Beavers in Scotland

Strategic Environmental Assessment
Environmental Report

May 2017

Scottish Government
Riaghaltas na h-Alba
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Beavers in Scotland – Environmental Report

Contents

Non-Technical Summary

1. Introduction

Policy Context

Beavers, initially widespread throughout Britain, were last recorded in Scotland in the 16th century. Consideration of the feasibility and desirability of reintroducing beavers to Scotland started in 1995 and culminated in the 'Beavers in Scotland' (BiS) report produced by Scottish Natural Heritage on behalf of the Scottish Government and published in June 2015.

Following completion of the Scottish Beaver Trial at Knapdale, the work of the Tayside Beaver Study Group and related projects and initiatives, Scottish Ministers are minded to allow beavers to remain in Scotland.

Scottish Ministers have agreed that:

- *Beaver populations in Argyll and Tayside can remain*
- *The species will receive legal protection, in accordance with the EU Habitats Directive*
- *Beavers will be allowed to expand their range naturally*
- *Beavers should be actively managed to minimise adverse impacts on farmers and other land owners*
- *It will remain an offence for beavers to be released without a licence, punishable by up to 2 years imprisonment and an unlimited fine*

Requirement for Strategic Environmental Assessment (SEA)

Section 5(3) (b) of the Environmental Assessment (Scotland) Act 2005 triggers the need for SEA where likely significant effects on the interests of sites designated in terms of the EU Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (the Habitats Directive) have been identified as requiring assessment in terms of Article 6 or 7 of that Directive (an appropriate assessment).

The Habitats Regulations

Habitats Regulations Appraisal (HRA) is the term used to describe the procedure required by regulation 48 of The Conservation (Natural Habitats, &c.) Regulations 1994, (as amended) (The 'Habitats Regulations'). These regulations transpose the Habitats Directive into Scottish law. HRA is a rigorous, precautionary procedure that examines the potential negative effects on Natura sites of a plan or project; and which, by the end of the procedure must allow the competent authority to come to a firm conclusion as to whether there are no adverse effects on the integrity of Natura sites. The HRA has been appended as Annex 2.

Related Plans, Programmes and Strategies

One of the key drivers for this Policy is the Habitats Directive and in particular, Article 22 of this Directive which states that EU Member States should:

'…*study the desirability of re-introducing species in Annex IV that are native to their territory where this might contribute to their conservation, provided that an investigation, also taking into account experience in other Member States or elsewhere, has established that such re-introduction contributes effectively to re-establishing these species at a favourable conservation status and that it takes place only after proper consultation of the public concerned*.'

The Eurasian, or European, beaver *Castor fiber* is one of the species listed in Annex IV. There are also other international legal instruments which refer to reintroductions in a more general sense, such as the 'Bern Convention' of 1979 and the Convention on Biological Diversity (1992).

Other key plans and policy documents likely to influence the Beaver Policy are those that relate to biodiversity, including the Scottish Biodiversity Strategy, animal welfare and water and flood risk management.

2. SEA Methodology

Topics within the scope of the assessment

Given the requirements of the Habitats Directive, the focus of the SEA will be on the effects on biodiversity issues. However, beavers are considered to be ''ecosystem engineers.' They undertake various activities such as felling trees, creating dams/ponds, direct herbivory, which can result in changes to the structure and composition of their surrounding habitat. Accordingly, impacts on population and human health, water, cultural heritage and material assets have also been considered. Impacts on landscape, climatic factors and air were considered to be outwith scope. Impacts on soils were initially considered to be within scope, but as the assessment progressed, it was considered more meaningful to consider this in terms of effects on water resources, and biodiversity.

Assessment approach

The focus of the assessment will be on the environmental effects arising from the policy to allow the beaver populations in Knapdale and Tayside to remain. Beaver activity is restricted to freshwater and associated riparian habitats, in particular broadleaved woodland which provides a key source of food and materials for building structures although there can be indirect impacts outwith the riparian zone if there is hydrological connectivity.

The findings of the assessment are reported in a narrative form with each receptor considered in turn as follows:

- A broad assessment of how beaver activity affects the receptor
- A table summarising an overview of the broad positive and negative effects of beavers on that receptor
- Where possible, details of the distribution of the receptor within the Beaver Policy Area and
- An assessment of the likely effects on important receptors within the Beaver Policy Area, including identifying any cumulative effects and links to mitigation measures and monitoring proposals where appropriate.

Mitigation

Based on experience of mitigation techniques and practice from elsewhere in Europe and North America and from some trial work in Scotland, there is sufficient evidence that the majority of the adverse effects identified can be satisfactorily and straightfowardly mitigated to avoid significant effects. Given that much of the same mitigation can be applied to many of the different receptors, this has been pulled together into one section (section 5) to avoid repetition throughout the document. This mitigation has been signposted in each section.

Environmental objectives

A list of environmental objectives relating to each of the receptors sets the context against which the identification of positive and negative effects has been reported in Section 2.

Limitations of the Assessment

There are a number of limitations associated with this assessment, not least with predicting the impact on the environment from the reintroduction of a wild animal. These include:

- Data collection – the two Beaver Policy Areas do not coincide with local authority areas which can present complications on compiling data which is often available on a local authority basis.
- The identification of cumulative and long and short term effects is complex when dealing with the interactions of a wild animal and its environment
- The under-recording of positive effects – due to the precautionary nature of the Habitats Regulations and in order to focus the assessment particularly on the identification of mitigation and monitoring opportunities, the positive effects have been recorded largely in terms of a general overview.

3. Environmental Characteristics

Core Beaver Woodland

The assessment has focussed on the geographical areas containing the two wild populations of beaver present at Knapdale in Argyll and centred around Tayside. These areas are mapped in section 3 and Appendix 1. The extent of the policy area is determined by the likely extent of habitat to accommodate the establishment of beaver territories – identified as 'potential core beaver woodland.

Beavers set up territories in areas of suitable habitat. A GIS-based tool has been developed to try and predict where such areas may occur based on the following characteristics: areas of suitable broadleaved woodland and shrubs (to provide a food and building source); located within 50m of freshwater; comprised of streams with less than a 15% gradient; and not within tidal areas. At least 1.9km of woodland has to occur within 4km river bank sections.

The Knapdale beaver policy area is 64,978 ha in size and Tayside comprises 1,140,075 ha. In terms of the amount of potential core woodland in the policy areas, this extends to 970 hectares (ha) in Knapdale (less than 1.5% of the total Knapdale Beaver Policy Area) and 14,717 ha in Tayside (less than 1.3%).

Environmental characteristics of the Beaver Policy Areas

Both Knapdale and Tayside Beaver Policy Areas contain significant and rich biodiversity interest, reflected in the high proportion of internationally and nationally important designations. There are 192 designated sites within the two Areas.

In terms of water quality, watercourses in Knapdale, where recorded along potential core beaver woodland are primarily good status, and there are no areas of poor/bad status. In Tayside, all classes of watercourses along potential core beaver woodland are recorded, ranging from high, good, moderate, poor and bad water quality status.

The characteristics of the two Beaver Policy areas vary considerably in terms of the characteristics of population and human activity. Knapdale has a small number of small settlements mainly on the shores of Loch Fyne and all within Argyll and Bute Council. Tayside, while also predominantly rural, is far more populated and includes the cities of Dundee and Perth and a number of medium sized settlements. The Tayside Beaver Policy Area falls into 8 Local Authority Areas and has a greater intensity of landuse. The human population in the Tayside Beaver Policy Area is projected to increase.

In Knapdale, there are nine Scheduled Monuments, and one Garden and Designed Landscape overlapping with core beaver woodland and there are no identified Battlefield sites. This compares in Tayside to 97 Scheduled Monuments, 54 Gardens and Designed Landscapes and 5 Battlefield sites.

In terms of Material Assets,

- Both Beaver Policy Areas contain a considerable amount of commercial conifer forestry, however, the overlap with core beaver woodland is limited. There is a greater proportion of commercially managed broadleaved woodland in Tayside which will be more accessible to beavers.
- The streams in the Knapdale Beaver Policy Area provide spawning habitat for those fish present in connected standing waters and lochs are popular trout fishing areas. The River Tay supports significant recreational fisheries for Atlantic salmon, trout (including sea trout) and grayling. It is one of the most iconic of the Scottish Atlantic salmon rivers and the number of rod-caught Atlantic salmon makes it one of the most important catchments for this species in the UK.
- There is no prime agricultural land in the Knapdale Beaver Policy Area although there is other improved grassland present. In Tayside the significant extent of prime agricultural land is located in the eastern lowlands of the study area.
- In terms of infrastructure, Tayside is a more populated area with a greater intensity of land use and major road infrastructure. The opportunities for beaver activity to impinge upon a range of land uses, and the associated infrastructure, are much higher than in Knapdale.

Evolution of the environment in the absence of the Policy

In the autumn of 2016 surveys indicated there were 8-10 animals still present in the Knapdale SBT area, comprising two to three breeding pairs with an unknown number of kits, born earlier that year. The Tayside beaver population was estimated to comprise 38-39 beaver occupied territories in 2012. In the absence of the policy, there is a high risk that the population in Knapdale face the threat of extinction, while modelling has shown that the population of beavers in the Tayside area is predicted to expand but the rate and distribution will be difficult to model because control of the population would be unregulated. The effects on the other environmental receptors will remain the same.

In respect of genetic implications for the two populations, without the policy and therefore the prospect of further releases, genetic considerations to date suggest that the risk of inbreeding depression with respect to the Knapdale population cannot be ruled out. The population on Tayside did not come about as a founder population; uncertainty remains as to whether the population has sufficient genetic diversity to ensure long term viability.

Existing environmental issues in the Beaver Policy Areas

The effects of the Policy on existing environmental issues within the two Beaver Policy Areas are detailed in Section 4.

4. Environmental Assessment

Beaver ecology

An overview of beaver ecology, including the distribution of beaver habitat is considered in this section to set the context for the assessment of environmental effects on other receptors. Beavers are semi-aquatic and are reliant on water to escape potential predators. They feed on a wide variety of aquatic and terrestrial plant species, and live in lodges or burrows, usually with underwater entrances. They construct dams to retain water, create feeding areas, provide safe refuge and allow for travel and movement of logs and branches.

Biodiversity

- **Beavers and woodland**

  The main mechanisms by which beavers affect riparian woodland are tree-felling for food and construction, and flooding. They generally avoid conifers, but will use most native broadleaved tree species that occur in Scotland, and other non-native broadleaved trees. Within the Beaver Policy Areas there are 90 woodland sites which are afforded European or national protection.

  Due to their activities, beavers have a variety of positive effects on woodland structure, leading to a greater diversity of age classes, particularly in even-aged stands, improving the variety of species present in woodlands and potentially creating hot spots of biodiversity through the creation of increased levels of standing dead wood.

  Many of the ninety sites identified in this analysis are currently in unfavourable condition and do not meet their site attribute targets for volume of deadwood, level of grazing / browsing, structural diversity (i.e. number of different age classes of target tree species) or evidence of regeneration. Beaver activity has the potential to address some of these failing targets.

  Conversely, selective browsing can lead to reduced tree diversity as well as reduced tree and shrub growth and regrowth, particularly within 30m of freshwater where the large majority of beaver browsing activity takes place. The main factor causing unfavourable condition across Scottish woodlands is grazing / browsing pressure from herbivores (largely deer and sheep). At present, saplings can be considered 'safe' from further browsing once they get to a certain size (the specific size varies with the species). However, since beavers are able to fell quite large trees, this will no longer be the case in areas colonised by beavers for a reasonable length of time. Continuation of woodland will depend on coppice regrowth from the felled stumps or suckering from roots. Whilst all native Scottish broadleaves are able to coppice or sucker, if the regrowth is subsequently eaten by deer, sheep, or other large herbivores, there could be a simplification in the structure of the woodland, and possibly deterioration or even loss of the woodland habitat.

  Any potential adverse impacts on the woodland interest could be mitigated through increased herbivore management measures (upon deer, goats, sheep, or beavers as appropriate) before they occur, such as fencing and tree protection. Signs of over-grazing can be detected before any adverse impacts result. Impacts should be monitored using the Woodland Grazing Toolbox methodology.

- **Beavers and bryophytes, fungi and lichens**

  Bryophytes (mosses and liverworts), fungi and lichens are diverse groups of organisms that make up a large proportion of Scotland's biodiversity. This diversity means that there will be a variety of positive and negative effects on these species. This is dependent on the requirements of the organisms and their response to changes brought about by beaver activity such as an increase in the amount of wet woodland, an increase in the amount of deadwood or opening the canopy to allow more light to reach the woodland floor, for example. Any mitigation required will therefore be specific to the requirements of the different species. Site condition monitoring will be required to identify any impacts and therefore develop specific mitigation accordingly.

- **Beavers and terrestrial vascular plants**

  There are two main mechanisms through which beavers affect vascular plants: directly by being eaten and indirectly through successional habitat change (tree-felling, changes in water levels and changes in wave action). There is limited scientific information on the impacts of beavers on terrestrial herbaceous vascular plants so it is possible to provide only a tentative prediction of possible future impacts.

Some terrestrial plant species might be expected to benefit from beaver activity in riparian habitat, whilst shade-loving species might decline. Terrestrial species which are associated with a high water table are expected to benefit from habitat creation by beavers.

Beavers are strictly herbivores; they have a very varied diet with strict seasonality and have been recorded eating around 80 different types of tree species and nearly 150 others plant species including aquatic macrophytes and herbaceous plants. Diet selection appears to be based on nutrient requirements and not necessarily related to local abundance. There are only a limited number of terrestrial herbaceous vascular plants of conservation importance found in the core beaver woodland in the Beaver Policy Areas and of these, only a few have the potential to be adversely affected by beaver activity. Site condition monitoring and appropriate mitigation can be employed to address potential adverse effects.

- **Beavers and invertebrates**
  The current literature suggests that the effects of beaver impoundments on aquatic invertebrates are mostly positive. By building dams and digging small canals, beavers create and extend wetland micro-habitats that support many invertebrate taxa. Beaver dams change the predominantly flowing character of aquatic ecosystems to a mixture of flowing and still conditions, which is of particular benefit to predatory invertebrates. The wetland micro-habitat created by beavers attracts water beetle colonists and several species of dragonflies and damselflies, which are at the top of the food pyramid. A possible negative effect relates to impacts on freshwater pearl mussel if migration of salmonid hosts is affected by the presence of dams, although dams may also benefit the juvenile mussels by filtering out finer sediments.

  Mitigation measures will concentrate on addressing issues to mitigate the impact of beaver foraging and damming activity.

- **Beavers and amphibians and reptiles**
  Beaver activity results in the creation of ponds and slow-moving water, the changing of water tables and development of wetland habitat, all of which will generally benefit Scottish amphibians. Scotland has six native amphibian species:
  - Frogs and toads– common frog, common toad and natterjack toad
  - Newts – smooth newt, palmate newt and great crested newt

  An indirect negative effect might arise from the predation on amphibians from fish which use the impounded ponds created by beaver dams or which become accessible to fish through construction of canals.

  In terms of reptiles, effects on the three known native species are likely to be incidental. Viviparous lizards and adders can persist in wetland habitats but they are sub-optimal for them. Beaver foraging thins out woodland canopy, which could lead to greater insolation of the woodland floor and a potential increase in microhabitats with thermoregulatory benefits to reptiles, depending on the pattern of regrowth and ground flora regeneration. The grass snake (which may start to colonise southern Scotland as environmental temperatures increase) could benefit from beaver activity as it often hunts in water, and frogs can be a major prey component. They lay eggs in piles of rotting vegetation, notably compost heaps, where increased temperatures speed up the development of the young. Detritus within beaver lodge structures can provide such conditions.

Great crested newt is of international importance and it is likely that effects will be largely positive as a result of beaver activity. Localised negative effects relate to predation from fish and changes to plant composition which may affect the preferred plant species on which the newts lay their eggs. There may also be some risk of waterlogging of hibernacula.

- **Beavers and birds**
  The main mechanism for beavers influencing bird biodiversity is the increase in wetland areas available for nesting and feeding. In particular this will benefit a variety of species of waterfowl, herons and kingfisher. While the effects are largely positive, attention will be needed to ensure any damming activity does not affect water levels in lochs being used by breeding black-throated divers. Mitigation measures are detailed in section 5.

- **Beavers and Mammals**
  Beaver activity may influence the local distribution and abundance of other mammal species in a number of ways, some of which may have a positive and some a negative effect. Many native species that occur in Scotland, such as bats, water vole and Eurasian otter are likely to benefit from the creation of new wetlands, from the construction of lodges and creation of burrow systems and from the creation of newly coppiced riparian woodland. Potential negative effects may arise from the construction of beaver dams which may restrict the movement of migratory fish which are a prey species for otters. There could also be benefits for the invasive non-native American mink. It is unclear how this species will respond to an increasing beaver population but will require monitoring to pick up any resulting threats on for example, water vole.

Water

- **Beavers and freshwater – running water**
  Beaver dams will impede the flow (quantity and velocity) of water in a channel. The extent to which they do will depend upon their height and porosity and the frequency at which they occur. Beaver dams therefore increase the in-channel storage of water. Beaver dams will not only attenuate flow but also impede the movement of sediment. The construction of beaver dams and ponds introduces many additional habitats to river reaches, resulting in a substantial increase in habitat diversity, the spatial complexity of the habitat mosaic and the overall resilience of river and riparian ecosystems to disturbances.

  Beaver activity is unlikely to adversely affect any running freshwater habitat of conservation importance and therefore mitigation is unlikely. Should future monitoring identify unforeseen issues, the mitigation measures detailed in section 5 would address any significant adverse effects.

- **Beavers and freshwater – standing water and wetlands**
  Beavers affect standing freshwater and wetland habitats through the effects of dam-building activities and foraging activities. A complex set of positive and negative effects can be experienced. For example, dams constructed on influent streams and which lead to the development of ponds may attenuate flows and reduce the pollutant loading of lochs. Ponds and wetland complexes created by beavers may also act as pollutant sinks and buffer against the effects of drought, and provide new habitat for aquatic plant species to colonise. Conversely, dam-building activities can also result in flooding of terrestrial land upstream or adjacent to lochs and ponds. Similarly, foraging activities can lead to both positive and negative effects, such as a localised loss of

some plant species and the emergence of others which might have previously been submerged.

The mitigation measures identified in section 5 will ensure that adverse effects can be satisfactorily addressed.

- **Beavers and fish**
  Eurasian beaver would have co-existed with native fish fauna in Scotland for millennia before the extinction of beavers in the 16th century. Beavers are likely to impact on fish species, mainly from changing the structure of the riparian woodland through foraging activity and changing the riverine habitat from running water to still water through damming activity. There will be both positive and negative effects on the variety of Scottish fish species from these activities. There are effective mitigation measures available to address adverse effects which are detailed in section 5.

Population and Human Health

Beavers can contribute positively to human well-being by providing recreational and educational opportunities and engagement with a charismatic species.

There are a number of potentially localised negative effects on settlements and households such as blocked drains and culverts experienced where properties may overlap with core beaver woodland or indirect impacts where there is hydrological connectivity. The scale and significance of the resulting impacts will vary according to local circumstances but in most situations management will be required, with associated costs. Mitigation techniques are well established elsewhere in Europe and North American and adverse effects can be mitigated by protection measures detailed more fully in section 5.

While the risks to human health are negligible, or low, there are a number of parasites or diseases associated with beavers which are more fully detailed in section 4.12. Mitigation of potential adverse health effects include health screening before the release of any animal and continued health surveillance of both beaver populations.

Cultural Heritage

There is the potential for beaver activity to affect historic or culturally important sites. This is through, for example, burrowing causing subsidence, or dam-building causing localised floods, and foraging of vegetation.

There is also a cultural value that people and local communities place on having beavers reintroduced into the environment. This was illustrated in the public support for the reintroduction which came out of the public consultation and survey work in particular.

From monitoring carried out at Knapdale on Loch Coille-Bharr crannog and on the Crinan Canal, the likelihood of impacts on historic monuments within the core beaver woodland from beaver activity was considered to be low. However it was also considered appropriate to identify and prioritise those structures that may be potentially vulnerable in riparian areas and monitor any beaver activity.

In terms of impacts on Gardens and Designed Landscapes, within core beaver woodland areas, there is the potential for adverse effects arising from the felling of trees and shrubs and foraging of vegetation. Again these adverse effects can be mitigated by protection measures detailed more fully in section 5.

Material Assets

- **Forestry**

  The main mechanisms by which beavers affect woodland are tree-felling (for food and construction) and flooding. Most Scottish forestry relies on conifers, therefore beavers are unlikely to have much impact through felling. However, none of the major coniferous species is tolerant of prolonged flooding, so beaver impoundments would lead to the death of trees within the flooded area. Flooding could also affect forestry infrastructure (e.g. forest tracks, culverts) and access for forest management, deer management and recreation, where it overlaps with inundated areas. The potential for beavers to affect forestry in Tayside is greater, as broadleaved tree species are managed commercially in parts of this area and, because of the flatter terrain, a greater proportion of the land is accessible to beavers.

  There are a number of positive benefits in terms of commercial forestry activities and achieving multi-benefit forestry, particularly in terms of enhancing management of riparian edges, increased biodiversity associated with an increase in deadwood, improvement in the hydrological cycle and the recreational benefits to the forest estate.

  There are established mitigation measures to address adverse effects which are detailed in section 5.

- **Fisheries**

  From a fisheries perspective, it is likely that the two species which are most likely to be influenced by the presence of beavers are Atlantic salmon and trout. There are a number of positive and negative effects from beavers on the fisheries interest. Beaver activities and dam-building may have positive effects on factors such as water quality downstream. Conversely, obstructions at the downstream end of important tributaries, such as those used by the spring stock component of Atlantic salmon populations, may impede access to important spawning areas.

  In streams where beaver and salmonid habitats may overlap, interactions will vary over time, between catchments and within catchments. As such, it is not possible to predict with certainty whether the overall net impact of beaver presence will be positive, negative or negligible on salmonid fish or other species of conservation importance. However, beaver dam-building activity, and the associated potential hindrance to fish passage, is of particular conservation concern to the spring component of the Atlantic salmon populations which utilise upland nutrient-poor streams.

  The fisheries resource in Knapdale is largely limited to brown trout because anadromous salmonids (Atlantic salmon and sea trout) are not able to migrate freely into the Knapdale Forest area due to local topography. The River Tay supports significant recreational fisheries for Atlantic salmon, trout (including sea trout) and grayling. It is one of the most iconic of the Scottish Atlantic salmon rivers and the number of rod-caught Atlantic salmon makes it one of the most important catchments for this species in the UK. On the River Tay, dam building will not occur on the in the downstream, wide and deep river sections but will expand into small water courses, both in the lower catchment and into upland streams which are particularly important for the spring Atlantic salmon stock component.

  In terms of mitigation, there are a number of measures recommended in section 5 to ensure free passage of migratory fish and the importance of a management strategy for salmon has been highlighted.

- **Infrastructure**
  Infrastructure and general land use will tend to be at risk only where they are in proximity to beaver activity, and therefore near running and standing waters. Impacts can arise from the direct and indirect implications of dam-building, burrowing and tree-felling. Since beavers readily use natural, semi-natural and artificial waterbodies, the likelihood of beavers sometimes coming into contact with human infrastructure is high. The scale and significance of the resulting impacts will vary according to local circumstances, but in most situations management will be required, with associated costs.

  Because of the limited infrastructure in the Knapdale Beaver Policy area, impacts are likely to be focussed on forestry infrastructure. However, it is recommended that monitoring should be carried out along the Crinan canal for any beaver burrowing activity.

  Tayside is more populated than Knapdale with a greater intensity of land use, and so the scope for beaver activity to impinge upon a range of land uses, and the associated infrastructure, is much greater.

  There are a number of methods that can be used to protect infrastructure interests and in some cases it may be prudent to protect especially sensitive interests before problems arise. This is more achievable for small-scale structures, such as culverts under roads. Consideration of fuller mitigation measures are detailed in section 5.

- **Agriculture**
  As beaver distribution is always associated with running or standing water, the potential for beaver activity to have an impact on agricultural interests is limited to where they occur in the vicinity of streams, rivers, drainage ditches, wetlands, lochs or ponds. As a result, there are unlikely to be significant *direct* impacts on prime agricultural land, i.e. land capability classification Class 1 and Class 2. However, there are likely to be a number of *indirect* and locally significant effects. These can include blocking of drains and drainage ditches and small watercourses causing localised flooding, bank erosion from burrowing, loss of crops from foraging and felling of trees of commercial value. Positive effects can also arise from improvement to water quality and the hydrological cycle and water flow maintenance.

  There is no prime agricultural land in the Knapdale Beaver Policy Area although there is other improved grassland present. In Tayside, it is located in the eastern lowlands of the study area where it is extensive. There are a number of specific measures that could be employed to assist with the management issues arising from beaver impacts. Further mitigation measures are detailed in section 5.

5. Mitigation

Section 4 identifies how beavers can have a wide range of interactions with both the natural and human environment. These interactions can be both positive and negative. Where negative effects have been identified, there is a range of measures which can be readily employed to avoid, mitigate and/or compensate for these impacts.

This section details these measures which range from the development of a management strategy, delivery of guidance and training to help avoid adverse effects, to the development of a licensing scheme to enable management to reduce or eliminate impacts from beaver activity. It also details site specific measures to address the key beaver activities of dam-building, burrowing and foraging. These measures will be developed in consultation with the

Scottish Beaver Forum, a group which comprises, Scottish Government, government agencies, wildlife conservation, land and fishery management organisations.

6. Assessment of alternatives

The Beavers in Scotland report set out 4 potential policy scenarios for beavers in Scotland, ranging from the full removal of beavers to the widespread reintroduction of beavers. The 4 policy alternatives considered are:

- Scenario 1 - full removal of beavers from the wild in Scotland
- Scenario 2 - restricted range. Allowing beavers to expand from their current range, but specific catchments would be managed to keep them free from beavers.
- Scenario 3 – widespread recolonisation. The beaver population would be allowed to expand to its natural limits. Eventually this could include further releases outside the two current population areas.
- Scenario 4 - accelerated widespread recolonisation. Proposals for new releases could be considered immediately.

The policy agreed by Scottish Ministers draws from both scenarios 2 and 3 in the report. That is:

- Beaver populations in Argyll and Tayside can remain;
- The species will receive legal protection, in accordance with the EU Habitats Directive;
- Beavers will be allowed to expand their range naturally;
- Beavers should be actively managed to minimise adverse impacts on farmers and other land owners;
- It will remain an offence for beavers to be released without a licence, punishable by up to 2 years imprisonment and an unlimited fine.

7. Monitoring

Undertaking the SEA has enabled a clear audit of key receptors and identification of the priority monitoring requirements. The monitoring programme will help to ensure that where mitigation measures have been employed to address a potential adverse impact that these measures are effective. To ensure that the monitoring captures the effectiveness of mitigation measures, a survey and monitoring protocol will be developed in consultation with the Scottish Beaver Forum. Monitoring proposals will make use of existing activities such as SNH's Site Condition Monitoring programme and will also establish the effectiveness of trial mitigation measures undertaken in partnership with land and fisheries managers.

Monitoring and research will be driven by an adaptive management approach. The outcomes of trials and monitoring results will enable SNH to modify their conservation management and guidance for natural heritage, socio-economic, land, fisheries and infrastructure managers.

1. Introduction

1.1 Beavers in Scotland Policy Objective

Beavers, initially widespread throughout Britain, were last recorded in Scotland in the 16th century. Consideration of the feasibility and desirability of reintroducing beavers to Scotland started in 1995 and culminated in the 'Beavers in Scotland' (BiS) report produced by Scottish Natural Heritage on behalf of the Scottish Government and published in June 2015.

Following completion of the Scottish Beaver Trial at Knapdale, the work of the Tayside Beaver Study Group and related projects and initiatives, Scottish Ministers are now minded to allow beavers to remain in Scotland.

Scottish Ministers have agreed that:

- *Beaver populations in Argyll and Tayside can remain*
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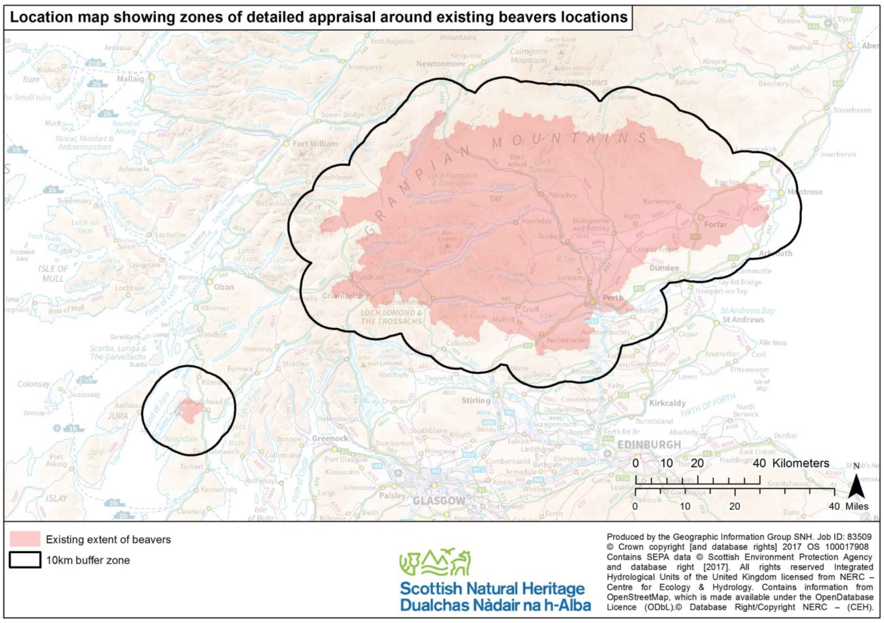
This assessment will consider the environmental effects arising from Scottish Ministers policy in relation to the reintroduction of beavers into Argyll and Tayside in Scotland. The policy relates to the two areas highlighted on Map 1 (Beaver Policy Areas). The assessment and the Environmental Report (ER) are underpinned by the Beavers in Scotland report (2015). This report is a distillation of the findings from a considerable body of research on the interactions beavers may have on the natural and human environments. To ensure proportionality, the Environmental Report focusses on those key significant environmental effects identified in the BiS report. To aid those wishing fuller more detailed analysis, the BiS report has been included as Annex 1.



Map 1 – Locations of Knapdale (Argyll) and Tayside Beaver Policy Areas

1.2 Purpose of the SEA and compliance with the Habitats Directive

The Environmental Assessment (Scotland) Act 2005 relates to those plans or programmes (including policy frameworks), produced by a Scottish public body and required by legislative, regulatory or administrative provision. Strategic Environmental Assessment (SEA) is required where it is considered that there will be likely significant environmental effects arising from the plan or policy. Further, in this case, Section 5(3) (b) of the 2005 Act triggers the need for SEA where likely significant effects on the interests of sites designated in terms of the EU Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (the Habitats Directive) have been identified as requiring assessment in terms of Article 6 or 7 of that Directive (an appropriate assessment).

The Habitats Regulations

Habitats Regulations Appraisal (HRA) is the term used to describe the procedure required by regulation 48 of The Conservation (Natural Habitats, &c.) Regulations 1994, (as amended) (The 'Habitats Regulations'). These regulations transpose the Habitats Directive into Scottish law. Article 6(3) of the Directive (and regulation 48 of the Regulations) requires that any plan or project which is not directly connected with or necessary to the management of a Natura site, but which would be likely to have a significant effect on such a site, either individually or in combination with other plans and projects, shall be the subject of an appropriate assessment of its impacts, in view of the site's conservation objectives.

HRA is a rigorous, precautionary procedure that examines the potential negative effects on Natura sites of a plan or project; and which, by the end of the procedure must allow the competent authority to come to a firm conclusion as to whether there are no adverse effects on the integrity of Natura sites. The way in which this question is framed reflects the degree to which the precautionary principle is written into the Habitats Directive, and consequently the Habitats Regulations and means that proof of the negative is required before consent can be given.

An HRA of the 'Beavers in Scotland' Policy has been carried out on Natura sites in the two beaver areas – Argyll and Tayside. This includes all the Natura sites which by virtue of their qualifying interests, were likely to be significantly affected by beavers. The HRA has been appended as Annex 2.

The findings from the HRA have been integrated into the assessment of the effects on those related elements of the biodiversity sections in this SEA.

1.3 Policy context

Assessing the need for beaver reintroduction has a legal basis. The key legal driver has been the Habitats Directive. Article 22 of this Directive states that EU Member States should:

'…*study the desirability of re-introducing species in Annex IV that are native to their territory where this might contribute to their conservation, provided that an investigation, also taking into account experience in other Member States or elsewhere, has established that such re-introduction contributes effectively to re-establishing these species at a favourable conservation status and that it takes place only after proper consultation of the public concerned*.'

The Eurasian, or European, beaver *Castor fiber* is one of the species listed in Annex IV. There are also other international legal instruments which refer to reintroductions in a more general sense, such as the 'Bern Convention' of 1979 and the Convention on Biological Diversity (1992). All of this should be considered in the context of the 2020 Challenge for Scotland's Biodiversity, a strategy launched by the Scottish Government in 2013 to protect and restore Scotland's biodiversity, in response to the Aichi Targets set by the United Nations Convention on Biological Diversity. It aims to:

- Protect and restore biodiversity on land and in our seas, and to support healthier ecosystems
- Connect people with the natural world, for their health and wellbeing and to involve them more in decisions about their environment
- Maximise the benefits for Scotland of a diverse natural environment and the services it provides, contributing to sustainable economic growth

SNH started investigating the feasibility and desirability of reintroducing beavers to Scotland in 1995, as part of its 'Species Action Programme'. A number of reviews and assessments were run during the 1990s, culminating in a national consultation in 1998. However, it wasn't until the Action Framework launched in 2007 by SNH that, shortly afterwards, a licence application was submitted by the Scottish Wildlife Trust (SWT) and Royal Zoological Society of Scotland (RZSS) to undertake the 'Scottish Beaver Trial' (SBT), a trial reintroduction at Knapdale. Permission was granted by the Scottish Government, and animals were released in 2009, followed by five years of monitoring.

1.4 Related Plans, Programmes and Strategies

The related plans, programmes and strategies that affect or could be affected by the Beavers in Scotland policy can be categorised into those relating to nature conservation legislation, animal welfare, water and flood risk management and environmental liability. Appendix 2 provides a synopsis of this list and a summary is provided below:

Nature conservation legislation and strategies

In addition to the requirements of the Habitats Directive and Habitats Regulations detailed in section 1.2 above, the Wildlife and Countryside Act 1981,(as amended) requires any release of beavers into the wild to require a non-native species licence as beavers are classed as a former native species. The Nature Conservation (Scotland) Act 2004 may trigger the need for consent from SNH if beavers are released onto a SSSI which then subsequently have the potential to affect other notified features. The Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 may require consultation with relevant district salmon fisheries boards, fishery owners and SEPA where riverine habitat is modified by beaver activity.

The Species Action Framework (2007) included Eurasian beaver as a species for conservation action.

Animal welfare

The Animal Health and Welfare (Scotland) Act 2006 ensures that the welfare of beavers are considered when the animals are capture, transported or held in captivity and during and after release into the wild.

Water and flood risk management

The Water Framework Directive and related domestic legislation means that the management of beaver on a site might result in a Controlled Activities Regulations (CAR) application to SEPA. The Floods Directive and related domestic legislation may require strategic and local flood risk management planning to take account of potential beaver activity in managing flood risk sustainably. The Reservoirs (Scotland) Act 2011 may require more frequent inspections of some controlled reservoirs, and plans for new reservoirs may need to take into account beaver activity in the area.

Environmental Liability

The Environmental Liability Directive 2004 and related domestic legislation requires that any operators who kill beavers or damage their breeding sites or resting places, when a protected species, may be held financially liable for remedying the situation.

1.5 Consultation on the Environmental Report

The 12 week consultation period on this Environmental Report and its Non-Technical Summary will run from Tuesday 12th December 2017 until Tuesday 6th March 2018. The documents are available to view as printed versions at The Scottish Government, Victoria Quay, Leith, EH6 6QQ.

Responses to the consultation should be sent to John Gray, Natural Resources Division, The Scottish Government, 3G-South, Victoria Quay, Leith, EH6 6QQ.

2. SEA Methodology

2.1 Scope of the Assessment

Following the feedback received from the Consultation Authorities (CAs), the environmental topics considered to be in and out of the scope of the assessment process were finalised as detailed in the table below.

Table 2.1 – Environmental Topics in and out of the scope of the assessment process

SEA topic	Scope in/out	Reasons
Biodiversity, flora and fauna	In	Beaver are considered to be ''ecosystem engineers.' They undertake various activities such as felling trees, creating dams/ponds, direct herbivory, which can result in changes to the structure and composition of their surrounding habitat. These changes can consequently impact on the species that depend on these habitats. Such changes may benefit some species (and habitats) but disadvantage others, although this will vary depending on scale and time.
Population and human health	In	The aspect of this environmental topic to be considered in this assessment relates to human health. Eurasian beavers host a number of external and internal parasites, some of which are already present in the UK and some are not. Many of these diseases and parasites have the potential to cause zoonotic diseases and maybe notifiable and/or reportable in the UK.
Soils and geomorphology	Out	Soils and river processes: Beavers undertake various activities e.g. felling trees, creation of dams/ponds, foraging activities, which results in changes to standing and running water habitats and their associated hydrological and geomorphological processes. In relation to soils, burrowing into banks may cause localised bank erosion and soil being washed into rivers. However, the principal effect of beaver dams is to slow down river flow, causing sediment deposition behind the dam and the eventual creation of 'beaver meadows'. Reduced river flow will also result in slower rates of bank erosion in the area upstream of the dam. Beaver dams may also help attenuate flood flows, slowing the downstream passage of peak flood flows. Consequently any likely significant effects on soil interests are considered within the freshwater and biodiversity topics. Geomorphological and geological conservation sites: Burrowing animals could locally impact on exposures of unconsolidated sediments in banks and cliffs, but there are a number of other burrowing riparian mammal species in Scotland already, like otters. Storage of branches and foliage, construction of beaver dams and consequent raised water levels could temporarily obscure rock outcrops and small scale landforms, such as river bars. This would be equivalent in scale and duration to fallen trees within water courses, and is similarly temporary and reversible. The visibility of rock outcrops or river geomorphology will eventually be restored after the dam has been abandoned and the woody and stony debris reworked by the river during subsequent floods.

Water quality, resource and ecological status	In	Beaver activity such as building dams and creating wetlands can influence water quality by reducing flushing times and increasing nutrient retention. Dam-building may also change water levels both upstream and downstream of structures. It is only the freshwater resource that is likely to be impacted upon by beavers. Marine waters or tidal waters are not significantly affected by beaver activity.
Air	Out	Beaver activity is unlikely to result in any significant changes to atmospheric emissions or air quality.
Climatic factors	Out	The policy will not give rise to emissions or pollutants that might impact on climatic factors. In terms of climate change adaptation, there may be positive impacts, for example, from flood alleviation and flow attenuation. However, this is considered in the assessment of the effects on freshwater, hydrology and associated geomorphological features.
Landscape	Out	The two beaver policy areas do include a number of National Scenic Areas (NSAs) within their boundaries. However, any changes to habitat structure or composition as a result of beaver activity will be local in nature and are unlikely to have significant effects on the special qualities of the NSAs.
Cultural heritage	In	There are a number of sites of historic value that overlap with or are near to beaver habitat at Knapdale and in Tayside e.g. Crinan Canal for which certain beaver activities, such as burrowing, could have an adverse impact. There are a number of sites in the Inventory of Gardens and Designed Landscapes that fall within the two beaver policy areas.
Material assets	In	**Forestry** – Since most of Scottish forestry relies on conifers, beavers are unlikely to have much direct impact through felling. However, there may be impacts on forest infrastructure (tracks, culverts), felling of planted riparian woodland and impacts arising from flooding. **Fisheries** –Tayside supports significant recreational fisheries for Atlantic salmon and there is the potential for impact by beaver activity. **Agriculture** – Impacts can arise from a range of activities, including burrowing and canal construction, dam-building, blocking culverts, direct foraging of crops and gnawing and felling of commercial trees. **Infrastructure** – Infrastructure will be at risk only in proximity to beaver activity, in the immediate vicinity of running and standing water with associated riparian habitat. Impacted infrastructure could include roads and tracks, culverts, weirs, sluices and fish passes, canals, water treatment plants etc. Beavers may also cause impacts on drainage from households, affecting private waste water treatment works.

The focus of the assessment is on the environmental effects arising from the proposal to allow the beaver populations in the Knapdale and Tayside beaver policy areas to remain. Beaver activity is largely restricted to freshwater and associated riparian habitats, in particular broadleaved woodland which provides a key source of food and materials for building structures. Whilst this approximates to only 1.4% of the land area of the two Policy areas, the assessment also considers indirect impacts arising on land and infrastructure linked to areas used by beavers.

Although difficult to predict, recent research suggests that beavers may not expand far from Tayside or Knapdale over the next two or three decades, but may over time disperse into neighbouring catchments. Accordingly, this SEA will not include consideration of environmental effects arising from any subsequent releases outwith the beaver policy areas, and these should be the subject of further assessment.

Chapter 4 details the findings of the assessment process. Following feedback, the reporting structure varies slightly from that detailed in the scoping report, but the content covers the same receptors. Section 4.1 provides an overview of beaver ecology which provides the context for the interactions with the following receptors:

- **Biodiversity**
    - Woodland
    - Bryophytes, fungi and lichens
    - Terrestrial vascular plants
    - Invertebrates
    - Amphibians and reptiles
    - Birds
    - Other mammals

- **Water**
    - Freshwater – standing water, including aquatic macrophytes and wetlands
    - Freshwater – running water
    - Fish

- **Population and Human Health**

- **Cultural Heritage**

- **Material assets**
    - Forestry
    - Fisheries
    - Agriculture
    - Infrastructure

Soils and geomorphology were initially considered within the scope of the assessment process. However consideration of any significant effects on soils and fluvial-geomorphology is captured within the sections on woodland, freshwater and material assets as these elements are too closely interconnected with these topics to separate out in any meaningful way.

Each receptor is detailed in a section which considers:

- A summary of how beaver activity affects the receptor (i.e. broad scale)
- A summary of positive and negative effects of beavers on receptor (i.e. broad scale)
- The distribution of receptor within beaver policy area
- An assessment of likely effects on important receptors within the beaver policy area, split into positive and negative (with link to mitigation / monitoring where appropriate).

Chapter 5 pulls together the relevant mitigation measures designed to address any potential adverse effects identified.

Chapter 6 considers the 4 policy alternatives below:

- Scenario 1 - full removal of beavers from the wild in Scotland
- Scenario 2 - restricted range. Allowing beavers to expand from their current range, but specific catchments would be managed to keep them free from beavers.
- Scenario 3 – widespread recolonisation. The beaver population would be allowed to expand to its natural limits. Eventually this could include further releases outside the two current population areas.
- Scenario 4 - accelerated widespread recolonisation. Proposals for new releases could be considered immediately.

The scenarios are broad and a number of sub-options were possible. As detailed in the scoping report, the preferred policy alternative draws from both scenarios 2 and 3.

Chapter 7 looks at opportunities to monitor the environmental effects arising from the reintroduction of beavers into both Knapdale and Tayside.

2.2 SEA Objectives

The following SEA objectives will form the basis against which the nature of the environmental effects on the receptors identified above will be considered:

- Biodiversity, flora and fauna – *to conserve and enhance the integrity of biodiversity interests in the two beaver policy areas*
- Population and human health – *to protect human health and enhance well being*
- Soils and geomorphology - *to maintain and improve soil quality and geomorphological features in the two beaver policy areas*
- Water quality, resource and ecological status – *to maintain and enhance key ecological processes e.g. hydrology, water quality in the two beaver policy areas*
- Climatic factors – *to reduce vulnerability to the effects of climate change – e.g. flooding in the two beaver policy areas*
- Material assets - *to protect material assets and promote the sustainable use of natural resources in the two beaver policy areas*
- Cultural heritage including archaeology – *to conserve and enhance the historic environment in the two beaver policy areas.*

2.3 Limitations of assessment

Geographical extent

The geographical extent of this SEA is limited to two beaver policy areas in Scotland – Knapdale and Tayside. The Knapdale beaver policy area is 64,978 ha in size and Tayside comprises 1,140,075 ha. Within these policy areas the likely extent of habitat to accommodate the establishment of beaver territories was identified as ‘potential core beaver woodland.’ This comprises 970 hectares (ha) in Knapdale (less than 1.5% of the total Knapdale beaver policy area) and 14,717 ha in Tayside (less than 1.3%). This approach is consistent with the approach in the HRA of the Policy (Annex 2).

Data collection

The two beaver policy areas by their nature do not correspond with local authority areas. This has resulted in some complications with data collection which is often available on a local authority basis. Where approximations have been necessary these has been recorded in the ER.

Assessment of the nature of likely significant effects on the environment

Difficulties in evidence to support long term effects will be examined as part of monitoring proposals. Monitoring and research will be driven by an adaptive management approach. The outcomes of trials and monitoring results will enable SNH to modify their conservation management and guidance for land, fisheries and infrastructure managers.

The assessment has focussed on significant positive and negative effects, and where there are cumulative effects these have been highlighted in individual sections. The assessment is complex as each beaver interaction can have more than one effect, both long term and short term. For example, in the short term a tree is felled but in medium term it may coppice and regrow which may result in a change in woodland diversity. However if there are herbivore impacts such as deer browsing there could be cumulative effects which in itself may open up the canopy and change the structure of the woodland.

Similarly, duration of effects is complex. For example beavers may temporarily exhaust the resources of an area and then move on. Beaver structures may degrade and new habitats such as 'beaver meadows' will form. In due course beavers may return to the site. The duration of these effects may vary according to local circumstances and environmental conditions influenced by weather events.

It is recognised that the nature of these effects and the difficulties with predicting wild animal behaviour and environmental events lead to uncertainty in the assessment and the need for a more generic approach in the ER.

Assessment approach

The SEA assessment particularly for biodiversity, flora and fauna and cultural heritage focusses on designated sites and focuses on the nationally and internationally important designations in the beaver policy areas, consistent with the approach of assessment of significant environmental effects. However, the wider importance of freshwater and riparian habitats should be recognised and that not all species of conservation interest are restricted to designated sites. For species and habitats of conservation interest in the wider countryside it is recognised that there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

The necessarily precautionary nature of HRA for European sites should be noted throughout the assessment and this rigorous approach needs to be viewed in this context.

Recording of Positive effects

As a result of the precautionary approach of the HRA and the aim of keeping the reporting succinct, many of the positive effects may get lost on reading because of their generic and long-term nature. Positive effects have been identified in each of the assessment sections, but mainly in terms of a general overview.

Time Limitations

The HRA (Annex 2) raises limitations in respect of validity of the timescale of the HRA assessment beyond 15 years. In particular, it states that “There should be a commitment to conduct an updated HRA after ten to twelve years, or at the point any new release site or other reinforcement is considered (whichever comes first). This should result in a new iteration of the HRA to take into account all relevant data acquired since the date of this HRA.” Accordingly, this will require a refresh of the SEA within in a similar timescale.

3. Environmental Characteristics of the Beaver Policy Areas

This chapter summarises the environmental characteristics of the beaver policy areas (section 3.1). These are detailed in A3 map based format in Appendix 1.

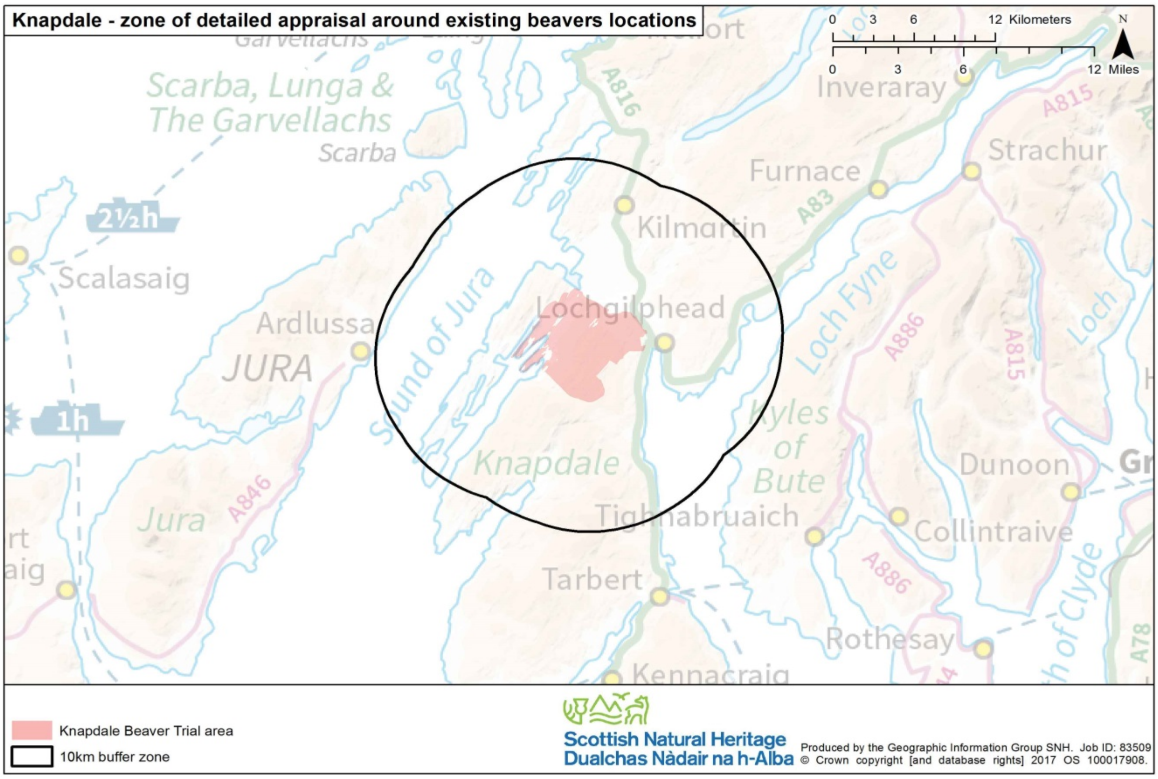
The current state of the environment in the absence of the policy to allow the beaver populations in Argyll and Tayside to remain is considered in section 3.2. Implicit in this policy statement is the requirement for a level of reinforcement of the Argyll population which forms the premise for the beaver SEA policy.

Specific existing environmental issues which are relevant to the policy are presented in section 3.3.

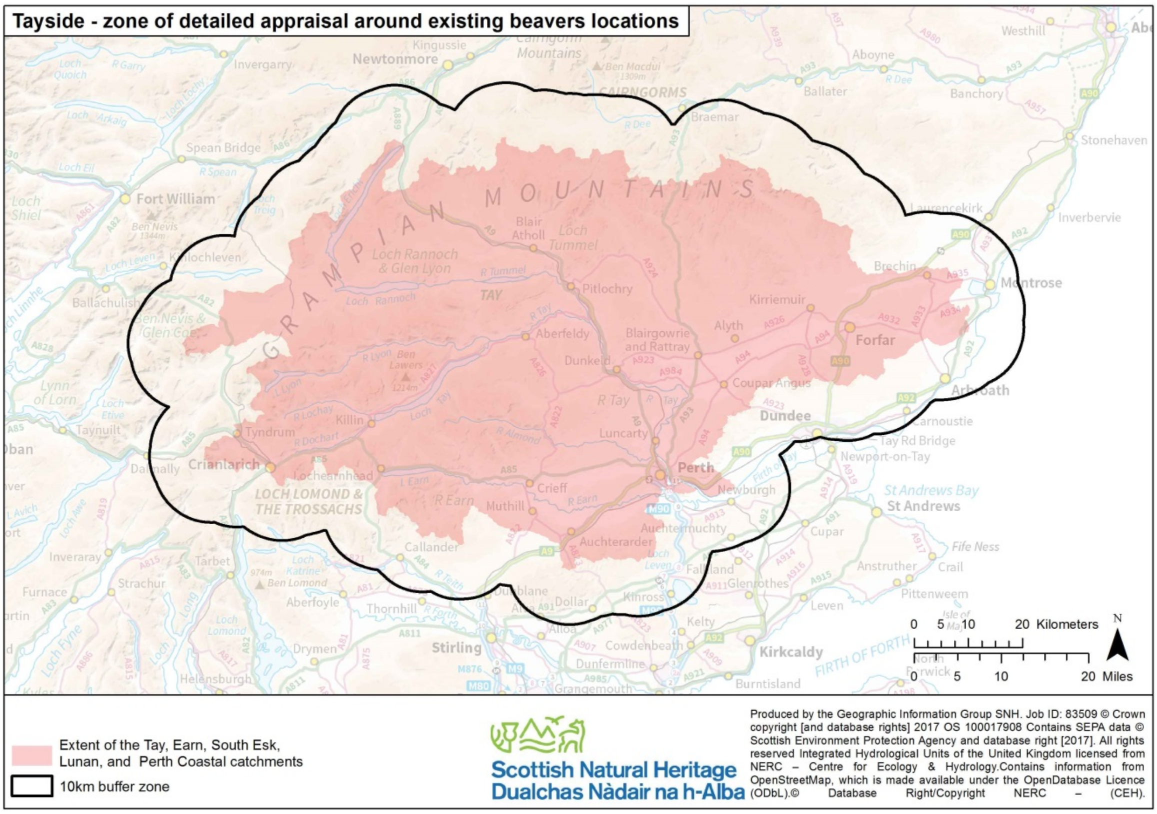
3.1 Summary of the environmental characteristics of the beaver policy area

3.1.1 Geographical extent

The assessment has focussed on the geographical areas containing the two wild populations of beaver present at Knapdale in Argyll (map 2 below) and centred around Tayside (map 3).



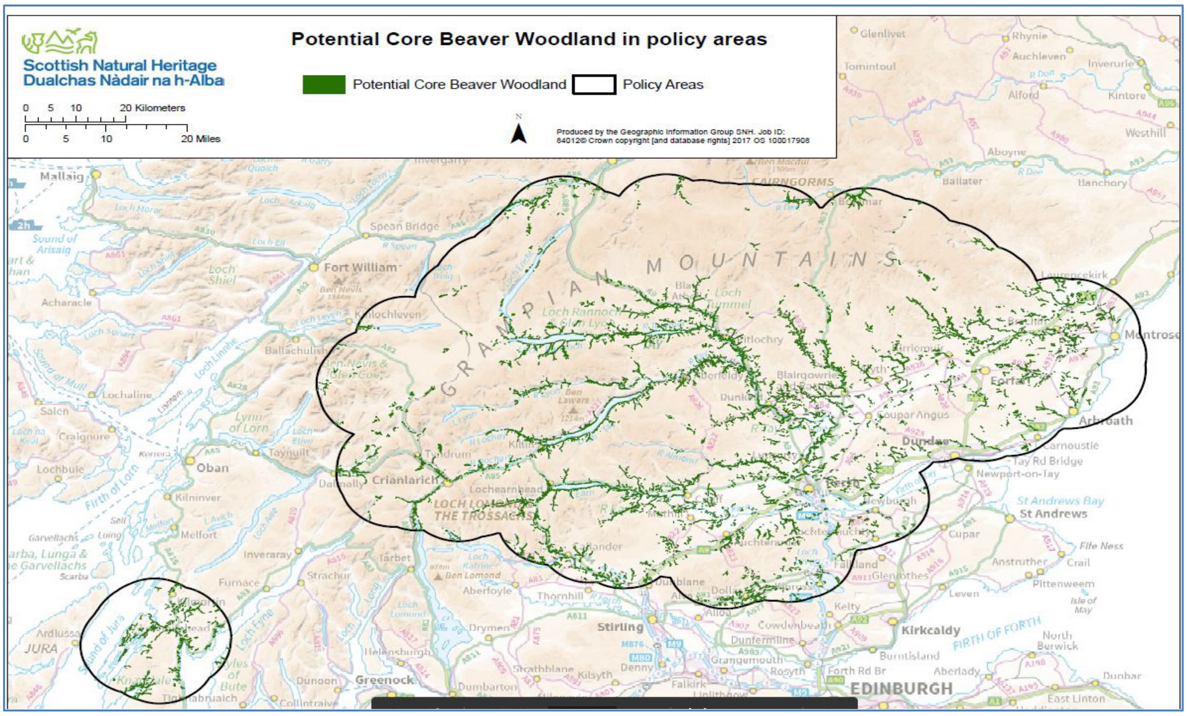
Map 2 - Knapdale Beaver Policy Area



Map 3 - Tayside Beaver Policy Area

The extent of the beaver policy area is determined by the likely extent of habitat to accommodate the establishment of beaver territories – identified as 'potential core beaver woodland.' This is consistent with the approach in the HRA of the Policy (Annex 2). The extent of the effects of this policy are limited to potential core beaver woodland which comprises 105,586 ha of suitable woodland in mainland Scotland.

The Knapdale beaver policy area is 64,978 ha in size and Tayside comprises 1,140,075 ha. In terms of the amount of potential core woodland in the beaver policy areas, this extends to 970 hectares (ha) in Knapdale (less than 1.5% of the total Knapdale beaver policy area) and 14,717 ha in Tayside (less than 1.3%).



Map 4 - Potential core beaver woodland in Knapdale and Tayside beaver policy areas

3.1.2 Potential core beaver woodland characteristics

Potential beaver woodland can be identified by the following environmental characteristics:

- Broadleaf woodland and shrub – the main predictor of the presence or absence of beavers is the availability of food, in particular the abundance of suitable woodland. Hence, the datasets used categories of broadleaf woodland and shrub and native pinewood taken from the National Forest Inventory (NFI) and Native Woodland Survey of Scotland (NWSS)

- Within 50 m of freshwater edge – beavers prefer to feed in close proximity to water. In Denmark, 95% of foraging was within 5 m of the water's edge. As the distance from the water increases, the amount of beaver foraging declines. The great majority of activity will be constrained to within 50 m of a watercourse [and] this matches observations recorded during the Scottish Beaver Trial.

- Streams with less than 15% gradient – higher gradient streams are known to be sub-optimal habitat for beavers. Although stream gradient has a gradual rather than absolute effect on beaver presence, evidence shows that stream gradients greater than 15% are very unlikely to be occupied by beavers.

- Not in tidal sections – beavers are only rarely seen in salt/tidal water and do not establish territories in such habitats. Hence, coastal and tidal sections of rivers were excluded from the dataset.

Potential core beaver woodland

The 'potential core beaver woodland' dataset is a refinement of the 'potential beaver woodland' dataset described above. Beavers require a certain area of suitable woodland to set up a territory. The potential beaver woodland dataset contained all woodland that could be utilised by beavers, but many of these are small, isolated patches.

The minimum amount of woodland needed for a beaver to establish a long-term territory was estimated based on the literature. Any suitable woodland that could not be part of approximately 1.9 km of woodland within a 4-km territory (measured by river bank length) was rejected. If a small woodland patch was isolated, and could not form part of beaver territory with sufficient woodland, it was not included in the core beaver woodland dataset.

The potential core beaver woodland map consists of 105,586 ha of suitable woodland in mainland Scotland. It is anticipated that beavers would be more likely to set up long-term territories in proximity to these areas of potential core beaver woodland.

A previous mapping exercise identified four catchments as key woodland areas for beavers: Lomond, Tay, Spey and Ness. Analysis showed that the catchments with the most core beaver woodland were the Tay and Spey.

The potential core beaver woodland map attempted to predict which woodland fragments would be utilised as part of a territory. To test this prediction, the 2012 Tayside beaver survey data were used. The potential core beaver woodland dataset was created using an estimated minimum territory size of 4 km of bank, which equates to 2 km of watercourse length. Therefore, assuming the centre of a territory is within a core woodland patch, a beaver territory may extend 1 km upstream and downstream from these patches. All beaver signs that were within this area were identified as being predicted by the dataset. It was found that 82% of feeding signs and 84% of territory signs (e.g. burrows, dams, lodges and scent mounds) were predicted by the map. In particular, 91% of scent mounds were predicted. This is relevant as the abundance of scent mounds is likely to be correlated with the quality of a territory and the length of beaver occupancy. These results suggest that the dataset does seem to be a useful tool in predicting long-term beaver territories.

There are a number of limitations to these datasets and the associated maps. Many other parameters have the potential to affect the ability of beavers to utilise woodland, such as the steepness of river banks. However, they were not used here because either there was not a clear consensus in the literature or they could not be derived accurately enough at a national scale. In addition, in some specific areas of Tayside the map was a poor predictor of beaver signs. This was primarily thought to be due to thin strips of woodland along watercourses that were too narrow to be picked up within the baseline woodland datasets. So, whilst the map should provide a good overview of beaver woodland at the national scale, particular care is needed when using the datasets to examine local patterns. If necessary, the potential beaver woodland datasets can be refined at a regional or local scale to address some of these limitations.

3.1.3 Biodiversity, flora and fauna

Both Knapdale and Tayside core beaver policy areas contain significant and rich biodiversity interest, reflected in the high proportion of internationally and nationally important designations.

Relevant designations which overlap with potential core beaver woodland in both Knapdale and Tayside beaver policy areas are illustrated in the maps 5-11 in Appendix 1

- Special Protection Areas (SPA)
- Special Areas of Conservation (SAC)
- Sites of Special Scientific Interest (SSSIs)
- Ramsar

Section 4 provides comprehensive information on species and habitats within the core beaver woodland, including types and sites of riparian woodland, bryophytes, fungi and lichens, terrestrial vascular plants, invertebrates, fish, amphibians and reptiles, birds and other mammals. . Please also see the HRA (Annex 2) for full details of SACs and SPAs.

Further details on all designations can also be obtained from SNH's Site link*:*
http://gateway.snh.gov.uk/sitelink/index.jsp

3.1.4 Water quality, resource and ecological status

Appendix 1 provides maps 12-15 illustrating water quality and flood risk in relation to potential core beaver woodland.

Section 4 provides further information on distribution of both suitable running and standing freshwater habitat, identification of important standing and running freshwater habitat types, wetland and aquatic macrophytes (plants that grows in or near water) within the potential beaver core habitat. Sites designated because of the presence of one of the habitat types and species of European importance associated with these habitats are identified.

- *Knapdale* - watercourses where recorded along potential core beaver woodland are primarily good status, and there are no areas of poor/bad status.
- *Tayside* – all classes of watercourses along potential core beaver woodland are recorded, ranging from high, good, moderate, poor and bad water quality status.
- *Flood risk* - As expected there is an overlap between flood risk areas and potential core beaver woodland in Tayside. The Tay catchment, and the five lochs within this, (Loch Ericht, L. Lyon, L. Rannoch, L. Tay, and L. Tummel) is a dominant characteristic of the Tayside beaver area. There is some overlap in the area between Lochgilphead and Kilmartin although the lower reaches of the River Add however have less potential core beaver woodland.

3.1.5 Population and human health

Appendix 1 provides maps 16-19 illustrating local authority boundaries and built up areas in relation to potential core beaver woodland.

- *Knapdale* – the population centres in the Knapdale beaver policy area are small and well scattered, and founded largely on forestry, tourism, agriculture, fishing and aquaculture. Many are dependent directly, or indirectly on the natural heritage. This area is sparsely populated in contrast to Tayside. The main settlements with a population of 500 or more are restricted to Lochgilphead and Ardrishaig on the shores of Loch Fyne.

  Potential core beaver woodland primarily lies outwith these settlements apart from a small area of overlap.

- *Tayside* – the Tayside beaver policy area extends into the local authority areas of Highland Council, Perth and Kinross Council, Angus Council, Aberdeenshire Council, Dundee City Council, Stirling Council, Clackmannanshire Council and Fife Council areas. The area is predominantly rural but it is a far more populated area than Knapdale with a greater intensity of land uses. There are two significant areas of population in these areas (the cities of Dundee and Perth) and a number of medium sized settlements primarily in the lowlands of Tayside – such as Forfar, Blairgowrie, Crieff, Arbroath and Montrose. A proportion of the population reside in rural areas outwith these settlements. There is a significant projected population increase across Perth and Kinross in particular.

Potential core beaver woodland is located mainly outwith settlements with a population of over 500, but the dispersed rural nature of villages and hamlets along watercourses will result in some direct interaction between beavers and people's properties.

3.1.6 Cultural heritage

Maps 20-23 in Appendix 1 provide details of sites in the Inventory of Gardens and Designed Landscapes, and Scheduled Monuments and Battlefield sites in relation to potential core beaver woodland.

Inventory of Gardens and Designed Landscapes - there is only one Garden and Designed Landscape which interacts with potential core woodland habitat in Knapdale, and 54 sites in Tayside.

Scheduled Monuments – 9 sites are identified as overlapping with potential core beaver woodland in Knapdale, including the Crinan Canal, a historic and well used waterway, and Loch Coille-Bharr crannog - a submerged artificial island presumed to be the site of a late prehistoric–early historic period lake dwelling. Further details are provided in section 4.13 (beavers and cultural heritage). There are 97 sites in Tayside.

Battlefield sites – there are no sites overlapping with potential core beaver woodland in Knapdale, and 5 sites in Tayside.

3.1.7 Material Assets

Forestry

National Forest Inventory cover in the Knapdale and Tayside beaver policy areas is provided in maps 24 and 25 in Appendix 1. Both areas comprise significant areas of forestry. However potential core beaver woodland is limited to those areas described under section 3.1.2 and broadleaved woodland and scrub rather than conifer species.

Knapdale - Taynish and Knapdale Woods SAC component of Knapdale is managed primarily for conservation.

Tayside - The National Inventory of Woodland and Trees' Tayside region, 2000 https://www.forestry.gov.uk/website/publications.nsf/DocsByUnique/3C2C5F7C1667BADE80257EBB0046FAFC estimated the total area of woodland in Forestry Commission (Scotland's) (FCS) Tayside region as 12.9% of the land area. Conifer woodland is the dominant forest type representing 61% of all woodland. Broadleaved woodland represents 19%. The main broadleaved species is birch covering 8 572 hectares or 38% of all broadleaved species. It should be recognised that FCS's Tayside region is not consistent with the Tayside beaver policy area so these figures should be viewed only as a general guide. Broadleaved tree species are managed commercially in parts of the Tayside beaver policy area and, because of the flatter terrain, a greater proportion of the land is accessible to beavers.

Fisheries

Maps 26 and 27 in Appendix 1 provide the extent of salmon rivers within the beaver policy areas and their proximity to suitable beaver habitat.

Knapdale - streams in the Knapdale beaver policy area provide spawning habitat for those fish present in connected standing waters and lochs are popular trout fishing areas.

Tayside - the River Tay supports significant recreational fisheries for Atlantic salmon, trout (including sea trout) and grayling. It is one of the most iconic of the Scottish Atlantic salmon rivers and the number of rod-caught Atlantic salmon makes it one of the most important catchments for this species in the UK.

Agriculture

Knapdale - there is no prime agricultural land in the Knapdale area.

Tayside – the extent of prime agricultural land is illustrated in map 28 (Appendix 1). This is exclusively located in the eastern lowlands of the study area. Areas of potential core beaver woodland are located along the watercourses in this area.

Infrastructure

Infrastructure could include roads and tracks, bridges, culverts, weirs, sluices and fish passes, canals, water treatment plants etc. Tayside is a more populated area with a greater intensity of land use and major road infrastructure. The opportunities for beaver activity to impinge upon a range of land uses, and the associated infrastructure, are much higher. This is likely to be at risk only in proximity to areas where beavers may be most active, i.e. immediate vicinity of running and standing water bodies bordered by suitable riparian habitat.

3.2 The likely evolution of the environment in the absence of the policy

Current status of the two beaver populations

16 Eurasian beavers were released in Knapdale through the Scottish Beaver Trial; 11 animals in 2009 in three family groups followed by two pairs and single animals in 2010. Management surveys carried out post-trial in the autumn of 2016 indicated there were 8-10 animals still present in the Trial area, comprising two to three breeding pairs with an unknown number of kits, born earlier that year.

The Tayside beaver population was estimated to comprise 38-39 beaver occupied territories in 2012.

3.2.1 Future population viability of the two beaver populations

The Knapdale population was intended as a trial population, not a founder population. Population modelling was undertaken towards the end of the Trial to assess the likely fate of this population in the short, medium and long-term post-trial under a number of different scenarios (Beavers in Scotland Report (2015) Annex 1 (section 3.2).

Predictive population models were developed, informed by work at Knapdale and Tayside. These demonstrated that the longer term viability of the Knapdale population will benefit from reinforcement (i.e. supplementing the current population with new releases). Very recent surveys at Knapdale have shown that numbers are now very low (possibly around eight animals) and that reinforcement may be required urgently if the population is to remain.

Modelling carried out with respect to the Tay and Earn catchments have predicted the population to continue to expand positively.

3.2.2 Population implications for the two beaver populations in the absence of the policy

The policy reflects the desire to see the two current beaver populations remain with provision for natural expansion with suitable adaptive management processes including population reinforcement of the Knapdale site and legal protection afforded through the EU Habitats Directive. Without the policy and therefore the prospect of population reinforcement, the threat of extinction with respect to the Knapdale population cannot be ruled out.

3.2.3 Genetic status of the two beaver populations

The SBT was the first licensed release of a mammal species into unenclosed, ‘wild’ conditions in Britain. The licence application submitted by the RZSS and the SWT for the release of beavers at Knapdale proposed that, on the basis of work undertaken up to that point, Norwegian *C. f. fiber* animals should be used. This precautionary approach was accepted and a licence was issued in May 2008.

Subsequent genetic analysis of the current Knapdale population has confirmed that all are *C. f. fiber*. The Norwegian source population has low levels of genetic diversity. Reinforcement could therefore provide an opportunity to increase diversity and therefore reduce the risks that can arise from inbreeding.

The Tayside beaver population is likely to have arisen through either captive escapes or unlicensed releases. Genetic analysis of this population has shown that founder individuals were most likely to have originated from Bavaria, Germany.

3.2.4 Overview of current thinking with respect to genetic consideration for translocated species

The genetic diversity within populations of the Eurasian beaver today is low. This reflects previous hunting to near-extinction and the extensive reduction in size of individual populations. This creates two potential problems: inbreeding depression, which means decreased genetic viability and fitness of individuals in contemporary conditions, and a lack of adaptive potential, which means constraints on populations to further adapt genetically to new pressures such as emerging diseases or environmental change.

Outbreeding depression resulting in reduced fitness or viability can occur when highly divergent lineages are mixed. The apparent viability of populations with mixed eastern/western ancestry (such as in Bavaria) suggests that either there is little, if any, detectable reproductive isolation or genetic incompatibilities between these two genetic groups or outbreeding depression has already occurred but natural selection has eliminated unfit individuals.

It is not possible to identify which precise combination of beaver genes is ideal for long-term survival of the beaver populations in Britain, based on the available genetic and morphological data (they inform only on population relatedness). A reasonable assumption is that the beavers that are most closely related to those previously found in Britain will be the best adapted. For some morphological traits, historical Scottish beavers seem to have been most similar to those from Norway, although it is unclear whether this is due to genetic or environmental factors, or a combination of both. The survival of both Norwegian and Bavarian beavers has been successful in Scotland so far, and they have adapted to a range of environments.

The Beavers in Scotland Report (2015) highlights a number of implications that should be considered for beaver reintroductions in Scotland, those that have a particular bearing to Knapdale and Tayside, in the absence of the policy, have been reproduced below:

- Problems arising from inbreeding are viewed as the greater challenge to the viability of introduced beaver populations to Scotland/Britain. The risks of outbreeding depression are considered low if currently mixed populations and/or a mixture of different populations from the western lineage are used as donors.
- Inbreeding – individuals from genetic clusters, source populations and areas that have not been previously used in British releases are preferred, and hence close relatives of beavers already present are not preferred. Founder populations should be as large as possible and sourced from a diverse range of genetic sources (populations and families).
- Future genetic management – an increased number of wild founders is preferred to ensure genetic diversity. However, it is critical that any future releases (including within-country relocations) should be planned, co-ordinated, licensed and managed.

3.2.5 Genetic implications for the two beaver populations in the absence of the policy

The policy reflects the desire to see the two current beaver populations remain with provision for natural expansion with for suitable adaptive management processes including further population reinforcement and legal protection afforded through the EU Habitats Directive. Without the policy and therefore the prospect of further releases, genetic considerations to date suggest that the risk of inbreeding depression with respect to the Knapdale population cannot be ruled out. The population on Tayside did not come about as a founder population; uncertainty remains as to whether the population has sufficient genetic diversity to ensure long term viability.

In the absence of the policy, it is likely that the population in Knapdale face the threat of extinction, while modelling has shown that the population of beavers in the Tayside Beaver area is predicted to expand but the rate and distribution will be difficult to model because control of the population would be unregulated. The effects on the other environmental receptors will remain the same.

3.3 Existing environmental issues

Environmental issues which are relevant to the policy are presented in the table below.

Table 3.3 – Existing environmental issues

SEA topic	Environmental problems
Biodiversity, flora and fauna	Indirect pressures such as sedimentation, nutrient enrichment in watercourses/waterbodies Invasive non-native species, which can have long-term impacts on ecological communities, is an increasing issue both along the riparian zones and in watercourses themselves

	Herbivore pressures, particularly lowland deer Cumulative effect of other pressures on water-related designated sites and species, and on wider biodiversity in Tayside (e.g. .development, disturbance of species, habitat fragmentation, agricultural intensification, and herbivore pressures).
Population and Human Health	Eurasian beavers host a number of external and internal parasites, some of which are already present in the UK (such as *Cryptosporidium parvum)* and some are not.
Soils and geomorphology	Pressures such as soil loss through action of wind and water, soil organic matter depletion, soil contamination through surface and groundwater pollution. For fluvial geomorphology, overwidening streams, canalising/realignment and culverting streams, hard bank/bed protection engineering, bank erosion and obstructions to migratory fish. Irreversible loss of soil through development, contamination and erosion.
Water quality, resource and ecological status	Diffuse pollution (sediments and fertilizers), abstraction, oxygen depletion, invasive non-native plants, abstractions and discharges.
Cultural heritage	Consideration of pressures from flood risk to property, natural ageing of veteran/ancient trees including significant champion trees in Tayside, and invasive non-native species.
Material assets	Climate change to weather patterns, storminess and pluvial/fluvial flood risk to transport infrastructure, property, public assets and economic facilities and infrastructure. High proportion of high quality agricultural land. The need to retain and safeguard this high quality land is recognised in Scottish Planning Policy (SPP).

4. Assessment of Environmental Effects

4.1 Overview of beaver ecology

This section sets the context for the assessment of the impacts of the policy on the other SEA environmental receptors. It is based on the findings in the Beavers in Scotland Report 2015, (BiS), provided in Annex 1 of this Environmental Report (ER) for further reference if required.

4.1.1 Beaver ecology

4.1.1.1 Beaver colonies and territories

Beavers are semi-aquatic rodents. Beavers form lifetime pairs, with a pair defending a strict territory against unrelated intruders. Beaver colonies are made of family groups, typically consisting of an adult pair, and a number of kits (young under one year of age) and sub-adults. The size of territories is often measured by the length of water bank utilised and is quite variable**.** Territories are rarely permanent. Beavers are strict herbivores, and their preferred food sources slowly deplete over time. Therefore beavers may leave a territory for a number of years, and will not recolonise the area until enough suitable food has regenerated.

4.1.1.2 Feeding and habitat

Beavers are strict herbivores and feed on a wide variety of plant species, including aquatic and terrestrial herbaceous and woody vegetation (see sections 4.2 and 4.4).
Smaller stems, less than 0.1 m in diameter, are often preferred. However, larger stems (up to 0.2 m) may still be commonly utilised, and the use of trees of more than 1 m diameter has been recorded.

Beavers are semi-aquatic and are reliant on water to escape from any potential predators. Because of this they feed only in close proximity to watercourses.

4.1.1.3 Beaver structures

Beavers live in lodges and/or burrows. Lodges are often highly visible structures made from cut branches, logs and mud. Burrows are often inconspicuous with underwater entrances. The two may be combined in a bank lodge, which is a burrow with further reinforcement and insulation provided above with a structure of logs and branches.

Beaver dams are built from a variety of logs, branches, grass, mud and stones. The majority are less than 1.5 m in height, ranging from 0.2 m in height and 0.3 m in length, up to 3 m in height and more than 100 m in length, although the latter are exceptional cases. They are built to retain water, create feeding areas, provide safe refuge (and keep the lodge entrance under water) and facilitate travel and movement of logs and branches. Dams may have a range of effects on the surrounding environment and nature of the watercourse (see section 4.4).

Owing to either siltation or dam failure, beaver ponds are often temporary. After a beaver pond has returned to a terrestrial state, a beaver meadow may be created, which can persist for many decades. However, a pond may also develop into other states such as emergent wetland, bogs or forested wetland, which may remain stable for centuries.

4.1.2 Distribution of suitable beaver habitat in Scotland

It is useful to predict where potential habitat exists for beavers in Scotland, and to use this to estimate potential future beaver distribution. Work has therefore been done, using

Geographic Information System (GIS) tools, to provide this information. This will help to identify where beavers may have effects on particular ecological and socio-economic factors

Beavers may utilise particular habitats, in particular riparian, broadleaf woodland, which provides a key source of food and materials for building structures (see section 4.2). GIS tools were used to create datasets of suitable beaver woodland across Scotland. The datasets were then used in a variety of overlapping analyses, described in later sections of the BiS report (Annex 1), to predict where beavers may potentially interact with certain species or land use issues.

Potential beaver woodland can be identified by the following characteristics, described in detail in Annex 1 section 3.2

- Broadleaf woodland and shrub – the main predictor of the presence or absence of beavers is the availability of food, in particular the abundance of suitable woodland
- Within 50 m of freshwater edge – beavers prefer to feed in close proximity to water.
- Streams with less than 15% gradient – higher gradient streams are known to be sub-optimal habitat for beavers.
- Not in tidal sections – beavers are only rarely seen in salt/tidal water and do not establish territories in such habitats.

Using these parameters, a dataset of 'potential beaver woodland' was created, which identified all woodland that could potentially be used by beavers in Scotland. This resulted in the identification of 120,390 ha of potential woodland on the mainland.

4.1.2.1 *Potential core beaver woodland*

The 'potential beaver woodland' dataset was further refined. Beavers require a certain area of suitable woodland to set up a territory. The potential beaver woodland dataset contains all woodland that could be utilised by beavers, but many of these are small, isolated patches. The minimum amount of woodland needed for a beaver to establish a long-term territory was estimated based on the literature. The potential core beaver woodland map consists of 57,309 polygons, covering 105,586 ha of suitable woodland. It is anticipated that beavers would be more likely to set up long-term territories in proximity to these areas of potential core beaver woodland. Section 3.2 provides further detail and map 4 which illustrates core beaver woodland within the SEA beaver policy areas. The Knapdale beaver policy area comprises 64,978 ha in size, with Tayside comprising 1,140,075 ha. Of this, the potential core woodland in the policy areas extends to 970 hectares (ha) in Knapdale (less than 1.5% of the total beaver policy area) and 14,717 ha in Tayside (less than 1.3%).

4.1.2.2 *Catchment mapping*

A previous mapping exercise identified four catchments as key woodland areas for beavers: Lomond, Tay, Spey and Ness. Analysis showed that the catchments with the most core beaver woodland were the Tay and Spey. Analysing which catchments have the most core woodland is useful, but is biased by the size of the catchment. For the purpose of this report, the River Tay falls within the SEA boundary, with only a small part of the upper section of the Spey. The River Tay and its riparian woodland comprises some 47% of the total potential core beaver woodland found within the Tayside SEA boundary.

4.1.2.3 *Areas where dam-building is less likely*

It would be useful to predict where beavers may build dams in Scotland, assuming any reintroduction. However, key ecological measures which might help predict dam sites (e.g. stream depth) are not currently available in national geospatial datasets. Therefore, it was decided that a reliable dataset could not be produced at the present time, and, instead, a dataset was created to predict where beavers are unlikely to dam. Areas not identified by this dataset contain watercourses where the potential for dam-building is unknown.

Building dams is a high-cost activity for beavers. For this exercise it was assumed that beavers would justify the investment in building and maintaining a dam only where resources exist to sustain a beaver territory. Hence, watercourses not adjacent to potential core beaver woodland were identified as being less likely dam sites.

Beavers cannot build dams where the flow rate of a stream is too great. The larger a watercourse, the more likely a dam will get washed away during flooding. This is why the great majority of beaver dams are found on smaller watercourses less than 6 m in width. Hence, all watercourses greater than 6 m in width were also identified as being unlikely dam sites.

Using these parameters, it was estimated that a minimum of 87% of watercourse length on mainland Scotland is less likely to be a dam site for beavers.

4.2 Beavers and Woodland

4.2.1 How beaver activity affects riparian woodland

The main mechanisms by which beavers affect riparian[1] woodland are tree-felling for food and construction, and flooding. They generally avoid conifers, but will use most native broadleaved tree species that occur in Scotland, and other non-native broadleaved trees.

Where numbers of other herbivores are high, the impacts of beavers may be exacerbated if subsequent browsing of regrowth by other herbivores prevents coppice regrowth and tree regeneration. Hence, careful management of deer and livestock in areas colonised by beavers will maximise the likelihood of an overall positive impact of beavers on woodland ecosystems.

These mechanisms can lead to a range of impacts on woodland, as outlined in section 4.2.1.1 – 4.2.1.3 below. A summary of the potential interactions between beavers and riparian woodlands is presented at the end of this section (see Table 4.2.1); where possible these have been attributed to a neutral, positive or negative effect.

4.2.1.1 Woodland structure

In general, beavers prefer smaller stems, less than 0.1 m in diameter, but will take much larger ones as well. When choosing material for construction, stem size may be more important than species. Most broadleaved trees can regrow from cut stumps, but the vitality of the regrowth varies with species and the age of the tree.

Since beavers select a tree according to its stem size, and as younger trees generally produce more, stronger, regrowth shoots than older trees, a younger age profile is likely to develop over time, with a loss of both older stems and older growth riparian woodland communities. If a large proportion of the woodland is affected then ecological continuity could be interrupted, particularly with impacts on lichens and other species characteristic of older stems.

Most felling is within 10 m of the water's edge and, because beavers are usually considered to be central place foragers, impacts vary along watercourses according to distance from lodges. The impact of beavers may therefore be patchy, leading to greater structural diversity along the length of watercourses.

Felling large trees opens the canopy, allowing more light to reach the ground, and allowing regeneration from seed, which could potentially lead to increased structural diversity in even-aged woodland.

