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[1] Salmonid-Beaver Working Group

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Abstract

Atlantic salmon are both a species of conservation importance listed under the EC Habitats Directive and the target of important Scottish rural fisheries. Scottish Government is considering the possibility of formally reintroducing the Eurasian beaver. In assessing the option, it is important to consider possible positive and negative effects of beavers on salmon. An important first requirement is to establish whether there would be substantial overlap of potential beaver habitat and known Atlantic salmon distribution. This issue was addressed using a Geographic Information System (GIS) to compare the current known distribution of Atlantic salmon in six river catchments with predicted beaver distributions should these animals be reintroduced and use all available suitable habitat. At the full catchment scale in the six rivers (Awe, Ayr, Conon, North Esk, Tay and Tweed), the percentage wetted area of salmon habitat likely to occur in proximity to potential beaver habitat (termed *percentage overlap*) ranged from 47-73%. In all six rivers the percentage overlap was greatest in major rivers (predominantly main stems) >10m in width (54-87%). In minor rivers <10m in width, that is predominantly tributaries, overlap ranged from 15% to 59%. Results of the mapping exercise are discussed in relation to understanding possible positive and negative effects of beavers on Atlantic salmon. While the figures presented here estimate the percentage spatial overlap in distributions of these species, impacts of beavers would likely extend further upstream and downstream of this physical overlap. Thus, in interpreting the findings of this study, the influence of beavers on salmon populations throughout moorland streams above beaver dams is identified as being a particular risk to weak salmon populations, whereas benefits of the presence of beavers might be accrued in other areas downstream.

1. Introduction

Eurasian beaver, *Castor fiber*, are large semi-aquatic mammals that use trees and herbs as food and also material for maintaining lodges and damming rivers under certain circumstances (Kitchener, 2001). Atlantic salmon, *Salmo salar* L., use rivers for development of eggs and early growth before a majority of the population migrates to sea as smolts and subsequently returns to spawn (Mills, 1991). Salmon are an iconic component of Scotland's cultural and natural resources and have a high conservation status, being listed under the EC Habitat Directive, as well as supporting high value fisheries. Beavers occurred in Scotland's ancient landscape but have been extinct since about 1600 (Raye, 2014). In the intervening years, the nature of that landscape and the character of river ecosystems have changed substantially. Against this backdrop, the Scottish Government is currently assessing the likely consequences of allowing beavers to re-colonise (Gaywood, 2014). This assessment includes a consideration of potential interactions between beavers, fish and fisheries with particular focus on Atlantic salmon.

Beavers radically change the characteristics of riverine habitats and influence a range of physical and chemical processes, many of which may have either or both positive and negative effects on fish communities and populations (Collen & Gibson, 2001, Kemp *et al*., 2012). The overall net impact (positive or negative) can be expected to vary depending on the species of fish involved and the local environment in which they live. Atlantic salmon are highly migratory swift-water specialists (Armstrong, 2010). As such they could be expected to be more negatively affected than many other fish species by obstructions from damming activities and change from fast-flowing riffle to pool habitat. However, they may also benefit from local presence of beavers if these animals increase food supply, the availability of cover from predators, and/or quantity of suitable local habitat (Kemp *et al*., 2012). The potential extent of these possible positive factors depends largely on the overlap that can be expected between salmon and beavers. By contrast, where damming hinders fish migration, the negative effects of this obstruction may extend for the entire area upstream.

A basic requirement in determining where potential interactions may occur is to estimate the spatial overlap between the expected range of beavers and the distribution of salmon. This study uses a geographic information system (GIS) approach to consider potential spatial overlap in six river catchments that cover much of Scotland's geographical and hydrological diversity: the Rivers Awe, Ayr, Conon, North Esk, Tay and Tweed (Fig.1). Salmon distribution is that recorded in recent years, whereas potential beaver distribution is based on predictions of suitable habitat, defined as existing broadleaf and mixed broadleaf woodland within 200m of freshwater habitats including rivers and wetlands, but excluding high gradient streams, tidal areas and land above 400m in elevation. The data are also considered as a comparison of larger and smaller river reaches, taking a 10-m width cut-off. This approach provides an estimate of how the area of overlap may differ between major rivers (predominantly main stems) and minor rivers (predominantly tributaries).

2. Methods

GIS was used to determine the percentage of river habitat known to be currently occupied by Atlantic salmon that would be predicted to be used by beavers should they extend to their full potential range. Salmon distribution data, provided by Marine Scotland Science (MSS) and last updated in 2008, includes the spatial range over which juvenile salmon have been detected in Scotland. Potential beaver habitat distribution data, produced, using the methodology of Webb et al. (1997), and provided by Scottish Natural Heritage (SNH), includes habitat types and topographies known to be used by the mammals in other European countries. The data set includes a wide range of habitat types, including small groups of trees and scrubland, including willow and alder. Hence, it emphasises the widest area of habitat likely to be used by beavers rather than only those areas that might sustain territories over long periods of time and hence encourage production of dams.

2.1 Datasets

Salmon distribution was compiled initially by Gardiner & Egglishaw (1986) and updated in 2008 with more recent data from surveys conducted by Marine Scotland Science and Fisheries Trusts. The updated salmon distribution data were incorporated in the Centre for Ecology and Hydrology (CEH) 1:50,000 Digital River Network (DRN) as a Scotland-wide line dataset. This information was transferred to Ordnance Survey MasterMap (OSMM) to create area-based polygon data for each catchment and subsequently split twice. Firstly to separate lochs and rivers, locations were identified using Scottish Environment Protection Agency (SEPA) loch coding in the CEH DRN and Ordnance Survey 1;10,000 data as a guide. Secondly, river polygons were split based on SEPA 1:50,000 stream width data, into two river types: those areas below and equal to, and those above 10m in width.

Potential beaver habitat distribution data were produced by SNH (August 2011) from fresh water, woodland and Ordnance Survey datasets as listed below, using a methodology based on earlier studies (Webb *et al*, 1997). Suitable beaver woodland was compiled from areas with existing broadleaved and mixed broadleaved woodland (Highland Birchwood's Scottish Semi-Natural Woodland Inventory - SSNWI - and Forestry Commission's National Inventory for Woodlands and Trees - NIWT), lying within 200m of suitable water or wetland habitat. Tidal areas were excluded as were areas above 400m, and stream reaches of greater than 2% gradient using a slope analysis of OS 1:50,000 Panorama Digital Terrain Model (DTM) data.

Catchment boundaries for the Rivers Awe, Ayr, Conon, North Esk, Tay and Tweed were extracted from data produced by SEPA from CEH 1:50,000 DTM data. For the study, the Tay catchment excluded the River Earn and the Tweed catchment included the River Whiteadder. Since SNH potential beaver habitat datasets did not extend into England, the Tweed catchment boundary was restricted to the area within Scotland, using OS Panorama 1:50,000 data at the Scottish Border.

