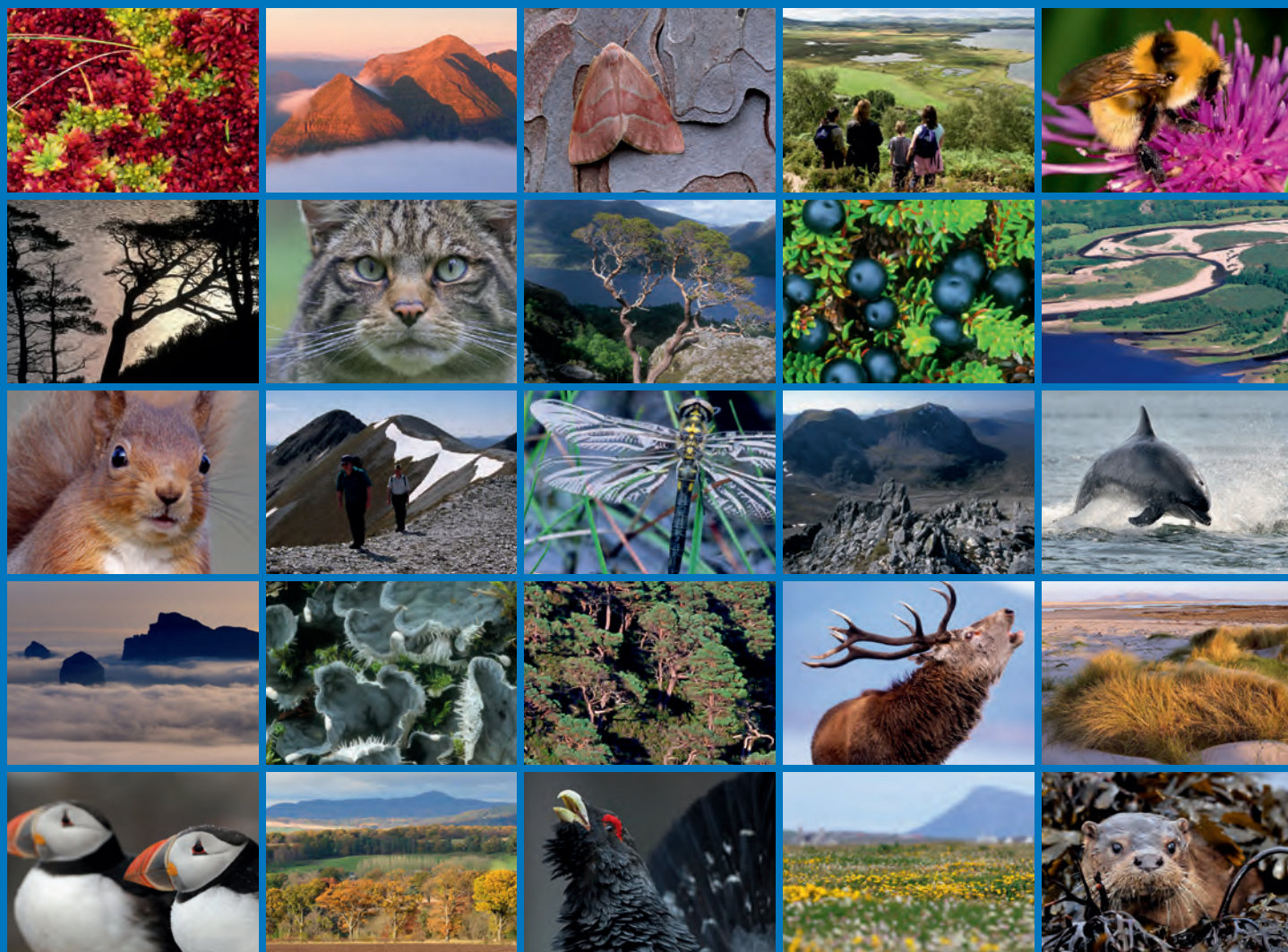


Distribution, Population Assessment and Activities of Beavers in Tayside





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COMMISSIONED REPORT

Commissioned Report No. 540

Distribution, Population Assessment and Activities of Beavers in Tayside

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COMMISSIONED REPORT

Summary

Distribution, Population Assessment and Activities of Beavers in Tayside

Commissioned Report No.: 540

Project no: 13810

Contractor: Dr R. Campbell, A. Harrington, A. Ross, and Dr L. Harrington

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Background

In response to evidence of increasing beaver (*Castor fiber*) activity in the Tay catchment, Scottish Natural Heritage (SNH) commissioned a study to examine the status of the beaver population in these rivers. In particular, the requirements of the survey were to establish the population size, distribution and impacts of the beavers. We combined surveys between 28 May and 6 July 2012, with long-term observations of beaver activity. This report outlines the methodologies and results of this survey, as well as our recommendations for future research and management.

