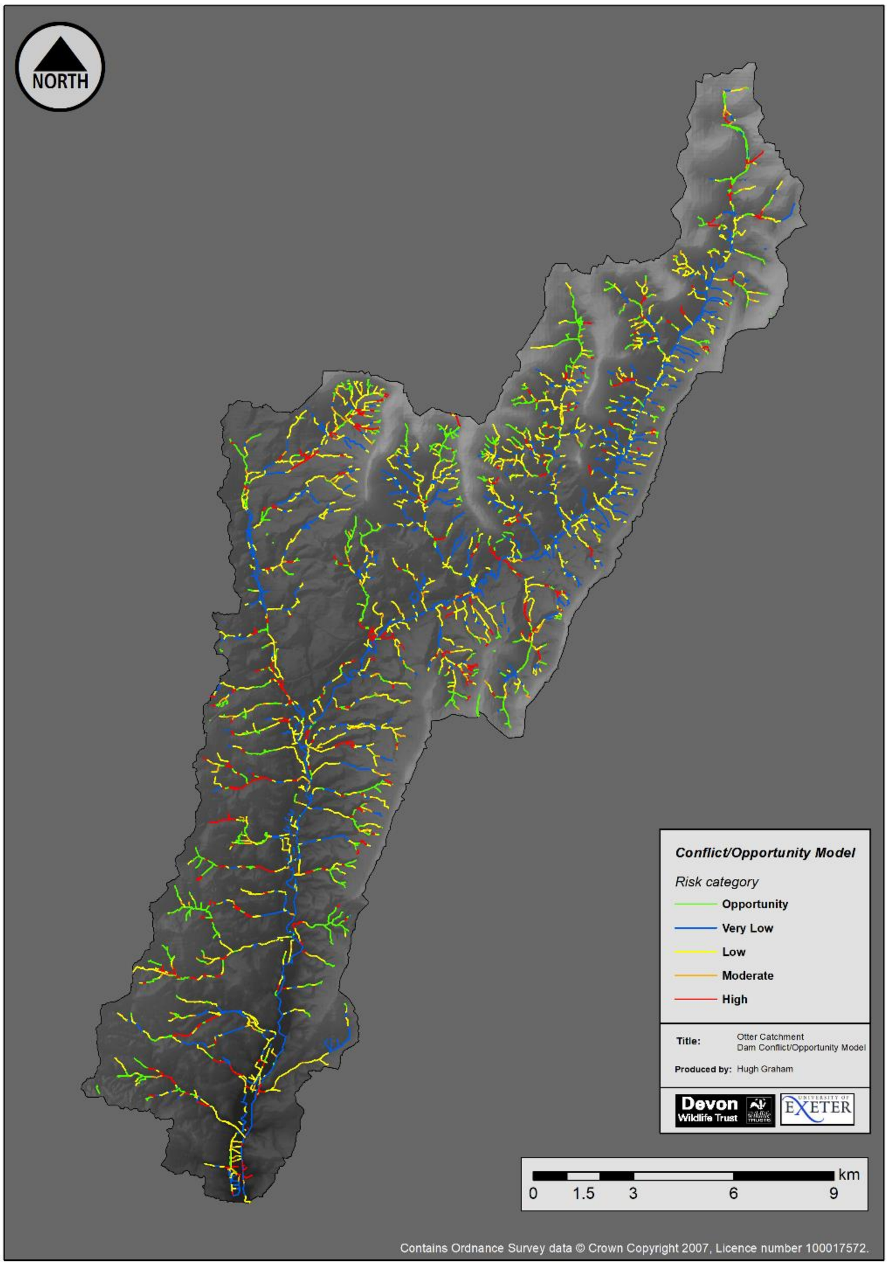




Dam Conflict modelling

A key element of the research underpinning the ROBT has been to classify different parts of the catchment according to the likelihood of conflicts occurring as a result of beaver damming activity. This information is balanced by identification of opportunity areas for ecosystem service provision.