2.2 Salmon and beaver distribution overlap

Salmon rivers data were required in polygon format to quantify the area of potential overlap. The salmon rivers DRN (line) dataset contains no area information, and processing used salmon rivers OSMM (polygon) data, extended with OSMM line data where necessary. With the potential beaver habitat datasets restricted to areas below 400m in elevation, salmon distribution polygons were checked against OS Profile 1:10,000 contour lines and salmon river sections above 400m altitude, which occurred only on the North Esk and Tay, were excluded.

To calculate the area of salmon rivers in proximity to potential beaver habitat at a catchment scale, suitable beaver woodland was “buffered” by 50m and the total area and percentage of salmon rivers within this buffer zone was calculated. Secondly, using the salmon river type categories (section 2.1), this overlap methodology was repeated to provide area values and percentages specific to each river category.

The method of analysis limited overlap to a 50m buffer zone, which was the smallest scale applicable given data resolution. Salmon lochs were also excluded, predominantly as the large surface area of lochs relative to that of rivers was found to exert a disproportionately large influence on species overlap figures. Further, as beavers would likely use the perimeter of lochs and would not be capable of creating dams across lochs, beaver-salmon interactions would likely be limited relative to the area of lochs.

2.3 Data limitations

A number of assumptions and approximations were required in view of data limitations. SEPA catchment boundaries are held separately for the Rivers Tweed and Whiteadder and for the Tay and Earn since the Whiteadder enters the Tweed below the tidal limit as does the Earn in the Tay estuary. Areas considered were for the Tweed including the Whiteadder and the Tay excluding the Earn.

SNH potential beaver habitat data exclude the Tweed in England. Consequently a boundary was produced for the Tweed within Scotland and figures for the Tweed relate to the Scottish part only.

OS MasterMap data for fresh water are held as both polygons and lines, depending on river width and scale of data capture. Line data occur mainly in upper river sections, usually where stream width is less than 5m, but may also denote field ditches in lower catchment areas. Consequently, the data for some of the upper tributaries are in line format only, with no width or area information. An accurate area can therefore be calculated for river and loch sections held as polygons but not for those river sections available only as lines. In the absence of width information for upper tributaries and following investigation of suitable buffer widths, an area was created for line sections by producing 4m total width polygon buffers on the lines.

OS Mastermap freshwater polygon data contains no separation between lochs and rivers or between larger rivers and any smaller tributaries. Where salmon distribution included lochs, breakpoints were required to separate loch polygons from the rivers flowing in or out of them. These were determined using a combination of SEPA loch coding in the CEH DRN, Ordnance Survey data (section 2.1) and best judgement.

SEPA river width data were used to assist in determining the breakpoint between minor tributaries and major tributaries or main-stem categories. All streams where width values were consistently recorded as being less than 10m were categorised as minor tributaries. In certain areas, width data values were limited, and as such breakpoints were determined using best judgement and OS 1:10,000 raster data.

3. Results

The distribution patterns of potential beaver and known salmon habitat and the degree of overlap at whole-catchment and major and minor river-scales are summarised in Table 1. At the catchment scale in the six rivers (Awe, Ayr, Conon, North Esk, Tay and Tweed), the percentage wetted area of known salmon distribution likely to occur in proximity to potential beaver habitat (termed *percentage overlap*) ranged from 47-73%. In all six rivers, the degree of overlap in the habitat distributions was greatest in major rivers (predominantly main stems) >10m in width, ranging from 54 to 87%. The highest percentage overlap in the River North Esk reflected the extensive woodland close to major rivers in this catchment. In minor rivers <10m in width, that is predominantly tributaries, percentage overlap ranged from 15% to 59%. In each case the higher or lower percentage values reflect the extent to which both major and minor rivers are currently accessible to salmon, and feature broadleaf riparian woodland. For example, percentage overlap is particularly low on the River Conon minor rivers due in part to limited accessibility to salmon and in part to comparatively low levels of suitable beaver woodland. Conversely, minor rivers of the River Tay feature relatively more suitable beaver woodland compared to the other catchments studied, resulting in a high overlap percentage.

Details of the salmon and beaver distributions in the six catchments are illustrated in Figure 2(a) – 2(f). From examination of the distributions it is evident that suitable beaver woodland is generally well dispersed throughout the major river reaches, while patterns of distribution are more variable in minor rivers. In many cases the distribution of salmon extends above the treeline to open moorland areas with no woodland, though in some cases suitable beaver habitat exists.

4. Discussion

The present study clearly demonstrates that a wide overlap currently exists between potential beaver habitat and known salmon distribution: in the order of 47-73% across six rivers of varied geographic location and topology. There was a consistent trend of more beaver-salmon habitat overlap in major than minor rivers. This variation largely reflected differences in the extent of riparian tree cover, and the prediction of little colonisation by beavers into steeper gradient streams at higher altitudes.

4.1 Biases in estimates

Any model of beaver distribution is speculative because the way that the animals actually use the Scottish landscape would only become clear should they be formally reintroduced and permitted to colonise suitable habitat. However, given assumptions, suitability of rivers for beavers can be estimated from knowledge of habitat use (Allen, 1983) and applied effectively using GIS (Anderson & Bonner, 2014) to predict the range of the animals. The putative suitable beaver woodland dataset used in this project is based on known parameters for the Eurasian beaver in a European context. However there are several potential biases. In practice, beaver distribution would be variable over time because colonies commonly abandon ponds before re-establishing years later (Pullen, 1971). This phenomenon would introduce a positive bias in the overlap estimates. The suitable beaver woodland dataset presently does not include woodland close to streams of greater than 2% gradient. Eurasian beavers have been observed to exist on stream gradients of up to 2.5% (Schulte, 1989), and North American beavers may use streams of up to a 6% gradient (Pollock *et al*., 2014). This factor may have resulted in systematic underestimation. Further, in future decades overlap will likely increase as riverine tree planting schemes generate bankside woodland in upland areas. Conversely, although beaver foraging activity may occur up to 100m from water, in Denmark for example, the majority (95%) occurs within 5m (Elmeros *et al*., 2003). Therefore, the beaver dataset, derived using a 200m buffer, may generate a systematic overestimate. Understanding of the present distribution of salmon is obtained from extensive field survey work, and can be expected to provide a good coverage of the distribution of salmon as of 2008. However, salmon distribution will change, for example as man-made barriers are removed. In view of these uncertainties the results should be considered indicative of the predicted general, rather than precise, level of overlap.