Main findings

- We estimate that there are 38-39 groups of beavers present in the Tay catchment, equating to approximately 146 individual beavers (range 106 – 187).
- On river sections where they occur, we estimate that there are 0.14 – 0.15 beaver groups (or 0.55 – 0.56 individuals) per km of waterway.
- The mean length of waterway covered by each beaver group was 2.9 km \pm 1.5 SD.
- 99% of felled trees and saplings were willow and the mean diameter of felled stems (at the cut) was 3.5 cm \pm 3.6 SD.
- Only three beaver groups had built dams. In these groups, seven dams were currently maintained. The dam-building activities of two of these groups were leading to localised issues, necessitating frequent dam-removal by the landowners.
- There were few signs of beaver foraging on crops, with evidence only found from two beaver groups. Foraged crops that were recorded covered a total area of < 0.01 ha.
- An analysis of the relationship between the diameter of beaver cut stems and the age of the cut indicates that as beavers become established, the diameter of trees and saplings felled by beavers declines. Therefore, problems with felled trees in rivers may be reduced over time.
- We recommend trialling mitigation methods to allow people and beavers to coexist, including installing i) flow-control devices at problem beaver dams, ii) protecting large or valuable trees next to rivers where issues may arise from felling, iii) protecting lodges from being washed away to minimise beaver construction activity and iv) maintaining and establishing riparian buffers which could benefit beavers and other wildlife and reduce conflict with human land-use.
- The presence of beavers in an area used for agriculture and fishing presents an opportunity to examine interactions between beavers and human land-use. Population

monitoring and assessments of the environmental and socio-economic impacts should therefore continue.

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1. INTRODUCTION

○ 1.1 Background

The European beaver *Castor fiber* became extinct in Scotland in around the 16th century as a result of over-hunting. Over recent years the potential for restoring this species to the natural fauna has been investigated, including establishing the Scottish Beaver Trial in Argyll. Relevant documents published by Scottish Natural Heritage (SNH) can be viewed at www.snh.gov.uk/scottishbeavertrial. SNH plays the lead role in co-ordinating the independent monitoring programme for the Scottish Beaver Trial and is due to report to the Scottish Government in 2015.

Since 2006, Scottish Natural Heritage and other Agencies have been aware of beavers living free in the Tay catchment. It is thought that these beavers have either escaped from private collections or been deliberately released. In March 2012, the Minister for the Environment announced that beavers in Tayside would be tolerated until a decision on the future direction of beaver reintroduction in Scotland is made in 2015.

In order to supplement the information that will be gained from the Scottish Beaver Trial and other sources, it was appropriate to gather information from Tayside to inform the work of the newly formed Tayside Beaver Group which will provide information to inform any future decision as to the desirability of reintroducing beavers to Scotland. The Tayside situation presents a number of challenges in terms of study in that, unlike the Scottish Beaver Trial area, there is no baseline data available.

Here we report on the findings of a field survey of the Tay catchment, carried out in 2012.

○ 1.2 Objectives of the study

The aim of this study was to establish the distribution and impact of beavers on Tayside, and to assess the size of the population.

Specific objectives of the study were as follows:

- i) To field-validate previous beaver records from Tayside, including records collated from a recent, preliminary aerial survey and anecdotal reports of beaver activity from members of the public
- ii) To provide an assessment of the geographic coverage of beavers on Tayside
- iii) To provide an assessment of the population of beavers on Tayside (the number and location of current, occupied territories as a minimum)
- iv) To record signs of 'significant' beaver activities (e.g. bank burrowing, grazing on agricultural crops, damming activity etc) and provide an initial assessment of potential effects on land use and environmental factors
- v) To provide the above in geo-referenced, digital format compatible with SNH GIS