Figure 5.5 – BDC conflict / opportunity mapping



This is achieved by combining landuse and infrastructure datasets with the Dam Capacity Model to identify likely conflict areas. From these outputs, it is possible to assess the extent of conflicts that might occur as the beaver population increases to fill the available territories. The tool could then be used to help inform the allocation of available resources to the highest risk locations and target the best locations for beaver colonisation to enhance the provision of ecosystem service delivery.

The results from the dam capacity modelling have been combined with the estimated valley bottom area data to present a spatial description of risk where channels that can support beaver dams may affect infrastructure or surrounding land use. The tool identifies the areas that may be at risk of localised impoundment of water due to the construction of a beaver dam.

If for example, key infrastructure or residential properties are present, and the channel can be dammed, then the reach is considered high risk. Where arable farmland is at risk of being dammed, the model apportions a greater level of risk if larger areas are likely to be inundated.

Finally, in those reaches where surrounding land is not considered to be of high agricultural value or natural/semi natural conditions occur and dam capacity is high, the reach is considered to represent an area of opportunity where beaver activity could be encouraged (with landowner support).

The flexible design of the model allows for other new spatial datasets to be incorporated easily, and for different conflict types to be prioritised.

Due to the lack of reliable information on fish populations within the catchment, it hasn't yet been possible to identify stretches where conflict with fish passage might require intervention, especially at key times of the year when fish are migrating. A new PhD has however recently been commissioned between the University of Exeter and Devon Wildlife Trust that will explore this risk modelling in detail.