Where browsing from other herbivores is high, regrowth may be prevented, and this could lead to a reduction in structural diversity and ultimately loss of woodland cover.

4.2.1.2 Species Composition

Beaver have a clear preference for some tree species over others, in particular aspen *Populus tremula* and willow *Salix* spp. These species generally resprout rapidly, and beavers seem to avoid young aspen regrowth. However, young shoots are very attractive to deer, and the combined impact may lead to the loss of beaver-preferred species.

[1] Refers to native woodland that occurs within the riparian zone, an often narrow strict of trees and vegetation associated with the banks of streams, rivers and lochs. http://scotland.forestry.gov.uk/managing/work-on-scotlands-national-forest-estate/conservation/habitats/woodland/riparian-zone

More generally, although beavers often use species according to their abundance, they may also preferentially select less common species in order to fulfil their need for a diverse diet. This could lead to reduced species diversity, which might be exacerbated by differences in the responses of tree species to beaver browsing and the preference of deer for different species. Willow and ash *Fraxinus excelsior* produce stronger shoots than alder *Alnus glutinosa* or birch *Betula pubescens*, but are also more attractive to deer.

Inundation of woodland will lead to the death of trees of many species, but could promote the growth of others, especially willow, which can grow well even in standing water.

4.2.1.3 Deadwood

Although tree-felling by beavers could lead to increased fallen dead wood in some areas, much of the material is removed for food and construction, some of which falls in, or is placed in, water bodies (see Annex 1, section 3.4.3).

In flooded areas, the death of trees which are unable to cope with increased water levels will lead to an increase in standing dead wood, which is generally present at only low levels in British woods. Such areas may become hotspots for dead wood biodiversity (see, for example, Annex 1, sections 3.4.6 and 3.4.9).

Table 4.2.1: Summary of potential interactions between beavers and woodland.

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• Most felling is within 10 m of the water's edge. Beavers are central place foragers, so impacts also vary along watercourses according to distance from lodges. The impact of beavers may therefore be patchy, leading to greater structural diversity along the length of watercourses • Felling large trees opens the canopy, allowing more light to reach the ground and allowing regeneration from seed, which could lead to increased structural diversity in even-aged woodland.	• Where woodland is already very open, the impact of beavers could lead to localised loss of woodland cover, especially where levels of deer browsing are high, and could prevent regeneration from seed	
Felling	Change in riparian woodland: Change in relative abundance of different tree species		• Young shoots are very attractive to deer, and the combined impact may lead to loss of preferred species. In some cases, aspen could be lost from parts of the core beaver habitat, where near-permanent beaver presence prevents substantial regrowth • Beaver may preferentially select less common species in order to fulfil their need for a diverse diet. This could lead to reduced species diversity, which might be exacerbated by differences in the responses of tree species to beaver browsing	Beavers have a clear preference for some tree species, particularly aspen and willow. These species generally resprout rapidly, and beavers seem to avoid young aspen regrowth
Felling	Change in riparian woodland: Change in age		• Where browsing from other herbivores is high, regrowth may be prevented, and this could lead to a reduction in structural diversity and ultimately loss of woodland	Most broadleaved tree species can regrow from cut stumps, but the

	classes of trees		cover • Since beavers select according to stem size, and as younger trees generally produce more and stronger shoots than older ones, a younger age profile is likely to develop over time, with a loss of older trees and of climax riparian woodland communities. If a large proportion of the woodland is affected then ecological continuity could be interrupted within the riparian zone	vitality of the regrowth varies with species and age. In Knapdale, ash and willow were found to produce stronger shoots than birch and alder
Felling	Change in riparian woodland: Amount/diversity of fallen dead wood on woodland floor	• Tree-felling by beavers could lead to increased fallen dead wood in some areas, although much of the material is removed for food and construction		
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• Inundation of woodland could promote the growth of some species, especially willow, which can grow well even in standing water. Bog woodland may be restored or more habitat created	• If a large proportion of an area of woodland is inundated, and willow is unable to regenerate, loss of woodland cover could be considered a negative impact	This might be positive/negative or neutral depending on the area, tree species and regeneration
Dams/pond creation	Change in standing dead wood resulting from inundation of trees	• Death of trees which are unable to cope with the water levels will lead to an increase in standing dead wood, which is generally present at only low levels in British woods	• Inundation of woodland will lead to the death of trees of certain species	This might be positive/negative or neutral depending on the area, tree species, regeneration and the pre-existing biodiversity value of the inundated woodland

Dams/pond creation	Longer term successional changes after dam abandonment, e.g. beaver meadows	• In previously homogeneous woods, this increase in integral open space would add diversity and improve the habitat for some species groups, e.g. the adults of dead wood invertebrates often require nectar sources	• In fragmented woodland, this loss of woodland cover would be considered a negative impact	This might be positive/negative or neutral depending on the pre-existing woodland structure
Indirect habitat creation/restoration initiatives as a result of beaver presence	Beavers used to promote opportunities for riparian and freshwater habitat creation/restoration	• Any riparian woodland restoration programme will aim to increase the abundance of this much reduced habitat, and of particular preferred species, such as aspen		

4.2.2 Distribution of suitable riparian woodland habitat in the beaver policy area

As identified in section 4.1, work has been done through the Beaver in Scotland report to further refine the 'potential beaver woodland' dataset to identify 'potential core beaver woodland' which anticipates areas that beavers would be more likely to set up long-term territories in proximity to these areas of woodland (see Map 4 in Appendix 1).

The Tayside beaver policy area is estimated to have around 14,700 ha of potential core beaver woodland. Woodland connectivity is relatively good, and if beavers were to remain on Tayside then it is anticipated that in the long term a significant proportion would eventually be colonised. The potential core beaver woodland is less than 1.3% of the Tayside beaver policy area.

The Knapdale beaver policy area is estimated to have almost 1000 ha of potential core beaver woodland. The beaver population at Knapdale, with additional reinforcement, is expected to expand and use additional areas of riparian woodland, although there may be limited colonisation outside Knapdale Forest over the medium term of 30 years (see Annex 1, section 3.2). The potential core beaver woodland is less than 1.5% of the Knapdale beaver policy area.

4.2.2.1 Riparian woodland habitat of conservation importance

To determine whether the activity of beavers on riparian woodland habitat is significant in the context of this Strategic Environmental Assessment, the assessment of impacts (positive and negative) has focussed on those woodland sites for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded European or national protection wherever they occur. Of these, ninety such sites have been identified that overlap with potential core beaver woodland. These can be grouped according to the dominant tree species.

Table 4.2.2: Summary of riparian woodland types and the sites that overlap with potential core beaver woodland, grouped as per the dominant tree species

	Conservation importance	
Woodland Type	**SAC**	**SSSI**
DOMINANT TREES SPECIES: ALDER AND WILLOW		
Alder woodland on floodplains	Shingle Islands SAC	
Wet woodland		Bolfracks Wood SSSI Cambusurich Wood SSSI Coille Chriche SSSI Damhead Wood SSSI Edinchip Wood SSSI Glen Coe SSSI Glen Lochay Woods SSSI Glen Lyon Woods SSSI Loch Tay Marshes SSSI Milton Wood SSSI Pollochro Woods SSSI Round Loch of Lundie SSSI Stronvar Marshes SSSI
Scrub		Bog Wood and Meadow SSSI Den of Ogil SSSI
DOMINANT TREE SPECIES: ASH		
Mixed woodland on base-rich soils associated with rocky slopes	Craighall Gorge SAC Keltneyburn SAC	

Upland mixed ash woodland		Back Burn Wood and Meadows SSSI Birks of Aberfeldy SSSI Cambusurich Wood SSSI Craighall Gorge SSSI Den of Airlie SSSI Den of Alyth SSSI Den of Fowlis SSSI Den of Riechip SSSI Devon Gorge SSSI Dollar Glen SSSI Finlarig Burn SSSI Flisk Wood SSSI Glen Lochay Woods SSSI Glen Tilt Woods SSSI Keltneyburn SSSI Romadie Wood SSSI
DOMINANT TREE SPECIES: OAK AND BIRCH		
Western acidic oak woodland	Moine Mhor SAC Tarbert Woods SAC Taynish and Knapdale Woods SAC Loch Lomond Woods SAC Upper Strathearn Oakwoods SAC	
Upland oak woodland		Artilligan and Abhainn Srathain Burns SSSI Cambusurich Wood SSSI Cardney Wood SSSI Carie and Cragganester Woods SSSI Comrie Woods SSSI Edinchip Wood SSSI Ellary Woods SSSI Glen Falloch Woods SSSI Innishewan Wood SSSI Inverneil Burn SSSI Knapdale Woods SSSI Moine Mhor SSSI Monzie Wood SSSI Pass of Killiecrankie SSSI Pass of Leny Flushes SSSI Taynish Woods SSSI Tayvallich Juniper and Fen SSSI
Upland birch woodland		Beinn a' Ghlo SSSI Black Wood of Rannoch SSSI Glen Lochay Woods SSSI Leven Valley SSSI Linn of Tummel SSSI Struan Wood SSSI
Lowland mixed broadleaved woodland		Drummond Lochs SSSI Kincardine Castle Wood SSSI Methven Woods SSSI
DOMINANT TREE SPECIES: PINE		
Bog woodland	Ballochbuie SAC Cairngorms SAC	
Caledonian forest	Ballochbuie SAC Black Wood of Rannoch SAC Cairngorms SAC	
Native pinewood		Black Wood of Rannoch SSSI Creag Clunie and the Lion's Face SSSI Cairngorms SSSI Easter Cairngorm SSSI

		Allt Broighleachan SSSI Coille Coire Chuilc SSSI Crannach Wood SSSI Crossbog Pinewood SSSI Doire Darach SSSI Glen Falloch Pinewood SSSI Meggernie and Croch na Keys Woods SSSI
DOMINANT TREE SPECIES: HAZEL		
Atlantic hazelwoods	See Map 11 for distribution below	

4.2.3 Assessment of likely effects on woodlands of conservation importance in the beaver policy area

Each of the woodland habitat types identified in Table 4.2.2 above are discussed in turn below in the context of those effects (positive or negative) that have been identified as a result of beaver activity. Where this relates to a habitat included in the Habitats Regulation Appraisal of the policy (i.e. in an SAC), a summary of the advice from SNH, provided to inform an appropriate assessment (AA) of the policy with respect to SAC sites (see Annex 2 for the full advice) has been used (referred to hereafter as 'SNH HRA advice'). For the purpose of this assessment, the concluding points of the SNH HRA advice have been replicated where appropriate for each woodland type. Assessment of other woodland habitat types (i.e. SSSI woodland habitat types), has been made in the context of the SNH HRA advice in combination with knowledge of the individual woodland sites and their condition. Where mitigation or monitoring maybe appropriate, this has been identified in the narrative. Further discussion relating to the management of beavers including mitigation and monitoring options is provided in sections 5 and 7 respectively.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

Mitigation
The need for mitigation will depend on site-specific circumstances related to the woodland type, the condition of the woodland and the influence of other pressures. Moreover, it will also depend on the degree and duration of beaver occupancy. Mitigation is therefore discussed more generally below, with further commentary provided in section 5 with reference to exclusion fencing, individual tree protection and management techniques to minimise or avoid unwanted impacts from beavers' activity.

Beaver opportunities
As summarised above, beaver activity has the potential to create positive effects. More than this, the presence of beavers in an area could provide a basis for a riparian woodland restoration programme to help increase the abundance of this much reduced habitat.

4.2.3.1 Consideration of potential positive effects on woodland of conservation importance

ALL WOODLAND TYPES (EXCLUDING ATLANTIC HAZELWOODS)

For all of the aforementioned identified woodland types, spanning some ninety sites, as outlined in Table 4.2.2 above, the precise effects will often be site-specific, wide-ranging and uncertain in their detail. Many of the effects can be positive or neutral in their outcomes, however taking a strategic and precautionary approach the SNH HRA advice considered that there remains the potential for a Likely Significant Effect in some cases – these are dealt with in section 4.2.4.2 below), as is Atlantic Hazelwoods.

As noted in the summary of effects above, due to their activities, beavers have a variety of positive effects on woodland structure, leading to a greater diversity of age classes, particularly in even-aged stands, improving the variety of species present in woodlands and potentially creating hot spots of biodiversity through the creation of increased levels of standing dead wood. Positive gains from beaver activity on woodland habitat can be described in general terms as follows:

- The impact of beavers may be patchy, leading to greater structural diversity along the length of watercourses.
- Felling large trees opens the canopy, allowing more light to reach the ground and allowing regeneration from seed, which could lead to increased structural and species diversity in even-aged woodland.
- In previously homogeneous woods, this increase in integral open space would add diversity and improve the habitat for some species groups, e.g. the adults of dead wood invertebrates often require nectar sources
- Inundation of woodland could promote the growth of some species, especially willow, which can grow well even in standing water. Bog woodland may be restored or more created.
- Death of trees which are unable to cope with the water levels will lead to an increase in standing dead wood, which is generally present at only low levels in British woods
- Tree-felling by beavers could lead to increased fallen dead wood in some areas, although much of the material is removed for food and construction

Short, medium or long-term changes in the vegetation structure, and / or hydrology of localised areas of accessible woodland as a result of beaver activity, is likely to increase the dynamism of woodland processes. Provided regeneration of felled trees and shrubs is able to continue, this is likely to increase the overall conservation value of the these woodland sites (for example, by increasing the amount of standing dead wood resulting from flooding, thereby increasing habitat for dead wood ‘typical species’, as discussed above).

Many of the ninety sites identified in this analysis are in unfavourable condition and do not meet their site attribute targets for volume of deadwood, level of grazing / browsing, structural diversity (i.e. number of different age classes of target tree species) or evidence of regeneration. As described above, beaver activity has the potential to address some of these failing targets. Monitoring will therefore be required to assess the impact of beaver activity and how any benefit may come about; see section 7 for discussion of Site Condition Monitoring and beavers.

4.2.3.2 Consideration of potential negative effects on woodland of conservation importance

Beaver browsing of trees and other elements of woodlands for food is the main mechanism of change considered; however trees may also be felled for, or flooded by, dam-building. Selective browsing can lead to reduced tree diversity as well as tree and shrub growth and regrowth, particularly within 30m of freshwater where the large majority of beaver browsing activity takes place. The most important factors in determining the degree of impact from beavers will usually be:

- The total size of woodland area, with a generally diluted impact on larger wooded areas and greater impact on smaller areas.
- The proportion of preferred tree species (such as aspen, willow, and possibly hazel) within a wooded area.

- The existing degree of pressure on woodland from browsing by other herbivores, especially deer.

Dam-building can also lead to the inundation of previously less wet areas drowning some trees with resulting impacts on woodland structures.

The main factor causing unfavourable condition across Scottish woodlands is grazing / browsing pressure from herbivores (largely deer and sheep). At present, saplings can be considered ‘safe’ from further browsing once they get to a certain size (the specific size varies with the species). However, since beavers are able to fell quite large trees, this will no longer be the case in areas colonised by beavers for a reasonable length of time. Continuation of woodland will depend on coppice regrowth from the felled stumps or suckering from roots. Whilst all native Scottish broadleaves are able to coppice or sucker, if the regrowth is subsequently eaten by deer, sheep, or other large herbivores, there could be a simplification in the structure of the woodland, and possibly deterioration or even loss of the woodland habitat.

The impact of beaver activity on the woodlands habitat types discussed below is considered to have a negative or have the potential for a negative effect.

ALDER AND WILLOW DOMINATED WOODLAND SITES

WOODLAND TYPE: ALDER WOODLAND ON FLOODPLAINS

Alder woodland on floodplains is also referred to as, Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae). The woodland canopy is varied but dominated by alder *Alnus glutinosa*, with frequent willows Salix spp., ash *Fraxinus excelsior*, downy birch *Betula pubescens* and occasional wych elm *Ulmus glabra*. Hawthorn *Crataegus monogyna*, rowan *Sorbus aucuparia*, bird cherry *Prunus padus* and hazel *Corylus avellana* all occur in the understorey. The ground flora is also very diverse with many fen species in the wetter areas and more typical woodland herbs elsewhere. Small areas of drier woodland, dominated by ash *Fraxinus excelsior* with occasional pedunculate oak *Quercus robur*, and transitions to other shingle, scrub and grassland communities, further enhance the site’s diversity.

Knapdale

There are no sites identified in Knapdale that are designated for alder woodland on floodplains habitat.

Tayside

- **Shingle Islands SAC**

SNH HRA advice

Beaver activity in combination with browsing pressure from other herbivores could lead to a loss of habitat, if regeneration is prevented. This qualifying interest is, by its nature, wholly within the core beaver woodland. There is no reason to suppose that impact will vary across the site and, provided regeneration is able to continue, there should be no change in the distribution of the habitat. Change in structure is likely, but difficult to predict. Possible impacts include changes in the volume of deadwood, increases in dense young growth or in open space. Provided regeneration is able to continue, these changes are most likely to be beneficial, contributing to the dynamism which is an important feature of this habitat. Short, medium or long-term changes in the vegetative structure, and/or hydrology of localised areas of alder woodland, as a result of beaver activity, are likely to increase the dynamism of woodland processes. Provided regeneration is able to continue, this is likely to increase the overall conservation value of the site (for example, by increasing the amount of standing dead wood resulting from flooding, thereby increasing habitat for dead wood ‘typical species'). Such changes would be compatible with this conservation objective and do not undermine it. The Eurasian beaver is a natural component of this habitat type across Europe.

The SNH HRA advice concluded that it cannot be ascertained that there is no adverse effect on site integrity as a result of the potential combined grazing and browsing impacts of beaver and other herbivores on the alder woodland on floodplains qualifier without mitigation.

Mitigation
Any potential adverse impacts on the integrity of the SAC should be mitigated through increased herbivore management measures (upon deer, goats, sheep, or beavers as appropriate) before they occur. Signs of over-grazing can be detected before any adverse impacts result. As beavers are now present at this site, impacts should be monitored using the Woodland Grazing Toolbox methodology. If the necessary mitigation measures, including monitoring are carried out then SNH advise that it can be ascertained that there is no adverse effect on site integrity.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

WOODLAND TYPE: WET WOODLAND
Wet woodland occurs on poorly drained or seasonally wet soils, usually with alder, birch and willows as the predominant tree species, but sometimes including ash, oak, pine and beech on the drier riparian areas. It is found on floodplains, as successional habitat on fens, mires and bogs, along streams and hill-side flushes, and in peaty hollows.

Many alder woods are ancient and have a long history of coppice management which has determined their structure, and in some situations it appears that this practice has maintained alder as the dominant species and impeded succession to drier woodland communities. Other wet woodland may have developed through natural succession on open wetlands (sometimes following cessation of active management) and structurally are little influenced by direct forestry treatments.

A review of the above identified wet woodland SSSI indicates that many are in unfavourable condition, failing to meet their site attribute targets for volume of deadwood, level of grazing / browsing, structural diversity (i.e. number of different age classes of target tree species) or evidence of regeneration

Knapdale
There are no sites identified in Knapdale that are designated for wet woodland habitat.

Tayside
- Bolfracks Wood SSSI
- Cambusurich Wood SSSI
- Coille Chriche SSSI
- Damhead Wood SSSI
- Edinchip Wood SSSI
- Glen Coe SSSI
- Glen Lochay Woods SSSI
- Glen Lyon Woods SSSI
- Loch Tay Marshes SSSI
- Milton Wood SSSI
- Pollochro Woods SSSI
- Round Loch of Lundie SSSI
- Stronvar Marshes SSSI

SSSI Assessment
Impacts within wet woodland SSSI habitat are likely to be similar to those described above for alder woodland on floodplains habitat. There is therefore potential for beaver activity in combination with other herbivores to adversely affect the natural heritage interests of national importance.

Mitigation
As beavers continue to naturally colonise some of these sites, impacts should be monitored using the Woodland Grazing Toolbox methodology. Signs of over-grazing can be detected before any adverse impacts result. These impacts should then be mitigated by using all necessary herbivore management measures (of deer or beavers, or both).

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

WOODLAND TYPE: SCRUB

Knapdale
There are no sites identified in Knapdale that are designated for scrub dominated woodland habitats.

Tayside
- Bog Wood and Meadow SSSI
- Den of Ogil SSSI

Bog Wood and Meadow SSSI
Below the fen meadow in Bog Wood and Meadow SSSI is a small area of fen interspersed with tussocks of greater tussock sedge, which grades into willow scrub which contains bay willow *Salix pentandra*. This type of scrub woodland is nationally scarce.

A review of SCM site attribute targets highlights little evidence of regeneration but noted prolific regeneration from cut stump on the wayleave intersecting the site indicating the potential for regeneration exits. As such, all target were deemed to have been met and the site is in favourable condition.

SSSI Assessment
Beavers show a clear preference for some trees species such as willow and that more generally they often use a species according to its abundance. At Knapdale (SBT) beavers showed a strong preference for willow (as well as ash, rowan and hazel) but avoided alder. Willow and ash show a higher propensity for coppice regrowth than alder or birch. While the inundation of woodland can lead to the death of trees of many species, it can promote the growth of others, especially willow, which can grow well even in standing water.

On balance while beavers show a strong preference for willow, its regeneration and water tolerate characteristics suggest it’s unlikely that beaver activity at this SSSI would detrimentally impact the overall condition of the area.

Monitoring
Beavers are now present on this site and so, impacts should be monitored using the Woodland Grazing Toolbox methodology and an assessment made of the extent to which they utilise the willow scrub. See section 7 for details on the approach to SCM and beavers.

Den of Ogil SSSI
The Den of Ogil SSSI is important because of its species-rich plant communities, particularly the fens associated with upwelling springs which drain into the Burn of Ogil, and also for its wet willow (Salix sp.) and alder (Alnus glutinosa) carr scrub woodland. A large proportion of the site is covered with alder and willow carr, much of which was originally planted in an attempt to dry out the area. A review of SCM site attribute targets indicated that all targets have been met. Consequently, this site is in favourable condition.

SSSI Assessment
Beavers show a clear preference for some trees species such as willow and that more generally they often use a species according to it abundance. At Knapdale beavers showed a strong preference for willow (as well as ash, rowan and hazel) but avoided alder. Willow and ash show a higher propensity for coppice regrowth than alder or birch. While the inundation of woodland can lead to the death of trees of many species, it can promote the growth of others, especially willow, which can grow well even in standing water.

On balance while beavers show a strong preference for willow, its regeneration and water tolerate characteristics suggest it’s unlikely that beaver activity at this SSSI would harm the overall condition of the area.

Monitoring
As beavers naturally colonise this site, impacts should be monitored using the Woodland Grazing Toolbox methodology and an assessment made of the extent to which they utilise the alder carr. See section 7 for details on the approach to SCM and beavers.

PINE DOMINATED WOODLAND SITES

Consideration of Aspen
Most of the aspen rich woodlands found in Scotland occur in the Strathspey area, beyond the SEA policy boundary. This is reflected in the GIS analysis undertaken, reporting a total area of 1.46ha of aspen (area with 80% or more in the tree canopy) present in the Tayside beaver policy area. The commentary below with respect to Cairngorms SAC includes reference to aspen because the SAC boundary, while only partially overlapping the Tayside beaver policy area, reaches north towards Strathspey and so has a greater proportion of aspen within the broadleaf woodland component. The HRA process takes a site wide precautionary view, hence its inclusion. Cairngorms and Eastern Cairngorms SSSI underpins Cairngorms SAC in extent and so reference is also made in the assessment to aspen, see below. SSSIs overlapping further south, well within the SEA policy boundary do not have much aspen within their pinewoods. Aspen is not present in Knapdale other in a few odd groups of trees.

SEA name	Area of aspen >= 50% canopy (ha)	Area of aspen >= 80% canopy (ha)
Knapdale	0	0
Tayside	2.30	1.46
TOTAL	2.30	1.46

WOODLAND TYPE: CALEDONIAN FOREST
Caledonian forest comprises relict, indigenous pine forests of Scots pine *Pinus sylvestris* var. *scotica*, and associated birch *Betula spp*. and juniper *Juniperus communis* woodlands of northern character. Self-sown stands naturally regenerated from stock of genuinely native local origin recorded in the Caledonian Pinewood Inventory are included in the Annex I type. It is usually found on strongly-leached, acidic podzols, and these soil conditions are reflected

in the ground flora, which typically includes the dwarf shrubs heather *Calluna vulgaris*, bilberry *Vaccinium myrtillus* and cowberry *V. vitis-idaea*, wavy hair-grass *Deschampsia flexuosa*, and the bryophytes *Dicranum scoparium*, *Hylocomium splendens, Pleurozium schreberi* and *Rhytidiadelphus loreus.*

Knapdale
There are no sites identified in Knapdale that are designated for Caledonian Forest habitat.

Tayside
- Ballochbuie SAC
- Black Wood of Rannoch SAC
- Cairngorms SAC

SNH HRA advice
Beaver generally avoid pine and other conifers however broadleaved species are an important component of Caledonian forest and beavers will utilise these. Changes in structure of the broadleaved component in the immediate vicinity of rivers is possible due to beaver foraging and dam building, although any potential impacts would only be considered adverse if their regeneration is impeded or restricted, e.g. due to excessive pressure from other herbivores. Short, medium or long-term changes in the vegetative structure, and/or hydrology of areas in the immediate vicinity of rivers, is likely to increase the dynamism of woodland processes. Provided regeneration is able to continue, this is likely to increase the overall conservation value of the site (for example, by increasing the amount of standing dead wood resulting from flooding, thereby increasing habitat for dead wood 'typical species'). Such changes would be compatible with this conservation objective and do not undermine it.

The SNH HRA advice concluded that it is not possible to ascertain no adverse effect on site integrity of Ballochbuie SAC and Black Wood of Rannoch SAC from impacts to Caledonian Forest without mitigation. Impacts could result from the cumulative effects of beavers and other herbivores on the broadleaved component of these sites: where beavers might fell some trees and / or shrubs, and other herbivores then prevent the natural regeneration of those trees through browsing.

In addition, an adverse effect on site integrity is possible in the Cairngorms SAC via the actions of beavers alone. In this SAC beavers could reduce the amount of aspen due to their preference for it as food, including mature and over-mature specimens which are especially important for maintaining biodiversity.

Mitigation
Adverse impacts on these SACs can be mitigated through any necessary herbivore management measures (of deer or beavers, or both). Monitoring for signs of over-grazing should be carried out using the Woodland Grazing Toolbox methodology to ensure any impacts can be avoided before they have an adverse effect on site integrity.

With respect to aspen and Cairngorms SAC, impacts on this SAC can be mitigated by protecting important areas of aspen, to prevent access by beavers. Monitoring for signs of over-grazing should be carried out using the Woodland Grazing Toolbox methodology to ensure any impacts can be avoided before they have an adverse effect on site integrity.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

WOODLAND TYPE: NATIVE PINEWOOD

Native pinewoods occur on infertile, strongly leached, podsolic soils. They do not support a large diversity of plants and animals compared with some more fertile habitats. However, there is a characteristic plant and animal community which includes many rare and uncommon species. The main tree species is Scots pine although birches *Betula* spp., rowan *Sorbus aucuparia*, alder *Alnus glutinosa*, willows *Salix* spp., bird cherry *Prunus padus* are also found. Sessile oak *Quercus petracea* also occurs infrequently, mainly in the northeast of Scotland. A shrub understorey, where browsing levels are low, includes common juniper *Juniperus communis*, aspen *Populus tremula*, holly *Ilex aquifolium* and hazel *Corylus avellana*. Old or dead trees and rotting wood supports significant beetle and bryophyte communities. The field layer is characterised by acid-tolerant plants like bell heather *Erica cinerea*, billberry *Vaccinium myrtillus* and crowberry *Empetrum nigrum*.

A review of SCM site attribute targets highlights that only two of the sites are in favourable condition, the rest are unfavourable mostly due to negative levels of browsing, poor structural diversity assessed through the number of age classes of trees present, a lack of regeneration and in a few sites, insufficient volume of deadwood.

Knapdale

There are no sites identified in Knapdale that are designated for Native pinewood habitat.

Tayside

- Black Wood of Rannoch SSSI
- Creag Clunie and the Lion's Face SSSI
- Cairngorms SSSI
- Easter Cairngorm SSSI
- Allt Broighleachan SSSI
- Coille Coire Chuilc SSSI
- Crannach Wood SSSI
- Crossbog Pinewood SSSI
- Doire Darach SSSI
- Glen Falloch Pinewood SSSI
- Meggernie and Croch na Keys Woods SSSI

SSSI Assessment

Impacts within Native pinewood SSSI habitat are undistinguishable from those described above for Caledonian Forest habitat. There is therefore potential for beaver activity in combination with other herbivores to adversely affect the natural heritage interests of national importance.

Moreover, the action of beavers alone may also adversely affect the natural heritage interests of national importance for some of the more northern SSSIs (egg Cairngorm and Eastern Cairngorm SSSIs) where aspen contribute to the broadleaf component of the native pinewoods. In these SSSI beavers could reduce the amount of aspen due to their preference for it as food, including mature and over-mature specimens which are especially important for maintaining biodiversity.

Mitigation

Adverse impacts on these SSSIs can be mitigated through any necessary herbivore management measures (on either deer or beavers or both). Monitoring for signs of over-grazing should be carried out using the Woodland Grazing Toolbox methodology to ensure any impacts can be avoided before they have an adverse effect on site integrity.

With respect to aspen, impacts within northern SSSIs can be mitigated by protecting important areas of aspen to prevent access by beavers. Monitoring for signs of over-grazing should be carried out using the Woodland Grazing Toolbox methodology to ensure any impacts can be avoided before they have an adverse effect on site integrity.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

WOODLAND TYPE: BOG WOODLAND

A few examples of this unusual habitat type are found in areas of Scotland where summer drying may permit the establishment and growth of tree roots in the upper peat layers. The structure and function of this habitat type is finely balanced between tree growth and bog development. Tree growth, however, is always slow (or the trees would take over the bog); the trees are likely to be widely-spaced (because much of the surface area is too wet for them to establish), and dead trees may be common even among the fairly small individuals (because their weight depresses the peat locally leading to waterlogging and death). Although stunted in form these trees may be of considerable age, with the oldest individuals in bog woodland in Scotland estimated at 350 years old.

The principal tree species in this form of Bog woodland is Scots pine *Pinus sylvestris*. Pine bog woodland types are likely to be intermediate in character between NVC type W18 Pinus sylvestris – *Hylocomium splendens* woodland and more open mire types such as M18 Erica tetralix – Sphagnum papillosum mire or M19 *Calluna vulgaris – Eriophorum vaginatum* blanket mire.

Knapdale

There are no sites identified in Knapdale that are designated for bog woodland habitat.

Tayside

- Ballochbuie SAC
- Cairngorms SAC

HRA advice

Beaver generally avoid felling pine trees, and other tree species form only a tiny component of bog woodland. Therefore there is an extremely limited ability for beavers to impact on the bog woodland qualifier for these two SACs in any way that might undermine the conservation objectives.

The SNH HRA advice concluded that it can be ascertained that there is no adverse effect on site integrity through impacts to bog woodland at Ballochbuie SAC and Cairngorms SAC.

OAK AND BIRCH DOMINATED WOODLAND SITES

WOODLAND TYPE: WESTERN ACIDIC OAK WOODLAND

Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles, often referred to as western acidic oak woodland, are a widespread woodland type found across much of the upland landscape of the UK. The habitat type comprises a range of woodland types dominated by mixtures of oak (*Quercus robur* and/or *Quercus petraea*) and birch (*Betula pendula* and/or *Betula pubescens*). The more frequently encountered associated trees and shrubs are holly *Ilex aquifolium* and rowan *Sorbus aucuparia*. It is characteristic of acidic, base-poor soils in upland areas with at least moderately high rainfall. It shows considerable variation across its range, in terms of the associated ground flora and the richness of bryophyte communities. There is also a continuous spectrum of variation between oak-dominated and birch-dominated stands. Often these local variations reflect factors such as rainfall, slope, aspect, soil depth, and past and present woodland management (e.g. coppicing, planting, grazing).

Knapdale

- Moine Mhor SAC
- Tarbert Woods SAC
- Taynish and Knapdale Woods SAC

Tayside

- Loch Lomond Woods SAC
- Upper Strathearn Oakwoods SAC

HRA advice

Beaver foraging activity in combination with grazing and browsing pressure from other herbivores could lead to a loss of qualifying habitat.

The Knapdale Beaver Trial monitoring suggested that beavers rarely moved more than 30m from waterbodies, so any loss of habitat is likely to be confined to a small proportion of the site. Therefore some loss or deterioration of qualifying woodland near waterbodies is possible due to the combined impacts of beaver and other herbivores, leading to a change in the distribution of the habitat.

Change in the structure of accessible woodland areas is likely, but difficult to predict with any accuracy at present. Possible impacts include changes in the volume of deadwood, increases in dense young growth or in open space. Provided regeneration of felled trees and shrubs is able to continue, these changes are most likely to be beneficial, contributing to the dynamism which is an important feature of this habitat.

SNH HRA advice is that it is not possible to ascertain no adverse effect on site integrity without mitigation. Impacts are possible in areas of qualifying habitat likely to be used by beavers (i.e. within c.30m of water-bodies), as a result of the cumulative impacts of beaver and other herbivores.

Mitigation

If beaver colonise these sites, impacts should be monitored using the Woodland Grazing Toolbox methodology. Signs of over-grazing can be detected before any adverse impacts result. These impacts should then be mitigated by using all necessary herbivore management measures (of deer or beavers, or both).

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

WOODLAND TYPE: UPLAND OAK WOODLAND

This is woodland type is found on well-drained to rather poorly drained, acidic to neutral soils in the upland parts of Britain, where either pedunculate or sessile oak forms at least 30% of the canopy cover. Other tree and shrub species occur commonly, especially downy birch, silver birch, rowan, hazel and holly. Like upland birchwoods (see below), the field layer is often grass or heath dominated, but when very heavily grazed can be dominated by large bryophytes. Small herbs, bryophytes and ferns, including bracken, can be very common, and on rocks, banks, trees and shrubs in the west there can be a rich flora of oceanic bryophytes including some uncommon species.

A review of the above identified upland oak woodland SSSIs indicates that many are in unfavourable condition and are failing to meet their site attribute targets for volume of deadwood, level of grazing / browsing, structural diversity or evidence of regeneration.

Knapdale

- Artilligan and Abhainn Srathain Burns SSSI
- Ellary Woods SSSI
- Inverneil Burn SSSI
- Knapdale woods SSSI
- Moine Mhor SSSI
- Taynish Woods SSSI
- Tayvallich Juniper and Fen SSSI

Tayside

- Cambusurich Wood SSSI
- Cardney Wood SSSI
- Carie and Cragganester Woods SSSI
- Comrie Woods SSSI
- Edinchip Wood SSSI
- Glen Falloch Woods SSSI
- Innishewan Wood SSSI
- Monzie Wood SSSI
- Pass of Killiecrankie SSSI
- Pass of Leny Flushes SSSI

SSSI Assessment

Impacts within upland oak woodland SSSI habitat are likely to be similar to those described above for western acidic oak woodland. There is therefore potential for beaver activity in combination with other herbivores to adversely affect the natural heritage interests of national importance.

Mitigation

As beavers naturally colonise some of these sites, impacts should be monitored using the Woodland Grazing Toolbox methodology. Signs of over-grazing can be detected before any adverse impacts result. These impacts should then be mitigated by using all necessary herbivore management measures (of deer or beavers, or both).

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

WOODLAND TYPE: UPLAND BIRCH WOODLAND

Upland Birchwoods in Scotland are dominated by a series of stands of downy and/or silver birch with constituents such as rowan, willow, juniper and aspen. Boundaries are often diffuse and liable to change as woodlands expand and contract in response to fires and changes in grazing pressure. Refuges, such as those occurring on cliffs or rocky patches, may develop permanent tree cover that can contain richer, less mobile species. On more acidic soils, rowan is a prominent component, and juniper can form the underwood in the eastern highlands.

A review of the above identified upland birch woodland SSSIs indicates that many are in unfavourable condition and are failing to meet their site attribute targets for volume of deadwood, level of grazing / browsing, structural diversity or evidence of regeneration.

Knapdale

There are no sites identified in Knapdale that are designated for upland birch woodland habitat.

Tayside

- Beinn a' Ghlo SSSI
- Black Wood of Rannoch SSSI
- Glen Lochay Woods SSSI
- Leven Valley SSSI
- Linn of Tummel SSSI
- Struan Wood SSSI

SSSI Assessment

Impacts within upland birch woodland SSSI habitat are likely to be similar to those described above for western acidic oak woodland. There is therefore potential for beaver activity in combination with other herbivores to adversely affect the natural heritage interests of national importance.

Mitigation

As beavers naturally colonise some of these sites, impacts should be monitored using the Woodland Grazing Toolbox methodology. Signs of over-grazing can be detected before any adverse impacts result. These impacts should then be mitigated by using all necessary herbivore management measures (of deer or beavers, or both).

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

WOODLAND TYPE: LOWLAND MIXED BROADLEAVED WOODLAND

Lowland mixed deciduous woodland includes woodland growing on the full range of soil conditions, from very acidic to base-rich, and takes in most semi-natural woodland in southern and eastern England, and in parts of lowland Wales and Scotland. It thus complements the ranges of upland oak and upland ash types. It occurs largely within enclosed landscapes, usually on sites with well-defined boundaries, at relatively low altitudes, although altitude is not a defining feature. Many are ancient woods. The woods tend to be small, less than 20ha. Often there is evidence of past coppicing, particularly on moderately acid to base-rich soils.

A review of the above identified lowland mixed broad leaved SSSIs indicates that many are in unfavourable condition and are failing to meet their site attribute targets for volume of deadwood, level of grazing / browsing, structural diversity or evidence of regeneration.

Knapdale

There are no sites identified in Knapdale that are designated for lowland mixed broad leaved woodland habitat.

Tayside

- Drummond Lochs SSSI
- Kincardine Castle Wood SSSI
- Methven Woods SSSI

SSSI Assessment

Impacts within lowland mixed broadleaved woodland SSSI habitat are likely to be similar to those described above for western acidic oak woodland. There is therefore potential for beaver activity in combination with other herbivores to adversely affect the natural heritage interests of national importance.

Mitigation
As beaver naturally colonise some of these sites, impacts should be monitored using the Woodland Grazing Toolbox methodology. Signs of over-grazing can be detected before any adverse impacts result. These impacts should then be mitigated by using all necessary herbivore management measures (of deer or beavers, or both).

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

ASH DOMINATED WOODLAND SITES

WOODLAND TYPE: MIXED WOODLAND ON BASE-RICH SOILS ASSOCIATED WITH ROCKY SLOPES
Tilio-Acerion forests of slopes, screes and ravines (also referred to as mixed woodland on base-rich soils associated with rocky slopes) are woods of ash *Fraxinus excelsior*, wych elm *Ulmus glabra* and lime (mainly small-leaved lime *Tilia cordata* but more rarely large-leaved lime *T. platyphyllos*). Introduced sycamore *Acer pseudoplatanus* is often present and is a common part of the community in mainland Europe, where it is native. The habitat type typically occurs on nutrient-rich soils that often accumulate in the shady micro-climates towards the bases of slopes and ravines. Therefore it is found on calcareous substrates associated with coarse scree, cliffs, steep rocky slopes and ravines, where inaccessibility has reduced human impact. It often occurs as a series of scattered patches grading into other types of woodland on level valley floors and on slopes above, or as narrow strips along stream-sides. More extensive stands occur on limestone and other base-rich rocks.

Knapdale
There are no sites identified in Knapdale that are designated for mixed woodland on base-rich soils associated with rocky slopes habitat.

Tayside
- Craighall Gorge SAC
- Keltneyburn SAC

HRA Advice
Beaver activity in combination with pressure from other herbivores could lead to a loss of qualifying habitat, but this is only possible on flatter ground at these SACs. The steeper slopes which are typical of this habitat are largely avoided by herbivores therefore the exact extent of possible impacts would be limited by the topography of the SACs (if beavers remain in the area).

SNH HRA advice is; as a result of the potential combined grazing and browsing impacts of beaver and other herbivores on this qualifying interest, that without mitigation, it cannot be ascertained that there is no adverse effect on site integrity.

Mitigation
Any potential adverse impacts on the integrity of the SAC should be mitigated through herbivore management measures (upon either deer or beavers or both) before they occur. Signs of over-grazing can be detected before any adverse impacts result. As beavers naturally colonise these sites, impacts should be monitored using the Woodland Grazing Toolbox methodology. If the necessary mitigation measures, including monitoring are carried out then SNH advise that it can be ascertained that there is no adverse effect on site integrity.

WOODLAND TYPE: UPLAND MIXED ASH WOODLAND
This is woodland on base-rich soils, in upland parts of the UK. The tree canopy typically includes ash Fraxinus excelsior, wych elm *Ulmus glabra* or sycamore *Acer pseudoplatanus*. Downy birch *Betula pubescens*, rowan *Sorbus aucuparia*, hazel, *Corylus avellana* goat willow *Salix caprea*, grey willow *Salix cinerea*, eared willow *Salix aurita*, bird cherry *Prunus padus* and alder *Alnus glutinosa* can occur too. Some examples, particularly in the extreme west, are dominated by hazel. The field layer is typically herb-rich. Bryophytes are generally common and epiphytic floras can be rich and include mosses, liverworts, large foliose lichens and many smaller crustose lichens.

A review of the below identified upland mixed ash woodland SSSIs indicates that many are in unfavourable condition and are failing to meet their site attribute targets for volume of deadwood, level of grazing / browsing, structural diversity or evidence of regeneration.

Knapdale
There are no sites identified in Knapdale that are designated for upland mixed woodland habitat.

Tayside
- Back Burn Wood and Meadows SSSI
- Birks of Aberfeldy SSSI
- Cambusurich Wood SSSI
- Craighall Gorge SSSI
- Den of Airlie SSSI
- Den of Alyth SSSI
- Den of Fowlis SSSI
- Den of Riechip SSSI
- Devon Gorge SSSI
- Dollar Glen SSSI
- Finlarig Burn SSSI
- Flisk Wood SSSI
- Glen Lochay Woods SSSI
- Glen Tilt Woods SSSI
- Keltneyburn SSSI
- Romadie Wood SSSI

SSSI Assessment
Impacts within upland mixed ash woodland SSSI habitat are undistinguishable from those described above for mixed ash woodland. There is therefore potential for beaver activity in combination with other herbivores to adversely affect the natural heritage interests of national importance.

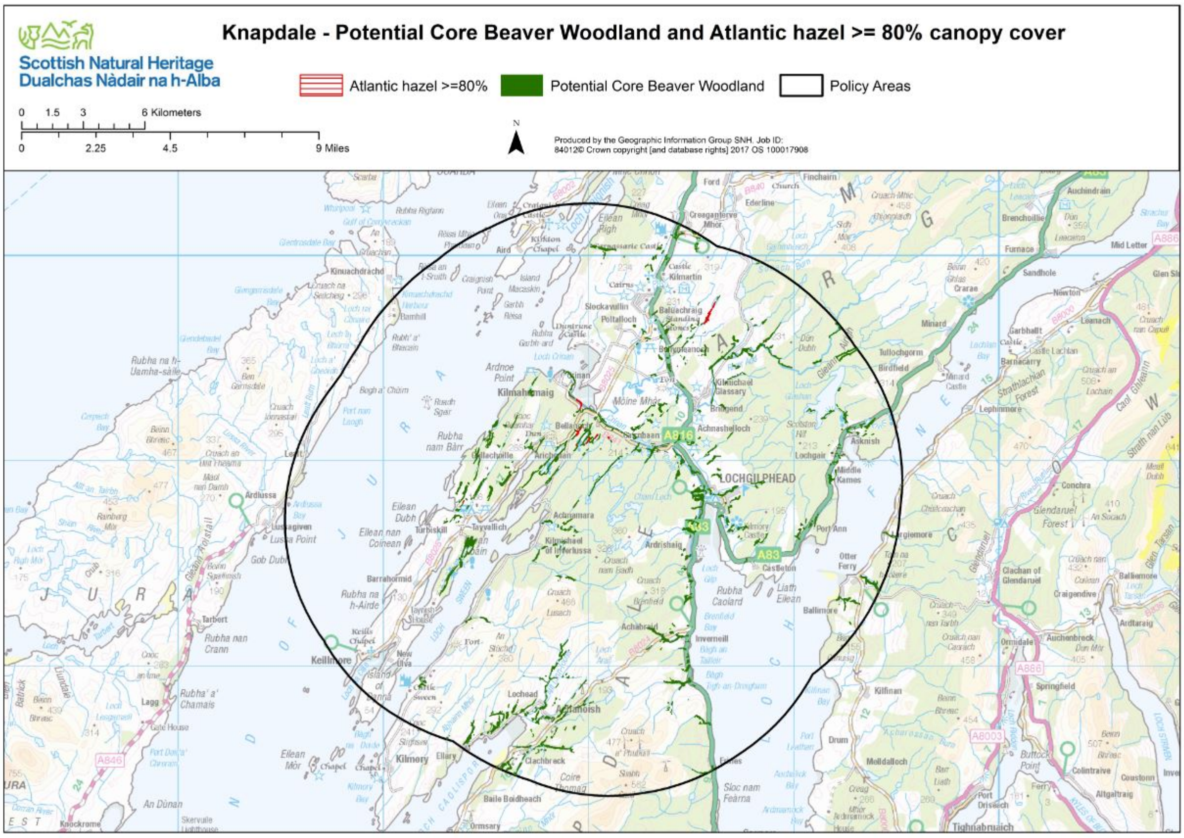
Mitigation
As beavers reach some of these sites, impacts should be monitored using the Woodland Grazing Toolbox methodology. Signs of over-grazing can be detected before any adverse impacts result. These impacts should then be mitigated by using all necessary herbivore management measures (of deer or beavers, or both).

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

HAZEL DOMINATED WOODLAND

WOODLAND TYPE: ATLANTIC HAZELWOODS
Atlantic hazel occurs in the oceanic climatic areas of the Western British Isles, but only in a very few places does it achieve particular characteristics that mark it out as a distinctive habitat of high biodiversity, particularly as it supports a diverse assemblage of oceanic lichens (see section 4.3). Hazel is a multi-stemmed pioneering and light-demanding shrub. A key requirement for its successful germination and establishment is that there is no closed canopy above to shade out the emerging seedling. When cut it coppices readily from its rootstock.

Knapdale
The distribution of Atlantic hazelwoods (with 80% or more hazel in the canopy) that occur within the Knapdale beaver policy area and overlap with beaver core woodland is illustrated in Map 11 below. NB Atlantic hazelwoods are not a qualifying feature of SAC or SSSI but are of conservation importance; they are rich in biodiversity, uncommon habitats, often hosting internationally important lichen populations.



Map 11: Distribution of Atlantic hazel woods that overlap with core beaver woodland in the Knapdale beaver policy area – also included in Appendix 1 for ease of reference.

Tayside

Atlantic hazelwoods primarily rely on oceanic climatic condition experienced by western Scotland. While there are hazelwoods within the Tayside policy area (0.72 ha with 80% canopy), they are less likely to host the internationally important lichen species referred to above. However, hazel along watercourses can provide habitat for the eastern European extent of otherwise oceanic lichens (see section 4.3, Map 11) and as such their importance should not be ignored.

Assessment

Beavers at Knapdale (SBT) showed strong preferences for willow, ash, rowan and hazel, but avoided alder. They displayed a greater use of hazel *Corylus avellana* in the two latter years of this study suggesting that this species may ultimately become less abundant, depending on the impact of deer on the regrowth. Alternatively, smaller younger shoots may predominate, with a loss of older stems.

There is therefore potential for beaver activity in combination with other herbivores to adversely affect the natural heritage interests of conservation importance. Monitoring will be required to detect whether beavers establish within these Atlantic hazelwood areas, and if they do their impact should be assessed and appropriate management put in place.

Mitigation

Further monitoring is therefore required over a longer period of time to clarify uncertainties as to the long-term impact on Atlantic hazel habitat, with a particular emphasis on the temporal continuity of young and old stems and interaction with deer browsing. If beavers reach these sites, impacts should be monitored using the Woodland Grazing Toolbox methodology. Signs of over-grazing can be detected before any adverse impacts result.

Consideration should also be given to the potential to strategically site future plantings of hazel stands in areas out of the reach of beavers which could provide mitigation against any future impacts on existing stands. There may also be merit in additional new planting within existing stands to improve their condition and minimise the impact of any losses attributed to beavers.

See section 7 for further details on the approach to monitoring and beavers. See section 5 for beaver management techniques used to mitigate the impact of beaver activity; those techniques outlined include measures that would avoid or reduce any impact considered to be detrimental to the lichen species within Atlantic hazelwoods.

4.3 Beavers and bryophytes, fungi and lichens

4.3.1 How beaver activity affects bryophytes, fungi and lichens

Bryophytes (mosses and liverworts), fungi and lichens are diverse groups of organisms that make up a large proportion of Scotland's biodiversity. Over 1,500 species of lichen occur in Scotland and the Scottish Biodiversity List includes 210 species of bryophyte, 207 fungi and 486 lichens. The majority of these species will never be affected by beavers because their habitat occurs mainly or entirely outside potential beaver habitat. However, Scotland is an internationally recognised hotspot for biodiversity associated with oceanic woodland. In particular, many species of bryophyte and lichen have the majority or all of their European population in Scottish woodlands (example species and maps are presented elsewhere). Since beavers directly affect trees – and therefore woodland structure, continuity and composition – their effect on woodland oceanic bryophytes and lichens is highlighted here. Fungi are less well known in terms of their distribution and conservation status. However, they provide key ecosystem services, so are considered here in terms of the mechanisms by which beavers may affect them.

When considering the overall impact of beavers on bryophytes, lichens and fungi, it is important to consider the scale of assessment. For example, most of these species respond to small-scale habitat variation as much as, if not more than, broad habitat variation. This means it is necessary to consider the impact of beavers not only on broad habitats, but also on the occurrence of small-scale habitats such as dead wood, boulders within woodland and deeply fissured bark on old trees. The biodiversity benefits of beavers should also consider the national and international impact of beavers as well as local impacts. It is important to compare local species losses and gains against each species' wider distribution. For example, negative local impacts on the globally restricted oceanic bryophytes and lichens referred to above should not be compared like-for-like with positive local impacts on species that have much wider global distributions.

The diversity of bryophytes, lichens and fungi makes it difficult to make general statements about the potential impact of beavers. It is possible, however, to identify the main mechanisms by which beavers may affect these species. A summary of the potential interactions between beavers and bryophytes, fungi and lichens is presented below (see Table 4.3.1) where possible these have been attributed to a neutral, positive or negative effect.

4.3.1.1 Loss of old woodland micro-habitats and habitat continuity

Species diversity is positively correlated with micro-habitat diversity. Old woodland supports a wider range of micro- habitats and associated species than young woodland.
Beaver activity is likely to result in localised loss of old woodland micro-habitats through medium - to long-term loss of old trees (section 4.2). This will result in medium - to long-term localised loss of old woodland species.

Species associated with young tree micro-habitats may increase in abundance, but these are much more common and widespread in Scotland.

Many old woodland species are poor recolonisers. Micro-habitats associated with old woodland may also take many years to recover. This may result in local extinction of old woodland species or species associated with old trees, many of which have their core European populations in Scotland, such as Atlantic Hazelwoods as discussed below.

A more detailed description of the importance of micro-habitat diversity and temporal habitat continuity is provided in the SBT monitoring report on lichens.

Atlantic Hazelwoods

Atlantic hazel provides habitat for a diverse assemblage of oceanic lichens. A community of crust-like lichens called the Graphidion grows on young smooth-barked stems while older, rougher stems support a community dominated by larger, leafy lichens called the Lobarion. The coexistence of these two lichen communities, along with the equitable oceanic climate, stand structure and the long temporal continuity of many Atlantic hazelwoods, all contribute to the ability of Atlantic hazel to support a high diversity of lichens.

Under natural conditions, hazel is a multi-stemmed shrub. Despite this growth form being similar to hazel that has been coppiced, there is no evidence that species-rich stands of Atlantic hazel were ever coppiced in the past. An individual is referred to as a ‘stool’, with each stool normally supporting a range of stem ages from thin, young stems (often called ‘sun-shoots’) to large old rough-barked stems. As the largest and oldest stems die or snap off under their own weight, they create a gap that allows replacement by young hazel stems from the bank of sun-shoots at the stool base. A single naturally self-perpetuating hazel stool can therefore be ancient and, while individual stems have a finite life, they provide long periods of ecological continuity of young, smooth-barked and old rough-barked stems. This temporal microhabitat continuity is an important determinant of lichen diversity. The loss of all, or a particular age-class, of stems from a stool, either through coppicing by humans or felling by beavers, can result in the loss of long-term habitat continuity and thereby loss or deterioration of ancient woodland lichens assemblages.

Atlantic hazel occurs in oceanic areas in western Britain. This climatic association and other attributes associated with hazel as described above result in a high diversity of lichens. While the strength of association between Atlantic hazel and a particular lichen varies, many species are of high conservation value e.g. IUCN near threated or vulnerable, nationally rare or scare and species for which Scotland has International Responsibility. For many Atlantic hazel associates, Scotland is their European headquarters. One endemic species, *Graphis alboscripta*, occurs nowhere else on earth other than in Scottish Atlantic hazelwoods.

4.3.1.2 Gains and losses in riparian woodland extent and suitability for bryophytes, lichens and fungi

The reintroduction of beavers may be accompanied by incentives to promote riparian woodland restoration and creation. This indirect effect may create future habitat for bryophytes, lichens and fungi. However, there may be localised losses of old woodland supporting bryophytes, lichens and fungi of conservation concern in the long term if beaver-felled trees do not regenerate due to over- browsing by deer. Areas of woodland habitat for these species may also be lost due to flooding, although many species associated with dead wood will benefit in the short to medium term in such circumstances.

Beavers are likely to increase the area of wet woodland. Wet woodland supports a different range of species from dry woodland. For example, there will be an increase in mycorrhizal fungi associated with wet woodland trees (e.g. aldercaps) and a decrease in species associated with dry woodland.

Moisture-loving species, such as bog mosses, and scarce species associated with damp, wet wood may increase (Swedish pouchwort *Calypogeia suecica* and Heller’s notchwort *Anastrophyllum hellerianum* are examples of nationally scarce liverworts associated with damp dead wood - Scotland has an international responsibility for the conservation of such oceanic species). Epiphytic species associated with moisture-intolerant trees may decline if these tree species are lost.

Species vary in their requirements for light and shelter. The more open canopy that would be created by beaver activity will favour species of bryophyte and lichen that require higher light levels but that can withstand exposure. Species that tolerate lower light levels and require shelter to maintain high humidity are likely to be negatively affected. Woodland floor features such as boulders and dead wood are particularly important habitats for mosses and liverworts. An increase in the cover of vascular plants and large, robust bryophyte cover in areas opened up by beavers may have a negative impact on smaller and less competitive woodland floor bryophytes through increased competition.

Many species of bryophyte, lichen and fungus are associated with specific tree species. Medium- to long- term loss of mature trees of species preferred by beaver may result in the loss of a suite of associated species.

4.3.1.3 Deadwood

Beavers may increase the quantity and variety of dead wood, at least in the short to medium term. Many bryophytes, lichens and fungi are associated with dead wood, either as a substrate or, in the case of fungi, as a food source. The long-term impacts of beaver on dead wood habitat are less clear. Depending on beaver colonisation patterns at the landscape scale, there may be fewer large trees in the future to supply large-volume dead wood. Many species of lichen, bryophyte and fungus have strong associations with large-volume dead wood and standing dead wood supports a number of threatened lichens. Standing deadwood supports lichens classed as 'vulnerable' by the IUCN, such as the forked hair-lichen *Bryoria furcellata* which is on the Scottish Biodiversity List.

4.3.1.4 Historical perspective

The Scottish landscape has changed significantly since the national extinction of beavers several hundred years ago. In this time, habitats have been subject to disturbance through often drastic changes in land use (e.g. conversion to conifer plantations). Hence, many areas, such as Knapdale, have suffered severe habitat reduction, and ancient woodland lichen, bryophyte and fungus populations could be described as remnants, only now beginning to recover. Beavers have the potential to reintroduce a further source of habitat disturbance, albeit one that occurred as a natural component of the landscape in the past. Whether habitats, particularly those that support ancient woodland species, have the resilience to withstand additional disturbance should be a key consideration when interpreting the information available on the effects of beavers.

Table 4.3.1: Summary of potential interactions between beavers and bryophytes, fungi and lichens.

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• More open canopy due to beaver activity will favour tree-dwelling species of bryophyte and lichen that require higher levels of light but that can withstand some exposure	• Some tree-dwelling species that tolerate low levels of light and require shelter to maintain high humidity may be negatively affected as beavers create more open woodland • An increase in the cover of vascular plants and large, robust bryophyte cover in areas opened up by beavers may have a negative impact on smaller and less competitive woodland floor bryophytes through increased competition • Where browsing from other herbivores is high, tree regrowth may be prevented, and this could lead to a reduction in structural diversity and ultimately localised loss of areas of important lichen, bryophyte and fungus woodland habitat	
Felling	Change in riparian woodland: Change in relative abundance of different tree species		• Medium- to long-term loss of mature trees of species preferred by beaver, such as aspen, may result in loss of a suite of associated species • Mature trees on river banks are particularly important for	

			lichens in eastern Scotland and support a number of rare or threatened species	
Felling	Change in riparian woodland: Change in age classes of trees		• Old trees provide habitat for a high diversity of bryophytes, lichens and fungi that do not occur in young woodland. Beavers may prevent trees from becoming old at local levels • Breaks in the temporal and spatial continuity of old woodland characteristic will have a negative impact on the many bryophytes, lichens and fungi that are poor dispersers and/or colonisers. There is a risk of local extinction for some species	Ecological, or micro-habitat, diversity and continuity are key requirements for many species for which Scotland holds internationally important populations
Felling	Change in riparian woodland: Amount/diversity of fallen dead wood on woodland floor	• Many bryophytes, lichens and fungi are associated with dead wood, either as a substrate or, in the case of fungi, as a food source. Beavers may increase the amount of dead wood in some areas • Any increase in the diversity of dead wood (e.g. size, moisture content, exposure, tree species, orientation) is likely to increase the diversity of these species	• Beaver activity may result in fewer large trees in the future to supply large-volume dead wood. Many species of lichen, bryophyte and fungus have strong associations with large-volume dead wood. • Large standing dead wood supports a number of threatened lichens and bryophytes, some of which may become locally extinct	Much of the beaver-felled timber is removed for food and construction Positive impacts are likely to be greater in the short term as large-volume dead wood is created, but this benefit may be lost in the long term
Dams/pond creation	Change in hydrological	• Wet woodland supports a different range of species from	• Wet woodland supports a different range of species from	There is overlap between potential

	processes on riparian and downstream habitat	dry woodland. Some species of bryophyte and fungus will benefit	dry woodland. Some species of bryophyte, lichen and fungus will decline or become locally extinct as moisture levels increase and woodland composition and structure changes	core beaver habitat and watercourses identified as being internationally important for water-loving oceanic bryophytes. The impacts of beaver activity on hydrology with respect to these species is unknown but requires monitoring
Dams/pond creation	Changes in water quality downstream	• Possible positive impact on aquatic lichens, e.g. the protected river jelly-lichen, due to changes to sediment transport and water chemistry	• Possible negative impact on aquatic lichens, e.g. the protected river jelly-lichen, due to changes to sediment transport and water chemistry	Many effects are unknown
Dams/pond creation	Change in standing dead wood resulting from inundation of trees	• Standing dead wood, particularly when it has lost its bark, provides an important habitat for a number of lichen and fungus species. Beaver may locally increase standing dead wood in the short term in inundated areas		There is uncertainty about the long-term availability of standing dead wood once trees have died and decayed in an area. However, volumes may be maintained at the landscape scale as beavers abandon territories and colonise new areas
Other	Beaver management		• Fencing to exclude beavers from sensitive habitat could result in deterioration of	It should be possible to use fencing that does not exclude

			habitat for bryophytes and lichens due to under-grazing and subsequent shading by dense herbaceous or tree regeneration within exclosures	other grazers. Fence requirements will be habitat and site specific
Indirect habitat creation/restoration initiatives as a result of beaver presence	Beavers used to promote opportunities for riparian and freshwater habitat creation/restoration	• Any riparian woodland restoration programme is likely to benefit woodland bryophytes, lichens and fungi in the medium to long term		Rhododendron control and deer management in particular will benefit bryophytes and lichens These may be compensatory measures outside the range of beavers to improve habitat for species that will be negatively affected within beaver habitat

4.3.2 Distribution of bryophytes, fungi and lichens in the beaver policy area

The following section concentrates on those bryophytes, fungi and lichens of conservation importance that are likely to overlap with core beaver habitat and as such maybe positively or negatively affected by beaver activity.

4.3.2.1 Bryophytes, fungi and lichens of conservation importance

To determine whether the activity of beavers on bryophytes, fungi and lichens is significant in the context of this SEA, the assessment of impacts (positive and negative) has focussed on those species for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded European or national protection wherever they occur.

Table 4.3.2 below therefore identifies those bryophytes and lichens or assemblages of conservation importance that utilise 'potential beaver core habitat' (as described in section 4.1. of this report) and are found within the beaver policy area.

In addition to these designated sites, the Atlantic hazelwood habitat has also been screened into this assessment in light of its international importance as discussed above.

While Cairngorm SAC designated for its green shield-moss bryophyte occurs within the beaver policy area, the known locations of this bryophyte do no overlap with potential core beaver habitat, and a conclusion of No Likely Significant Effect was reached in the SNH HRA advice (see Annex 2). It has therefore been screened out of the SEA. Fungi assemblage has also been screened out as the three sites that overlap with potential core beaver woodland are associated with Scots pine – beavers generally avoid pine and other conifer tree species.

Table 4.3.2: Summary of bryophytes and lichens of conservation importance within the beaver policy area that overlap with potential beaver core habitat

Conservation importance: SSSI	Species or assemblage
LICHEN	
Den of Airlie SSSI	River jelly lichen
Birks of Aberfeldy SSSI Black Wood of Rannoch SSSI Cairngorms SSSI Craighall Gorge SSSI Drummond Lochs SSSI Ellary Woods SSSI Gannochy Gorge SSSI Glen Lyon Woods SSSI Inverneil Burn SSSI Knapdale Woods SSSI Milton Wood SSSI Pollochro Woods SSSI Taynish Woods SSSI	Lichen assemblage
BRYOPHYTE	
Cairngorms SSSI Den of Airlie SSSI Ellary Woods SSSI Gannochy Gorge SSSI Glen Coe SSSI Inverneil Burn SSSI	Bryophyte assemblage

Knapdale Woods SSSI Pollochro Woods SSSI Taynish Woods SSSI	

4.3.3 Assessment of likely effects on bryophytes, fungi and lichens of conservation importance in the beaver policy area

Each of the species or assemblages identified in Table 4.3.2 above are discussed in turn below in the context of those effects (positive or negative) that have been identified as a result of beaver activity. Where this relates to a habitat included in the Habitats Regulation Appraisal of the policy (i.e. in an SAC), a summary of the advice from SNH, provided to inform an appropriate assessment (AA) of the policy with respect to SAC sites (see Annex 2 for the full advice) has been used (referred to hereafter as 'SNH HRA advice'). Assessment of SSSI features is based on expert judgement together with knowledge of each site and its condition. Where mitigation or monitoring maybe appropriate, this has been identified in the narrative. Further discussion relating to the management of beavers including mitigation and monitoring options is provided in sections 5 and 7 respectively.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

Monitoring
There are no significant studies from other countries on the specific impact of beavers on bryophytes, lichens or fungi. It is possible to interpret studies on habitat structure and diversity which would affect these species, but this does not add significantly to the evidence acquired from the SBT. So far it is possible to predict the impact of beavers based only on information from the SBT at Knapdale.

SBT monitoring focused on the impact on lichens because of the relatively large overlap of important lichen habitat (Atlantic hazel woodland) with potential beaver habitat. To the best of our knowledge, this is the first specific monitoring to assess the impact of beavers on lichens. Although the Tayside beaver population is much larger than the Knapdale population, its impact on lichens, bryophytes and fungi has not yet been assessed. Further details outlining the key conclusion from this monitoring on lichens can be found in Annex 1, section 3.4.4.

Monitoring the effect of beavers on bryophytes, lichens and fungi will therefore be required going forward. A number of principal policy, monitoring and analysis recommendations, as well as actions, can be summarised as follows:

- Promote the proactive expansion of aspen woodland, ensuring temporal continuity of young and old trees
- Promote the proactive expansion of Atlantic hazelwood lichen habitat in western Scotland
- Address existing pressures on priority bryophyte, lichen and fungus woodland habitat, e.g. rhododendron, under- or over-grazing
- Assess the relative impact on restricted compared with widespread species
- Assess the overlap between lichens, bryophytes and fungi of conservation concern, particularly those that depend on old trees, and potential beaver habitat prior to local reintroductions, and monitor and manage where appropriate

- Assess the overlap between potential beaver habitat and nationally/internationally important wooded oceanic ravine bryophyte habitat, and monitor and manage where appropriate
- Monitor impact on species of European importance (see below) and manage as required
- Research the impact of beaver control fencing on woodland lichen and bryophyte habitat quality, and produce guidance
- Research the long-term impact of beavers on large- volume dead-wood habitat

Where it has been possible to provide more site-specific commentary on monitoring requirement this has been outlined below. Further narrative is detailed in section 5.

Beaver opportunities
Any riparian woodland restoration programme, as highlighted in section 4.2, is also likely to benefit woodland bryophytes, lichens and fungi in the medium to long term. In addition, there may also be positive long-term benefits to international restricted old woodland species, for example:

- Expansion of fluvial woodland to improve beaver habitat could result in an overall increase in old woodland habitat if beavers move about within the landscape and allow old-growth woodland to develop
- Management of deer to prevent over-grazing within beaver habitat will benefit the long-term continuity of bryophyte, lichen and fungal habitat by promoting woodland regeneration
- An increase in dead wood (but note that there is some uncertainty as to the impact beavers will have on important large-diameter dead wood, see Annex 1 section 3.4.1)

4.3.3.1 Consideration of potential positive effects on bryophytes and lichens conservation importance

The impact of beaver activity on bryophytes and lichens discussed below is considered to be either positive or neutral. Where there is considered to be a negative effect or the potential for a negative effect, these are discussed in the following section, see 4.3.3.2.

RIVER JELLY LICHEN
The river jelly lichen *Collema dichotomum*, an aquatic species which is nationally rare, is found on flat sandstone rocks in the River Isla within Den of Airlie SSSI. The population here is thoughts to be the largest in the Britain.

Knapdale
There are no SSSIs within the Knapdale beaver policy area designated for river jelly lichen.

Tayside
- Den of Airlie SSSI

SSSI Assessment
This lichen is sensitive to changes in water depth and sediment deposition, both of which could be affected by beavers, in positive way depending on where dams are created.

Monitoring
Monitoring will therefore be required to detect whether beavers establish within this site, and if they do the potential for positive effects should be assessed and any appropriate management put in place. See section 7 for further details on the approach to Site Condition Monitoring (SCM) and beavers.

LICHEN ASSEMBLAGE
Scotland has an amazing diversity of lichens, with just over 1500 species. Clean air, diverse habitats, relatively cool summers and mild winters all contribute to this diversity and abundance. Scotland is important for lichens on a European and even global scale. Each type of lichen is a successful partnership between two species, a fungus and an alga (or blue-green alga). The fungus provides a protective home for the alga and in return, the alga produces food for the fungus from sunshine, water and air.

The lichen assemblages referred to below are mostly associated with Native pinewoods, Upland oak woodland, Upland mixed ash woodland, Lowland mixed broadleaved woodland and Wet woodland habitats, see section 4.2 Beavers and woodlands.

Knapdale
- Ellary Woods SSSI
- Inverneil Burn SSSI
- Knapdale Woods SSSI
- Taynish Woods SSSI

Tayside
- Birks of Aberfeldy SSSI
- Black Wood of Rannoch SSSI
- Cairngorms SSSI
- Craighall Gorge SSSI
- Drummond Lochs SSSI
- Gannochy Gorge SSSI
- Glen Lyon Woods SSSI
- Milton Wood SSSI
- Pollochro Woods SSSI

SSSI Assessment
As mentioned above, there are no significant studies from other countries on the specific impact of beavers on lichens, with the only monitoring carried out occurring at the SBT. Therefore, it is possible, so far, to predict the impact of beavers based only on information from the SBT at Knapdale. Potential positive effects are anticipated to include:
- A more open canopy due to beaver activity will favour tree-dwelling species of lichen that require higher levels of light but that can withstand some exposure.
- Many lichens are associated with dead wood utilising it as a substrate. Beavers may increase the amount of dead wood in some areas. Any increase in the diversity of dead wood (e.g. size, moisture content, exposure, tree species, orientation) is likely to increase the diversity of lichen species. Standing dead wood, particularly when it has lost its bark, provides an important habitat for a number of lichen species. Beaver may locally increase standing dead wood in the short term in inundated areas

However uncertainty does remain as to the precise effect beaver activity will have on lichens. Therefore, further site-specific monitoring tailored to each site will be required going forward.

Monitoring
See section 7 for further details on the approach to Site Condition Monitoring (SCM) and beavers.

BRYOPHYTE ASSEMBLAGE
Mosses and liverworts are tiny plants that produce spores instead of flowers and seeds. There are differences between mosses and liverworts, but they share many important characteristics and are collectively called bryophytes. Despite their small size, they play a hugely important role in health and function of our environment. Present on land since before the dinosaurs, Scotland's 977 mosses and liverworts represent a diverse and unique part of our biodiversity at a European and global scale. This is due to Scotland's diverse landscape and a climate influenced strongly by the Atlantic Ocean. Relatively warm winters and cool, wet summers, especially on the west coast, provide perfect conditions for these little plants.

The bryophyte assemblages referred to below are mostly associated with Native pinewoods, Upland oak woodland, Upland mixed ash woodland, and Wet woodland habitats, see section 4.2 Beavers and woodlands.

Knapdale
- Ellary Woods SSSI
- Inverneil Burn SSSI
- Knapdale Woods SSSI
- Taynish Woods SSSI

Tayside
- Cairngorms SSSI
- Den of Airlie SSSI
- Gannochy Gorge SSSI
- Glen Coe SSSI
- Pollochro Woods SSSI

SSSI Assessment
As mentioned above, there are no significant studies from other countries on the specific impact of beavers on bryophytes. Potential positive effects are anticipated to include:
- A more open canopy due to beaver activity will favour tree-dwelling species of bryophyte that require higher levels of light but that can withstand some exposure
- Many bryophytes are associated with dead wood, utilising it as a substrate. Beavers may increase the amount of dead wood in some areas. Any increase in the diversity of dead wood (e.g. size, moisture content, exposure, tree species, orientation) is likely to increase the diversity of bryophyte species.

The Beaver in Scotland report (2015) assessed the likely impact to these sites from beaver activity and concluded they were unlikely to be affected (see Annex 1, section 3.4.4) and as such no adverse effects to natural heritage interests of national importance are expected within these sites.

4.3.3.2 Consideration of potential negative effects on bryophytes and lichens of conservation importance
The impact of beaver activity on the bryophytes and lichens discussed below is considered to have a negative effect or have to the potential for a negative effect.

RIVER JELLY LICHEN
The river jelly lichen *Collema dichotomum*, an aquatic species which is nationally rare, is found on flat sandstone rocks in the River Isla within Den of Airlie SSSI. Although found elsewhere, the population here is thought to be the largest in the Britain,

Knapdale
There are no SSSIs within the Knapdale beaver policy area designated for river jelly lichen.

Tayside
- Den of Airlie SSSI

SSSI Assessment
This lichen is sensitive to changes in water depth and sediment deposition, both of which could be affected by beavers, in negative way (acknowledging in *4.3.3.1* above that these could be positive) depending on where or if dams are created. There is therefore potential for beaver activity to adversely affect natural heritage interests of national importance. Monitoring will be required to detect whether beavers establish within this site, and if they do their impact should be assessed and appropriate management put in place.

Mitigation
See section 7 for further details on the approach to Site Condition Monitoring (SCM) and beavers. See section 5 for beaver management techniques used to mitigate the impact of damming beaver activity; those techniques outlined include measures that would avoid or reduce any impact considered to be adverse to the River jelly lichen at the Den of Airlie SSSI.

LICHEN ASSEMBLAGE
Scotland has an amazing diversity of lichens, with just over 1500 species. Clean air, diverse habitats, relatively cool summers and mild winters all contribute to this diversity and abundance. Scotland is important for lichens on a European and even global scale. Each type of lichen is a successful partnership between two species, a fungus and an alga (or blue-green alga). The fungus provides a protective home for the alga and in return, the alga produces food for the fungus from sunshine, water and air.

The lichen assemblages referred to below are mostly associated with Native pinewoods, Upland oak woodland, Upland mixed ash woodland, Lowland mixed broadleaved woodland and Wet woodland habitats, see section 4.2 Beavers and woodlands.

Knapdale
- Ellary Woods SSSI
- Inverneil Burn SSSI
- Knapdale Woods SSSI
- Taynish Woods SSSI

Tayside
- Birks of Aberfeldy SSSI
- Black Wood of Rannoch SSSI
- Cairngorms SSSI
- Craighall Gorge SSSI
- Drummond Lochs SSSI
- Gannochy Gorge SSSI
- Glen Lyon Woods SSSI
- Milton Wood SSSI
- Pollochro Woods SSSI

As mentioned above, there are no significant studies from other countries on the specific impact of beavers on lichens, with the only monitoring carried out occurring at the SBT. Therefore, it is possible, so far, to predict the impact of beavers based only on information from the SBT at Knapdale. Potential negative effects are anticipated to include:

- Some tree-dwelling species that tolerate low levels of light and require shelter to maintain high humidity may be negatively affected as beavers create more open woodland.
- Where browsing from other herbivores is high, tree regrowth may be prevented, and this could lead to a reduction in structural diversity and ultimately localised loss of areas of important lichen habitat.
- Old trees provide habitat for a high diversity of lichens that do not occur in young woodland. Beavers may prevent trees from becoming old at local levels. Breaks in the temporal and spatial continuity of old woodland characteristic will have a negative impact on the many lichens that are poor dispersers and/or colonisers. There is a risk of local extinction for some species.
- Beaver activity may result in fewer large trees in the future to supply large-volume dead wood. Many species of lichen have strong associations with large-volume dead wood. Large standing dead wood supports a number of threatened lichens some of which may become locally extinct

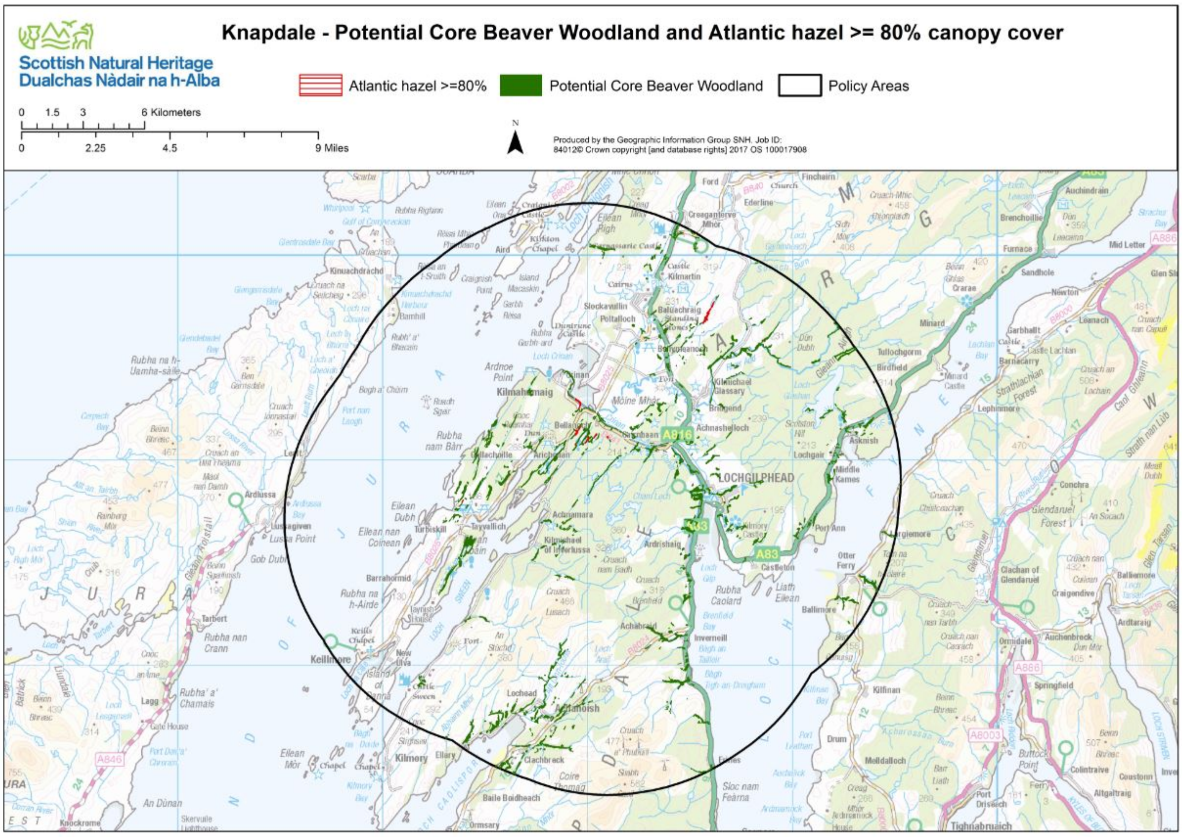
There is therefore potential for beaver activity to adversely affect natural heritage interests of national importance. Monitoring will be required to detect whether beavers establish within these sites, and if they do their impact should be assessed and appropriate management put in place.

Mitigation
See section 7 for further details on the approach to Site Condition Monitoring (SCM) and beavers. See section 5 for beaver management techniques used to mitigate the impact of beaver activity; those techniques outlined include measures that would avoid or reduce any impact considered to be adverse to the SSSIs identified in the list above.

The impact of beaver management options on lichens will require careful consideration. For example, fencing may not be an appropriate method to protect trees or shrubs that provide important lichen habitat. The long-term absence of grazing can be as damaging as over-grazing due to thicket regeneration and shading of light-demanding lichens.

ATLANTIC HAZELWOOD LICHENS
As discussed in section 4.3.1.1 above, Atlantic Hazelwoods host many lichen species of high conservation importance including internationally. However, there are no designated sites specifically for Atlantic hazelwoods. Instead, their value is recognised as component habitat features of some woodland SACs such as Taynish and Knapdale Woods SAC.

Knapdale
Atlantic hazel woodland is a particularly important habitat for lichens at Knapdale because it supports a wide range of species, many of which have their main European populations in western Scotland. The distribution of Atlantic hazelwoods with 80% or more hazel in the canopy that occur in the Knapdale beaver policy area, that overlap with beaver core habitat are illustrated in Map 11 below.



Map 11: Distribution of Atlantic hazel woods that overlap with core beaver woodland in the Knapdale beaver policy area

Tayside

Atlantic hazelwoods primarily rely on oceanic climatic conditions experienced by western Scotland. While there are hazel woods within the Tayside beaver policy area (0.72 ha with 80% canopy), they are less likely to host the internationally important licence species referred to above. However, hazel along watercourses can provide habitat for the eastern European extent of otherwise oceanic lichens (Figure 4.3.1) and as such their importance should not be ignored.

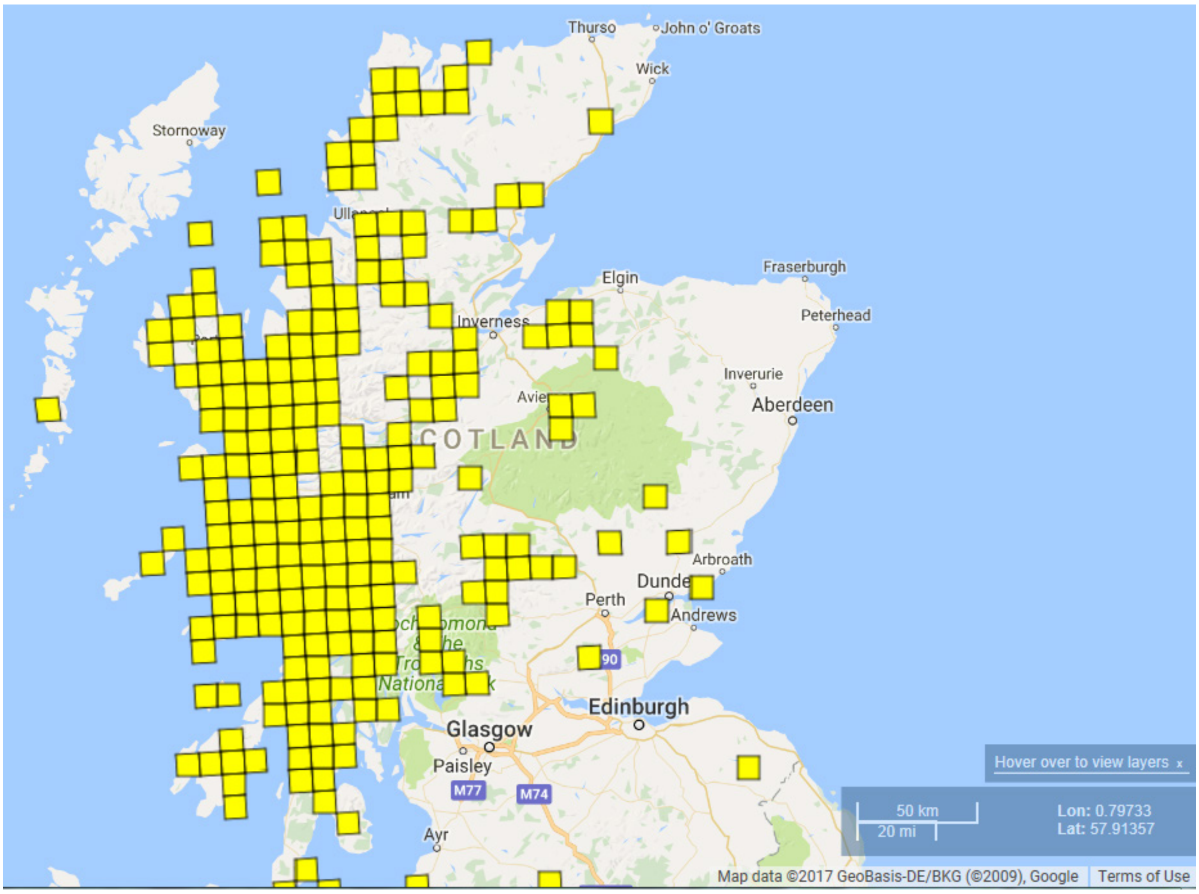


Figure 4.3.1: The distribution of notable lichens associated with Atlantic hazelwoods.