2. METHODS

○ 2.2 Field survey

▪ 2.2.1 Survey area

The initial survey data provided by SNH suggested that beaver activity is only present on the Tay; the Tummel; the Isla (and tributaries including Ericht, Dean Water, Kerbet Water, Burn of Kilry and Lunan Burn with Loch Clunie, Marlee Loch and Rae Loch); the mouth of the Almond; and the Earn (and tributaries including the Farg, Dron Burn and Pow Water). A report of beaver activity in a burn in Invergowrie on the edge of Dundee also suggested that a survey of that burn and the lower reaches of watercourses that lie between it and the mouth of the Tay was required. We carried out a full survey encompassing all the above rivers (as well as the R. Garry) up to and slightly beyond the outlying points located in the SNH survey (Figure 1). The extent to which we surveyed beyond these outlying points was dictated by habitat. Where riparian deciduous vegetation was plentiful and rivers were large enough to allow easy transit by dispersing beavers, we continued surveys upstream at least 2km from the last area where historic records or beaver signs were located. Where river conditions were not suitable, we surveyed only a short distance (<1km) past the last record. Two people (RC and AH) surveyed, over the 6 week period (28th May to the 6th of July), a total of approximately 690 km of contiguous river and loch bank with non-contiguous surveys (spot-checks) on a further 450km of bank. We combined this survey work with data already gathered by AR over several years of observation covering approximately 310 km of river and loch bank. Areas where AR found no beaver activity on recent previous surveys (within the past year) were omitted from the current survey and some areas within the Isla catchment where beaver activity was found by AR were resurveyed by RC and AH to assess the match of the data collected by the team in other areas (the value of 690km above includes these areas). Because the field survey by RC and AH was carried out in late May to early July, summer vegetation will have hidden some signs of beaver activity and therefore we may have failed to locate all beaver signs during the survey. Our aim was, thus, to provide a detailed overview of beaver activity in the study area, rather than to report on every sign of beaver activity in the area.

▪ 2.2.2. Survey methods

2.2.2.1 Field surveys

Rapid surveys conducted by RC and AH

Rivers were surveyed from open canoe or on foot, depending on channel navigability (total bank length surveyed on foot = 360km and by canoe = 330km). Surveys from canoe are more likely to detect waterside activity and less likely to detect activity inland while the opposite is true for foot based surveying. All signs of beaver activity observed were logged on a GPS (Garmin eTrex). All signs subsequently identified within 10m of riverbank from the first identified sign were logged under the same GPS waypoint, thus GPS waypoint data has a linear resolution of 10m. If signs were located over an

area >10m in riverbank length, a new GPS waypoint was logged every 10m until no more signs were identified. A subset of field signs recorded was photographed and the following details recorded:

1. Activity type*
2. OS grid square
3. Waypoint Nr. (from the original GPS file)
4. Photo Nr.
5. Estimated age (categorised as Fresh or Old, see Annex 2)
6. Distance from water (m)
7. Area affected (in m along the river bank up to a maximum of 10m, except in the case of agricultural feeding which was recorded as the area of crop affected in m²)
8. River width and approximate depth (m)
9. Land use (on the river bank and in the surrounding area)
10. Other notes and observations

* Activity types were designated as locational foraging signs (evidence of beaver foraging in-situ such as agricultural feeding, cutting (of woody vegetation including trees), herbaceous feed), other non-locational feeding signs (where food items are obtained and then consumed elsewhere, such as food caches, feeding station and refuse from aquatic feeding, or indirect evidence of foraging such as foraging trails), beaver (sighting), burrow, lodge, dam, scent mound, scent site (> 1 scent mound at a single site), tracks and other. Crop type was recorded for all agricultural feeding signs. The length (bank to bank in m) and height (on downstream side in m) of dams was measured and recorded.

GPS files were recorded in ETRS89 and converted into OS Grid coordinates using the National GPS Network online coordinate transformer provided by the Ordnance Survey (http://www.ordnancesurvey.co.uk/oswebsite/gps/osnetfreeservices/about/overview_osnet.html). Data were input into an ArcGIS geodatabase, and provided with this report (see Annex 1).

Long-term monitoring conducted by AR

AR has undertaken monitoring of beaver activity in the Tay catchment for a number of years, with effort concentrated on beavers in the River Isla and its tributaries. Monitoring involved locating lodges and, through observations at these lodges, assessing presence of beavers and their breeding success. In addition, signs of fresh foraging over sections of river, locations where scent-marking was frequent and other evidence of current beaver activity such as tracks were recorded. This allowed, over time, the presence of, and area used by, beaver groups to be assessed.