4.2 Scottish salmon populations: status and structuring

The relevance of overlap in salmon and beaver distributions can be understood through consideration of the state of salmon populations in Scotland and the mechanisms by which the two species may interact. The overall strength of the Scottish salmon stock (all populations combined) has declined markedly in the last fifty years due to increased mortality at sea (Anon, 2014). A reduction in international and coastal net fisheries has generally offset this change at the whole-Scotland scale to maintain or increase stocks entering rivers to support rod fisheries and provide a spawning escapement. However, little scope remains for further such compensation. Furthermore, serious reductions in populations have occurred at more local scales. Atlantic salmon are geographically structured within the larger rivers into genetically distinct groups with significantly different phenotypes (Stewart *et al*., 2006). Those salmon from upstream tributaries tend to leave and return earlier in the year and support a “spring fishery” which is both highly valued for sport and at highest conservation risk. There is evidence that some such populations have approached a level that is sufficiently low that further reduction in spawning will have a direct effect on the numbers of emigrants they produce and hence the next generation of returning adults (Anon, 2014; Jonsson *et al*., 1998). Salmon are protected at the local sub-stock level within SACs under the EC Habitats Directive. Hence, there would evidently be a need to manage any adverse effects of beavers on spring salmon. If mortality of salmon on the high seas increases further, then it is likely that adverse effects of beaver dams will exacerbate the situation across a wider range of tributaries and river main stem areas as summer and autumn stocks decline. Furthermore, reduction in the condition and fecundity of salmon due to high seas warming (Todd *et al*., 2008) can be expected to lead to an increase in the number of returning fish needed to attain a conservation limit.

4.3 Key interactions between Atlantic salmon, the fish community and the thermal, physical and chemical environment

Given the precarious state of some Atlantic salmon populations, it would be particularly welcome if presence of beavers resulted in overall beneficial effects. In reviewing effects of beavers on fish, Kemp *et al.* (2012) highlighted that generally a greater number of positive than negative factors had been identified and demonstrated. However, such a general assessment does not inform on likely effects of beavers on individual fish species in specific contexts. The Scottish native fish communities are of relatively low diversity compared with others in Europe due to isolation in the last Ice Age (Maitland & Campbell, 1992). In Scotland, Atlantic salmon co-occur across much of their range with the closely related brown trout, *Salmo trutta* L.. These two species differ in their morphology such that salmon have adapted to life in swift waters, whereas brown trout are dominant in pools (Armstrong, 2010). Both species are threatened by invasive fish species, notably the European minnow, *Phoxinus phoxinus* L and the northern pike, *Esox Lucius* L. Minnow are small shoaling cyprinid fish that occupy pools and may filter out food and hence exert competition on salmon and trout (Museth *et al*., 2007). Pike are predatory fish that also generally inhabit slower flowing areas and can have devastating consequences for salmon populations, particularly through consumption of smolts on their downstream emigration to sea (Kekalainen *et al*., 2008).

An increase in pool habitats may favour trout over salmon and increase habitat for minnows, pike and other competitors and predators. However, there may also be benefits for salmon of additional pool habitat, at least in some situations. For example, the interaction between trout and salmon is complex. The presence of trout may reduce dominance hierarchies among salmon of similar size (Höjesjö *et al*., 2010) with possible growth benefits for subordinate individuals. There is indeed some evidence of relatively fast summer growth among salmon parr in a beaver pond (Sigourney *et al*., 2006), although this has not been demonstrated on fish communities of Scotland. Pools may also modulate thermal properties of the water, with possible positive or negative consequences, depending on how the local temperature relates to optima and lethal levels for trout and salmon (Elliott & Hurley, 1997; Elliott, 1994). Beaver ponds may constitute nutrient sinks (Wilby *et al*., 2014) which may be beneficial in agricultural areas. However, this process may result in the stripping out of chemicals (Danell, 1996) that are essential for growth of salmon in the faster-flowing reaches they occupy in upland areas (Williams *et al*., 2009).

An increase in large woody debris due to beaver activities may benefit young salmon by increasing the availability of good foraging and hiding areas (Nislow *et al*., 1999). The importance of this effect in Scotland is unknown and would depend on local habitat structure and on which size-specific habitats limit overall production of salmon (Armstrong & Nislow, 2006).

Bankside tree cover affects light and temperature in streams (Malcolm *et al*., 2008; Finstad *et al*., 2010). In some circumstances a reduction in vegetation cover due to beaver activity would increase light and temperature, and thereby increase production at primary levels and up into higher trophic levels including salmon (Kemp *et al*., 2012). In other cases, reduction in the tree canopy could increase temperature above the optimum for growth (about 16^{o}C for salmon) with negative consequences. Indeed, in exposed upland moorland areas, daytime summer temperatures may already far exceed these optimal levels. Contemporary management of salmon involves modelling geographic variation in temperature regimes to guide the plantation of riparian vegetation specifically to protect against anticipated elevation in temperature if climate change continues. Clearly, beaver activities would need to be incorporated into such assessments and management plans.

It is evident that there is a complex range of mechanisms relating to light, temperature, nutrients, water depth and in-stream cover via which beavers may affect production of salmon. In some situations the balance may be positive (for example where competing fish and still water predators are absent) and in others they may be negative (for example where summer stream temperatures are high and pike are abundant in pools). The mapping work is important because it shows that the potential for those positive effects that are not directly related to damming activity is greatest in larger rivers where the degree of overlap is most extensive.

4.4 Damming

A major clear potential negative effect of beavers is obstruction to migration of salmon due to damming, which is most likely to occur in relatively shallow and hence generally narrower tributary areas. Variation among tributaries in the area of overlap of distribution of salmon and beavers is not in itself relevant to the extent of such impacts since the whole area of tributary upstream may be affected by a dam. However, such overlap delimits the areas where obstructions would be most likely to be constructed should local conditions be suitable. In the context of identifying locations where dams would be built, it may in the future be useful to refine mapping procedures to identify core habitat in which beavers would be most likely to establish territories (Webb *et al.*, 1997). However, in the absence of maps of water depths and channel morphology it is in any case not currently feasible to apply GIS meaningfully to predict likely dam locations.

It is well established that man-made dams and weirs may affect survival and energetics of salmon moving upstream (Gowans *et al*., 2003) and downstream (Gauld *et al.*, 2013) even if those structures are passable. It is also clear that beaver dams in some contexts may be impassable and that the occurrence, stability and abilities of salmon to pass beaver dams would be likely to vary greatly depending on local geomorphological and hydrological conditions, which would influence river discharge characteristics (Mitchell & Cunjak, 2007). It seems likely that there would be strong interactions between beavers and man-made structures in rivers. For example, fish passes and culverts constitute structures against which beavers can engineer dams; furthermore, regulated hydro rivers may lack the seasonal high flows that would otherwise displace dams.