Assessment

Particular attention should be given to impacts on the internationally restricted Graphidion and Lobarion lichen communities found within Atlantic hazelwood as there is a moderate risk that hazel stems supporting such species of conservation concern will be felled by beavers and that this could result in local extinctions.

Old trees provide habitat for a high diversity of lichens that do not occur in young woodland and beavers may prevent trees from becoming old at local levels. Breaks in the temporal and spatial continuity of old woodland characteristic will have a negative impact on the many lichens that are poor dispersers and/or colonisers. There is a risk of local extinction for some species

Detailed monitoring of Atlantic hazel habitat within the Knapdale SBT area has demonstrated relatively high impacts that may eventually result in the permanent or temporary localised loss of a globally restricted lichen habitat. The impact was restricted to a maximum of about 60 m from a loch and within woodland on gentler, less bouldery slopes. Within this utilised zone, 24.4% of stems had been felled, affecting just over half of the stools. There was no observable impact on lichens beyond areas where felling had occurred. Within the SBT five-year monitoring period, only 8% of Taynish and Knapdale Woods SAC's area of Atlantic hazel had been affected. Most felled stems supported oceanic lichen communities, including a number of species that are of national and/or international conservation concern. These impacts have to be considered against the fact that the majority of Atlantic hazel habitat within Taynish and Knapdale Woods SAC is unlikely ever to be affected by beavers.

There is therefore potential for beaver activity to adversely affect natural heritage interests of international importance. Monitoring will be required to detect whether beavers establish within these Atlantic hazelwood areas, and if they do their impact should be assessed and appropriate management put in place.

Mitigation
Further monitoring is therefore required over a longer period of time to clarify uncertainties as to the long-term impact on Atlantic hazel habitat, with a particular emphasis on the temporal continuity of young and old stems and interaction with deer browsing. As beavers reach some of these sites, impacts should be monitored using the Woodland Grazing Toolbox methodology. Signs of over-grazing can be detected before any adverse impacts result. Consideration should also be given to the potential to strategically site future plantings of hazel stands in areas out of the reach of beavers which could provide mitigation against any future impacts on existing stands. There may also be merit in additional new planting within existing stands to improve their condition and minimise the impact of any losses attributed to beavers.

See section 7 for further details on the approach to monitoring and beavers. See section 5 for beaver management techniques used to mitigate the impact of beaver activity; those techniques outlined include measures that would avoid or reduce any impact considered to be detrimental to the lichen species within Atlantic hazelwoods.

4.4 Beavers and Terrestrial vascular plants

4.4.1 How beaver activity affects terrestrial vascular plants

There are two main mechanisms through which beavers affect vascular plants: directly by being eaten and indirectly through successional habitat change (tree- felling, changes in water levels and changes in wave action). Habitat change is specifically addressed in this report in sections 4.2 impacts upon tree species and sections 4.3/4.4 impacts upon freshwater plant species.

Compared with the information available on indirect impacts caused by habitat change, there is relatively little information on direct impacts by beavers on vascular plants. Despite 60–80% of the North American beaver diet being reported as aquatic vegetation, much of the literature on beaver impacts on vascular plants is in connection with tree species. At Knapdale, it was noted that the proportion of the beaver diet comprising plants other than trees is unknown, but is likely to be higher during the summer due to greater availability and nutritional quality of plant material.

4.4.1.1 The terrestrial vascular plants at greatest risk from direct impacts will tend to be species which occur in habitats close to waterbodies and watercourses.

In Norway, Eurasian beavers have been found to be strongly associated with deciduous trees. It has been shown that the abundance of deciduous trees within 40 m of the river bank was a key determinant of beaver presence (or absence) in Norway. Vascular plant species associated with woody shrubs and trees are therefore available for beavers to eat.

The importance of terrestrial open land for foraging is not clear. Land outside woodland has been recorded as part of the territory of Eurasian beavers in both the Netherlands and Norway. Activity is generally constrained to within 50 m of a watercourse, with the majority much closer. In the Netherlands Eurasian beavers were found to forage mainly within 6 m of the water's edge. Vascular plants in open areas are therefore potentially available for beavers to eat, but foraging might be predicted to be within a few metres of the water's edge.

4.4.1.2 The proportion of non-woody plants in beavers' diets varies according to the habitat in which the beavers live and the time of year.

Beavers have been considered to be opportunistic feeders, eating what is available. However, they do appear to be selective as regards their diet. One study found that Eurasian beavers mainly ate woody food in all seasons. Bark and a small amount of roots of monocotyledonous plants were eaten in the winter. In the spring, woody food was eaten with a few herbs and roots. The summer diet was similar to the spring diet, but with more bark. The conclusion was that beavers select food according to the nutrients it provides. Where nutrients are lacking, beavers may target certain plant species in order to obtain sufficient quantities of essential nutrients. Yellow water lily *Nuphar lutea*, a relatively scarce plant in Scotland and eaten by beavers, is rich in sodium and phosphorus. In the Netherlands the large size of Eurasian beaver territories may be because beavers require sufficient sources of minerals during gestation.

Plant defence mechanisms are also important and might explain why captive North American beavers have been recorded eating more North American white water lily *Nuphar odorata* than expected. Plant defences might also explain why, at some locations, beavers avoid non- woody plants. Therefore, beavers will tend to feed on both woody and non-woody plants, targeting those species which are most nutritious and avoiding species with natural defences.

4.4.1.3 Habitat change influenced by beavers is a consequence of increased water inundation and herbivory.

Flooding has significant impacts upon riparian vegetation as terrestrial habitat is converted to aquatic, lentic habitat. Initially, flooding will kill many tree species that become submerged. However, the shallow edges, characteristic of beaver ponds, encourage emergent vegetation. The hydrological gradient associated with the edge of beaver ponds increases vascular plant diversity and provides habitat characterised by saturated soils with an open canopy.

Plant biodiversity within beaver meadows is no greater than adjacent riparian communities. However, the community composition of these meadows is fundamentally different from other riparian ecosystems. Hence, the presence of beavers results in an increase in habitat heterogeneity, which may ultimately increase herbaceous plant species richness. One North American study recorded species richness increasing by 33% in the riparian zone at the landscape scale as a result of beaver activity.

A summary (see Table 4.4.1) of the potential interactions between beavers and terrestrial vascular plants is presented below; where possible these have been attributed to a neutral, positive or negative effect.

Table 4.4.1: Summary of potential interactions between beavers and terrestrial vascular plants.

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• Potential overall increased diversity at landscape scale due to increase in habitat heterogeneity • Increased localised diversity of species associated with an open canopy, e.g. grassland species	• Theoretical localised decrease in or loss of species which require lower light levels	Very little information regarding species impacts. See Annex 1 Table 4.2.1 for effects on woody species
Felling	Change in riparian woodland: Change in relative abundance of different tree species	• Increased localised diversity of species associated with an open canopy, e.g. grassland species	• Theoretical localised decrease in or loss of species which require lower light levels	Very little information on species impacts. See Annex 1 Table 4.2.1 for effects on woody species
Feeding	Feeding on specific terrestrial herbaceous and aquatic plant species		• Potential localised decrease in or loss of palatable species	Direct impacts recorded for a very small number of species. Some species on the Scottish Biodiversity List could be adversely affected at local levels. See Annex 1 Table 3.7 for effects on aquatic species
Dams/pond creation	Change from lotic to lentic habitat		• Potential localised decrease in or loss of riparian species, although opportunities for new riparian edge to be colonised	Indirect loss through water inundation not recorded, but theoretical. Loss might be balanced by displacement. See Annex 1 Table 3.7 for effects on aquatic

				species
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• Species of wetland habitats likely to benefit at local levels	• Species which may be sensitive to wetter conditions may decrease or be lost at local levels	This might be positive/negative or neutral, depending on the area and species concerned
Dams/pond creation	Longer term successional changes after dam abandonment, e.g. beaver meadows	• Increased diversity of species associated with increased habitat heterogeneity		
Indirect habitat creation/restoration initiatives as result of beaver presence	Beaver used to promote opportunities for riparian and freshwater habitat creation/restoration	• Any riparian woodland and/or wetland restoration programme is likely to benefit many flowering plant species in the medium to long term. There will be increased diversity of species associated with increased habitat heterogeneity		

4.4.2 Distribution of terrestrial vascular plants in the beaver policy area

The following section concentrates on those terrestrial vascular plant species of conservation importance that are likely to overlap with core beaver woodland and as such may be positively or negatively affected by beaver activity.

4.4.2.1 Terrestrial vascular plant species of conservation importance

To determine whether the activity of beavers on (native) terrestrial vascular plant species is significant in the context of this Strategic Environmental Assessment, the assessment of impacts (positive and negative) has focussed on those species for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded national protection wherever they occur. N.B unlike other receptors discussed in this SEA, there are no species of European importance.

Table 4.4.2 below therefore identifies those terrestrial vascular plant species of conservation importance that utilise ‘potential core beaver woodland’ (as described in section 4.1 of this report) and are found within the beaver policy areas. Most of the sites have a vascular plant assemblage. Only those species within the assemblage that overlap with beaver core habitat have been screened in. Some of the sites are also notified for a single individual vascular plant species. The assessment in section 4.4.3 deals with each individual vascular plant species in turn.

Table 4.4.2: Summary of terrestrial vascular plant species of conservation importance within the beaver policy area that overlap with potential core beaver woodland

SSSI	**SSSI feature**	**Species that overlaps with beaver core woodland**
Craighall Gorge SSSI	Vascular plant assemblage	Lesser hairy brome *Bromopsis benekenii* Shady horsetail *Equisetum pratense* *Whorled Solomon's-seal Polygonatum verticillatum*
Den of Airlie SSSI	Whorled Solomon's-seal *Polygonatum verticillatum*	Whorled Solomon's-seal Polygonatum verticillatum
Den of Riechip SSSI	Whorled Solomon's-seal *Polygonatum verticillatum*	*Whorled Solomon's-seal Polygonatum verticillatum*
Eastern Cairngorms SSSI	Vascular plant assemblage	Twinflower *Linnaea borealis*
Hare Myre, Monk Myre and Stormont Loch SSSI	Vascular plant assemblage	Twinflower *Linnaea borealis* *Creeping Lady’s-tresses Goodera repens*
Keltneyburn SSSI	Vascular plant assemblage	Shady horsetail *Equisetum pratense* Lesser hairy brome *Bromopsis benekenii* *Small cow-wheat Melampyrum sylvaticum* Whorled Solomon's-seal Polygonatum verticillatum Wintergreen (Orthilia secunda)
Milton Wood SSSI	Whorled Solomon's-seal *Polygonatum verticillatum*	Whorled Solomon's-seal *Polygonatum verticillatum*
Rescobie and Balgavies Lochs SSSI	Vascular plant assemblage	Coralroot Orchid *Corallorhiza trifida*
Romadie Woods SSSI	Whorled Solomon's-seal Polygonatum verticillatum	Whorled Solomon's-seal *Polygonatum verticillatum*
Tulach Hill SSSI	Vascular plant assemblage	Shady horsetail Equisetum pratense

4.4.3 Assessment of likely effects on terrestrial vascular plant species of conservation importance in the beaver policy area

Each of the vascular plant species identified in Table 4.2.2 above are discussed in turn below in the context of those effects (positive or negative) that have been identified as a result of beaver activity. Assessment of has been made in the context knowledge of the species ecology as well as the individual sites and their condition. Where mitigation or monitoring maybe appropriate, this has been identified in the narrative. Further discussion relating to the management of beavers including mitigation and monitoring options is provided in section 5 and 7 respectively.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

Beaver opportunities
As summarised above, beaver activity has the potential to create many positive effects. More than that, any riparian woodland and/or wetland restoration programme is likely to benefit many flowering plant species in the medium to long term. There will be increased diversity of species associated with increased habitat heterogeneity.

4.4.3.1 Consideration of potential positive effects on terrestrial vascular plant species of conservation importance

The impact of beaver activity on those vascular plant species discussed below is considered to have a positive or neutral effect. A summary is provided outlining positive effects in general terms, following by individual species assessment at the end of this section.

Some terrestrial plant species might be expected to benefit in riparian habitat, whilst shade-loving species might decline. Terrestrial species which are associated with a high water table are expected to benefit from habitat creation by beavers.

Based on the experience in North America, and at Knapdale, interactions between beavers and other grazing and browsing animals will be important. It is likely that at both Knapdale and Tayside impacts caused by beavers will be influenced by local grazing pressures.

There is limited scientific information on the impacts of beavers on vascular plants (other than tree or shrub species), so it is possible to provide only a tentative prediction of possible future impacts.

Impacts through herbivory are most likely to affect terrestrial species within the foraging range of beavers, alongside ponds and streams. Some species currently growing in areas where beavers might change the habitat might be displaced. Other species will benefit from the creation of such habitat change.

The species most likely to be affected, either positively (or negatively, see below), by beavers are those which are already restricted in distribution and/or abundance, and which occur in potential beaver habitat close to waterbodies.

The positive effect of beaver interaction with terrestrial vascular plant species can be summarised as:

- Changes in relative abundance of different tree species likely to see increased localised diversity of species associated with an open canopy, e.g. grassland species
- Species of wetland habitats likely to benefit at local levels (see section 4.9)

- Successional changes after dam abandonment likely to see increased diversity of species associated with increased habitat heterogeneity
- Potential overall increased diversity at landscape scale due to increase in habitat heterogeneity

Individual species accounts follow below.

The main mechanisms by which beavers could impact this species is either through felling of trees in the riparian zone leading to the opening up of the canopy which could lead to change in light levels, especially shading, or through directly herbivory. Beavers are strictly herbivores; they have a very varied diet with strict seasonality and have been recorded eating around 80 different types of tree species and nearly 150 others plant species including aquatic macrophytes and herbaceous plants. Diet selection appears to be based on nutrient requirements and not necessarily related to local abundance.

SHADY HORSETAIL (EQUISETUM PRATENSE)
This is an evergreen herb, typically found on sloping sites where the substrate is derived from calcareous alluvial silts or sands, especially lightly wooded stream banks in the lower parts of upland valleys. It can also extend onto open moorland, and is found on grassy slopes beneath base-rich upland cliffs.

Knapdale
There are no sites in the Knapdale beaver policy area designated for shady horsetail.

Tayside
- Craighall George SSSI
- Keltneyburn SSSI
- Tulach Hill SSSI

SSSI Assessment
As described above, the general habitat requirements of shady horsetail are such that they could overlap with beaver core habitat. Although some of the sites listed above may have populations of shady horsetail that are located beyond the reach of beavers due to local topography, as beavers don't generally utilise steeply sloping banks.

The shady horsetail generally prefers a light canopy so any felling and subsequent changes to the woodland structure are likely to be generally positive. There is no scientific evidence available to determine whether beavers would preferentially select this national scarce species when foraging.

Therefore, while there are natural heritage interests of national importance on these sites, they are unlikely be adversely affected by beaver activity. Monitoring would add to the knowledge base and help clarify whether the potential benefits indicated above would contribute to the provision of improved habitat conditions for this species.

Mitigation
If beaver colonise these sites, impacts should be monitored through SCM and appropriate mitigation put in place. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging activity. See section 7 for details on the approach to SCM and beavers.

TWINFLOWER LINNAEA BOREALIS
This is a creeping perennial, woody at base, of both native and planted Scot pine *pinus sylvestris* woodland, where it occurs in slight to moderate shade, on barish ground or leaf

litter, sometimes with an acidic healthy herb flora. It spread vegetatively and by seed, though seedling establishment seems largely restricted to disturbed ground.

Knapdale
There are no sites in the Knapdale beaver policy area designated for twinflower.

Tayside
- Eastern Cairngorm SSSI
- Hare Myre, Monk Myre and Stormont Loch SSSI

SSSI Assessment
As beavers generally avoid pine (see section 4.2), the overlap between this nationally scarce species is expected to be minimal at both sites. With respect to the Eastern Cairngorms SSSI, previous surveys of twinflower populations across the Cairngorms National Park have revealed that tall and dense growth of sub-shrubs e.g. Ling Heather *Calluna vulgaris,* which cast heavy shade on plants below are limiting vegetative spread and flowering of Twinflower. At Hare Myre, Monk Myre and Stormont Loch SSSI, it's the old growth pine woodland surrounding Stormont Loch and Hare Myre that provides suitable habitat for this plant.

Therefore, while there are natural heritage interests of national importance on these sites, they are unlikely be adversely affected by beaver activity.

Mitigation
No mitigation has been identified. See section 7 for details on the approach to SCM and beavers.

CREEPING LADY'S-TRESSES (GOODERA REPENS)
This is a creeping, evergreen perennial herb of semi-natural and planted coniferous woodland, usually of Scots Pine *Pinus sylvestris*, where it grows in slight to moderate shade in moist layers of moss and pine needles.

Knapdale
There are no sites in the Knapdale beaver policy area designated for creeping lady's-trees.

Tayside
- Hare Myre, Monk Myre and Stormont Loch SSSI

SSSI Assessment
The old growth pine woodland surrounding Stormont Loch and Hare Myre provides habitat for the nationally scarce creeping lady's-tresses *Goodyera repens*. As beavers generally avoid pine (see section 4.2), the overlap between them is expected to be minimal.

Therefore, while there are natural heritage interests of national importance on this site, they are unlikely be adversely affected by beaver activity.

Mitigation
No mitigation has been identified. See section 7 for details on the approach to SCM and beavers.

WINTERGREEN (ORTHILIA SECUNDA)
A rhizomatous, mycorrhizal, evergreen perennial herb of damp *Calluna* heather and *Vaccinium* (cranberry, cowberry and bilberry) dominated plant communities, mostly in pine and birch woodland but also on open moorland. It also grows in lefts and on ledges in rocky gullies and on rocky stream banks.

Knapdale
There are no sites in the Knapdale beaver policy area designated for wintergreen.

Tayside
- Keltneyburn SSSI

SSSI Assessment
While this species appears to occupy a number of different micro-habitats (as referred to above), some of which may overlap with beaver core woodland, it appears to like more open less shady habitats. Suggesting that any beaver felling and subsequent changes to the woodland structure are likely to be generally positive or neutral.

Therefore, while there are natural heritage interests of national importance on this site, they are unlikely be adversely affected by beaver activity. Monitoring would add to the knowledge base and help clarify whether the potential benefits indicated above would contribute to the provision of improved habitat conditions for this species.

Mitigation
If beaver colonise these sites, impacts should be monitored through SCM and appropriate mitigation put in place. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging activity. See section 7 for details on the approach to SCM and beavers.

4.4.3.2 Consideration of potential negative effects on terrestrial vascular plant species of conservation importance
The impact of beaver activity on the vascular plant species discussed below is considered to have a negative effect or have to the potential for a negative effect.

The main mechanisms by which beavers could impact this species is either through felling of trees in the riparian zone leading to the opening up of the canopy which could lead to change in light levels, especially shading, or through directly herbivory. Beavers are strictly herbivores; they have a very varied diet with strict seasonality and have been recorded eating around 80 different types of tree species and nearly 150 others plant species including aquatic macrophytes and herbaceous plants. Diet selection appears to be based on nutrient requirements and not necessarily related to local abundance.

WHORLED SOLOMON'S-SEAL (POLYGONATUM VERTICILLATUM)
This is a rhizomatous perennial herb usually found on moist, nutrient-rich, usually basic, soils in wooded gorges and on a wooded river bank. Plants reproduce vegetatively, by rhizomatous spread but fruiting is generally poor with recruitment from seed apparently infrequent. Flowering seems to be restricted by excessive shading.

Knapdale
There are no sites in the Knapdale beaver policy area designated for whorled Solomon’s-seal.

Tayside
- Craighall George SSSI
- Den of Airlie SSSI
- Den of Riechip SSSI
- Keltneyburn SSSI
- Milton wood SSSI
- Romadie Woods SSSI

SSSI Assessment
In Great Britain, on the western fringe of its range, it is confined to a comparatively small area of East-Central Scotland, where it is known from twelve sites, all in wooded ravines in Perthshire, of which five overlap with core beaver woodland. It's generally located in steep gullies and wooded ravine; the population located in the Den of Airlie SSSI, in particular, is considered to be on the edge of habitat likely to be accessible to beavers.

Whorled Solomon's-seal appears to tolerate a lighter open canopy so any felling and subsequently changes to the woodland structure are likely to be generally positive, particularly for flowering. There is no scientific evidence available to determine whether beavers would preferentially select this species when foraging. However, its distribution is severely restricted and it is considered nationally rare.

Therefore, there are natural heritage interests of national importance on these sites, which could potential be adversely affected by beaver activity.

Mitigation
If beaver colonise these sites, impacts should be monitored through SCM and appropriate mitigation put in place. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging activity. See section 7 for details on the approach to SCM and beavers.

LESSER HAIRY BROME (BROMOPSIS BENEKENII)
This is a tufted perennial herb of lightly shaded habitats on moist, moderately base-rich soils, including woodlands especially, upland ash woodland, beech also scrub and hedgerows; it occasionally persists on sites of former woodland. Some bare soil is necessary for successful establishment from seed. Almost entirely lowland.

Knapdale
There are no sites in the Knapdale beaver policy area designated for lesser hairy brome.

Tayside
- Craighall George SSSI
- Keltneyburn SSSI

SSSI Assessment
The lesser hairy brome generally prefers a lightly shaded canopy so any felling and subsequently changes to the woodland structure are likely to be generally positive overall. There is no scientific evidence available to determine whether beavers would preferentially select this species when foraging. However, this is a rare plant which is deemed nationally scarce.

Therefore, there are natural heritage interests of national importance on these sites, which could potential be adversely affected by beaver activity.

Mitigation
If beaver colonise these sites, impacts should be monitored through SCM and appropriate mitigation put in place. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging activity. See section 7 for details on the approach to SCM and beavers.

SMALL COW-WHEAT (MELAMPYRUM SYLVATICUM)
Once widespread in Britain and Ireland small cow-wheat, an annual hemiparasite (and therefore gains additional water, nutrients and organic compounds from the roots of host plants), is now restricted to only 19 sites, mostly in Scotland north of the Highland Boundary

Fault. Of these, only five sites support more than 500 plants and seven sites support populations of 100 individuals or fewer.

These small populations typically persist in isolated remnants or small fragments of upland woodland along river gullies, in steep-sided ravines or high up on rock ledges. At lower altitudes this species occupies high humidity sites - close to water, north-facing and under a closed canopy. At higher altitudes the climate is cool enough to maintain adequate moisture levels without a dense canopy, although the shorter growing season constrains plant size.

Knapdale
There are no sites in the Knapdale beaver policy area designated for small cow-wheat.

Tayside
- Keltneyburn SSSI

SSSI Assessment
The overlap with core beaver woodland is likely to encompass the humid, damp shady conditions referred to above. Therefore any beaver felling that opens up the woodland canopy and reduces this micro-habitat is potentially unlikely to be beneficial to this nationally scare plant.

Therefore, there are natural heritage interest of national importance on this site, which could potential be adversely affected by beaver activity.

Mitigation
If beaver colonise this site, impacts should be monitored through SCM and appropriate mitigation put in place. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging activity. See section 7 for details on the approach to SCM and beavers.

CORALROOT ORCHID (CORALLORHIZA TRIFIDA)
A saprophytic herb usually found in shaded damp, alder Alnus and willow Salix carr on raised mires and lake margins, but also occurs in dune-slacks with creeping willow salix repens. More rarely, it grows in tall-herb fen in birch Betula and pine Pinus woods (amongst sphagnum) and on moorland. It may colonise secondary habitats including plantations and quarries.

Knapdale
There are no sites in the Knapdale beaver policy area designated for coralroot orchid.

Tayside
- Rescobie and Balgavies Lochs SSSI

SSSI Assessment
There is potential for some overlap in the distribution of this species and beavers, particularly to the west of Balgavies Lochs. Given its relatively wide ecological niche as described above, any felling activity by beavers at this site which opens up the woodland canopy and reduces the shaded nature of the woodland may not be beneficial to this nationally scarce orchid, although this remains uncertain.

Therefore, there are natural heritage interest of national importance on this site, which could potential be adversely affected by beaver activity.

Mitigation
If beaver colonise these sites, impacts should be monitored through SCM and appropriate mitigation put in place. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging activity. See section 7 for details on the approach to SCM and beavers.

4.5 Beavers and Invertebrates

4.5.1 How beaver activity affects invertebrates

4.5.1.1 Effects from dam building activity

The current literature suggests that the effects of beaver impoundments on aquatic invertebrates are mostly positive. By building dams and digging small canals, beavers create and extend wetland micro-habitats that support many invertebrate taxa. Beaver dams change the predominantly flowing character of aquatic ecosystems to a mixture of flowing and still conditions, which is of particular benefit to predatory invertebrates. The wetland micro-habitat created by beavers attracts water beetle colonists and several species of Odonata (dragonflies and damselflies), which are at the top of the food pyramid.

Studies in Germany have shown that the numbers of Odonata are significantly higher in beaver territories and dammed waters than in areas without beavers. In a river system where beavers had been established since 1981, 29 species of dragonflies were associated with beaver ponds and the surrounding wetland. In comparison, only four species were found in the streams. These figures are not surprising, as the number of dragonfly species that breed in flowing water is far fewer than those breeding in still waters. In North America, dragonflies have long been associated with newly created beaver ponds. In Virginia, 43 dragonfly and 23 damselfly species (a third of them on the state's rare species list) were found in the Laurel Fork recreation area, which consists of a series of river systems with beaver ponds. The majority of species were in beaver ponds and four were known from only beaver ponds or their vicinity. At one specific site of the study, the number of species of dragonflies fell from 61 to four when beavers abandoned it.

In Sweden, Dytiscidae (predatory diving beetles) and Corixidae (aquatic Hemiptera, or true bugs) are abundant and typical beaver pond fauna. Studies in Canada and Finland showed that larval densities of Ephemeroptera (mayflies), Trichoptera (caddisflies) and Plecoptera (stoneflies) decreased in dammed river beds. In the USA, a site immediately downstream of a beaver dam exhibited lower Plecoptera and Trichoptera densities than upstream, but the densities of Diptera (true flies), Ephemeroptera and invertebrate predators in general were higher immediately downstream of the beaver dam.

4.5.1.2 Effects from beaver foraging activity

Beaver herbivory on cottonwood trees in western USA caused an increase in shoot length, which subsequently led to an increase in sawfly (Hymenoptera: Symphyta) abundance. In addition, the open canopy created by beavers allowed the white pine weevil *Pissodes strobi* to flourish where it had been absent previously even in the presence of its food source, the white pine *Pinus strobus*.

A summary (see Table 4.5.1) of the potential interactions between beavers and invertebrates is presented below; where possible these have been attributed to a neutral, positive or negative effect.

Table 4.5.1: Summary of potential interactions between beavers and invertebrates.

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• If scrub is removed as a result of beaver grazing, clearings will be created, which is favourable to some invertebrates, such as some sun-loving dragonfly and butterfly species • Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat heterogeneity and patchiness through the creation of canopy gaps, etc. • Increased light penetration may lead to increased production within streams, ponds and lochs. Increased primary productivity and temperature may increase production of aquatic macroinvertebrates	• May benefit species which can damage or kill tree species (e.g. white pine weevil in North America can benefit from open canopy created by beavers)	Limited information in the literature so there are many areas of uncertainty
Felling	Change in riparian woodland: Change in relative abundance of different tree species		• Bark-stripping of felled, larger aspen trees destroys the microhabitat required by the rare aspen hoverfly. Felled young aspen also interrupt the succession process and reduce the availability of dead wood. Fourteen moth species and 14 saproxylic flies also depend on aspen	See also Annex 1 Table 3.4 for beaver effects on aspen
Felling	Change in riparian woodland: Amount/diversity of fallen dead wood	• Increase in the volume of dead and decaying wood will be beneficial to saproxylic species, particularly beetles		

	on woodland floor			
Felling and constructions	Changes in amount/diversity of woody material in watercourses	• Accumulation of woody debris may shelter water beetles from predatory fish and provide protection for water beetle prey species • In deeper water, submerged debris may sustain an invertebrate fauna dependent on the algal biofilm that grows on wood		
Dams/pond creation	Change from lotic to lentic habitat	• Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat heterogeneity and patchiness, with lentic and associated wetland habitat interspersed with lotic habitat • A change to localised lentic conditions is beneficial to some predatory groups such as Dytiscidae (predaceous diving beetles) and Corixidae (aquatic Hemiptera, or true bugs)	• A reduction in the volume of floating macrophyte detritus may reduce the size of breeding habitat for some dragonflies • Reducing the amount of flowing water may be negative for the beautiful demoiselle and other fast water species such as the golden-ringed dragonfly • Possible localised reduction in larval densities of Ephemeroptera (mayflies), Trichoptera (caddisflies) and Plecoptera (stoneflies) in ponds • A possible reduction in habitat suitability for juvenile freshwater pearl mussel in beaver ponds	.
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat			Likely to be a range of subtle effects, which will affect different species in different ways.
Dams/pond	Changes in water	• Reduction in sediment loads		

creation	quality downstream	resulting from filtering effect of dams, potentially improving downstream habitat quality for species such as freshwater pearl mussel		
Dams/pond creation	Change in standing dead wood resulting from inundation of trees	• Standing dead trees and semi-submerged wood may create suitable breeding sites for several species groups (among them the rare *Lipsothrix* spp. craneflies)		
Dams/pond creation	Impacts on movement of species		• Possible effect on freshwater pearl mussel if migration of salmonid hosts is affected by the presence of dams (see Annex 1 Table 3.14 for beaver effects on fish)	
Other constructions	Creation of lodges, burrows, canals etc.	• Beaver activity (foraging and excavation of canals) will increase habitat diversity (heterogeneity and patchiness)		
Indirect habitat creation/restoration initiatives as result of beaver presence	Beaver used to promote opportunities for riparian and freshwater habitat creation/restoration	• Any programme of riparian woodland/wetland restoration and creation is likely to benefit overall invertebrate diversity		

4.5.2 Distribution of invertebrates in the beaver policy area

The following section concentrates on those invertebrates of conservation importance that are likely to overlap with core beaver woodland and as such maybe positively or negatively affected by beaver activity.

4.5.2.1 Invertebrates of conservation importance

To determine whether the activity of beavers on invertebrates is significant in the context of this Strategic Environmental Assessment, the assessment of impacts (positive and negative) has focussed on those species for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded European or national protection wherever they occur.

Table 4.5.2 below therefore identifies those invertebrates of conservation importance that utilise ‘potential beaver core woodland’ (as described in section 4.1 of this report) and are found within the beaver policy areas.

The Aspen Hover fly has been screened out due to the limited overlap with the beaver policy area and Aspen dominated woodlands as discussed in the section 4.2 Beavers and Woodland. The Northern emerald dragonfly has been screened out, as it breeds in moorland bogs and pools as well as open areas in pine woods; there is therefore very limited overlap with habitats utilised by beavers. Similarly for Marsh Fritillary butterfly which tends to inhabit short coastal grasslands. Both species of whorl snail (Round-mouthed and Geyer’s) found in areas where calcareous ground water percolates to the surface have been screened out as their locations are very unlikely to be significantly affected by beaver activity either through dam building or tree felling.

Table 4.5.2: Summary of invertebrates of conservation importance within the beaver policy area that overlap with potential beaver core woodland

Invertebrate (species or group)	Conservation importance
Beetles	Coille Coire Chuilc SSSI Gannochy Gorge SSSI Loch Leven SSSI Rossie Moor SSSI Struan Wood SSSI Taynish Woods SSSI
Moths	Struan Wood SSSI Taynish Woods SSSI
Fresh water pearl mussel	River Dee SAC River South Esk SAC River Spey SAC River Spey SSSI Lubnaig Marshes SSSI
Dragonflies and Damselflies	Black Wood of Rannoch SSSI Ellary Woods SSSI Knapdale Woods SSSI Taynish Woods SSSI Tayvallich Juniper and Fen SSSI
Flies	Cambusurich Wood SSSI Coille Coire Chuilc SSSI Pass of Killiecrankie SSSI Taynish Woods SSSI Rossie Moor SSSI Shingle Islands SSSI Loch Lubnaig Marshes SSSI
Invertebrate assemblage	Black Wood of Rannoch SSSI

	Cairngorms SSSI Crannach Wood SSSI Den of Airlie SSSI Eastern Cairngorms SSSI Glen Lochay Woods SSSI Methven Woods SSSI

4.5.3 Assessment of likely effects on invertebrates of conservation importance in the beaver policy area

Each of the invertebrate species identified in Table 4.5.2 above are discussed in turn below in the context of those effects (positive or negative) that have been identified as a result of beaver activity. Where this relates to a habitat included in the Habitats Regulation Appraisal of the policy (i.e. in an SAC), a summary of the advice from SNH, provided to inform an appropriate assessment (AA) of the policy with respect to SAC sites (see Annex 2 for the full advice) has been used (referred to hereafter as 'SNH HRA advice'). For the purpose of this assessment, the concluding points of the SNH HRA advice have been replicated where appropriate for species. Assessment of other species (i.e. SSSI notified features), has been made in the context of the SNH HRA advice in combination with knowledge of the individual sites and their condition. Where mitigation or monitoring maybe appropriate, this has been identified in the narrative. Further discussion relating to the management of beavers including mitigation and monitoring options is provided in sections 5 and 7 respectively.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

Beaver opportunities
As summarised above, beaver activity has the potential to create positive effects. More than this, the presence of beavers in an area could provide a basis for any programme of riparian woodland/wetland restoration and creation which is likely to benefit overall invertebrate diversity.

4.5.3.1 Consideration of potential positive effects on invertebrates of conservation importance

The impact of beaver activity on the invertebrate species discussed below is considered to be either positive or neutral. Where there is considered to be a negative effect or the potential for a negative effect, these are discussed in the following section, see 4.5.3.2. A more general discussion is provided first, followed by a more species / site-based assessment.

The effects of beavers on aquatic invertebrates are considered generally positive because their activity (such as foraging and excavation of canals) markedly increases habitat heterogeneity and patchiness by the creation of canopy gaps, and generates wetland habitats through impoundment. Structures built by beavers, such as dams, lodges and beaver meadows, also create novel colonising opportunities for different species groups. As a consequence, beaver ponds show greater abundance and diversity of aquatic invertebrates in relation to other wetland types.

The positive effect of beaver interaction with woodland habitats for invertebrates can be summarised as:

- If scrub is removed as a result of beaver grazing, clearings will be created, which is favourable to some invertebrates, such as some sun-loving dragonfly and butterfly species.
- Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat heterogeneity and patchiness through the creation of canopy gaps, etc.
- Increase in the volume of dead and decaying wood will be beneficial to saproxylic species, particularly beetles.
- Standing dead trees and semi-submerged wood may create suitable breeding sites for several species groups (among them the rare Lipsothrix spp. craneflies)

The positive effect of beaver interaction with freshwater/wetland habitats for invertebrates can be summarised as:

- Increased light penetration may lead to increased production within streams, ponds and lochs. Increased primary productivity and temperature may increase production of aquatic macroinvertebrates.
- Accumulation of woody debris may shelter water beetles from predatory fish and provide protection for water beetle prey species. In deeper water, submerged debris may sustain an invertebrate fauna dependent on the algal biofilm that grows on wood.
- Reduction in sediment loads resulting from filtering effect of dams, potentially improving downstream habitat quality for species such as freshwater pearl mussel
- A change to localised lentic conditions is beneficial to some predatory groups such as Dytiscidae (predaceous diving beetles) and Corixidae (aquatic Hemiptera, or true bugs)
- Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat heterogeneity and patchiness, with lentic and associated wetland habitat interspersed with lotic habitat.

Further narrative is provided below with respect to certain groups of invertebrates: beetles and moths.

BEETLES
Beetles belong to the Order Coleoptera, meaning "sheath-winged", a reference to their hardened forewings. They range in size from 0.25 mm to over 17 cm, and occur in almost every habitat.

Beetles are the largest group of insects, with approximately 400,000 species described across the world. There are about 4,000 species from the British Isles of which about two thirds, or between 2,500 and 3,000, occur in Scotland. However, most of Scotland remains poorly surveyed and our knowledge of the beetle fauna as a whole is patchy and incomplete.

Beetles fulfil a range of roles in a healthy ecosystem. Many beetles are important pollinators, while dung beetles (especially (scarabs) remove vast quantities of dung from the environment.

Knapdale
- Taynish Woods SSSI

Tayside
- Coille Coire Chuilc SSSI
- Gannochy Gorge SSSI
- Loch Leven SSSI
- Rossie Moor SSSI
- Struan Wood SSSI

SSSI Assessment
See section 4.5.3.2 below for narrative with respect to the following SSSIs, Coille Coire Chuilc, Gannochy Gorge, Struan Wood and Taynish Woods.

Rossie Moor SSSI is designated for its aquatic beetle assemblage. Recent studies in Swedish wetlands have found that the diversity of aquatic plants and water beetles was higher at the patch, site and landscape scale than in other non-beaver-related wetland types within the same area. This was also reflected through monitoring at Knapdale (SBT) which recorded an increase in water beetle diversity when compared to baseline surveys without beaver occupancy. The creation of woody debris in particular, through feeding and creation of food caches may be an important component of habitat complexity in beaver occupied ponds/lochs. It provides many beetle species with direct shelter and refugia from fish, as well as concealment from other predatory species of beetles. Therefore, while there are natural heritage interests of national importance on this site, they are unlikely be adversely affected by beaver activity.

Loch Leven SSSI has an extremely rare carrion beetle associated with its wetland habitat. The adult beetle feeds on any type of carrion on the water's edge and the larvae feeds on aquatic snails. The presence of beaver will not affect these food sources. Therefore, while there are natural heritage interests of national importance on this site, they are unlikely be adversely affected by beaver activity.

Mitigation
No mitigation has been identified.

MOTHS
Moths are less known compared with butterflies mainly because they generally fly by night. They are, however, also much more diverse and include some species that are even more striking than our butterflies. There are about 34 species of butterfly seen regularly in Scotland but about 1,300 species of moth. Some moths do fly by day such as the red and black burnet moths in grassland that still has a good range of flowers, especially by the sea.

Knapdale
- Taynish Woods SSSI

Tayside
- Struan Wood SSSI

SSSI Assessment
Taynish Woods SSSI is designated for its micro moth *Clepsis rurinana* and other moths associated with semi natural woodland. Struan Wood SSSI is designated for its Rannoch roller moth *Ancylis tineana*.

Woodlands that benefit moth species are generally diverse and uneven in structure. They are likely to have a mixture of mature and tall trees, patches of open areas as well as patches of dense regeneration and tree canopy. All of which provide different micro habitats for moth species to carry out various parts of their life cycle such as areas where eggs can be laid, where pupae can develop undisturbed and where caterpillars can feed; for example the Rannoch roller utilises birch, blackthorn and hawthorn, whereas *Clepsis rurunana* larve mainly feed on honeysuckle, oak and dog rose species.

As noted in section 4.2 (Beavers and Woodland), beaver felling activity can lead to changes in the structural diversity or patchiness of the riparian woodland zone all of which could contribute to many of the ecological requirements of moth species including those identified above, noting however that beaver activity is mostly found within 10m of the water's edge and as such, depending on the individual moth species requirement, there may be very little overlap with beavers. Therefore, while there are natural heritage interests of national importance on these sites, they are unlikely be adversely affected by beaver activity.

4.5.3.2 Consideration of potential negative effects on invertebrates of conservation importance

The impact of beaver activity on the invertebrate species discussed below is considered to have a negative or have the potential for a negative effect.

FRESHWATER PEARL MUSSEL

The freshwater pearl mussel is an important part of our biodiversity and has an important place in our cultural heritage. Moreover, the species is one of the most critically endangered molluscs in the world. Part of the reason pearl mussels are rare in Scotland is due to ongoing, illegal pearl fishing. Scotland contains many of the world's most important remaining populations.

Freshwater pearl mussels are similar in shape to common marine mussels but grow much larger and live far longer than their marine relatives. Incredibly, they can live for more than 100 years, making them one of the longest-lived invertebrates. They can grow to as large as your hand and are dark brown to black in colour. They live at the bottom of clean, fast-flowing rivers, where they can be completely or partly buried in course sand or fine gravel. They feed by drawing in river water and filtering out fine particles. Each day an adult is able to filter more water than we use in an average shower. They have a complex lifecycle and, in their first year, they harmlessly live on the gills of young salmon or trout.

Knapdale

There are no sites identified at Knapdale beaver policy area for fresh water pearl mussel.

Tayside

- River Dee SAC
- River South Esk SAC
- River Spey SAC
- River Spey SSSI
- Lubnaig Marshes SSSI

HRA advice

The principle means by which beavers could affect pearl mussels in any SAC, is through the construction of dams. This could have a detrimental effect if pearl mussels are immediately upstream, potentially causing disturbance of the species and changing the habitat that can support pearl mussels. However, it is worth noting that in all SACs more than 99.9% of pearl mussels are in the main stems of the rivers which are too large for beavers to dam.

The other relevant potential impact is the effects on the salmonid host(s). Dam building in the tributaries of the SACs could impede the migration of local Atlantic salmon and trout populations upon which the mussels depend to complete their life cycle, although nearly all of the mussels in all three SACs live further downstream in the mainstems of the SAC rivers where damming will not affect the pearl mussels. The appraisal for the Atlantic salmon qualifying interest of each of the three riverine SACs in section 4.11 Beavers and Fish, which concludes that an adverse effect on Atlantic salmon cannot be ruled out without mitigation.

The SNH HRA concluded given that freshwater pearl mussels (within only limited exceptions on the River Spey) are located far downstream of locations where beavers may be able to build dams, then an indirect impact on pearl mussels is improbable. However, an adverse effect cannot be ruled out with certainty for the three SACs without the implementation of the mitigation required for Atlantic salmon.

SSSI Assessment
Impacts to freshwater pearl mussel for River Spey SSSI and Lubnaig Marshes SSSI are likely to be similar to those described above for the aforementioned SACs. There is therefore potential for beaver activity to adversely affect the natural heritage interest of national importance.

Mitigation
The relevant text from Section 4.11 Beavers and Fish, has been replicated here to aid the reader.

Mitigation to ensure passage may be achieved through the easement or removal of barriers at certain times of year important for salmon (i.e. during spawning and smolt emigration) or through the installation of flow control devices. However; it is unclear at this time whether flow control devices could be used to assist the upstream migration of large Atlantic salmon (which is typical of ‘Spring’ fish). If a beaver dam might cause an adverse effect on the integrity of the SAC and a flow control device might not allow passage upstream, then alternative mitigation measures which will allow passage must be put in place. These mitigation measures should be included in a Beaver Management Plan for the individual SACs, which should also set out in what circumstances there could be an adverse effect on site integrity, and a framework through which to implement any mitigation measures should they become necessary.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

BEETLES
Beetles belong to the Order Coleoptera, meaning "sheath-winged", a reference to their hardened forewings. They range in size from 0.25 mm to over 17 cm, and occur in almost every habitat.

Beetles are the largest group of insects, with approximately 400,000 species described across the world. There are about 4,000 species from the British Isles of which about two thirds, or between 2,500 and 3,000, occur in Scotland. However, most of Scotland remains poorly surveyed and our knowledge of the beetle fauna as a whole is patchy and incomplete.

Beetles fulfil a range of roles in a healthy ecosystem. Many beetles are important pollinators, while dung beetles (especially (scarabs) remove vast quantities of dung from the environment.

Knapdale
- Taynish Woods SSSI

Tayside
- Coille Coire Chuilc SSSI
- Gannochy Gorge SSSI
- Loch Leven SSSI
- Rossie Moor SSSI
- Struan Wood SSSI

SSSI Assessment
The following SSSIs, Coille Coire Chuilc, Gannochy Gorge, Struan Wood and Taynish Woods, all have beetle assemblage comprising of saproxylic beetles i.e. beetles dependant on dead or decaying wood. They may not be dependent on dead wood for their entire life cycle, for example for some species it's the larvae that feed on decaying wood whereas the adults may feed on other things such as nectar.

Rossie Moor SSSI is designated for its aquatic beetle assemblage; and Loch Leven for it's rare beetle species; assessment of impacts to these sites have been dealt with above in section 4.5.3.1. and are expected to be positive or neutral.

Coille Coire Chuilc, Gannochy Gorge, Struan Wood and Taynish Woods SSSIs
As noted in section 4.2 (Beavers and Woodland), beaver felling of trees could lead to increased fallen dead wood in some areas, although much of the material is removed for food and construction. Beaver damming activity and pond creation can lead to the death of trees which are unable to cope with the water levels will lead to an increase in standing dead wood, which is generally present at only low levels in British woods. Therefore while beaver activity is expected to increase the volume of deadwood within woodlands, and noting that most beaver felling occurs with 10m of the water's edge in the riparian zone, monitoring would be required to assess the scale of effect of removing the wood for consumption i.e. it could be eaten immediately or placed underwater by a beaver in a food cache, both of which would make it unavailable to saproxylic beetles. This demonstrates that there is some potential for beaver activity to adversely affect the natural heritage interests of national importance but the extent to which will be dependent on site-specific circumstances, including the size of the riparian woodland zone compared with the distribution of suitable woodland across the designated site, the volume and location of the existing deadwood resource and the nature of the beaver occupancy.

DRAGONFLIES
The order Odonata comprises dragonflies (wings outstretched at rest) and damselflies (wings folded at rest). They are an ancient group, having arisen in the Carboniferous Period (300 million years ago). This is 150 million years before the first birds, and 295 million years before man appeared on Earth.

They are mainly tropical insects with over 5,000 species worldwide. Europe has about 114 breeding species, the British Isles 38 and Scotland 21. In Scotland, the commonest species breed in ponds and lochans.

The adults feed on live insects which they catch while in flight, particularly midges and mosquitoes. They also will take butterflies, moths and smaller dragonflies. The adults frequent sheltered, sunny glades where prey is plentiful. Eggs are deposited in, or near, fresh water or into aquatic vegetation. The larvae prey on a variety of aquatic organisms and moult several times over a period of months, or years depending on species.

Knapdale
- Ellary Woods SSSI
- Knapdale Woods SSSI
- Taynish Woods SSSI
- Tayvallich Juniper and Fen SSSI

Tayside
- Black Wood of Rannoch SSSI

SSSI Assessment
Each of the sites identified above have a variety of different damsel and dragonfly species that contribute to its assemblage feature. Evidence from Europe suggests that numbers of Odonata species are higher in areas occupied by beavers where they make use of beaver pond and surrounding wetlands. In North America, dragonflies have long been associated with newly created beaver ponds. In Virginia, 43 dragonfly and 23 damselfly species were found in the Laurel Fork recreation area, which consists of a series of river systems with beaver ponds. At one specific site of the study, the number of species of dragonflies fell from 61 to four when beavers abandoned it.

Beavers can feed directly on many of the aquatic and emergent plant species that some dragonflies rely upon to complete certain stages in their life history. This was noted in Knapdale (SBT) in relation to the hairy dragonfly *Brachytron pratense* where the loss of cover of key emergent vegetation through beaver grazing or water level rise, resulted in a loss of trapped floating macrophyte detritus habitat and so a loss of suitable breeding habitat. Conversely, glades created in the willow and birch scrub around many of the beaver lochs, created sheltered feeding areas for adults including other species such as the beautiful demoiselle *Calopteryx virgo* which was similarly monitored at Knapdale. The beautiful demoiselle is adapted to flowing water conditions and the impact of damming on the habitat requirements of this species may be affected by reducing the amount of flowing water downstream of any dam.

Experience from Scotland and elsewhere suggests that while there are positive benefits to many odonata species (see section 4.5.3.1 above), that the interaction between beavers and individual species is complex and while there may be positive gain overall all, some species may lose out. Therefore, there may be some potential for beaver activity to adversely affect the natural heritage interests of national importance with respect to the above mentioned SSSIs but the extent to which will be dependent on the site-specific circumstances.

Mitigation
If beaver colonise these sites, impacts should be monitored through SCM and appropriate mitigation put in place if required. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

FLIES
Although beetles are the dominant insect group worldwide, flies (Order Diptera, meaning "two wings") are more abundant in temperate regions. In the British Isles, there are about 7,000 species.

The young stages of flies - the larvae - are commonly found in the soil, water, plants, carrion, dung, dead wood - mostly places with high levels of moisture. Many are nectar feeders and play an important role as pollinators. That's the case of hoverflies; they are familiar garden visitors. Others feed on decaying matter and are important for recycling dung and dead animals.

Scotland is home of two hoverflies of special interest because of their rarity and the conservation efforts put together to protect them; they are the aspen hoverfly and the pine hoverfly.

Other important species in Scotland are the craneflies, Scottish yellow splinter and the Northern yellow Splinter, and the stiletto fly *Spiriverpa lunulata*.

Knapdale
- Taynish Woods SSSI

Tayside

- Cambusurich Wood SSSI
- Coille Coire Chuilc SSSI
- Pass of Killiecrankie SSSI
- Rossie Moor SSSI
- Shingle Islands SSSI
- Loch Lubnaig Marshes SSSI

SSSI Assessment
The aforementioned SSSIs are all notified for their fly species or assemblage features. Some are associated with specific habitats such as semi-natural woodland at Cambusurich Wood and Pass of Killiecrankie SSSIs, or more moist areas such as mire, fen and flush habitats at Coille Coire Chuilc, Taynish Woods and Rossie Moor SSSIs. Some sites, such as Loch Lubnaig Marshes SSSI are important for specific species such as the hoverfly *Chamaesyrphus scavoides* and the cranefly *Tipula limbata* or the stiletto fly *Spiriverpa lunulata* at Shingle Islands SSSI.

The limited current knowledge of the habitat requirements of many of these fly species for which these sites have been designated, combined with their often complex life history characteristics, makes understanding how and when beaver activity could affect them, either positively or negatively, particularly difficult. And while we have a growing evidence base demonstrating how beaver activity affects certain habitats types, some of which has been described in other sections e.g. 4.2 Beavers and Woodlands as well as 4.9 Beavers and standing freshwater habitats, the scale of effects at an individual site or species level is not always possible in the context of currently available science.

Therefore, there may be some potential for beaver activity to adversely affect the natural heritage interests of national importance with respect to the above mentioned SSSIs but the extent to which will be dependent on the site-specific circumstances.

Mitigation
If beaver colonise these sites, impacts should be monitored through SCM and appropriate mitigation put in place if required. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

INVERTEBRATE ASSEMBLAGE
Most invertebrates have annual life cycles and, unlike plants, which can have dormant seed or resistant vegetative rootstocks, they cannot survive adverse conditions or periods when their habitat is unsuitable. This position is further complicated by the fact that many invertebrates, particularly insects, have complex life histories in which the early growing stages (e.g. larvae) typically have different needs from the more mobile, reproductive adult stage. A familiar example is the plant-feeding larva of a butterfly in contrast to the flower-visiting adult.

Invertebrates are small, and their body temperature - and hence their activity - is greatly influenced by the micro-climate where they live. Consequently, vegetation structure, as well as species composition, has a profound effect upon the distribution and numbers of many species.

Although many invertebrates are highly mobile and can rapidly colonise newly available habitats (for instance some butterflies and moths, dragonflies and caddis flies), others are sedentary and typically move only short distances. Another characteristic of many invertebrates is their great specialisation: they are able to occupy narrow niches and exploit tiny micro-habitats within, for example, plant seeds or sap runs on mature trees, or they are the internal parasitoids of the eggs or later stages of other invertebrates. This specialisation enables many species to coexist within a habitat, but it can also mean that the rarest species, which tend to display the greatest specialisation, are vulnerable to local extinction if their precise habitat requirements and life cycle needs disappear.

Knapdale
There are no sites identified with the Knapdale beaver policy area with an Invertebrate assemblage feature.

Tayside

- Black Wood of Rannoch SSSI
- Cairngorms SSSI
- Crannach Wood SSSI
- Den of Airlie SSSI
- Eastern Cairngorms SSSI
- Glen Lochay Woods SSSI
- Methven Woods SSSI

SSSI Assessment
The aforementioned SSSIs all have notified invertebrate assemblage features. Each site has a variety of the different invertebrate groups including, spiders, wood ants, flies, beetles as well as dragonflies, butterflies and moths. Some of these will be associated with the woodland habitats distributed on the site and others may be associated with lochs and wetlands. As indicated above (4.5.1) there are many example of beaver foraging and damming activity that provides positive benefits to a wide range of invertebrate species, however the interaction between beavers and invertebrates at an individual species level is complex and while there may be positive gain overall all, some species may lose out.

Therefore, there may be some potential for beaver activity to adversely affect the natural heritage interests of national importance with respect to the above mentioned SSSIs but the extent to which will be dependent on the site-specific circumstances.

Mitigation
If beaver colonise these sites, impacts should be monitored through SCM and appropriate mitigation put in place if required. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

4.6 Beavers and Amphibians and Reptiles

4.6.1 How beaver activity affects amphibians

Beaver activity results in the creation of ponds and slow-moving water, the changing of water tables and development of wetland habitat, all of which will generally benefit Scottish amphibians.

Scotland has six native amphibian species:

- Frogs and toads (Anuran species) – common frog *Rana temporaria*, common toad Bufo bufo and natterjack toad *Epidalia calamita*
- Newts and salamanders (Caudatan species) – smooth newt *Lissotriton vulgaris*, palmate newt *Lessotriton helvetica* and great crested newt *Triturus vulgaris*

The great crested newt and natterjack toad are European Protected Species[2]. All six species are dependent on water for breeding sites and all prefer, or are dependent on, standing water. The natterjack toad is the least likely to interact with beavers, as it is associated with coastal dune or saltmarsh habitats in Scotland, which are not expected to be potential beaver habitat.

4.6.1.1 Dam building

Dam-building on watercourses by beavers is the primary factor which will influence amphibians. Impoundment provides more standing water where flowing water was present before. The literature covering beavers' effects on amphibians is not large, although there are a number of published studies from North America. Whilst these support the idea that beaver impoundments are beneficial to amphibians, they largely concern guilds of species which are not fully analogous to the Scottish situation, for example stream-living salamanders.

One study examined the impact of beaver reintroduction on a guild of amphibians in the European central highlands, including four of the Scottish species. It found that beaver impoundments are important for all species, especially the common frog and palmate newt. Beaver ponds were compared with artificial ponds present before beaver reintroduction and it was concluded that artificial ponds acted as a surrogate for natural beaver ponds in their absence.

There is likely to be a benefit to amphibians, particularly anurans, where beaver dam-building changes the water table to induce wetland conditions. Newts, in the terrestrial phases of their annual cycle, favour damp rather than waterlogged habitats, such as leaf litter and friable dead wood. Hibernation sites are in damp habitats, and these would become unsuitable if they were waterlogged by beaver impoundments, although potential new sites may become available.

4.6.1.2 Fish within beaver impoundments

One negative aspect may be the presence of fish within these impoundments. Beaver ponds tend to be in-stream waterbodies rather than stand-alone ponds, isolated from fish colonisation. Great crested newts are particularly vulnerable to fish predation as their larvae are largely pelagic in habit, swimming in the water column to prey on species such as Daphnia and copepods. The larvae of the smaller newt species, and tadpoles of anurans, are more benthic, so are less vulnerable to, although not immune from, fish predation. Flooding by impounding or canal-building could also open up isolated ponds to fish invasion. Interactions between beaver dams and fish are further described in Annex 1 section 3.4.7.

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[2] http://www.snh.gov.uk/protecting-scotlands-nature/protected-species/legal-framework/habitats-directive/euro/

One study reported evidence that great crested newts thrive in beaver ponds in continental Europe, although it also highlighted the need for fish-free conditions for great crested newt survival.

4.6.1.3 Impacts to riparian tree and aquatic plant cover

By reducing riparian tree cover, beaver activity can also raise the temperature of waterbodies by increasing insolation, a key factor in amphibian breeding success, particularly for great crested newts. Aquatic vegetation is important for cover for adult and larval amphibians and as egg-laying sites for newts. The effects of beaver presence on aquatic plants will vary between sites and are difficult to predict. Creation of ponds and wetland habitat is expected to increase the invertebrate biota overall (Annex 1 section 3.4.6), and hence prey for all life stages of amphibians.

4.6.2 How beaver activity affects reptiles

There are three terrestrial reptile species native to Scotland:

- Lizards – viviparous or common lizard *Zootoca vivipara* and slow worm *Anguis fragilis*
- Snake – adder *Vipera berus*

There is also some evidence of populations of grass snake *Natrix natrix* in Scotland, although it is not known whether any of these have arisen from natural sources rather than from escaped captives or releases.

Effects on the three known native species are likely to be incidental. Viviparous lizards and adders can persist in wetland habitats but they are sub-optimal for them. Beaver foraging thins out woodland canopy, which could lead to greater insolation of the woodland floor and a potential increase in microhabitats with thermoregulatory benefits to reptiles, depending on the pattern of regrowth and ground flora regeneration.

The grass snake could benefit from beaver activity as it often hunts in water, and frogs can be a major prey component. They lay eggs in piles of rotting vegetation, notably compost heaps, where increased temperatures speed up the development of the young. Detritus within beaver lodge structures can provide such conditions.

A summary (see Table 4.6.1.) of the potential interactions between beavers amphibians and reptiles is presented below; where possible these have been attributed to a neutral, positive or negative effect.

Table 4.6.1: Summary of potential interactions between beavers and amphibians and reptiles.

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• Increased insolation of waterbodies will advance breeding times and accelerate maturation times in amphibians • Increased insolation will benefit reptiles through increased thermoregulatory opportunities		
Felling	Change in riparian woodland: Amount/diversity of fallen dead wood on woodland floor	• Increased fallen dead wood will provide additional foraging, resting and hibernation sites for amphibians and reptiles		
Felling and constructions	Changes in amount/diversity of woody material in watercourses	• May benefit amphibian larvae by providing shelter and foraging habitat diversity, and through increasing abundance/diversity of some invertebrate prey species		
Feeding	Feeding on specific terrestrial herbaceous and aquatic plant species	• Newts have plant species which they prefer to lay eggs on, so changes in plant composition may have some positive localised effects	• Newts have preferred plant species on which to lay eggs, so changes in plant composition may have some negative localised effects	
Dams/pond creation	Change from lotic to lentic habitat	• Increase in lotic habitat will benefit breeding amphibians	• Risk to great crested newt from fish predation where impoundments give access to fish predators	

Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• Increase in wetland habitat, and increasing habitat heterogeneity, will benefit amphibians overall	• Some risk of waterlogging of hibernacula	
Dams/pond creation	Changes in water quality downstream			Likely to be impacts on water quality of impoundments created downstream, which amphibians may use
Other constructions	Creation of lodges, burrows, canals, etc.	• Lodge and dam structures will provide some benefit in providing shelter for amphibian larvae • Lodge and dam structures may provide shelter and breeding sites for grass snakes should they become established in Scotland	• Canals may provide access for fish to great crested newt breeding ponds	
Other			• Beaver impoundments and structures may provide a haven for invasive non-native terrapin species	
Indirect habitat creation/restoration initiatives as result of beaver presence	Beaver used to promote opportunities for riparian and freshwater habitat creation/restoration	• Presence of beavers may act as an incentive for greater investment, management and monitoring. This could include those related to the restoration and management of riparian woodland and wetland habitats		

4.6.3 Distribution of amphibians and reptiles in the beaver policy area

The following section concentrates on those amphibian and reptile species of conservation importance that are likely to overlap with core beaver habitat and as such maybe positively or negatively affected by beaver activity.

4.6.3.1 Amphibians and reptiles of conservation importance

To determine whether the activity of beavers on amphibians and reptiles is significant in the context of this Strategic Environmental Assessment, the assessment of impacts (positive and negative) has focussed on those species for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded European or national protection wherever they occur.

Table 4.6.2 below therefore identifies those amphibians and reptiles of conservation importance that utilise ‘potential beaver core habitat’ (as described in section 4.1 of this report) and are found within the beaver policy areas.

Turflundie Wood

Turflundie Wood SAC and SSSI is of conservation importance for its population of great crested newts *Triturus cristatus*, and for its assemblage of breeding amphibians, the richest in east Perth & Kinross. The site is predominantly an area of planted coniferous woodland and contains a number of natural and man-made pools which are used by breeding great crested newts, common frogs *Rana temporaria*, common toads *Bufo bufo*, palmate newts *Lissotriton helveticus* and smooth newts *Lissotriton vulgaris*. Despite this importance, the site does not overlap with potential core beaver habitat and so has been screened out of any further assessment.

There are no other designated sites in the beaver policy area for any amphibian or reptile species or assemblages that overlap with potential core beaver habitat.

Table 4.6.2: Summary of amphibians and reptiles of conservation importance within the policy area that overlap with potential beaver core habitat

Amphibians and reptiles species	Conservation importance
Great crested newt	EPS

4.6.4 Assessment of likely effects on amphibians and reptiles of conservation importance in the beaver policy area

The species identified in Table 4.6.2 above is discussed in turn below in the context of those effects (positive or negative) that have been identified as a result of beaver activity. Where this relates to a species included in the Habitats Regulation Appraisal of the policy, a summary of the advice from SNH provided to inform an appropriate assessment (AA) of the policy with respect to SAC sites (see Annex 2 for the full advice) has been used. Where a species is afforded protection as a European Protected Species through the Habitats Regulation 1994, consideration is given as to the policy impact on the favourable conservation status of the population of the species in its natural range. Where mitigation or monitoring maybe appropriate, this has been identified in the narrative with further discussion relating to the management of beavers including mitigation and monitoring options is provided in section 5 and 7 of this report.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

Beaver opportunities
As mentioned above beaver activity has the potential to create many positive effects for a variety of native amphibian and reptile species. The presence of beavers may act as an incentive for greater investment, management and monitoring. This could include those related to the restoration and management of riparian woodland and wetland habitats.

4.6.4.1 Consideration of potential positive effects on amphibian species of conservation importance

GREAT CRESTED NEWT
The great crested newt *Triturus cristatus* is the largest of the three British newt species with an adult length of 90 -170 mm. The adult male has a jagged crest along his back which decreases in size outside the breeding season. Both sexes are very dark in colour with a vivid orange belly patterned with irregular black spots. The skin is granular giving the species its alternative common name of warty newt.

The great crested newt spends the bulk of its life on land but is dependent on small to medium sized freshwater ponds to breed. Naturally a creature of rough grassland, scrub and woodland, the species has long been associated with lowland farmland but has also found a niche in former (and current) mineral workings and other 'brownfield' habitats. Terrestrial life is typically spent within 250 m of the breeding ponds but dispersal of up to 1000 m can occur.

They are nocturnal predators on invertebrates, spending daytime in damp refuges, for example, under stones and logs. Breeding takes place in ponds in spring to early summer, governed by temperature.

A number of positive and negative effects have been identified for great crested newts. Potential positive effects are anticipated to include:

- Increased insolation of waterbodies will advance breeding times and accelerate maturation times in amphibians
- Increased fallen dead wood will provide additional foraging, resting and hibernation sites for amphibians
- May benefit amphibian larvae by providing shelter and foraging habitat diversity, and through increasing abundance/diversity of some invertebrate prey species
- Newts have plant species which they prefer to lay eggs on, so changes in plant composition may have some positive localised effects
- Increase in lotic habitat will benefit breeding amphibians
- Increase in wetland habitat, and increasing habitat heterogeneity, will benefit amphibians overall
- Lodge and dam structures will provide some benefit in providing shelter for amphibian adults and larvae

European Protected Species
Great crested newts are classed as European Protected Species, and are fully protected under The Habitats Regulations 1994 (as amended in Scotland).

In general, the spread of beavers would appear to be beneficial for amphibians in providing more pond habitat, especially in areas where the current stream gradients preclude standing water. Increased water tables may also create wet woodland or wetland habitat favourable to most amphibians.

While this assessment has identified the potential for some localised negative effects on great crested newt, which are discussed in section 4.6.4.2 below, it is anticipated that the potential impacts from the policy will not be detrimental to the maintenance of the population of the species (great crested newt) concerned at Favourable Conservation Status in their natural range.

4.6.4.2 Consideration of potential negative effects on amphibian species of conservation importance

A number of positive and negative effects have been identified for great crested newts. Potential negative effects are anticipated to include:

- Newts have preferred plant species on which to lay eggs, so changes in plant composition may have some negative localised effects
- Risk to great crested newt from fish predation where impoundments give access to fish predators
- Some risk of waterlogging of hibernacula
- Canals may provide access for fish to great crested newt breeding ponds

EPS Assessment

Great crested newts are classed as European Protected Species, and are fully protected under The Habitats Regulations 1994 (as amended in Scotland).

In general, the spread of beavers would appear to be beneficial for amphibians, a proviso might be that the continued presence of fish in beaver impoundments may not be ideal for great crested newts, although there is evidence from continental Europe that they do exploit beaver-created habitats. Despite the identified negative effects above, the interaction between great crested newt and beavers is likely to be broadly positive.

It is therefore anticipated that the potential impacts from the policy will not be detrimental to the maintenance of the population of the species (great crested newt) concerned at Favourable Conservation Status in their natural range.

4.7 Beavers and Birds

4.7.1 How beaver activity affects birds

The main mechanism for beavers influencing avian biodiversity is the increase in wetland areas available for nesting and feeding. Overall, international studies show that beavers increase avian biodiversity in riparian areas by increasing the amount of slow-moving water and well-vegetated wetland habitat. Groups that respond best to increases in these habitats are waterfowl, herons and kingfishers. A summary (see Table 4.7.1) of the positive and negative effects of beaver activity on bird species is presented at the end of this section.

The aquatic characteristics of beaver ponds, such as large shallow water areas with gradual edges, may be particularly important for a variety of species of waterfowl. The gradual edges of beaver ponds may be a key driver of high bird biodiversity, as they provide a structurally complex habitat that may improve nest concealment, reduce predation, increase food production and provide a diverse range of ecological niches. The interspersion of different vegetation types seems to be a key component of this habitat, which can provide cover for waterfowl in particular.

The habitats created by beavers also provide a more abundant food supply for birds. Beaver impoundments tend to contain an abundant aquatic assemblage including a diverse range of macro-invertebrates which are an excellent food source for ducks. An increased abundance and diversity of fish and amphibians within beaver impoundments provides food for species such as grey heron *Ardea cinerea* and kingfisher *Alcedo atthis*.

The ponds created by beaver dams often flood and kill trees in the riparian zone. This attracts woodpeckers, as standing dead wood is an important nesting and feeding habitat for them. Woodpecker holes are also used by a range of secondary cavity-nesting species. Dead trees and snags are an important site for foraging and nesting raptors, which may also prey on beavers.

Beaver meadows support diverse grassland vegetation, which promotes bird biodiversity and may be an essential source of habitat for grassland birds on a landscape scale. In Canada, one study found that beaver meadows had higher levels of songbird biodiversity than all the adjacent riparian habitats.

Beavers may also encourage bird abundance in less obvious ways. Where ponds are covered with ice and snow for much of the winter, beaver physical activity causes the ice to melt earlier in the spring. This can bring benefits to wildfowl, for example beaver ponds have been shown to give Canada geese *Branta canadensis* access to an important habitat for an extended period.

Table 4.7.1: Summary of potential interactions between beavers and birds

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• A more open woodland canopy improves foraging habitat for small insectivorous birds, e.g. tree pipit • Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat heterogeneity and patchiness through the creation of canopy gaps, etc.		
Felling	Change in riparian woodland: Change in age classes of trees	• Beaver-coppiced riparian woodland is likely to benefit many small insectivorous species, e.g. warblers	• Fewer large trees may adversely affect some groups of birds, e.g. woodpeckers	
Felling	Change in riparian woodland: Amount/diversity of fallen dead wood on woodland floor	• Uncertain, but may be beneficial impacts on invertebrate and other prey species		
Felling and constructions	Changes in amount/diversity of woody material in watercourses	• Uncertain, but may be beneficial impacts on prey species, e.g. fish for mergansers, goosanders, etc.		
Dams/pond creation	Change from lotic to lentic habitat	• Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat	• The creation of habitat which may benefit invasive non-native species such as mandarin duck	

		heterogeneity and patchiness, with lentic and associated wetland habitat interspersed with lotic habitat • The creation of pond habitat will boost prey abundance for many bird species		
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• The creation of new riparian wetland will boost prey abundance for many bird species		
Dams/pond creation	Changes in water quality downstream	• Uncertain, but may be beneficial impacts on prey species, e.g. fish		
Dams/pond creation	Change in standing dead wood resulting from inundation of trees	• May provide increased nesting and feeding opportunities for woodpeckers, nuthatches and raptors		
Dams/pond creation	Longer term successional changes after dam abandonment, e.g. beaver meadows	• Evidence from North America of an increase in diversity and number of grassland bird species on beaver meadows		
Dams/pond creation	Impacts on movement of species		• Beaver dams may sometimes have adverse impacts on migratory fish species, with consequent localised impacts on piscivorous birds	See Annex 1, Table 3.14 for effects of beavers on fish
Other	Creation of lodges,	• Lodges provide additional	• Invasive non-native	

constructions	burrows, canals, etc.	secure nesting and resting places for a variety of bird species	Canada geese may utilise these structures	
Other		• Beavers (especially juveniles) may be a prey species for predators, such as white-tailed eagle		
Indirect habitat creation/restoration initiatives as result of beaver presence	Beaver used to promote opportunities for riparian and freshwater habitat creation/restoration	• Presence of beavers may act as an incentive for greater investment, management and monitoring. This could those related to the restoration and management of riparian woodland and wetlands, which would benefit a range of bird species		

4.7.2 Distribution of birds in the beaver policy area

The following section concentrates on those bird species of conservation importance that are likely to overlap with core beaver woodland and as such maybe positively or negatively affected by beaver activity in the policy area.

4.7.2.1 Bird species of conservation importance

To determine whether the activity of beavers on bird species is significant in the context of this Strategic Environmental Assessment, the assessment of impacts (positive and negative) has focussed on those species for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded European or national protection wherever they occur.

Table 4.7.2 below therefore identifies those bird species of conservation importance that utilise 'potential beaver core woodland' (as described in section 4.2. of this report) and are found within the beaver policy areas.

Table 4.7.2: Summary of bird species of conservation importance within the policy area that overlap with potential beaver core woodland

Bird species (B = breeding, NB = Non-breeding)	**SPA**	**SSSI**
Black throated diver (B)	Rannoch Lochs SPA Knapdale Lochs SPA	Rannoch Lochs SSSI Knapdale Lochs SPA
Scottish crossbill (B)	Ballochbuie SPA Cairngorms SPA	Creag Clunie and the Lion's Face SSSI
Greylag goose (NB)	South Tayside Goose Roosts SPA (& Ramsar) Loch of Lintrathen SPA (& Ramsar) Loch of Kinnordy SPA (& Ramsar) Firth of Tay and Eden Estuary SPA (& Ramsar) Montrose Basin Ramsar (Dun's dish component only)	Carsebreak and Rhynd Lochs SSSI Loch of Lintrathen SSSI Loch of Kinnordy SSSI Loch Leven SSSI Inner Tay Estuary SSSI Hare Myre, Monk Myre and Stormont Loch SSSI Lochs Clunie and Marlee SSSI Meikleour Area SSSI Drummond Lochs SSSI Lochs Clunie and Marlee SSSI Lochs of Butterstone, Craiglush and Lowes SSSI
Pink footed goose (NB)	Firth of Tay and Eden Estuary SPA (& Ramsar) Loch Leven SPA (& Ramsar) Loch of Kinnordy SPA (& Ramsar) South Tayside Goose Roosts SPA (& Ramsar) Montrose Basin Ramsar (Dun's dish component only)	Inner Tay Estuary SSSI Loch Leven SSSI Loch of Kinnordy SSSI Carsebreak and Rhynd Lochs SSSI Dupplin Lakes SSSI
Whooper swan (NB)	Loch Leven SPA	Loch Leven SSSI
Breeding bird assemblage		Black Wood of Rannoch SSSI Cairngorms SSSI Dunalastair Reservoir SSSI Dun's Dish SSSI Dupplin Lakes SSSI Eastern Cairngorms SSSI Forest of Clunie SSSI Inner Tay Estuary SSSI

		Knapdale Woods SSSI Lindores Loch SSSI Loch Leven SSSI Loch of Kinnordy SSSI Lochs of Butterstone, Craiglush and Lowes SSSI Moine Mhor SSSI Shingle Islands SSSI

4.7.3 Assessment of likely effects on bird species of conservation importance in the policy area

Each of the bird species identified in Table 4.7.2 above are discussed in turn below in the context of those effects (positive or negative) that have been identified as a result of beaver activity. Where this relates to a species included in the Habitats Regulation Appraisal of the policy, a summary of the advice from SNH, provided to inform an appropriate assessment (AA) of the policy with respect to SPA sites (see Annex 2 for the full advice) has been used (referred to hereafter as 'SNH HRA advice'). For the purpose of this assessment, the concluding points of the SNH HRA advice have been replicated where appropriate for each species. Assessment of other bird species (i.e. SSSI notified features), has been made in the context of the SNH HRA advice in combination with knowledge of the individual sites and their condition. For completeness, Ramsar sites have also been included, assessment of which is considered analogous with the SPA. Where mitigation or monitoring maybe appropriate, this has been identified in the narrative. Further discussion relating to the management of beavers including mitigation and monitoring options is provided in section 5 and 7 respectively.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

Beaver opportunities
As summarised above, beaver activity has the potential to create positive effects. More than this, the presence of beavers may act as an incentive for greater investment, management and monitoring. This could those related to the restoration and management of riparian woodland and wetlands, which would benefit a range of bird species.

4.7.3.1 Consideration of potential positive effects on bird species of conservation importance

The impact of beaver activity on the bird species discussed below is considered to be either positive or neutral. Where there is considered to be a negative effect or the potential for a negative effect, these are discussed in the following section, see 4.7.3.2. A more general discussion is provided first, followed by a more species / site-based assessment.

Those bird species that utilise woodland for breeding foraging and shelter may benefit from beaver felling activity. These can be summarised as:

- A more open woodland canopy improves foraging habitat for small insectivorous birds, e.g. tree pipit.
- Beaver-coppiced riparian woodland is likely to benefit many small insectivorous species, e.g. warblers.

- Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat heterogeneity and patchiness through the creation of canopy gaps, etc.
- Standing deadwood may provide increased nesting and feeding opportunities for woodpeckers, nuthatches and raptors.

Those bird species that utilise standing freshwater and wetland habitats for breeding and foraging may benefit from beaver damming activity and herbivory. These can be summarised as:

- The creation of pond habitat will boost prey abundance for many bird species.
- The creation of new riparian wetland will boost prey abundance for many bird species.
- Evidence from North America of an increase in diversity and number of grassland bird species on beaver meadows
- Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat heterogeneity and patchiness, with lentic and associated wetland habitat interspersed with lotic habitat.
- Lodges provide additional secure nesting and resting places for a variety of bird species.

BLACK THROATED DIVER

Scotland's fresh water environments are diverse, extensive, and typically have a high water quality. It's therefore no surprise that they support a wide range of bird species. The shores of nutrient-poor upland lochs are breeding sites for black-throated diver.

Within Britain, which is the extreme oceanic edge of its range, it is restricted to western and northern Scotland (although not including Orkney and Shetland). The main concentrations are centred within Sutherland, Wester Ross and the Outer Hebrides with breeding birds becoming scarcer southwards into Perthshire and Argyll as far south as Dumfries and Galloway. In the absence of ringing, it is not known where British breeding divers spend the winter.

Breeding habitat in Britain is normally large oligotrophic lochs amongst mountains, on open moorland or in lightly forested area. Breeding lochs, usually with large islets, have highly indented shorelines and support a typical aquatic vegetation where the emergent and edge species are mainly *Carex* spp. and *Juncus* spp. All breeding and feeding activities are normally carried out on these lochs or their immediate satellites; salt water is rarely used outside passage and wintering periods.

Knapdale

- Knapdale Lochs SPA
- Knapdale Lochs SSSI

Tayside

- Rannoch Lochs SPA
- Rannoch Lochs SSSI

See section 4.7.3.2 below with respect to Knapdale Lochs SPA and SSSI.

Rannoch Lochs SPA / SSSI
HRA Advice
For three of the lochs (Ossian, Laidon and Ba) the size of the loch and their major out flows are so large that beaver dams couldn't affect the water levels within the loch. None of the remaining 5 smaller lochs have areas of potential core beaver woodland on their shores or along their outflow burns. Colonisation of these lochs within the next 10 years is extremely improbable despite their inclusion in this appraisal due to both their distance from existing beaver locations and the nature of their habitat i.e. that of oligotrophic lochs with little available foraging resource for beavers.

The only physical impact the beavers would have on the lochs would be by raising the water level but this would not affect the divers if it remained stable. The lochs are mostly oligotrophic hill lochs and contain few macrophytes and are unlikely to be colonised by beavers during the next 10 years.

SNH HRA advice concluded that it can be ascertained that there is no adverse effect on site integrity of the Rannoch Lochs SPA as at present, and in the foreseeable future, because of the very low percentage of woodland cover in the catchment of the Rannoch Moor lochs (c. 2%), the harsh climate, and exposed nature of Rannoch Moor, meaning beavers are not expected to colonise the area. Therefore there will be no adverse effect on site integrity. In addition what woodland is present is adjacent to Loch Ossian and Loch Laidon: both of which are sufficiently large that beavers will not be able to raise the water level during a single diver breeding season.

SSSI Assessment
Impacts to Black throated diver in Rannoch Lochs SSSI are likely to be similar to those described above for the Rannoch Lochs SPA. While there are natural heritage interests of national importance on this site, these are unlikely to be affected by beaver activity.

Mitigation
No mitigation identified.

SCOTTISH CROSSBILL
The Scottish Crossbill is globally endemic to the UK, where it occurs in the northern and eastern Highlands of Scotland. It is a species associated with remnant native Scots Pine *Pinus sylvestris* forests, and plantations of Scots Pine and other conifers. Breeding distribution is limited by suitable food supply, the main food being Scots Pine seeds.

Knapdale
There are no sites designated in the Knapdale beaver policy area for Scottish crossbill.

Tayside
- Ballochbuie SPA
- Cairngorms SPA
- Creag Clunie and the Lion's Face SSSI

HRA Advice
Beaver activity may result in small areas of suitable habitat being lost within the SPAs. However, pine trees are known to grow in some wet habitats, e.g. bog woodland, within the Caledonian forest. Alteration of the woodlands to wetter types would not therefore result in complete loss of habitat for Scottish crossbill as the Scots pines are a key tree species in bog woodland. As noted in section 4.2 (Beavers and Woodlands) beaver also generally avoid felling pine trees, and other tree species form only a tiny component of bog woodland, therefore the extent of any loss of crossbill habitat will be very small.

SNH HRA advice concluded that, due to the ecological characteristics of the qualifier and the scale, nature and degree of potential impacts by beavers, there will be no adverse effect on the integrity of the Ballochbuie and Cairngorms SPAs.

SSSI Assessment
Impacts to Scottish crossbill in Creag Clunie and the Lion's Face SSSI are likely to be similar to those described above for the two above mentioned SPA. While there are natural heritage interests of national importance on this site, these are unlikely to be adversely affected by beaver activity.

Mitigation
No mitigation identified.

GEESE & SWANS

Each of the two geese and one swan species identified in Table 4.7.2 above are grouped together and discussed below.

GREYLAG GOOSE
Greylag Geese have a Palearctic distribution extending from Iceland in the west, discontinuously through Europe and central Asia to the Pacific shores of Russia). Two sub-species have been described, both of which occur in Europe, of which the nominate form occurs in west and north-west Europe, including the UK.

A number of distinct biogeographic populations of the nominate sub-species are recognised. Birds from the Icelandic breeding population of Greylag Goose winter exclusively in Great Britain and Ireland, most winter in Scotland, with concentrations in the Moray Firth, Aberdeenshire, eastern central Scotland, the central Southern Uplands and southwest Scotland.

PINK FOOTED GOOSE
The breeding areas of the monotypic Pink-footed Goose are globally restricted to eastern Greenland, Iceland and Svalbard. The geese migrate to winter in the countries surrounding the North Sea, meaning that the entire world population winters in just a few European countries. There are two biogeographical populations: those that breed in east Greenland and Iceland migrate to spend the winter months in Britain and Ireland, and those that breed in Svalbard that winter in the Netherlands, Denmark and Belgium. There is no mixing between these two populations which are separated throughout the year.

Most British-wintering Pink-footed Geese occur around estuaries between eastern Scotland and North Norfolk/The Wash. Up to three-quarters of Britain’s wintering Pink-footed Geese are found in Scotland, with strongholds in Aberdeenshire, Perth, Kinross, Stirlingshire, the Lothians, and, in late winter, the Dumfries coast of the Solway.

WHOOPER SWAN
The Whooper Swan is monotypic and has a Palearctic breeding distribution between 55oN and 70oN, from Iceland to the Bering Sea. They winter south to western Europe, the Black Sea, the Caspian Sea, central China and Japan. In the UK, most non-breeding Whooper Swans occur in northern Britain and Northern Ireland. Ringing recoveries indicate that the majority of these birds originate from the Icelandic breeding stock.

Knapdale
There are no sites designated for greylag or pink-footed goose or whooper swan located within the Knapdale beaver policy area.

Tayside

PINK FOOTED GOOSE

- Firth of Tay and Eden Estuary SPA (& Ramsar)
- Loch Leven SPA (& Ramsar)
- Loch of Kinnordy SPA (& Ramsar)
- South Tayside Goose Roosts SPA (& Ramsar)
- Montrose Basin Ramsar (Dun's dish component only)
- Inner Tay Estuary SSSI
- Loch Leven SSSI
- Loch of Kinnordy SSSI
- Carsebreak and Rhynd Lochs SSSI
- Dupplin Lakes SSSI

GREYLAG GOOSE

- South Tayside Goose Roosts SPA (& Ramsar)
- Loch of Lintrathen SPA (& Ramsar)
- Loch of Kinnordy SPA (& Ramsar)
- Firth of Tay and Eden Estuary SPA (& Ramsar)
- Montrose Basin Ramsar (Dun's dish component only)
- Carsebreak and Rhynd Lochs SSSI
- Loch of Lintrathen SSSI
- Loch of Kinnordy SSSI
- Loch Leven SSSI
- Inner Tay Estuary SSSI
- Hare Myre, Monk Myre and Stormont Loch SSSI
- Lochs Clunie and Marlee SSSI
- Meikleour Area SSSI
- Drummond Lochs SSSI
- Lochs Clunie and Marlee SSSI
- Lochs of Butterstone, Craiglush and Lowes SSSI

WHOOPER SWAN

- Loch Leven SPA
- Loch Leven SSSI

HRA Advice

The Greylag geese which are qualifiers of SPAs tend to be in unfavourable condition because most of the Icelandic Greylags now winter to the north west of a line roughly from Bute to Aberdeen – mostly in Orkney & Caithness. The Pink-footed goose SPAs are in favourable condition because of the large increases in the Greenland / Iceland populations of these geese. Whooper swan populations in the UK are also increasing according to the International Surveys in 2010 and 2015.