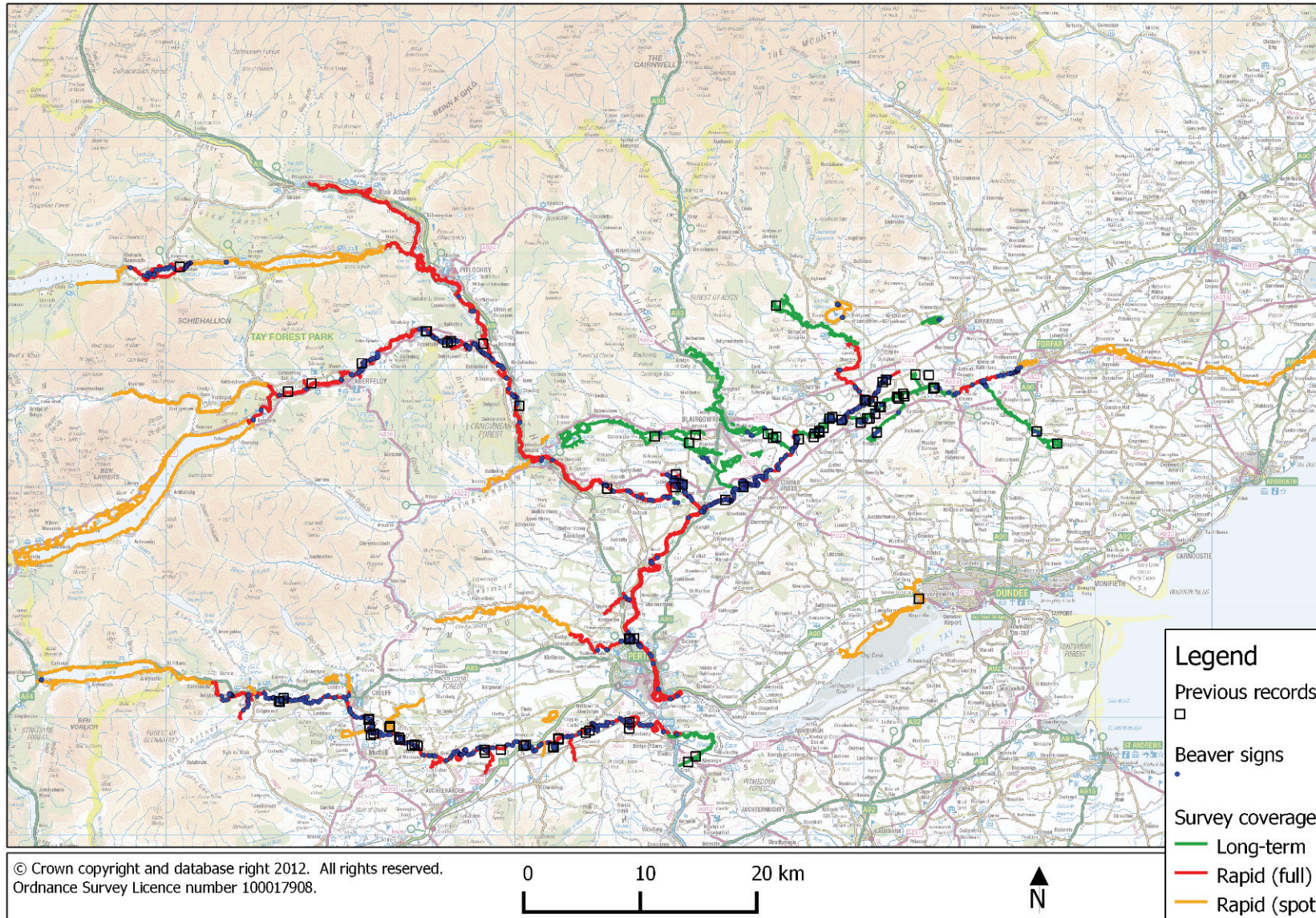


Figure 2. Areas covered during AR's long-term monitoring (Long-term) and RC and AH's full survey (Rapid, full) and spot-check survey (Rapid, spot). Note that most of the waterways in the Isla catchment have been covered by AR's long-term monitoring. Also shown are locations of prior records held by SNH from an aerial survey and reports from the public, and the locations of beaver activity signs found during this survey.

2.2.2.2 Camera trapping

Camera traps (Bushnell Trophy-Cam) were set on two separate occasions at groups Tay 2 and Tay 3 for 1-3 nights (see Annexes 3-4) to confirm activity. On the first occasion, carrots were used as bait; on the second, samples collected from beaver scent mounds in territories downstream were used.