4.5 Population responses to beaver-induced impacts

There are often more adult salmon spawning than are required to replenish a stream. Reduction in the number of upstream migrating salmon would be of concern only if it brought the spawning stock below a critical level termed the conservation limit. Below this level, there is little scope for compensation from density-dependent processes and a reduction in smolt production would be expected, although the preceding and subsequent couple of cohorts may be enhanced as a consequence of a single weak year class (Einum *et al*., 2011;

Gurney *et al*., 2008). Regardless of the year class strength, reduction in numbers of emigrating smolts due to obstruction of downstream migration would be likely to have a direct proportionate effect on returning adults since mortality at sea is thought to be density independent (Jonsson *et al*., 1998). Although dams may have these immediate negative effects, populations of salmon would also have substantial resilience to becoming extinct due to damming because in Scotland there may typically be two to four cohorts in fresh water and two at sea at any time. Hence, a tributary population might recover from several consecutive missing year classes in the scenario that beaver damming fully prevented upstream passage. If a tributary population is eliminated then it would likely be replaced over time should damming subside, but possibly with a loss of the locally-adapted gene pool and hence lower productive potential. Such change has conservation implication through reduction in genetic diversity.

4.6 General conclusions

Beavers are a natural component of Scotland's wildlife heritage that was lost due to man's activities. Atlantic salmon evolved with beavers over millennia and clearly the two species co-occurred in Scotland. There is little doubt that beavers can generally have overall positive effects on production of some species of salmonid fishes due to their role in engineering river habitats and influencing the chemical dynamics within the watercourse (Kemp *et al*., 2012). However, their influence on Atlantic salmon is more ambiguous, because this species of fish is specialised for swift waters, which would be reduced by extensive beaver damming. Furthermore, Atlantic salmon is highly migratory and hence vulnerable to obstruction of free passage. As with beavers many years ago, Atlantic salmon may be threatened now by human activities, but in this case through the current general effects of climate change on the high seas (Todd *et al*., 2008) combined with a range of local impacting factors. It is therefore by no means certain that salmon across their range can tolerate negative effects of beavers in the way that once they could. It is likely that beavers would need to be managed to avoid negative effects and if done so carefully then any positive effects may be harnessed for the good of salmon. In this regard, the mapping work in this study provides a foundation for planning effective management strategies and can usefully be extended more widely. If beavers expand their range in Scotland and more is understood of their detailed biology in this new landscape, then GIS might usefully be applied to predict damming points (Dryburgh, 2009). GIS might also be used to estimate the linear extent of tributaries in which dams might be constructed as an aid to management surveys for identifying and breeching beaver dams to protect spring salmon in upper river tributaries.

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Table 1. *Estimates of key parameters from current distributions of salmon and predicted area of suitable woodland for beavers. Potential beaver-salmon overlap is the percentage of salmon distribution within 50m of suitable beaver habitat. Major rivers (predominantly main stems) and minor rivers (mainly tributaries) refer to rivers width deemed to be above and below 10m respectively*.

	River					
	Awe	**Ayr**	**Conon**	**North Esk**	**Tay**	**Tweed in Scotland**
Area of beaver woodland in catchment (m^2)	18655128	16728110	21516908	23437700	121500771	86154807
Area of salmon habitat in catchment (m^2)	2328842	2530925	3094610	2572830	17605365	17468072
Area of salmon habitat in major rivers (m^2)	1531006	2028734	2665312	1793813	14723015	11127785
Area of salmon habitat in minor rivers (m^2)	797835	502191	429298	779018	2882350	6340287
Potential beaver-salmon overlap in catchment (%)	62	71	55	73	72	47
Potential beaver-salmon overlap within major rivers (%)	70	80	61	87	75	54
Potential beaver-salmon overlap within minor rivers (%)	46	32	15	39	59	36

Figure 1. General overview of the six study catchments in which distributions of salmon rivers and suitable beaver woodland were compared.