Most of the Greylag, Pink-footed geese, and Whooper swans roosting on the inland SPAs are feeding on agricultural land, and importantly the availability of feeding areas is not considered to be a limiting factor on their populations. A recent paper in 'Ambio' states:

"*Continental scale spatial and temporal shifts among geese undergoing spring fattening confirm their flexibility to respond rapidly to broad scale changes in agriculture. These dramatic changes support the hypothesis that use of agricultural landscapes has contributed to elevated reproductive success and that European and North American farmland currently provides unrestricted winter carrying capacity for goose populations formerly limited by wetlands habitats prior to the agrarian revolution of the last century*".

SNH HRA advice concluded that it can be ascertained that there is no adverse effect on site integrity of the SPAs listed for greylag and pink-footed goose or whooper swan. This is due to the evidence that the availability of feeding areas is not a limiting factor in the populations of the qualifying geese, as well as the evidence for increasing Whooper swan populations in the UK. This evidence provides the basis for the advice that any minor, temporary reductions in extent of supporting habitat in the areas surrounding the five SPAs that may occur from flooding due to beavers will not have an AESI on them.

SSSI Assessment
Impacts to greylag and pink-footed goose and whooper swan features of the above mentioned SSSIs are likely to be similar to those described above for the aforementioned SPAs. While there are natural heritage interests of national importance on these sites, these are unlikely to be affected by beaver activity.

Mitigation
No mitigation identified.

BREEDING BIRD ASSEMBLAGE
There are a number of sites within the beaver policy area that overlap with core beaver woodland designated for their breeding bird assemblage feature. This means the number of bird species recorded breeding across all the habitat(s) distributed within the site is significantly high to warrant special designation. For the purpose of this assessment only those species that utilise the woodland or standing freshwater / wetland habitats are considered.
Typical species of each breeding bird assemblage will depend on the woodland habitat type on site and may include those associated with the woodland edge and integral open habitat within the woodland, and so will generally include passerines (perching birds) such as those belonging to the following families: thrushes, flycatchers, tits and finches. Non-passerines may include bird species belonging to the following families: pigeons, owls, cuckoos, woodpeckers, falcons and hawks. Whilst those species more associated with standing freshwater or wetland habitats includes birds belonging to the following families: grebes, herons, wildfowl, kingfishers, rails. Impacts to relevant diver, geese and swan species are dealt with elsewhere as is Scottish crossbill.

Knapdale
- Knapdale Woods SSSI

Tayside

- Black Wood of Rannoch SSSI
- Cairngorms SSSI
- Dunalastair Reservoir SSSI
- Dun's Dish SSSI
- Dupplin Lakes SSSI
- Eastern Cairngorms SSSI
- Forest of Clunie SSSI
- Inner Tay Estuary SSSI
- Lindores Loch SSSI
- Loch Leven SSSI
- Loch of Kinnordy SSSI
- Lochs of Butterstone Craiglush and Lowes SSSI
- Moine Mhor SSSI
- Shingle Islands SSSI

SSSI assessment
As described above, the evidence for effects of beavers on birds in Scotland is extremely limited. However, given that beavers are known to create diverse habitats rich in structural complexity. It would be expected that their presence would result in greater avian diversity than may be expected from the existing remnant riparian habitats in Scotland.

Specifically, the increase in amount of standing deadwood, for example, is likely to improve the avian diversity of the riparian zone. If deer grazing is controlled, the increased structural diversity resulting from the cyclical copping and regrowth of riparian trees is likely to open niches for species not found in mature closed canopy woodland, e.g. tree pipits. The increased shrub layer resulting from regeneration of three stools will also create habitat for a range of insectivorous songbirds particularly warblers. Inundation of woodland, leading to the death of standing trees, would also create feeding and nesting opportunities for a range of bird species including raptors, and deadwood feeders such as woodpeckers and nuthatch. Examples of scarcer native species that may benefit include marsh harrier and bearded tit which currently have populations within the sites identified above. Woodcook may benefit from use of areas of damp woodland and beaver ponds; osprey may benefit from an increase in the number of 'drowned' trees surrounding by wetland, providing potential nest sites and kingfishers may benefit from an increase in suitable slow moving freshwater habitat.

Studies at Knapdale (SBT) have shown that beavers create woodland with a more open canopy and a more diverse field layer. If deer grazing is controlled, regrowth from gnawed stumps should also increase the shrub layer. This is a similar effect to coppicing, a management technique that has been shown to be beneficial to a range of declining woodland bird species in England. Dam creation at Dubh Loch has also increased the shallow water habitats available for nesting and feeding birds. Despite the lack of specific bird monitoring at Knapdale, it would appears that beavers have increased the diversity of the woodland structure and the amount of wetland habitats available for birds.

Therefore while there are natural heritage interests of national importance on these aforementioned sites, these are unlikely to be adversely affected by beaver activity.

Mitigation
No specific mitigation identified.

4.7.3.2 Consideration of potential negative effects on bird species of ecological and conservation importance

The impact of beaver activity on the bird species discussed below is considered to have a negative effect or have the potential for a negative effect.

BLACK THROATED DIVER
Scotland's fresh water environments are diverse, extensive, and typically have a high water quality. It's therefore no surprise that they support a wide range of bird species. The shores of nutrient-poor upland lochs are breeding sites for black-throated diver.

Within Britain, which is the extreme oceanic edge of its range, it is restricted to western and northern Scotland (although not including Orkney and Shetland). The main concentrations are centred within Sutherland, Wester Ross and the Outer Hebrides with breeding birds becoming scarcer southwards into Perthshire and Argyll as far south as Dumfries and Galloway. In the absence of ringing, it is not known where British breeding divers spend the winter.

Breeding habitat in Britain is normally large oligotrophic lochs amongst mountains, on open moorland or in lightly forested area. Breeding lochs, usually with large islets, have highly indented shorelines and support a typical aquatic vegetation where the emergent and edge species are mainly *Carex* spp. and *Juncus* spp. All breeding and feeding activities are normally carried out on these lochs or their immediate satellites; salt water is rarely used outside passage and wintering periods.

Knapdale
- Knapdale Lochs SPA
- Knapdale Lochs SSSI

Tayside
- Rannoch Lochs SPA
- Rannoch Lochs SSSI

See section 4.7.3.1 above with respect to Rannoch Lochs SPA and SSSI.

Knapdale Lochs SPA / SSSI
HRA Advice
Although all the lochs in the SPA are in catchments that contain potential beaver woodland only one has any of this type of woodland within 1km. Loch Fuar-Bheinne has potential beaver woodland approximately 900m downstream of its outflow. The likelihood of beavers colonising the SPA lochs would appear to be low but this assessment is based on the assumption that it is possible.

The site supports four pairs of breeding divers. Dam building in the outflow burns from the nesting lochs during the breeding season could cause changes in water levels that might flood nests with eggs or prevent adults brooding young. This would only occur if the birds nested on the shore. Beavers could have a direct impact if dam building took place during the nesting period. A dam established before breeding and which maintained a near constant water level would not have an impact. An increase in water level is unlikely to have an adverse impact on divers through indirect impacts to fish prey. Under natural conditions fluctuations occur both during, and outwith the breeding season. One loch in the SPA is used as a water supply for the Crinan Canal by Scottish Canals and to avoid impacts on the SPA water is only taken from this loch outwith the diver breeding season. If damming was prevented during the crucial part of the breeding season then there would be no adverse impact from beavers on the SPA lochs.

The birds will use the lochs in the SPA, and attempt to nest, irrespective of fluctuations in water level. The damming of an outflow burn on any particular loch will not affect the distribution of birds in the site. However their breeding distribution in the site would be affected as would the overall breeding success of the site. Therefore, as above, if damming was prevented during the key part of the breeding season would be no direct adverse impact from beavers.

SNH HRA advice concluded that it can be ascertained that there is no adverse effect on site integrity if the proposal is undertaken strictly in accordance with the following conditions.

SSSI Assessment
Impacts to Black throated diver in Knapdale Lochs SSSI are likely to be similar to those described above for the Knapdale Lochs SPA. There is therefore potential for beaver activity to adversely affect the natural heritage interest of national importance. See mitigation below.

Mitigation

No dam building by beavers in outflow burns of the SPA will be permitted during the period April to July inclusive. Any dams being built during that period should be removed without disturbance to the divers. If divers are breeding on the lochs within the SPA in any year then checking for beaver dams must be carried out without any disturbance to the breeding birds. Black-throated diver is listed on Schedule 1 of the Wildlife & Countryside Act 1981, as amended.

4.8 Beavers and other mammals

4.8.1 How beaver activity affects other mammals

Beaver activity may influence the local distribution and abundance of other mammal species in a number of ways, some of which may have a positive and some a negative effect on mammal species. In some instances these affects can be attributed entirely to the activity of beavers themselves. Some may be magnified when considered in-combination with the effect of other receptors. A summary (see Table 4.8.1) of these positive and negative effects of beaver activity on other mammals is presented at the end of this section. The main mechanisms are:

- By creating new areas of open water and associated wetland rich in aquatic plants, fish, amphibians and invertebrates, beavers can increase the availability of food for other mammal species. Many species that occur in Scotland, such as bats, water vole *Arvicola amphibius* and Eurasian otter *Lutra lutra* are likely to benefit from the creation of these new wetlands.
- Through effects on some invasive non-native mammals, notably American mink *Neovison vison*, which are also likely to benefit. However, there is evidence from Patagonia and Russia of American mink avoiding beavers, so the assumed habitat benefits to mink may potentially be cancelled out, at least to some extent, by such behaviour.
- Through the construction of lodges and the creation of burrow systems in riverbanks, beavers can create additional secure dens and resting places for other mammal species. Again, there are perceived benefits and disadvantages, as both native species, such as otter, and non-native American mink may utilise these structures, although how mink respond to the presence of beavers is not clear.
- By creating newly coppiced riparian woodland, the resultant opening of the woodland canopy is likely to be beneficial to some species, such as bats. However, the regrowth is also likely to attract herbivores, such as deer, which, if browsing rates are excessive, may ultimately inhibit the regeneration capacity of the affected woodland (see section 4.2.1. of this report).
- By creating channels through dense emergent vegetation (reed beds, etc.), beavers can potentially increase the permeability of these habitats to other mammal species. This could have both positive and negative effects. For example, there is evidence from England that water voles and American mink, which rarely coexist, can do so in dense reed beds as the mink tend to occupy the main water channels while the water voles occur in the more densely vegetated areas.

A recent review identified 35 published studies investigating the impact of beavers on terrestrial mammal diversity and abundance. Twenty-five of these studies suggested that terrestrial mammal species interact with beavers, either as predators or by making use of beaver ponds and other beaver-created habitat, but did not make a comparison with where beavers were absent. The remaining 10 studies investigated the differences between areas affected by beavers and areas where there was no impact from beavers. Beaver activity was found to have a positive effect on the abundance of a mammal species, or overall mammal diversity, in half of these studies, and no difference in the other half. No study found a negative impact of beavers on mammal diversity or abundance.

4.8.1.1 *Beavers and bats*

Four of the studies focused on bats, with two finding a positive impact of beaver activity. One Finnish study showed that ponds created by beavers supported a higher abundance of bats than other ponds. Bats are thought to benefit from beaver activity because of an increase in prey abundance and availability, and improved foraging habitat due to the creation of more gaps in the forest canopy.

In a Polish study, four species of bat that also occur in Scotland – the widespread and abundant common pipistrelle *Pipistrellus pipistrellus* and soprano pipistrelle *P. pygmaeus* and the much rarer noctule *Nyctalus noctula* and Nathusius' pipistrelle *P. nathusii* – were all positively affected by beaver activity. No impact of beavers on Daubenton's bats *Myotis daubentonii* was found, which is unexpected given that this species is particularly associated with water and frequently catches its insect prey directly off the water surface. In this case, the lack of any effect of beavers may have been due to a layer of duckweed impeding hunting on some of the beaver ponds in the study. However, the effect of beavers on Daubenton's bats may be either positive or neutral depending on the characteristics of the open water habitat created, and indeed an increased abundance of this species was found following beaver impoundment in another study. Beaver impoundments that result in waterbodies characterised by a smooth, uncluttered surface might be expected to benefit Daubenton's bats, as these provide an ideal foraging environment. When ponds created by beavers develop further to form beaver meadows, any benefit for Daubenton's bats seems to be lost.

Bats may also make use of beaver habitat in other ways, for instance by roosting under the exfoliating bark from trees killed by beaver flooding.

4.8.1.2 *Beavers and otters*

Otters are likely to benefit from beaver activity. Beavers increase the amount of aquatic habitat, and hence increase suitable otter habitat. The ponds formed are often rich in otter prey species such as fish, amphibians and invertebrates. Abandoned beaver lodges and bank dens may also provide important shelter for otters. Beaver-created habitat is an important predictor of North American river otter distribution.

While the majority of the literature focuses on the North American river otter, a number of reports also describe the benefit beavers have on Eurasian otter. As the positive mechanisms are associated with pond creation and the creation of shelter for resting sites, similar effects are expected for both species.

The Danish trial reintroduction of beaver to Klosterheden State Forest included an assessment of the effect on the resident otter population. No negative effects were observed on the otter population. The number of locations with evidence of otter presence has increased throughout the catchment following beaver reintroduction. After the beavers were released at the site, otter was put forward as a Habitats Directive Annex II interest at the SAC at Klosterheden, and it is the view of the Danish Forest and Nature Agency that the otter interest can be maintained in the presence of beavers.

4.8.1.3 *Beavers and water vole*

Beaver pond creation and herbivory has the potential to have a large positive influence on water voles in the absence of American mink. The water vole has experienced a dramatic population decline across Britain, particularly in the latter part of the twentieth century. Reintroducing beavers would create and improve habitat for water voles, which have a strong preference for slow-moving water with abundant aquatic, emergent and herbaceous bankside vegetation; all features that are characteristic of beaver ponds. A key management technique used to improve water vole habitat is thinning woody riparian vegetation, an effect beavers can also create. Evidence for a positive relationship may come from the muskrat *Ondatra zibethicus*, which is ecologically similar and seems to derive benefit from beaver-influenced habitat.

4.8.1.4 Beavers and non-native invasive species (American mink)

Beavers may influence local America mink *Neovision vison* activity, as mink are known to use beaver lodges as den sites and beaver ponds for foraging elsewhere in Europe and in North America. The highest densities of mink (and otters) occur in productive coastal habitats, and therefore the potential for interaction with beavers may be limited.

Table 4.8.1: Summary of potential interactions between beavers and other mammals.

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• A more open woodland canopy improves foraging habitat for bats • Increased light levels at water's edge may improve water vole habitat • Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat heterogeneity and patchiness through the creation of canopy gaps, etc.		Water vole populations are expected to respond to improved habitat conditions only where American mink are controlled
Felling	Change in riparian woodland: Change in age classes of trees	• Coppiced riparian woodland is likely to benefit many species • Regrowth is likely to attract herbivores such as deer	• Regrowth may be restricted where deer numbers are high	
Felling	Change in riparian woodland: Amount/diversity of fallen dead wood on woodland floor	• Uncertain, but may be beneficial impacts on prey species		
Felling and constructions	Changes in amount/diversity of woody material in	• Uncertain, but may be beneficial impacts on prey species, e.g. fish for otter		

	watercourses			
Dams/pond creation	Change from lotic to lentic habitat	• Overall positive effects on diversity at landscape scale since beaver activity markedly increases habitat heterogeneity and patchiness, with lentic and associated wetland habitat interspersed with lotic habitat • The creation of pond habitat will boost prey abundance for many bat species and otter	• Non-native American mink may benefit from new pond creation	The water shrew may be influenced; however, it occupies both lentic and lotic habitats and the effects are unknown
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• The creation of new riparian wetland will boost prey abundance for many bat species and otter	• Non-native American mink may benefit from new wetland creation	
Dams/pond creation	Changes in water quality downstream	• Uncertain, but may be beneficial impacts on prey species, e.g. fish for otter		
Dams/pond creation	Change in standing dead wood resulting from inundation of trees	• May provide roosting opportunities for bats		
Dams/pond creation	Impacts on movement of species		• Beaver dams may sometimes have adverse impacts on migratory fish species, with consequent localised impacts on otter	See Table 3.14 for effects of beavers on fish

Other constructions	Creation of lodges, burrows, canals etc.	• Burrows and lodges will provide additional secure dens and resting places for a variety of mammal species	• Non-native mink may utilise these structures • Foraging trails increase accessibility to dense habitats used as cover, such as reed beds, potentially increasing predation	
Other		• Beavers (especially juveniles) may be a prey species for a variety of predators		
Indirect habitat creation/restoration initiatives as result of beaver presence	Beaver used to promote opportunities for riparian and freshwater habitat creation/restoration	• Presence of beavers may act as an incentive for greater investment, management and monitoring. This could include those related to the restoration and management of riparian woodland, which would benefit a range of mammal species, e.g. otter, water vole, bats, red squirrel		

4.8.2 Distribution of mammals in the policy area

The following section concentrates on those mammal species of conservation importance that are likely to overlap with core beaver habitat and as such maybe positively or negatively affected by beaver activity.

4.8.2.1 Mammal species of conservation importance

To determine whether the activity of beavers on (native) mammal species is significant in the context of this Strategic Environmental Assessment, the assessment of impacts (positive and negative) has focussed on those species for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded European or national protection wherever they occur.

In addition, the invasive non-native species, American mink *Neovision vision* has also been included in this section because of its overlap in some of its habitat and foraging requirements. Moreover many of the potential positive effects of beaver activity for mammal species of conservation concern are often in the absence of predation by mink.

Table 4.8.2 below therefore identifies those mammal species of conservation importance that utilise 'potential beaver core habitat' (as described in section 4.2. of this report) and are found within the beaver policy area. Red squirrel, has not been included as any impact from beaver felling activity is expected to be negligible.

Table 4.8.2: Summary of mammal species of conservation importance within the beaver policy area that overlap with potential beaver core habitat

Mammal species	Conservation importance
European otter	European Protected Species <u>Qualifying feature of the following SACs</u>: Ballochbuie SAC Cairngorms SAC Dunkeld-Blairgowrie Lochs SAC Loch Lomond Woods SAC Moine Mhor SAC Rannoch Moor SAC River Dee SAC River Spey SAC River Tay SAC Taynish & Knapdale Woods SAC Tayvallich Juniper & Coast SAC <u>Notified feature of SSSI:</u> River Spey SSSI
Bat species	European Protected Species
Water vole	Schedule 5 of the Wildlife & Countryside Act 1981 (as amended)
American Mink	Invasive non-native species

4.8.3 Assessment of likely effects on mammal species of conservation importance in the beaver policy area

Each of the species identified in Table 4.8.2 above is discussed in turn below in the context of those effects (positive or negative) that have been identified as a result of beaver activity.

Where this relates to a species included in the Habitats Regulation Appraisal of the policy, a summary of the advice from SNH that has been provided to inform an appropriate assessment (AA) of the policy with respect to SAC sites (see Annex 2 for the full advice) has been used (referred to hereafter as 'SNH HRA advice') . For the purpose of this assessment, the concluding points of the SNH HRA advice have been replicated where appropriate. Assessment of other sites (i.e. SSSI notified features), has been made in the context of the SNH HRA advice in combination with knowledge of the individual sites and their condition. Where mitigation or monitoring maybe appropriate, this has been identified in the narrative. Further discussion relating to the management of beavers including mitigation and monitoring options is provided in section 5 and 7 respectively.

Where a species is afforded protection as a European Protected Species through the Habitats Regulation 1994, consideration is given as to the policy impact on the favourable conservation status of the population of the species in its natural range.

Where mitigation or monitoring maybe appropriate, this has been identified in the narrative, with further discussion provided in section 5 and 7 of this report.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

Beaver opportunities
As mentioned above beaver activity has the potential to create many positive effects for a variety of native mammal species such as habitat creation or improvement with resulting benefits for prey abundance or foraging habitat. The presence of beavers could therefore act as an incentive for greater investment, management and monitoring. This could include those related to the restoration and management of riparian woodland, which would benefit a range of mammal species, including otter, water vole and bats.

4.8.3.1 Consideration of potential positive effects on mammal species of conservation importance

The impact of beaver activity on the mammal species discussed below is considered to be either positive or neutral. Where there is considered to be a negative effect or the potential for a negative effect, these are discussed in the following section, see 4.8.3.2.

EUROPEAN OTTER
Otters are land mammals, but they spend a considerable amount of time in water. They can be found in both freshwater (such as rivers and lochs) as well as in the sea.

Otters live in holts, for example burrows, natural holes, caves or other structures (including man-made ones) that are used for shelter or for breeding. They can also use other structures to rest in or take temporary shelter, for example couches

A number of positive and negative effects have been identified for otter. Potential positive effects are anticipated to include:

- The creation of pond habitat will boost prey abundance for otter
- The creation of new riparian wetland will boost prey abundance for otter
- Burrows and lodges will provide additional secure dens and resting places for a variety of mammal species

Knapdale

- Moine Mhor SAC
- Taynish & Knapdale SAC
- Tayvallich Juniper and Coast SAC

Tayside

- Ballochbuie SAC
- Cairngorms SAC
- Dunkeld-Blairgowrie Lochs SAC
- Loch Lomond Woods SAC
- Rannoch Moor SAC
- River Dee SAC
- River Spey SAC
- River Tay SAC

Knapdale

Beaver activity in Knapdale can be expected to lead to the creation of further areas of wetland that will provide additional foraging resource for otters and (other species) reliant on wetland and riparian habitats. The extent to which this extra resource will actually benefit otters is difficult to judge, as the habitat in the SBT release area and nearby coast is already excellent for otters. The coast is likely to remain the focus for much of the otter foraging activity in the area. Should beavers expand north of the Crinan Canal into the River Add catchment, more tangible benefits to otters can be expected, as the SBT monitoring indicated that otter activity in this area was consistently less than in Knapdale with its more varied habitats.

Beaver activity can be expected to lead to the creation of additional otter holts and lie-ups (and dens for other species including the non-native mink, see below) in the form of disused and abandoned lodges and bankside burrows. It is unclear whether these extra places of shelter would actually influence the population density of territorial species at Knapdale. In the case of otters, for example, food supply is more likely to limit population density than the availability of holt sites or lie-ups.

Beaver activity can be expected to result in local increases in amphibian populations, which will benefit otters. Frogs and toads are important seasonal prey items for otters, notably at breeding ponds in the early spring. Fish form a significant component of otter diet, and fish surveys undertaken at Knapdale during the trial period found no significant change in the species composition or the number of fish found at sites where beavers have become active. Should further beaver releases take place in Knapdale, ongoing monitoring of the fish population would be recommended.

Tayside

In Tayside, further expansion of the beaver population is anticipated as the species colonises the remaining parts of the catchment where suitable habitat exists. Many habitats and species are expected to benefit, as noted above for the Knapdale area, with positive or neutral effects on native mammals, as summarized in Table 4.8.2 above.

European Protected Species

Otter are classed as European Protected Species, and are fully protected under The Habitats Regulations 1994 (as amended in Scotland).

While this assessment has identified the potential for some localised negative effects on otters, which are discussed in section 4.8.3.2 below, it is anticipated that the potential impacts from the policy will not be detrimental to the maintenance of the population of the species (otter) concerned at Favourable Conservation Status in their natural range.

BATS

There are at least ten species of bat to be found in Scotland. The most numerous and familiar of these are common and soprano pipistrelles, which can be seen flitting about near woodland or open water at dusk, in search of midges and other flying insects.

Potential positive effects are anticipated to include

- A more open woodland canopy improves foraging habitat for bats
- The creation of new riparian wetland will boost prey abundance for many bat species

Knapdale & Tayside

Beaver activity in the policy area can be expected to lead to the creation of further areas of wetland that will provide additional foraging resource for certain bat species reliant on wetland and riparian woodland habitats. Evidence from elsewhere in Europe strongly suggests that local bat populations will benefit from the activities of beavers in the area.

European Protected Species

Bats are classed as European Protected Species, and are fully protected under The Habitats Regulations 1994 (as amended in Scotland).

While this assessment has identified the potential for some localised negative effects on bats, which are discussed in section 4.8.3.2 below, it is anticipated that the potential impacts from the policy will not be detrimental to the maintenance of the population of the (bat) species concerned at Favourable Conservation Status in their natural range.

WATER VOLE

Water voles are the largest species of vole found in the UK, so big that they are often mistaken for rats. The water vole is a rare species that has suffered significant declines in population and range in the past. They live in burrows alongside, generally small, watercourses and feed on bankside grasses and sedges.

Potential positive effects are anticipated to include increased light levels at the water's edge which may improve water vole habitat

Knapdale

The water vole was included in the SBT monitoring programme, but no evidence of the species was recorded during the trial. This is not surprising given the unfavourable heavily shaded habitat at many of the locations where the surveys were undertaken, and the autumn and early winter survey period that was employed. A single sighting of a water vole was recorded by the SBT staff on Loch Linne in August 2012, suggesting that this species is present in the area, but at a low density.

Tayside

As noted above that, although habitat for water voles may improve as a result of beaver activity, they are unlikely to thrive if mink are present in the area. Predation by mink has resulted in the extinction of water vole colonies along most river main-stems and major tributaries in Scotland where the species previously occurred. The best populations are now mostly found in upland headwaters and are characterised by slow-flowing small burns meandering through areas underlain by deep peat. Potential beaver woodland habitat is usually absent at these sites.

Coordinated landscape-scale mink control projects, such as the Scottish Mink Initiative, have resulted in an apparent recovery of water voles in some areas which, if colonised by beavers, could allow water voles to realise the anticipated benefits of beaver activity. Overall, the current distributions of mink and water vole across Scotland suggest that there is likely to be a greater degree of overlap between an expanding beaver population and mink than with the more restricted water vole population.

The policy is not expected to results in any offence under the Wildlife and Countryside Act 1982 (as amended) to either of the beaver areas, for which water voles are listed on schedule 5.

4.8.3.2 Consideration of potential negative effects on mammal species of conservation importance

The impact of beaver activity on the mammal species discussed below is considered to have a negative or have the potential for a negative effect.

AMERICAN MINK (NON-NATIVE INVASIVE SPECIES)

American mink *Neovison vison,* a semi-aquatic carnivore, first became established in the wild in Britain in the 1930s. Initially the population developed from animals escaping from fur farms, and throughout the second half of the twentieth century it spread through most of mainland UK. The spread of mink and their continued presence across many part of Scotland acts as a threat to many mammal (and bird) populations.

Beaver activity is likely to lead to an increase in the availability of prey for mink, notably invertebrates, fish and amphibians. However, the apparent avoidance of beaver-modified habitat by mink reported from Patagonia and Russia may potentially occur elsewhere and, if observed in Scotland, could have important implications for the future strategic management of mink in Scotland. Consequently, the interaction between the two species needs to be carefully monitored if further beaver expansion occurs; see section 7.

Assessment

Knapdale

Mink abundance in Knapdale (based on records of scats and footprints on mink-monitoring rafts) appeared to be low, although there is ample evidence from other studies that mink are abundant in coastal habitats in Argyll. The highest densities of mink (and otters) occur in productive coastal habitats, and therefore the potential for interaction with beavers may be limited. Control methods for this non-native invasive species are well established and are already in place at Knapdale and the wider area.

Monitoring

Further monitoring of the mink population would also be recommended, as it is unclear how this species will respond to an increasing beaver population, given the evidence from other parts of the world that suggests mink appear to avoid beaver- modified habitat. Mink monitoring would need to take place in areas where mink are both controlled and not controlled. See section 7 for details on the approach to SCM and beaver which would pick up the threat of this non-native species.

Tayside
Mink are already controlled throughout much of the Tay catchment, but it is unclear how an expanding beaver population might affect this species. If it transpires that mink, in fact, do not avoid beaver-altered sections of watercourses (as suggested by other studies) and actively utilise them, they could conceivably become easier to detect and control. This is because the rafts which form the basis of the Tayside control operation are best placed in still, slack water, such as that created by beaver activity.

Monitoring
Further monitoring of the mink population would also be recommended. See section 7 for details on the approach to SCM and beaver which would pick up the threat of this non-native species.

EUROPEAN OTTER
Otters are land mammals, but they spend a considerable amount of time in water. They can be found in both freshwater (such as rivers and lochs) as well as in the sea.

Otters live in holts, for example burrows, natural holes, caves or other structures (including man-made ones) that are used for shelter or for breeding. They can also use other structures to rest in or take temporary shelter, for example couches

Knapdale
- Moine Mhor SAC
- Taynish & Knapdale SAC
- Tayvallich Juniper and Coast SAC

Tayside
- Ballochbuie SAC
- Cairngorms SAC
- Dunkeld-Blairgowrie Lochs SAC
- Loch Lomond Woods SAC
- Rannoch Moor SAC
- River Dee SAC
- River Spey SAC
- River Tay SAC

SNH HRA assessment
European beaver is a natural component of freshwater ecosystems in Europe, and beaver and otter are often recorded in the same areas. This is reflected by the fact that there are 396 SACs within the EU (within eight Member States) where both beaver and otter are both identified as Annex II SAC interests.

European beavers and otters do not compete directly for resources. The otter is a predatory species, and the beaver is herbivorous. Otter and beaver territories will overlap. There are occasional records of otter predation on beaver.

Information from Europe indicates that the presence of beavers does not appear to be detrimental to otters, and indeed may be beneficial. This is supported by the findings of the monitoring undertaken during the Scottish Beaver Trial. This is believed to be linked to the habitats that are created where beavers have been active, such as ponds, localised wetland areas etc., which are also good quality habitat for otters and otter prey.

However, beaver dams may sometimes have adverse impacts on migratory fish species which are one of the many prey species for otter.

The SNH HRA advice is that if the proposal is undertaken in accordance with the following mitigation condition, then the proposal will not adversely affect the integrity of the these sites.

Mitigation
Where beaver dams are constructed that impede the movement of migratory fish to such a degree that there might be an adverse effect on site integrity via impacts to otter, all appropriate mitigation measures to facilitate fish passage are put in place to avoid this.

Section 5 of this report details those techniques used to mitigate the impact of dam building activity including methods to alleviate the potential for impeding movement of migratory fish, should a situation arise where this is deemed likely.

EPS Assessment
Otter are classed as European Protected Species, and are fully protected under The Habitats Regulations 1994 (as amended in Scotland).

Although this assessment (see above) has identified the potential for some localised negative effects on otter, it is anticipated that the potential impacts from the policy will not be detrimental to the maintenance of the population of the species (otter) concerned at Favourable Conservation Status in their natural range.

BATS
There are ten species of bat to be found in Scotland. The most numerous and familiar of these are common and soprano pipistrelles, which can be seen flitting about near woodland or open water at dusk, in search of midges and other flying insects.

EPS Assessment
Bats are classed as European Protected Species, and are fully protected under The Habitats Regulations 1994 (as amended in Scotland).

Some bat species found in Scotland use trees for roosting either during the summer as maternity roosts to given birth and raise young or to hibernate during the winter. Colony size varies between species, but in Scotland bats are usually found either singly or in small groups in the winter, with slightly larger groups in the summer. There is therefore potential for a beaver to fell a tree (s) within the riparian (core beaver woodland) zone, that contains roosting bats, however the number of individual bats likely to be affected in is considered to be low.

Although this assessment has identified the potential for some localised negative effects on individual bats, it is anticipated that the potential impacts from the policy will not be detrimental to the maintenance of the population of the (bat) species concerned at Favourable Conservation Status in their natural range.

4.9 Beavers and standing freshwater habitats and wetland habitats

This section on standing freshwater habitats includes assessment of aquatic vascular macrophytes and wetland habitats, referred to hereafter as ‘standing freshwater and wetland habitats’.

4.9.1 How beaver activity affects standing freshwater and wetland habitats

4.9.1.1 Effects of dam-building activities on standing freshwater lochs

The effects of beavers on plants have been linked to changes occurring as a consequence of habitat modification. Numerous studies have looked at the ecological effects of beaver dam-building around pond–wetland complexes and on streams. However, there is less information on the effects of beaver activity on larger, more discrete lake environments. Beavers tend not to dam in water bodies more than 0.85 m deep or more than 6 m wide which means that dam-building does not tend to occur within lakes, but it may occur in outflow and inflow streams.

Pond–wetland complexes inhabited by beavers represent a variety of habitats, which exhibit different stages of colonisation by biota, and therefore support a diversity of species. The diversity of plant species present in beaver ponds has been found to increase with time. Beaver activity also increases the number of invertebrate taxa present in ecosystems. Dam-building in stream systems introduces environments that provide habitat for invertebrates associated with standing waters.

The flooding of terrestrial environments results in the creation of wetland habitats adjacent to fully aquatic environments, increasing the number of niches associated with the standing water. Increased plant and invertebrate species richness supports other components of standing water/wetland systems, for example birds, bats, amphibians and fish. Where ponds are formed as a result of dam-building on stream systems, there may be an overall biodiversity gain, and downstream lotic (i.e. running water) habitats may benefit from better water quality with the dams creating sediment traps, although there may also be localised losses in stream biota.

4.9.1.2 Effects of foraging activities on standing freshwater lochs

Research has been carried out on the terrestrial food preferences of beavers, but also on grazing in aquatic habitats. Aquatic plants have been found to constitute a considerable proportion of beaver diet, though the degree of reliance on such plants varies with time of year and differs between sites.

In North America, beavers have been known to have both positive and negative effects on the abundance of invasive plant species. Although much of the literature relates to terrestrial rather than aquatic plants, parrot’s feather *Myriophyllum aquaticum* and *Elodea* pondweeds, which are aquatic invasive non-native species present in Scotland, have been found to be highly preferred food species for beavers elsewhere.

Foraging by beavers affects existing habitat not only through the removal of preferred plant species, but also deposition of harvested plant material. Such material includes food for consumption during winter, but also discarded matter. Food caches are stored in slow moving waters and have been linked with positive effects on biodiversity. Compared with existing sand and gravel substrates, a higher abundance of macroinvertebrates, fish and amphibians has been found to be associated with beaver lodges and wood caches in lakes in Ontario and, in general, woody material is considered beneficial for invertebrates and fish in lakes.

4.9.1.3 Effects of damming and foraging activities on wetland habitats

The effects of dam-building activities by beavers on wetlands will vary depending on the local topography and wetland type. Effects are likely to cover the extent of wetland habitats and species, succession processes and the species composition and diversity of wetland communities. The construction of beaver dams can affect the hydrology, water chemistry, sediment transport patterns and nutrient levels in a number of different ways depending on local circumstances. Reduced flow velocity behind dams can lead to increased sediment deposition. Alternatively, the flooding of adjacent land can lead to an increase in the sediment load. The build-up of woody debris can lead to the formation of braided channels, pools and islands.

Dam building and feeding activities can also lead to changes in nutrient levels in the water and, depending on local conditions, beaver ponds can either act as a source of raised nitrogen and phosphorus levels or as nutrient sinks.

In some places raised water levels may lead to the creation of new wetlands or an expansion of the existing wetland habitats. Elsewhere, the maintenance of raised water levels may lead to a reduction in the extent of some wetland habitats, or a change in the vegetation communities present, in response to changes in the hydrological regime, water chemistry, sediment transport patterns and nutrient levels.

A summary of the potential interactions between beavers and standing waters is presented at the end of this section (see Table 4.9.1); where possible these have been attributed to a neutral, positive or negative effect.

Table 4.9.1: Summary of potential interactions between beavers and standing freshwater and wetland habitats

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• Increased light levels may increase the maximum depth of colonisation by aquatic plants in lochs • Felling/coppicing of trees by beavers could be beneficial to fen flora and fauna by keeping the wetland habitat open		
Felling and construction	Changes in amount/diversity of woody material in watercourses	• Complexity of habitat is likely to increase with an increase in woody material within standing waters • Abundance and diversity of aquatic invertebrates, fish and amphibians may increase as a result of caches, woody debris, etc.	• Woody debris may adversely affect plants in shallow water during strong winds, although this is likely to be a localised and minor effect overall	
Feeding	Feeding on specific terrestrial herbaceous and aquatic plant species	• Selective consumption of edge/emergent plants may lead to colonisation of habitat by submerged species • There is a possibility that some invasive non-native species may be consumed • Clearance of vegetation that is acting as a barrier to water flow may restore flushing rates in standing waters and prevent backing-up and consequent flooding	• Preferential selection of uncommon species, such as saw sedge, may lead to localised losses at individual sites • Negative effects on the area covered by aquatic plants may occur in lochs after a number of years of high occupancy by beavers • Beavers may spread invasive non-native plant species by increasing fragmentation and incorporating plant material in lodges	Consumption of common species, such as bogbean, white water lily, common club-rush and water horsetail, may have localised effects, but neutral effects overall Incidental uprooting of isoetids when beavers are foraging for other species is not likely to have a considerable effect
Dams/pond	Change from lotic to	• Creation of pond-wetland systems	• Localised losses of lotic species	

creation	lentic habitat	may improve the quality of water flowing into lochs, thereby improving the water quality of standing waters • Numbers of invertebrate and plant species are likely to increase with the presence of both lotic and lentic environments, rather than the presence of running water habitat only	where lentic habitat is created are likely • Considerable change in the balance of lotic and lentic species is possible at the catchment scale, if there are high densities of new ponds	
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat and adjacent wetland habitats	• Creation of ponds and wetlands in loch catchment areas may protect lochs from the effects of drought • Hydrological alternations may restore natural connectivity in wetland-loch systems • Creation of ponds and wetlands in loch catchments is likely to increase the number of species present • Water level rise in standing waters would be expected to increase the area of standing water habitat • Water level rise increases the volumes of standing waters, and greater volume may improve the capacity of a loch for dilution of nutrients and phytoplankton • Where the topography is suitable, raised water levels may lead to an expansion of existing wetland habitats or the creation of new ones	• Flooding of terrestrial land upstream/adjacent to lochs may result in deterioration of water quality through decay of vegetation and leaching of nutrients from soils • Flooding of peaty soils may result in an increase in the concentration of humic substances in the water of lochs, thereby causing a decrease in light penetration • With loch water level increases, there is a potential for loss of plant habitat in deeper water because of light limitation • With increasing loch volume, water retention time increases, flushing rate decreases and nutrients and phytoplankton are retained for longer within the loch • Areas of wetland habitat may be lost where water levels are permanently raised and there is no space for expansion into adjacent areas.	Problems resulting from leaching of nutrients from soils are more likely in catchment areas that are fertilised The significance of increasing levels of humic substances or dissolved organic carbon has not been quantified and would be site specific Areas of wetland habitat lost with increasing water depth may not be replaced if new areas of substrate at suitable depths are smaller or are unsuitable for plant growth Volume and flushing rate are variables that

			• Changes in water levels and flooding regimes may lead to change in the wetland type and plant communities present - e.g. leading to transitions from fen vegetation to swamp vegetation. The effects will be dependent on site topography and water levels.	have considerable influence on the effects of nutrient loadings in lochs. Effects of alteration of these factors by beavers are unknown and would be site specific. In effect, reduction in flushing rate may offset increase in volume
Dams/pond creation	Changes in water quality downstream and on adjacent wetlands	• Creation of ponds on inflow waters may lead to improvement in the quality of water in the receiving water body through attenuation of flow, sedimentation of solids and assimilation of nutrients within the ponds	• Creation of ponds on inflow waters may lead to deterioration of water quality of loch inflows through changes in pH, a decrease in dissolved oxygen levels, a build-up of pollutants and disturbance within the ponds • Flooding with impounded river/ loch water onto adjacent wetlands may lead to a loss of those plant communities which are dependent on flushing with base-rich and/or nutrient poor water	Build-up of pollutants within created ponds would be a consequence of upstream land use rather than of beaver activity, so overall the effects of beavers may be neutral/positive
Other				
Indirect habitat creation/restoration initiatives as a result of beaver presence	Beavers used to promote opportunities for riparian, freshwater and wetland habitat creation/restoration	• Restoration of riparian habitat, for example by extending 'buffer zones' along the edges of watercourses, is likely to result in improvements to water quality of standing waters, and therefore to habitat		

4.9.2 Distribution of suitable standing freshwater and wetland habitats in the beaver policy areas

4.9.2.1 Standing freshwater and wetland habitats of conservation importance

To determine whether the activity of beavers on standing freshwater and wetland habitats is significant in the context of this Strategic Environmental Assessment, the assessment of impacts (positive and negative) has focussed on those freshwater sites for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded European or national protection wherever they occur. Many such sites have been identified that overlap with potential core beaver woodland, where possible, these have be grouped according to the dominant habitat type.

Table 4.9.2 shows those standing freshwater habitat types and their respective designated sites identified as overlapping with potential core beaver woodland. Maps of these SAC and SSSI sites are detailed in Appendix 1. Those pertaining to aquatic vascular plants (macrophytes) are given in Table 4.9.3 below and those relating to wetland habitats are given in Table 4.9.4.

Table 4.9.2. Summary of sites that overlap with potential core beaver woodland for standing freshwater habitat features of conservation importance, grouped by main loch habitat types.

Standing freshwater habitat	Designated sites
OLIGOTROPHIC LOCHS	
Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*	Cairngorms SAC Dunkeld - Blairgowrie Lochs SAC Glencoe SAC Rannoch Moor SAC River Tay SAC Taynish and Knapdale Woods SAC
Oligotrophic lochs	Cairngorm Lochs Ramsar Cairngorms SSSI Eastern Cairngorms SSSI Geal and Dubh Lochs SSSI Rannoch Moor SSSI
Oligo-mesotrophic and mesotrophic lochs	Lochs of Butterstone, Craiglush and Lowes SSSI Taynish Woods SSSI Lindores Loch SSSI Loch of Lintrathen SSSI Lochmill Loch SSSI Lochs Clunie and Marlee SSSI Long Loch of Lundie SSSI
Loch trophic range	Stronvar Marshes SSSI Knapdale Woods SSSI
EUTROPHIC LOCHS	
Eutrophic lochs	Loch Leven Ramsar Loch of Kinnordy Ramsar Dun's Dish SSSI Loch Leven SSSI Loch of Kinnordy SSSI Round Loch of Lundie SSSI

Following the approach taken in the HRA (Annex 2), dystrophic lochs also referred to as acid peat-stained lakes and ponds have been screened out of this assessment as there is very little core beaver woodland which overlaps with them.

Table 4.9.3. Summary of sites that overlap with potential core beaver woodland with aquatic vascular plant features of conservation importance

Aquatic vascular plant species	Designated site
Slender naiad *Najas flexilis*	Dunkeld - Blairgowrie Lochs SAC European Protected Species
Pillwort *Pilularia globulifera*	Dalcroy Promontory SSSI

Table 4.9.4. Summary of sites that overlap with potential core beaver woodland with wetland habitats

Wetland habitats	Designated site
Transition mires and quaking bog	Cairngorms SAC, Dunkeld - Blairgowrie Lochs SAC, Rannoch Moor SAC
Alkaline fens	Beinn a' Ghlo SAC Glen Coe SAC Tulach Hill and Glen Fender Meadows SAC Morrone Birkwoods SAC Tullach Hill SSSI
Basin fen	Ardblair and Myreside Fens SSSI Eslie Moss SSSI Lochs of Butterstone, Craiglush and Lowes SSSI Mill Dam SSSI Rescobie and Balgavies Lochs SSSI Restenneth Moss SSSI
Open water transition fen	Dunalastair Reservoir SSSI Dun's Dish SSSI Hare Myre, Monk Myre and Stormont Loch SSSI Kings Myre SSSI Lindores Loch SSSI Loch Lubnaig Marshes SSSI Loch of Kinnordy SSSI Lochs Clunie and Marlee SSSI Lochs of Butterstone, Craiglush and Lowes SSSI Round Loch of Lundie SSSI Stronvar Marshes SSSI
Transition open fen	Loch Tay Marshes SSSI
Flood Plain Fen	Westerton Water Meadow SSSI
Hydromorphological mire range	Carsebreck and Rhynd Lochs SSSI Geal and Dubh Lochs SSSI Loch Leven SSSI Meikleour Area SSSI
Valley fen	Brig o' Turk Mires SSSI Den of Ogil SSSI Rossie Moor SSSI Tayvallich Juniper and Fen SSSI
Spring fen	Forest Muir SSSI Quoigs Meadow SSSI
Spring and flushes: -Springhead rill and flush -Springs (including flushes)	Cairngorms SSSI Glen Fender Meadows SSSI Pass of Leny Flushes SSSI Pitarrig Meadow SSSI Schiehallion SSSI

Ben Heasgarnich SAC has been screened out of the SEA as the wetland features are very much confined to the higher steeper slopes, and considered beyond the reach of beavers.

4.9.3 Assessment of likely effects on standing freshwater and wetland habitats of conservation importance in the beaver policy area

Each of the species and habitat types identified in Tables 4.9.2, 4.9.3 and 4.9.4 above are discussed in turn below in the context of those effects (positive or negative) that have been identified as a result of beaver activity. Where this relates to a habitat included in the Habitats Regulation Appraisal of the policy (i.e. in an SAC), a summary of the advice from SNH, provided to inform an appropriate assessment (AA) of the policy with respect to SAC sites (see Annex 2 for the full advice) has been used (referred to hereafter as 'SNH HRA advice'). For the purpose of this assessment, the concluding points of the SNH HRA advice have been replicated where appropriate for each habitat or species. Assessment of other habitat or species (i.e. SSSI notified features), has been made in the context of the SNH HRA advice in combination with knowledge of the individual standing water and wetland sites and their condition. Where mitigation or monitoring maybe appropriate, this has been identified in the narrative. Further discussion relating to the management of beavers including mitigation and monitoring options is provided in sections 5 and 7 respectively.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

Beaver opportunities
As summarised above, beaver activity has the potential to create positive effects. More than this, the presence of beavers in an area could provide a basis for a riparian woodland restoration programme; by extending 'buffer zones' along the edges of watercourses, for example, improvements to water quality of standing waters, and therefore to habitat is likely to result.

4.9.3.1 Consideration of potential positive effects on standing freshwater and wetland habitats of conservation importance

The impact of beaver activity on standing freshwater and wetland habitats discussed below is considered to have a positive or neutral effect. A more general discussion is provided first, followed by a more species / site-based assessment.

Beavers may have a variety of beneficial effects on standing freshwater and wetland habitats. These are mostly connected with their dam building and foraging habits and the physical, hydrological and chemical changes these can effect.

Dams constructed on influent streams and which lead to the development of ponds may attenuate flows and reduce the pollutant loading of lochs. Ponds and wetland complexes created by beavers may also act as pollutant sinks and buffer against the effects of drought.

Positive effects from dam building activity can lead to, for example, the creation of new habitat, perhaps through changing from running (lotic) to standing (lentic) water systems, or changes to hydrological process downstream of a dam. This can be summarised as:

- Creation of pond-wetland systems may improve the quality of water flowing into lochs, thereby improving the water quality of standing waters
- Numbers of invertebrate and plant species are likely to increase with the presence of both lotic and lentic environments, rather than the presence of running water habitat only

- Creation of ponds and wetlands in loch catchment areas may protect lochs from the effects of drought
- Hydrological alternations may restore natural connectivity in wetland-loch systems
- Creation of ponds and wetlands in loch catchments is likely to increase the number of species present and an expansion of the area of wetland habitat
- Water level rise in standing waters would be expected to increase the area of standing water habitat
- Water level rise increases the volumes of standing waters, and greater volume may improve the capacity of a loch for dilution of nutrients and phytoplankton
- Creation of ponds on inflow waters may lead to improvement in the quality of water in the receiving water body and in connected wetlands through attenuation of flow, sedimentation of solids and assimilation of nutrients within the ponds

Positive effects from foraging activity, either through direct herbivory on aquatic macrophyte or wetland species or indirectly through felling trees can lead to a number of positive effects. These can be summarised as:

- Increased light levels may increase the maximum depth of colonisation by aquatic plants in lochs
- Complexity of habitat is likely to increase with an increase in woody material within standing waters
- Abundance and diversity of aquatic invertebrates, fish and amphibians may increase as a result of caches, woody debris, etc.
- Selective consumption of edge/emergent plants may lead to colonisation of habitat by submerged species
- Clearance of vegetation that is acting as a barrier to water flow may restore flushing rates in standing waters and prevent backing-up and consequent flooding
- Felling/coppicing of trees by beavers may help to keep wetland habitats open and largely free of encroaching scrub.

Individual site/species accounts follow:

SLENDER NAIAD (NAJAS FLEXILIS)
Slender naiad *Najas flexilis* is a submerged rooted macrophyte that occurs in lochs, often strongly associated with the mesotrophic and oligo-mesotrophic lochs priority habitat.

Knapdale
There are no sites identified in the Knapdale beaver policy area that are designated for slender naiad.

Tayside
- **Dunkeld - Blairgowrie Lochs SAC**

This site contains the most easterly occurrence of slender naiad *(Najas flexilis)* on the Scottish mainland and is the second-largest known population. The site consists of a cluster of five lochs lying along a river valley – the Lochs of Butterstone, Craiglush and Lowes are about 5 km upstream of Lochs Clunie and Marlee. They are all mesotrophic waterbodies with a diverse macrophyte flora. Slender naiad has been recorded since the 19th century in the lochs.

HRA Advice
Theoretically, should damming raise the water level sufficiently in one of the lochs, or should new habitat at appropriate depth be unsuitable for colonising, it is possible that there could

be negative effects on the qualifier. This could also happen if water quality was adversely affected, e.g. by increased water opacity, or additional nutrients were released as an effect of inundation of nutrient rich areas. However, dam building by Eurasian beavers is not considered to be of sufficient scale to deepen the lochs to such an extent that slender naiad might be negatively affected. Neither will their feeding on other water plants have a negative effect on the species.

The SNH HRA advice concluded that that it can be ascertained that there is no adverse effect on site integrity of the Dunkeld – Blairgowrie Lochs SAC through impacts to slender naiad.

European Protected Species
Slendar naiad is classed as European Protected Species, and is fully protected under The Habitats Regulations 1994 (as amended in Scotland).

It is anticipated that the potential impacts from the policy will not be detrimental to the maintenance of the population of the species (slender naiad) concerned at Favourable Conservation Status in their natural range.

PILLWORT *PILULARIA GLOBULIFERA*
This tiny plant is a type of creeping fern. It is hard to spot because it has thin, grass-like leaves and often grows with water grasses or small rushes. The 'pills' are tiny round spore cases at the bases of the stems.

Knapdale
There are no sites identified in the Knapdale beaver policy area that are designated for pillwort.

Tayside
- **Dalcroy Promontory SSSI**

SSSI Advice
Beaver dams may stabilize water levels. Whilst this might be expected to provide stable conditions suitable for submerged plants, there are also plants that rely on the exposure of substrate such as pillwort, an aquatic fern which grows on bare mud and is able to tolerate seasonal fluctuations in water levels. However, it has been reported that beavers may not tolerate excessive or unnatural water-level fluctuations. This suggests that they are less likely to inhabit lochs where water levels are significantly affected by activities such as power generation, e.g. Loch Tummel which, at its western end supports pillwort at Dalcroy Promontory SSSI.

Therefore, while there are natural heritage interests of national importance on this site, these are unlikely be affected by the beaver activity.

4.9.3.2 Consideration of potential negative effects on standing freshwater and wetland habitats of conservation importance
The impact of beaver activity on standing freshwater habitats discussed below is considered to have a negative effect or have the potential for a negative effect.

ALL OLIGOTROPHIC LOCH TYPES
Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea is often referred to as,* clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels. The Oligotrophic (and dystrophic) lochs priority habitat occurs throughout Scotland and includes thousands of sparsely-vegetated lochs on acid, generally impermeable geology. It is characterised by water with acid to neutral pH, low levels of alkalinity and low concentrations of easily available nutrients. Oligotrophic lakes have water column total phosphorus (TP) levels of less than 10 µg P L-1 (OECD, 1982). Dystrophic standing waters may have higher TP levels, but P is present in a form that is not readily available to plants.

Oligotrophic sites are more variable than dystrophic standing waters. They range in size from 1 ha up to several hundred hectares in size. Some of Scotland's largest lochs are examples of this habitat, for example, Loch Tay. They generally have coarse substrates, but large sites may have sheltered bays with soft substrates, as well as rocky, wave-washed shores. A greater range of species may be found in oligotrophic lochs than in dystrophic sites, but overall biomass remains fairly low. There may be extensive stands of sedges in shallow, sheltered bays (typically bottle sedge *Carex rostrata*). Small, rosette species are often found along rocky shores, including shoreweed *Littorella uniflora* and water lobelia *Lobelia dortmanna*. Water colour may be clear, or peat-stained, though not to the intensity of water colour found in dystrophic water bodies.

Knapdale
- Taynish and Knapdale Woods SAC
- Taynish Woods SSSI
- Knapdale Woods SSSI

Tayside
- Cairngorms SAC
- Cairngorm Lochs Ramsar
- Dunkeld - Blairgowrie Lochs SAC
- Glencoe SAC
- Rannoch Moor SAC
- River Tay SAC
- Cairngorms SSSI
- Eastern Cairngorms SSSI
- Geal and Dubh Lochs SSSI
- Rannoch Moor SSSI
- Lochs of Butterstone, Craiglush and Lowes SSSI
- Lindores Loch SSSI
- Loch of Lintrathen SSSI
- Lochmill Loch SSSI
- Lochs Clunie and Marlee SSSI
- Long Loch of Lundie SSSI
- Stronvar Marshes SSSI

SNH HRA advice
Advice is outlined below with respect to each SAC included reference to appropriate mitigation. See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

Taynish and Knapdale Lochs SAC
Work already published concludes that there is no AESI on the submerged vegetation community of the standing water habitat from the beavers resident in the SAC area. However, dam management was a condition of the SBT and although dam-building did not have an AESI during the SBT, there may be adverse effects in the future should circumstances change (such as additional water-level increases, higher densities of beavers etc.). Any potential adverse impacts on the site from water level changes must be mitigated.

Grazing by beavers may affect most macrophyte species though it may be limited to effects upon the structure and abundance of rhizomatous edge vegetation. However any negative impacts on the vegetation community that might constitute an AESI should be avoided. Monitoring of beaver grazing activity is required and such mitigation could form part of a management plan to control the potentially damaging effects of beavers on the SAC.

The SNH HRA advice concluded it that it can be ascertained that there is no adverse effect on the site integrity of Taynish and Knapdale Woods SAC provided the ability to implement mitigation is maintained**.**

Mitigation
Monitoring of dams is required, and water flows that will not have an AESI must be maintained. Mitigation could include a management plan involving measures such as the installation of dam-regulators or the removal of dams.

SSSI Assessment
Impacts within SSSI loch habitats are likely to be similar to those described above for Taynish and Knapdale Lochs SAC. There is therefore potential for beaver activity to adversely affect the natural heritage interests of national importance. Mitigation outlined above will be relevant to both Taynish Woods and Knapdale Woods SSSIs.

Cairngorm SAC
Colonisation of the catchment of Loch Einich, and the plateau and corrie lochs over 900m is improbable given the harsher climate and low extent of tree cover. However, beavers are more likely to colonise the areas around the lower lying lochs which are generally found further north in the SAC.

Damming of inflows, if it occurred, may result in reduction of silt and finer sediments flowing into the lochs. This would reduce the nutrient inputs and would be considered positive. The overall phosphorus loading will not be increased by the trapping of silt. Silt from failed or abandoned dams is likely to be remobilised by storm and flooding events when flushing rates will be relatively high. In some circumstances the wetting-up of drier areas and the trapping of organic material may result in more anaerobic conditions resulting in the release of phosphorus. Damming may also affect the timing of the release of sediment. The precise effects on water chemistry and nutrients will vary for each site and may be complex. The effects of these changes on the qualifying interests may also be complex; however, the scale and speed of the impacts means that where they were thought to possibly lead to an adverse effect on site integrity, they would need to be mitigated through appropriate management measures which are able to identify impacts to site integrity before they occur and modify or remove dams as necessary.

The SNH HRA advice concluded if beavers settle in the vicinity of the valley lochs any potential adverse impacts from water level changes could be prevented by having a mitigation plan in place to identify those impacts before they had an adverse effect on site integrity.

Mitigation
Mitigation is likely to include the use of flow control devices to manage dams, the removal of dams, or if necessary beavers. Any adverse impacts on the vegetation community would also be avoided by having a mitigation / management plan in place for beavers.

Ramsar & SSSI Assessment
Impacts within Ramsar and SSSI loch habitats are likely to be similar to those described above for Cairngorms SAC. There is therefore potential for beaver activity to adversely affect the natural heritage interests of national and international importance. Mitigation outlined above will be relevant to Cairngorm Lochs Ramsar, Cairngorm SSSI and Eastern Cairngorms SSSI.

Dunkeld – Blairgowrie Lochs SAC
The impact of damming is generally considered to be beneficial returning catchments to a more natural and diverse condition which would have been in place prior to the removal of beavers. Damming of inflows may result in reduction of silt and finer sediments flowing into the lochs. This would reduce the nutrient inputs and would be considered positive. The overall phosphorus loading will not be increased by the trapping of silt. Silt from failing or abandoned dams is likely to be remobilised by storm or flooding events when flushing rates will be relatively high. In some circumstances the wetting up of drier areas and the trapping of organic material may result in more anaerobic conditions resulting in the release of phosphorus. Damming may also affect the timing of the release of sediment. The effects on water chemistry and nutrients will vary for each site and may be complex. The effects of these changes on the qualifying interests may also be complex.

The SNH HRA advice concluded it can be ascertained that there is no adverse effect on site integrity of Dunkeld – Blairgowrie Lochs SAC through impacts to the loch qualifying interest, provided any potential adverse impacts on integrity from damming are prevented by having a management plan in place to monitor beaver activity and install control devices or remove dams as necessary.

Potential adverse impacts on the vegetation community of the SAC lochs should also be avoided by having a management plan in place to monitor and control beavers where their activities might result in an AESI.

Mitigation
Mitigation is likely to include the use of flow control devices to manage dams, the removal of dams, or if necessary beavers. Any adverse impacts on the vegetation community would also be avoided by having a mitigation / management plan in place for beavers.

SSSI Assessment
Impacts within SSSI loch habitats are likely to be similar to those described above for Dunkeld-Blairgowrie Lochs SAC. There is therefore potential for beaver activity to adversely affect the natural heritage interests of national importance. Mitigation outlined above will be

relevant to both Lochs Clunie and Marlee SSSI and Lochs of Butterstone, Craiglush and Lowes SSSI.

Glen Coe SAC
Dam-building is unlikely, though possible, given the low level of tree cover near the loch. If the area was colonised, grazing by beavers might have an effect on most macrophyte species though it is likely to be limited to effects upon the structure and abundance of rhizomatous edge-vegetation.

The SNH HRA advice concluded that it can be ascertained that there is no adverse effect on site integrity Glen Coe SAC provided suitable mitigation is identified, and will be implemented if it proves necessary.

Mitigation
In such a situation any potential adverse impacts on the vegetation community should be avoided by having a suitable management plan with mitigation, in place to manage beavers.

Rannoch Moor SAC
The SAC is sufficiently unattractive to beavers due to: the low percentage of woodland cover in the catchment of the Rannoch Moor lochs (c. 2%), the harsh climate, and exposed nature of Rannoch Moor, meaning they are not expected to colonise the area.

The SNH HRA advice concluded that it can be ascertained that there is no adverse effect on site integrity.

SSSI Assessment
Impacts within SSSI loch habitats are likely to be similar to those described above for Rannoch Moor SAC.

River Tay SAC
Colonisation of the catchments of the lochs is possible given the level of tree cover and the existing areas of the Tay catchment already colonised. Should beavers settle near the smaller lochs and build dams at their outflows, any potential adverse impacts on these smaller lochs from water level changes should be prevented by having suitable mitigation in place that can identify potential adverse effects and install control devices, or remove dams or beavers where necessary.

The SNH HRA advice concluded that it can be ascertained that there is no adverse effect on site integrity of the River Tay SAC, provided suitable mitigation is identified and can be implemented if it proves necessary.

Mitigation
Grazing by beavers might have an effect on macrophyte species though it is likely to be limited to effects upon the structure and abundance of rhizomatous edge-vegetation. Where it is identified that this might happen any potential adverse impacts on the vegetation community should be avoided by having a suitable management plan with mitigation in place to manage the impacts of beavers.

- Geal and Dubh Lochs SSSI
- Lindores Loch SSSI
- Loch Lintrathen SSSI
- Lochmill Loch SSSI
- Long Loch of Lundie SSSI

- Stronavar Marshes SSSI

SSSI Assessment
Impacts to these lochs are likely to be similar to those described above and so may include effects of beaver grazing on macrophyte species or the effects on water chemistry and nutrients from damming activity which are likely to vary for each site and may be complex. There is therefore potential for beaver activity to adversely affect the natural heritage interests of national importance.

Mitigation
Mitigation is likely to include the use of flow control devices to manage dams, the removal of dams, or if necessary beavers. Any adverse impacts on the vegetation community would also be avoided by having a mitigation / management plan in place for beavers.

EUTROPHIC LOCHS
Eutrophic standing waters have high productivity as a result of presence of high alkalinity and nutrient levels; the water column typically contains at least 35 µg P L-1 of total phosphorus (TP) (OECD, 1982) and 500 µg N L-1 or more total inorganic nitrogen (mainly in the form of dissolved nitrate).

Unpolluted examples of this habitat are often characterised by deep fringes of emergent vegetation comprising common reed *Phragmites australis* or bulrush *Typha spp*., and beds of floating-leaved species such as yellow water lily *Nuphar lutea*. Submerged species associated with this type of water body include fennel-leaved pondweed *Potamogeton pectinatus* and spiked water-milfoil *Myriophyllum spicatum*. The open water of richer sites may be dominated by algae, which gives the water a green colour.

This habitat supports abundant populations of planktonic algae and zooplankton. Snails, dragonflies and water beetles dominate the benthic fauna. In sites that have suffered from artificial enrichment, the variety of species may be reduced to one or two pollution-tolerant species of leech and chironomid larvae, although the numbers of each species may be high. The abundance of food resulting from the artificial enrichment may support internationally important numbers of birds. For example, Loch Leven supports over 20,000 waterfowl including nationally important numbers of wigeon *Anas penelope*, gadwall *Anas strepera*, Shoveler *Anas clypeata* and large numbers of wintering whooper swan *Cygnus cygnus*.
The fish fauna is usually dominated by coarse fish, such as pike *Esox lucius*.
Eutrophic standing waters are generally shallow, and have bays or shores that are sheltered from wave action. Dark anaerobic muds, rich in organic matter may be the dominant substrates.

Knapdale
There are no sites identified in the Knapdale beaver policy area designated for eutrophic lochs.

Tayside

- Loch Leven Ramsar
- Loch of Kinnordy Ramsar
- Dun's Dish SSSI
- Loch Leven SSSI
- Loch of Kinnordy SSSI
- Round Loch of Lundie SSSI

Ramsar and SSSI Assessment
Although eutrophic lochs differ in their environmental characteristic from the range of oligotrophic lochs described above, mainly through their much higher nutrient loading and resulting suite of aquatic macrophytes adapted to such conditions, the likely impact from beaver activity will be broadly similar.

Grazing by beavers may affect macrophyte species though it may be limited to effects upon the structure and abundance of rhizomatous edge vegetation. Monitoring of beaver grazing activity is therefore required and such mitigation could form part of a management plan to control any potentially damaging effects of beavers on these sites.

Damming of any inflows may result in reduction of silt and finer sediments flowing into these lochs. Silt from failed or abandoned dams is likely to be remobilised by storm and flooding events when flushing rates will be relatively high. In some circumstances the wetting-up of drier areas and the trapping of organic material may result in more anaerobic conditions resulting in the release of phosphorus. Damming may also affect the timing of the release of sediment. The precise effects on water chemistry and nutrients will vary for each site and may be complex.

Any damming on outflow burns may reduce the existing water level fluctuation or slow down certain nutrient processes. The resulting impacts on water chemistry will vary for each site and may be complex.

There is therefore potential for beaver activity to adversely affect the natural heritage interests of national importance.

Mitigation
Potential adverse impacts on the vegetation community of these lochs should be avoided by having a management plan in place to monitor and control beavers where their activities might result in an adverse effect.

Any potential adverse impacts from damming should be avoided by having a management plan in place to monitor beaver activity and install control devices or remove dams as necessary.

Many of the lochs (e.g. Loch of Kinnordy and Loch Leven) do have existing management or catchment plans in place; any mitigation would seek to align with these.

TRANSITION MIRES AND QUAKING BOG
Transition mires and quaking bogs occur in waterlogged situations where they receive water from rainfall, as well as water and nutrients from the surrounding catchment. The vegetation is typically dominated by sedges and rushes over a ground layer of semi-aquatic bog-moss *Sphagnum* species or feather-mosses such as *Calliergon* species. The term transition mire refers to the fact that the vegetation and ecological/hydrochemical characteristics are transitional between acidic bog and alkaline fen conditions. This transitional state can arise either by being in an intermediate position between bog and fen or by being a successional stage in which, after accumulating in fen or over open water, rainwater-fed (ombrogenous) peat, which is wholly or partly isolated from groundwater influence, accumulates.

Many of these systems are very unstable underfoot and are also described as ‘quaking bogs’. Examples include the transitions between bog and fen vegetation associated with valley mires or basin mires, or the marginal lagg areas of raised bogs.

Small quaking bogs can occur in a wide variety of landscape situations, including small basins in post-glacial landscapes, the margins of lochs and lochans in blanket bog, and the edges of coastal machair lochs. Larger examples are found in floodplain mires. They are usually found within other, larger, wetlands such as valley mires and blanket bogs.

Knapdale
There are no sites identified in the Knapdale beaver policy area which are designated for transition mires and quaking bog.

Tayside
- Cairngorms SAC
- Dunkeld - Blairgowrie Lochs SAC
- Rannoch Moor SAC

SNH HRA Advice
Cairngorms SAC and Dunkeld - Blairgowrie Lochs SAC
Very wet mires (quaking bogs) would generally not be disadvantaged by the presence of beavers as the habitat tends to form a floating raft of vegetation which can rise and fall in response to the water levels and can effectively become isolated from the underlying water. However, the 'tethered' quaking mire at the edges of the habitat is not able to move freely and could be affected by a change in water levels and water chemistry arising from beaver impoundments. Increased mineral and nutrient levels in the water could result in a shift in the species composition towards more typical fen communities. Precise changes cannot yet be predicted, and will depend upon the nature, scale, duration of the changes and the location of beavers and their activities
Beavers are also selective feeders and may graze on some of the vegetation that contributes to the qualifying habitat.

SNH advice is that it cannot be ascertained that there is no adverse effect on the site integrity of Cairngorms SAC, and Dunkeld – Blairgowrie Lochs SAC without monitoring, and management of beaver dams.

Mitigation
Mitigation in the form of monitoring and management of beaver dams is required to avoid the adverse effect where dams might cause individual stands of transition mires or quaking bogs to be flooded.

Rannoch Moor SAC
Due to the low percentage of woodland cover in the catchment of the Rannoch Moor lochs (c. 2%), the harsh climate, and exposed nature of Rannoch Moor, beavers are not expected to colonise the area.

SNH advice is that it can be ascertained that there is no adverse effect on site integrity.

ALKALINE FENS
Alkaline fens consist of a complex assemblage of vegetation types characteristic on sites where there is a high water table, a calcareous base-rich water supply and tufa and/or peat formation. The characteristic vegetation is short sedge communities.

At many sites there are well-marked transitions to a range of other fen vegetation and alkaline fens may occur in association with tall-herb fen, swamp, wet grasslands, rush species, as well as fen carr and, especially in the uplands, wet heath and acid bogs.

There is considerable variation between sites in the associated communities and transitions present, depending on the geomorphological situation in which the fen occurs (e.g. flood plain mire, valley mire, basin mire, hydroseral fen) and the altitude.

Knapdale
There are no sites identified in the Knapdale beaver policy area which are designated for alkaline fens.

Tayside
- Beinn a' Ghlo SAC
- Glen Coe SAC
- Tulach Hill and Glen Fender Meadows SAC
- Morrone Birkwoods SAC
- Tullach Hill SSSI

SNH HRA Advice
Where the topography is shallow, beaver dams constructed close to base-rich fen communities could lead to an expansion of the habitat by increasing the area with suitably high water levels to support wetland habitats. However, if raised water levels are maintained in alkaline fens over long periods this could lead to a transition from fen to swamp, reed-bed or open water.

If damming activity leads to a change in the water quality or water chemistry within the fens, e.g. by flooding the fens with surface waters and effectively reducing the influence of the base-rich, low fertility flushes, this could result in a change in the vegetation communities present and a reduction of the extent of the feature on the site. Changes in the nutrient and base status of the water may lead to a change in the extent, diversity and succession processes of wetland communities.

Beavers are selective feeders and may graze on some of the vegetation that contributes to the qualifying habitat.

SNH advice is that that it can be ascertained that there is no adverse effect on the site integrity of these SACs provided there is monitoring of the location of beaver dams within and upstream of the SACs, in order to manage water flows, and managing or removing any beaver dams which could cause alkaline fens to be flooded with impounded water.

SSSI Assessment
The impacts within the alkaline fen SSSI habitat are likely to be similar to those described above for the SAC alkaline fen habitat. There is therefore potential for beaver activity in combination with other herbivores to adversely affect the natural heritage interests of national importance at Tullach Hill SSSI.

Mitigation
Mitigation in the form of monitoring and management of beaver dams is required to avoid adverse effects where dams might cause individual stands of alkaline fens to be flooded.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

BASIN FEN
As the name suggests basin fens occur in waterlogged depressions or hollows in the landscape, for example those associated with glacial or peri-glacial processes such as kettle holes, or in solution hollows on limestone. Their main water supply source is from overland flow (topogenous) or sometimes from a river or lake. Surface run-off from surrounding slopes can be an important source of water, depending on the surrounding topography, and this may include small flushes along the sides of the basin. These sites may have no surface water flow outlet. Basin and open water transition fens are very similar in characteristics but differ in the proportion of fen area to that of open water.

Knapdale
There are no sites identified in the Knapdale beaver policy area which are designated for basin fens.

Tayside
- Ardblair and Myreside Fens SSSI
- Eslie Moss SSSI
- Lochs of Butterstone, Craiglush and Lowes SSSI
- Mill Dam SSSI
- Rescobie and Balgavies Lochs SSSI
- Restenneth Moss SSSI

SSSI Assessment
Impoundment resulting from beaver activity could lead to raised water levels in basin fens. Prolonged raised water levels could lead to a loss of fen habitat and a transition to swamp communities or open water. Flooding the fens with surface waters could alter the nutrient status and hydrochemistry of the water supply to the fens – thereby reducing the influence of inflow from any base-rich, low fertility springs and flushes. This could result in a change in the vegetation communities present and a reduction of the extent of the feature on the site.

In some situations, where the topography is shallow, impoundment could lead to an expansion of fen habitat but basin fens are often located in confined basins with little scope for this type of expansion.

In some cases an increase in water volume in the fen may dilute the effects of pollutants and this would be beneficial. The felling or coppicing of trees on basin fens by beavers would be beneficial by keeping the fen vegetation open and reducing encroachment by scrub.

Beavers are selective feeders and may graze on some of the vegetation that contributes to the basin fen feature.

There is therefore potential for beaver activity to adversely affect the natural heritage interests of national importance. This could be avoided provided there is monitoring of the location of beaver dams within and in the vicinity of basin fen features in order to assess the impacts and manage water flows where necessary.

Mitigation
Mitigation is required in the form of monitoring to assess the effects of beaver dams and, where necessary, management to avoid adverse effects on basin mires.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

OPEN WATER TRANSITION FEN
Open water transition fens are associated with significant areas of open water, where the water table in the fen is determined by vertical fluctuations of the open water body. They are essentially similar to basin fens but the proportion of open water is greater than that of fen. Extensive areas of transition from swamp to fen vegetation may occur around the open water with further transitions to tall herb fen vegetation and fen woodland reflecting transitions to drier conditions. In the fen the summer water table would generally be at or below ground level while in the swamp the summer water table will be at or above the surface. The particular fen and swamp communities present will be influenced by the trophic status and fluctuations in the levels of the water body. Springs may occur within the feature Some swamp and tall-herb fen vegetation types are ubiqitous, some are associated with nutrient or base-poor conditions and others with nutrient or base-rich conditions.

Knapdale
There are no sites identified in the Knapdale beaver policy area which are designated for the open water transition fen feature.

Tayside
- Dunalastair Reservoir SSSI
- Dun's Dish SSSI
- Hare Myre, Monk Myre and Stormont Loch SSSI
- Kings Myre SSSI,
- Lindores Loch SSSI
- Loch Lubnaig Marshes SSSI
- Loch of Kinnordy SSSI
- Lochs Clunie and Marlee SSSI
- Lochs of Butterstone, Craiglush and Lowes SSSI
- Round Loch of Lundie SSSI
- Stronvar Marshes SSSI

SSSI Assessment
Some of the impacts within open water transition fen SSSI habitat are likely to be similar to those described above for basin fens. In some cases impoundment could lead to an expansion of the overall area of swamp and fen habitat and this would be beneficial but the degree to which this will be possible will depend on local topography and on land management practices.

A lowering of the water table could lead to a marked expansion of tall-herb fen communities at the expense of swamp communities. Conversely, a landward expansion of swamp communities may be caused by raised water levels. These changes may or may not be beneficial to the site. On sites where springs contribute to the water supply of the fen vegetation, an increase in water levels may lead to the dilution of the impacts of any spring water and a change in the nutrient and base-status of the water. Changes in the nutrient and base status of the water may lead to a change in the extent, diversity and succession processes of wetland communities

In some cases an increase in water volume in the fen may dilute the effects of pollutants and this would be beneficial. The felling or coppicing of trees within the fen vegetation by beavers would be beneficial by keeping the fen vegetation open and reducing encroachment by scrub.

Beavers are selective feeders and may graze on some of the vegetation that contributes to the basin fen feature.

There is therefore potential for beaver activity to adversely affect the natural heritage interests of national importance. This could be avoided provided there is monitoring of the location of beaver dams within and in the vicinity of open water transition fen features in order to assess impacts and manage water flows where necessary.

Mitigation
Mitigation is required in the form of monitoring to assess the effects of beaver dams and, where necessary, management to avoid adverse effects on open water transition fens.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

TRANSITION OPEN FEN
The only site in the beaver policy area which is notified for this feature is Loch Tay Marshes SSSI. This site, on the shores of Loch Tay, has extensive areas of poor fen with transitions to submerged and emergent plant communities, fen meadow, carr woodland and heathland.

Knapdale
There are no sites identified in the Knapdale beaver policy area which are designated for the transition open fen feature.

Tayside
- Loch Tay Marshes SSSI

SSSI Assessment
Impacts within transition open fen SSSI habitat are likely to be similar to those described above for the open water transition fen feature habitat. Increased water levels could lead to an increase in the extent of fen vegetation on the site. Poor fen vegetation is generally fed water low in nutrients. Changes in the nutrient and base status of the water may lead to a change in the extent, diversity and succession processes of wetland communities

A lowering of the water table could lead to an expansion of tall-herb fen communities at the expense of swamp communities. Conversely, raised water levels may lead to an expansion of swamp communities.

Beavers are selective feeders and may graze on some of the vegetation that contributes to the transition open fen feature. The felling or coppicing of trees and scrub in the fen feature by beavers would be beneficial to the condition of the fen communities.

There is therefore potential for beaver activity to adversely affect the natural heritage interests of national importance. This could be avoided provided there is monitoring of the location of beaver dams within and in the vicinity of transition fen features in order to assess impacts and manage water flows where necessary

Mitigation
Mitigation is required in the form of monitoring to assess the effects of beaver dams and, where necessary, management to avoid adverse effects on the transition fens.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

FLOOD PLAIN FEN
Floodplain fen develops on a waterlogged, periodically inundated floodplain adjacent to a river or stream. In addition to large rivers this includes sites on flat valley bottoms where the watercourse is small and does not provide significant amounts of water through overbank flooding.

Although the primary water supply mechanism for flood plain fens is topogenous, percolating (soligenous) water sources can be important in some sites and groundwater discharge can also be an important water supply mechanism where the wetland is underlain by an aquifer and not separated by impermeable strata. Topographic variations can result in areas of ponding or soakways and the differences in water levels across a site give rise to zonation within the vegetation. The vegetation of flood-plain fen is varied including, for example, tall eutrophic fen, single species swamps or in some cases poor fen. Reedbed is common, as are other tall fen plant communities in which reed is a major component. The fens may be nutrient-enriched, nutrient-poor, base-rich or base-poor, and these factors are reflected within the vegetation present on each site.

Flood-plain fens are very vulnerable to drainage and interruption of their flooding regime, especially when fragmented by agricultural practices or affected by river engineering. There is commonly a transition from flood-plain fen to wet grassland.

Knapdale
There are no sites identified in the Knapdale beaver policy area which are designated for the flood plain fen feature.

Tayside
- Westerton Water Meadow SSSI

SSSI Assessment
Some of the impacts within flood plain fen SSSI habitat are likely to be similar to those described above for open water transition fen habitat.

Given their flood plain location, the extent of the feature is less likely to be constrained by topography than, for example, basin fen. Raised water levels resulting from beaver activities could therefore lead to an increase in the extent of flood plain fen, though this would also be dependent on land management practices.

The vegetation present in flood plain fens shows a large amount of variation both in the communities present and in transitions between vegetation types. A lowering of the water table could lead to an expansion of tall-herb fen communities at the expense of swamp communities. Conversely, raised water levels may lead to an expansion of swamp communities. Changes in the nutrient and base status of the water may also lead to a change in the extent, diversity and succession processes of some wetland communities.

In some cases an increase in water volume in the fen may dilute the effects of pollutants and this would be beneficial. The felling or coppicing of trees within the fen vegetation by beavers would be beneficial by keeping the fen vegetation open and reducing encroachment by scrub.

Beavers are selective feeders and may graze on some of the vegetation that contributes to the flood plain fen feature.

There is therefore potential for beaver activity to adversely affect the natural heritage interests of national importance. This could be avoided provided there is monitoring of the location of beaver dams within and in the vicinity of open water flood plain fen features in order to assess impacts and manage water flows where necessary.

Mitigation
Mitigation is required in the form of monitoring to assess the effects of beaver dams and, where necessary, management to avoid adverse effects on flood plain fens.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

HYDROMORPHOLOGICAL MIRE RANGE
Many wetland sites contain a wide range of habitats and plant communities and on some designated wetland the importance of this diversity is acknowledged by the designation of the hydromorphological mire range feature. This feature can contain several different wetland habitats on each site, with a wide range of requirements in terms of the supporting hydrological regime and water chemistry.

Within the Tayside beaver policy area, the wetland habitats for this feature are as follows:
Geal and Dubh Lochs SSSI: fen meadows, springs and flushes, open water transition fen
Carsebreck and Rhynd Lochs SSSI: acid wet heaths and flushes, nutrient-rich flushes, rich fen
Loch Leven SSSI: fen and mire communities
Meikleour Area SSSI: fen, willow scrub, swamp, basin mire, lowland raised mire, wet woodland

On most sites there will be a range of wetland plant habitats present including areas of vegetation that represents a transition between different plant community types. There will also be variations over time in the relative proportions of each habitat as a result of natural succession processes. In some cases the succession processes may be further influenced my current or historic land management practices.

Knapdale
- There are no sites identified in the Knapdale beaver area which are designated for this feature.

Tayside
- Carsebreck and Rhynd Lochs SSSI
- Geal and Dubh Lochs SSSI
- Loch Leven SSSI
- Meikleour Area SSSI

SSSI Assessment
This feature is represented by a wide range of wetland communities, each with different requirement in terms of the optimum water levels, the flooding regime and the water chemistry. Water impoundment activity by beavers clearly has the potential to affect some or all of the component wetland communities by altering the maximum water levels in the habitats and the length and timing of the periods when water levels are raised. In some cases, where the topography allows, raised water levels may lead to an increase in the extent of some wetland communities or of the overall extent of wetland habitat. In other

cases raised water levels may lead to a reduction the extent of some wetland types and an increase in others e.g. a transition from fen to swamp communities.

In addition some of the wetland communities are dependent on a water supply with specific hydrochemical characteristics e.g. acidic, base–rich or nutrient-poor water. Where beaver dams raise water levels they may thereby reduce the influence of inflow from any acid, base-rich or low fertility springs and flushes. This could result in a change in the vegetation communities present and a reduction of the extent of the specific features on the site.

The nature of the effects, positive or negative, will vary between sites and between different habitats within sites, depending on the plant communities present and the site specific topography and hydrology.

Beavers are selective feeders and may graze on some of the vegetation that contributes to the wetland types that make up the hydromorphological mire range. In addition they may fell or coppice trees in fen, mire or wet woodland communities. In some cases this may be beneficial in helping to keep the wetland communities open.

There is therefore potential for beaver activity in combination with other herbivores to adversely affect the natural heritage interests of national importance. This could be avoided provided there is monitoring of the location of beaver dams within and in the vicinity of the hydromorphological mire range features in order to assess impacts and manage water flows where necessary.

Mitigation
Mitigation is required in the form of monitoring to assess the effects of beaver dams and, where necessary, management to avoid adverse effects on hydromorphological mire range features.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

VALLEY FEN
Valley fens are usually described as soligenous mires although differing porosity and mineralogy of the underlying rocks can give rise to several different patterns of water supply. Springs and seepages from the valley sides provide the main source of water but they can also receive inputs from surface water and from groundwater seepage.

This type of fen develops along the lower slopes and floors of small valleys where there is some water movement. They are often drained by an axial stream. The topography of the valley often also helps to maintain a high water table.

Each valley mire may contain a range of wetland types, from base-rich to base-poor, and from oligotrophic to eutrophic, with other variations arising from patterns of land use such as grazing and mowing. There may be a band of scrub or woodland with taller, more eutrophic fen around the axial stream, and poor fen or bog between this and the soligenous margins.