2.2.2.3 Visual observations

Visual observations of beaver lodges were conducted at the Almond group (2 nights) and at the two lodges (simultaneously) in Dean Water 2-3 (1 night), with the aim of further assessing the size and composition of beaver groups (see 2.3 below) (and specifically, for the Dean Water groups, to assess whether this was one or two groups, see Annex 3). Observations were from the bank opposite the lodges and began at approximately 7pm, continuing for at least 2 hours.

○ 2.3 Population estimate

We estimated the number of beavers present based on the number of family groups inferred, assuming that there are a mean of 3.8 ± 1.0 SD individuals per group (Rosell et al. 1998). Evidence of single animals was ignored for the purpose of the population estimate since these may be beavers temporarily living away from their natal group. The most appropriate method for estimating the number of family groups depends on the density of the beaver population, and is not necessarily related to the number of active lodges or burrows (for example, unpublished work by Frank Rosell and RC on a beaver population in Norway indicates that established beaver groups frequently make use of more than one lodge or burrow at any one time). In a low density, expanding population, Hartman et al. (1995) found that beaver groups were initially far apart and it was only later that gaps between groups was in-filled by new recruits. In a high density, established population, once beaver groups occur in close proximity to each other, territorial behaviour emerges and, in some circumstances, clearly defined borders are visible between territories where individuals repeatedly scent-mark (Campbell et al. 2005). We, therefore, used information on the aggregation of scent mounds and the distribution of other recent beaver activity signs to delineate family groups. Where no scent mound aggregates were found, we used clusters of beaver activity signs (covering a suitably large area, e.g. 2 ± 1 km of river length, see Campbell et al. 2005) to delineate individual groups, assuming that gaps between aggregated beaver signs indicated gaps between groups. A similar method has been used by Fustec et al. (2001) to delineate beaver group home-ranges in the Loire River. Where scent mound aggregates were visible, these were considered to indicate a border between two beaver groups, even where there was no gap in the distribution of other beaver signs. Care should be taken however to not confuse a gap in suitable foraging habitat (which may result in a gap in activity signs) with a gap between groups (Campbell et al. 2005), and, therefore, gaps in the distribution of signs were cross-referenced with habitat type (particularly an absence of woody vegetation) based on notes from the field survey and

aerial photographs in Google Maps. Data from camera-traps and lodge observations were also used to refine the delineation of groups.

○ **2.4 Impacts of beaver activities**

During the survey, notes were taken on any likely impacts, and we conducted informal chats with stakeholders (in particular, farmers, fishermen and gillies) to assess their reactions to the presence of beavers and their opinions on the impacts of beaver activity.

In addition, a more detailed assessment of beaver felling activity was conducted to examine changes in felling activity over time. We randomly selected 27 points across the survey area where we had previously recorded beaver felling. These were split in approximately equally into points where we recorded an area covered of <1m (N=7), 1-9m (N=8) and 10m (N=11). We revisited each point with the aid of a GPS and counted the number of stems in a 10m × 10m quadrat, within beaver cutting height (approximately 40cm from ground-level). We then recorded the size (to the nearest 0.5cm) at cut for each stem that had been felled together with the age of the cut. Cut age was graded on a scale of 1 – 10, where 1 was very fresh and 10 very old (Annex 2). The genus of cut trees was also noted.

Statistical analysis was conducted within the R programming environment (R v. 2.14.0, R Development Core Team 2011). We used the package lme4 (v. 0.999375-42, Bates and Maechler 2011) in R to construct Generalized Linear Mixed Models (GLMMs) describing the effect of stem diameter on the age class of each cut stem. A Poisson model was used with a log link function. A random intercept was specified for quadrat within river catchment (Tay, Isla or Earn). Stem diameter was log transformed. We constructed two alternative models, one with and one without stem diameter. The two models were compared using AICc (AIC adjusted for small sample sizes), where a lower AICc indicates a better model.

3. RESULTS

○ **3.1 Existing records**

The data already held by SNH from public sightings and an aerial survey (Figure 1) consisted of 91 point locations of beaver activity. Of these, the rapid survey and long-term monitoring did not detect beaver activity nearby 19 locations. Of these, ten were within the areas occupied currently or previously by beaver groups. Five of the remaining SNH data points were however >2km (straight line distance) from any other evidence of beaver activity. Of the river sections highlighted as occupied by beavers based on the new survey, only the upper reaches of the Earn catchment (group Earn 1 and a few signs near Lochearnhead from a transient animal) were outwith areas highlighted as beaver occupied from the SNH data.