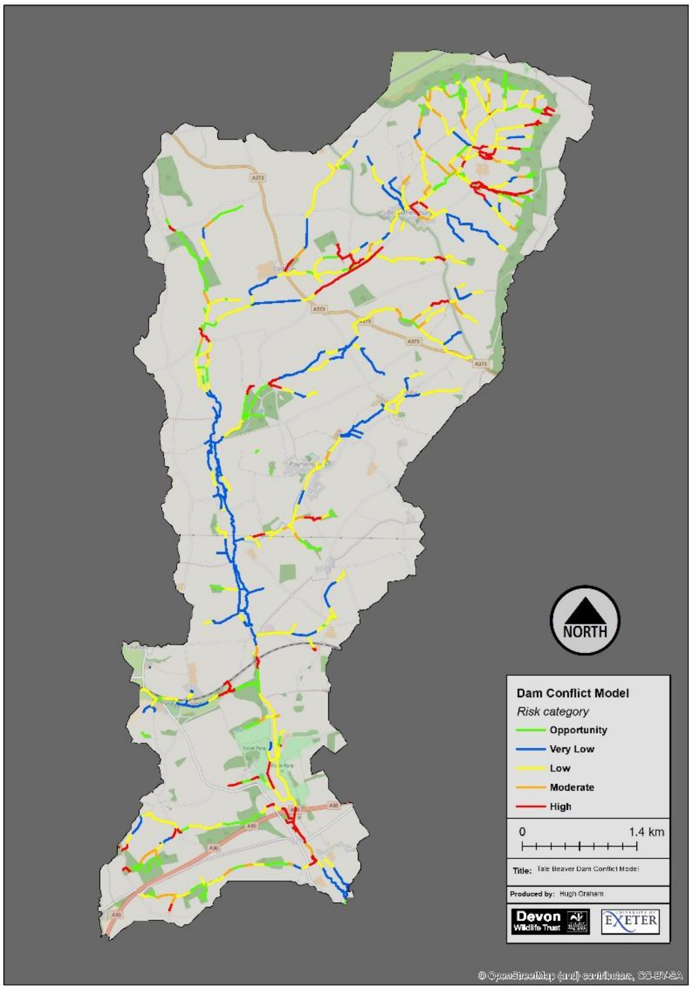
Wider context and application

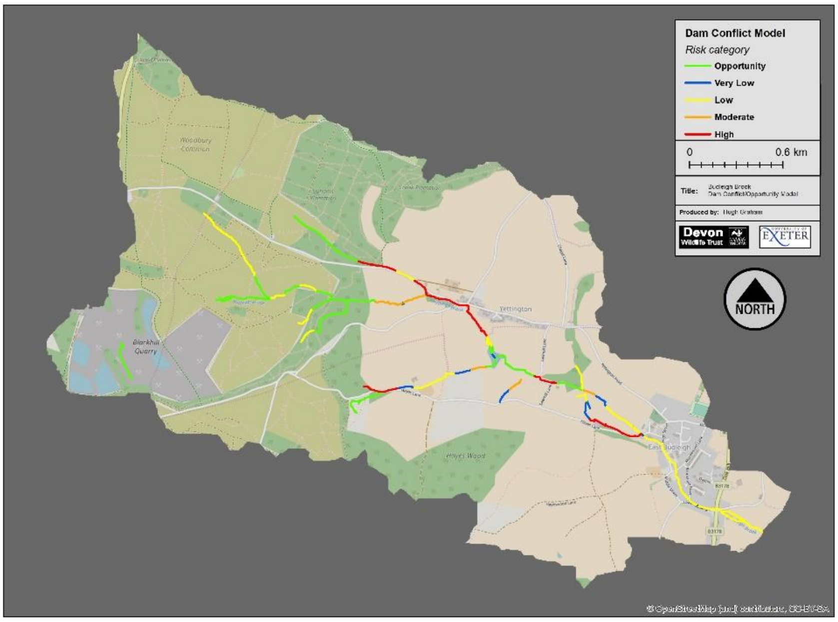
It is important to note that while this modelling provides a powerful strategic decision support tool, it does have limitations. The tool allows for classification of risk only and is not predictive. To further increase its application, risk levels should be considered alongside contemporary knowledge of the beaver population density and territory distributions within the catchment.

Alongside the crucial information presented by these tools, it is essential that these data are complemented by local knowledge and information. At the strategic level, specific areas may be considered low risk due to the absence of high-grade agricultural land or municipal infrastructure. However, from the perspective of the individual landowner, a particular area may be of critical importance to the farming system. For example, if part of the farm is accessed through a valley bottom, the farmer might strongly oppose raised water levels as this will impede access to part of the holding. Or if a landowner owned land solely in the valley bottom, they might find the majority of their holding at risk of being impacted.

Figure 5.6 - BDC conflict / opportunity modelling of the River Tale Tributary (top) and Budleigh Brook (bottom).

These two following maps categorise the likelihood of beaver dams causing conflicts with infrastructure and arable agriculture. Opportunities for wetland creation within the Tale tributary (right) and Budleigh Brook (below), both part of the River Otter catchment are presented on an OS basemap. (© Crown Copyright and database rights 2012. Ordnance Survey Licence number 100022021).





Beaver dams and fish populations

The River Otter contains a variety of small-bodied fish species including bullheads, brook lamprey, minnows, and larger species including eels, grey mullet, sea lamprey, and trout. The River Otter also supports a small Atlantic salmon population. The river is highly valued locally as a wild brown and sea trout fishery.

The relationships between beavers and fish populations are complex and have been subject to extensive scientific research. Dams constructed in headwater streams and tributaries can have many and varied impacts on fish. The report commissioned by Scottish Natural Heritage in 2010 ‘A critical review of beavers upon fish and fish stocks’ (see refer to link in Appendix 11) is a useful summary of the current scientific picture.

It is based around an Expert Opinion Survey (EOS) which revealed that the majority of fisheries scientists and managers tended to suggest that the overall impact of beavers on *fish populations* was positive. The impact of beavers on the abundance and productivity of migratory salmonids was also considered positive. The impact of beaver dams on the *movement* of aquatic organisms in tributary streams, including upstream and downstream migrating salmonids, and on the availability of suitable salmonid spawning habitat was generally considered negative.