Knapdale

- Tayvallich Juniper and Fen SSSI

Tayside

- Brig o' Turk Mires SSSI

- Den of Ogil SSSI
- Rossie Moor SSSI

SSSI Assessment
Impacts within valley fen SSSI habitat are likely to be similar to those described above for other fen habitats.

Where the topography is shallow, beaver dams constructed close to valley fen communities could lead to an expansion of the habitat by increasing the area with suitably high water levels to support wetland habitats. However, if raised water levels are maintained over long periods this could lead to a transition from fen to swamp, reed-bed or open water.

The construction of dams in the small axial streams could potentially lead to a change in the water quality or water chemistry within the fens, e.g. by flooding the fens with surface waters and effectively reducing the influence of the original water supply from the springs and flushes. Where this leads to a change from base-rich, low fertility water to more nutrient rich water this could result in a change in the type of vegetation communities present, their diversity and succession processes, and a reduction of the extent of the feature on the site.

Beavers are selective feeders and may graze on some of the vegetation that contributes to the qualifying habitat.

Therefore there is potential for beaver activity to adversely affect the natural heritage interests of national importance. This could be avoided provided there is monitoring of the location of beaver dams within and in the vicinity of the valley fen features in order to assess impacts and manage water flows where necessary.

Mitigation
Mitigation is required in the form of monitoring to assess the effects of beaver dams and, where necessary, management to avoid adverse effects on valley fens.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

SPRING FEN
This type of fen is often found on sloping land beneath a spring or a line of water seepage, or on flatter land at the base of a slope where they are irrigated by groundwater discharge from water reaching the surface under artesian pressure, giving rise to a small dome of mire, usually on flat ground. These fens are frequently small and discrete and not part of an elongated mire along a valley. They are soligenous - water comes out of the saturated soils or rock at one point (spring) or in a discrete zone (seepage). The springs will show a discrete difference in vegetation type from the surrounding fen vegetation as a result of the temperature and nutrient influences from the different water sources.

Knapdale
There are no sites identified in the Knapdale beaver policy area which are designated for Spring fen.

Tayside
- Forest Muir SSSI
- Quoigs Meadow SSSI

SSSI Assessment
The main route for any effects on spring fen habitats would be if impoundment arising from a beaver dam caused flooding of the spring fed fens with a resulting change in the hydrological regime and water chemistry. In these cases there could be a loss of the characteristic plant communities, e.g. those that are dependent base-rich, acidic or nutrient-poor water, and a transition to other types of wetland communities. The likelihood of any adverse effects on particular fens or sites will depend on their location in the landscape and the surrounding topography. Those located high on steep slopes in the uplands are unlikely to be affected by beaver activity. Those located on flatter ground at the base of slopes may be affected if there is a nearby beaver dam.

Beavers are selective feeders and may graze on some of the vegetation that contributes to the qualifying habitat.

Therefore there is potential for beaver activity to adversely affect the natural heritage interests of national importance. This could be avoided provided there is monitoring of the location of beaver dams within and in the vicinity of the spring fen features in order to assess impacts and manage water flows

Mitigation
Mitigation is required in the form of monitoring to assess the effects of beaver dams and, where necessary, management to avoid adverse effects on spring fens.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

SPRINGS AND FLUSHES
Springs and flushes are generally small features. They are often dominated by bryophytes but low-growing sedges and dicotyledonous plants also play an important role in these habitats. There are several different types, depending on the nature of the underlying bedrock. These include base-rich petrifying springs with tufa formation, neutral flushes and acid flushes. Most base-rich wetlands on slopes are spring-fed.

Springs and their associated flushes occur when water wells up to the surface from underground aquifers or reaches the surface at seepage slopes. Where the spring emerges onto a sloping terrestrial surface and the drainage is impeded but not pooled on the surface, the water then feeds flush communities. Spring fens are usually very small, but may form an important part of otherwise extensive wetland complexes.

Hillslope wetlands are found where low-permeability bedrock coupled with high precipitation permits the development of sometimes extensive wetlands fed primarily by surface run-off and rainfall.

Springs and flushes in the lowlands are usually associated with soligenous fens, and often with peat-accumulating systems. Lowland springs often also contain a considerable calcareous input which may support a mosaic of acid and basic mire plant types. Peat deposits associated with calcareous springs are often mixed with tufa.

Springs that flow into water bodies can provide an important water source to swamps, where they contribute to the water quality of the wider wetland. The flow pattern of spring water into standing water is determined by the nature of each water body. Density and temperature differences may constrain the movement of water, resulting in discrete bodies of water, characterised by specific swamp communities. These may be different from the surrounding swamp vegetation, as they are affected by temperature and nutrient influences from the different water sources.

Spring features (including flushes)

- Glen Fender Meadows SSSI
- Pass of Leny Flushes SSSI
- Pitarrig Meadow SSSI
- Schiehallion SSSI

Springhead rill and flush

- Cairngorms SSSI (assemblage feature component)

Knapdale

There are no sites identified in the Knapdale beaver policy area which are designated for either of the spring and flushes feature.

SSSI Assessment

As for spring fen habitats, the main route for any effects on spring features would be if impoundment arising from a beaver dam caused flooding of the spring fed fens with a resulting change in the hydrological regime and water chemistry. In these cases there could be a loss of the characteristic plant communities, e.g. those that are dependent base-rich, acidic or nutrient-poor water, and a transition to other types of wetland communities. The likelihood of any adverse effects on particular fens or sites will depend on their location in the landscape and the surrounding topography. Most spring and flush features are located on steep slopes in the uplands are unlikely to be affected by beaver activity. Those that are located on lower ground and on flatter ground at the base of slopes may be affected if there is a nearby beaver dam.

Beavers are selective feeders and may graze on some of the vegetation that contributes to the qualifying habitat.

Therefore there is potential for beaver activity to adversely affect the natural heritage interests of national importance. This could be avoided provided there is monitoring of the location of beaver dams within and in the vicinity of the spring features in order to assess impacts and manage water flows.

Mitigation

Mitigation is required in the form of monitoring to assess the effects of beaver dams and, where necessary, management to avoid adverse effects on spring features.

See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

4.10 Beavers and running freshwater habitat

4.10.1 How beaver activity affects hydrology, fluvial geomorphology and river habitat

4.10.1.1 Effects on hydrology

Beaver dams will impede the flow (quantity and velocity) of water in a channel. The extent to which they do will depend upon their height and porosity and the frequency at which they occur. Beaver dams therefore increase the in-channel storage of water. When dams extend beyond the channel, floodplain storage will also increase. One study concluded that abandoned beaver ponds played a role in increasing channel retention, and that changes in in-channel storage resulting from beaver dams were a positive aspect of beaver activity. By increasing the amount of water stored in a channel or on a floodplain the effects of prolonged periods of dry weather may be lessened. Some of the findings of a recent literature review include that beaver dams moderate stream flow, increase surface water and riparian groundwater storage, regulate hyporheic flows (i.e. flows in the groundwater–surface water mixing zone, which is now known to be important for the maintenance of running water habitat) and enhance evapotranspiration rates (i.e. the evaporation of water from plants and the earth's surface).

By slowing flow, and therefore reducing the speed at which intercepted precipitation passes through a catchment, beaver dams can increase the length of time taken for a flood to reach its peak and reduce the height of the peak. Beaver activity may therefore result in the development of natural flood defences. Investigations of the effects of dams on flow have been undertaken in North America and Europe. Following the reintroduction of Eurasian beaver to Belgium, one study investigated some of the effects of their dams on hydrology. It indicated a significant lowering of peak flow downstream of dams, an increase in the length of interval between major floods, and an increase in the depth of low flows. Another study in Glacier National Park, Montana, found that North American beaver dams reduced the velocity and quantity of water emerging downstream of them and that older dams had a greater effect than newer ones.

Modifications to stream hydrology as a result of beaver activity are unlikely to be solely in response to dam building. In-channel accumulations of wood are a feature of many naturally functioning river systems, and wood derived from beaver activity is likely to increase both the total amount of material available and the incidence of accumulations. Investigations into the effects of accumulations of coarse wood in streams in the New Forest showed an increase in the amount of time taken for water to pass through a channel.

Localised changes in the connectivity between channels and their riparian zone and floodplains are likely, including alternating patches of high and low water table. Beaver canals may increase channel–floodplain connectivity including via the connection of previously discrete floodplain water bodies with a stream or river.

4.10.1.2 Effects on geomorphology

Beaver dams will not only attenuate flow but also impede the movement of sediment. As the ability or 'competence' of a flow to transport sediment decreases, fine material will begin to fall out of suspension and coarser material will come to a stop. These interruptions to sediment transport will happen upstream of beaver dams where flowing water enters a ponded reach. Work in Glacier National Park showed that beaver ponds clearly trapped sediment and that the depth and volume of sediment substantially increased with dam age. In the Republic of Tatarstan, Russia, three beaver dams stopped 4,250 tonnes of particles in the Sumka River during a period of flooding in 2001.

The dissipation of energy associated with flows slowed by beaver activity will result in increased channel stability, i.e. less erosion and deposition and therefore less lateral and vertical movement of the channel. Undammed reaches in systems affected by beaver activity are likely to become more geomorphologically complex.

Changes in geomorphological processes, and therefore channel shape and position, are also likely to occur in response to increased amounts of in-channel wood derived from beaver activity. Pieces of wood may coalesce and have a significant effect. Smaller accumulations or single large pieces may also instigate changes to both channel cross-section shape and the lateral movement of the channel by increasing channel roughness, and therefore altering patterns of erosion and deposition.

4.10.1.3 Effects on habitat

The construction of beaver dams and ponds introduces many additional habitats to river reaches, resulting in a substantial increase in habitat diversity, the spatial complexity of the habitat mosaic and the overall resilience of river and riparian ecosystems to disturbances. The hydrological and geomorphological effects of beaver activity will alter the amount of lotic (running water), lentic (still water) and wetland habitat supported by a stream or river. These alterations will affect the composition of some aquatic communities, for example the diversity of lentic and lotic habitat-dwelling invertebrate species may change. The system is dynamic, with dams eventually degrading due to abandonment and/or heavy spates.

The sediment accumulating in the ponded reaches upstream of beaver dams will be sorted, with larger particles being deposited at the head and finer material in the main body. A change in the composition of bed material downstream of dams is also likely to occur as a result of sediment being retained behind dams. These changes will increase habitat diversity.

The retention of organic and mineral matter by beaver dams is likely to improve downstream water clarity and quality. The flushing of fine and sorting of coarse sediment in reaches between ponds may also occur. These effects may be beneficial for fish-spawning habitat and have provided a rationale for beaver reintroduction into degraded, incising river systems in the USA. Changes in the aquatic invertebrate community composition are also likely in response to changes in flow, sediment and food availability.

Beaver activity in streams will increase habitat diversity, notably in watercourses that have been managed. It has been demonstrated that beavers enhance habitat availability, heterogeneity and connectivity. In Scotland, as in many other parts of the world, streams and rivers have been modified by humans, for example straightened, widened and deepened, for a variety of reasons. This engineering has reduced the diversity of aquatic habitat, and therefore the species supported by it. Re-establishing the natural habitat complexity of running waters has been the focus of many restoration projects, including several that have been undertaken in Scotland in recent years (see the River Restoration Centre website). Beaver activity can hasten the restoration of habitat mosaics, and their use as initiators of recovery has been explored. One study concluded that in areas inhabited by beaver, the evolution of stream planform (i.e. the shape of the channel when viewed from above) is the result of not only physical variables but also biotic processes, for example beavers constructing dams.

A summary of the potential interactions between beavers and running waters is presented at the end of this section (see Table 4.10.1); where possible these have been attributed to a neutral, positive or negative effect.

Table 4.10.1: Summary of potential interactions between beavers and running waters

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• Development of diverse riparian understory, and therefore increase in habitat diversity and species richness • Increase in amount of light reaching watercourses, and therefore: - increase in diversity of in-stream habitat provided by aquatic plants - increase in geomorphological change initiated by the presence of plants (and therefore increase in habitat diversity) - stabilisation of banks and reduction in erosion due to binding effect of bank and riparian species	• Reduction in shading, and therefore a potential increase in thermal stress upon some species such as fish	
Felling	Change in riparian woodland: Change in relative abundance of different tree species		• Possible reduction in type of food preferred by some aquatic invertebrates, and therefore possible indirect effects upon species such as fish • Possible reduction of deep-rooted species that bind bank material, and therefore possible increase in erosion	
Felling	Change in riparian woodland: Change in age classes of trees	• Possible eventual reduction in the size of wood entering watercourse, and therefore a change in the nature and scale of geomorphological change initiated	• Possible eventual reduction in size of wood entering watercourse, and therefore change in in-stream habitat structure provided and nature and scale of geomorphological	

			change initiated	
Felling	Change in riparian woodland: Amount/diversity of fallen dead wood on woodland floor	• Greater source of wood available to be entrained by overbank flows, and therefore possible increase in habitat diversity and likelihood of wood jams in streams and rivers		
Felling and construction	Changes in amount/diversity of woody material in watercourses	• Increased number of wood jams, resulting in: - attenuation of flow and lowering of downstream flood risk - greater geomorphological, hydraulic and habitat diversity - improvements in water quality as fines settle in areas of slower flow	• Increased number of wood jams, so a possibility of localised floodplain inundation and impacts on land use	
Feeding	Feeding on specific terrestrial herbaceous and aquatic plant species	• Change in nature and scale of geomorphological change initiated by the presence of vegetation	• Change in nature and scale of geomorphological change initiated by the presence of vegetation	
Dams/pond creation	Change from lotic to lentic habitat	• Increase in habitat diversity • Increased flood storage, and therefore decrease in downstream flooding • Improvements in base flow during periods of low precipitation due to increased water storage	• Increased fish predation opportunities	
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• Increased habitat and species diversity	• Increased flooding of riparian zone and beyond, so potential impacts on land use	
Dams/pond creation	Changes in water quality downstream	• Reduction in the amount of fine material deposited on bed	• Smothering of bed sediment upstream of dams resulting in	

		sediment, and therefore habitat, e.g. spawning redds, maintained • Reduction in rate of sediment movement, and therefore the speed at which it leaves streams and rivers	change in habitat quality • Reduction in turbulence upstream of dam, so decrease in rate of water oxygenation	
Dams/pond creation	Change in standing dead wood resulting from inundation of trees			
Dams/pond creation	Longer term successional changes after dam abandonment, e.g. beaver meadows	• Reconnection of streams and rivers with floodplains, and therefore lateral extension of river corridors • Increased habitat and species diversity • Improvements in natural flood management		
Dams/pond creation	Impacts on movement of species		• Dams are a possible impediment to migratory fish • Increased fish predation opportunities	
Other construction	Creation of lodges, burrows, canals, etc.	• Expansion in amount of aquatic habitat and attendant increase in habitat and species diversity and abundance		
Other				
Indirect habitat creation/restoration initiatives as a result of beaver presence	Beavers used to promote opportunities for riparian and freshwater habitat creation/restoration	• Beavers may be used to promote river restoration projects (as well as contributing to low-cost restoration through their own activities)		

4.10.2 Distribution of suitable running freshwater habitat in the beaver policy areas

4.10.2.1 Running freshwater habitat of conservation importance

To determine whether the activity of beavers on running freshwater habitat is significant in the context of this Strategic Environmental Assessment, the assessment of impacts (positive and negative) has focussed on those running freshwater sites for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded European or national protection wherever they occur. Shingle Islands SSSI is the only designated running freshwater habitat that lies within beaver policy area that overlaps with potential beaver core woodland.

Table 4.10.2 shows the running freshwater habitat that lie within the potential beaver core woodland in the beaver policy areas and the site for which it is designated. See Appendix for a map of all SSSIs including Shingle Islands.

Table 4.10.2 Summary of sites that overlap with potential core beaver woodland for running freshwater habitat features of conservation importance.

Running freshwater habitat	Designated site
River shingle/sand	Shingle Islands SSSI

4.10.3 Assessment of likely effects on ecologically important running freshwater habitat in the beaver policy area

The habitat identified in Table 4.10.2. above is discussed in the context of those effects (positive or negative) that have been identified as a result of beaver activity. Where mitigation or monitoring maybe appropriate, this has been identified in the narrative. Further discussion relating to the management of beavers including mitigation and monitoring options is provided in sections 5 and 7 respectively.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

Beaver opportunities

4.10.3.1 Consideration of potential positive effects on running freshwater habitats of conservation importance

Narrative is provided in section 4.10.1 above including reference to the likely positive effects of beaver activity on running water habitats in general. A summary of which is then provided in the Table 4.10.1 above. More than this, the presence of beavers in an area could provide a basis for river restoration projects (as well as contributing to low-cost restoration through their own activities).

RIVER SHINGLE/SAND

Knapdale

There are no sites identified in Knapdale that are designated for river shingle/sand habitat.

Tayside

- Shingle Islands SSSI

SSSI Assessment

Shingle Island SSSI, comprises several islands and stretches of riverbank in the lower reaches of the Rivers Tummel and Tay. A key feature of the site is its dynamic nature. The morphology of the features changes in response to high flows and results in a continuously changing mosaic of habitat in various stages of colonisation from bare shingle and sand to alluvial alder woodland, and includes old abandoned river channels and backwaters and mixed woodland.

As beavers are unlikely to dam rivers greater than 6 m wide and the Rivers Tummel and Tay are both significantly wider than this in the vicinity of the designated site, it seems unlikely that they would have any effect. Were any of the smaller, backwater channels that flow through some of the islands to be modified by beaver activity the modifications are likely to be temporary due to the energy of the rivers in the vicinity of the designated site. Additionally any changes are likely to contribute to the dynamic nature of the habitat. Therefore, while there are natural heritage interests of national importance on this site, these are unlikely be detrimentally affected by the beaver activity.

Mitigation
Mitigation is unlikely to be necessary but could involve a number of beaver management options as outlined in section 5 relating to preventing beaver access to the habitat or managing impact from damming activity such as use of flow device.

As beavers have colonised this stretch of riverbank and islands of the designated site they may alter the composition of any alluvial alder woodland present. See section 4.2 Beavers and Woodland for further consideration. See section 7 for details on the approach to SCM and beavers. As Stirling University have a long history of studying the fluvial-geomorphology and habitat change of Shingle Islands, there may be scope for a more detailed study if judged necessary.

4.10.3.2 Consideration of potential negative effects on running freshwater habitats of conservation importance
While table 4.10.1 above summarises a number of potential negative effects for running water habitat that could arise from beaver activity, these are not expected in the context of Shingle Islands SSSI river shingle/sand habitat.

4.11 Beavers and Fish

Our native freshwater fish can be broadly separated into diadromous and freshwater-resident species. Fish which are diadromous (i.e. migrate between fresh water and the sea to complete their life cycle) include Atlantic salmon, trout (as sea trout), European eel, brook, river and sea lamprey, sparling and the shads. Those species that, in Scotland, are found only in fresh water are Arctic charr, powan, vendace, pike, roach, perch, minnow and stone loach. Three- and nine-spined sticklebacks can utilise both freshwater and marine habitats.

All species, regardless of whether they are diadromous or freshwater-resident, may undergo migrations at some period within their life history. These movements may be ontogenetic (e.g. based on life stage) changes in habitat use, or migrations may be undertaken to allow fish to fulfil a specific function, such as spawning. Some species, such as freshwater-resident trout, and in some cases Arctic charr, may undertake movements from lochs to riverine spawning areas. Others, such as pike, roach and perch, may undertake migrations to particular habitats within lochs or large rivers to spawn. The timing and location of these movements varies significantly between species.

A summary (see Table 4.11.2) of the potential interactions between beavers and fish is presented below; where possible these have been attributed to a neutral, positive or negative effect.

4.11.1 How beaver activity affects fish

This complex ecology, as described above, means that many of our native fish species have the potential to interact with beavers and, in fact, these fish will have co-existed with beaver for millennia prior to their extinction in Scotland. Table 4.11.1 provides a summary of the perceived positive and negative impacts of beavers on fish derived from the published literature during a recent major review. The scale and direction of impact of beavers on fish will differ according to the species concerned and its ecology.

Table 4.11.1: Summary of the perceived positive and negative impacts of beavers on fish.

Positive impacts	**Negative impacts**
Enhanced habitat availability / complexity	Barriers to fish movement
Enhanced over-wintering habitat	Reduced spawning habitat
Enhanced rearing habitat	Altered temperature regime
Provision of cover	Reduced oxygen levels
Enhanced diversity/ species richness	Reduced habitat quality
Enhanced abundance / productivity	Altered flow regimes
Provision of habitat under low flows	Loss of cover
Provision of high flow refuge	Reduced productivity
Provision of temperature refuge	Reduced growth
Enhanced water quality	Abandonment of better settlements
Sediment trap	Reduced water quality
Enhanced invertebrate productivity	
Enhanced growth rates	
Enhanced fish condition	
Provision of fishing areas	

4.11.2 Evidence of beaver fish interaction

Eurasian beaver would have co-existed with native fish fauna in Scotland for millennia before the former species was extirpated. The absence of Eurasian beaver from the Scottish fauna for the last 500 years means that, prior to the SBT, nothing was known about the impact of this species on Scottish freshwater fish. The range of interactions, positive as well as negative, could, however, be inferred from the published work available before the trial.

Two SNH-commissioned reviews of the impacts of beaver on a variety of fish species have been carried out and these, together with more recently published data, were considered by the Beaver-Salmonid Working Group (BSWG).

Much of the published literature on the impacts of beavers on freshwater fish originates from North America and relates to the activities of the North American beaver. Far fewer data are available on the impact of Eurasian beavers on European fish species or fish communities. Some concern has been expressed about the extrapolation of data gathered relating to the impact of the North American beaver on fish to the European (or Scottish) situation, largely because of differences in habitat typology and dissimilarity in the range of species concerned, including salmonids. Regardless of these differences, the recent SNH review [and] the BSWG concluded that, in general, issues such as the removal of riparian vegetation and tree cover; ponding; inundation and impacts on sediment transport as a result of beaver dam construction; and hydrological alterations and their influence on fish migration can be considered to be impacts common to both species.

Eurasian beavers co-exist with fish throughout their geographical range. However, in areas such as Denmark, Finland, France, Norway and Sweden and some Baltic states, where beavers co-exist with high economic value species such as Atlantic salmon, there is surprisingly little published information relating to beaver–salmonid interactions. The information available has been reviewed within the BSWG report. Data relating to other, non-salmonid, species are also limited.

The conclusions reached in the available studies are mixed. This is also complicated by the fact that some of the data available come from areas where beavers have been reintroduced and management is varied. In Lithuania, where beavers were reintroduced in 1947, it has been recommended that beaver dams in the middle and lower reaches of trout-spawning streams should be removed to reduce impacts on spawning trout. In Scandinavia, where Atlantic salmon and beaver are both native, beavers have been actively managed for centuries and there is little published evidence of negative impacts.

Table 4.11.2: Summary of potential interactions between beavers and fish.

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• Increased light penetration may lead to increased production within streams, ponds and lochs. Increased primary productivity and temperature may increase production of aquatic macroinvertebrate prey items for fish. This could lead to increased fish productivity and improved individual growth rates • Increased temperatures may favour the establishment of non-salmonid species which have a higher tolerance to lower dissolved oxygen concentrations (such as cyprinids and sticklebacks) • Increased light may lead to the establishment of macrophyte communities, creating complex habitats that offer shelter to some fish species (such as pike, perch, roach and sticklebacks) and their prey • Penetration of light to the riparian zone may result in the development of plant communities that will stabilise banks, reduce erosion and provide increased opportunities for greater terrestrial input of food items for fish	• Reduction in shading has the potential to increase water temperature and result in increased thermal stress upon some fish species, particularly salmonids • Increased temperatures may favour the establishment of fish species which may compete with, or predate, salmonids • Increased temperatures can contribute to reduced levels of dissolved oxygen in some circumstances. This may be unfavourable for some fish species (such as salmonids)	Tree-felling may also undo some of the extensive tree-planting restoration work that has taken place in some catchments (particularly the upper areas of catchments, which have little natural tree cover)
Felling	Change in riparian	• Possible changes in the amount	• Possible reduction in type and	

	woodland: Change in relative abundance of different tree species	of allochthonous material derived from different sources (principally leaf litter), which may benefit some aquatic macroinvertebrates and potentially the fish which prey on them	quantity of allochthonous material (principally leaf litter) may lead to a reduction in aquatic macroinvertebrate community composition and production. This may negatively affect fish which prey on them • Possible reduction in the quantity of terrestrial (invertebrate) prey items that enter the aquatic environment as food for fish	
Felling	Change in riparian woodland: Change in age classes of trees	• Possible changes to tree age class in riparian or littoral areas may result in a more open canopy and increased light penetration, with consequent benefits for some species (see above)	• Loss of mature woodland may result in lesser quantities of allochthonous material entering waterbodies. This can affect macroinvertebrate production and therefore the production of fish • Possible reduction in size and quantity of large woody debris entering the watercourse in the longer term may affect in-stream habitat structure, and this may adversely affect some fish species • Possible changes to tree age class in riparian or littoral areas may result in a more open canopy and increased light penetration, with consequent negative effects for some species (see above)	Effects will depend on nature of changes, and the extent to which trees affected by beavers regrow. See Annex 1 Table 3.4.1 for beaver effects on woodland trees
Felling and construction s	Changes in amount/diversity of woody material in watercourses	• Greater quantities of large wood items in streams, rivers and lochs can result in increased habitat diversity and an increase in the	• The establishment of large log jams could hinder the in-stream movement of some fish species if they act as barriers	

		availability of prey items and fish cover • Where large woody debris occurs, it may reduce the transport of sediment downstream	• Depending on where woody items aggregate, such material can act as a barrier to movement or result in the loss of habitat • Where the quantity of large and small woody items is too great, this may result in blockages which may affect the transport of important gravels	
Feeding	Feeding on specific terrestrial herbaceous and aquatic plant species	• Changes to macrophyte community structure may favour some species of (non-salmonid) fish and their prey	• Decrease in macrophyte species in some lochs may have a negative impact on species that depend on them for food or shelter. Pike, for example, are often associated with macrophytes because they use these as cover when ambushing prey. Roach and perch may utilise macrophytes as cover from pike. Salmonids are rarely associated with macrophytes	See Annex 1, Table 3.7.for a summary of beaver effects on aquatic plants
Dams/pond creation	Change from lotic to lentic habitat	• Increase in habitat diversity, which may favour some fish species or fish life history (ontogenetic) stages. In some situations this may also result in an increase in species richness – of both fish and invertebrate prey items • Increased temperatures, changes in habitat availability and feeding opportunities in lentic habitats may result in increased individual growth rates, fish condition and overall production • Depending on depth and location,	• Increase in habitat diversity for fish may favour some species over others, or benefit only some life history stages (e.g. juvenile or adult fish) • Depending on location, the creation of lentic habitats may result in habitat loss for species which favour or dominate lotic habitats • Accumulation and smothering of bed sediment upstream of dams, and a reduction in habitat quality for some species (principally salmonids)	

		impoundments may offer a high-temperature refuge for some fish	• Reduction in turbulence (or mechanical mixing) may occur upstream of dams, resulting in a reduction in dissolved oxygen • Possibility of increased opportunities for fish predators (e.g. piscivorous birds, mammals such as otter, or man)	
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• Reduction in the transport of fine material may improve the quality of spawning and rearing habitats downstream of any impoundment • Impoundments may create low- and high-flow refuges for fish • Flooding of riparian and wetland habitats can provide spawning opportunities for species such as pike and additional habitat for species such as European eel	• Changes in flow may result in sediment starvation in gravel spawning areas. This can affect both salmonids and spawning lamprey • A reduction in flow downstream of the structure may result in a reduced wetted width and a loss of juvenile fish habitat	
Dams/pond creation	Changes in water quality downstream	• Reduction in the amount of fine material deposited on the stream or riverbed downstream of the impoundment. This may result in an improvement in the quality of gravel spawning areas (downstream) for salmonids and lamprey • Accumulation of fine sediments may increase the volume of available habitat for lamprey ammocoetes		
Dams/pond creation	Impacts on movement of species		• Prevention of the free movement of fish to all habitats required during their life cycle. This is particularly relevant to key migration periods (such as	

			spawning migrations), but also at other times • The scale of impact may be greater for species which have a limited ability to overcome in-stream obstacles (such as lamprey)	
Other	Fisheries		• Beaver habitats (impoundments and flooded wetlands) may benefit North American signal crayfish, an invasive non-native species, if these are present within the catchment	
Indirect habitat creation/restoration initiatives as result of beaver presence	Beaver used to promote opportunities for riparian and freshwater habitat creation/restoration	• Presence of beaver may act as an incentive for greater investment, management and monitoring. This could include those related to the restoration and management of riparian woodland	• Beaver presence may eliminate fish-related riparian woodland restoration activities that are currently under way	

4.11.2 Distribution of fish in the beaver policy area

The following section concentrates on those fish of conservation importance that are likely to overlap with core beaver woodland and as such maybe positively or negatively affected by beaver activity.

The potential overlap between beaver habitat and Atlantic salmon is described in section 4.2 of the Beavers in Scotland Report (see Annex 1). Dam-building activity will not occur in the downstream, wide and deep river sections of the Tay catchment, and indeed it is unlikely in much of the higher reaches where potential beaver habitat does not occur (Annex 1, section 4.2). However, dam- building and other beaver activity will continue to expand throughout the Tay catchment as the population increases and spreads (Annex 1, section 3.2).

4.11.2.1 Fish of conservation importance

To determine whether the activity of beavers on (native) fish species is significant in the context of this Strategic Environmental Assessment, the assessment of impacts (positive and negative) has focussed on those species for which beaver activity may affect directly or indirectly (as discussed above), which are considered as having conservation importance and as such are afforded European or national protection wherever they occur.

Table 4.11.3 below therefore identifies those fish of conservation importance that utilise 'potential beaver core woodland' (as described in section 4.1 of this report) and are found within the beaver policy areas.

Table 4.11.3: Summary of fish of conservation importance within the beaver policy area that overlap with potential beaver core woodland

Fish species	Conservation importance
Atlantic salmon	River Dee SAC River South Esk SAC River Spey SAC River Spey SSSI River Teith SAC River Tay SAC
Sea lamprey	River Tay SAC River Teith SAC River Spey SAC River Spey SSSI
River lamprey	River Tay SAC River Teith SAC
Brook lamprey	River Tay SAC River Teith SAC

4.11.3 Assessment of likely effects on fish of conservation importance in the beaver policy area

Each of the fish species identified in Table 4.11.3 above are discussed in turn below in the context of those effects (positive or negative) that have been identified as a result of beaver activity. Where this relates to a species included in the Habitats Regulation Appraisal of the policy, a summary of the advice from SNH, provided to inform an appropriate assessment (AA) of the policy with respect to SAC sites (see Annex 2 for the full advice) has been used (referred to hereafter as 'SNH HRA advice'). For the purpose of this assessment, the concluding points of the SNH HRA advice have been replicated where appropriate for each species. Assessment of other fish species (i.e. SSSI notified features), has been made in the context of the SNH HRA advice in combination with knowledge of the individual sites and their condition. Where mitigation or monitoring may be appropriate, this has been identified in the narrative. Further discussion relating to the management of beavers including mitigation and monitoring options is provided in section 5 and 7 respectively.

For species and habitats of conservation interest in the wider countryside there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary. This will be informed by a more strategic approach to management being developed in due course.

4.11.3.1 Consideration of potential positive effects on fish of conservation importance

ALL FISH SPECIES
The anticipated positive effects of beaver activity for the aforementioned fish species of conservation importance are discussed below in general terms. There is a role for further monitoring at each of the designated sites identified in Table 4.11.3 above, to assess such effects via the SCM process – further narrative is outlined in section 7 of this report.

Beaver foraging activity
Through foraging activity, beavers are able to change the structure of riparian woodland (see section 4.2), impacting on the amount of open canopy or age class of tree species or abundance of particular trees through their preference for certain tree species against their relative abundance. These changes can bring about positive effects for prey species or terrestrial input of food items and can creates suitable shelter areas for fish and their prey species to hide and rest. These indirect effects from changes to woodland habitat can be summarised as:

- Increased light penetration may lead to increased production within streams, ponds and lochs. Increased primary productivity and temperature may increase production of aquatic macroinvertebrate prey items for fish. This could lead to increased fish productivity and improved individual growth rates
- Increased light may lead to the establishment of macrophyte communities, creating complex habitats that offer shelter to some fish species (such as pike, perch, roach and sticklebacks) and their prey
- Penetration of light to the riparian zone may result in the development of plant communities that will stabilise banks, reduce erosion and provide increased opportunities for greater terrestrial input of food items for fish
- Possible changes in the amount of allochthonous material derived from different sources (principally leaf litter), which may benefit some aquatic macroinvertebrates and potentially the fish which prey on them

Beaver foraging on tree species creates woody debris that finds its way into streams, rivers and lochs either being abandoned after feeding or through creation of food caches for the winter. This has a number of indirect effects for fish, summarised as:

- Greater quantities of large wood items in streams, rivers and lochs can result in increased habitat diversity and an increase in the availability of prey items and fish cover
- Where large woody debris occurs, it may reduce the transport of sediment downstream

While beaver predominately feed on woody stems they also forage on herbaceous and aquatic plant species, the impact of which can benefit fish:

- Changes to macrophyte community structure may favour some species of (non-) fish and their prey

Beaver damming activity
The creation of beaver dams across a stream or river (<6m diameter) changes the habitat from a running water to one that is still. This change adds habitat diversity to the river or

stream which can provide in case situations benefits to fish and prey species. It also brings about a change to the environmental characteristics of the stream or river which can provide refuge for some fish or benefit growth rates. These effects from be summarised:

- Increase in habitat diversity, which may favour some fish species or fish life history (ontogenetic) stages. In some situations this may also result in an increase in species richness –of both fish and invertebrate prey items
- Increased temperatures, changes in habitat availability and feeding opportunities in lentic habitats may result in increased individual growth rates, fish condition and overall production
- Depending on depth and location, impoundments may offer a high-temperature refuge for some fish

Dams can also exert an effect on the hydrological processes of the river or stream, affecting the sediment transport and water quality as well as potentially creating new habitat available for fish, these indirect effects can be summarised:

- Reduction in the transport of fine material may improve the quality of spawning and rearing habitats downstream of any impoundment
- Impoundments may create low- and high-flow refuges for fish
- Flooding of riparian and wetland habitats can provide spawning opportunities for species such as pike and additional habitat for species such as European eel
- Reduction in the amount of fine material deposited on the stream or riverbed downstream of the impoundment. This may result in an improvement in the quality of gravel spawning areas downstream) for salmonids and lamprey
- Accumulation of fine sediments may increase the volume of available habitat for lamprey ammocoetes

Evidence from elsewhere in Europe
The table below (Table 4.11.4) provides a summary of impact of beavers on fish species of conservation importance, taken from studies in Norway (Atlantic salmon) and Denmark (brook lamprey) showing either a positive or neutral effect. The fish population monitoring carried out through the SBT at Knapdale did not feature Atlantic salmon or lamprey species.

Table 4.11.4: Summary of impact of beavers on fish species of conservation importance.

Species	Overview
Atlantic salmon	Dam construction led to the loss of some spawning habitat due to the siltation of gravels. Juvenile Atlantic salmon were found above dams. Authors state that while the hypothesis that beaver dams have had no impact on Atlantic salmon cannot be supported, neither can the view that fish are unable to negotiate beaver dams. Beavers constructed five dams which had the potential to prevent access to spawning areas. While there is the potential to negatively affect upstream and downstream migration of Atlantic salmon, the actual impact may be negligible due to the low frequency, small size and short lifetime of dams. The length affected was minor, but tree-felling resulted in a loss of shade over a greater area. There has been a simultaneous increase in beaver population size and Atlantic salmon catches over a 40-year period.
Brook lamprey	Dams are a complete barrier to brook lamprey, but they will not have an overall negative effect on this species.

Lastly, the presence of beaver may act as an incentive for greater investment, management and monitoring. This could include those related to the restoration and management of riparian woodland with associated benefits to fish species.

4.11.3.2 Consideration of potential negative effects on fish of conservation importance

ATLANTIC SALMON
Atlantic salmon are widely distributed across Scotland and within the network of Atlantic salmon SAC's. However, when considering the viability of individual populations it is important to consider the complex nature of Atlantic salmon populations within UK rivers. Stock structure can, for example, incorporate a variety of discrete populations each of which are adapted to complete their life history within certain geographical areas of a catchment. The time taken to smolt, the timing and duration of the smolt migration, time spent at sea and timing of return may all have a genetic basis. In terms of location, it is widely accepted that early running multi-sea-winter fish (known as the Spring stock component) tend to spawn in the upper catchments of rivers, and that late-running fish (Autumn spring stock component) may ultimately spawn in the lower reaches of river systems. Whilst this may be a simplistic view, it demonstrates that Atlantic salmon can, and often do, utilise the entire catchment during spawning time and for the production of juvenile fish.

The Spring stock component typically spawns in the upper reaches of rivers, and damming activity in areas downstream of such areas may have a negative impact on this portion of the Atlantic salmon stock. This life history type, which is included as a reason for selection in many Atlantic salmon SACs, has undergone a long-term national decline and remains a key issue for those involved in the maintenance of Atlantic salmon fisheries, as well as SNH. The resilience of migratory Atlantic salmon populations to new pressures is an issue that must be considered in respect of how beaver–salmon interactions are managed.

Knapdale
There are no sites in Knapdale designated for Atlantic salmon.

Tayside
- River Dee SAC
- River South Esk SAC
- River Spey SAC
- River Spey SSSI
- River Teith SAC
- River Tay SAC

SNH HRA advice
Eurasian beaver have the potential to impact Atlantic salmon populations within all of the affected, or potentially affected, SACs, listed above. Beaver activity may be restricted to certain areas of the catchment (with river width <6 m and presence of potential core beaver woodland) but the locations of impacts may be coincident with vulnerable life history types of Atlantic salmon (the 'Spring' stock component).

The building of dams in areas where river widths are <6m may have a particularly significant impact on the Spring stock component, or other fish which spawn in river tributaries which are narrow (i.e. <6m). Even if a dam does not form a complete barrier to upstream Atlantic salmon movement, delays caused by such an obstruction can increase the probability of predation, result in a loss of fish condition, and delay movement to a point where low water temperature becomes a physiological constraint. Barriers may also slow or prevent the movement of juvenile Atlantic salmon as they occupy all areas of suitable habitat, or impact the downstream movement of smolts.

To maintain the distribution of Atlantic salmon into such areas it is important to ensure that the passage of fish past any barrier is assured. This may be achieved through the easement or removal of barriers at certain times of year (e.g. during spawning time) or through the installation of devices such as flow management devices. However; it is unclear whether such a device could be used to assist the upstream migration of large Atlantic salmon (which is typical of 'Spring' fish) as it has not yet been scientifically tested in Scotland this regard.

Barriers and other in-stream/riparian beaver activities may impact sediment transport within rivers and streams, either directly or by influencing the hydrology of affected watercourses. This can negatively impact the replenishment of Atlantic salmon spawning areas.

SNH HRA advice conclude that there is the potential for beavers to have an adverse effect on site integrity of the SACs designated for Atlantic salmon through dam-building activities and other related activities. Mitigation to avoid these impacts is necessary. It is important to ensure that the passage of fish past any barrier is assured (this precautionary approach is currently needed due to the existing lack of understanding of the full details of any potential impacts on the SACs).

SSSI Assessment
Impacts to sea lamprey in the River Spey SSSI are likely to be similar to those described above for the River Spey SAC. There is therefore potential for beaver activity to adversely affect the natural heritage interest of national importance.

Mitigation
Mitigation to ensure passage may be achieved through the easement or removal of barriers at certain times of year important for salmon (i.e. during spawning and smolt emigration) or through the installation of flow control devices. However; it is unclear at this time whether flow control devices could be used to assist the upstream migration of large Atlantic salmon (which is typical of 'Spring' fish). If a beaver dam might cause an adverse effect on the integrity of the SAC and a flow control device might not allow passage upstream, then alternative mitigation measures which will allow passage must be put in place. These mitigation measures should be included in a Beaver Management Plan for the individual SACs, which should also set out in what circumstances there could be an adverse effect on site integrity, and a framework through which to implement any mitigation measures should they become necessary.
See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

BROOK, RIVER AND SEA LAMPREY
Little is known about intraspecific variation within lamprey species, although anadromous forms are not considered to 'home' to their natal streams in the same way as Atlantic salmon do. However, the distribution of lamprey within catchments does differ according to species: with Brook lamprey being more widely distributed within catchments, while Sea lamprey are typically found in the lower reaches of rivers, and River and Brook lamprey are more closely associated with the middle and upper catchment. Whilst most attention has focussed on upstream migrating adult fish, both Sea and River lamprey may spend significant time in areas affected by beavers prior to migrating to sea.

Knapdale
There are no sites in Knapdale designated for lamprey species.

Tayside

Sea lamprey	River lamprey	Brook lamprey
River Tay SAC	River Tay SAC	River Tay SAC
River Teith SAC	River Teith SAC	River Teith SAC
River Spey SAC		
River Spey SSSI		

Assessment
Eurasian beaver have the potential to impact lamprey populations within all of the potentially affected SACs through dam building restricting their movements. However, given the distribution of anadromous lamprey (particularly Sea lamprey) within river catchments where they are often restricted to the lower reaches of rivers and mainstems, the potential for impact by Eurasian beaver is not as high as it may be for Atlantic salmon. For instance Sea lamprey surveys have only ever found this species in rivers wider than 6m which means they are largely found outwith areas of beaver dam building activity.

The potential overlap with Brook lamprey, and to a lesser extent River lamprey, requires more consideration. Brook lamprey is not anadromous and remains in freshwater for its entire life cycle. Little is known about its movement within river systems, although it is clear that the species is mobile enough to utilise all available habitats within a river system. In the River Tay SAC Brook lamprey have a wider distribution than the other two species. Research in Denmark suggests that whilst dams are a complete barrier to Brook lamprey, they did not have an overall negative effect on this species and therefore may not undermine the conservation objectives. (See Annex 1 Table 3.13, page 84). The distribution of River lamprey within the SACs is less certain.

Barriers and other in-stream/riparian beaver activities may impact sediment transport within rivers and streams, either directly or by influencing the hydrology of affected watercourses. This can negatively impact the replenishment of lamprey spawning areas, which like those required for Atlantic salmon are clean, well oxygenated, gravels.

SNH HRA advice conclude that there is the potential for beavers to have an adverse effect on site integrity of the SACs designated for lamprey through dam-building activities and other related activities. Mitigation to avoid these impacts is necessary. It is important to ensure that the passage of fish past any barrier is assured (this precautionary approach is currently needed due to the existing lack of understanding of the full details of any potential impacts on the SACs).

Mitigation
The efficacy of flow management devices for the downstream movement of juvenile lamprey, and the upstream migration of adult (particularly river and sea) lamprey is unknown. If flow management devices are not effective at facilitating the movement of lamprey species across in-stream barriers, then consideration must be given to alternative mitigation measures. These mitigation measures should be included in a Beaver Management Plan for the individual SACs, which should also set out in what circumstances there could be an adverse effect on site integrity, and a framework through which to implement any mitigation measures should they become necessary.
See section 5 for beaver management techniques used to mitigate the impact of beaver foraging and damming activity. See section 7 for details on the approach to SCM and beavers.

4.12 Beavers and Population and Human Health

The following section provides narrative on how beaver activity affects population and human health.

4.12.1 Population - General overview

The Beavers in Scotland (BiS) report (Annex 1) summarised work that examined the interaction of beavers with the Human Environment. Beavers can provide a range of ecosystem services. These include ‘provisioning ecosystem services’ such as increased ground water storage, ‘regulation and maintenance ecosystem services’ such as flow stabilisation and flood prevention, and ‘cultural ecosystem services’ that relate to people’s recreational, educational and spiritual interactions with the environment. They can act as agents of natural change and restoration. These all contribute to human wellbeing and have socio-economic impacts

The BiS report also considered the socio-economic implications of beaver presence at both Knapdale and Tayside, the arguments of which are largely outwith the scope of the environmental assessment. However, it did illustrate the social value that some people and local communities place on having beavers reintroduced into the environment. This was further illustrated in the public support for beaver reintroduction which came out of a number of public consultation and survey exercises done since the late 1990s. These benefits include recreational and educational value, and the ‘non-use’ value attributed to the reintroduction of a charismatic species.

The differences in the natural environmental characteristics between the two Beaver Policy Areas have been highlighted throughout this report. Similarly, there are considerable differences in the human environment. Maps 18 and 19 in Appendix 1, illustrate the extent of the overlap between built up areas and the core beaver woodland. The Tayside catchment has a considerably greater amount of physical development than Knapdale, but in both cases the larger concentrations of built up areas, understandably, are largely outwith core beaver woodland. However, particularly in the Tayside Beaver Policy Area, there are a number of rural and remote properties that will coincide with core beaver woodland and the potential for impacts to built-up areas, roads, rail and other infrastructure that are hydrologically linked to areas used by beavers.

Flood risk

There is no data available at the moment to quantify the extent of any beaver influence but the understanding of flood risk is constantly developing. The National Flood Risk Assessment (NFRA) was published by SEPA in December 2011 and is to be re-released in 2018 to include among other factors:

- Improvements in our understanding of flood hazard;
- Consideration of communities across Scotland that have experienced flooding;
- Availability of climate change scenarios;
- Research and development that has refined understanding of impacts and influencing factors.

SEPA are also currently reviewing the methodology for designating Potential Vulnerable Areas (PVA) and expects to apply this from April 2017 with new Draft PVAs published at the end of the year. Local Authorities in the Tayside Beaver Policy Area, in line with LA across Scotland have recently published Flood Risk Management Plans and identified several Flood Studies. These took account of SEPA’s flood risk maps which are included in Appendix 1 (Maps 14 and 15 illustrate the coincidence of potential core beaver woodland and low probability flood risk in rivers). Strategic scale documents may consider the presence of beavers but impacts from the activities of beavers is likely to be at a local scale and may best be considered in Flood Studies.

Casework handled by SNH in the Tayside area highlights some of the issues and perceived issues arising from the presence of beavers in or near built-up areas where flooding is a hazard.

In Pitlochry, on the Moulin Burn, beavers had built a dam, enhanced a pre-existing pond and felled trees. This presented a flood hazard to the culverted burn and residential and commercial property on it. Following work from the Local Authority Flood Team to prevent further incursions from beavers present in the nearby River Tummel and with the advice and cooperation of the Flood Team the beavers were trapped and relocated out of the Burn.

In Bridge of Earn a family of beavers had set up a dam and lodge on a small stream running between a row of gardens and public open space. Downstream from the area is a PVA with constructed flood defences protecting several residential properties. It was feared by some local people and the Community Council that the presence of beavers increased the risk of blockage and consequent flooding. The Local Authority Flood Team were able to advise that this was a perceived rather than real risk and so beavers remain in the heart of the village with local impacts being managed by voluntary effort and riparian owners.

In July 2015 a significant flood event occurred in Alyth. This caused significant local damage to property and infrastructure both within and downstream of the town. Four footbridges collapsed, and a number of mixed commercial and residential properties were affected along with two electrical substations. This last resulted in around 700 properties being left without power. At least 59 properties and businesses were thought to be flooded internally. The presence of several families of beavers with associated lodges and dams upstream of the town was thought by some to have contributed to the flooding by the addition of debris which choked bridges and culverts. The flood event was described and investigated by the local authority, SEPA and SNH and reported in the Joint Agency Report on the Flooding in Alyth of 17 July 2015 *PKC, SEPA, SNH* September 2015. The report concluded that the presence of beavers upstream had little if any impact on the flooding either positively in attenuating the peak or negatively by adding to the debris. All the beaver dams present before the flood were present after the event.

There is also increasing interest in the role beavers may play in 'Natural Flood Management' (NFM) especially in situations where they may modify their local environments in higher, upstream catchment areas. Although there is information on the roles beavers can play in hydrological and geomorphological processes (e.g. section 4.10), it is less clear how this may contribute to NFM. SNH will therefore investigate opportunities for investigating this further.

Mitigation

Settlements with a history of flooding are well documented in the Tayside Policy Area. The presence of beavers may be perceived as increasing the risk to households. Whilst strategic scale documents could take account of the presence of beavers, impacts from the activities of beavers are likely to be at a local scale and may best be considered in Flood Studies or on a case by case basis.

There are a number of methods that can be used to protect infrastructure and settlements and in some cases it may be prudent to protect especially sensitive interests before problems arise. This is more achievable for small-scale structures, such as culverts under roads or in bridge design. Scotland could draw on European approaches to protection of settlements and GIS-based tools to identify areas where beaver activity is predicted to be more likely.

This will need to include guidance on management techniques (for both pre-emptive and reactive actions) and information on sources of advice and support. The effectiveness of beaver management in Scotland will increase over time as experience is gained and methods refined.

Section 5 also details the hierarchy of mitigation techniques that can be used to address impacts from beaver activities, including generic management and licencing approaches to more practical measures including those to address:

- Dam building activities
- Burrowing activities and
- Foraging activities

These mitigation measures apply to the potential negative effects identified in relation to beaver activity and infrastructure.

4.12.2 Human Health

The section below considers the health implications of the Policy. To ensure this issue is comprehensively reported, the following sections detail potential health interactions between beavers and humans. However, animals used for the Scottish Beaver Trial (SBT) were quarantined and screened before and monitored after, release, and there was a programme of public health monitoring at Knapdale. A sample of Tayside beavers were also tested for a range of parasites and diseases and no evidence was found of pathogens that may cause an increased health risk to humans, livestock and other wildlife.

The conservation translocation of a species involves a whole ‘biological package’, reflecting the assortment of bacteria, viruses, fungi, parasites and other micro- organisms which any single animal or plant, such as a beaver, may naturally harbour. Some of these additional organisms have the potential to become pathogenic (i.e. capable of causing disease), while others may be present (although not necessarily prevalent) and exert no discernible effect upon its host or the wider receiving environment.

These additional organisms have the potential to influence the fitness and survival of individual beavers. Translocated animals may be vulnerable to stress-induced immunosuppression, or a lack of acquired immunity from previous exposure. Existing wildlife may act as a reservoir for infection and could ultimately affect the success of any reintroduction project. Populations of wild and domesticated animals and humans alike could be at risk through the transfer of new zoonotic diseases or the addition of new transmission pathways for existing pathogens.

Clinical veterinary examination and screening is therefore a fundamental part of understanding how disease transfer mechanisms influence beaver health and survival as well as the risk to wider indigenous, domestic and human populations. Reintroduction is increasingly being used as a conservation tool with at least 203 known beaver translocation projects (outside the former Soviet Union) since the first known reintroduction in Sweden in 1922. Despite long-standing recommendations and a general acceptance that pre-release health screening is good practice, little baseline health status information has been published for many translocated species, including beaver.

Eurasian beavers host a number of external and internal parasites. A list of common European rodent diseases and parasites associated with beavers has recently been compiled. Some of these are already present in the UK (e.g. *Cryptosporidium parvum*) and some are not (e.g. *Echinococcus multilocularis*). Many of these rodent diseases and parasites have the potential to cause zoonotic diseases and may be notifiable and/or reportable in the UK.

Beavers may be involved in the transfer and hosting of diseases and parasites in three main ways:

1. Beavers acting as a mechanism for the introduction of new or eradicated diseases and parasites, and acting as potential transmission routes for the infection of humans, domesticated livestock and existing wildlife.
2. Diseases and parasite transfer from existing wildlife populations to translocated and wild beavers (see Annex 1 section 4.6).
3. Beavers acting as a reservoir host for infectious diseases and parasites already present in Scotland, with potential transmission routes for infection of humans, domesticated livestock and existing wildlife.

Prior to the Scottish Beaver Trial (SBT), little information was published on beaver health surveillance, disease or mortality despite the relatively large number of beaver translocation projects across Europe and elsewhere. A beaver health surveillance programme for the SBT was established that addressed International Union of Conservation of Nature (IUCN) and governmental guidelines, as well as public health concerns. This included pre-release health screening and regular post-release monitoring including the post mortem examination of all cadavers. It was used as a template for a health screening programme carried out on a sample of live and dead beavers from Tayside. During the SBT there was also public health monitoring by independent local authority specialists. At a wider scale, and once the SBT was completed, the Centre of Expertise on Animal Disease Outbreaks (EPIC) also undertook a public health risk assessment of *Cryptosporidium* and *Giardia* posed by beavers in Scotland.

The commentary provided below explores the influence of beavers on the potential for disease transfer to humans and makes reference to interaction with existing wildlife and domesticated animals where relevant. Each parasite / disease is discussed in turn with an overview of the life cycle and how this involves beavers and human populations. The implications from which are then discussed with respect to the two beaver areas and policy.

4.12.2.1 Introduction of new or eradicated diseases

Beavers acting as a mechanism for the introduction of new or eradicated diseases and parasites, and acting as potential transmission routes for the infection of humans, domesticated livestock and existing wildlife

ALVEOLAR HYDATID TAPEWORM ECHINOCOCCUS MULTILOCULARIS

Beaver-parasite-human interaction

E. multilocularis is one of the most pathogenic parasitic zoonoses in the northern hemisphere and is the causative agent of alveolar echinococcosis disease in humans
It is endemic in large parts of Europe and has recently been identified in Sweden. Adult tapeworms live in the small intestine of the definitive (final) host, usually red foxes. Eggs are shed into the environment with host faeces. Small mammals, which are the main intermediate host, are then infected through ingesting parasite eggs. The indirect wildlife-based life cycle is then completed by carnivorous predation of an infected intermediate (non-egg-shedding) host.

Infection of unusual intermediate hosts, such as beavers, occurs through an increase in infected foxes leading to heavy environmental contamination with eggs. The first cases of beaver infection were reported in Switzerland and Austria, and more recently in Serbia

Finland, Ireland, Malta and the UK are considered free of *E. multilocularis*, and in order to maintain this status these countries are obliged to implement surveillance programme aimed at detecting the parasite in any part of the country (Regulation (EU) No 1152/201130). As with previous surveys, the recently published report on the 2012-2013 surveillance of UK fox populations did not identify any *E. multilocularis*. The translocation of beavers from central Europe is generally accepted to present a risk of importing the disease.

Implications of beaver policy
Beavers imported for the SBT were not considered to present a risk, as the donor country, Norway, was considered free of *E. multilocularis*. At the time of trapping, there was no diagnostic test available for live animals.

The animals on Tayside were from unknown sources. Recently developed techniques, including in-field laparoscopy and abdominal ultrasound, were used to diagnose *E. multilocularis* abdominal lesions together with corroborative immunoblotting. None of the beavers tested from the Tayside catchment using these techniques were positive for *E. multilocularis.*

Previous assessments have concluded that the risk of this tapeworm becoming established as a result of infected beavers imported from *E. multilocularis*-free areas is negligible, and is low but very uncertain for those from endemic areas.

It follows, therefore, that the risk appears negligible for the beavers at Knapdale, as well as for other wildlife and humans. The risk associated with any future releases of beavers at Knapdale would need to be re- assessed, taking into account the origin of the animals. The situation at Tayside is more complicated in that the origin and health status of the entire beaver population is unknown, although no evidence of *E. multilocularis* has been found in the sample tested.

Mitigation
Health assessment and pathogen screening before release of any animal is regarded as a key requirement in any translocation. There is now an effective diagnostic test for live animals, together with serological screening. Such testing would provide further reassurance that the parasite does not become present in the wild in Scotland as a result of any beaver translocation and therefore not pose any threat of human infection.

RABIES

Beaver-parasite-human interaction
Rabies is an acute infection of the central nervous system caused by a lyssavirus of the Rhabdoviridae family. It affects all mammals, including humans, and the main reservoir is wild and domestic canids (e.g. dogs, wolves and foxes). The notification of rabies in humans and animals is mandatory in most member states across Europe.

The last case of classical (sylvatic) rabies in an animal outside of quarantine in the UK (a dog in Newmarket) was in 1970, although the related European Bat Lyssavirus, which causes the same clinical symptoms as classical rabies, has been recorded in a small number of wild British Daubenton's bats since 2002. The last case of human terrestrial rabies acquired in the UK was in 1902; however occasional travel-related cases do occur. Between 2000 and 2012, there were five cases of imported human rabies in the UK. There were no human cases of rabies infection in the UK in 2013.

The import of beavers to the UK is subject to strict animal health and disease-control legislation, notably The Rabies Importation (Dogs, Cats and other Mammals) Order 1974 (as amended) as well as The Balai Directive. The quarantine period, where required, is deemed sufficient to prevent the entry of rabies.

Implications of beaver policy
A total of 27 European beavers were imported from Norway for use in the SBT. They were quarantined for a period of six months during which time six individuals died with no common cause identified. In view of these mortalities, and the fact that Norway is considered free of classical (sylvatic) rabies, the RZSS received permission to import a further four Norwegian beavers without the full quarantine requirements. This was subject to strict criteria, including the need for four weeks' quarantine in Norway under veterinary supervision.

Mitigation
There is no reason to believe that any further import of beavers for Knapdale, would increase the risk of rabies, provided appropriate statutory animal health procedures are followed.

TUARAEMIA (*FRANCISELLA TULARENSIS*)

Beaver-parasite-human interaction
F. tularensis is an intracellular bacterium found in a wide range of invertebrates, birds and mammals, with transmission to humans causing tularaemia via contamination of food or water, or through bites from infected insects. It has a broad geographical distribution across Europe but does not occur in the UK. Human outbreaks appear to follow outbreaks in rodents, examples include common voles and water rat in the Russian Federation as well as vole and hare populations in Sweden.

It is thought to be spread in the environment by rodents, particularly water voles but also squirrels (Sciuridae), muskrats *Ondatra zibethicus*, beavers and rabbits (Leporidae). However, there is no evidence to suggest that any of these species constitute a natural reservoir of this bacterium.

Implications of beaver policy
None of the 29 beavers tested at Knapdale were antibody positive for *F. tularensis*, nor were any of those tested at Tayside.

Mitigation
Health screening during quarantine provides an opportunity to test for infection with *F. tularensis* and, if necessary, to act accordingly to ensure that the UK remains free of the pathogen. If captive animals already present in the UK were used to bolster the population at Knapdale, then they would require screening for *F. tularensis* (and other pathogens/parasites) as they may not have been subject to any additional health testing during the original rabies quarantine.

4.12.2.2 Beaver acting as a reservoir host
Beavers acting as a reservoir host for infectious diseases and parasites already present in Scotland, with potential transmission routes for the infection of humans, domesticated livestock and existing wildlife.

LEPTOSPIRA SPP.

Beaver-parasite-human interaction
Leptospira bacteria have been found in virtually all mammalian species and the associated pathogenic disease, leptospirosis, is the most widespread zoonosis worldwide present in all continents except Antarctica. Humans most commonly acquire infection through

occupational, recreational or domestic contact with the urine of carrier animals either directly or via contaminated water or soil.

There is a general paucity of information exploring the relationship between beavers and Leptospira spp, although it has been documented in North American beavers from a number of Swiss zoos. Elucidation of the role of free-living beaver as a potential reservoir host for Leptospirosis was attempted in South-West Germany through examination of kidney tissue of 26 beavers found dead. Whilst positive results were detected in four of the beavers, cause of death was not attributed to pathogen infection. Infection in humans is usually associated with recreational activities (e.g. triathlon) with the transmission pathway via contaminated water and small skin lesions or other injuries.

Implications of beaver policy
Pre-release testing at Knapdale found five animals positive for Leptospira antibodies. Post-release testing found two animals seropositive for Leptospira. None of the 17 beavers tested positive at Tayside.

Given the widespread nature of Leptospira infection (160 mammalian species have been identified as a natural carrier) and the lack of evidence of beaver as a reservoir host, it would seem likely that the additional risk to existing wildlife populations at Knapdale and Tayside, and therefore onwards to humans, would be minimal.

Mitigation
Continued health surveillance of both beaver populations would help to verify this assessment in the longer term. Any significant increase in beaver numbers across Scotland in the longer term could conceivably lead to a greater overlap of human recreational activity in areas inhabited by beavers. However, the risk of acquiring leptospirosis appears to be highest among farmers, veterinarians and sewer workers, who all work around animals, rather than among those engaged in recreational activity.

CRYPTOSPORIDIUM **SPP.**

Beaver-parasite-human interaction
Cryptosporidium species are intestinal, protozoan parasites of mammals that cause cryptosporidiosis, the symptoms of which may include life-threatening diarrhoea in immunosuppressed humans and young livestock. Disease in humans is predominantly caused by *C. parvum* and *C. hominis*. Rodents are considered important reservoirs of the parasite. It is considered endemic in most cattle holdings and is common in sheep and deer. Cryptosporidiosis is relatively common in animals in Great Britain. Infection in humans most commonly occurs through the consumption of food or water, but can also occur through the exposure to faeces in the environment, contact with infected animals and person-to-person contact.

Cryptosporidium are shed from the gut in faeces as environmentally-resistant oocysts which are able to survive in water or moist soil for several months. Faecal screening of 182 beavers in Norway found no oocysts in any sample despite the frequent occurrence of oocysts in surface water sources.

Implications of beaver policy
No *Cryptosporidium* was detected from beavers screened during quarantine and prior to release at Knapdale. *Cryptosporidium* was detected in a dead wild-born beaver kit at Knapdale, suggesting that the parasite was acquired from existing sources in the wider environment. One beaver from Tayside was found to be positive for *Cryptosporidium* following faecal examination. The individual was in good body condition with no signs of ill health.

Public health monitoring at Knapdale showed that *Cryptosporidium* is present in the existing wild mammal population. Many of the surface waters across Scotland are contaminated with *Cryptosporidium*. The additional risk to human health from the presence of beavers in Knapdale has been assessed as very low.

At a wider scale, the Centre of Expertise on Animal Disease Outbreaks (EPIC) consider the likelihood of beavers acting as an important source of contamination of *Cryptosporidium* to water supplies as 'very low to low (high uncertainty)' in the context of other sources of contamination, such as humans, livestock, other wildlife and domestic animals.

Mitigation
As a precaution, and to provide further reassurance, it has also been recommended that there is enhanced surveillance of human cases for a set period; further reintroduction proposals should be discussed with local authority environmental health teams and Scottish Water to allow levels of risk to be evaluated; and best practice in relation to public and private water supplies should continue to be promoted.

GIARDIA DUODENALIS

Beaver-parasite-human interaction
Giardia duodenalis (also known as *G. lamblia* or *G. intestinalis*) is an intestinal, protozoan parasite of mammals. It causes giardiasis, the most common cause of parasitic, diarrhoeal disease in humans worldwide. It was the most frequently raised public health issue relating to beavers prior to the SBT, perhaps because giardiasis is sometimes referred to as 'beaver fever' in North America.

Studies of *Giardia* prevalence showed rates of 8% in Eurasian beavers in Poland, and 7–16% in North American beavers in the USA. In comparison, other semi-aquatic rodents, such as muskrats, are thought to constitute a more important reservoir with a much higher prevalence of 37–96%.

Faecal screening of 241 beavers in Norway found no *Giardia* cysts, despite the frequent presence of the parasite in Norwegian surface water sources. A 2002 study noted that there had been no waterborne outbreaks of giardiasis reported in Norway despite having a beaver population of over 50,000 animals at the time, and the rate of giardiasis in the human population was similar to that of Scotland that had no beavers (with most cases originating from travel abroad).

A single study in Colorado found that beavers shed *Giardia* cysts in their faeces throughout the year, with temporal variation in prevalence. They became infected as kits and remained so into adulthood, presumably related to their coprophagic (eating of faeces) behaviour. This led to the suggestion that beavers act as an 'amplification host'.

Implications of beaver policy
Giardia was not detected during the screening of the Knapdale beavers, before or after release. This suggested that no transfer had occurred from wildlife populations to beavers during the trial, and therefore it was also unlikely that any of the beavers acted as a reservoir for other wildlife populations. There were similar observations at Tayside, with no detection of *Giardia* in beavers.

Public health surveillance monitoring carried our as part the SBT assessed the additional risk to human health from the presence of beavers in Knapdale as very low. While the presence of *Giardia* cysts in the watercourses at Knapdale means there is potential for individual beavers to become infected, it should be noted that there has been no evidence to date of such transmission occurring in Norway.

Mitigation
Continued health screening of beavers to confirm the presence of this parasite in the beaver populations at Knapdale and Tayside would also help elucidate any amplification role given the lack of evidence for this in the published literature.

At a wider scale, EPIC considers the likelihood of beavers acting as an important source of contamination of *Giardia* to water supplies as 'very low to low (high uncertainty)' in the context of other sources of contamination, such as humans, livestock, other wildlife and domestic animals. However, as a precaution, and to provide further reassurance, it has also been recommended that there is enhanced surveillance of human cases for a set period; further reintroduction proposals should be discussed with local authority environmental health teams and Scottish Water to allow levels of risk to be evaluated; and best practice in relation to public and private water supplies should continue to be promoted.

4.13 Beavers and Cultural Heritage

4.13.1 How Beaver activity affects the Cultural Heritage

Historically important monuments and structures

As detailed in section 4.1, beavers are burrowing animals that dig into banks along suitable water courses, lined with deciduous tree cover to create dens. They will also utilise suitable islands for shelter and foraging. They create scrapes, slides and bankside dens in particular areas of their territories and will therefore have an impact upon some banks of watercourses. They dive to shallow depths to dig up tubers of aquatic plants and use nearby bankside mud when building lodges and dams. In the course of constructing these, trees are felled and the timber floated to the required location. Accordingly, there is the potential for beaver activity, for example through burrowing causing subsidence, or dam-building causing localised floods, to affect historic sites.

There appear to be no documented cases of beavers damaging archaeological sites, but beavers' use of timber for construction material and underwater foraging could mean that any exposed timbers or archaeological deposits on, for example, crannog sites could be at risk from disturbance. In addition to potential direct impacts on submerged features from the above activity, the potential for changes in water levels which could affect the preservation of organic remains on such sites.

Gardens and Designed Landscapes

Ornamental gardens and ponds that connect to watercourses may be occupied by beavers. In most cases they may not be present for very long, but they can radically alter the aesthetic appearance by felling ornamental trees, burrowing or feeding on garden plants. Ornamental gardens and arboreta are relatively common features in Scottish, and the wider British, landscapes, with some being of international importance. Large specimen trees in the vicinity of watercourses can be readily protected, although this may be harder for multi-stemmed shrubs or other palatable vegetation. It is likely that they will feed on a range of plant species that do not occur in their natural habitats.

Other cultural benefits derived from the reintroduction of Beavers

The Beavers in Scotland (BiS) report studied the interaction of beavers with the Human Environment. This considered the socio-economic implications of the reintroduction policy, the economic arguments of which are largely outwith the scope of the environmental assessment. However, it does illustrate the cultural value that people and local communities place on having beavers reintroduced into the environment. This was illustrated in the public support for the reintroduction which came out of the public consultation and survey work in particular. These benefits include recreational and educational value and a 'non-use' value attributed to the reintroduction of a charismatic species.

Table 4.13.1 Summary of positive and negative effects of beaver on cultural heritage interests

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• Increase in amount of light reaching watercourses and therefore stabilisation of banks and reduction in erosion due to binding effect of bank and riparian species, could help to protect historically important features within the riverine area	•	
Felling	Change in riparian woodland: Change in relative abundance of different tree species	•	• Possible reduction in deep-rooted species that bind bank material and therefore possible increase in erosion. • Felling of trees of commercial or ornamental value.	
Felling and Constructions	Changes in amount/diversity of woody material in watercourses	• Increased number of wood jams, resulting in attenuation of flow and lowering of downstream flood risk and improvements in water quality as fine sediments settle in areas of slower flow • Maintaining water levels which could help in the preservation of submerged organic remains.	• Increased number of wood jams so a possibility of localised floodplain inundation and impacts on historic land use.	
feeding	Feeding on specific terrestrial herbaceous and aquatic plant species		• Underwater foraging could mean that any exposed timbers or archaeological deposits could be at risk from disturbance. • Feeding on specimen trees, shrubs and garden plants could impact on the quality of gardens	

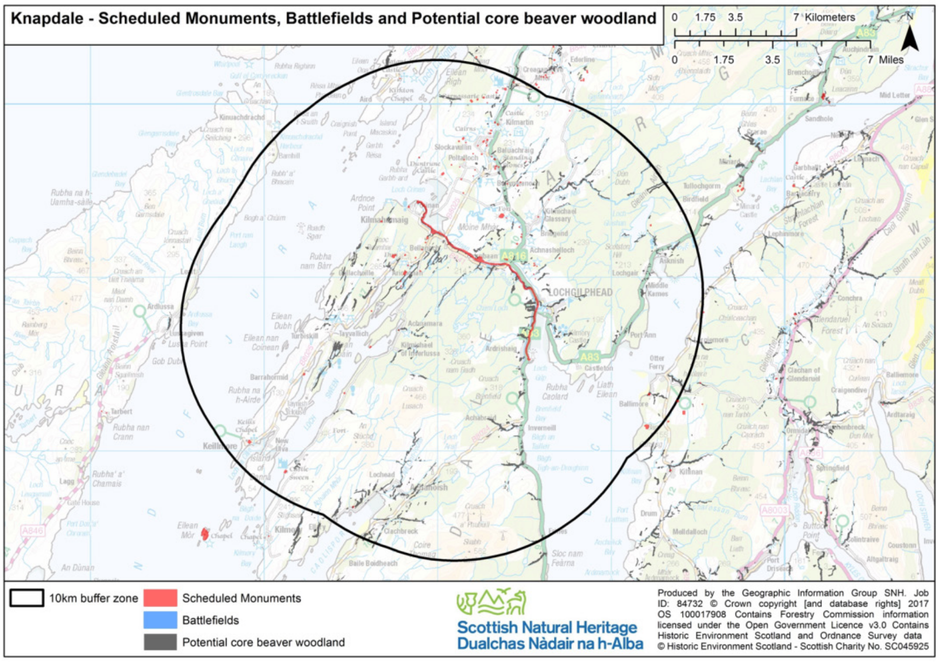
			and designed landscapes	
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• Hydrological cycle and water flow maintenance: - increased flood storage, and therefore a decrease in downstream flooding, maintaining water levels which could help in the preservation of submerged organic remains.	• Increased flooding of riparian zone and beyond, so potential impacts on historic land uses such as historic gardens and designed landscape, encampments, settlements and field systems within riparian areas • Flooding of terrestrial land upstream/adjacent to lochs may result in deterioration of water quality through decay of vegetation and leaching of nutrients from soils	
Dams/pond creation	Changes in water quality downstream	• Bio-chemical remediation, e.g. beaver dams reduce the rate of erosion and sediment movement, and therefore the speed at which sediment leaves streams and rivers which could help protect submerged archaeological remains • Creation of ponds on inflow waters may lead to improvement in the quality of water in the receiving waterbody through attenuation of flow, sedimentation of solids and assimilation of nutrients within the ponds	• Reduction in turbulence upstream of dam, and so a decrease in the rate of water oxygenation • Creation of ponds on inflow waters may lead to deterioration of water quality of loch inflows through changes in pH, a decrease in dissolved oxygen levels, a build-up of pollutants and disturbance within the ponds which could have an effect on submerged archaeological remains	
Other constructions	Creation of lodges, burrows, canals etc.		• Burrowing activity affects flood defences, sites of historical importance such as	

			canals, crannogs, moats, earthworks etc.	
Other		• Various 'cultural ecosystem services' related to recreational, educational, aesthetic and symbolic aspects		These types of impacts are not connected to any single beaver activity *per se*, and may relate to the mere presence of beavers (e.g. as an 'iconic' animal). Also relates to socio-economic 'existence' values, and the bequest value for future generations.
Indirect habitat creation/restoration initiatives as result of beaver presence	Beaver used to promote opportunities for riparian and freshwater habitat creation /restoration	• Restoration of riparian habitat, aquatic and wetland, for example by extending 'buffer zones' along the edges of watercourses, is likely to result in improvements to water quality of standing waters, restore natural connectivity in wetland–loch systems and benefit habitat and species (including those which may be otherwise adversely impacted, e.g. aspen), with consequent 'cultural ecosystem services' benefits		This may include positive impacts on tourism (e.g. for wildlife watching associated with riparian and freshwater habitats). Also relates to socio-economic 'existence' values, and the bequest value for future generations

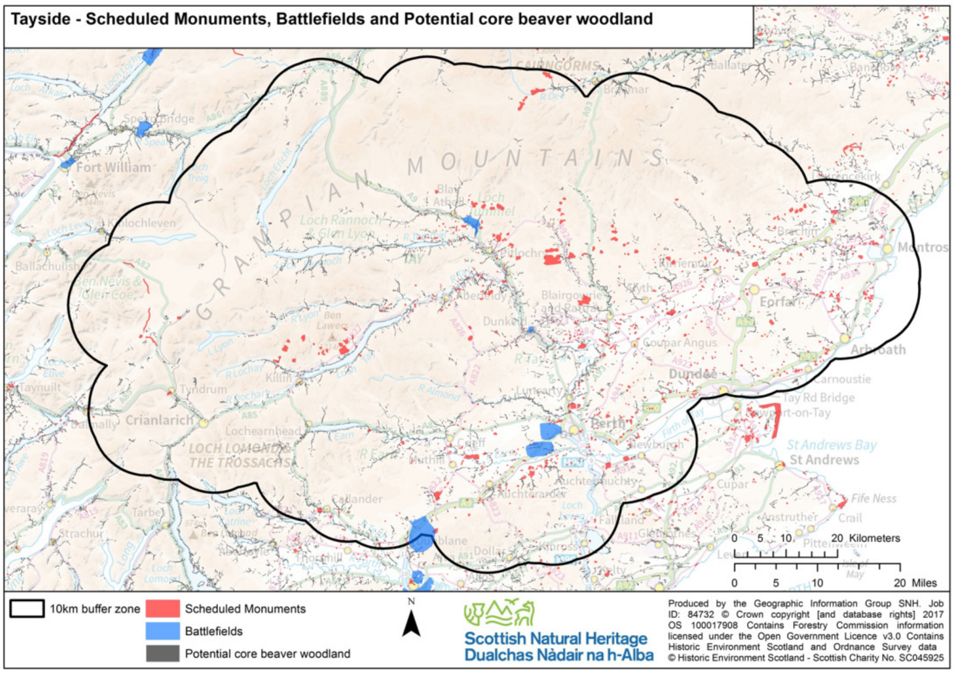
4.13.2 Distribution of historically important monuments and structures within Policy Areas

4.13.2.1 Scheduled monuments in Knapdale and Tayside

Maps 20 and 21 and table 4.13.2 below detail the sites and locations of Scheduled Monuments within the Knapdale and Tayside potential core beaver woodland Policy Areas. Within this area beaver activity and impacts will be restricted to some freshwater features and the immediate riparian habitat. For ease of reading, larger maps are also included at A3 size in Appendix 1.



Map 20 Knapdale Scheduled Monuments, Battlefields and potential core beaver woodland



Map 21 Tayside Scheduled Monuments, Battlefields and potential core beaver woodland

Table 4.13.2 Scheduled Monuments and potential core beaver woodland in the beaver policy areas

Scheduled Monument title	**Policy area**
Achnamara, clapper bridge, Knapdale	Knapdale
Barnluasgan, enclosures	Knapdale
Cnoc Mhic Eoghainn, motte 170m WSW of Ballimore	Knapdale
Crinan Canal, Cairnbaan - Ardrishaig	Knapdale
Crinan Canal, Crinan to Cairnbaan	Knapdale
Crinan Canal, Loch a' Bharain canal feeder	Knapdale
Loch Coille-Bharr, mill and lade, Knapdale	Knapdale
St Columba's Cave, cave and chapel, Knapdale	Knapdale
Ardblair Castle, earthwork	Tayside
Ardoch, Roman military complex 900m NNE of Ardoch Bridge	Tayside
Auchenlaich, fort	Tayside
Auchrannie, enclosure	Tayside
Balhomie, cup-marked stone	Tayside
Balintyre, homestead	Tayside
Ballownie, mound	Tayside
Balnaguard, settlements & field systems	Tayside
Bandirran, stone circle & standing stones	Tayside
Bertha, Roman fort	Tayside
Bochastle Roman fort, temporary camp and prehistoric enclosures	Tayside
Braclaich, deserted township & field system	Tayside
Broich, cursus, ring-ditch, barrow & palisade 600m SE of Duchlage	Tayside
Campsie Linn, grange site	Tayside
Cardean Roman Camp and pre-historic barrow, Wester Cardean	Tayside
Cardean, Roman fort 230m NW of Cardean Mill	Tayside
Carnbane Castle, Glen Lyon	Tayside
Castle Campbell	Tayside
Castle Hill, motte W of Mains of Cargill	Tayside
Clunie, Castle Hill and The Ward, motte,castle and settlement	Tayside
Colliston Castle, enclosure, souterrain, ring ditches & pit alignment	Tayside
Comrie Castle	Tayside
Cragganester, farmsteads, field systems, shielings and roadways	Tayside
Craig Hill, fort and broch	Tayside
Creag Eilid, settlements, field system and cairn	Tayside
Damside, fort	Tayside
David's Hill, enclosure	Tayside
Doune Castle	Tayside

Doune Roman Fort, fort 60m S of Doune Primary School	Tayside
Duncroisk, cup & ring marked rocks	Tayside
Dundurn Fort, fort St Fillan's Hill	Tayside
Dunkeld Cathedral	Tayside
Edinchip, chambered cairn	Tayside
Elcho Castle	Tayside
Finavon Castle	Tayside
Findynate, homestead	Tayside
Fisherhills, fort	Tayside
Foirche, settlement, Dalshian	Tayside
Friock Mains, pit alignment	Tayside
Glasclune Castle	Tayside
Glenbran, ring fort	Tayside
Gleneagles Castle, tower and earthwork	Tayside
Grassy Walls, Roman camp and prehistoric settlement, Sheriffton	Tayside
Haugh of Grandtully, fort	Tayside
Huntingtower Castle	Tayside
Hurly Hawkin, enclosure, broch and souterrain	Tayside
Inchbervis Castle	Tayside
Inchrye, motte	Tayside
Inchtuthil, Roman fortress	Tayside
Innerpeffray Wood, Roman camps	Tayside
Innes Bhuidhe, forts, NE of Bridge of Dochart	Tayside
Invercauld Bridge	Tayside
Invergighty Cottage, barrow cemetery N of Boysack	Tayside
Invermark Castle and township 220m SW of House of Mark	Tayside
Inverquharity, Roman fort, Roman camp and Iron Age settlement	Tayside
Invervar, shrunken township, Glen Lyon	Tayside
Kerrowmore, motte and settlement 590m S of Innerwick	Tayside
Kilspindie, unenclosed settlement N of Mill House	Tayside
Kinclaven Castle	Tayside
Kinnaird, settlements & field systems	Tayside
Lassintullich, St Blane's Chapel	Tayside
Loch of Kinnordy, crannog 500m NW of Balbrydie	Tayside
Lochleven Castle	Tayside
Lowbank, souterrain	Tayside
Lui Water, townships 800m to 2780m SE of Derry Lodge	Tayside
Lundin, dun	Tayside
Meikleour House, motte	Tayside
Millearnwood, Roman Road, 450m N of Raith	Tayside
Millhaugh, enclosures and other cropmarks	Tayside
Milton of Ogil ring ditch	Tayside
Moulinearn, military bridge, Mill Lands of Dalcapon	Tayside
Netherton, enclosure	Tayside
Newhall Bridge, two standing stones	Tayside
Old Faskally Farm, church	Tayside
Old Lawers Village, deserted settlement, Lawers Acres	Tayside
Orchill Fort, fort 450m NNE of Orchill	Tayside
Panmure Castle and Moat	Tayside
Parkhead, ring-ditch, souterrain and enclosure	Tayside
Pitcarmick Estate, settlements, field systems and cairns	Tayside
Pitmiddle, deserted village	Tayside

Pitroddie Farm, souterrain and unenclosed settlement	Tayside
Powmouth, settlement 400m E of Haughs of Kinnaird	Tayside
Prince Charlie's Bridge, military bridge, Dalcapon Wood	Tayside
Rait Hill, fort	Tayside
Restenneth Priory	Tayside
Ryehill, unenclosed settlement	Tayside
St Blane's Chapel	Tayside
Stormont Loch, crannog	Tayside
Stracathro, Roman fort and camp	Tayside
Strageath Mains, Roman fort, annexe and field system	Tayside
Strowan Church, church and burial ground	Tayside
Tirai, settlement and standing stone	Tayside
Tom na Croiche, castle	Tayside
Tyndrum, lead mines and associated remains	Tayside
Vayne Castle, castle 290m SSW of Vayne	Tayside
Wester Tullich, sulphuric acid works	Tayside
Whiteloch, ring-ditch	Tayside

4.13.2.2 Battlefield sites

The table 14.13.3 below and maps 20 and 21 above and in Appendix 1 detail the location of the Battlefield sites within the Tayside beaver policy area. Within this area beaver activity and impacts will be restricted to some freshwater features and the immediate riparian habitat.

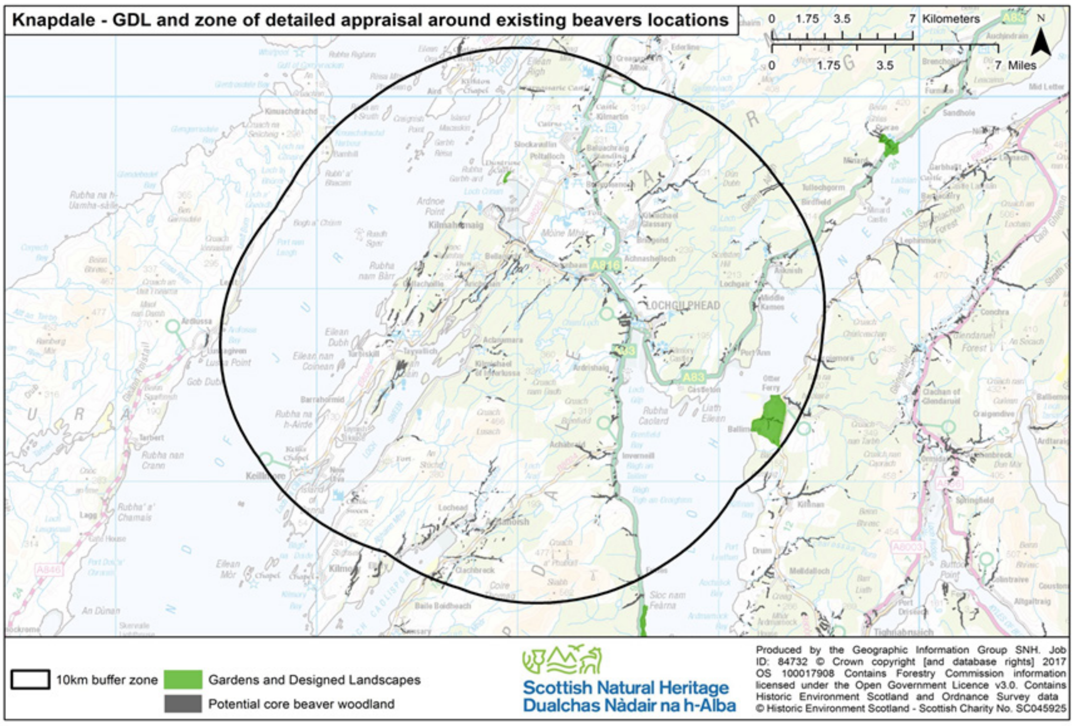
There are no battlefield sites in Knapdale which overlap with potential core beaver woodland.