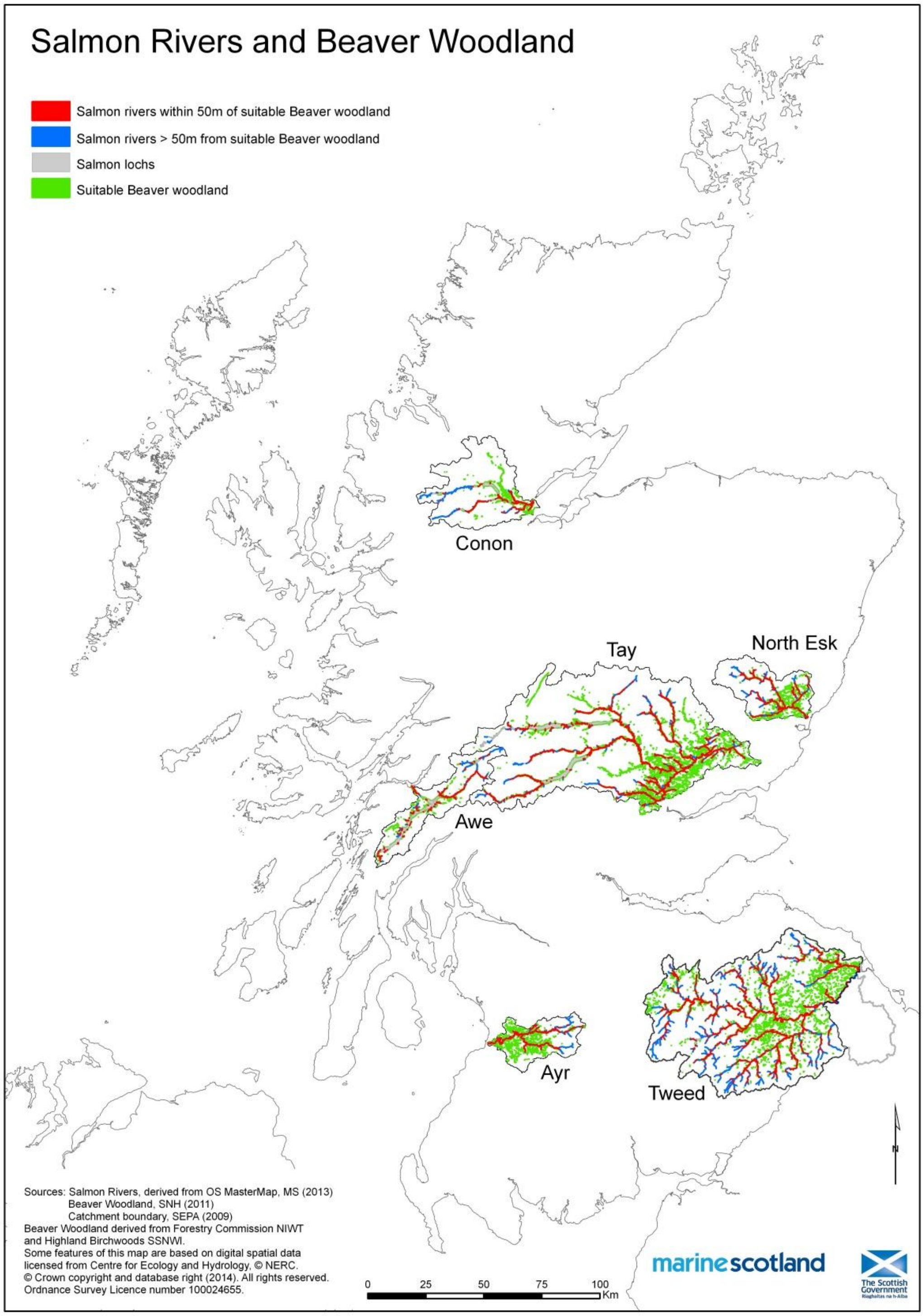
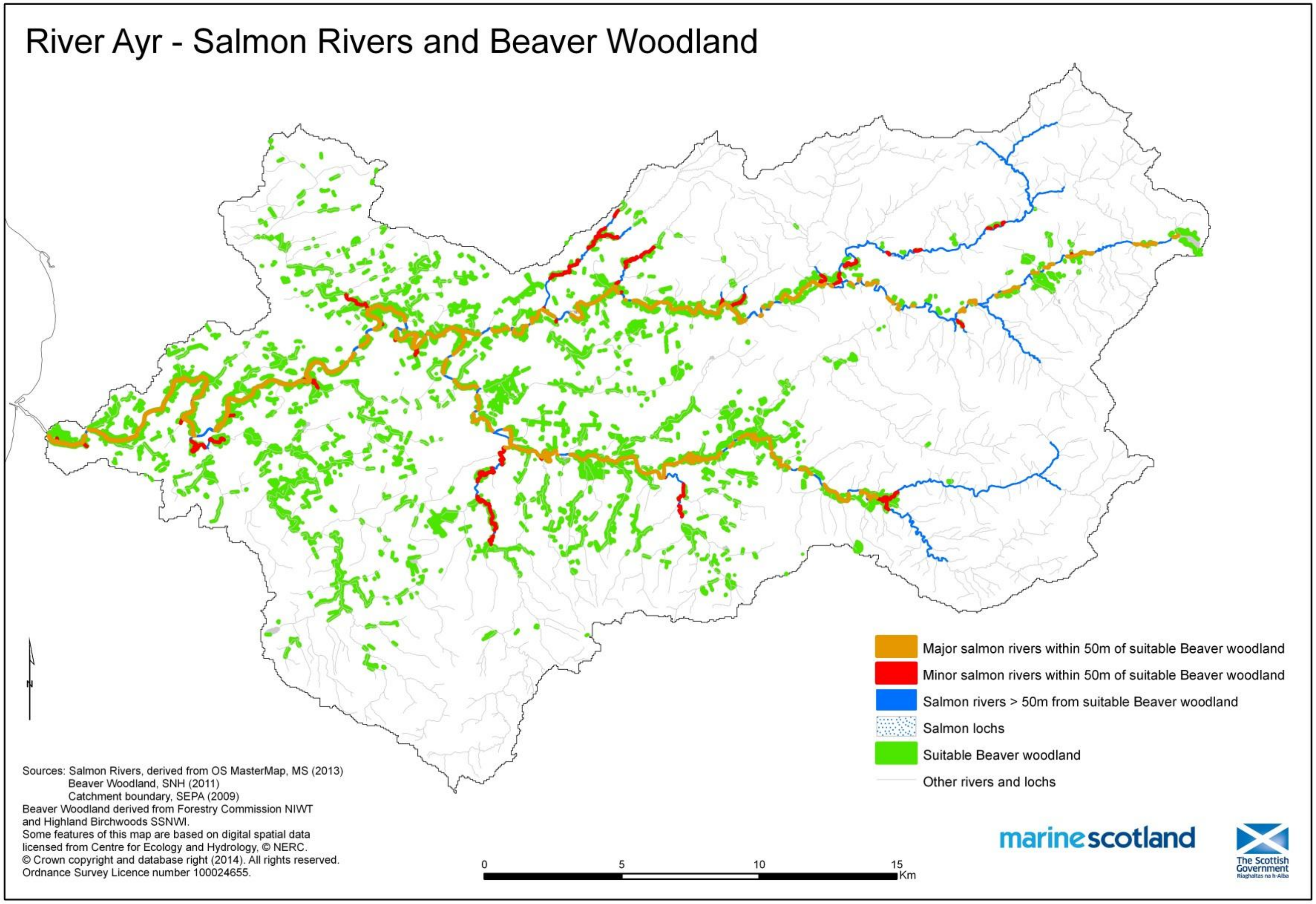


Figure 2. Maps showing salmon rivers within 50m of suitable beaver woodland in six Scottish river catchments. Figure 2(a) River Ayr, Figure 2(b) River Awe, Figure 2(c) River Tweed, Figure 2(d) River Tay, Figure 2(e) River North Esk, Figure 2(f) River Conon.