- **3.2 Survey results**

- **3.2.1 Field signs**

During the rapid survey, we recorded a total of 1,522 field signs; six beaver sightings were also recorded. The vast majority (74%) of field signs recorded were cuttings, all other field sign types constituted < 10% of the total (Figure 3). A total of 72 burrows, 10 lodges and 7 dams were recorded. 98.5% of locational foraging signs were cuttings; few herbaceous (n=8) feeding signs were found (but these are less visible than cuttings), and few instances (n=9) of agricultural feeding were detected. Approximate age was estimated for 1,344 of the recorded field signs: 459 (34%) were Fresh, 588 (44%) were Old, 297 (22%) consisted of a mixture of Fresh and Old signs. For cuttings, 350 (31%) were Fresh, 532 (47%) Old, and 243 (22%) a mixture of Fresh and Old (n=1125 foraging signs for which age was estimated) (see also Annex 2); all agricultural feeding signs recorded were Fresh. Most (98%) field signs recorded were found within 10 m of the water's edge, and 58% on the riverbank (0 m from the water's edge); mean distance from the water's edge was 1.6 ± 3.7 m (n=1287 field signs for which distance from the water's edge was recorded).

In addition to data on the presence of beavers and an assessment of their territories, the long-term monitoring also included locations on 25 lodges, four burrows, two dams, nine scent mounds, 11 scent-sites and four locations of cutting.

In river sections on the Isla, Dean Water and Baikie Burn where both long-term monitoring and the rapid survey were conducted (groups Isla 2 – 5 inclusive, Dean Water 1 and Baikie Burn), data from the two methods were generally corroborative. Due to constraints in the rapid survey discussed below, the rapid survey failed to detect three lodges in group Isla 3. The greater detail of the rapid survey did however yield insight into recent activity that improved the delineation of groups covered by the long-term monitoring. For example, while the long-term monitoring had showed previous activity around where groups Isla 5 and Baikie Burn were situated, the rapid survey showed the two groups as currently active and allowed their extent to be defined. Similarly, the current extent of groups Isla 2, Isla 4 and the downstream extent of Isla 3 were not known prior to the rapid survey. Conversely, the division between groups Isla 2b and Isla 3 would not have been found without knowledge gained from the long-term monitoring. Overall, no areas previously unoccupied by beavers were discovered during the rapid survey while the rapid survey successfully detected all beaver groups that were known from the long-term monitoring.

The R. Earn, R. Isla and Dean Water displayed the greatest density of beaver signs (and beaver groups), whereas the R. Tay had the lowest density. With the exception of Dunalistair Water (where a beaver group resides and three beaver-cut saplings within approximately 6km of the confluence with the R. Tay), no beaver groups were detected on the R. Tummel. No beaver signs were detected in the R. Garry either. We estimate that beaver groups occupy

a total linear length of 112 km of river and associated tributaries in the Tay catchment.

River and land use data were not analysed further in this report but are included in the geodatabase, and are available for further analysis if appropriate.