Table 4.13.3: Battlefield sites and potential core beaver woodland in the beaver policy area

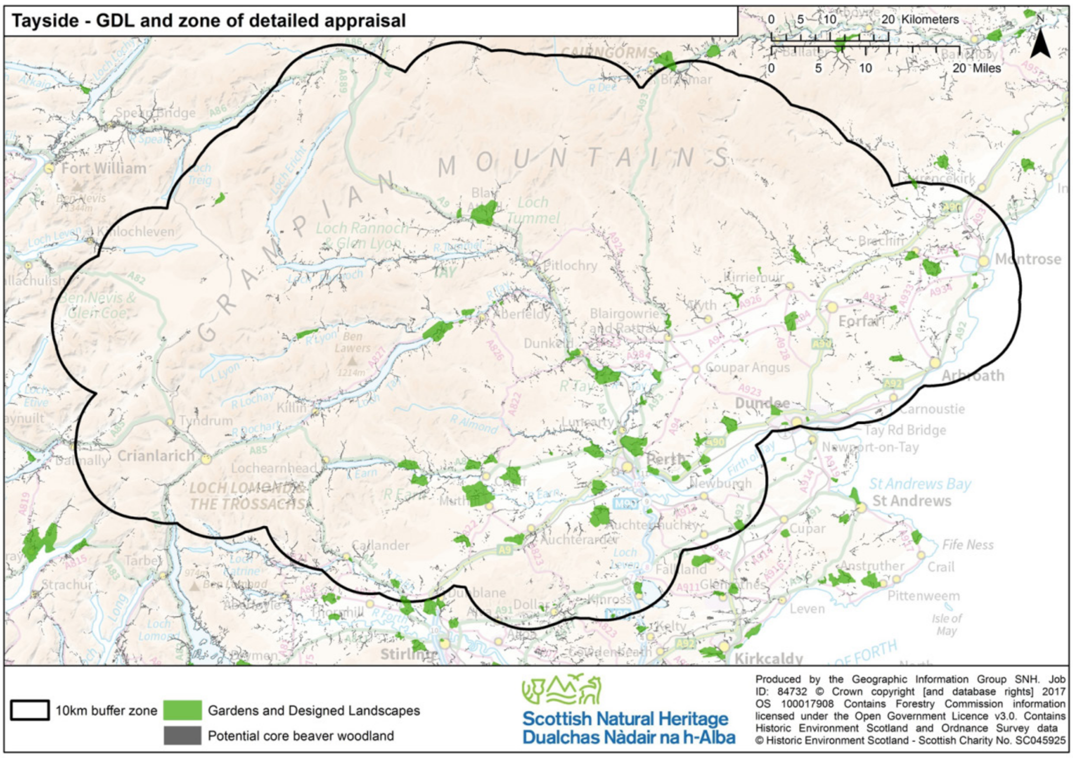
Battle of Dunkeld	Tayside
Battle of Dupplin Moor	“
Battle of Killiecrankie	“
Battle of Sheriffmuir	“
Battle of Tippermuir	“

4.13.2.3 Gardens and Designed Landscapes

Table 4.14.4 and maps 22 and 23 below (see also Appendix 1) detail the location of the Gardens and Designed Landscapes within the Knapdale and Tayside beaver policy areas and overlap with potential core beaver woodland. Within this area beaver activity and impacts will be restricted to some freshwater features and the immediate riparian habitat.



Map 22 Knapdale Gardens and Designed Landscapes and potential core beaver woodland



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Map 23 Tayside Gardens and Designed Landscapes and potential core beaver woodland

Table 4.13.4: Gardens and Designed Landscapes and potential core beaver woodland in the beaver policy areas

	GDL title	PA code
Knapdale	Ballimore	8779
Tayside	Abercairny	8742
Tayside	Aberuchill Castle	8744
Tayside	Airlie Castle	8749
Tayside	Balmanno	8782
Tayside	Blair Castle	8796
Tayside	Blair Drummond	8797
Tayside	Bolfracks	8800
Tayside	Braco	9212
Tayside	Brechin Castle	8804
Tayside	Castle Campbell	9216
Tayside	Castle Menzies	8823
Tayside	Cleish Castle	9219
Tayside	Cluny House	8830
Tayside	Corrour Lodge	8832
Tayside	Cortachy Castle	8833
Tayside	Cowden Japanese-Style Garden	10439
Tayside	Craighall Rattray	8835
Tayside	Doune Park	8863
Tayside	Drummond Castle	8867
Tayside	Dunira	8877
Tayside	Dunkeld House	8878
Tayside	Dupplin Castle	9226
Tayside	Falls of Bruar	9229
Tayside	Fingask Castle	8894
Tayside	Glamis Castle	8904
Tayside	Glendoick	8911
Tayside	Grantully Castle	8915
Tayside	Guthrie Castle	8918
Tayside	House of Dun	8928
Tayside	House of Pitmuies	8930
Tayside	Invercauld	8938
Tayside	Invermay	9233
Tayside	Keillour Castle	8942
Tayside	Keir	8943
Tayside	Kinfauns Castle	8950
Tayside	Kinnaird Castle	8955
Tayside	Kinross House	8957
Tayside	Meggernie Castle	8984
Tayside	Megginch Castle	8985
Tayside	Meikleour	8986
Tayside	Melville House	8990
Tayside	Methven Castle	8992
Tayside	Monzie Castle	9238
Tayside	Murthly Castle	8998
Tayside	Ochtertyre	9010
Tayside	Rossie Priory	9032
Tayside	Scone Palace	9038
Tayside	Stobhall	9046

Tayside	Taymouth Castle	9051
Tayside	The Burn	9052
Tayside	The Gleneagles Hotel	9056
Tayside	The Guynd	9057
Tayside	The Hermitage	9059
Tayside	The Roman Camp	9248

4.13.3 Assessment of effects on cultural heritage interests within the beaver policy areas

Knapdale

At Knapdale, Historic Scotland monitored potential beaver impacts on a crannog on Loch Coille-Bharr, in particular to assess whether foraging on aquatic plants might affect the scheduled monument. Loch Coille-Bharr crannog (Scheduled Monument Index No. 10131) is a submerged artificial island presumed to be the site of a late prehistoric – early historic period lake dwelling. The recovery of timber artefacts from the site in 1867 suggests that the lake silts around the site have preserved organic deposits relating to the occupation and use of the crannog. No impact was observed and the likelihood of impact was thought to be low. The Crinan Canal (Scheduled Monument Index Nos. 6500 and 6501) is an historic and well used waterway, mostly consisting of clay-lined earthen banks with intermittent areas of stone pitching revetting the banks. The canal is fed by a system of streams and lochs, mostly unscheduled. No impact was observed during the trial period on the Canal.

The Knapdale beaver population would be expected to expand, with some likely further impacts on forestry infrastructure. This might include some flooding of tracks and other infrastructure resulting from beaver dam-building activity (including attempts to block culverts) and some occasional felling of trees onto tracks and footpaths. Animals will eventually start to move outside the forest itself, with increasing incidences of the types of impacts described above in the wider area. Continued monitoring would be required along the Crinan Canal, in particular to look for any burrowing into the canal embankments and for any beaver activity in the feeder lochs above the canal.

There is only one Garden and Designed Landscape which overlaps with core beaver woodland at Ballimore. There are no known Battlefield sites within the Knapdale Beaver Policy Area.

Tayside

The effects on the cultural heritage interests in Tayside have not been analysed to the same degree as the study at Knapdale. However, there have been nine records of beaver impacts on ornamental and amenity value trees in private gardens in Tayside. There was also a record of a fish pond being flooded.

The overall findings and recommended mitigation and monitoring measures from the study in Knapdale could be applied similarly to both submerged features and archaeological interests with riverine areas in Tayside. Table 4.13.1 above details the range of positive and negative effects with consequent implications for cultural ecosystem services. There are 97 scheduled ancient monuments coincide with the core beaver woodland within the Tayside Policy area, 5 Battlefield sites and 54 Gardens and Designed Landscapes.

4.13.4. Mitigation Measures

There are a number of methods that can be used to protect cultural heritage interests and in some cases it may be prudent to protect especially sensitive interests before problems arise. This is more achievable for small-scale structures, such as individual features. The pre-emptive protection of larger scale structures that may be vulnerable to beaver activity, such as canals and settlements and earthworks, would be more challenging. The scale and costs involved for revetment or reinforcement to prevent burrowing would be high. There would therefore be a need to identify and prioritise those structures that may be most vulnerable. Scotland could draw on European approaches to targeting sites for management, and GIS-based tools to identify areas where beaver activity is predicted to be more likely.

There are other issues that might affect small numbers of individuals, for example damage to ornamental trees and gardens. For these, and the more complex infrastructure issues described above, the development of an appropriate management framework will be required. This will need to include guidance on management techniques (for both pre-emptive and reactive actions) and information on sources of advice and support. The effectiveness of beaver management in Scotland will increase over time as experience is gained and methods refined.

Section 5 also details the hierarchy of mitigation techniques that can be used to address impacts from beaver activities, including generic management and licencing approaches to more practical measures including those addressing:

- Dam building activities
- Burrowing activities and
- Foraging activities

These mitigation measures apply to the potential negative effects identified in relation to beaver activity and the cultural heritage.

4.14 Beavers and Material Assets

4.14.1 Beavers and Forestry

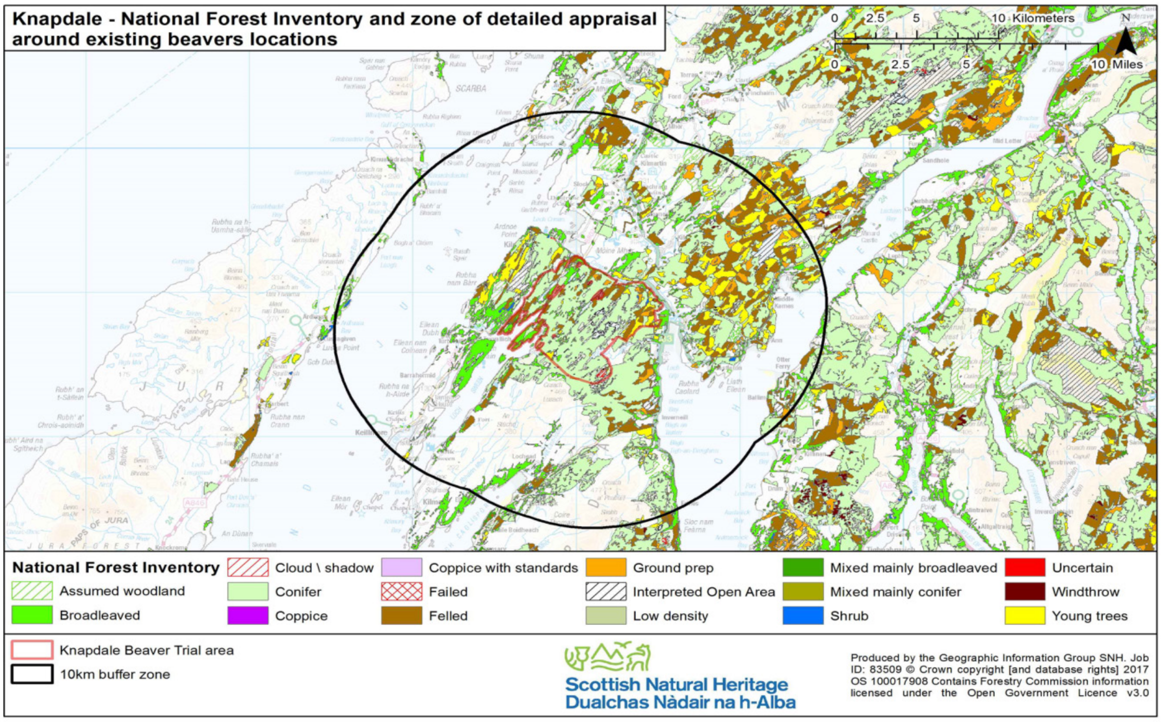
4.14.1.1 How beaver activity affects forestry

As detailed in section 4.2, the main mechanisms by which beavers affect woodland are tree-felling (for food and construction) and flooding. They use most Scottish broadleaved species but generally avoid conifers, although they may occasionally ring-bark them or feed on saplings in the late winter/early spring. They may also fell them for construction purposes if few broadleaved trees are available. Since most Scottish forestry relies on conifers, beavers are unlikely to have much impact through felling. None of the major coniferous species is tolerant of prolonged flooding, so beaver impoundments would lead to the death of trees within the flooded area. Flooding will also affect forestry infrastructure (e.g. forest tracks, culverts) and access for forest management, deer management and recreation, where it overlaps with inundated areas.

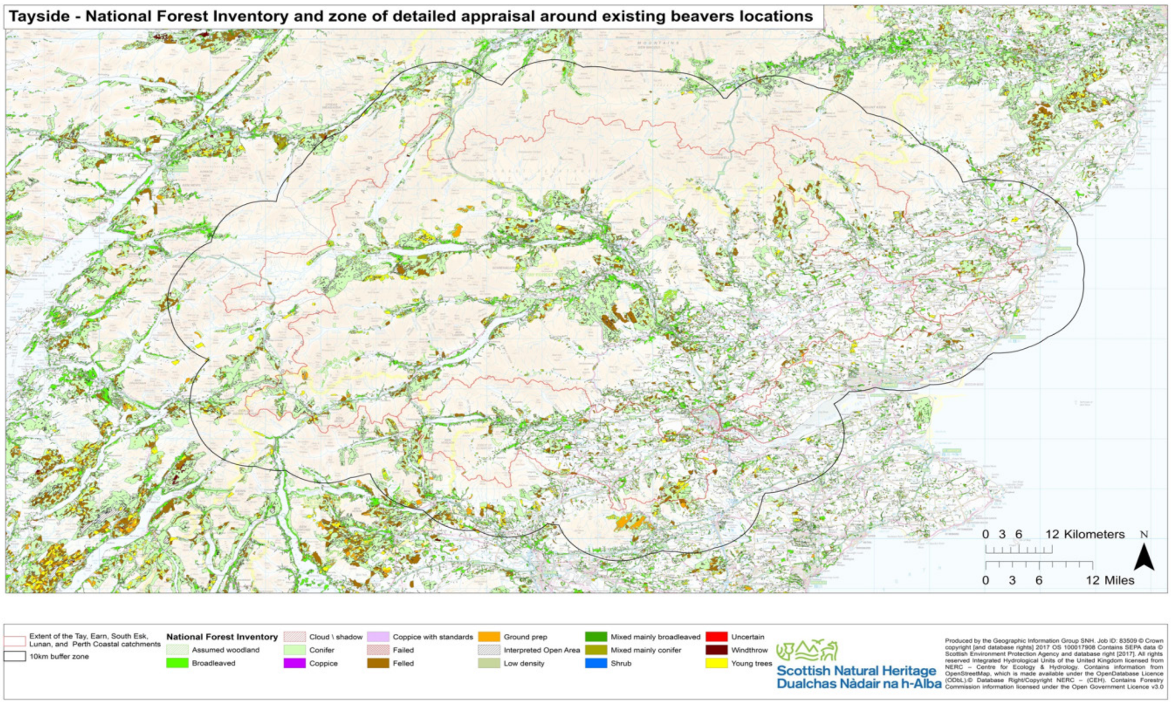
Relatively little information is available on the impact of beavers on forestry. Damage to forestry by felling is reported only where broadleaved tree species are managed commercially, but minor damage from flooding is more widespread. This is largely anecdotal, although a Polish survey reported that 3,200 ha out of a total of 27,472,000 ha (i.e. 0.01%) of agricultural and forestry land in Poland was flooded by beavers. In addition, 65 km of embankment and 229 culverts were affected, but it is not known whether these were in forested areas. Given that, at the time, Poland had a population of 18,000–23,000 beavers, this suggests a relatively minor impact on forestry. However, there is less rainfall in Poland and there is likely to be less use of culverts there than in Scotland, so any comparisons should be treated with caution. It has also been reported that 0.1% of the productive forest in a 34.7-km^2 study area in south-eastern Norway was flooded as a result of beaver dams. Finnish foresters have expressed more concerns about beaver damage than Norwegians, probably because of smaller mean property size, making the cost of even small areas of damage relatively high for the individual foresters affected.

The Scottish Forestry Strategy is the Scottish Government's framework for taking forestry forward through the first half of this century and beyond. It identifies timber production as a core theme, but also sets out six others: climate change, business development, community development, access and health, environmental quality and biodiversity. Therefore, although beaver presence will result in some costs to forestry, it will also bring about a range of benefits that will contribute to the outcomes set out in the strategy, such as improving the health and wellbeing of people, and ensuring a high-quality, robust and adaptable environment. This approach is further developed in the strategy for Scotland's National Forest Estate, which highlights the multi-purpose role of the estate and the growing emphasis on integrated land management, including its substantial contribution to the Scottish Biodiversity Strategy.

Maps 24 and 25 below detail the extent of the beaver policy areas and the National Forest Inventory (NFI) cover (these are reproduced as A3 maps in Appendix 1 for ease of reference). Within this area beaver activity and impacts will be restricted to some freshwater features and the immediate riparian habitat.



Map 24 - Knapdale Beaver Area and National Forest Inventory cover



Map 25 - Tayside Beaver Area and National Forest Inventory cover

Table 4.14.1 Summary of positive and negative effects of beaver on forestry activities

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland	• Enhancement of biodiversity elements of commercial forestry plantations • Presence of beavers could be used in support of the funding of planting schemes in riparian areas	• Whilst beavers use most Scottish broadleaved species but generally avoid conifers, they may occasionally ring-bark or feed on conifer saplings in late winter or early spring or if few broadleaved trees are available. Given the extent of overlap of core beaver woodland habitat and commercial forestry however, the effect is likely to be minimal. The presence of beavers could discourage the planting of commercial broadleaves in some areas.	
Felling	Change in riparian woodland: Change in age classes of trees		• Implications for deer management planning	
Felling	Change in riparian woodland: Change in relative abundance of different tree species		• Possible reduction in deep-rooted species that bind bank material, and therefore possible increase in erosion • Minor, localised reduction in timber availability in longer term	Timber availability likely to be a minor impact, as Scottish forestry relies mainly on conifer species which are unattractive to beavers
Felling	Change in riparian woodland: Amount/ diversity of fallen dead wood on woodland floor	• An increase in standing dead wood, which is generally present at only low levels in British woods	•	
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• Hydrological cycle and water flow maintenance - increased flood storage, and therefore a decrease in downstream flooding	Increased flooding of riparian zone and beyond, so potential impacts on land use such as timber (indirect impacts due to localised flooding), plus infrastructure (direct impacts due to localised flooding of roads and tracks, blocking of culverts, etc.)	Problems resulting from leaching of nutrients from soils are more likely in catchment areas that are fertilised

Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• The development of a robust and adaptable environment	• The loss of commercial forestry conifers and certain broadleaves within the flooded area • Impacts on forestry infrastructure such as culverts tracks and access for forestry management such as deer management etc. where these are within the flooded area	
Dams/pond creation	Change in standing deadwood resulting from inundation of trees	• Death of trees which are unable to cope with the water levels will lead to an increase in standing dead wood, which is generally present at only low levels in British woods		
Indirect habitat creation/restoration initiatives as a result of beaver presence	Beavers used to promote opportunities for riparian and freshwater habitat creation/restoration	• Any riparian woodland restoration programme will aim to increase the abundance of this much reduced habitat, and of particular preferred species, such as aspen		Further research on the localised flooding of forestry areas would also help clarify potential impacts of beavers.
Other	Beavers used to promote health benefits	• Further attraction of visitors to forest/woodland environments - improving the health and wellbeing of people, and ensuring a high-quality, robust and adaptable environment (an outcome set out in the Scottish Forestry Strategy).		

4.14.1.2 Assessment of effects on forestry interests within the Beaver Policy Areas

Beavers are currently present mainly within the Taynish and Knapdale Woods SAC component of Knapdale, which is managed primarily for conservation, so any impacts on commercial tree species in these areas might be considered acceptable unless they have a negative ecological impact. In the short to medium term, beavers would be expected to colonise other parts of Knapdale and move more widely outside the SAC. The terrain would limit areas vulnerable to inundation due to beaver activity. However, depending on the site of future dams, including the blocking of any culverts, it is possible that forest tracks might be flooded, affecting forestry activities. The level of deer management may also need to be reviewed to take into account the ability of trees felled by beavers to re-sprout and the longer term implications for woodland structure and quality.

The potential for beavers to affect forestry in Tayside is greater, as broadleaved tree species are managed commercially in parts of this area and, because of the flatter terrain, a greater proportion of the land is accessible to beavers. Based on experience elsewhere in Europe, it seems unlikely that impacts will be severe at the catchment scale, although they may be more significant at the very local scale.

4.14.1.3 Mitigation measures and opportunities

The UK Forestry Standard Guidelines on Forests and Water provide statements of requirements for sustainable forest management. The guidelines specifically highlight the environmental roles of the riparian zone and the need to identify effective buffer areas to protect them and aquatic habitats. Forest managers are required to identify and set aside such areas to help buffer any potentially adverse effects of adjacent forest management. The recommended minimum buffer widths range from 10 m wide along watercourses less than 2 m wide, 20 m along lochs, wetlands and watercourses more than 2 m wide, and 50 m wide along abstraction points for public or private water supply. Therefore, riparian zones should already be set aside by forest managers where most beaver activity is likely to be concentrated. However, in some cases the location of riparian zones will change as a result of beaver activity, which will mean changes to the location of buffer areas. Beavers will add a new dimension to how the guidelines are applied.

The diversification of the national forest resource is currently under way and it is likely that larger areas of more productive broadleaved tree species will be planted, including more substantial floodplain forests, where beavers are likely to have a particular impact. The development of strategic planning, and appropriate best practice management, will be required to deal with negative beaver impacts and issues, including mitigation against flooding and the management of forest operations near breeding lodges. There are also opportunities for forestry in terms of the biodiversity and socio-economic benefits that beavers can bring, and should also be included within any management planning.

Section 5 also details the hierarchy of mitigation techniques that can be used to address impacts from beaver activities, including generic management and licencing approaches to more practical measures including those addressing:

- Dam building activities
- Burrowing activities and
- Foraging activities

These mitigation measures apply to the potential negative effects identified in relation to beaver activity and forestry operations.

4.14.2 Beavers and Fisheries

4.14.2.1 How beaver activity affects fisheries interests

The potential for interactions between beavers and fish have been reviewed extensively, and details of these have been summarised within the Beavers in Scotland (BiS) Report. Whilst these reviews focused on the potential impact of beavers on 'fish' rather than 'fisheries', it is clear that any impacts on fish of commercial or sporting value may also have direct impacts on associated fisheries. Published data on the direct impact of beavers on freshwater fisheries outside Scotland are surprisingly few.

From a fisheries perspective, it is likely that the two species which are most likely to be influenced by the presence of beavers are Atlantic salmon and trout. Whilst Atlantic salmon and trout co-exist across much of their range, they differ in respect of their in-stream habitat requirements. As well as differing in their usage of in-stream habitats, trout do not make as much use of larger tributaries for spawning as Atlantic salmon. This means that beaver activity on small streams may have a disproportionate importance for trout production. The contribution of trout from these streams to the overall fishery resource within the Scottish river catchments, including the supply of fish to already declining sea trout fisheries, is a key consideration.

When assessing the scale and direction of any possible interactions between beavers and fisheries (for any species), it is important that the ecological requirements and behaviour of beavers, and the fish species concerned, are understood. The ecology of Atlantic salmon is well understood and the ecology of Eurasian beaver can be broadly inferred from published literature, including that arising from the Scottish Beaver Trial (SBT). This approach allowed the Beaver Salmonid Working Group (BSWG) to assess the potential magnitude of spatial overlap between the possible range of beavers and the distribution of salmon. These analyses suggested that a large overlap would generally be expected but will vary spatially, both within and between catchments.

This does not infer that the level of overlap equates to the total area over which interactions between beavers and Atlantic salmon may occur. Neither does it predict the scale or direction of any impact. The BSWG report suggests that whilst tributaries can be important spawning and rearing areas for Atlantic salmon throughout catchments, the upper tributaries which are commonly used to produce the spring Atlantic salmon stock component are currently under the most threat, and hence are the most vulnerable to any obstructions from beaver dams.

In some areas, beaver activities and dam-building may have positive effects on factors such as water quality downstream. Conversely, obstructions at the downstream end of important tributaries, such as those used by the spring stock component of Atlantic salmon populations, may affect access to important spawning areas.

The impact of beaver activity on other native species for which recreational fisheries exist in Scotland, such as pike, roach and perch, may be less controversial. These are species which utilise a wide range of habitats and can establish in both rivers and standing waters. Whilst these species do undertake spawning migrations, or spawning movements, they are possibly less likely to be found in situations where they are affected by beaver dams.

In streams where beaver and salmonid habitats may overlap, interactions will vary over time, between catchments and within catchments. As such, it is not possible to predict with certainty whether the overall net impact of beaver presence will be positive, negative or negligible on salmonid fish or other species of conservation importance. However, beaver dam-building activity, and the associated potential hindrance to fish passage, is of particular conservation concern to a component of the Atlantic salmon stock called spring salmon, which utilise upland nutrient-poor streams.

It is widely accepted that the Eurasian beaver is a natural component of Scotland's wildlife heritage and that it was lost as a result of man's activities. Atlantic salmon and other native freshwater species, such as trout, European eel and lamprey, evolved with beavers over millennia and clearly these species co-occurred in Scotland.

Past and recent reviews, as well as the report of the BSWG, acknowledge that beavers can have overall positive effects on the production of some species of fish. This is largely because of the ability of beavers to modify river habitats and, as a consequence, influence hydrological characteristics and water chemistry within the watercourse. This must, however, be balanced against possible negative impacts of dam-building on the movement of fish within river systems and their effect on critical in-stream habitats.

The likely positive and negative effects identified in section 4.11 relating to Beavers and Fish (which include those of fishery significance) have been reproduced here for ease of reference.

Table 4.14.2 - Summary of positive and negative effects of beaver on fisheries interests.

Activity	**Mechanism**	**Positive effects**	**Negative effects**	**Notes**
Felling	Change in riparian woodland: Opening of woodland canopy and increased patchiness	• Increased light penetration may lead to increased production within streams, ponds and lochs. Increased primary productivity and temperature may increase production of aquatic macroinvertebrate prey items for fish. This could lead to increased fish productivity and improved individual growth rates. • Increased temperatures may favour the establishment of non-salmonid species which have a higher tolerance to lower dissolved oxygen concentrations (such as cyprinids and sticklebacks). • Increased light may lead to the establishment of macrophyte communities, creating complex habitats that offer shelter to some fish species (such as pike, perch, roach and sticklebacks) and their prey. Penetration of light to the riparian zone may result in the development of plant communities that will stabilise banks, reduce erosion and	• Reduction in shading has the potential to increase water temperature and result in increased thermal stress upon some fish species, particularly salmonids. • Increased temperatures may favour the establishment of fish species which may compete with, or predate, salmonids. • Increased temperatures can contribute to reduced levels of dissolved oxygen in some circumstances. This may unfavourable for some fish species (such as salmonids)	Tree felling may also undo some of the extensive tree-planting restoration work that has taken place in some catchments (particularly the upper areas of catchments which have little natural tree cover)

		provide increased opportunities for greater terrestrial input of food items for fish.		
Felling	Change in riparian woodland: Change in relative abundance of different tree species	• Possible changes in the amount of allochthonous material derived from different sources (principally leaf litter) which may benefit some aquatic macroinvertebrates, and potentially the fish which prey on them.	• Possible reduction in type and quantity of allochthonous material (principally leaf litter) may lead to a reduction in aquatic macroinvertebrate community composition and production. This may negatively affects fish which prey on them. • Possible reduction in the quantity of terrestrial (invertebrate) prey items that enter the aquatic environment as food for fish.	
Felling	Change in riparian woodland: Change in age classes of trees	• Possible changes to tree age class in riparian or littoral areas may result in a more open canopy and increased light penetration, with consequent benefits for some species (see above)	• Loss of mature woodland may result in lesser quantities of allochthonous material entering waterbodies. This can affect macroinvertebrate production and therefore the production of fish. • Possible reduction in size and quantity of large woody debris entering the watercourse in longer term may impact in-stream habitat structure, and this may adversely affect some fish species. • Possible changes to tree age class in riparian or littoral areas may result in a more open canopy and increased light penetration, with consequent negative effects for some	Effects will depend on nature of changes, and the extent to which trees affected by beavers regrow. See Table 3.4.1 for beaver effects on woodland trees.

			species (see above)	
Felling	Change in riparian woodland: Amount/ diversity of fallen dead wood on woodland floor			
Felling and constructions	Changes in amount/diversity of woody material in watercourses	• Greater quantities of large wood items in streams, rivers and lochs can result in increased in habitat diversity, and an increase in the availability of prey items and fish cover. • Where large woody debris occurs, it may reduce the transport of sediment downstream.	• The establishment of large log jams could hinder the in-stream movement of some fish species if they act as barriers. • Depending on where woody items aggregate, such material can act as a barrier to movement, or result in the loss of habitat. • Where the quantity of large and small woody items is too great, this may result in blockages which may impact the transport of important gravels.	
Feeding	Feeding on specific terrestrial herbaceous and aquatic plant species	• Changes to macrophyte community structure may favour some species of (non-salmonid) fish and their prey.	• Decrease of macrophyte species in some lochs may have a negative impact on species that depend on them for food or shelter. Pike, for example, are often associated with macrophytes because they use these as cover when ambushing prey. Roach and perch may utilise macrophytes as cover from pike. Salmonids are rarely associated with macrophytes.	

Dams/pond creation	Change from lotic to lentic habitat	• Increase in habitat diversity which may favour some fish species or fish life history (ontogenetic) stages. In some situations this may also result in an increase in species richness – of both fish and invertebrate prey items. • Increased temperatures, changes in habitat availability and feeding opportunities in lentic habitats may result in increased individual growth rates, fish condition and overall production. • Depending on depth and location, impoundments may offer a high temperature refuge for some fish.	• Increase in habitat diversity for fish may favour some species over others, or benefit only some life history stages (e.g. juvenile or adult fish). • Depending on location, the creation of lentic habitats may result in habitat loss for species which favour or dominate lotic habitats. • Accumulation and smothering of bed sediment upstream of dams, and a reduction in habitat quality for some species (principally salmonids) • Reduction in turbulence (or mechanical mixing) may occur upstream of dam resulting in a reduction in dissolved oxygen. • Possibility of increased opportunities for fish predators (e.g. piscivorous birds, mammals such as otter, or man).	
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• Reduction in the transport of fine material may improve the quality of spawning and rearing habitats downstream of any impoundment. • Impoundments may create low and high flow refuges for fish. • Flooding of riparian and wetland habitats can provide spawning opportunities for species such as pike, and additional habitat for species such as European eel.	• Changes in flow may result in sediment starvation in gravel spawning areas. This can affect both salmonids and spawning lamprey. • A reduction in flow downstream of the structure may result in a reduced wetted width and a loss juvenile fish habitat.	
Dams/pond	Changes in water	• Reduction in the amount of fine		

creation	quality downstream	material deposited on stream or river bed downstream of the impoundment. This may result in an improvement in the quality of gravel spawning areas (downstream) for salmonids and lamprey. • Accumulation of fine sediments may increase the volume of available habitat for lamprey ammocoetes.		
Dams/pond creation	Change in standing dead wood resulting from inundation of trees			
Dams/pond creation	Longer term successional changes after dam abandonment e.g. beaver meadows			
Dams/pond creation	Impacts on movement of species		• Prevention of the free movement of fish to all habitats required during their life cycle. This is particularly relevant to key migration periods (such as spawning migrations), but also at other times. • The scale of impact may be greater for species which have a limited ability to overcome in-stream obstacles (such as lamprey).	
Other	Creation of			

constructions	lodges, burrows, canals etc.			
Other	Fisheries		Beaver habitats (impoundments and flooded wetlands may benefit North American signal crayfish, an invasive non-native species, if these are present within the catchment.	
Indirect habitat creation/restoration initiatives as result of beaver presence	Beaver used to promote opportunities for riparian and freshwater habitat creation/restoration	• Presence of beaver may act as an incentive for greater investment, management and monitoring. Including those related to the restoration and management of riparian woodland.	Beaver presence may eliminate fish-related riparian woodland restoration activities that are currently underway.	

4.14.2.2 Distribution of fisheries interest in Beaver Policy Areas

Knapdale
The fisheries resource in Knapdale is largely limited to brown trout because anadromous salmonids (Atlantic salmon and sea trout) are not able to migrate freely into the Knapdale Forest area. Whilst brown trout undoubtedly utlise stream habitats within the area covered by the Knapdale beaver trial area, only those fish which inhabit the standing waters (lochs) are used as an angling resource. These fish, whilst resident in lochs for the majority of the year, may still use local streams at spawning time, and these remain an important area for maintaining brown trout populations within the areas occupied by European beaver.

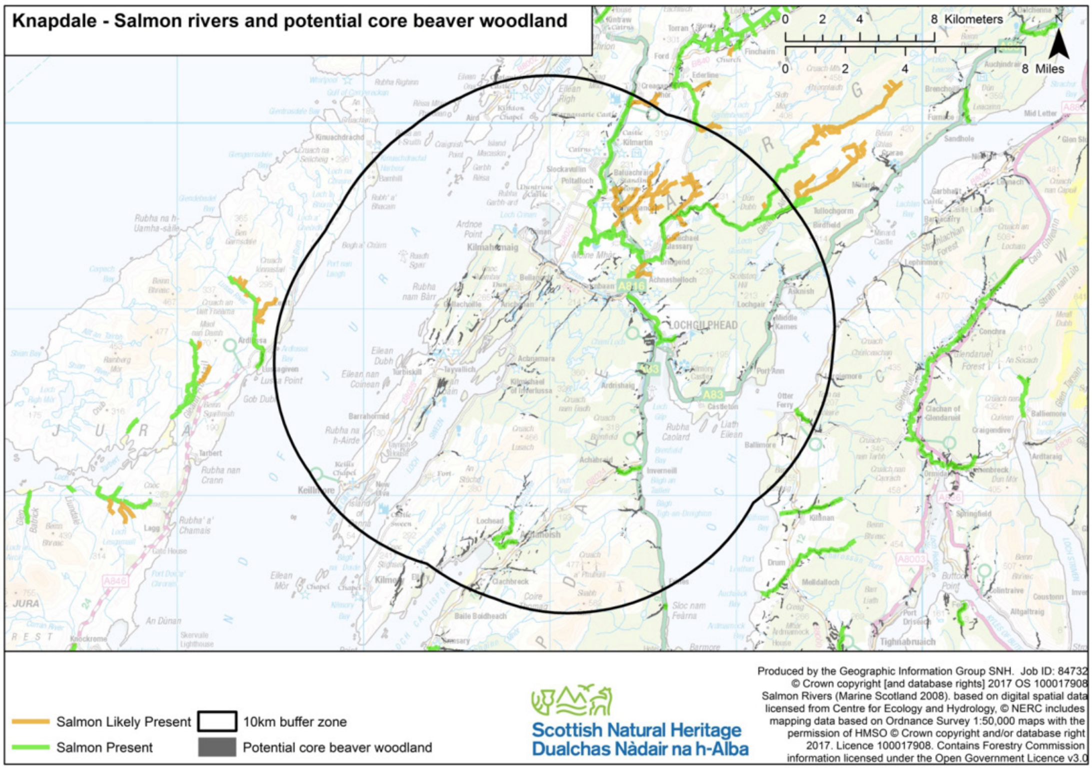
Tayside
The River Tay supports significant recreational fisheries for Atlantic salmon, trout (including sea trout) and grayling. It is one of the most iconic of the Scottish Atlantic salmon rivers and the number of rod-caught Atlantic salmon makes it one of the most important catchments for this species in the UK. Data available for 2016 showed that the Tay rod catch (6,590 fish) was the third highest in Scotland in that year.

The spring salmon rod catch in 2016 was 582 fish and was the highest spring catch recorded in Scotland. All of these fish are now returned to the water after capture in line with the requirements of The Conservation of Salmon (Scotland) Regulations 2014. The River Tay remains important for this stock component in a national context.

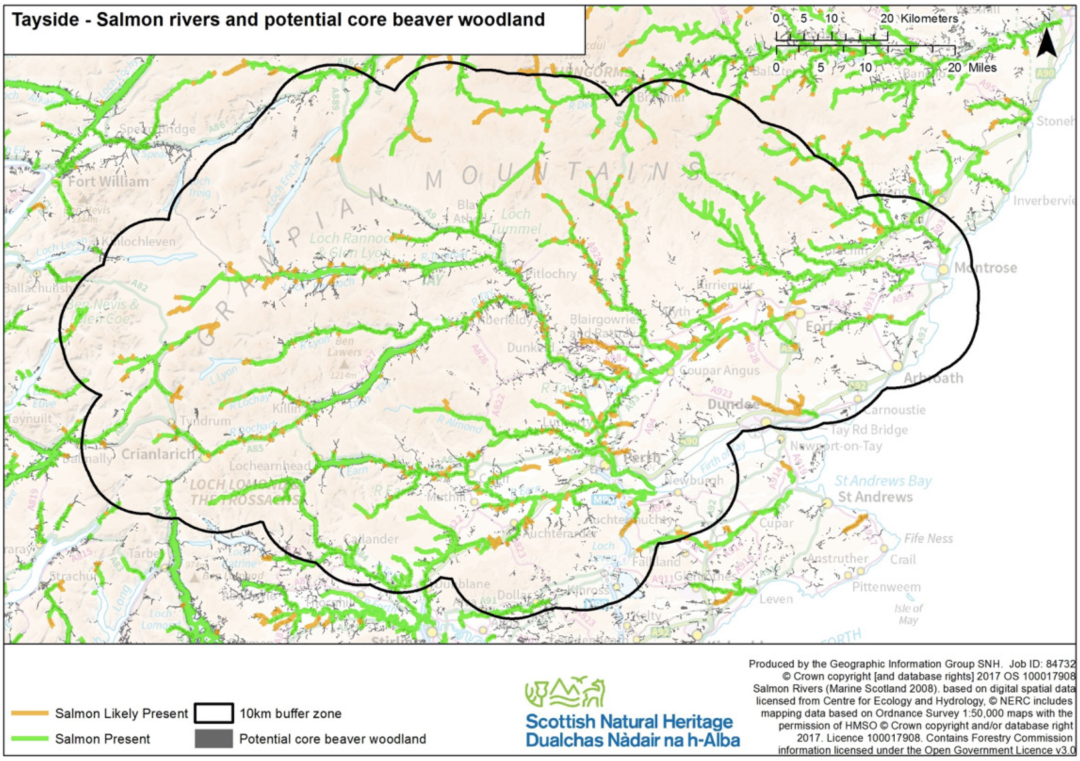
The Conservation of Salmon (Scotland) Regulations 2016, determine whether the exploitation of Atlantic salmon is sustainable, through a process of measuring catch against the estimated number of fish required for the population to reach its conservation limit. In 2016, the River Tay SAC was considered to be a ‘Grade 1’ river, which means that there is at least an 80% chance of the Atlantic salmon population reaching its conservation limit and that exploitation levels are currently sustainable.

A recent database was produced by SNH to identify river sections which are less likely to be dammed based on two main criteria: river widths greater than 6 m and the absence of potential core beaver woodland. This showed that, for the River Tay, which has a total river length of 1,029 km, a low likelihood of dam-building was estimated, along about 93% of the river.

Maps 26 and 27 below detail the extent of Atlantic salmon rivers in relation to core beaver woodland (these are reproduced as larger maps in Appendix 1 for ease of reference).



Map 26 - Knapdale salmon rivers and potential core beaver woodland



Map 27 - Tayside salmon rivers and potential core beaver woodland

4.14.2.3 Assessment of effects on fisheries interests within the Beaver Policy Areas

Knapdale
Opportunities to monitor the impact of the beaver reintroduction at Knapdale have been limited. Recreational angling within the SBT area is controlled by the Lochgilphead & District Angling Club (LADAC). LADAC maintains boats for its members and carries out light stocking activities to supplement brown trout populations within each of the 15 hill lochs that it manages. There was no indication during the trial period that beavers, which utilised the lochs more extensively than anticipated, negatively affected the operation of Loch Barnluasgan and Loch Coillie-Bharr as a recreational fishery.

The potential for using Knapdale as a study site for assessing the impact of beavers on stream fisheries is extremely limited because these areas are themselves not used as a fisheries resource. These streams do, however, provide spawning habitat for those fish which are present in connected standing waters. The existing monitoring programme has already provided some evidence that trout are able to utilise spawning habitat in the presence of beavers, although these data are limited.

All angling in the Knapdale area is restricted to standing waters. These waters are regularly, but lightly, stocked by LADAC with brown trout. Rainbow trout have also been stocked into at least one loch within the area. Baseline data for fish in standing waters within the Knapdale area are lacking, making an assessment of fisheries impact difficult.

Tayside
Although little is known about the actual impact of beaver activity on fish in Scotland, the potential for fishery impacts within the River Tay is considered high, particularly if beaver management measures are not in place.

The River Tay SAC is currently in favourable condition for its Atlantic salmon, lamprey and otter conservation features, and deterioration from this status, for any feature, should be prevented. This suggests that a careful assessment of the potential and current impact of beaver not only on Atlantic salmon, but also on brook lamprey, river lamprey, sea lamprey and otter should be carried out to ensure that deterioration in conservation status is avoided. For Atlantic salmon, the Scottish Government must also consider its international obligations, such as those to the North Atlantic Salmon Conservation Organization (NASCO), to maintain and manage this species. See section 4.11 for further detailed assessment of beavers in relation to fish, including those of fishery significance.

Angling within the River Tay catchment is not, however, restricted solely to Atlantic salmon, and well-developed riverine fisheries exist for a range of other species, such as trout and grayling. These are well described within the Tay District Fisheries Management Plan. Trout are, as in most Scottish fresh waters, the most widely distributed fish within the Tay catchment, including upland areas that are inaccessible to Atlantic salmon. Both brown trout (the freshwater resident form of *S. trutta*) and sea trout (the anadromous form) typically spawn in small watercourses that range from 1 to 3 m in width, and these fish may migrate over short and (particularly in the case of sea trout) long distances to reach these areas. Both forms of trout are exploited by anglers, although information relating to the actual contribution of this species to the local economy is lacking. As a function of their widespread distribution within small watercourses, it is possible that the potential overlap between beaver activity and trout may be more significant than has been estimated for Atlantic salmon. It is therefore not possible at this time to predict what impact reintroduced beaver might have on trout fisheries within the River Tay catchment.

Grayling are not native to Scotland, but have been present in the River Tay since the nineteenth century and have spread throughout the main stem of the Tay, the Isla, the lower

Tummel and the Earn. Grayling angling, mostly on a catch-and-release basis, is well established in these watercourses. As this species appears to be limited to relatively large watercourses, the interaction between beavers and grayling may be less than that predicted for Atlantic salmon and trout. Little information is available relating to the population status and local ecology of grayling within the River Tay system, and few data are publicly available on the numbers of grayling caught and its value to the local economy. This makes an assessment of the impact of beavers on the grayling fishery difficult.

Both the European eel and pike are present within running waters in the Tay system. European eel is widely distributed throughout the catchment, although pike is limited to slower-moving reaches of the larger river systems and standing waters. Although angling for pike is popular where they occur within the system, this activity appears to be unregulated and unmonitored. Both European eel and pike are species which benefit from the presence of impoundments and the creation of wetland habitats. For instance, a study of fish community structure in the Canadian Shield Lakes suggested that North American beavers had an overall positive impact on pike abundance and productivity. It might be expected that a similar response could occur in relation to the Eurasian beaver. Perch and roach are probably not native to the Tay catchment and are also present in slower-moving reaches of the larger river systems, as well as some standing waters. Similar to the situation for pike, this fishery is unregulated and unmonitored. The ecology of these species suggests that they may also benefit from the presence of beaver-created impoundments and the creation of wetland habitats.

4.14.2.4 Mitigation Measures

The development of a management strategy is key to the successful coexistence of beavers and fisheries. The BSWG is clear that such a strategy should be a fundamental prerequisite of any decision to license the reintroduction of beavers in Scotland. This strategy should provide guidance on type(s) of interventions which can be made, the evidence base required and resourcing. The strategy should be developed in full consultation with stakeholders from the fisheries management sector.

The group recommended that this management strategy should be developed in full consultation with all key stakeholders. From a fisheries perspective, this would also include representation from trout and grayling anglers as well as input from the coarse angling sector. The BSWG report also recommended that any strategy should consider the following:

- The construction of beaver dams, beavers at pinch-points adjacent to in-stream human infrastructure including culverts, weirs and fish passes. Experience from abroad and recently in Scotland suggests that in this particular scenario, fish passage concerns may be exacerbated, presenting an elevated requirement for management intervention. A GIS-based analysis of the overlap of areas predicted to be less likely to be dammed with existing anthropogenic watercourse structures showed that 78% of all culverts, weirs, and fish passes in Scotland were at locations where damming was less likely. However, of key importance is the location of impassable dams, and the reduction in accessible habitat that they would cause. Further analysis could be done in the future to highlight which structures risk impeding Atlantic salmon access to key habitats.
- The development of a beaver management strategy, which should set out minimal intervention approaches as well as the criteria by which relocation or lethal control of beavers would be appropriate for the conservation of salmonids. The BSWG recommendations go on to state that beaver presence alone should not be a trigger for action and that a strategy should allow a range of management interventions to be undertaken from short-term action to longer-term intervention. The requirement or otherwise for such intervention may be determined partly by river flow levels, and may

be necessary in advance of fish migration periods during spring and/or autumn, particularly during prolonged periods of low flow

- The imperative of ensuring free passage of migratory fish suggests that any management strategy should recognise the dynamic nature of beaver dams and the resources required in assessing such structures on multiple occasions. In addition, any removals of dams from watercourses must adhere to current regulatory guidance and be completed without causing pollution or affecting stream biota
- The resource implications associated with monitoring and management. The BSWG considered it vital that such resources are committed, over the medium to long term, to relevant management authorities
- The significant gaps in our knowledge of beaver–salmonid interactions, both within Scotland and abroad. Further research in Scotland is considered necessary to help inform when management intervention may, or may not, be required
- The potential, and possibly extensive, overlap between known Atlantic salmon distribution and potential beaver habitat in major rivers, with potential overlap in minor rivers varying considerably between catchments. Both the mapping study carried out by MSS and the more recent GIS-based analyses of dam-building potential in SACs suggest significant variability in the extent of areas likely to be affected

Section 5 also details the hierarchy of mitigation techniques that can be used to address impacts from beaver activities, including generic management and licencing approaches to more practical measures including those addressing:

- Dam building activities
- Burrowing activities and
- Foraging activities

These mitigation measures apply to the potential negative effects identified in relation to beaver activity and fisheries operations.

4.14.3 Beavers and Infrastructure

4.14.3.1 How beaver activity affects Infrastructure

Infrastructure and general land use will tend to be at risk only where they are in proximity to beaver activity, and therefore near running and standing waters. Impacts can arise from the direct and indirect implications of dam-building, burrowing and tree-felling. Since beavers readily use natural, semi-natural and artificial waterbodies, the likelihood of beavers coming into contact with human infrastructure is high. The scale and significance of the resulting impacts will vary according to local circumstances, but in most situations management will be required, with associated costs.

There is limited information in the literature about beaver impacts on such issues, so many of the following experiences have been collated from discussions with European and North American colleagues, from a recent review of beaver management and from Scottish experience to date.

Felled trees have the potential to cause incidental damage when they fall on fences, power lines, buildings or transport routes. Although the frequency of these events is rare, if they occur they may be significant in terms of disruption, cost and risk to human wellbeing.

Roads and tracks

Dam-building on a stream, ditch or pond outflow can cause direct flooding of an adjacent road or access track. If this is located in a low-lying area, the scale and depth of flooding can cause significant obstruction until the dam is removed or managed. Beaver burrows may also undermine roads, tracks and other structures, causing subsidence.

Culverts, weirs, sluices, fish passes

Although beavers normally construct dams using natural foundations, they can also use man-made structures. Even with no beavers present, such structures tend to be vulnerable to blockage by water-borne debris, and therefore need regular checking and maintenance. Beaver activity, however, can exacerbate problems. There are many records from across Europe and North America of beavers building dams across the mouths of culverts, on sluices and weirs and on fish counters and fish passes. Any suitable structure located in water can be used in this way.

Subsidence caused by beaver burrows can also lead to in-stream structures, such as weirs and fish passes, being bypassed. Water may flow into a burrow upstream and then re-enter the watercourse downstream, eroding the bank in the process.

Flood-banks and other river structures

Burrowing into flood-banks weakens their structure and renders them more susceptible to collapse and overtopping, or direct erosion in times of spate. The protected land behind, which might include housing, business/industry and farmland, is then vulnerable to flooding. Dams and burrowing can also cause a diversion of water flow and lead to erosion of riverbanks and the undermining of any associated water-side infrastructure, which could potentially include bridge supports, utility pipes, roads and tracks.

Canals

Beavers readily use artificial as well as more natural watercourses, so are frequently found in canal systems. There are cases of burrows damaging retaining banks of canals not reinforced by revetments, leading to leakage or localised failure. Similar impacts can occur in canals constructed to distribute water supplies for drinking, hydro-schemes and other purposes. The impact on the Crinan Canal is considered further in section 4.13.

Water treatment plants
If sewage settlement beds are in close proximity to a watercourse, they may be accessible to beavers and may overflow as result of any woody debris and dam-building. They contain reliable water supplies and are commonly surrounded by lush vegetation that may attract beavers.

Recreational facilities
Beavers will readily occupy environments that are regularly used for recreational activities such as swimming, leisure boating, sunbathing, jet skiing and canoeing. They can habituate to reasonable levels of disturbance, and tend to be more active at quieter times of the day when there is less human activity. Streams and ponds in places such as golf courses or parks can also provide suitable habitat. In most cases there are few conflicts, although dam-building, burrowing and tree-felling may sometimes cause problems.

Table 4.14.3 - Summary of potential interactions between beavers and infrastructure

Activity	Mechanism	Positive effects	Negative effects	Notes
Felling	Change in riparian woodland: felling		• Felled trees have the potential to cause incidental damage when they fall on fences, power lines, buildings or transport routes. Although the frequency of these events is rare, if they occur they may be significant in terms of disruption, cost and risk to human wellbeing.	
Other construction, e.g. burrows	burrowing		• Burrowing can: • Undermine roads, tracks and other structures causing subsidence • Lead to instream channels causing weirs and fish passes to be bypassed. • Cause bank erosion	
Dams/pond creation	Change in hydrological processes on riparian an downstream habitat	• Hydrological cycle and water flow maintenance: - improvements in base flow, and protection of lochs, during drought periods due to increased water storage. Increase in water tables would lead to larger stock of water for drinking and non-drinking purposes (e.g. domestic use, irrigation, livestock consumption, industrial use) - increased flood storage, and therefore a decrease in downstream flooding - hydrological alternations may restore natural connectivity in wetland–loch systems - water level rise in standing waters would be expected to increase the area of standing water habitat - water level rise increases the volumes	• Dam building can cause: • Direct flooding of an adjacent road or access track • Blocking of culverts, sluices and weirs and fish counters and fish passes • Overflowing of sewage settlement beds as a result of woody debris and dam building • Flooding of terrestrial land upstream/adjacent to lochs may result in deterioration of water quality through decay of vegetation and leaching of nutrients from soils • Blocking of septic tanks outfalls	

		of standing waters, and greater volume may improve the capacity of a loch for dilution of nutrients and phytoplankton		

4.14.3.2 Assessment of the effects on infrastructure within the Beaver Policy Areas

The Knapdale beaver population would be expected to expand, with some likely further impacts on forestry infrastructure. This might include some flooding of tracks and other infrastructure resulting from beaver dam-building activity (including attempts to block culverts) and some occasional felling of trees onto tracks and footpaths. Animals will eventually start to move outside the forest itself, with increasing incidences of the types of impacts described above in the wider area. Continued monitoring would be required along the Crinan Canal, in particular to look for any burrowing into the canal embankments and for any beaver activity in the feeder lochs above the canal.

Tayside is a more populated area with a greater intensity of land use, and so the scope for beaver activity to impinge upon a range of land uses, and the associated infrastructure, is much greater. The TBSG have already recorded a variety of issues experienced by land managers and members of the public, many of which are summarised above. The expectation is that this pattern of impact will continue as the beaver population continues to expand throughout the catchment and beyond.

Roads and tracks

The flooding of a forest track occurred during the SBT at Knapdale, following the impounding of water behind a beaver dam across a minor watercourse.

On Tayside, beavers felled some poplar trees alongside a 200-m stretch of the A90 trunk road near Forfar, presenting a risk of some falling onto the carriageway. Transport Scotland arranged for trees gnawed by beavers to be cut down and the remainder to be protected with mesh fencing. Transport Scotland’s A9 road dualling programme is currently underway and there is some early recognition of the need for future proofing for beaver activity as well as mitigation when there is a need.

At the Loch of the Lowes, an SWT nature reserve near Dunkeld in Tayside, there was beaver activity along a narrow strip of riparian woodland situated 10 m from the edge of approximately 1.6 km of a well-used road. Over the last few years at least two trees have fallen onto the road, presenting risks in terms of safety and obstruction. This led to a greater intensity of checking by ranger staff to identify any beaver-damaged trees, which were then felled. Fencing to prevent beavers gaining access to the trees was judged not to be a practical option.

At another Tayside site, 150 m of an access track to a small area of residential housing, next to a burn, was flooded during a period of high rainfall. The flow patterns of the burn had been affected by the raising of the water table on adjacent land caused by beaver dam-building.

Culverts, weirs, sluices, fish passes

A recent GIS-based analysis was done to examine the overlap of areas predicted to be less likely to be dammed by beavers, with existing anthropogenic watercourse structures. It was found that 78% of all culverts, weirs and fish passes in Scotland were at locations where dam-building was predicted to be less likely.

On Tayside there were two instances where dam-building activity had the potential to impede fish movement along fish passes. At one of these sites, the dam was built against a fish counter. The manager cleared the dam but then had to remove new debris from the counter every morning over a number of weeks after the beavers started to replace it. The debris prevented the counter from working and the manager eventually decided to remove it to discourage further dam-building.

Flood-banks and other river structures
Bank erosion was reported at four Tayside sites resulting from the redirection of water flows around a beaver dam. At one of these, access for farm machinery had been impeded. At another, there was a report of dam-building causing erosion next to a bridge, although there are no details of the type of bridge, size or scale of impact. Issues and potential issues were also recorded on five sites where there were beaver burrows in flood defence banks.

4.14.3.3 Mitigation Measures

There are a number of methods that can be used to protect infrastructure interests and in some cases it may be prudent to protect especially sensitive interests before problems arise. This is more achievable for small-scale structures, such as culverts under roads. The pre-emptive protection of larger scale structures that may be vulnerable to beaver activity, such as canals and flood-banks, would be more challenging. The scale and costs involved for revetment or reinforcement to prevent burrowing would be high. There would therefore be a need to identify and prioritise those structures that may be most vulnerable. Scotland could draw on European approaches to targeting sites for management, and GIS-based tools to identify areas where beaver activity is predicted to be more likely.

There are other issues that might affect small numbers of individuals, for example damage to ornamental trees and gardens. For these, and the more complex infrastructure issues described above, the development of an appropriate management strategy will be required. This will need to include guidance on management techniques (for both pre-emptive and reactive actions) and information on sources of advice and support. The effectiveness of beaver management in Scotland will increase over time as experience is gained and methods refined.

Section 5 also details the hierarchy of mitigation techniques that can be used to address impacts from beaver activities, including generic management and licencing approaches to more practical measures including those to address:
- Dam building activities
- Burrowing activities and
- Foraging activities

These mitigation measures apply to the potential negative effects identified in relation to beaver activity and infrastructure.

4.14.4 Beavers and Agriculture

4.14.4.1 How beaver activity affects agriculture

Since beaver distribution is always associated with running or standing water, the potential for beaver activity to have an impact on agricultural interests is limited to where they occur in the vicinity of streams, rivers, drainage ditches, wetlands, lochs or ponds. Once beavers occupy an area, they actively modify their surroundings to suit their needs, so they are able to use a wide range of wet environments, whether artificial or more natural.

Published information about beaver impacts on agriculture is limited. Impacts can arise from a range of beaver activities, including burrowing and canal construction to gain safe access to a lodge/den or to feeding areas; dam-building on smaller watercourses, ditches and pond outflows; blocking of culverts; direct foraging of crops; and gnawing and felling of trees of commercial value for food or construction materials. The extent and significance of the impacts will depend on the local topography, soil structure and hydrology, and the vulnerability of the affected interests. In general, there appears to be less concern about beaver activity in areas of low commercial value. The greatest concern arises where beaver activities affect areas of more intensive agricultural activity.

Beavers come into direct contact with agricultural land usually within about 20 m of watercourses, although very occasionally they have been found to range up to 150 m to gain access to a favoured food source. Indirect impacts on agriculture can be more extensive, such as those arising from the flooding or waterlogging of fields behind beaver dams.

Burrowing

Beavers will burrow into the banks of watercourses, as do a number of other species. All burrows, whether constructed by beavers or other species, can make banks more vulnerable to erosion during high water flows, especially in areas with more friable soils. The construction of canals by beavers may do the same. Damage to a river bank can result in the subsequent erosion of adjoining productive land and localised flooding of crops. There are some records of beaver burrows collapsing on farm land. Each individual burrow will be of a limited extent, but there can be many burrows along a stretch of river, and their collapse may potentially pose a hazard for walkers, livestock and machinery operations, although few occurrences of actual harm have been recorded. These effects would have cost implications, in particular where they impede farming operations that have strict time constraints, such as during harvesting.

Burrowing may be a particular problem where it occurs in flood-banks protecting intensive agriculture on low-lying flood plains. The more extensive the floodplain, the more vulnerable it is to the consequences of any flooding caused by the failure of a flood-bank. Flooding can inhibit or prevent cultivation and damage or destroy crops and grazing for livestock. Flood-bank failures arise in the absence of beavers, including as a result of burrowing activity by other species, although beaver activity can render them more vulnerable because the entrances to beaver burrows are usually below the water level. This means that during high flows there can be a build-up of water pressure within a burrow, which is then applied to the internal structure of a flood-bank. This can cause a collapse of the soil above the burrow, leading to the possible flooding of protected farm land behind it.

Although burrowing can be completely prevented by the installation of ‘hard’ reinforcements such as stone-filled gabions, large rocks, sheet/mesh metal or concrete piling, these options may be neither commercially viable nor ecologically desirable along extensive lengths of watercourse.

Dam-building
Dam-building by beavers on running waters, or at the outflow of a pond, loch or reservoir, will raise water levels, but will be of little concern in many situations. However, it may cause direct waterlogging of adjacent farm land, and sometimes the erosion of banks. Beaver canals may also radiate from beaver ponds to extend their feeding range into the surrounding farmland. If a dam is at a pinch point and some water level rise is acceptable, the agricultural impacts may be managed and limited through the installation of a water flow device or the cutting of a notch into the dam. Beavers may also block drainage culverts using woody material and other vegetation, and can cause localised flooding of crops and farm access infrastructure.

The most significant impacts of dam-building activity on agriculture are likely to occur on intensive arable land on fertile flood plains, where cultivation is reliant upon an extensive network of drainage ditches and field drains. In these situations the shallow gradients present a very low tolerance threshold for any rise in the water table before the drainage system fails. Such failure can cause the direct damage of crops through flooding or waterlogging, and the inhibition of cultivation across a large area well beyond dam-building sites. As a consequence, checking for and managing beaver dams may become a regular activity for land managers, with attendant costs in terms of time and machinery. Where inundated soil has been fertilised, this may also result in a significant increase in nutrient loading of waterbodies. The use of techniques such as notch weirs or flow devices is not always effective in these situations, and the removal of dams is usually followed by rapid reconstruction if the beavers remain. Effective mitigation is difficult and farmers, and farmers' organisations, have expressed the view that the presence of beavers is not appropriate on these types of farmland.

Feeding on crops
Beavers are highly adaptable and may quickly exploit new food resources. Agricultural crops may be eaten in close proximity to watercourses. Feeding on a wide variety of agricultural crops has been recorded, including sugar beet, maize, cereals, oilseed rape, peas, potatoes, asparagus and carrots. In most cases the scale of crop loss is not commercially significant and usually confined to an arc of about 10 m in radius extending from the water access point. There are a number of fencing techniques to help minimise this, including the use of temporary electric fencing.

Tree- and shrub-felling
Felling of woody material for food or construction materials can be an agricultural issue for a variety of reasons. Felled trees can obstruct farm roads and access tracks, damage fences and block drainage ditches. There can also be a direct loss or damage to orchard trees, soft fruit bushes, landscape trees, farm woods and shelter belts, and the potential for damage to hedges. Protection measures include fences, tree guards and protection paint.

Table 4.14.4 - Summary of positive and negative effects of beaver activity on agriculture

Activity	**Mechanism**	**Positive effects**	**Negative effects**	**Notes**
Felling	Changes in riparian woodland		Felled trees can obstruct farm roads and access tracks, damage fences and block drainage ditches. There can also be a direct loss or damage to orchard trees, soft fruit bushes, landscape trees, farm woods and shelter belts, and the potential for damage to hedges.	
Felling and constructions	Changes in amount/diversity of woody material in watercourses	• Increased number of wood jams, resulting in attenuation of flow and lowering of downstream flood risk and improvements in water quality as fine sediments settle in areas of slower flow	• Increased number of wood jams, so a possibility of localised floodplain inundation and impacts on land use	
Other constructions, i.e. burrows	Burrowing		• Damage to a river bank can result in the subsequent erosion of adjoining productive land and localised flooding of crops. Burrowing may be a particular problem where it occurs in flood-banks protecting intensive agriculture on low-lying flood plains	
Feeding	Feeding on specific terrestrial herbaceous and aquatic plant species	• Clearance of vegetation that is acting as a barrier to water flow may restore flushing rates in standing waters and prevent backing-up and consequent flooding	• Feeding on crops in the riparian zone	
Dams/pond creation	Change in hydrological processes on riparian and downstream habitat	• Hydrological cycle and water flow maintenance: - improvements in base flow, and protection of lochs, during drought periods due to	• Increased flooding of riparian zone and beyond, so potential impacts on land use such as cultivated crops, meat and dairy products and timber (indirect impacts due to localised flooding), plus infrastructure (direct	

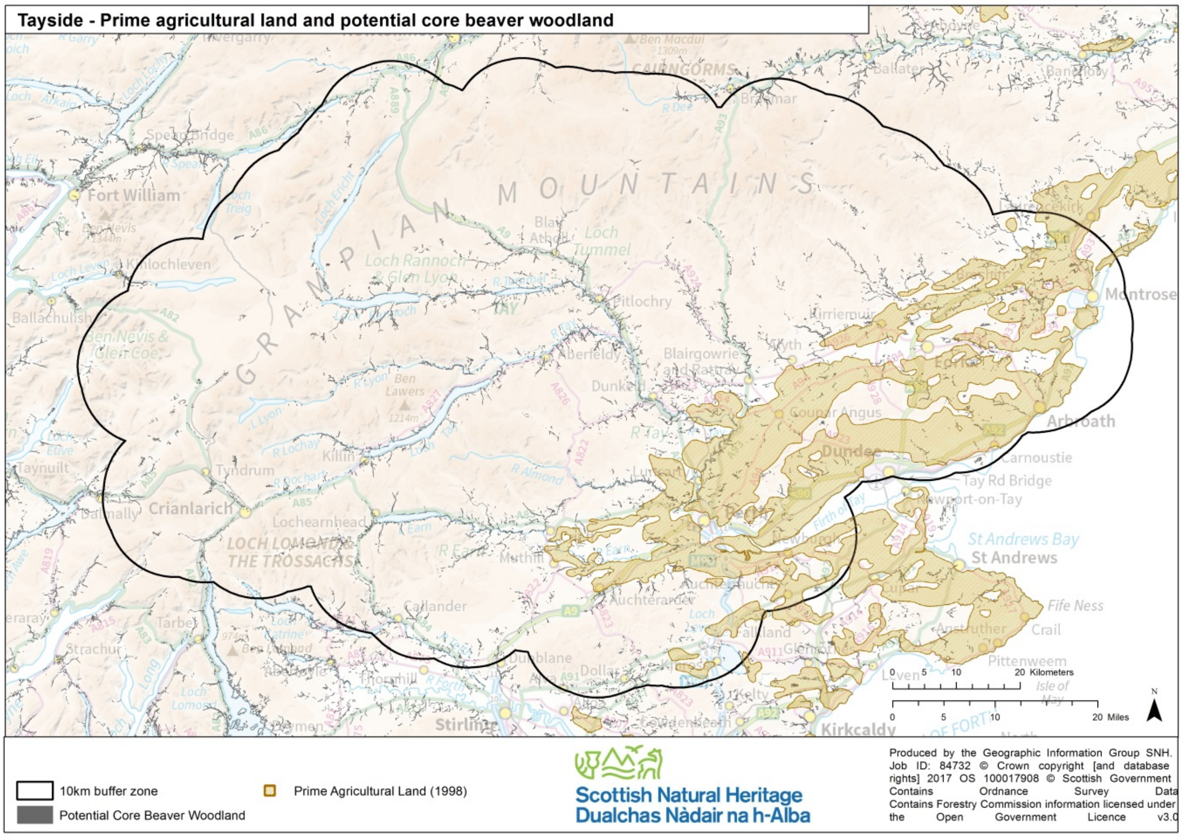
		increased water storage. Increase in water tables would lead to larger stock of water for drinking and non-drinking purposes (e.g. domestic use, irrigation, livestock consumption) - increased flood storage, and therefore a decrease in downstream flooding - water level rise increases the volumes of standing waters, and greater volume may improve the capacity of a loch for dilution of nutrients and phytoplankton • Carbon sequestration through wetland creation	impacts due to localised flooding of roads and tracks, blocking of culverts, weirs, fish passes, etc.) • With increasing loch volume, water retention time increases, flushing rate decreases and nutrients and phytoplankton are retained for longer within the loch. • Beavers may also block drainage culverts using woody material and other vegetation, and can cause localised flooding of crops and farm access infrastructure.	
Other: Indirect habitat creation/restoration initiatives as result of beaver presence	Beaver used to promote opportunities for riparian and freshwater habitat creation/restoration	• Presence of beavers may act as an incentive for greater investment, management and monitoring. This could those related to the restoration and management of riparian woodland and wetlands, which would benefit a range of bird species		

4.14.4.2 Distribution of the prime agricultural land resource within the Beaver Policy Area

Knapdale
There is no prime agricultural land in the Knapdale Beaver Policy Area although there is other improved grassland present.

Tayside
The distribution of prime agricultural land in relation to core beaver woodland habitat is detailed in map28 below and reproduced as A3 size in Appendix 1.

Within the prime agricultural land area beaver activity and impacts will be restricted to some freshwater features and the immediate riparian habitat.



Map 28 - Tayside prime agricultural land and potential core beaver woodland

4.14.4.3 Assessment of the effects on agriculture within the Beaver Policy Area

Given the nature of the habitat on which beavers depend, i.e. riparian broadleaved woodland and shrub within 50m of freshwater, there are unlikely to be significant *direct* impacts on prime agricultural land, i.e. land capability classification Class 1 and Class 2. However, there are likely to be a number of *indirect* and locally significant effects, some of which have been reported and are detailed below.

Knapdale
At present, there is a very limited opportunity for beavers to come into contact with agricultural activity in Knapdale. There are some small areas of grazing within Knapdale Forest but the main land use is forestry. If beavers were to remain at Knapdale, and the population reinforced, then it is anticipated that the animals would start to colonise along freshwater networks in the medium to longer term, some of which borders agricultural land,

primarily grazing. Inevitably there is likely to be some increase in management issues related to agricultural activity and impacts of local significance to individual farmers, although probably not to the extent that might be expected on Tayside.

Tayside
In Tayside there is already considerable beaver presence in agricultural areas. Between early 2012 and late 2014 during the course of the TBSG studies, the beaver range continued to expand within the catchments of the Rivers Tay and Earn, and colonisation is expected to continue into the future, ultimately occupying most of the suitable habitat. Colonisation of adjacent catchments is also anticipated if there is no intervention. This will inevitably bring them into further and increasing contact with riparian farmland. The incidence of agricultural conflicts would increase with particular concern for the management implications for the intensively drained and flood-bank-protected arable farms such as those on the floodplains of the Rivers Tay and Earn.

The TBSG was informed about 56 beaver sites across Tayside, 28 of which (50%) reported negative impacts. The majority of negative impacts were recorded in the more intensively farmed lowland areas at sites directly adjacent to watercourses. The types of impacts recorded included burrowing into banks and increased erosion and bank collapse; crop foraging (wheat, barley and carrots); and dam-building and associated erosion and flooding. Of those experiencing negative impacts, 70% reported a financial cost.

One particular lowland farm on Tayside had 13.8 km of actively managed burns and drainage ditches on 445 ha of arable land. Between September 2013 and November 2014, 32 dams were built, or in the process of being built, by beavers. Dam-building occurred in seven sections of burns and drainage ditches. The dams were regularly removed by the landowner, mainly by hand, to avoid potentially serious impacts on field drainage. Dams in two of the seven sections were rebuilt within one day of removal, and at another two sections they were rebuilt a week after removal. Before beavers started to occupy the area, farm staff carried out walked inspections of burns and ditches twice a year to monitor for blockages. Following the arrival of beavers, the frequency of inspection was reported as increasing to once a week, requiring one day of work on each occasion. Approximately four hours per week was spent removing dams.

Issues and potential issues arising from beaver burrows in flood defence banks protecting intensive arable land were recorded on five sites on Tayside. At two sites, beaver burrowing activity had resulted in several breaches costing £5,000 to repair in 2013, and flood debris deposited on the land behind. A further breach was reported in early 2014. No breaches were recorded on the other three sites, but concerns were raised about increased risk due to burrowing activity in the area. In all cases, the flood-banks were within 10 m of the river and the burrow entrances were below the water level, resulting in a greater risk of erosion and collapse during spate flows.

4.14.4.4 Mitigation Measures

The Scottish Rural Development Programme (SRDP) 2014–2020, Pillar 2, Agriculture Environment and Climate Scheme (AECS), promotes land management practices which protect and enhance Scotland's natural heritage, improve water quality, manage flood risk, mitigate and adapt to climate change, improve public access and preserve historic sites. (has the aim of encouraging sustainable economic growth in Scotland’s rural areas. Its priorities include supporting agricultural business and protecting and improving the natural environment).

There are several management options and capital items available to encourage land managers to create new habitat and manage existing areas of farmland likely to be most affected by beaver activity. Agri-Environment Climate Scheme funding could be considered (for management) in the following areas:

- Water margins in arable fields
- Water margins in grassland fields
- Grass strips in arable fields
- Conversion of arable at risk of flooding or erosion to low-input grassland
- Wetland management
- Restoring (Protecting) River Banks
- Small-scale Tree and Shrub Planting

In addition, the Greening element of Pillar 1, Basic Payment Scheme, requires farms with a certain % of arable ground, to manage 5% of this area as an Ecological Focus Areas (EFA). The main aim of an EFA is to improve biodiversity and may potentially include the management of riparian buffer zones. There are six EFA options to choose from and fallow land, buffer strips and field margins could be adopted by land managers on land affected by beaver activity.

Section 5 also details the hierarchy of mitigation techniques that can be used to address impacts from beaver activities, including generic management and licencing approaches to more practical measures including those addressing:

- Dam building activities
- Burrowing activities and
- Foraging activities

These mitigation measures apply to the potential negative effects identified in relation to beaver activity and agricultural operations.

It is recognised however that mitigation for burrowing into flood banks may not be readily practicable and trialling of different deterrent techniques is required. SNH will work with the farming community to undertake trials. It is also recognised that there may be a desire to exclude beavers from some areas of prime agricultural land in the long term, and the efficacy of such an approach will also need to be trialled.

5.0 Environmental assessment mitigation

Section 4 sets out how beavers can have a wide range of interactions with both the natural and the human environment. Beavers are often described as a keystone species because of their ability to influence and shape their environment. This ability to alter the environment, either natural or man-made, is one of the reasons that may bring beavers into conflict with people. Although conflict with human land uses such as for agriculture, fisheries, property and infrastructure is likely to be the main driver for management intervention, there may also be a need to manage beavers and their impacts for other reasons, for example to protect the natural heritage or prevent the spread of animal diseases. The environmental assessment in section 4 identified instances where the creation of beaver dams has the potential to negatively affect a biological receptor. The mitigation measures outlined below will address impacts on the natural heritage as well as conflicts with human uses and disease spread.

Across the beaver range, whether in Europe, Asia or North America, a wide variety of techniques has been developed either to manage the impact of beavers or to directly manage the animals themselves. Some of this has been summarised in "The Eurasian Beaver Handbook, ecology and management of *Castor fiber*" (Campbell-Palmer *et al*. 2016). This helps to demonstrate that mitigation measures are already well-established and being practiced and therefore can be feasible and straightforward when applied in the Scottish situation. Existing literature reviews of the effectiveness of mitigation measures are being complemented by experience from trialling of different solutions/techniques in Tayside.

In the Scottish context the aim is to establish approaches that will avoid potential damage and then, where it occurs, to mitigate as appropriate. A Scottish Beaver Forum has been established by SNH and the membership includes non-government conservation bodies, land use and fishery bodies, and government agencies. Proposals for managing the impacts of beaver will be developed in consultation with this Forum to produce a management framework. The framework will include guidance on adaptive management, mitigation techniques, deterrence and exclusion, species licencing, positive management options, beaver welfare and provision of an SNH advisory service.

5.1 Mitigation hierarchy

The mitigation of impacts arising from the activities or presence of beavers range from practical measures to manage the local environment that influence the behaviour of beavers, mitigating the damage, through to the trapping and removal of animals or their lethal control. These are considered below in an environmental assessment mitigation hierarchy.

5.2. Avoidance of detrimental impacts

Positive and adaptive conservation management to enable beavers to establish and remain, and to reduce the potential for conflict with some types of land management. This management would likely be promoted on land owned by nature conservation or government agencies or through positive incentive schemes. It also provides wider environmental benefits. Positive measures could include the following:

- allowing some land to revert to wetlands, retention of existing wetlands
- 20 – 50m wide *riparian buffer zones* - woodland creation and restoration
- flood attenuation schemes
- flood-bank re-alignment

5.3 Mitigation techniques

A large number of mitigation techniques could apply to the two policy areas to reduce the impact of beaver activity. These relate to dam building, burrowing and foraging. The decision as to which technique(s) is most appropriate will depend on site-specific conditions. Consideration will also be needed to address, for example, animal welfare, legal and regulatory implications which may be relevant to beavers themselves or other protected species.

5.3.1 Dam-building

As has been discussed in sections 3.4.3 and 4.1, beavers building dams on rivers may bring a range of benefits. It is also important to accept that beaver dam-building will sometimes conflict with human interests and impose a cost in terms of resources (including time and money), especially in intensively managed landscapes. There is a particular issue over the possible effects of beaver dams on the movement of migratory salmonids under certain conditions (section 4.2), and a question as to whether this may indirectly affect other species such as otter that will sometimes feed on them (section 4.8).

Dam-building and the incidence of dams varies depending on habitat characteristics. On lochs or rivers more than 6 m wide, dam-building is uncommon. Beavers utilising narrower water bodies (less than about 6 m wide and 0.8 m deep) often build dams and can create extensive systems of multiple dams and impoundments. Where watercourses are steeper in gradient with higher banks in narrow valleys, the capacity for beaver activity to alter or create habitats on a significant scale is much more limited.

The length of time that dams persist in the environment varies and can be relatively short lived, particularly if food resources become depleted and/or they are not worth maintaining compared with the costs and benefits of exploiting resources elsewhere.

A summary of those management techniques used to mitigate the impacts of beaver damming activity is provided in Table 5.3.1 below.

Table 5.3.1: Summary of measures to mitigate impacts from the dam-building activities of beavers

	Summary of technique	Purpose	Limitation
Dam-notching	Removal of a small section of beaver dam, usually by hand, to increase water flow over that section	Most often associated with aiding fish passage. May be used to lower water levels in beaver ponds behind a dam.	In active territories, beavers will often repair notched dams within 48 hours. Labour intensive, especially at a catchment scale.
Flow devices	Placing a pipe through a dam to manage the water level behind it on a permanent basis	Used to manage water level behind or above a dam where a certain water level is tolerable, but any further increase would not be. Essentially, it acts as an overflow device for the dam.	Can be time consuming to install. Unlikely to be effective if poorly installed or the pipe is sized wrongly. Generally ineffective if less than 0.8 m of water remains behind the dam. Requires some ongoing maintenance.
Dam removal	Removal of a dam, either by hand or using mechanical devices	Used where no increase in water level, or potential blockage to fish passage, is considered acceptable in a watercourse or part of a watercourse.	Removal of dams often stimulates beavers to rebuild the structure using fresh woody material. Likely to require repetition. Manual removal may be more time consuming than using heavy machinery, but less likely to result in sudden release of water and/or silt.
Discouraging	Use of dissuasive techniques to prevent dam-building either where known 'pinch points' occur or where a dam has been removed and is likely to be reconstructed	Prevention of dam-building or rebuilding where dam-building is deemed intolerable.	A range of techniques have been trialled and found ineffective. Might include electric fencing strung above the dam site. Flashing lights etc. may work until animals become habituated to them.
Grilles	Use of metal grilles to prevent access to certain types of likely damming points, such as culverts	Prevents access for beavers to dam natural pinch points in watercourses.	Easily blocked by debris from beaver activities upstream or general detritus. Requires regular clearance and monitoring.

5.3.2 Burrowing

Beavers are strong and able diggers, and can readily excavate burrows and canals, which may collapse and/or increase bankside erosion to varying extents, depending on associated water flow and substrate type. Beaver burrows tend to be large and can end in sizeable chambers. Although the route of these structures is occasionally visible, the position of many others is difficult to determine. Beavers will readily excavate burrow systems which begin under water with entrances which can be obscured by tree roots or vegetation. Although the actual instances of beaver burrows causing the collapse of engineered flood walls are few, European natural resource agencies have developed a range of remedial measures. Other concerns relate to the possibility of livestock, horses, humans or farm machinery breaking through the surface into a beaver burrow with resultant damage or injury.

A summary of those management techniques used to mitigate the impacts of beaver burrowing activity is provided in Table 5.3.2 below.

Table 5.3.2: Summary of management techniques used to mitigation beaver burrowing activity

	Summary of technique	Purpose	Limitation
Prevention of burrowing	Use of sheet metal piling, rock armour or mesh to prevent burrowing, or further burrowing, into vulnerable flood defences or adjacent land.	Prevents beaver burrowing activity from starting or continuing in new or remodelled flood banks or into adjacent land.	Not straightforward or cheap. Can have considerable hydrological or hydrogeomorphological impacts. Likely to displace activity rather than completely prevent it.
Realignment of flood banks	Expanding the riparian zone used by beavers by moving existing flood defences a minimum distance (in the region of 20 m) from the edge of a watercourse.	Reduces the likelihood of beaver activity in flood defences or productive land. Allows for a greater floodable area within a catchment and may provide wider opportunities for riparian habitat creation and restoration and flood management.	Loss of productive land. Not all areas have sufficient room for expansion. Likely to be significant resistance from some stakeholders. Expensive.

5.3.3 Foraging activity

Beavers are herbivores and will readily consume a wide range of bark, shoots and leaves of woody (primarily broadleaved species), herbaceous and aquatic vegetation. Whilst beaver foraging activity is most noticeable on trees and woody vegetation, beavers will also forage in crops both as a source of food and for construction material where there is limited woody material available. Beavers display regular routines and feeding patterns, resulting in well-worn trails and canals being easily visible.

A summary of those management techniques used to mitigate the impacts of beaver foraging activity is provided in Table 5.3.3 below.

Table 5.3.3: Summary of management techniques used to mitigation beaver foraging activity

	Summary of technique	Purpose	Limitation
Exclusion fencing	Fencing, either permanent or temporary, to prevent beavers accessing areas of water, crops or trees where damage is deemed intolerable.	Prevents beaver access to areas where their impacts cannot be tolerated or prevents beavers accessing vulnerable or valuable crops or trees.	Not suitable for extensive areas. All fencing requires maintenance. Fencing to prevent the movement of beavers along a waterway may provide a dam-building point or act as an impediment to the movement of fish and other species. Inappropriate fencing could exclude other grazing/browsing species with consequent impacts on habitats. Probability of displacing impacts.

Individual tree protection	Protection of individual or small numbers of amenity or other valuable trees by use of individual fences, mesh wrapping or deterrent paints	Prevents beavers foraging on individual trees.	Relatively high visual impact. Only suitable for small numbers of trees.

5.4 Management of beavers – physical removal and exclusion

In cases where beaver conflicts cannot be suitably managed, because costs are too high or potential impacts too great, their removal or complete exclusion may be the only practical solution. These options would be more highly regulated and most would require an SNH licence as well as having to address other regulatory regimes. Methods of regulating beaver populations could include the following:

- Trapping and removal – live trapping by authorised persons for transport and release at approved sites
- Lethal control – authorised persons to kill specified beavers
- Lodge destruction – destruction of burrow/lodge by infilling or flattening
- Exclusion - for example from areas of prime agricultural land, designed gardens, road culverts and waste water treatment works. There may be some sub-catchments where effective fencing can exclude beavers from areas where consistent and constant removal may be the only other alternative.
- Fertility control – may allow for retention of stable but non-breeding beaver populations but there is little knowledge of the efficiency

5.5 Compensatory measures

Where mitigation measures are not feasible and there is beaver damage, e.g. to aspen and other vulnerable tree species, then biodiversity net gain should be considered such as compensatory planting elsewhere which is less susceptible to beaver activity. The limitation is that this approach would not always be able to address the loss of certain key habitat features, such as woodland of a particular structure and age, and the species associated with such features.