River Ayr - Salmon Rivers and Beaver Woodland
N
Major salmon rivers within 50m of suitable Beaver woodland
Minor salmon rivers within 50m of suitable Beaver woodland
Salmon rivers > 50m from suitable Beaver woodland
Salmon lochs
Suitable Beaver woodland
Other rivers and lochs
0
5
10
15
Km
Sources: Salmon Rivers, derived from OS MasterMap, MS (2013)
Beaver Woodland, SNH (2011)
Catchment boundary, SEPA (2009)
Beaver Woodland derived from Forestry Commission NIWT
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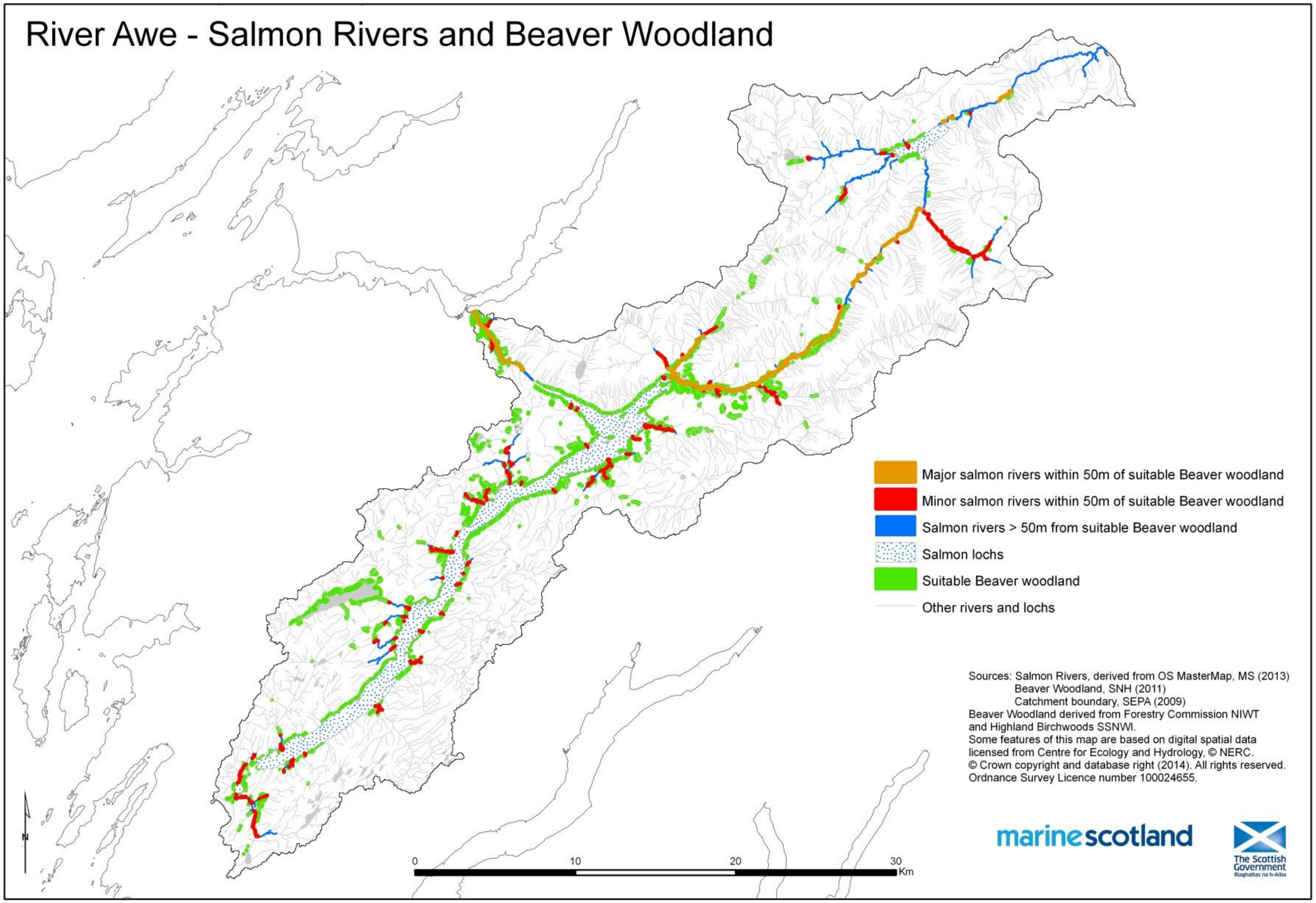
River Awe - Salmon Rivers and Beaver Woodland
Major salmon rivers within 50m of suitable Beaver woodland
Minor salmon rivers within 50m of suitable Beaver woodland
Salmon rivers > 50m from suitable Beaver woodland
Salmon lochs
Suitable Beaver woodland
Other rivers and lochs
Sources: Salmon Rivers, derived from OS MasterMap, MS (2013)
Beaver Woodland, SNH (2011)
Catchment boundary, SEPA (2009)
Beaver Woodland derived from Forestry Commission NIWT
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marinescotland
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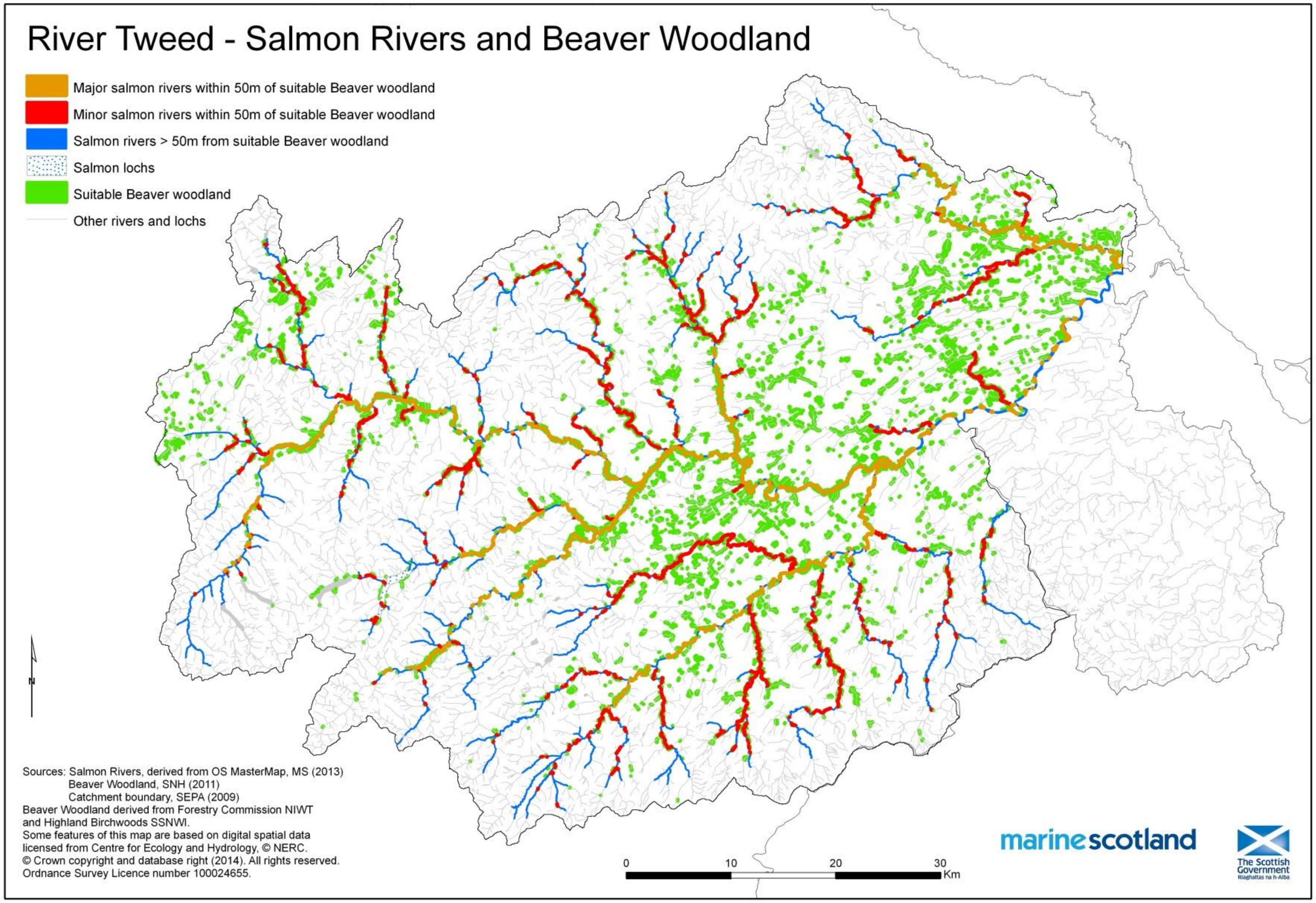
Km