In the River Otter, the detailed knowledge and recording of key spawning areas and migration routes for sea trout is not currently sufficiently robust to build into the conflict modelling. However, significant resources have been focussed to improve our knowledge. There are four key areas within the River Otter catchment where dams have been constructed in streams and ditches where impacts on fish populations have been considered. Fisheries surveys are being undertaken in order to help quantify impacts, both positive and negative.

Experience in this catchment highlights the critical importance of a wide riparian strip in allowing new riverside wetlands to develop and simple river channels to become more complex and diverse. This allows the potential habitat gains for fish to be generated, and new bypass channels to provide opportunities for fish passage around obstacles.

However, where channels are deeply incised and space for new habitats to develop adjacent to watercourses in not available, dams will tend to be higher and could potentially present barriers to movement of individual fish at certain times. This may be of particular concern to fisheries stakeholders if they are still present during the autumn salmonid migration season.

Surveys of dam permeability are also being undertaken and a protocol for applying mitigation measures to facilitate fish passage is outlined in Appendix 7.

3. Burrowing

Beavers have the capacity (depending on the substrate) to excavate large burrows, many metres into the banks of watercourses and ponds. These are used by the beavers for shelter and can be dug rapidly if required and the substrate permits. They can be many metres long, and generally have a submerged entrance with a chamber constructed above the water level. Large burrows can compromise civil engineered structures such as dams, flood embankments, or canal banks, or can collapse when agricultural machinery, livestock or potentially people put weight on them.

Beavers in the lower reaches of the River Otter are digging and sheltering in burrows in the riverbanks and have been observed to have multiple burrows within each territory. When they are living in ponds and wetlands associated with dams and in smaller ditches and tributaries, they are more likely to adapt a burrow into a large lodge. They will often still construct outlying burrows in other parts of the territory.

Burrows often go undetected as their entrance is accessed from underwater which increases the risk of unforeseen collapse. The soft sandy nature of the River Otter soils also mean they are more prone to collapse, particularly during high flows. The presence of numerous burrows has been detected during the ROBT annual winter survey of feeding signs. In the majority cases in the River Otter catchment, they have been located in the semi-natural buffer strip of woody and tall herb vegetation alongside the river, rather than in open agricultural fields. Outside of the River Otter catchment and where this buffer does not exist, cases of damage to farm machinery have been recorded.

The lower floodplains and estuarine areas of many rivers are heavily modified and protected by raised flood defences and/or land drainage embankments, protecting built development and low-lying farmland. In the River Otter the reclaimed estuary floodplain is protected by an embankment that stretches upstream for approximately two kilometres from the mouth of the river. The location and design of this embankment is preventing major conflict with beaver burrows, as it is set back from the river by approximately 5-10 metres along most of its length. On occasions, the beavers have burrowed into the low-lying berm from the water's edge without any risk to the flood defences.

In the headwaters of the River Otter, the beavers have established a territory in an old ornamental lake, now used as a water supply reservoir. Although there has been no evidence of it to date, burrowing into the dams has been identified as a risk which is being rigorously monitored. Proactive vegetation clearance in this area has been employed to reduce the likelihood of burrowing and to facilitate access for regular monitoring of beaver activity.

There are no man-made canals within the catchment where burrowing could cause failure of banks, and no burrows have been found associated with EA hydrometric gauging equipment or other water management infrastructure.

4. Feeding and tree felling

Beavers are entirely herbivorous. There are however significant seasonal variations in their diet. In the spring and summer months beavers will feed/graze on a wide variety of soft aquatic and riverside plants within easy access of the water's edge. Where agricultural crops are grown within this zone, there can be localised impacts arising from beaver feeding. No landowners have contacted the ROBT to report any significant crop damage within the first four years of the Trial, although feeding on maize has been observed. Along much of the River Otter a buffer of semi-natural vegetation between the river and arable farmland has been retained which will have reduced the risk that this behaviour becomes unacceptable.