5.6 Pathogen / Disease transfer

In addition to mitigation measures to reduce the impact of beaver activity, it may be necessary to address the potential risk of disease transfer. The risk of spreading diseases associated with beavers is considered to be low, however surveillance should continue. In addition, any imported animals will be quarantined and screened. Table 5.1.4 below provides a summary of those mitigation measures identified to reduce this risk of disease transfer.

Table: 5.6.1: Summary of mitigation measures to reduce the risk of disease transfer

Pathogen / disease identified in assessment with risk of transfer to human populations	Mitigation identified
Alveolar hydatid tapeworm *Echinococcus multilocularis*	Health assessment and pathogen screening before release of any further beaver – use of diagnostic test of live animals and serological screening
Tuaraemia (*Francisella tularensis*)	Health assessment and pathogen screening before release
Leptospira spp.	Continued health surveillance of both beaver populations
Cryptosporidium spp.	Enhanced surveillance of human cases for a set period; Approaches to be discussed and agreed with local authority environmental health teams and Scottish Water

Giardia duodenalis	Continued health surveillance of both beaver populations. Enhanced surveillance of human cases for a set period; Approaches to be discussed and agreed with local authority environmental health teams and Scottish Water.

5.7 Management measures

Management of beavers and their impacts will involve the interaction of a number of different pieces of legislation. Further advice for mangers will be required. The following information, support and guidance have already been identified, as presented in Table 5.1.5 below:

Table 5.7.1 summary of mitigation advice, support and guidance

Mitigation Measure	***Purpose***	***Lead Authority***	***Proposed Timescale***
Guidance	Disseminate information on appropriate techniques to manage for the presence of beavers, or eliminate or reduce unwanted impacts e.g. tree protection	SNH	Available when legal protection enacted
Stakeholder forum	Set up and support appropriate a stakeholder group to facilitate knowledge exchange and communication	SNH	Ongoing
Best practice including training	Publication of information and provision of training for staff of public bodies, key stakeholders, consultants (e.g. through CIEEM)	SNH	Some ongoing activities, SNH Sharing Best Practice event(s) in 12-24 months from legal protection.
Trial mitigation techniques	To test efficacy and applicability and cost of management techniques e.g. exclusion fencing, fish passes	SNH	Ongoing
Advisory service	One to one advice to affected parties on the reduction or elimination of unwanted impacts.	SNH In due course, private operators will provide advice	Available now from SNH
Licensing scheme	Development of a fit-for-purpose scheme of appropriate derogations to enable legal management that can reduce or eliminate impacts from beaver activity	SNH	Available when legal protection enacted
Animal health monitoring and quarantine	To prevent the introduction of harmful biological pathogens into Scotland, and monitor existing populations if judged appropriate	SG	To be decided for existing beaver populations that have already been monitored. Also would be required for any future, approved importations

6. Assessment of Alternatives

The BiS report set out 4 potential policy scenarios for beavers in Scotland, ranging from the full removal of beavers to the widespread reintroduction of beavers. The scenarios were broad and a number of sub-options were possible. The benefits and risks were outlined for all scenarios.

6.1 Alternative scenarios

As detailed in the scoping report, the preferred policy alternative draws from both scenarios 2 and 3.

This is also based on the understanding that any scenarios which proposed future beaver presence would also require population reinforcement.

The 4 policy alternatives considered are:

- Scenario 1 - full removal of beavers from the wild in Scotland
- Scenario 2 - restricted range. Allowing beavers to expand from their current range, but specific catchments would be managed to keep them free from beavers.
- Scenario 3 - widespread recolonisation. The beaver population would be allowed to expand to its natural limits. Eventually this could include further releases outside the two current population areas.
- Scenario 4 - accelerated widespread recolonisation. Proposals for new releases could be considered immediately.

The key benefits and risks of each scenario are provided in the table below.

Comparison of benefits and risks of alternative policy scenarios

Table 6.1 Comparison of the benefits and risks of alternative policy scenarios

Scenario	Benefits	Risks
1. Full Removal	• Certain environmental and land use interests would no longer be at risk from beaver activity • After removal, the recent historical status quo would be maintained and there would be no need to plan for and resource beaver management • The Tayside population, the origin of which has been perceived as having undermined lawful best practice, would be removed	• The active removal of a former native species would be viewed as a controversial decision and could undermine Scotland's international reputation for biodiversity conservation. There could be an impact on Scotland's image as a destination for wildlife experiences and tourism • There would be the cultural loss of a species with high popular appeal • There would probably be a strong public response to any beaver eradication programme (there was a campaign to prevent the removal of beavers on Tayside prior to the ministerial decision in 2012 to tolerate their presence for a trial period, and a petition with over 13,000 signatures was produced against the removal of beavers from the River Otter in southern England) • There are a number of risks associated with the effectiveness of eradication techniques and the length

		of time eradication could take • The removal of beavers would be seen as a lost opportunity to benefit biodiversity and key ecosystem services and to contribute to Aichi 2020 targets on biodiversity • There may be legal challenges over the interpretation of the Habitats Directive and the use of lethal control, and any decision on the desirability of reintroducing beavers
Scenario 2 - restricted range	• The ecological and ecosystem service benefits of beavers would be maintained in specific areas. A programme of riparian habitat restoration and creation ('buffer zones') targeted in beaver areas, and areas which may be colonised, could help to promote the positive effects of beavers, reduce conflict, benefit land managers and users and protect vulnerable species • Beaver-free catchments could be identified to reduce the risk of potential negative impacts on sensitive land use or vulnerable habitats and species such as Atlantic hazelwood and aspen • Beaver areas could be promoted to benefit socio-economic interests, such as wildlife tourism	• There is no experience of this type of restricted reintroduction for any other native species in Scotland. Clear justification, taking into account biological and socio-economic factors, would be required to garner support • Costly, intensive management would be required, and it would be very difficult to guarantee catchments could be kept beaver free into the long term • The translocation of beavers from beaver-free catchments, rather than culling, may be a more acceptable approach for many people. However, the identification of suitable receptor sites will become more challenging as beaver density increases • There would need to be a clear legal basis for any licensing decisions over the use of certain management techniques, taking into account the conservation status of the species. Even in the long term there would be only a relatively small population and restricted range, which may have implications on the conservation status of beavers and on licensing decisions relating to management • If numerous catchments are designated as beaver free, beavers may be restricted to a series of restricted and isolated ranges. Hence, the population(s) may require regular reinforcement to combat genetic drift • Appropriate levels of deer management would be needed in beaver areas to avoid potential negative effects and enable positive ecological effects • Monitoring and research into the impacts on vulnerable species and habitats, and wider environmental and socio-economic interests, would be required to inform management requirements • Predicted recolonisation rates of

		beavers are expected to be slow in the short to medium term, resulting in a delay to the realisation of potential benefits across a larger part of Scotland
Scenario 3 – widespread recolonisation	• This scenario would be expected to provide a stable population of beavers over the long term, and the conservation status of the species will progressively improve • Decisions on further releases could be highly selective. This would allow specific locations to be chosen, for example to limit human conflict and protect vulnerable species and habitats • New release sites would not be approved for a few years, and this would allow more time to improve and streamline management techniques before a widespread beaver population becomes established. Management techniques could be based on European experience and tailored to the Scottish situation • This would also allow time for research to be completed on issues where there is still uncertainty over impacts, such as on Atlantic salmon • There would be widespread ecological and ecosystem service benefits in current and future beaver areas. A programme of riparian habitat restoration and creation (‘buffer zones’) targeted in beaver areas, and areas which may be colonised, would help to promote the positive effects of beavers, reduce conflict, benefit land managers and users, and protect vulnerable species • A widespread beaver reintroduction would enhance Scotland’s international reputation for biodiversity conservation, and as a wildlife destination for visitors. This may translate into a specific tourism boost near release sites and wider socio-economic benefits	• For the current and future populations, as the range and population densities of beavers increase, there will be an increase in human–beaver conflict and associated management needs. Appropriate measures would need to be established to reduce conflict in consultation with relevant stakeholders, such as careful selection of release sites, the establishment of riparian buffer zones where acceptable, etc. In the medium to long term, there may be a need for culling under certain circumstances, which may prove contentious • There would need to be a pragmatic and flexible approach to licensing in relation to releases and the use of certain management techniques, taking into account the conservation status of the species • Appropriate levels of deer management would be needed in beaver areas to avoid potential negative effects • Monitoring and research into the impacts on vulnerable species and habitats, and wider environmental and socio-economic interests, would be required • Predicted recolonisation rates of beavers are expected to be relatively slow in the short term, resulting in a delay to potential benefits in the wider countryside and possible frustration amongst some stakeholders • Tourism benefits for specific areas with beavers may decrease as they become more ubiquitous
Scenario 4 - accelerated widespread recolonisation	• This scenario would be expected to provide a stable population of beavers over the long term, and the conservation status of the species will progressively improve. It is possible this may	*Key risks* • New releases may take place before any management strategy has been finalised. This could mean a lost opportunity in planning beaver reintroduction at the national scale

	happen a few years earlier than scenario 3 if wider releases are authorised sooner, although scenario 3 would ensure they could be planned more carefully, and thereby increase the chances of better outcomes • There would be widespread ecological and ecosystem service benefits in current and future beaver areas. A programme of riparian habitat restoration and creation ('buffer zones') targeted in beaver areas, and areas which may be colonised, would help to promote the positive effects of beavers, reduce conflict, benefit land managers and users, and protect vulnerable species • A widespread beaver reintroduction would enhance Scotland's international reputation for biodiversity conservation and as a wildlife destination for visitors. This may translate into a specific tourism boost near release sites and wider socio-economic benefits • This scenario may minimise the risk of unauthorised releases taking place	that could bring most environmental and socio-economic benefits and minimise conflicts • There may be a risk that land use organisations, and some specialist conservation groups, feel beaver reintroduction is being rushed before some of their concerns are being adequately addressed through the development of a management strategy • The effectiveness of management techniques may require time to be tried, tested and refined, and for managers to become suitably trained and experienced • For the current and future populations, as the range and population densities of beavers increase, there will be an increase in human–beaver conflict and associated management needs. Appropriate measures would need to be established to reduce conflict in consultation with relevant stakeholders, such as careful selection of release sites, the establishment of riparian buffer zones where acceptable, etc. However, in the medium to long term, there may be a need for culling under certain circumstances, which may prove contentious • There would need to be a pragmatic and flexible approach to licensing in relation to releases and the use of certain management techniques, taking into account the conservation status of the species. • Appropriate levels of deer management would be needed in beaver areas to avoid potential negative effects and enable positive ecological effects • Monitoring and research into the impacts on vulnerable species and habitats, and wider environmental and socio-economic interests, would be required • Tourism benefits for specific areas with beavers may decrease as they become more ubiquitous.

6.1.1 Scenario 1 – Full removal

Description
Beavers would be fully removed from the wild in Scotland.

Timescale
It should be possible to remove the vast majority of beavers from the wild in Scotland within five years. However, this will be dependent on the scale of resources available. There would need to be a certain level of surveillance and reactive management to deal with any remaining individuals, further escapes from captive collections and illegal releases.

Implications for beavers
This would involve the killing and/or capture of all beavers from Knapdale (likely to be over 10 animals) and the Tay and Earn river catchments (where there may be 150–200 animals). Some may be rehoused in private collections, but given the numbers involved it is likely that most would have to be humanely destroyed.

There may also be longer term inconsistency and implications if England decided to reintroduce beavers more widely in the future and animals start to colonise the Scottish Borders and Dumfries and Galloway. These animals would then need to be removed, probably on a continuous basis. At present, beaver reintroduction has been proposed in Wales and beavers are being tolerated and monitored at the River Otter in south-west England for a trial period.

Effects on the environment
Removal would avoid the need to put in place management to protect certain vulnerable species and habitats from detrimental impacts.

However, there would be an overall loss of potential future biodiversity benefits and wider positive ecosystem services. The overall detrimental impact on long-term ecological goals to halt biodiversity loss, including contributions to meeting Aichi 2020 targets on biodiversity, would be hindered.

Management implications
It can be assumed that the Tayside beaver population has grown since the last Tay beaver survey in 2012, which estimated 38 or 39 beaver colonies (approximately 106–187 animals). The TBSG final report noted that there were 11 reports of beaver activity between 2013 and 2014 in areas not identified in the 2012 survey. Population growth rates have been measured at anywhere between 5% and 34% per year in other studies. The recent modelling study estimated 46 colonies (198 beavers) present in 2016.

One study has estimated the time required to clear a beaver colony as being three days using two people and a combination of trapping and shooting techniques, although this is based on methods that would be illegal under Scots law (Chapter 5). If these figures are applied to Tayside, then approximately 280 person-days would be required to clear the estimated number of colonies if the locations are known. However, it would take longer to remove the animals because of the types of techniques that would be legal and appropriate for Scotland.

Once the main recorded colonies have been removed, it becomes more difficult to estimate the medium to longer term resources required for this scenario. There would be diminishing returns as the beaver density is reduced, since finding individuals from a low-density, dispersed population would be a difficult task. Significant time would be needed to deal with any new reports of activity or sightings and to monitor the Tay, Earn and surrounding catchments to confirm eradication.

The 2012 Tay survey involved identifying previously reported areas of beaver activity and suitable beaver habitat to target the fieldwork. Similar techniques could be used for any beaver removal operation, for example by applying the types of mapping and predictive modelling outputs described in section 3.2, combined with more recent field records and preliminary survey work.

Resources would also be required to remove several beaver families from Knapdale. Although a detailed assessment would be required to calculate the likely costs of removal, a rough estimate, taking the above into account, could be around 1,000 person-days needed to complete the main initial task, with further time required for follow-up surveillance. For example, any beaver originating from an unauthorised release presents increased risks associated with unknown provenance, including those relating to public health. This can be compared to the complex and ambitious Hebridean Mink Project which started in 2001 and costs about £350,000 per year. Mink are more difficult to locate than beavers, and the original numbers of mink were far higher, but statistical models have predicted that the project will have successfully extirpated American mink from Lewis and Harris between 2014 and 2021.

It is anticipated that many land managers would be willing to collaborate with any removal of beavers. Working with land managers through a voluntary approach is always the preferred option, although legal powers now exist to compel people to take action when necessary.

A trial reintroduction of beavers to Wales has been proposed and the English wild beaver population on the River Otter will be tolerated until 2020. There are reports of beavers living in the wild in other parts of England, although to date these have been in the south. In the long term it is possible that other populations may become established in England or Wales, arising from authorised or unauthorised releases, and ultimately beavers may start to colonise Scotland. Under scenario 1, beavers would be culled if they colonised Scotland, with the possibility of ongoing and long-term management and associated costs.
Removal will be contentious and will be opposed by a range of individuals and organisations. There is the possibility of interference with any trapping or culling operations.

Discussion
This scenario has similarities to the approach used for some non-native species, such as American mink.
There would be short-term costs of eradication and longer term costs of monitoring within Scotland and preventing colonisation from any potential populations south of the border. Resources already invested in the SBT and other Scottish initiatives may be perceived as wasted by some parties. These can be compared with the costs and benefits associated with allowing beavers to remain.

6.1.2 Scenario 2 – Restricted range

Description
Beavers would be allowed to expand from their current range, but specific catchments would be managed to keep them free from beavers.

Timescale
Although it is difficult to predict, population models suggest that beavers may not expand far from their current catchments over the next two or three decades (section 3.2), assuming there is no human assistance. However, as the density of the populations increase over time, there is an increased likelihood of dispersal into neighbouring catchments.

Implications for beavers
There would be no further releases of beavers other than for population reinforcement, for genetic reasons and/or to increase the numbers of animals. Beaver range expansion would probably be slow from the current populations (see section 3.2) with population models suggesting no or limited natural expansion outside the Tay and Earn catchments over the next 30 years. Range expansion at the national scale would therefore take longer in comparison with scenarios 3 and 4.

Although the Knapdale population is currently stable, there are inherent risks to it if reinforcement is delayed. It was not designed as a founder population for a reintroduction, and there is a risk that it will become extinct in the short term (section 3.2). There may also be a risk of inbreeding on Tayside in the future, and so further monitoring of genetic health would be needed to decide if reinforcement is required.

If numerous catchments were 'designated' as beaver free, beavers could be restricted to a series of isolated ranges, and there is a risk that the overall population would require regular reinforcement to combat genetic drift.

Effects on the environment
Some of the potential benefits of reintroduction would be retained, although over a relatively small area, particularly in the short to medium term. There would be some future biodiversity benefits, and wider positive ecosystem services, including a limited contribution to meeting Aichi 2020 targets on biodiversity. The status quo would be maintained within beaver-free catchments.

Beavers would have positive and negative impacts on a wide range of environmental and socio-economic interests where they occur. Within the areas where beavers are currently present, or may be colonised, appropriate monitoring and management would be needed. For example, the monitoring of potentially vulnerable species and habitats would be required and robust beaver management required in specific areas. Further research may also be needed (e.g. examining potential impacts on biological or socio-economic factors) and appropriate levels of targeted deer management may be required to avoid potential negative, and promote positive, ecological effects (see section 3.4.1).

Within the catchments concerned there would be an opportunity to develop a programme of riparian habitat restoration and creation targeted in beaver areas, and areas which may be colonised ('buffer zones', see Chapter 5), which would help to promote the positive effects of beavers, benefit land managers and users, reduce conflict and benefit vulnerable species.

Management implications
The management strategy developed for this scenario would include detailed guidance on the practical and legal issues surrounding beaver management. Standard beaver management techniques, outlined in Chapter 5, would be employed in the colonised area. The costs of management would increase as the beaver population increased in size and range. There is predicted to be a relatively high level of connectivity between catchments for beavers (see section 3.2). Therefore, over the long term and once populations within catchments are established, beavers are unlikely to be significantly restricted from colonising other catchments by the natural features of the landscape. However, beaver colonisation from the two current beaver areas is expected to be slow in the short to medium term.
Keeping an entire catchment beaver free would be labour intensive. The difficulties would be highly dependent on the nature of the catchment, the potential barriers to dispersal to adjacent catchments and surrounding beaver populations. For example, large catchments, with large borders, adjacent to high-density beaver populations, may require high levels of monitoring and management to keep them beaver free into the long term.

An option that might be applied within this scenario would be 'designating' specific beaver-free areas within an individual catchment, based on factors such as sensitive land use. This approach would require intensive management over the long term. Non-lethal options, such as the creation of 'buffer zones' in other areas (see Chapter 5), may have a role, but it would also require the culling or trapping of potentially high numbers of dispersing beavers on an annual basis. A Norwegian study highlighted that: '…the spread of beavers within a river system cannot, in practice, be contained without a heavy, and constant, directed hunting or trapping effort'. Any future management strategy would need to examine the feasibility, practicality and resourcing of such an approach.

Certain types of management, such as culling or trapping, would be more likely to be required in the longer term and would be more contentious. Keeping areas free of beavers may go against the wishes of some land managers, as well other individuals and organisations.

There is a risk that some may view this as too slow an approach and unauthorised releases may become more prevalent. Appropriate management and legal action would then be needed.

Discussion
This scenario has similarities to the approach used to manage the spread of some non-native species, such as sika deer *Cervus nippon*.
Although there are uncertainties, it seems likely that, overall, the ongoing costs of keeping a catchment (or part of a catchment) beaver free could be significant.

6.1.3 Scenario 3 – Widespread recolonisation

Description
The beaver population would be allowed to expand to its natural limits. Eventually this could include further releases outside the two current population areas. However, initially the focus of resources would remain with Tayside and Knapdale and in developing an appropriate management strategy. This would be a more cautious approach than in scenario 4.

Timescale
Although it is difficult to predict, population models suggest that beavers may not expand far from their current catchments over the next two or three decades (section 3.2) without human assistance. As the density of the populations grew over time, there would be an increased pressure upon young animals to disperse into neighbouring catchments to find unoccupied suitable territories. Conversely, if further releases took place in new catchments with large areas of available suitable beaver habitat, then populations may not expand substantially beyond those catchments for two or three decades. At a national level, the range of beavers and size of the population will depend on the number and timeframe of further releases.

This scenario envisages a cautious approach to further releases over the short term (e.g. the next five years or so), allowing time to develop a detailed management strategy and for resources to be focused on ensuring that viable, appropriately managed populations are established at Tayside and Knapdale.

Implications for beavers
The Knapdale beaver population borders the River Add and a series of small coastal catchments. These are the areas that would be expected to be colonised first after population reinforcement. In the longer term the population is likely to expand into Loch Awe and across much of Argyll.

The 2012 River Tay beaver survey located animals in the Tay, Earn and Forth river catchments. These catchments border the Dee, South Esk, Lunan, Monikie, Dighty, Dundee

Coastal, Annaty, Farg, Loch Leven, Devon, Allan, Bannock, Carron, Lomond, Awe, Etive, Blackwater, Lochy and Spey catchments, which would be expected to be colonised first (section 3.2 highlights the predicted high connectivity between catchments). Therefore, the Tay population has the potential to colonise much of Scotland in the longer term. In particular, the Spey catchment to the north and the Loch Lomond catchment to the south-west, have large areas of suitable beaver habitat.

It is expected that beavers will need to be present within an area for 25 years before population growth plateaus and beavers may be considered to be at high density. A key conclusion of the recent population modelling work was that beaver range expansion will be slow. For example, beavers are unlikely to significantly expand from their current catchments within the next two or three decades.

Therefore, there is an argument for further releases in due course. The size of the founder populations and the suitability of release sites will be the key determinants of the success of beaver reintroduction, as for any species reintroduction. The Best Practice Guidelines for Conservation Translocations in Scotland sets out key considerations. This scenario provides time to develop a more strategic approach to planning a national reintroduction that addresses these issues, and therefore a better chance of establishing a viable, long-term beaver population.

For example, enabling the two current populations to link up may provide improved population stability. Further releases within the Awe catchment may be the simplest approach to linking the populations, as it borders the Tay catchment, and lies just 8 km from the Knapdale population.

Other prioritised areas could be identified for further releases based on the abundance of potential core beaver habitat within a catchment. The Ness, Spey, Tay and Lomond river catchments were previously identified as major areas of potential beaver habitat within Scotland. More recent analyses have supported this assessment (section 3.2), although other areas would also be suitable.

Effects on the environment
The current benefits of the Knapdale and Tayside beavers to biodiversity and wider positive ecosystem services would be retained. In addition, the wider reintroduction of beavers would represent a clear commitment to creating longer term biodiversity benefits.

The speed of colonisation in this scenario would depend on the timing and extent of further releases. A slow speed of colonisation would mean widespread positive ecological effects might not be felt for some years and beaver presence would play a limited role in contributing to Scotland's Aichi 2020 targets. However, a slower colonisation may also provide more time to plan and prepare for appropriate management. Further beaver releases could be targeted to help restore degraded ecosystems.

Beavers would have an impact on a wide range of environmental and socio-economic factors where they occur. Within the areas where beavers are currently present, and are likely to be colonised, appropriate monitoring and management would need to be in place. For example, the monitoring of potentially vulnerable species and habitats would be required, and robust beaver management in specific areas. Further research may be also be needed (e.g. examining potential impacts on biological or socio-economic factors), and appropriate levels of targeted deer management may be required to avoid potential negative, and promote positive, ecological effects. A programme of riparian habitat restoration and creation targeted in beaver areas, future release sites, and areas which may be colonised ('buffer zones'), would help to promote the positive effects of beavers, reduce conflict, benefit land managers and users, and benefit vulnerable species.

Management implications
In this scenario further releases of beavers would be considered, although releases at sites outside Knapdale and Tayside would not be encouraged for a number of years. Short-term effort could concentrate on improving the viability of the Knapdale and/or Tayside populations.

The management strategy developed under this scenario would include detailed guidance made available on the practical and legal issues surrounding beaver management. This would be developed over the next few years with key stakeholders, and would include a strategic approach to identifying where further releases might be most appropriate.

The types of standard beaver management techniques outlined in Chapter 5 would be employed in areas with beavers. In the longer term the costs of management would increase as the beaver population increases in size and range. There are no significant predators of beavers in Scotland, and populations may become large and/or high density in places. Management would be required to reduce potential negative impacts (much like deer management currently). Certain types of management that are more likely to be required in the longer term, such as culling or trapping, will be more contentious.

All further releases would need to address the Scottish Code for Conservation Translocations. The merit of further releases would be assessed against a range of criteria including local public support, ecological impacts, impacts on the status of the wider beaver population and an assessment of how quickly they may colonise an area without a release.
There is a possible risk that some may view this as too slow an approach, and unauthorised releases may become more prevalent.

The option of 'designating' specific beaver-free areas within an individual catchment, described in scenario 2, could be considered for scenario 3 as well.

Discussion
This is similar to the approach taken in Denmark. There, 18 beavers were released at a single site at Kosterheden in 1999 and impacts were monitored. The population had increased to approximately 165 individuals by 2011. Animals were then released at a second release site, at Arresø, in 2009. In the long term the Danish population is expected to be reinforced through the natural migration of beavers from Germany.

6.1.4 Scenario 4 – Accelerated widespread recolonisation

Description
The beaver population would be allowed to expand to its natural limits. Proposals for new releases could be considered immediately. This would be a less cautious approach than scenario 3, and more reactive to new release proposals.

Timescale
Many of the timescale issues set out for scenario 3 also apply to scenario 4. However, it is anticipated that releases at sites other than Knapdale and Tayside would happen sooner under this scenario, probably within the next few years. This would be subject to organisations coming forward with appropriate project proposals and resources.

Implications for beavers
Many of the implications for beavers set out for scenario 3 also apply to scenario 4. However, under this scenario releases at new sites may happen over the next few years, and therefore beavers will become re-established over wider areas within a quicker timeframe. However, there are risks that resources may be diverted from ensuring that the current populations at Knapdale and Tayside are viable. There may also be a lost opportunity in planning for the next

phase of beaver releases at a national level, and ensuring the best chance of establishing a viable, long-term beaver population with wider benefits.

Effects on the environment
Many of the effects on the environment set out for scenario 3 also apply to scenario 4. Since there is the possibility of more beaver release sites over the next few years under this scenario, then that would mean any benefits to biodiversity and ecosystem services could be distributed more widely more quickly. The potential disadvantage is that there would not be the opportunity to plan the next phase of further releases in a way that may target and maximise these benefits most effectively and efficiently.

Management implications
Many of the management implications set out for scenario 3 also apply to scenario 4. However, new beaver release sites may be approved before a management strategy has been finalised. There may be a risk that land use organisations, and some specialist conservation groups, feel beaver reintroduction is being rushed before some of their concerns are being adequately addressed. Other stakeholders may welcome such an approach, and there may be less risk of unauthorised releases taking place.

The option of 'designating' specific beaver-free areas within an individual catchment, described in scenario 2, could be considered for scenario 4 as well.

Discussion
This approach has some parallels with other beaver reintroductions. In Switzerland there were uncoordinated releases of beavers at 33 sites over a 22-year period, and this lack of strategic approach to reintroduction was judged to be a major reason why there were initial problems with the viability of the population.

6.2 Conclusion

The policy agreed by Scottish Ministers draws from both scenarios 2 and 3 in the report. That is:

- Beaver populations in Argyll and Tayside can remain;
- The species will receive legal protection, in accordance with the EU Habitats Directive;
- Beavers will be allowed to expand their range naturally;
- Beavers should be actively managed to minimise adverse impacts on farmers and other land owners;
- It will remain an offence for beavers to be released without a licence, punishable by up to 2 years imprisonment and an unlimited fine.

The decision acknowledges the range of benefits of beavers being present in Scotland but also the importance of demonstrating how the re-introduction can best be actively managed to minimise adverse impacts on land managers in Tayside and Argyll before considering further reintroductions elsewhere in Scotland.

7. Beaver SEA – Monitoring, Survey and Research

Undertaking the SEA has enabled a clear audit of key receptors and identification of the priority monitoring requirements. This will provide a template for the survey and monitoring protocol which will be developed by SNH and partners in 2017 and longer term to assess the impacts of the proposal to allow beavers to remain in Scotland.

7.1 Natural heritage monitoring

Habitat and species changes on designated sites arising from impacts of beavers will largely be covered through the SNH 6 yearly Site Condition Monitoring programme. The next 6 year cycle is due to commence in 2019 and beaver impacts will be part of the assessment. Monitoring results from 2019 onwards can be compared with the baseline established through the previous three SCM cycles. Prior to 2019, SNH will undertake a review to establish whether there will be gaps in the SCM programme and whether the methodology is appropriate.

The key features likely to be monitored are:

- The Natura features on 34 sites identified in the HRA where beaver mitigation plans are required to avoid an *adverse effect on site integrity*"
- river jelly lichen
- freshwater pearl mussel
- Atlantic salmon
- three species of lamprey – sea, river and brook
- otter
- habitat of invertebrates: dragonflies and flies
- woodland habitats of bryophytes, lichens and fungi
- American mink
- woodlands particularly alder woodland on flood plain, bog woodland, scrub woodland and Atlantic hazelwood lichen assemblage and aspen woodland associated with the Spey if beavers colonise
- lowland lochs and wetlands, particularly soligenous mire communities
- fluvial-geomorphology

The findings of SCM will be used to develop habitat and species management plans and promote effective mitigation measures to reduce impacts of beaver. For woodland habitats the impacts should also be monitored using the Woodland Grazing Toolbox methodology.

Outwith designated sites, for those species and habitats of conservation interest in the wider countryside, there will be an ongoing need to assess data derived from general surveillance and monitoring activities that are already in place, and intervene with management if and when necessary.

7.2 Other Environmental monitoring

In addition, in 2017 a survey and monitoring protocol of beaver impacts will be developed in consultation with the Scottish Beaver Forum. This will include monitoring of:

- agriculture - focussed on prime agricultural land
- forestry
- lowland deer
- fisheries - particularly salmon and trout
- public and animal health if judged appropriate

- cultural heritage interests – key examples are Designed Gardens and associated veteran trees, The Crinan Canal and in standing waters; crannogs.
- infrastructure and property – e.g. canals and associated feeder lochs, fish passes, culverts, drainage systems etc.
- wider socio-economic interests

The information will help refine adaptive management approaches and production of guidance. This will also include collated and coordinated information and surveys of lowland deer populations.

7.3 Beaver surveys and monitoring

- Tayside – A beaver survey of the River Tay catchment was undertaken in 2012 with some further records collated in 2014. A new 2017 survey is currently underway to establish key areas of beaver activity, the population size and the range expansion of the population. This will provide information on population increase and distribution which will aid the production of guidance.
- Knapdale –Surveys have been undertaken in 2016 and 2017 at Knapdale by RZSS to establish the status of the current population, and to inform decisions for reinforcement.

These surveys will contribute towards both the national scale monitoring and reporting of beavers: The Habitats Directive Article 17 Reporting and to inform our management decisions.

7.4 Monitoring of effectiveness of trial mitigation measures

To supplement evidence from European techniques and trials conducted by the Tayside Beaver Study Group, trials will be undertaken in Tayside in partnership with land and fisheries managers to establish the effectiveness of electric fencing, “swept wing fences” on water courses, flow devices in dams, techniques for preventing burrowing into flood banks and fish pass design. The effectiveness of the trials will be monitored and used as case study examples in guidance and will enable feedback so that we can adapt our approach in light of experience.

7.5 Promoting opportunities for further research and monitoring

SNH will work with research partners to further develop and refine geospatial and modelling tools to help predict beaver habitat use, population expansion and re-colonisation and interaction with land uses.

A partnership funded PhD at Southampton University is in its final year and is investigating interactions between trout and beavers, in particular the ability of the fish to migrate in the presence of beaver dams. Ultimately this work will contribute towards the production of guidance for fisheries managers.

SNH will work with key partners to identify research needs develop a programme of work and identify opportunities for taking it forward. These will focus on key topics such as beavers and salmonids, interactions with deer and impact on woodland regeneration, beavers and their role in natural flood management and the efficiency of beaver management techniques.

7.6 Conclusion

Monitoring and research will be driven by an adaptive management approach. The outcomes of trials and monitoring results will enable SNH to modify their conservation management and guidance for natural heritage, socio-economic, land, fisheries and infrastructure managers.

List of acronyms/abbreviations

AECS	Agriculture Environment and Climate Scheme
BiS	Beavers in Scotland report
BSWG	Beaver-Salmonid Working Group
CAR	Water Environment (Controlled Activities) (Scotland) Regulations 2011
DSFBs	District Salmon Fishery Boards
EPIC	Epidemiology, Population health and Infectious disease Control (Centre of Expertise on Animal Disease Outbreaks)
EPS	European Protected Species
ER	Environmental Report
ESF	Ecosystem Services Framework
ESU	Evolutionary Significant Unit
EU	European Union
FCS	Forestry Commission Scotland
GDL	Gardens and Designed Landscapes
GIS	Geographic Information Systems
HRA	Habitats Regulations Appraisal
IUCN	International Union for the Conservation of Nature
LADAC	Lochgilphead and District Angling Club
LAR	Live Animals Regulations
MSS	Marine Scotland Science
NASCO	North Atlantic Salmon Conservation Organisation
NFI	National Forest Inventory
NUV	Non-Use Value
NWSS	Native Woodland Survey of Scotland
ORC	Operations Requiring Consent
PPS	Plan, programme or strategy
RZSS	Royal Zoological Society of Scotland
SAC	Special Area of Conservation
SAF	Species Action Framework
SBT	Scottish Beaver Trial
SCM	Site Condition Monitoring
SEA	Strategic Environmental Assessment
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
SPA	Special Protection Area
SRDP	Scottish Rural Development Programme
SSSI	Site of Special Scientific Interest

SWT	Scottish Wildlife Trust
TBSG	Tayside Beaver Study Group
UK	United Kingdom
UK BAP	UK Biodiversity Action Plan
WCA	Wildlife and Countryside Act 1981 (as amended)
WTP	Willingness to pay

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Appendix 1 – Environmental Characteristics

LIST OF MAPS

Biodiversity, flora and fauna

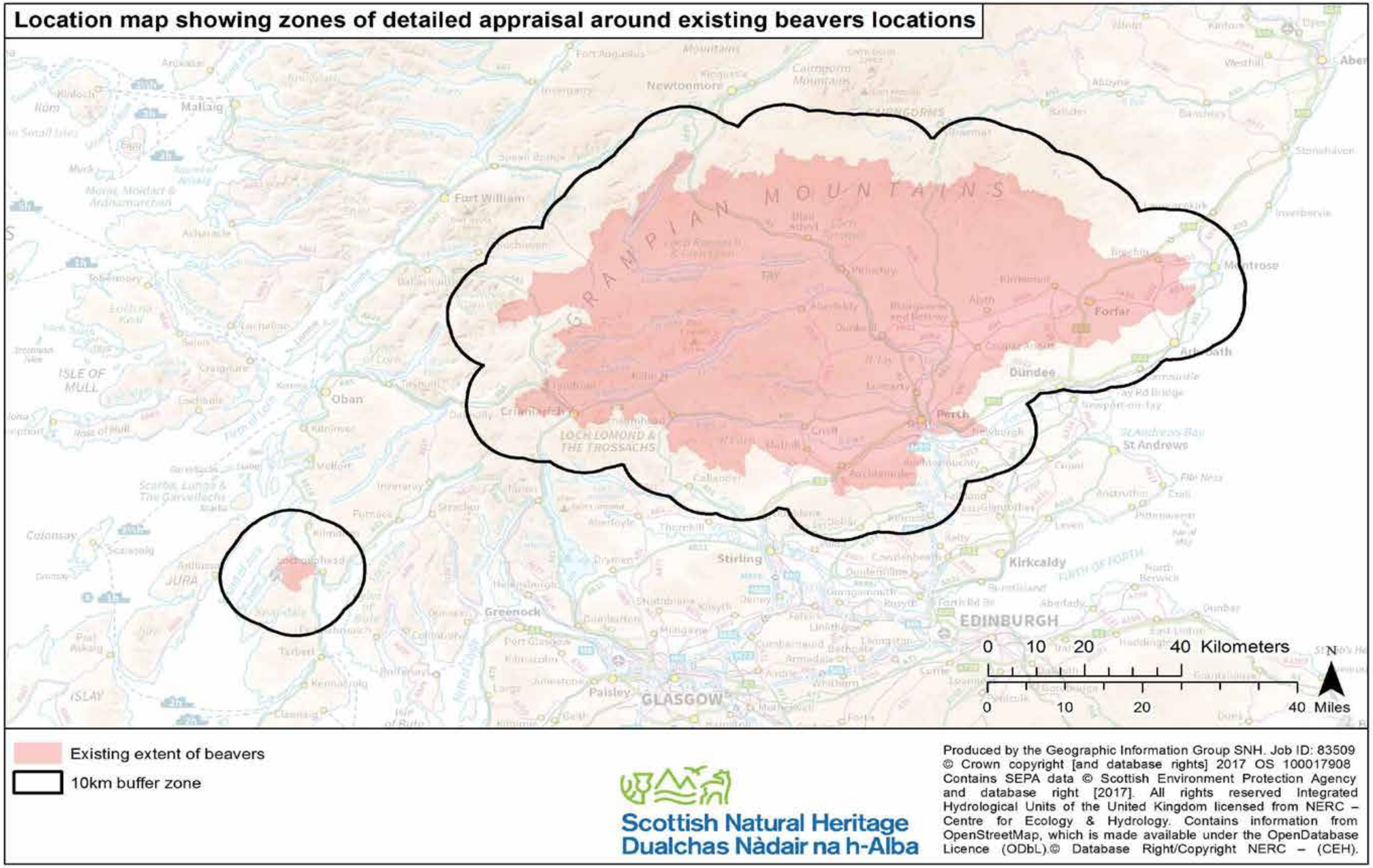
Water

Population and Human Health

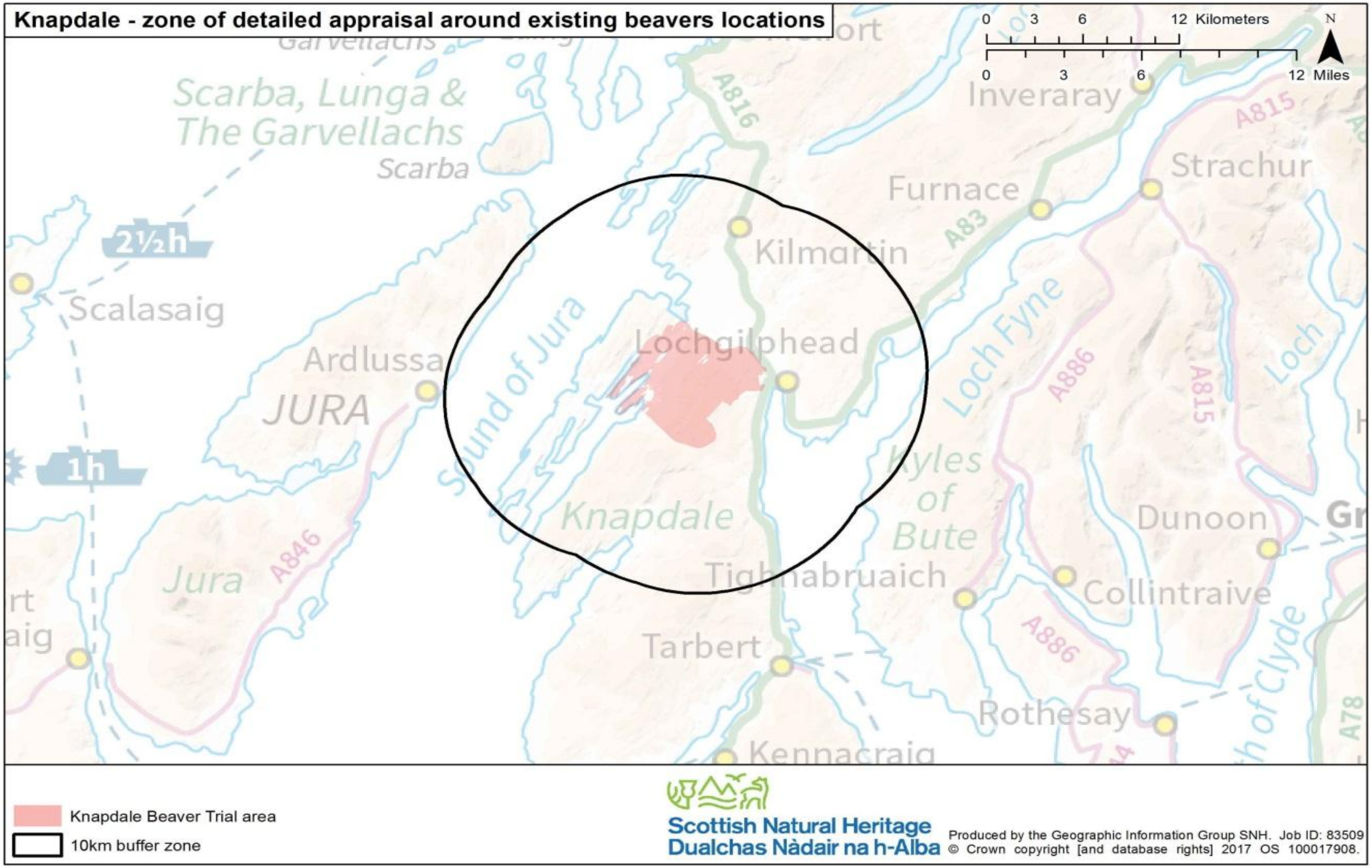
Cultural heritage

Material Assets

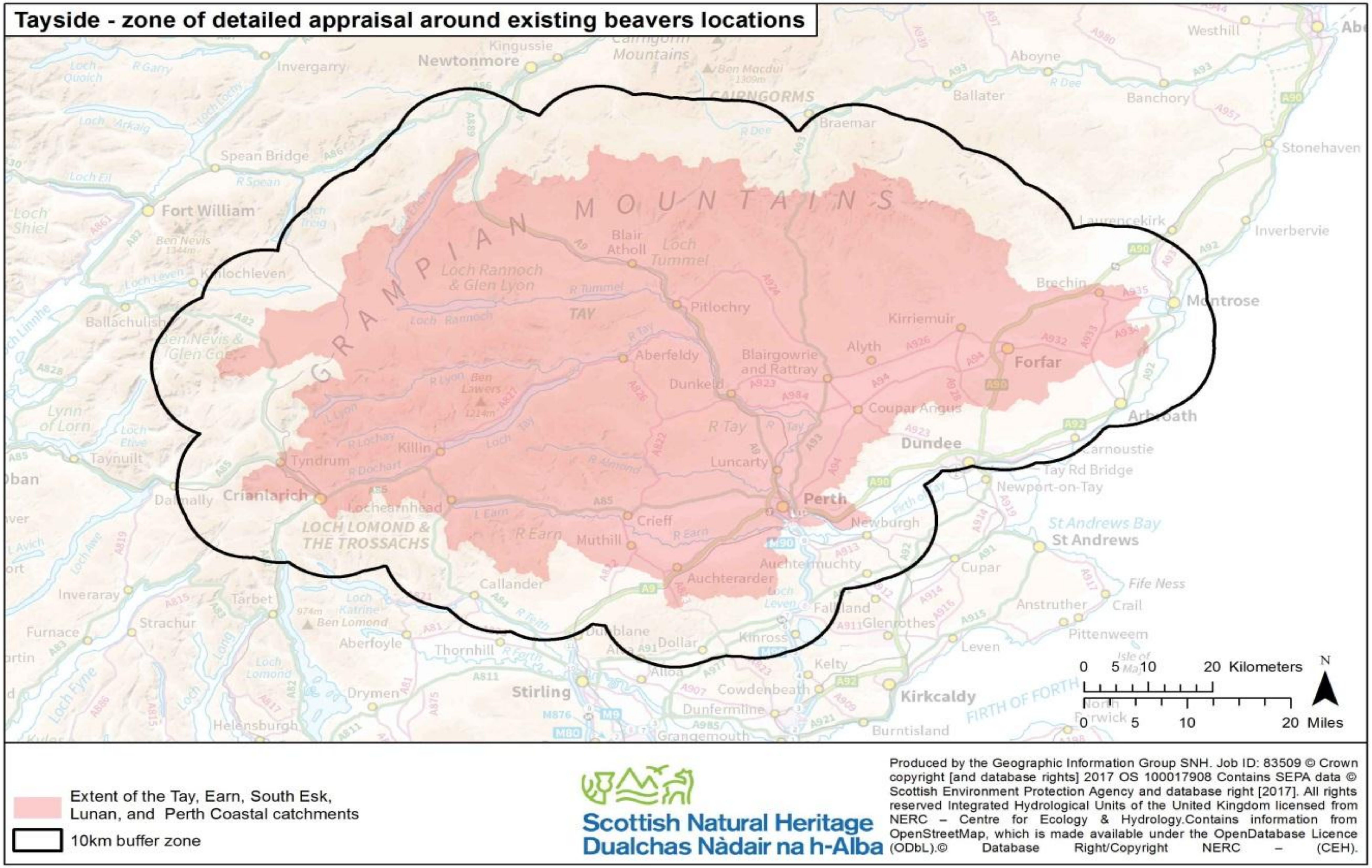
Map 1 - Locations of Knapdale (Argyll) and Tayside Beaver Policy Areas



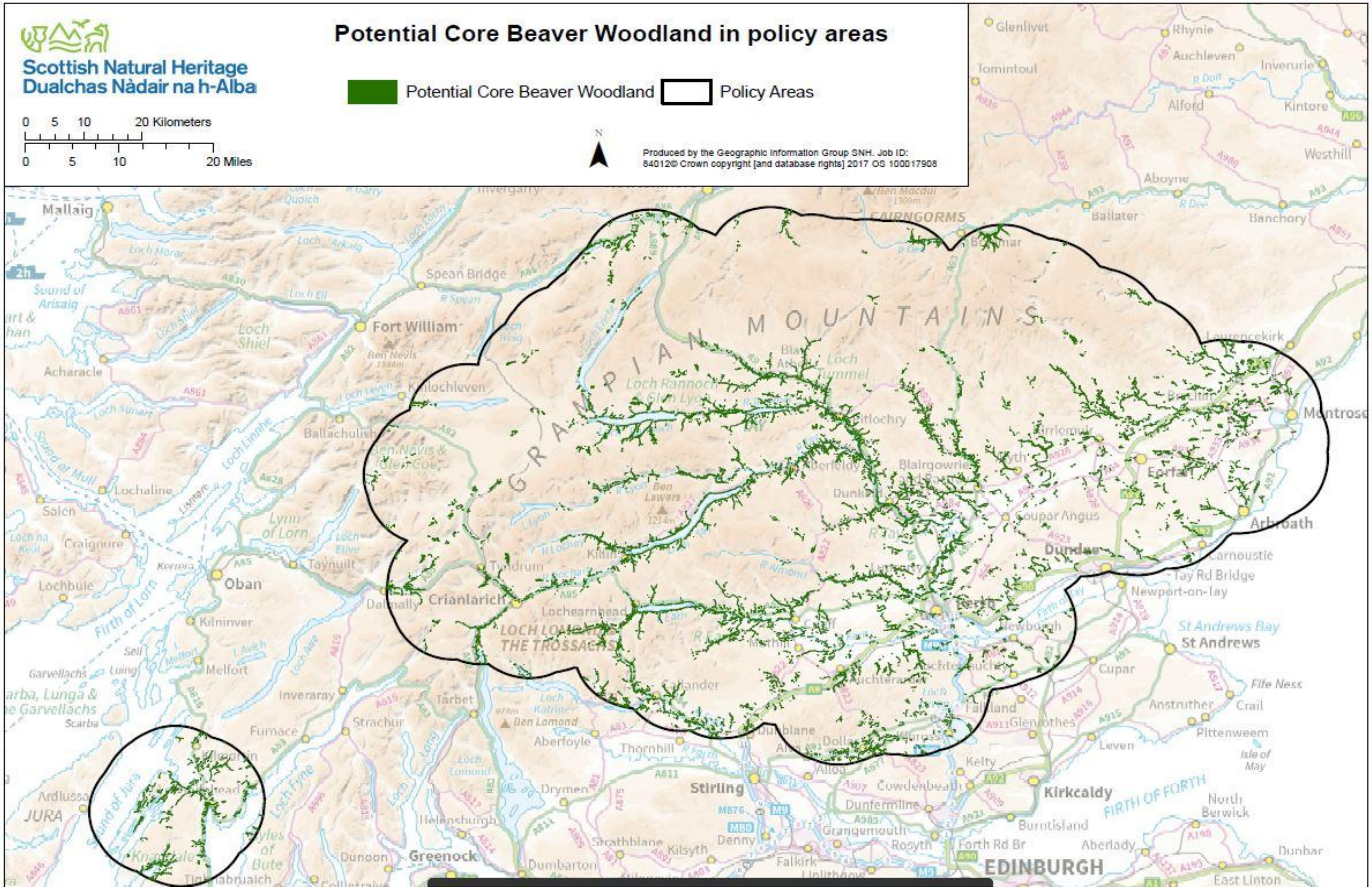
Map 2 - Knapdale beaver policy area



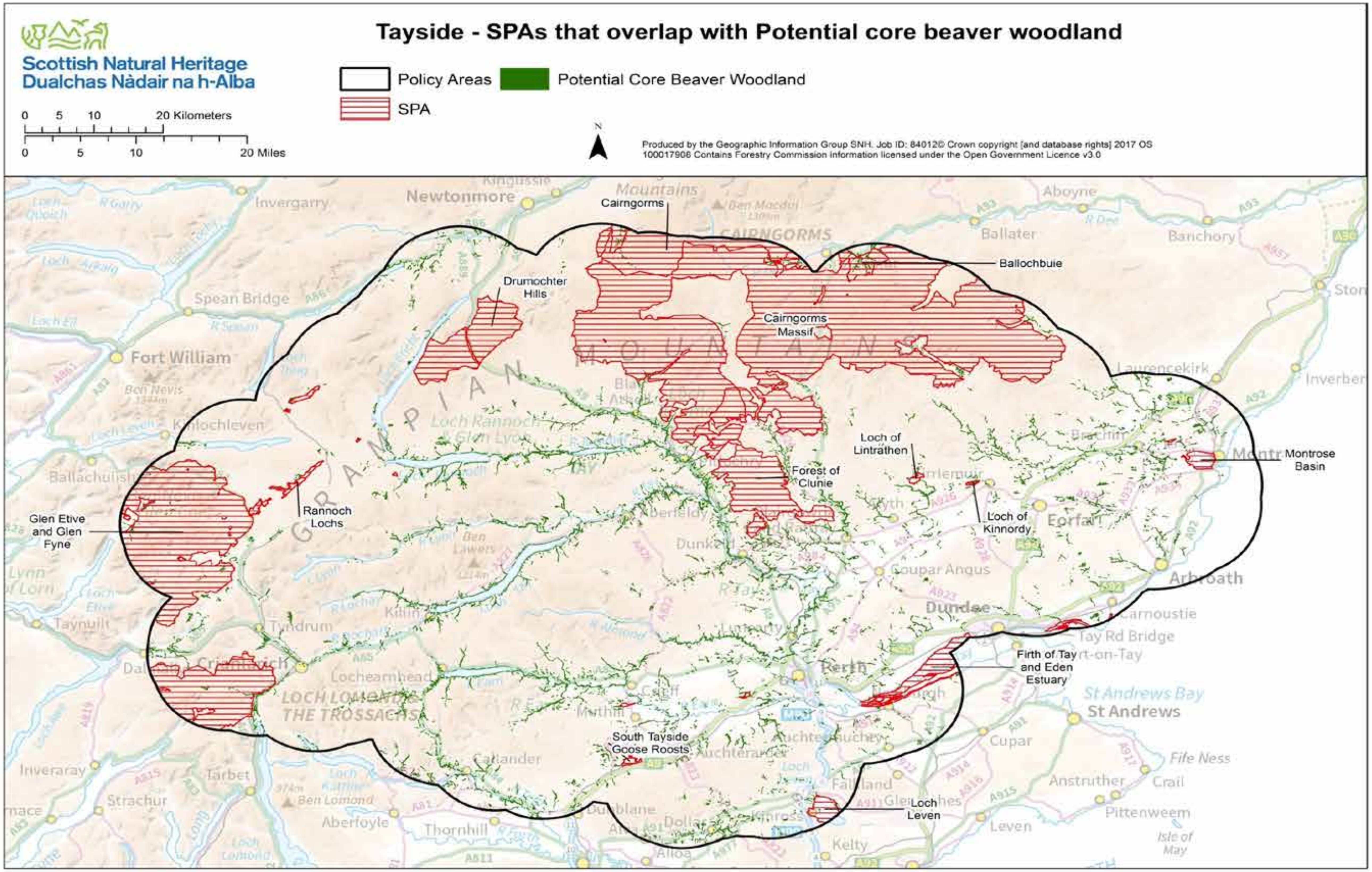
Map 3 - Tayside beaver policy area



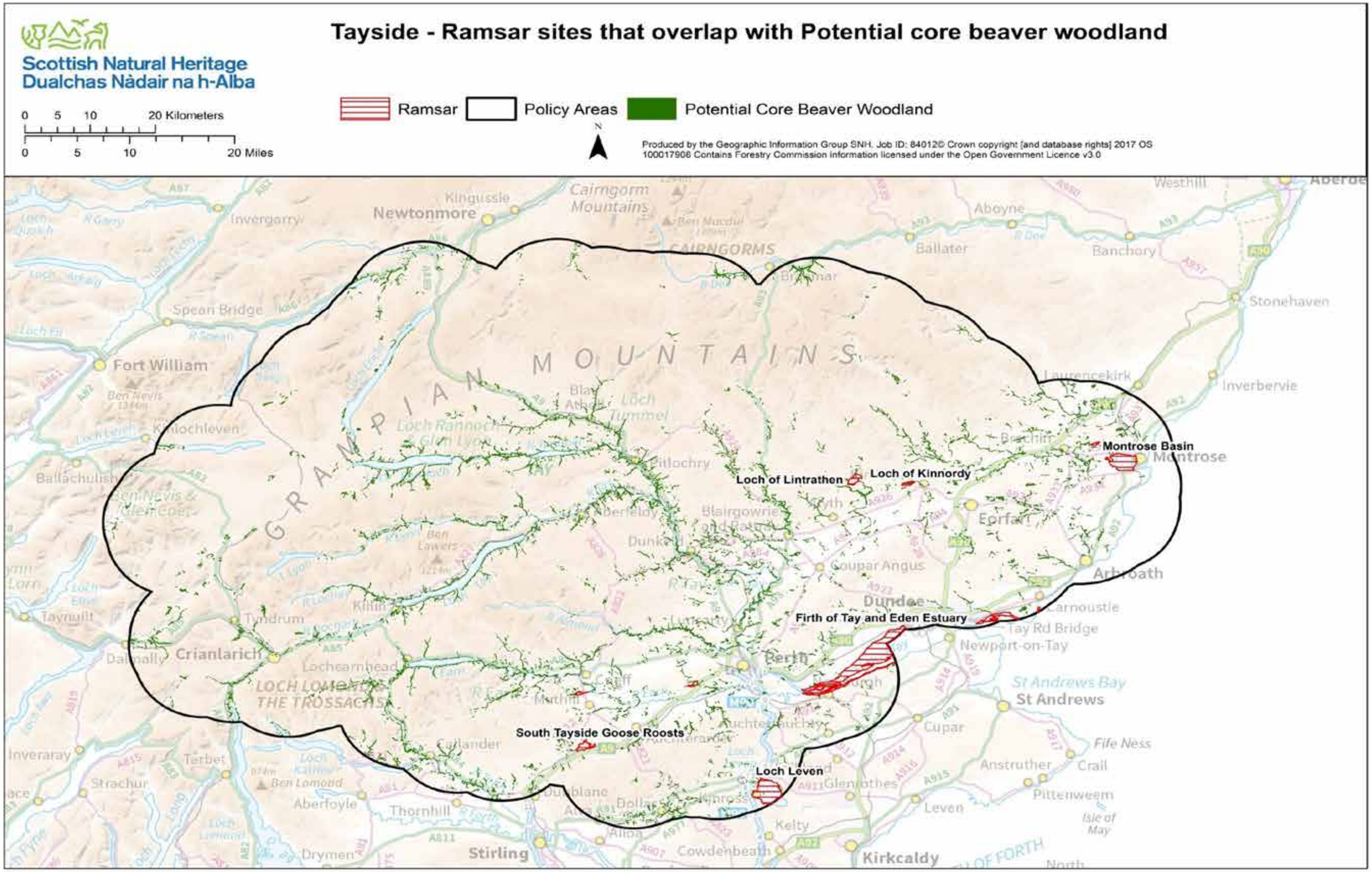
Map 4 - Potential core beaver woodland in Knapdale and Tayside areas



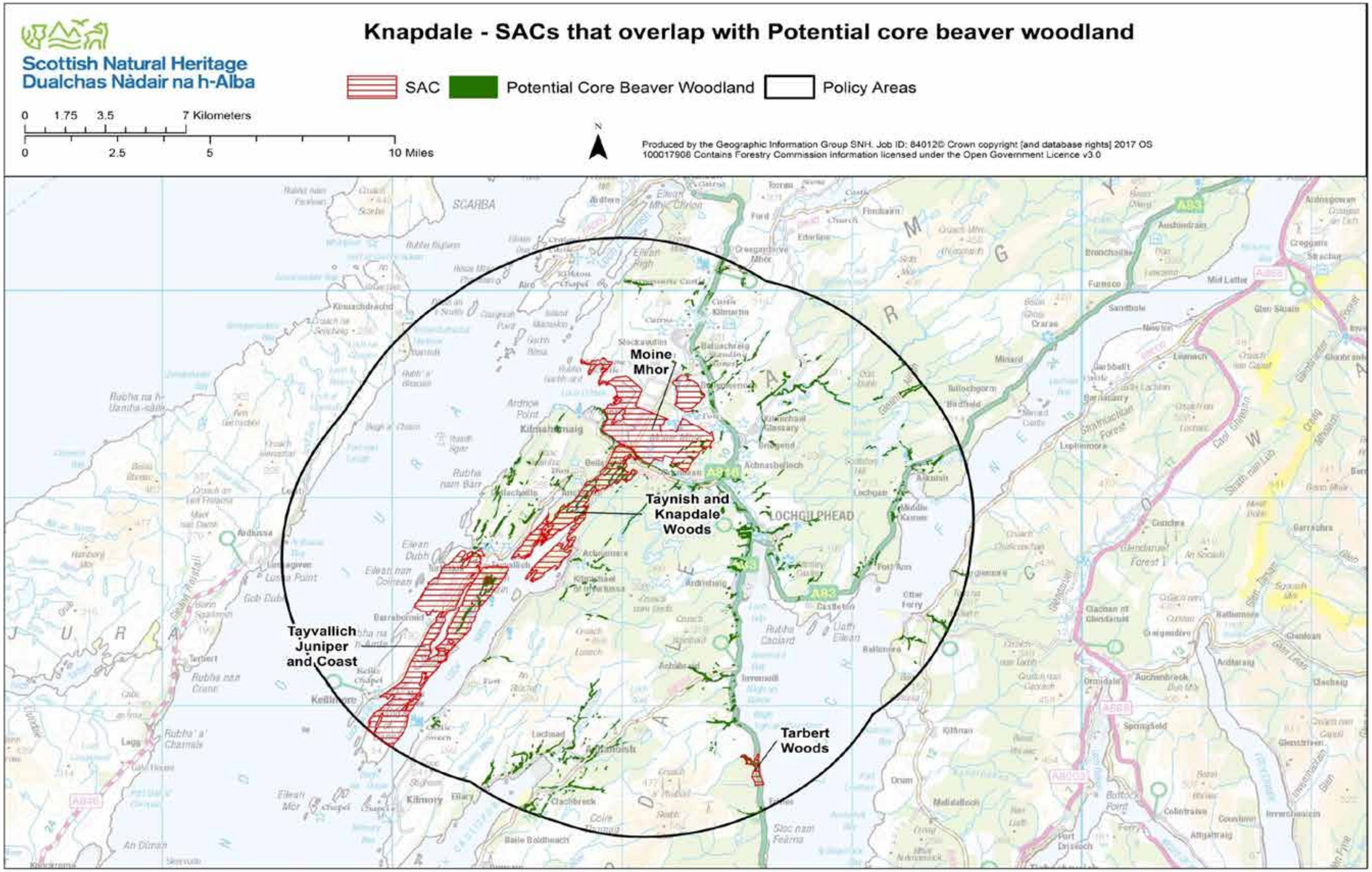
Map 5 - Tayside Special Protection Areas (SPAs) and potential core beaver woodland



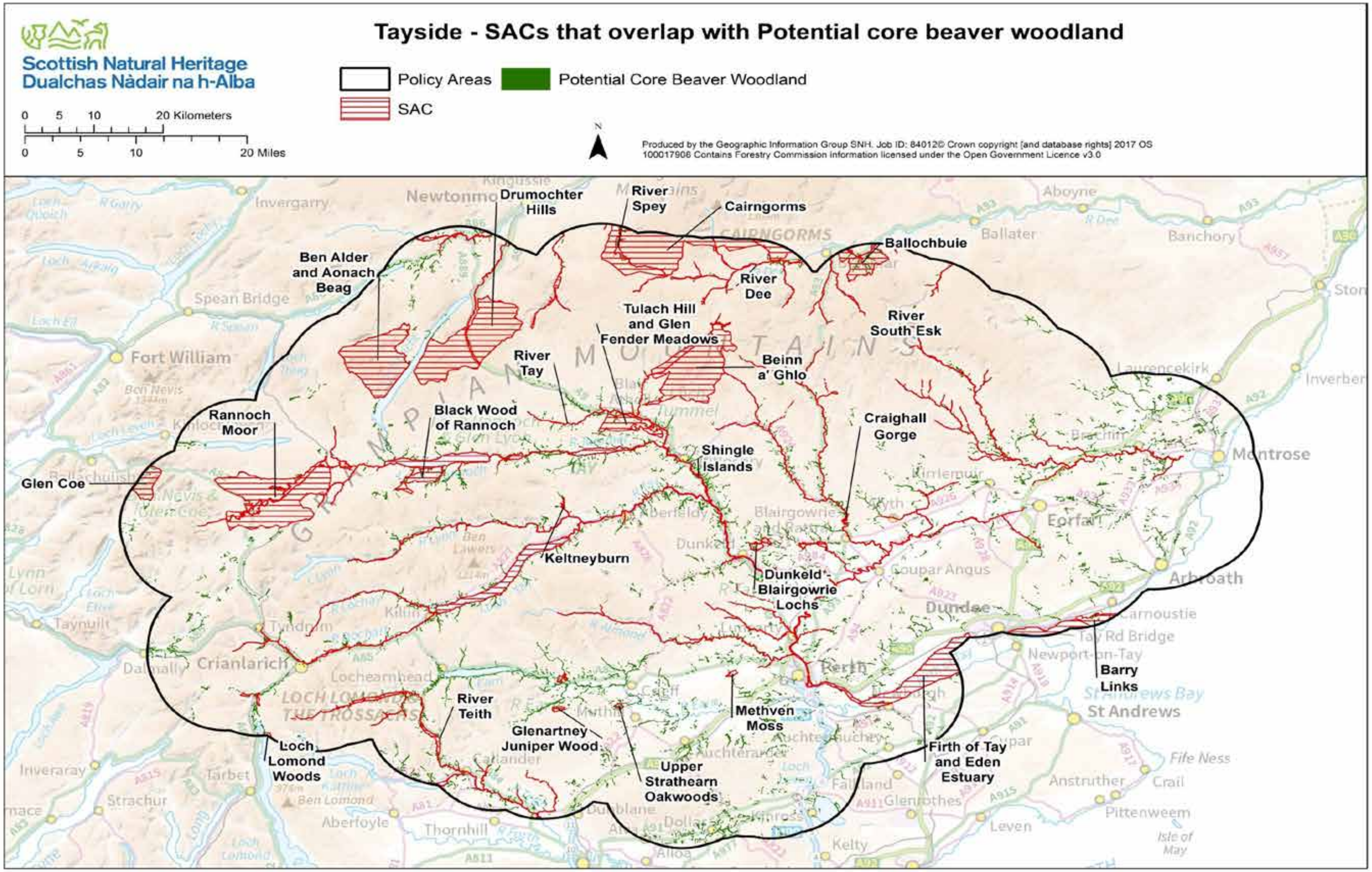
Map – 6 - Tayside Ramsar sites and potential core beaver woodland



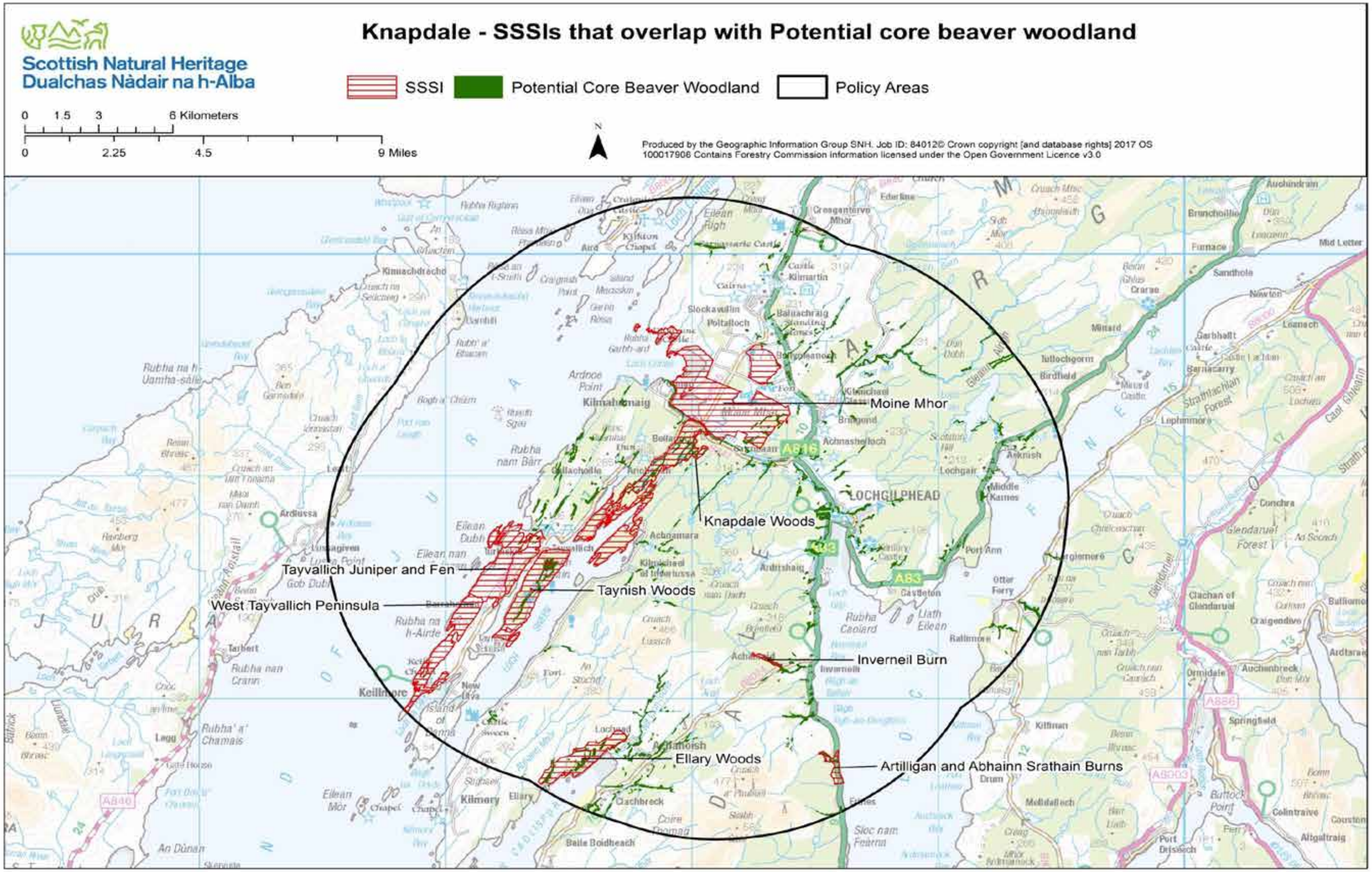
Map 7 – Knapdale Special Areas of Conservation (SACs) and potential core beaver woodland



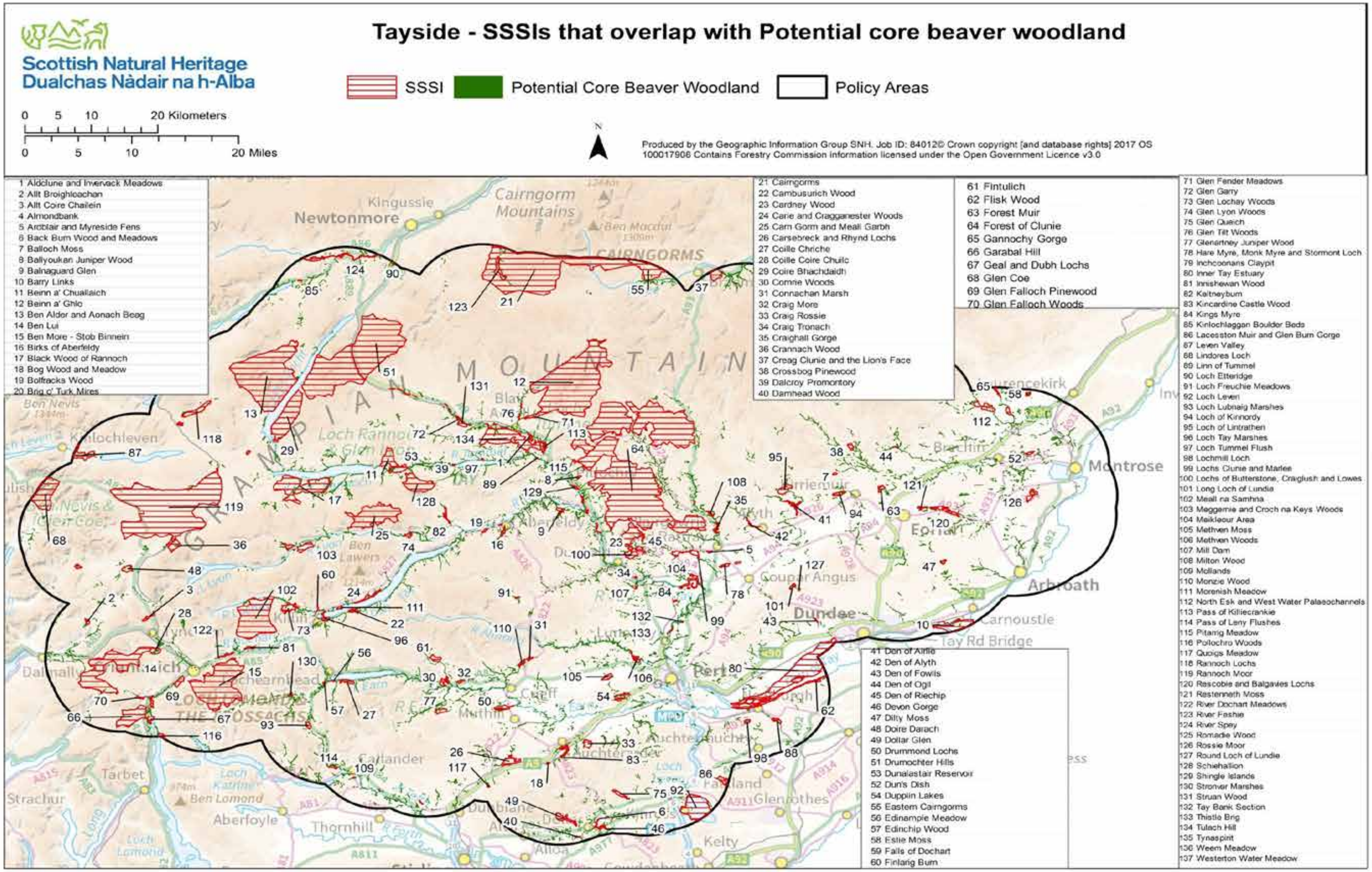
Map 8 - Tayside Special Areas of Conservation and potential core beaver woodland



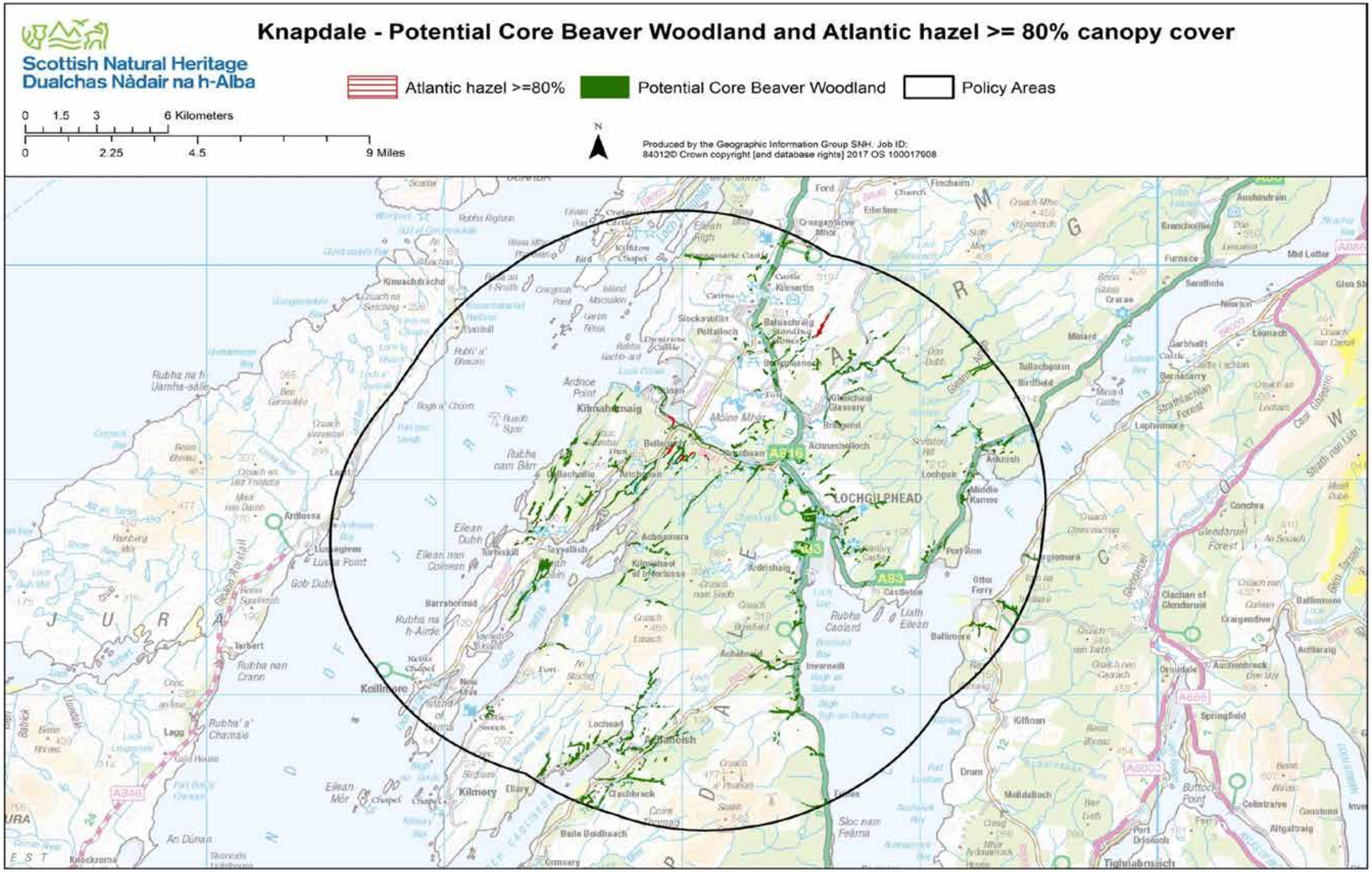
Map 9 - Knapdale Sites of Special Scientific Interest (SSSIs) and potential core beaver woodland



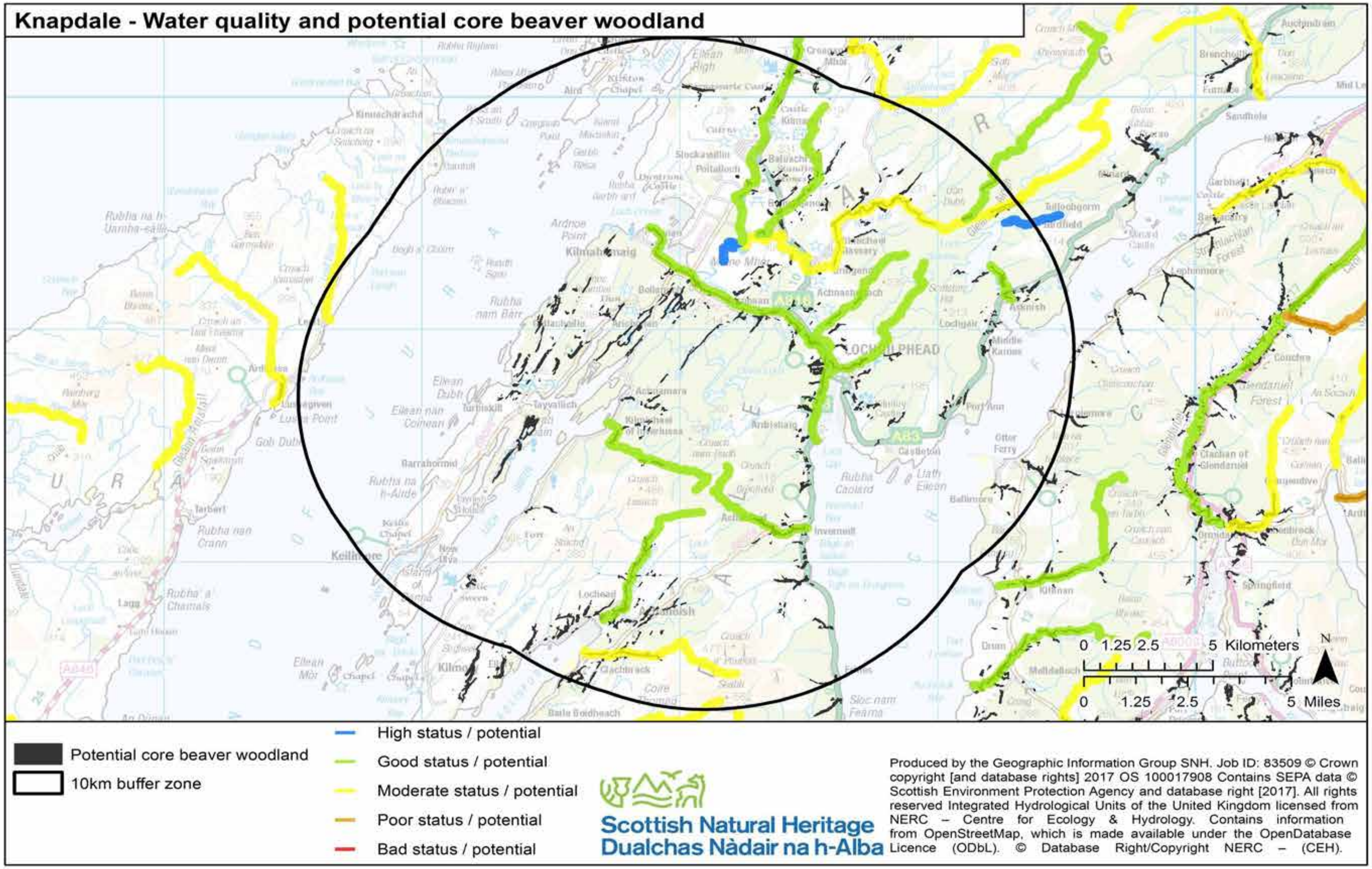
Map 10 - Tayside Sites of Special Scientific Interest (SSSIs) and potential core beaver woodland



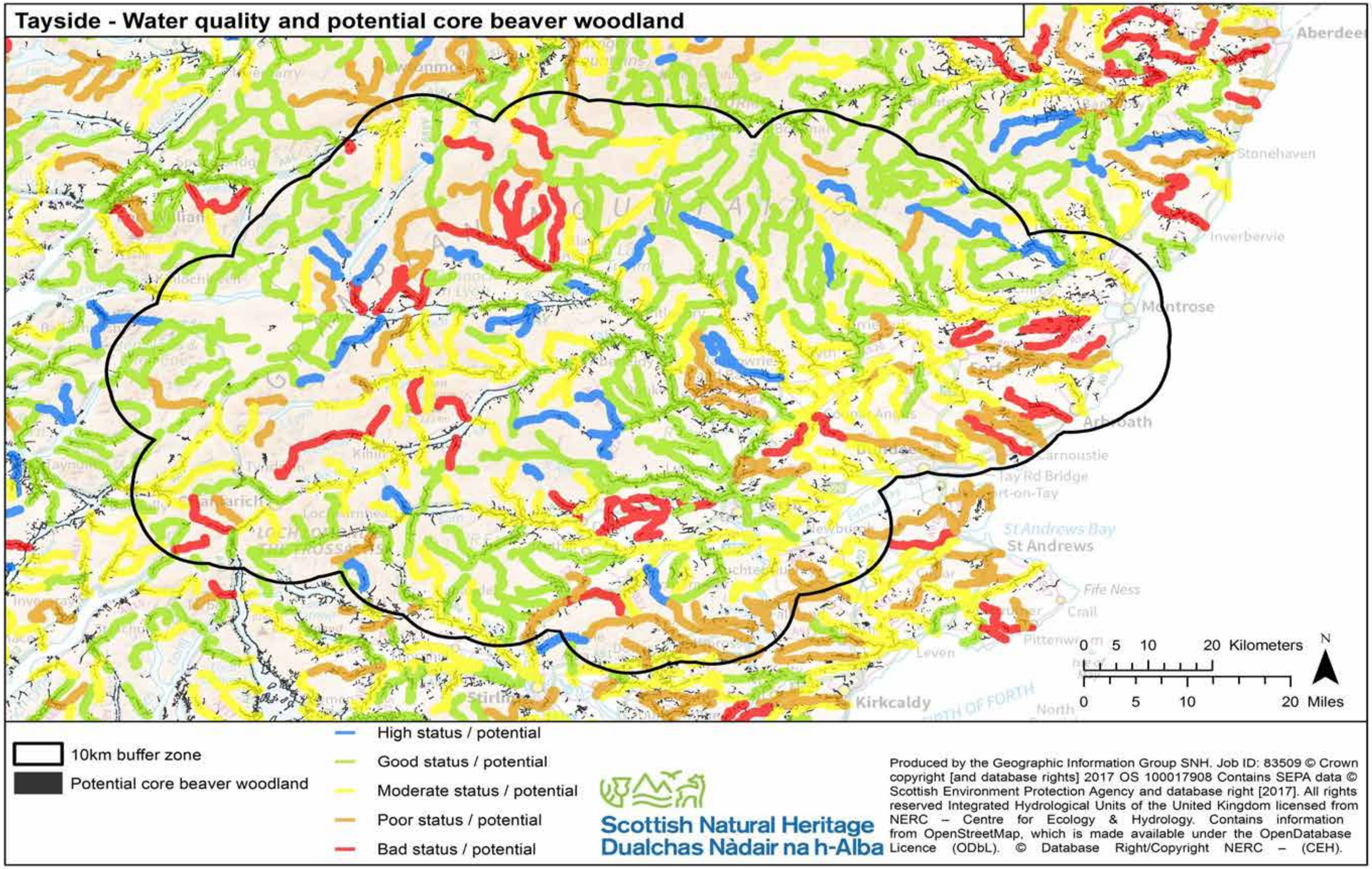
Map 11 - Knapdale potential core beaver woodland and Atlantic hazel