River Tweed - Salmon Rivers and Beaver Woodland
Major salmon rivers within 50m of suitable Beaver woodland
Minor salmon rivers within 50m of suitable Beaver woodland
Salmon rivers > 50m from suitable Beaver woodland
Salmon lochs
Suitable Beaver woodland
Other rivers and lochs
N
Sources: Salmon Rivers, derived from OS MasterMap, MS (2013)
Beaver Woodland, SNH (2011)
Catchment boundary, SEPA (2009)
Beaver Woodland derived from Forestry Commission NIWT
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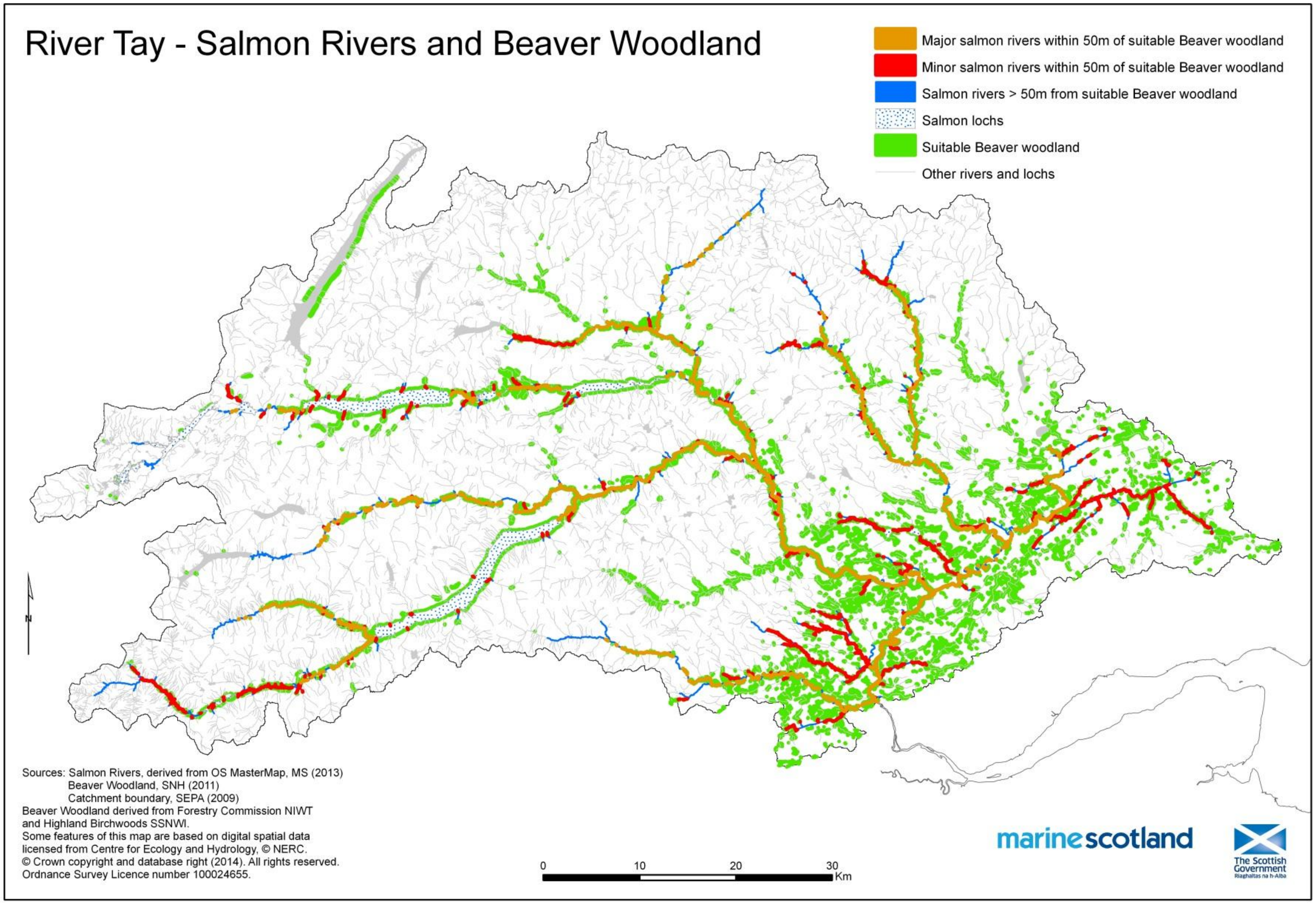

River Tay - Salmon Rivers and Beaver Woodland
Major salmon rivers within 50m of suitable Beaver woodland
Minor salmon rivers within 50m of suitable Beaver woodland
Salmon rivers > 50m from suitable Beaver woodland
Salmon lochs
Suitable Beaver woodland
Other rivers and lochs
N
0
10
20
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Km
Sources: Salmon Rivers, derived from OS MasterMap, MS (2013)
Beaver Woodland, SNH (2011)
Catchment boundary, SEPA (2009)
Beaver Woodland derived from Forestry Commission NIWT
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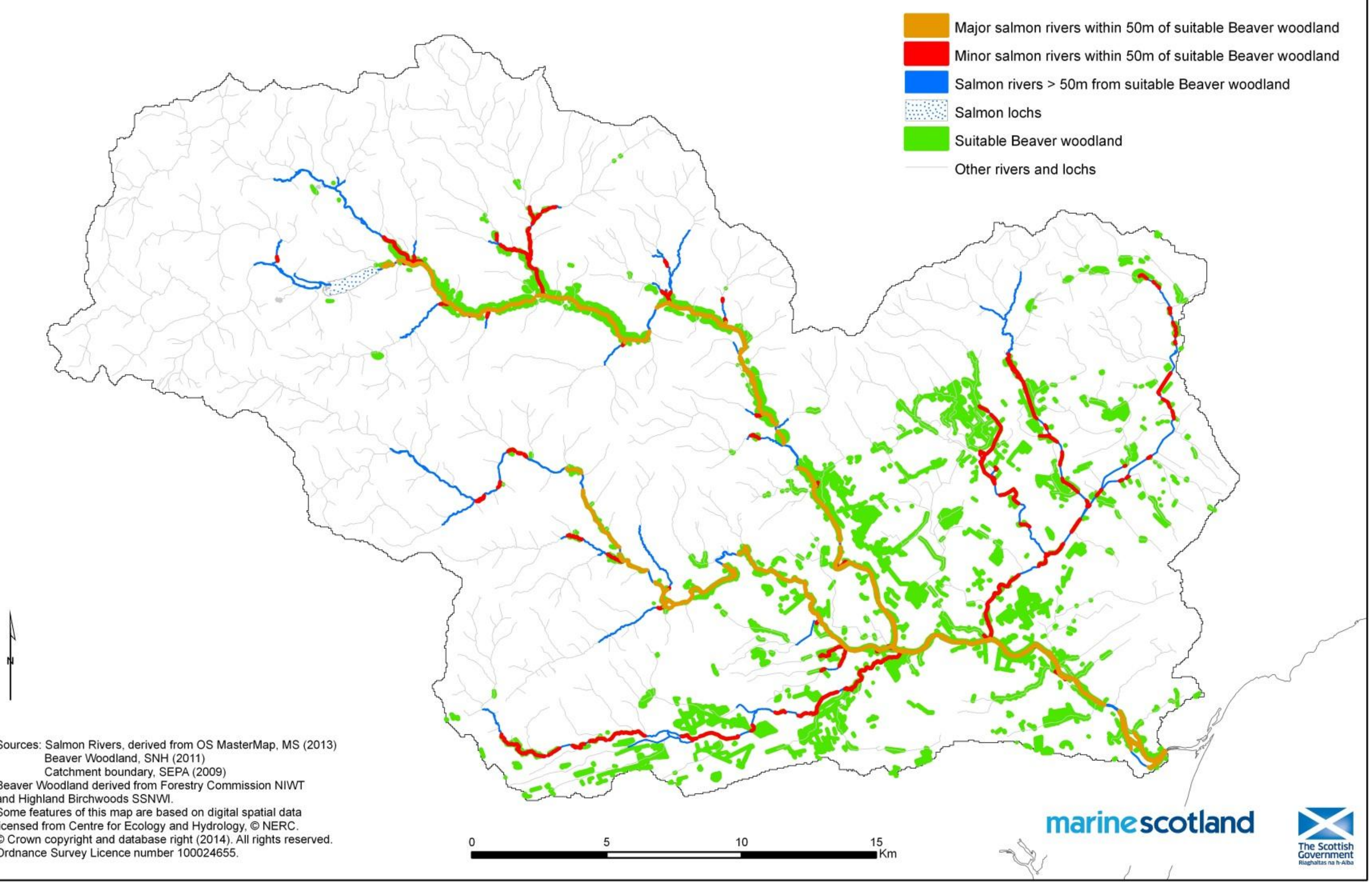
River North Esk - Salmon Rivers and Beaver Woodland