During the autumn and winter, beavers more frequently browse on woody material, feeding on branches overhanging or within watercourses, or on coppiced regrowth. They fell larger trees to reach more nutritious upper branches which has the added benefit of stimulating young fresh coppice regrowth, on which they can feed in future years. The detrimental impacts of beavers on important riverside trees are often cited, but these impacts are generally localised, predictable and in most cases easily preventable with low cost interventions. In some locations there can be a change of canopy structure as a result of intensive beaver activity, as some of the larger trees are gradually coppiced. The only two locations where this is being seen to any degree in the River Otter are both open wetland habitats where the continuous coppicing of encroaching willow is exerting a beneficial ecological impact.

Elsewhere, impacts have been highly localised and have not resulted in any significant changes to the shading of the watercourse or the landscape character. It is important to consider the cultural and ecological significance of individual trees when prioritising protection. Native black poplar or other veteran trees, for example, will warrant regular monitoring and proactive protection. Trees known to support important bat roosts, or those with particular historic or cultural value might also require greater levels of protection.

Comprehensive beaver / tree impact data for the River Otter has been collated for three winter periods. The results show the tree species which have been selected and the level of impact. As the numbers of beavers has increased over the course of the Trial period, the numbers of trees impacted has also gradually increased.

Winter 2014 / 15 – Nine beavers living in two territories fed on 354 trees (86 % willow)

Winter 2015 / 16 – 11 beavers living in three territories fed on 402 trees (80% willow)

Winter 2016 / 17 – 20 beavers living in six territories fed on 527 trees (65% willow)

Within this same period, five landowners expressed concern about the beavers' impacts on trees. In all cases advice and support has been provided, tree protection measures employed, and the situations resolved to the satisfaction of all parties.

Irrespective of landowner complaints or concerns, some higher-risk trees have been identified and are proactively protected by ROBT staff, actively contacting landowners. Riverside orchards are known to be targeted by beavers for feeding and three are being protected from damage. In two other locations large trees adjacent to powerlines have been protected once beaver activity had been identified. A poplar plantation adjacent to the main river is also being monitored; no impacts have been detected to date.

__Figure 5. 7 - A chart showing the extent of tree impacts by beaver feeding up to and including the winter survey conducted in early 2017. The level of impact assigned is based on the numbers and size of cuts, the size of the tree, and the area of bark stripping.__

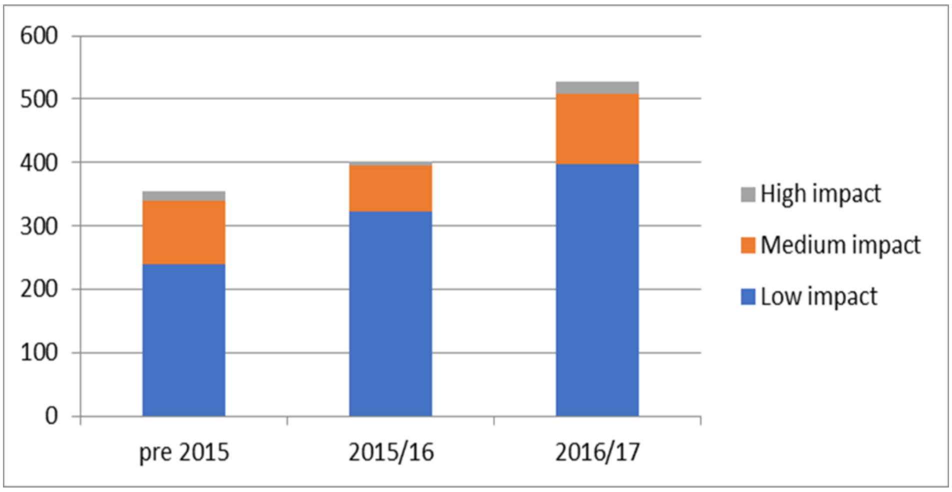


__Figure 5.8 - The following graphs show the species of tree upon which beaver feeding signs were found. Willow species made up the majority of trees impacted, with alder and hazel also significant. Hazel was particularly coppiced from hedges adjacent to dam building sites where it was often observed being used in construction.__