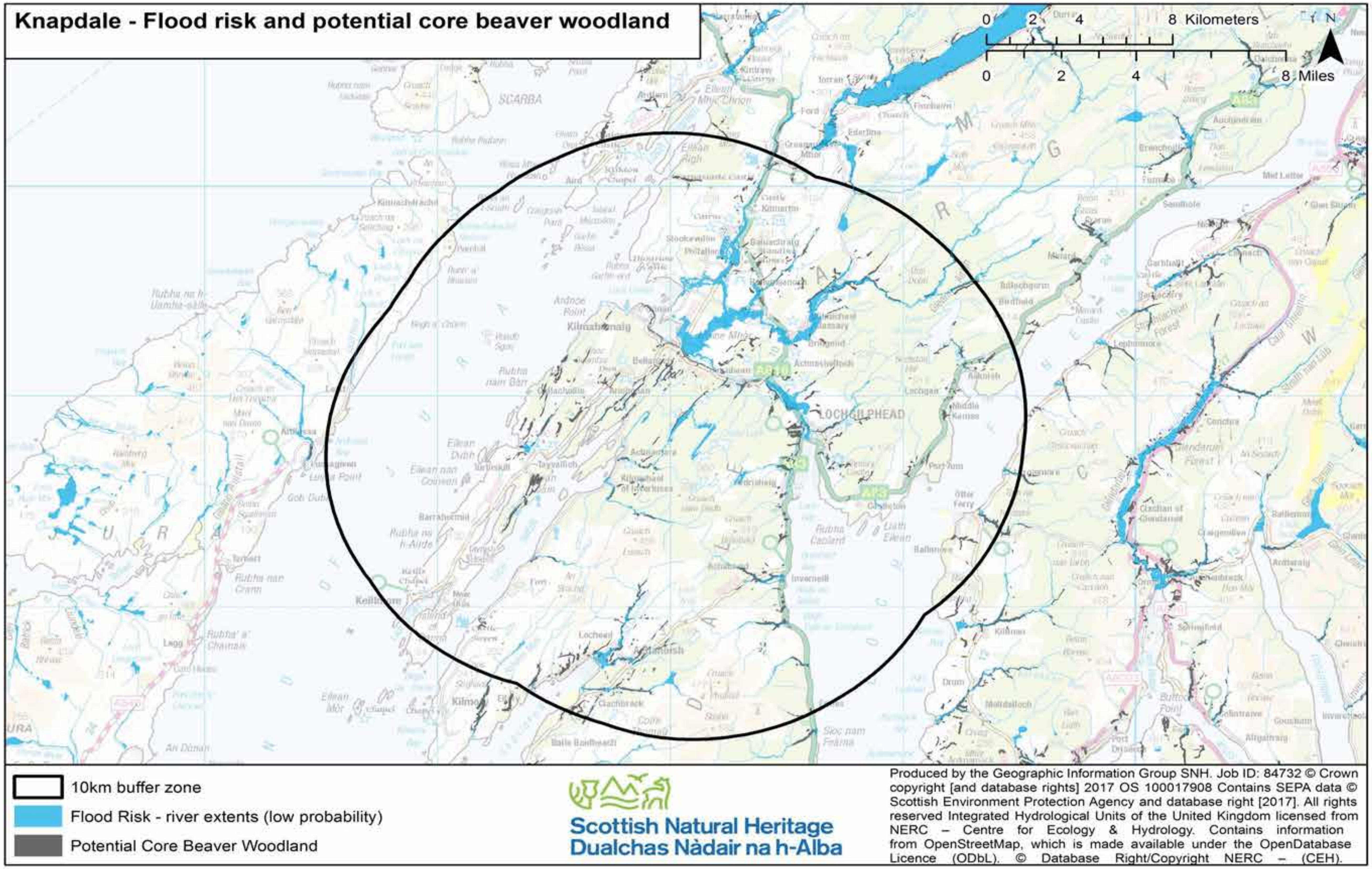
Map 12 - Knapdale water quality and potential core beaver woodland



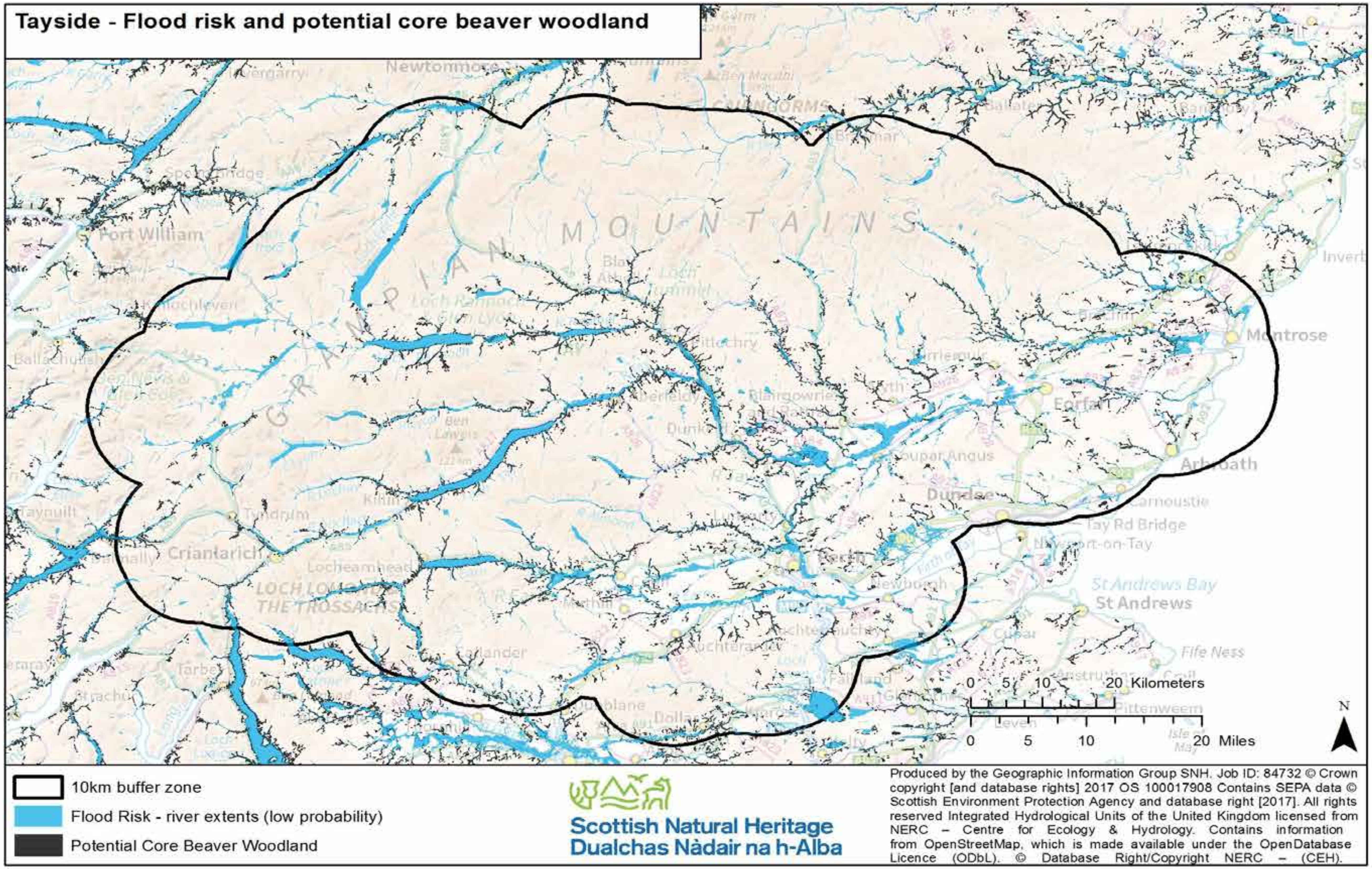
Map 13 - Tayside water quality and potential core beaver woodland



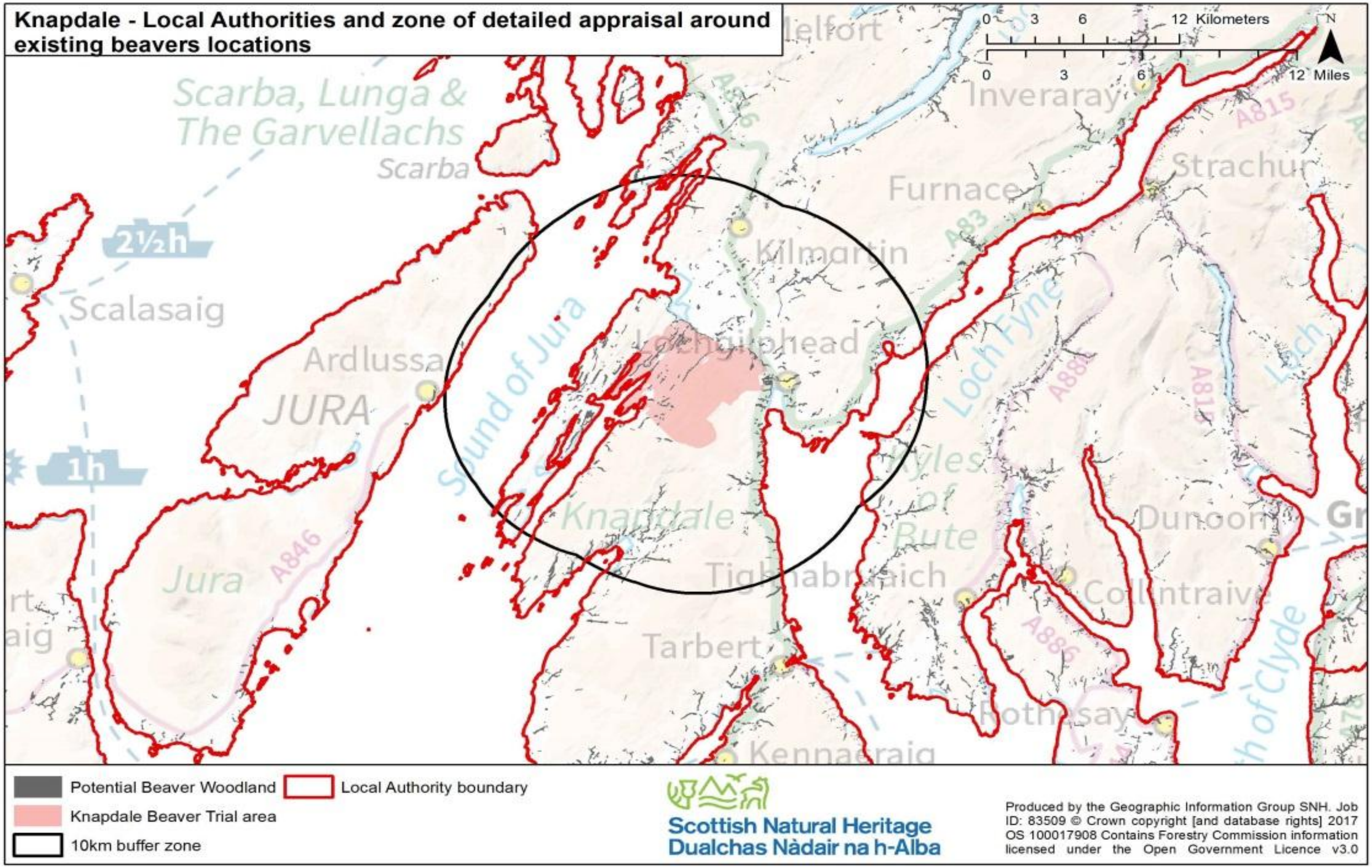
Map 14 - Flood Risk and Knapdale potential core beaver woodland



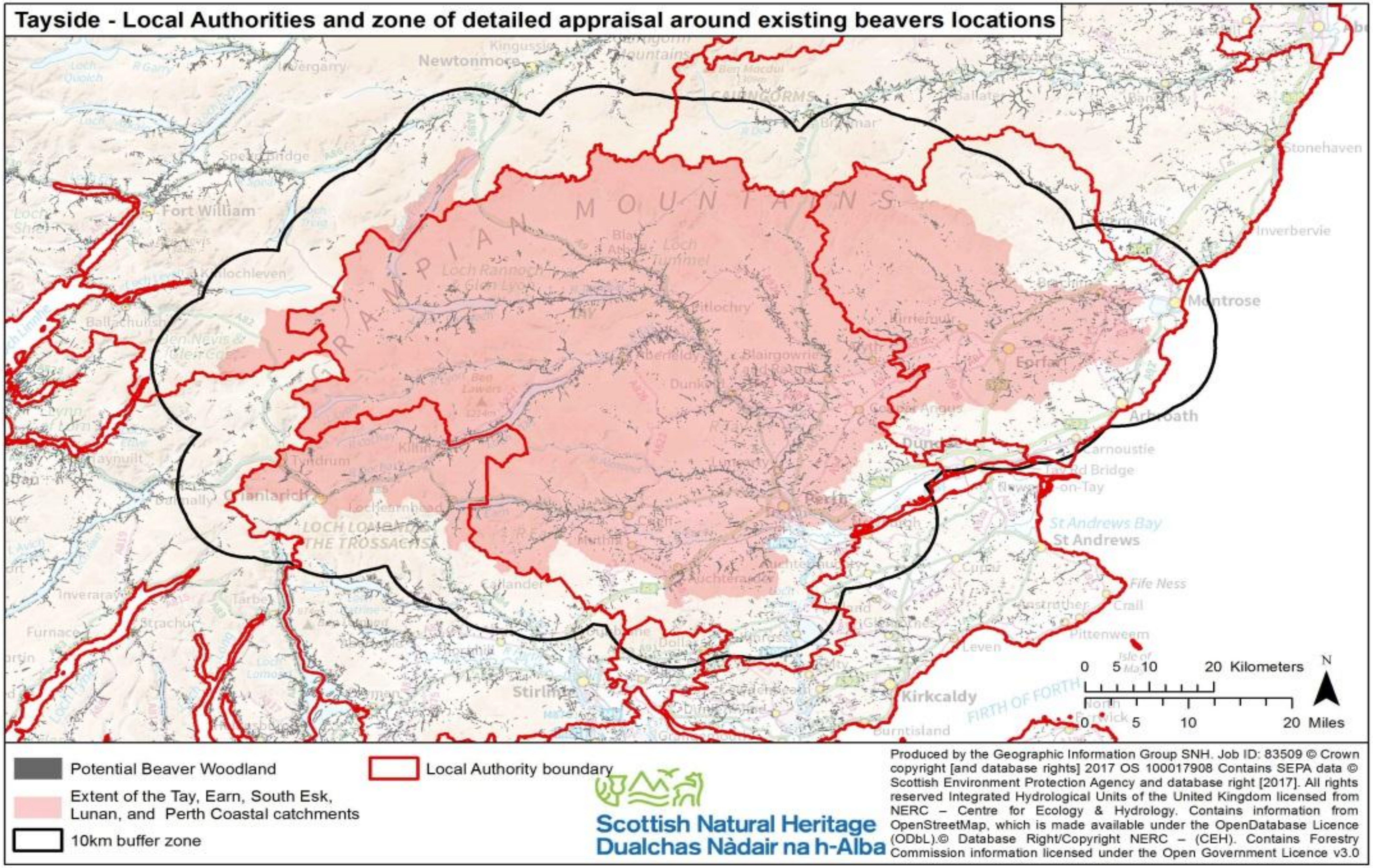
Map 15 - Flood risk and Tayside potential core beaver woodland



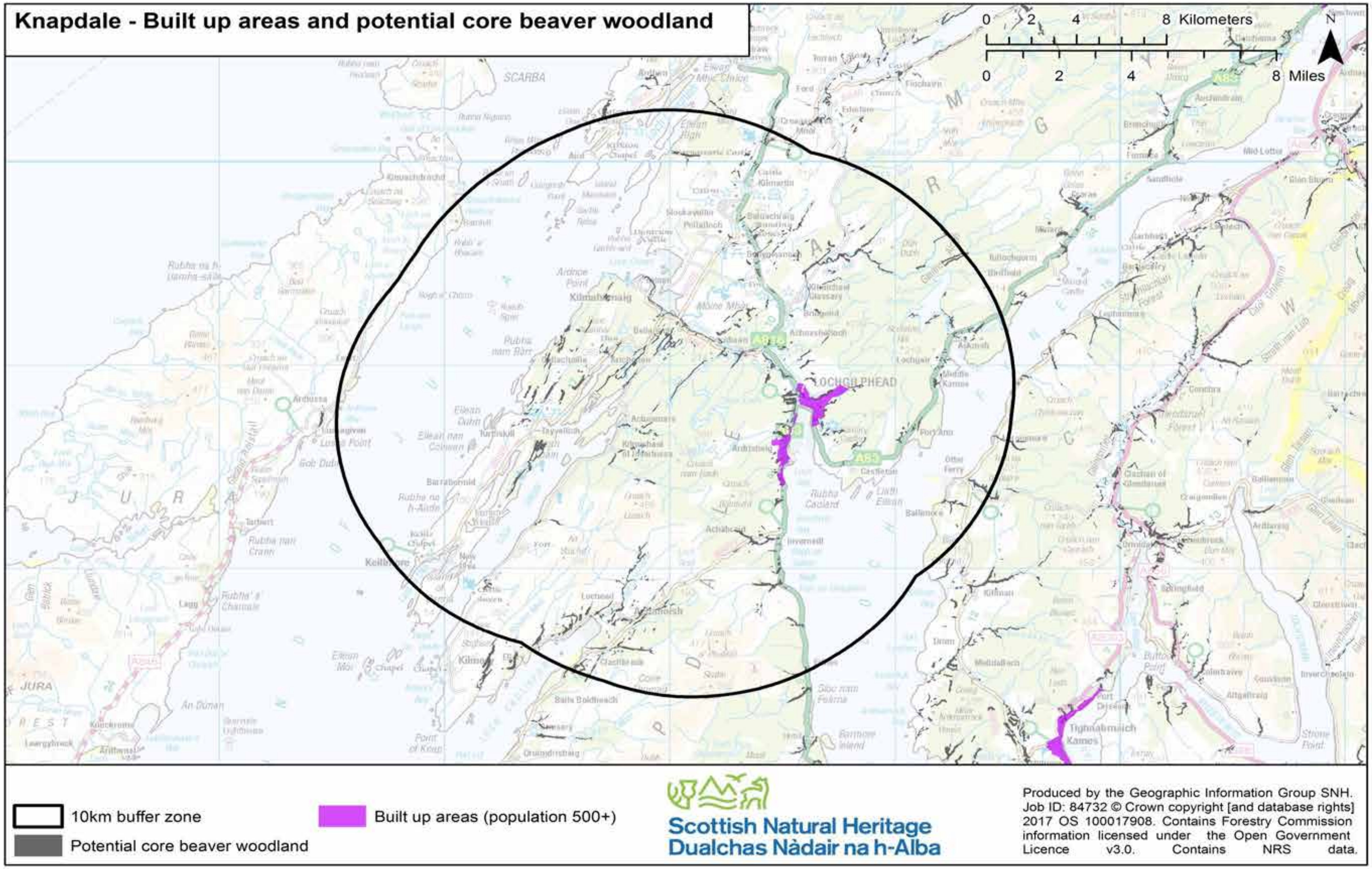
Map 16 - Knapdale Beaver Area and local authority boundary of Argyll and Bute Council



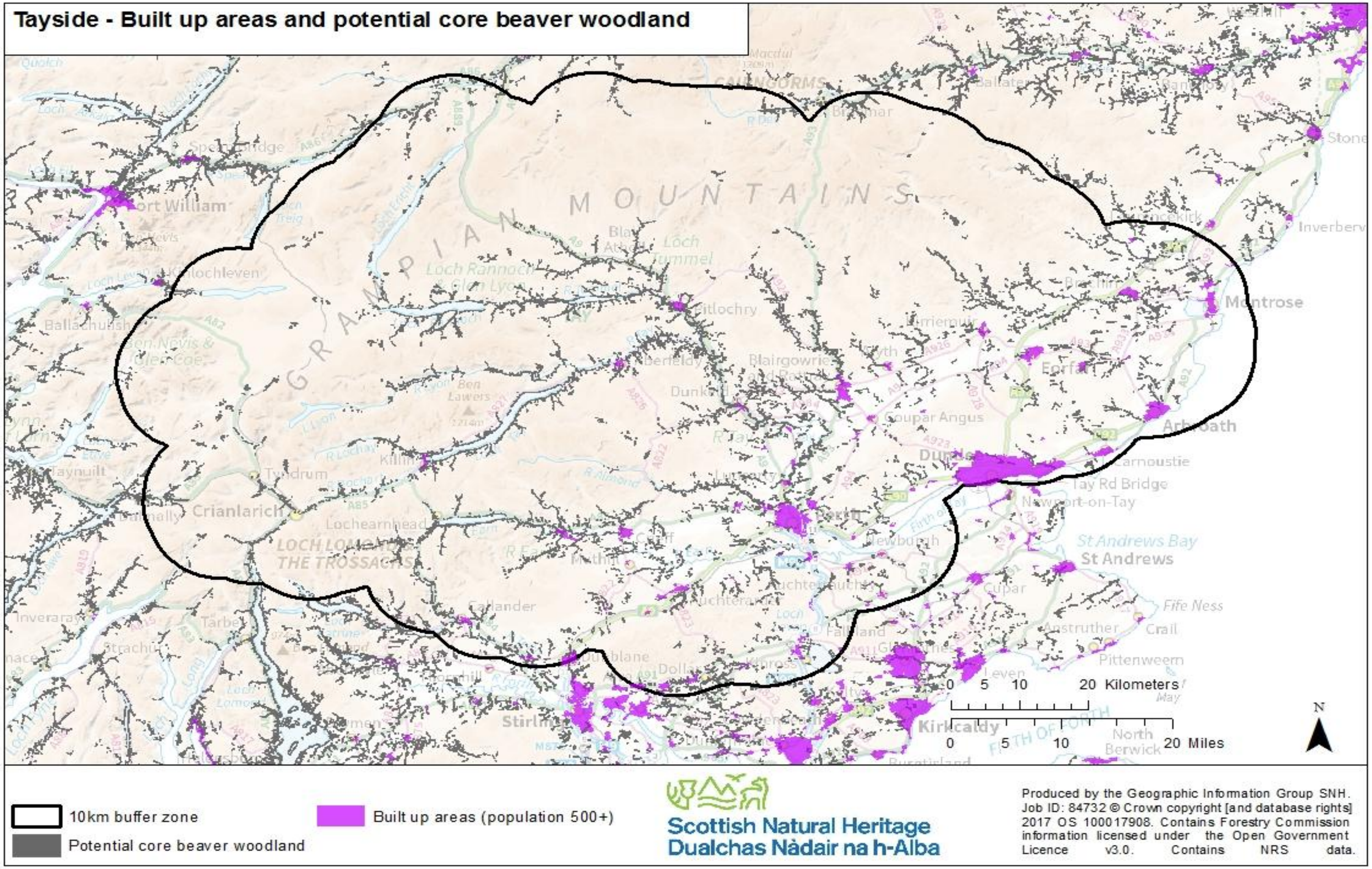
Map 17 - Tayside Beaver Area and local authority boundaries



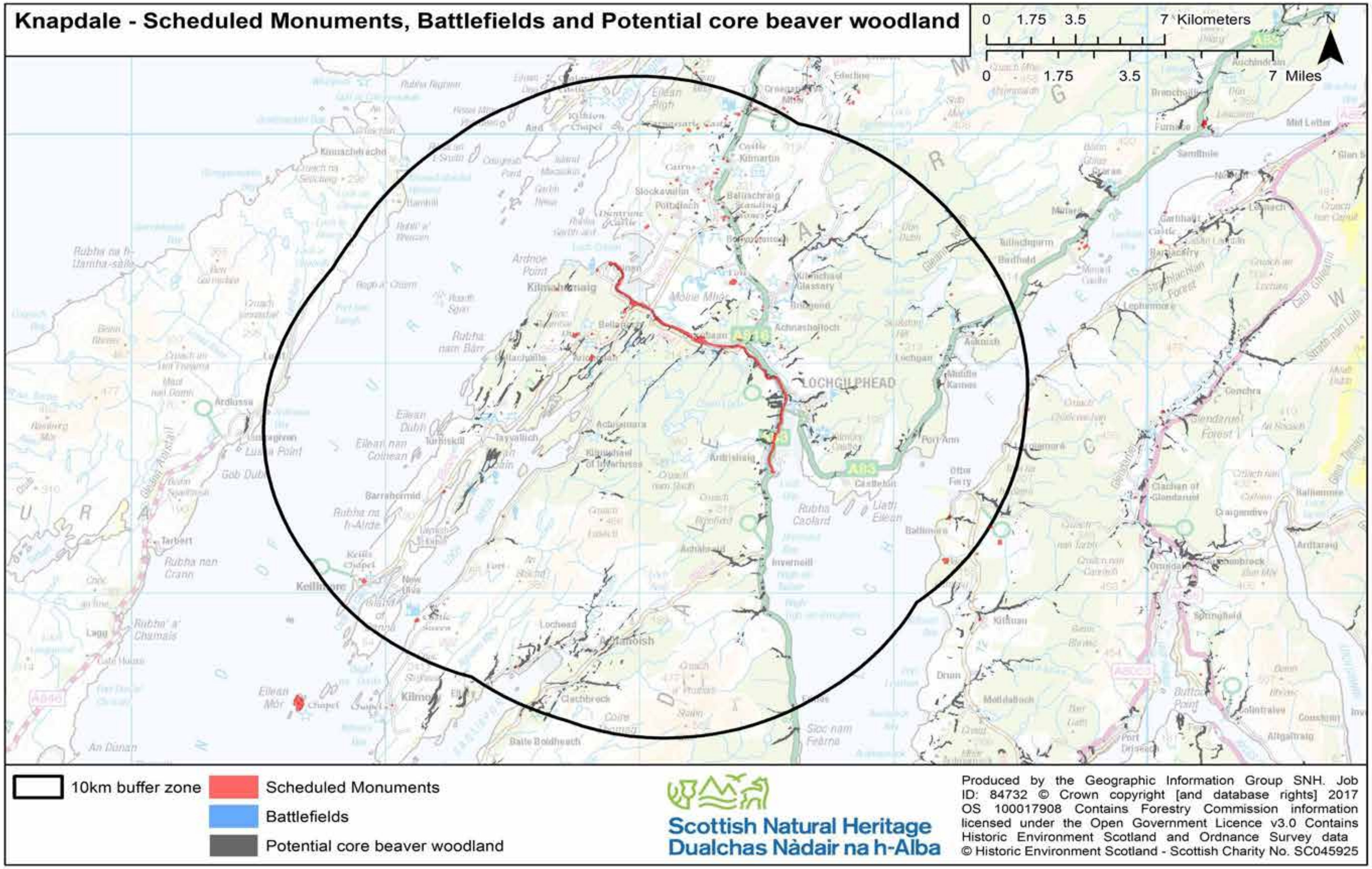
Map 18 - Knapdale built up areas (population 500+) and potential core beaver woodland



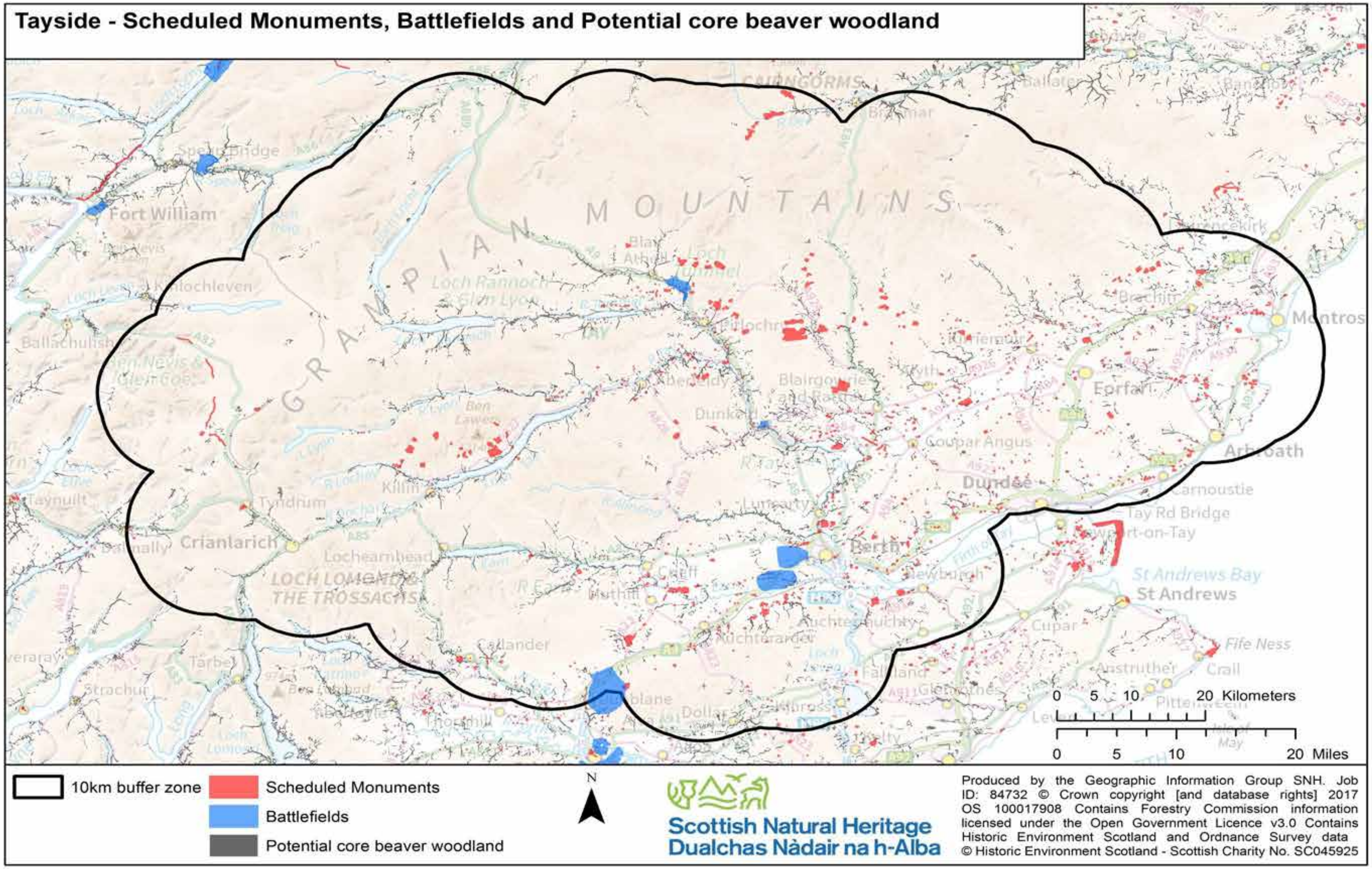
Map 19 - Tayside built up areas (population 500+) and potential core beaver woodland



Map 20 - Knapdale Scheduled Monuments, Battlefields and potential core beaver woodland

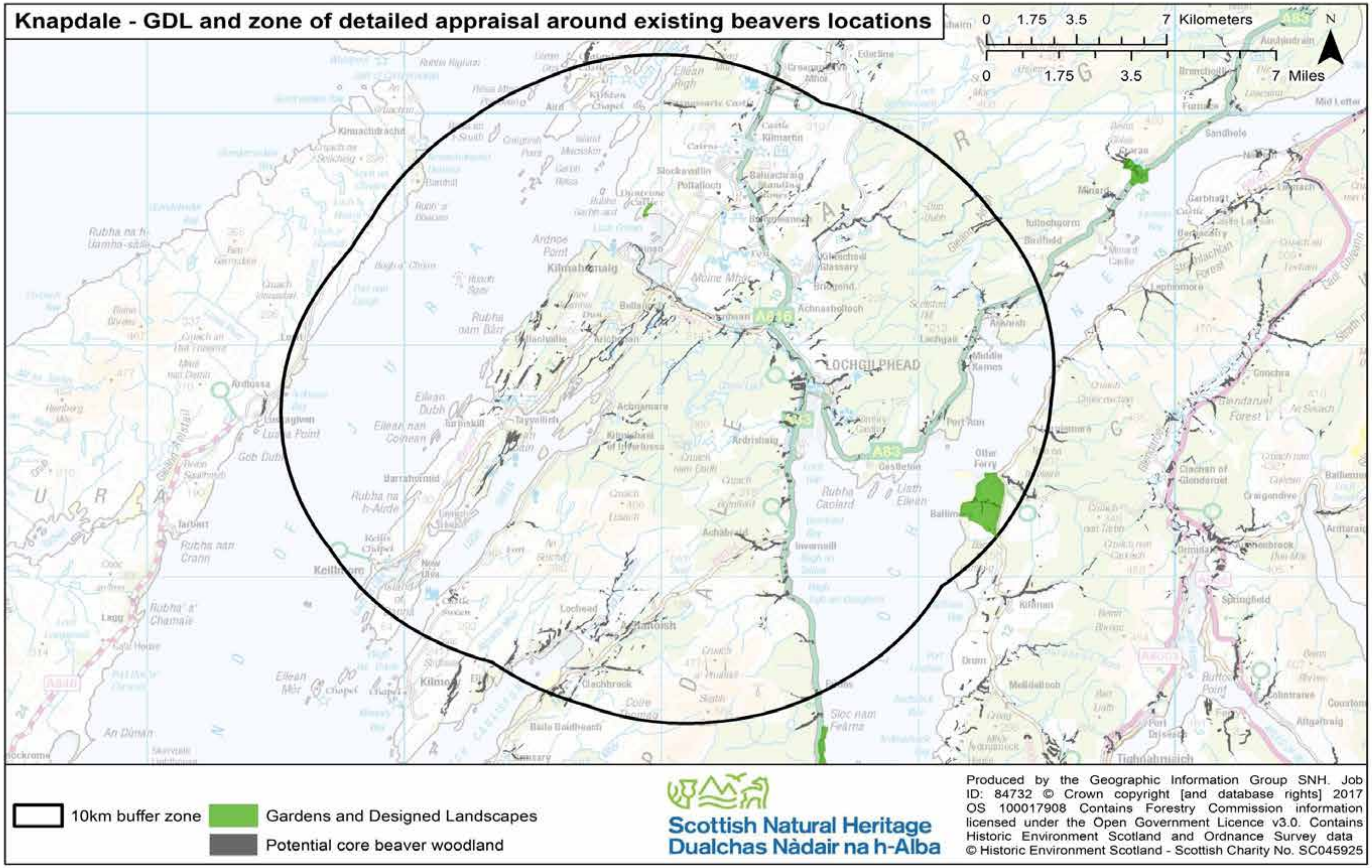


Map 21 - Tayside Scheduled Monuments, Battlefields and potential core beaver woodland

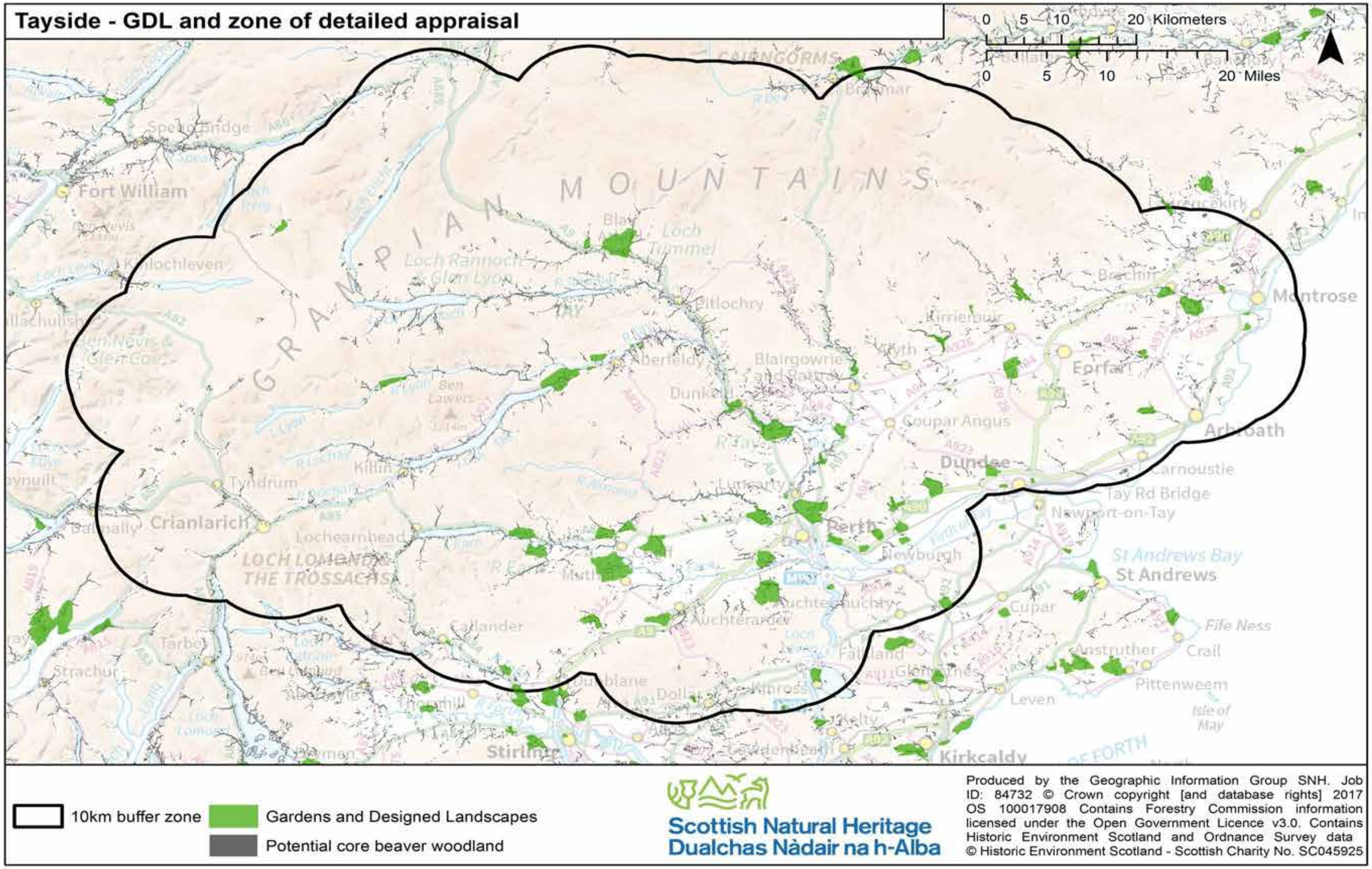


Map

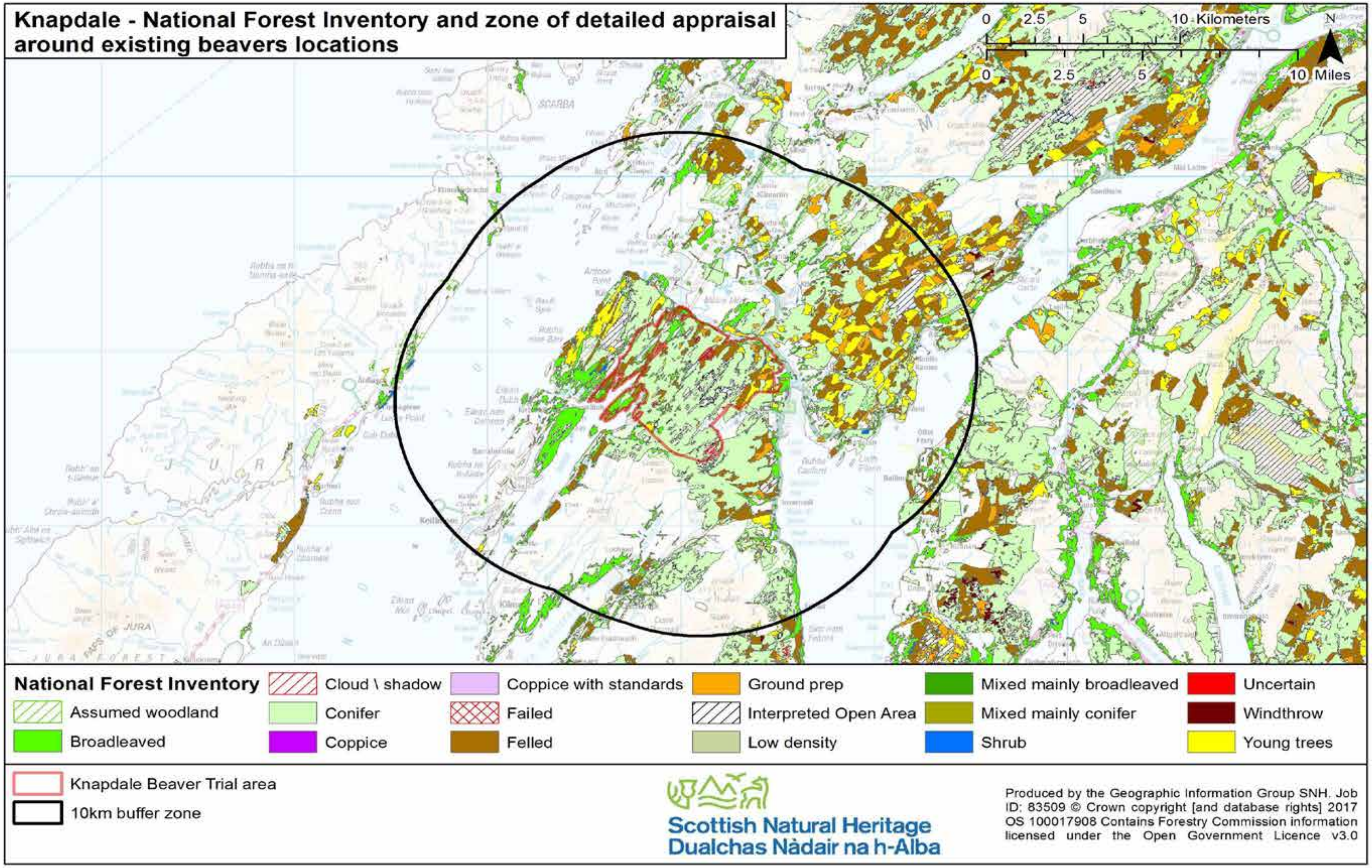
Map 22 - Knapdale Gardens and Designed Landscapes and potential core beaver woodland



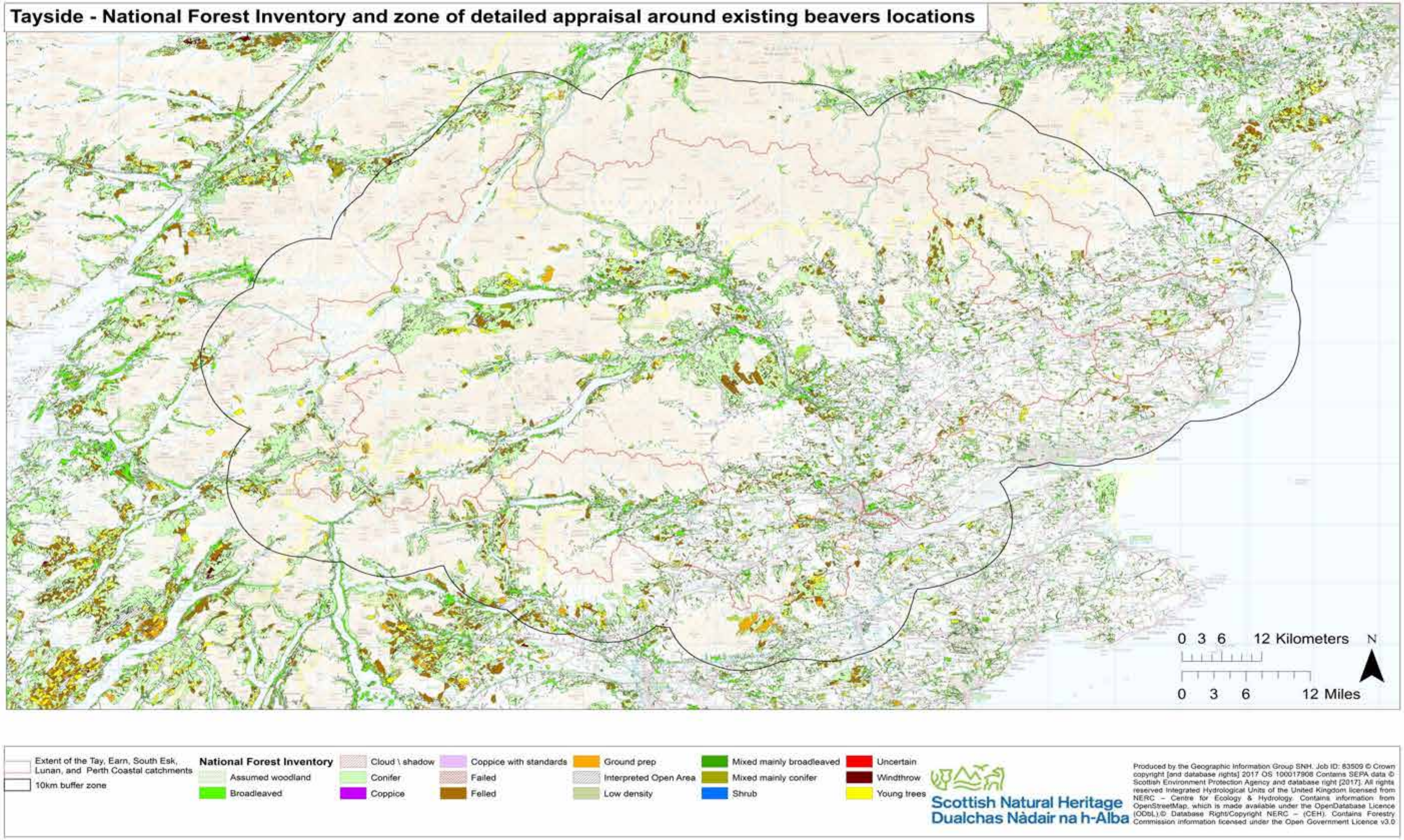
Map 23 - Tayside Gardens and Designed Landscapes and potential core beaver woodland



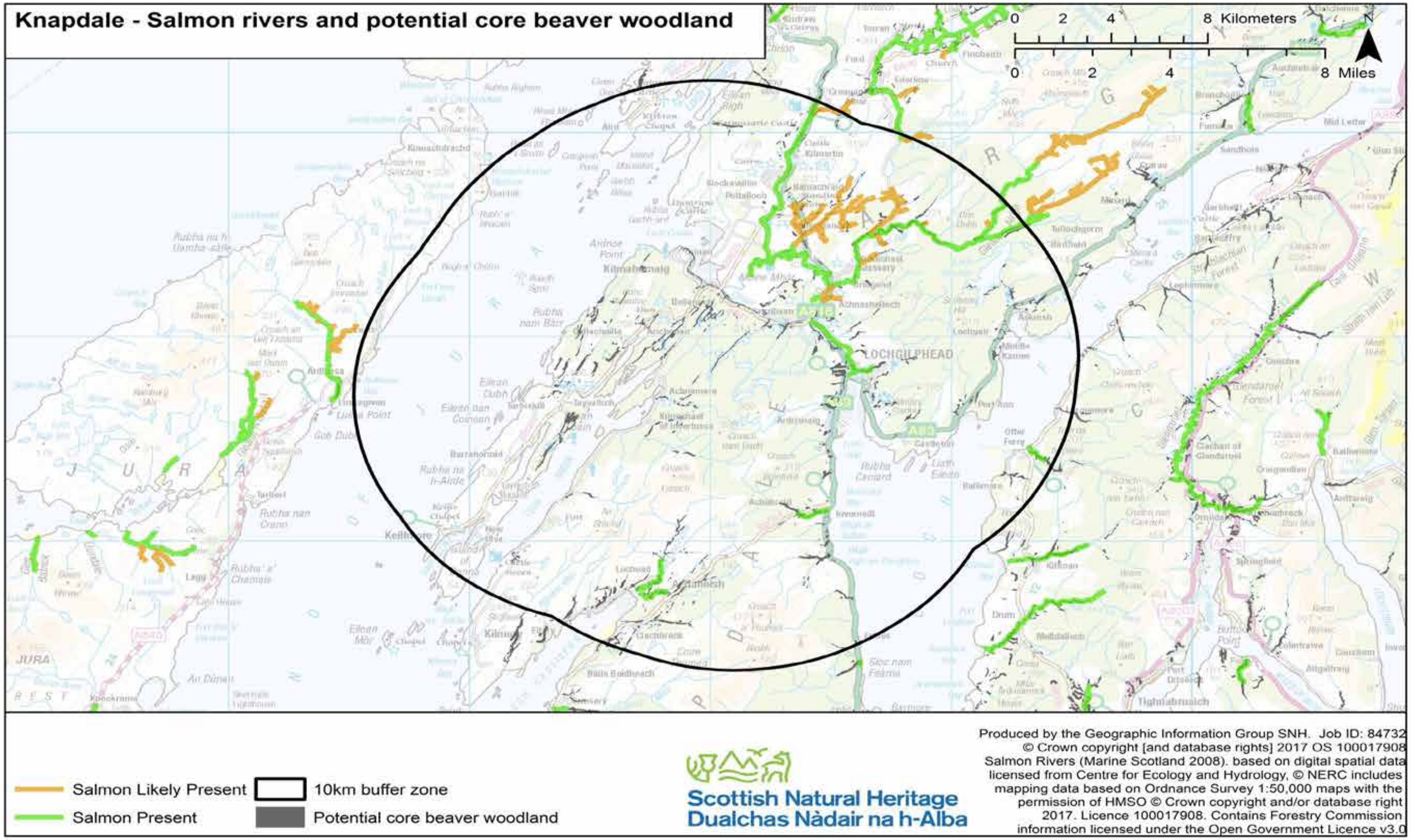
Map 24 - Knapdale Beaver Area and National Forest Inventory cover



Map 25 - Tayside Beaver Area and National Forest Inventory cover

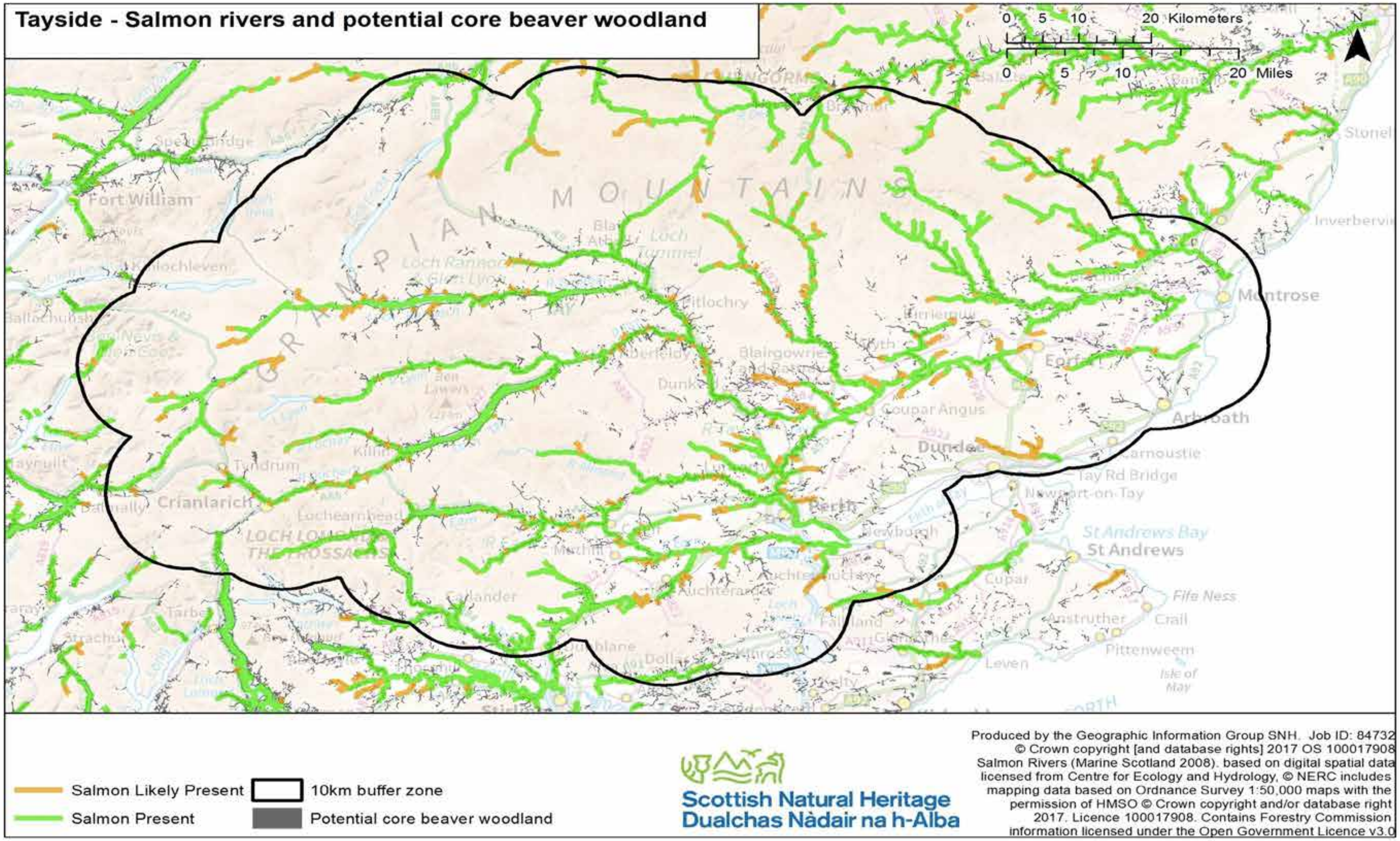


Map 26 - Knapdale salmon rivers and potential core beaver woodland



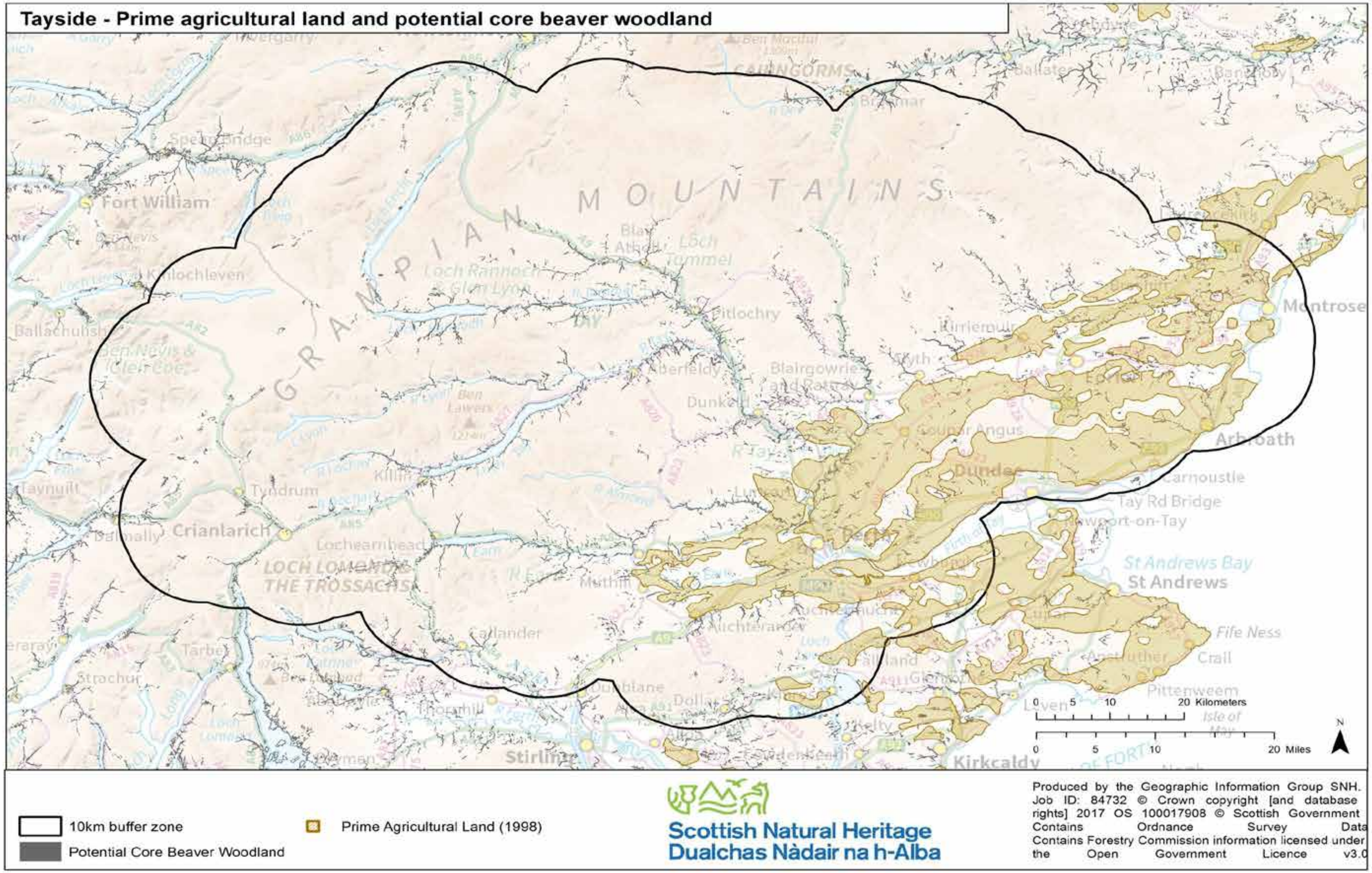
References: Salmon rivers: Gardiner, R. and Egglishaw, H. (1986). A Map of the Distribution in Scottish Rivers of the Atlantic Salmon, Salmo salar L. Department of Agriculture and Fisheries for Scotland, Freshwater Fisheries Laboratory, Pitlochry. 5pp + folded map. Scottish Fisheries Publication.
1:50,000 rivers: Moore RV, Morris DG and Flavin RW, 1994. Sub-set of UK digital 1:50,000 scale river centre-line network. NERC, Institute of Hydrology, Wallingford.

Map 27 - Tayside salmon rivers and potential core beaver woodland



References: Salmon rivers: Gardiner, R. and Egglishaw, H. (1986). A Map of the Distribution in Scottish Rivers of the Atlantic Salmon, Salmo salar L. Department of Agriculture and Fisheries for Scotland, Freshwater Fisheries Laboratory, Pitlochry. 5pp + folded map. Scottish Fisheries Publication.
1:50,000 rivers: Moore RV, Morris DG and Flavin RW, 1994. Sub-set of UK digital 1:50,000 scale river centre-line network. NERC, Institute of Hydrology, Wallingford.

Map 28 - Tayside prime agricultural land and potential core beaver woodland



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Appendix 2 - Relevant Plans, Programmes and Strategies

The table below details the related policy and regulatory framework which sets the context for the assessment

Related Policy and legislative context.	Summary description	Relevance to beavers
Nature conservation law		
Habitats Directive	Requires Member States to study the desirability of reintroducing Annex IVa species; to establish a system of strict protection for these species; to keep their conservation status under surveillance and to allow for derogations; and to designate Special Areas of Conservation (SACs) for species listed on Annex II, avoiding disturbance to the species for which a site has been selected and deterioration of dependent habitats, and assess the impacts of projects or plans proposed on these sites on such species	Beavers are listed on Annex IVa for the UK. Some EU populations are not listed on Annex IVa. Beavers are listed on Annex II for the UK. Note: Beavers are listed on Annex V for those Member States whose populations are not listed on Annex IVa. Annex V listing is therefore not relevant to the UK
Habitats Regulations 1994	Regulations 37A–46A describe the protection given to Annex IVa species and European Protected Species (EPSs; those Annex IVa animals whose natural range includes any area of Great Britain), and the licensing regime. Regulations 7–37 and 47–85E describe the Natura site designation process and assessment implications	Limited Scottish protection given to Annex IVa listing at the moment. If beavers are to stay in Scotland they would require to be become a European Protected Species and be given strict protection in accordance with the Habitats Directive (this can be done for Scotland only within the UK). A licensing regime would become applicable. Site(s) may require designation as SACs for beavers. Plans or proposals affecting beaver SACs would require assessment in the light of the site's conservation objectives before being approved. Plans or proposals affecting any Natura site (SAC or Special Protection Area for birds), including any beaver reintroduction, would also require a 'Habitats Regulations Appraisal' before proceeding. Some of these might require an

		'Appropriate Assessment' before a decision is made about whether or not to proceed
Wildlife & Countryside Act 1981	Under Section 14 it is illegal to release, allow to escape from captivity or cause to be at a place outside the control of any person any animal species outside its native range without a licence under Section 16. Former native species are considered to be 'non-native species' for the purposes of the Act	Any release of beavers in Scotland would require a non-native species licence from SNH, given the beaver's 'former native' status
Nature Conservation (Scotland) Act 2004	SNH must notify Sites of Special Scientific Interest (SSSIs) for natural features (including certain animals) according to published selection guidelines and describe 'operations requiring consent' (ORCs). The ORC provides details of acts or omissions which might damage the natural feature of interest, and therefore require SNH consent before being carried out	Currently, SSSIs cannot be notified for beavers. However, if released onto an existing SSSI notified for other feature(s), beaver management might require consent
Salmon & Freshwater Fisheries (Consolidation) (Scotland) Act 2003	Brings together the law governing Scotland's District Salmon Fishery Boards and other important regulatory areas, including an offence in relation to passage of salmon. Persons acting to prevent salmon passage or disturb any spawning bed may be guilty of an offence	The implications of possible riverine habitat change/engineering resulting from beaver activity (e.g. dam construction) or beaver management which might impede fish movement within river systems and affect in-stream habitat require clarification and guidelines to be produced. Consultation with relevant DSFBs, fishery owners and SEPA will be a requirement
Trade and movement of animals		
Not applicable		
Animal welfare law		
Animal Health & Welfare (Scotland) Act 2006	This law protects the welfare of all vertebrate animals kept on a temporary or permanent basis in Scotland. Animals transported by air (either outside or within Scotland) must comply with the International Air Transport Association's 'Live Animals Regulations' (LAR)	Beaver welfare should be considered when animals are captured, transported or held in captivity, and during and after release into the wild. Persons responsible for holding beavers in captivity must not cause them unnecessary suffering or fail to take reasonable steps to ensure their welfare. Where capture or release of beavers is undertaken in another country, the relevant animal welfare legislation of that country must be adhered to.

		If transported by air in Scotland or to/from Scotland, beavers must be held in containers as specified under LAR
Pests and diseases		
Not applicable		
Water and flood risk management		
Water Framework Directive 2000 Water Environment & Water Services (Scotland) Act 2003 Water Environment (Controlled Activities) (Scotland) Regulations 2011 ('CAR')	Establishes a regulatory structure aimed at protecting, improving and sustainably using water. The 2003 Act and 2011 Regulations transpose the Directive into Scots law and gives Scottish Ministers regulatory controls over water activities – the Controlled Activity Regulations (CAR). Persons intending to carry out any activity which might affect Scotland's water environment require authorisation from SEPA	The management of beaver on a site might result in CAR applications to SEPA (e.g. river impoundment works to protect river banks). SEPA has developed a pragmatic position statement on the management of beaver structures (available from the SEPA website)
Floods Directive 2007 Flood Risk Management (Scotland) Act 2009	The 2009 Act transposes the Floods Directive into Scots law, introducing requirements to reduce the adverse consequences of flooding for a range of reasons, including human health and the environment. It aims to establish a framework of responsibility for assessing and managing flooding and places a strong emphasis on working with nature to manage flood risk	Habitat change brought about by beaver activity might contribute to restoring natural processes within catchments. Beaver presence might increase or reduce flood risk at a local level. Strategic and local flood risk management planning will need to take account of potential beaver activity in managing flood risk sustainably
Reservoirs (Scotland) Act 2011	Sets down the regulatory regime for the safe construction and operation of 'controlled reservoirs' in Scotland. Requires compulsory registration of controlled reservoirs, regulates their construction and denotes inspection requirements. SEPA must assess the risk of uncontrolled releases of water from reservoirs (in terms of adverse consequences and probability). The Act also gives SEPA the power to act in an emergency to protect people or property from water escaping from a reservoir	There is the potential for beaver burrowing, for example, to damage 'controlled reservoirs' with consequent risk to public and infrastructure safety. More frequent inspection of some controlled reservoirs may be required. Plans for new reservoirs might need to take into account possible beaver activity in the area
Environmental liability and impact assessments		
Environmental Liability Directive 2004	Under the Directive and the transposed Scots law, opera-	Operators who kill (large numbers of) beaver (when their population is

Environmental Liability (Scotland) Regulations 2009	tors causing environmental damage (which includes offences affecting Annex II species and Annex IV species and their breeding sites or resting places) are held financially liable for remedying the damage. Protection applies whether the species is inside or outside a Natura site	low) or damage their breeding sites or resting places may be held financially liable for remedying the situation
Related policy/programmes		
Species Action Framework and Handbook	The Species Action Framework (SAF) was a five-year programme of targeted species management from 2007-12. It covered 32 species including Eurasian beaver and led to the Scottish Beaver Trial project. The subsequent SAF **Handbook** summarises the knowledge and experience gained through the SAF, and includes details of more recent work that followed on from SAF	Eurasian beaver is a species for conservation action in the SAF and Handbook

Beavers in Scotland Strategic Environmental Assessment

Environmental Report

Appendix 3 - Compliance with the Environmental Assessment (Scotland) Act 2005

What	Where	Comment
An outline of the contents and main objectives of the plan or programme, and of its relationship (if any) with other qualifying plans and programmes.	Section 1.1	
The relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or programme	Section 3 and Appendix 1	
The environmental characteristics of areas likely to be significantly affected.	Section 3 and Appendix 1 and section 4.1	
Any existing environmental problems which are relevant to the plan or programme including, in particular, those relating to any areas of a particular environmental importance, such as areas designated pursuant to Council Directive 79/409/EEC on the conservation of wild birds and Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (as last amended by Council Directive 97/62/EC).	Section 3	
The environmental protection objectives, established at international, Community or Member State level, which are relevant to the plan or programme and the way those objectives and any environmental considerations have been taken into account during its preparation	Section 2.2	
The likely significant effects on the environment, including— (a)on issues such as— (i)biodiversity; (ii)population; (iii)human health; (iv)fauna; (v)flora; (vi)soil; (vii)water; (x)material assets; (xi)cultural heritage, including architectural and archaeologi-	Section 4 – Biodiversity, flora and fauna – sections 4.1 – 4.8 Population – section 4.12 Human health – section 4.12 Soil – sections 4.1, 4.9, 4.10, 4.14 Water – sections 4.9 and 4.10	The inter-relationship between the issues is picked up within the subject sections. For example, the consideration of effects on soils is considered within the sections on woodland and freshwater. This is akin to an ecosystems approach to the assessment process.

cal heritage; (xiii)the inter-relationship between the issues referred to in heads (i) to (xii);	Cultural heritage – section 4.13	
(b)short, medium and long-term effects; (c)permanent and temporary effects; (d)positive and negative effects; and (e)secondary, cumulative and synergistic effects	Section 4 – sections 4.2 to 4.14 See also section 2.3	The nature and duration of the effects, is picked up within the consideration of each of the different interests in section 4.
The measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme.	Sections 4.2 to 4.14 Section 5	Specific mitigation measures have been highlighted within each section, however there are a number of generic measures which are applicable to all interests and these have been pulled together in section 5
An outline of the reasons for selecting the alternatives dealt with, and a description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of expertise) encountered in compiling the required information	Section 6	
A description of the measures envisaged concerning monitoring in accordance with section 19.	Section 7	
A non-technical summary of the information provided under paragraphs 1 to 9	Following contents page	

Beavers in Scotland Strategic Environmental Assessment

Environmental Report

Appendix 4 - Consideration of Consultation Authority comments on SEA scoping report

Organisation	Issue	Comment	How this has been addressed
Historic Environment Scotland	Scope and level of detail	We note that the historic environment has been scoped into the assessment. On the basis of the information provided, we are content with this approach and are satisfied with the scope and level of detail proposed for the assessment, subject to the detailed comments provided below.	Noted
	Environmental Topics to be scoped in and out of the assessment process	We welcome that the historic environment has been scoped into the process. As the scoping report notes, when considering policy relating to wild animals there will be a degree of uncertainty in the prediction of environmental effects. In this regard much of the assessment of potential effects on the historic environment will be generic in nature.	Agreed – this uncertainty will be recorded in the ER
	Environmental Topics to be scoped in and out of the assessment process	We note that this section proposes to scope gardens and designed landscapes (GDLs) out of the assessment yet baseline information on these historic environment assets has been provided in the Environmental Characteristics of Beaver Areas section of the report. Elements of beaver activity can include tree felling, dam building and construction activity that has the potential for significant effects on attributes of GDLs through important tree loss, disruption of water features and increased erosion. Therefore it is likely that the assessment findings and generic mitigation outputs from the assessment of effects on the historic environment would be equally applicable to GDLs and we would advise that this should not be scoped out as the assessment can provide beneficial management advice for the	Agreed – GDLs will be included to the ER

		mitigation of beaver activity in these sensitive sites.	
	Reasonable Alternatives	We are content to agree with the preferred option and reasonable alternatives suggest within the scoping report. The work already carried out within the future scenarios section of the Beavers in Scotland Report (2015) provides a sound starting point for the assessment of these alternatives.	Noted
	Assessment Methodology	We note that the assessment will be narrative based and we welcome the draft example of a table for the presentation of findings. We particularly welcome the approach of considering the likely environmental effects of different forms of beaver activity and consider it a sound method for identifying effects and tailoring mitigation. It will be important that an approach to the monitoring of this is built into the outcomes of the assessment.	Noted and agreed
	SEA Environmental Objectives	We are content to agree with the suggested SEA objective for the historic environment	Noted
	Consultation period for the Environmental Report	We note that the Environment Report, Policy Statement and Draft Management Framework are proposed to be out for public consultation for a period of 6 weeks. We can confirm that we are content with this consultation period.	Noted
Scottish Natural Heritage	Scope and level of detail	Subject to the specific comments set out in the Annex to this letter, SNH is content with the scope and level of detail proposed for the environmental report.	Noted
	Consultation period for the environmental report	SNH notes that a period of 6 weeks is proposed for consultation on the Environmental Report and is content with this proposed period.	Noted
	General Approach	The SEA Scoping report is well set out and easy to follow. It would be good to see this approach and simple layout continued in the Environmental Report.	Noted
	Setting the Context	I note that there is no reference to Local Authority plans in the section on Relevant Plans Programmes and Strategies. Local Authority plans could be affected by this policy and may need	The policies in local authority plans are likely to be generic in relation to the potential core

		changing to support delivery of Scottish Governments Policy on Beavers in Knapdale and Tayside.	beaver woodland areas and it would be difficult to attribute anything meaningful from this policy.
	Baseline information	The maps for baseline information need to be at a bigger scale to ensure the information in them can be used and easily interpreted in the final Environment Report.	Agreed, these will be presented as A3 format in Appendix 1
		The population distribution maps seem to focus on the main towns and cities but both Knapdale and Tayside geographical areas are made up of small rural communities. It is important to ensure that the assessment considers how these communities could be affected by the Policy, e.g. impact on their infrastructure. As well as the more urban areas already identified.	Agreed, beavers and their interactions with the human environment are assessed under material assets – specifically forestry, fisheries, agriculture and infrastructure.
		The baseline information identifies National Scenic Areas, however earlier in the scoping report these were scoped out because it was felt that they would not be impacted by the Policy. I assume they have been included as context to both areas, but this is not clear.	Agreed, these will not be included in the ER.
	Significant issues	There are a number of Natura sites in both areas identified in the Policy. These have been highlighted in the baseline data. Where relevant an assessment to determine significant effect of the policy on these sites If in the result of the assessment indicates there is likely to be a significant effect on the Natura sites then a Habitats Regulations Appraisal will be required.	Agreed. A HRA of Natura sites has been undertaken. This will be an Annex of the ER.
		Please note that if a Habitats Regulations Appraisal is required it can be undertaken in parallel with SEA, it is important that the findings of both appraisals are separate and clearly documented and that the record of the Habitats Regulations Appraisal uses the correct terminology, applying them appropriately. In practice, it is easier to set out the Habitats Regulations Appraisal in a separate record, and where appropriate provide a cross-reference to it in the Environmental Report.	Agreed. The SEA and HRA are separate documents.
	SEA objectives	The SEA scoping details objectives which are being linked to receptors identified, however there are no targets associated with	The assessment is not target related but it is intended that

		them and/or details of how achievement will be measured.	any indicators to assess the effectiveness of the policy will be identified at monitoring
	Assessment Methodology	The assessment methodology includes a review of alternatives, assessment criteria, however, it does not include details of known indicators or monitoring arrangements. A description of the indicators chosen and the associated monitoring arrangements is needed.	As above
Scottish Environment Protection Agency	Relationship with other Plans, Policies and Strategies (PPS	Some of the PPS included have themselves been subject to SEA. Where this is the case you may find it useful to prepare a summary of the key SEA findings that may be relevant to the Beavers in Scotland programme. This may assist you with data sources and environmental baseline information and also ensure the current SEA picks up environmental issues or mitigation actions which may have been identified elsewhere.	Noted
	Baseline Information	SEPA holds significant amounts of environmental data which may be of interest to you in preparing the environmental baseline, identifying environmental problems, and summarising the likely changes to the environment in the absence of the PPS, all of which are required for the assessment. Many of these data are now readily available on SEPA's website. We would refer you to the following which are of particular relevance: • Flood Risk Management Strategies and Local Flood Risk Management Plans are partnership strategies which focus action in the areas with the greatest risk of flooding and which provide details on proposed actions, funding and delivery timescales http://apps.sepa.org.uk/FRMStrategies/ • The River Basin Management Plan for the Scotland River Basin District 2015-2027 contains details of the pressures on the water environment and objectives to be achieved in line with Water Framework	Noted

		Directive objectives www.sepa.org.uk/media/163445/the-river-basin-management-plan-for-the-scotland-river-basin-district-2015-2027.pdf	
	SCOPING IN / OUT OF ENVIRONMENTAL TOPICS	With regard to the topics which fall within our remit (air, soil, water, material assets, human health and climatic factors) and based on the information provided to date we are content with the topics proposed to be scoped into the assessment.	Soils and geomorphology were scoped into the assessment process. However consideration of any significant effects on soils and geomorphology is captured within the sections on woodland, freshwater and material assets as these elements are too closely interconnected with these topics to separate out in any meaningful way.
		We understand that effects related to flooding will be considered across the whole range of environmental receptors which have been identified in section 6 of the scoping report. We consider this to be appropriate and note that a specific SEA objective associated with this will be used	Agreed
		With regards to material assets it would be useful to include consideration of the potential impacts on strategic transport corridors from changes in other areas (such as changes to morphology or flooding regimes) which may result from beaver activity. Such activity may influence erosion and deposition in watercourses adjacent to main road and rail infrastructure even if the beaver activity is not in direct proximity.	Consideration of A9 dualling programme included.
		We understand that many of the issues to be considered in the assessment are related to the water environment and will therefore be assessed under this SEA topic. It will be important to clearly identify the individual elements being considered (e.g. geomorphology, water quality, fauna, flora, etc.) as well as their	Agreed. Interrelations are embedded throughout the assessment. The nature of these is also discussed in assessment limitations.

		interrelationships with each other and the other SEA topics under consideration in order that significant effects can be documented in a way which clearly identifies potential cause and effect relationships	
		Implications for non-native species might also usefully be considered (either under the water topic or biodiversity, fauna and flora) in terms of whether the presence of beavers potentially enhances or reduces the risk of spread or establishment of any existing, or potential future introductions of freshwater or riparian high impact non-native species.	Agreed
	ALTERNATIVES	We are satisfied with the alternatives outlined in Section 5 of the scoping report. These should be assessed as part of the SEA process and the findings of the assessment should inform the choice of the preferred option. This should be documented in the Environmental Report.	Noted
	METHODOLOGY FOR ASSESSING ENVIRONMENTAL EFFECTS	We support the use of SEA objectives in the assessment as they will allow a systematic, rigorous and consistent framework with which to assess environmental effects in relation to the environmental receptors identified in Section 6 of the scoping report.	Agreed
	Mitigation and enhancement	We would encourage you to be very clear in the Environmental Report about mitigation measures which are proposed as a result of the assessment. These should follow the mitigation hierarchy (avoid, reduce, remedy or compensate). One of the most important ways to mitigate significant environmental effects identified through the assessment is to make changes to the plan itself so that significant effects are avoided. The Environmental Report should therefore identify any changes made to the plan as a result of the SEA. Where the mitigation proposed does not relate to modification to	Agree and this structure is reflected in the mitigation section of the ER.

<table>
<tr><td></td><td></td><td>the plan itself then it would be extremely helpful to set out the proposed mitigation measures in a way that clearly identifies: (1) the measures required, (2) when they would be required and (3) who will be required to implement them. The inclusion of a summary table in the Environmental Report such as that presented below will help to track progress on mitigation through the monitoring process.
<table>
<tr><th>Issue / Impact Identified in ER</th><th>Mitigation Measure</th><th>Lead Authority</th><th>Proposed Timescale</th></tr>
<tr><td>Insert effect recorded in ER</td><td>Insert mitigation measure to address effect</td><td>Insert as appropriate</td><td>Insert as appropriate</td></tr>
<tr><td>etc</td><td>etc</td><td>etc</td><td>etc</td></tr>
</table>
</td><td></td></tr>
<tr><td></td><td>Monitoring</td><td>Although not specifically required at this stage, monitoring is a requirement of the Act and early consideration should be given to a monitoring approach particularly in the choice of indicators. It would be helpful if the Environmental Report included a description of the measures envisaged to monitor the significant environmental effects of the plan.</td><td>Noted</td></tr>
<tr><td></td><td>Consultation period</td><td>We are satisfied with the proposal for a 6 week consultation period for the Environmental Report</td><td>Noted</td></tr>
</table>

Responding to this Consultation

We are inviting responses to this consultation by Tuesday, 6 March 2018.

Please respond to this consultation using the Scottish Government's consultation platform, Citizen Space. You view and respond to this consultation online at: https://consult.scotland.gov.uk/forestry/beavers-in-scotland

You can save and return to your responses while the consultation is still open. Please ensure that consultation responses are submitted before the closing date of Tuesday, 6 March 2018.

If you are unable to respond online, please complete the Respondent Information Form (see "Handling your Response" below) and send it to:
John Gray
Wildlife and Protected Areas
Natural Resources Division
Environment & Forestry Directorate
Area 3G South
The Scottish Government
Victoria Quay
Edinburgh
EH6 6QQ

Handling your response

If you respond using Citizen Space (http://consult.scotland.gov.uk/), you will be directed to the Respondent Information Form. Please indicate how you wish your response to be handled and, in particular, whether you are happy for your response to published.

If you are unable to respond via Citizen Space, please complete and return the Respondent Information Form attached included in this document to: beaversseaconsultation@gov.scot

If you ask for your response not to be published, we will regard it as confidential, and we will treat it accordingly.

All respondents should be aware that the Scottish Government is subject to the provisions of the Freedom of Information (Scotland) Act 2002 and would therefore have to consider any request made to it under the Act for information relating to responses made to this consultation exercise.

Next steps in the process

Where respondents have given permission for their response to be made public, and after we have checked that they contain no potentially defamatory material, responses will be made available to the public at http://consult.scotland.gov.uk. If you use Citizen Space to respond, you will receive a copy of your response via email.

Following the closing date, all responses will be analysed and considered along with any other available evidence to help us. Responses will be published where we have been given permission to do so.

Comments and complaints

If you have any comments about how this consultation exercise has been conducted, please send them to: beaversseaconsultation@gov.scot

Scottish Government consultation process

Consultation is an essential part of the policy-making process. It gives us the opportunity to consider your opinion and expertise on a proposed area of work.

You can find all our consultations online: http://consult.scotland.gov.uk. Each consultation details the issues under consideration, as well as a way for you to give us your views, either online, by email or by post.

Consultations may involve seeking views in a number of different ways, such as public meetings, focus groups, or other online methods such as Dialogue (https://www.ideas.gov.scot)

Responses will be analysed and used as part of the decision making process, along with a range of other available information and evidence. We will publish a report of this analysis for every consultation. Depending on the nature of the consultation exercise the responses received may:

- indicate the need for policy development or review
- inform the development of a particular policy
- help decisions to be made between alternative policy proposals
- be used to finalise legislation before it is implemented

While details of particular circumstances described in a response to a consultation exercise may usefully inform the policy process, consultation exercises cannot address individual concerns and comments, which should be directed to the relevant public body.

Scottish Government
Riaghaltas na h-Alba
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This publication is available at **www.gov.scot**

Any enquiries regarding this publication should be sent to us at
The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

ISBN: 978-1-78851-273-2 (web only)

Published by The Scottish Government, December 2017

Produced for The Scottish Government by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
PPDAS305046 (12/17)