Sources: Salmon Rivers, derived from OS MasterMap, MS (2013)
Beaver Woodland, SNH (2011)
Catchment boundary, SEPA (2009)
Beaver Woodland derived from Forestry Commission NIWT and Highland Birchwoods SSNWI.
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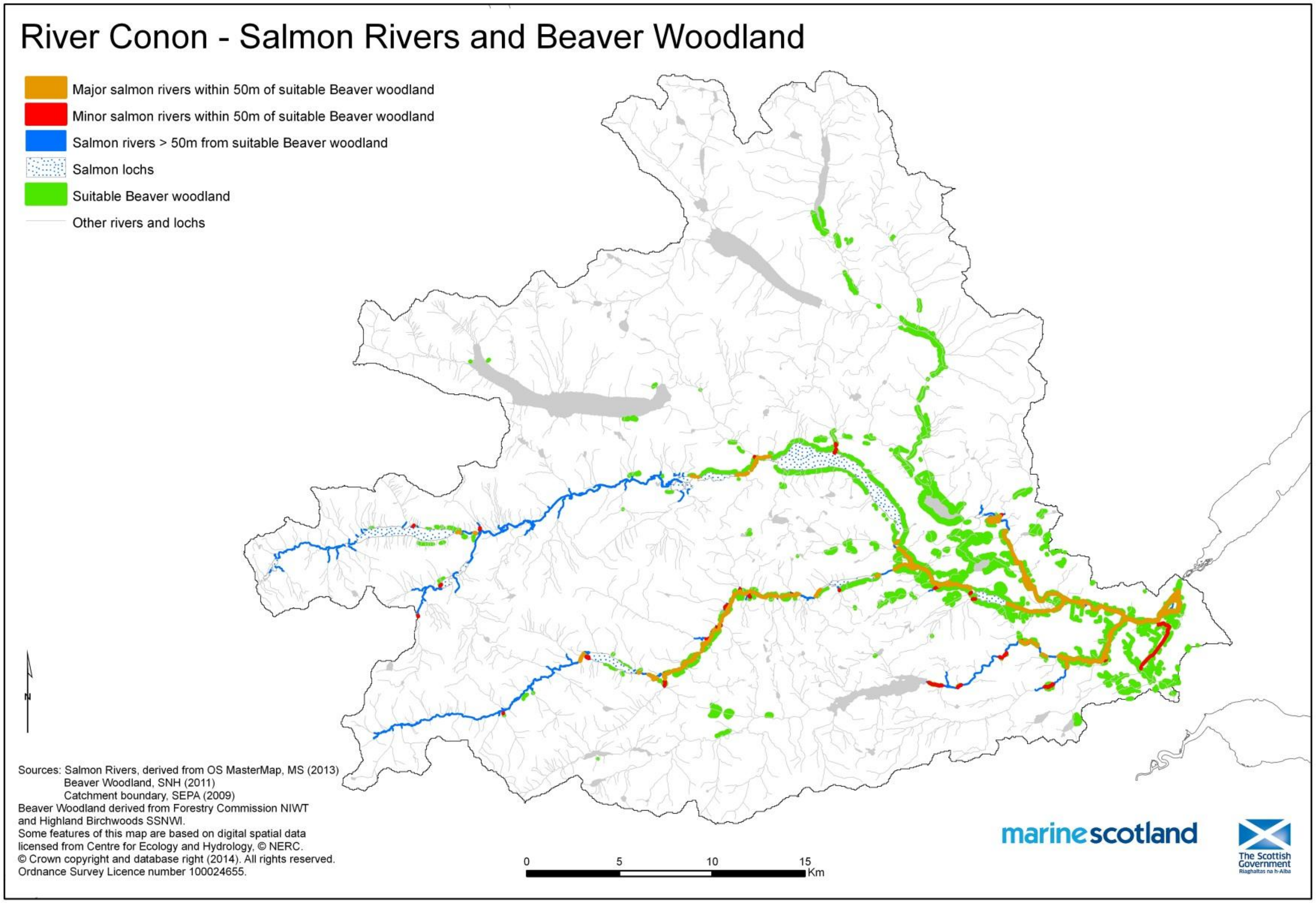
River Conon - Salmon Rivers and Beaver Woodland
Major salmon rivers within 50m of suitable Beaver woodland
Minor salmon rivers within 50m of suitable Beaver woodland
Salmon rivers > 50m from suitable Beaver woodland
Salmon lochs
Suitable Beaver woodland
Other rivers and lochs
N
Sources: Salmon Rivers, derived from OS MasterMap, MS (2013)
Beaver Woodland, SNH (2011)
Catchment boundary, SEPA (2009)
Beaver Woodland derived from Forestry Commission NIWT
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