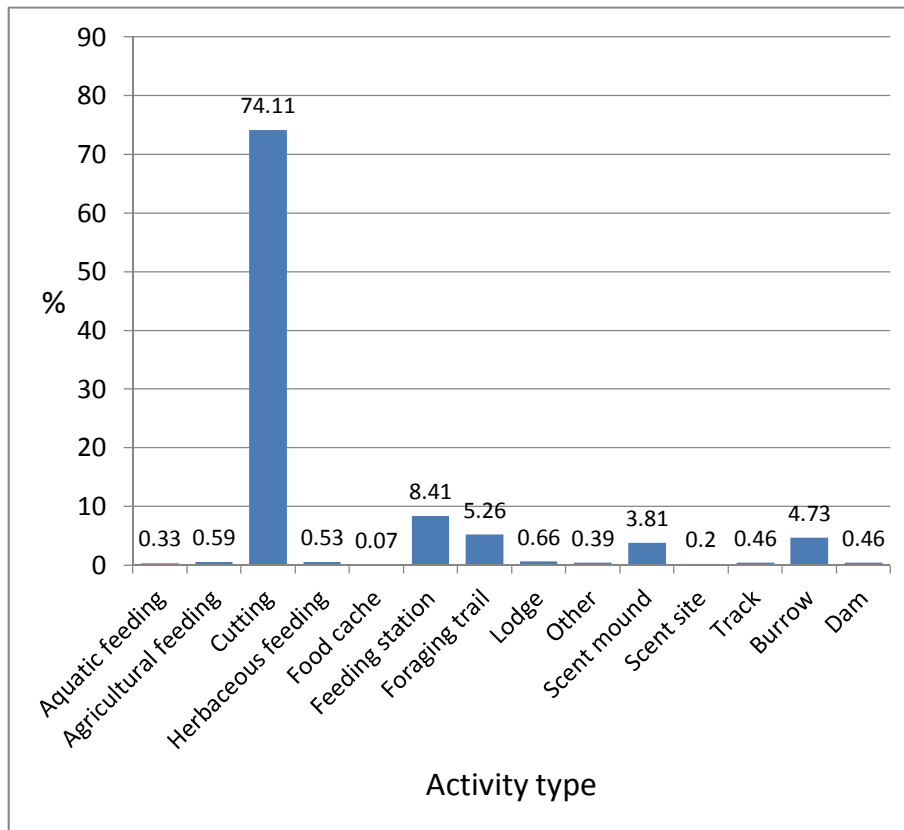


Figure 4. Types of beaver field sign recorded in the Tay catchment, 2012.

3.2.2 Camera trapping

No beaver activity was recorded in either of the two camera trap sessions. None of the cameras were placed at lodges and instead were located at concentrations of beaver activity, such as feeding stations, or were near routes between lodges and foraging areas. Total camera time was 10 camera nights. We conclude that using cameras in this way is not a reliable method for rapid population assessments of beavers since we observed a beaver at one of the locations we placed a camera. Placing the cameras closer to the lodges and setting them over a longer period would increase the likelihood of capturing a beaver.

▪ 3.2.3 *Visual observations*

Simultaneous observations at the lodges at Dean Water 2 (DW2) and Dean Water 3 (DW3) proved inconclusive as to whether these were separate groups or not. Two adults at DW2 were observed, of which one swam upstream towards DW3. Within 10 minutes an adult was observed at DW3 and so could have been the same individual. A juvenile was also noted at DW3, indicating successful reproduction in 2010 or 2011.

Observations at the Almond group during June yielded a sighting of an adult female showing enlarged nipples, indicating she was lactating. Also observed was a yearling. Two beaver kits were seen later the same month by a member of the public.

More observations have been conducted by AR on groups in the Isla catchment (see Annex 3) and show evidence that Isla 2 bred successfully in 2010, Isla 2, Isla 3, Ericht all bred successfully in both 2011 and 2012 and Dean Water 1 bred successfully in 2012. In this latter group, kits were observed on June 24th (Annex 3).

○ **3.3 Population estimate**

Based on clusters of signs and locations of scent mounds, we estimate that there are 38 – 39 beaver groups present in the Tay catchment (Table 1, Fig 3, Annex 3-4). Based on an average of 3.8 ± 1.0 individuals per group, this equates to approximately 146 beavers in total (range 106-187). There were, in addition, 11 locations where there was evidence of single individuals resident at some time this year, although we cannot tell if these individuals have since moved on or are still resident.

The mean density of beaver groups over all rivers was 0.14 – 0.15 groups per km of waterway and the mean territory size of the groups was 2.9km (± 1.5 SD) of linear waterway (Table 1). The River Earn and rivers in the Isla catchment (particularly Dean Water) exhibited the greatest density of beaver groups while the Rivers Tummel and Tay had the lowest density. Group territories on tributaries of the River Isla, excluding the Ericht, were the smallest (mean 1.5 – 1.6km linear length) while group territories on the Rivers Isla, Earn and Tay were all of a similar larger size (mean 3.4 – 3.8km linear length). Note however that survey methods in many stretches of the Isla catchment differed to that employed in the other rivers, which could influence group range delineation and therefore territory size and density estimates. Specifically, the long-term monitoring employed in the Isla catchment would more likely detect separate groups in the absence of gaps in activity signs or aggregates of beaver scent mounds. Density could therefore be underestimated on rivers outside the Isla catchment. On the R. Tay, near the village of Caputh, we also found one territory that appears to have been abandoned since there were very few signs of fresh activity present.

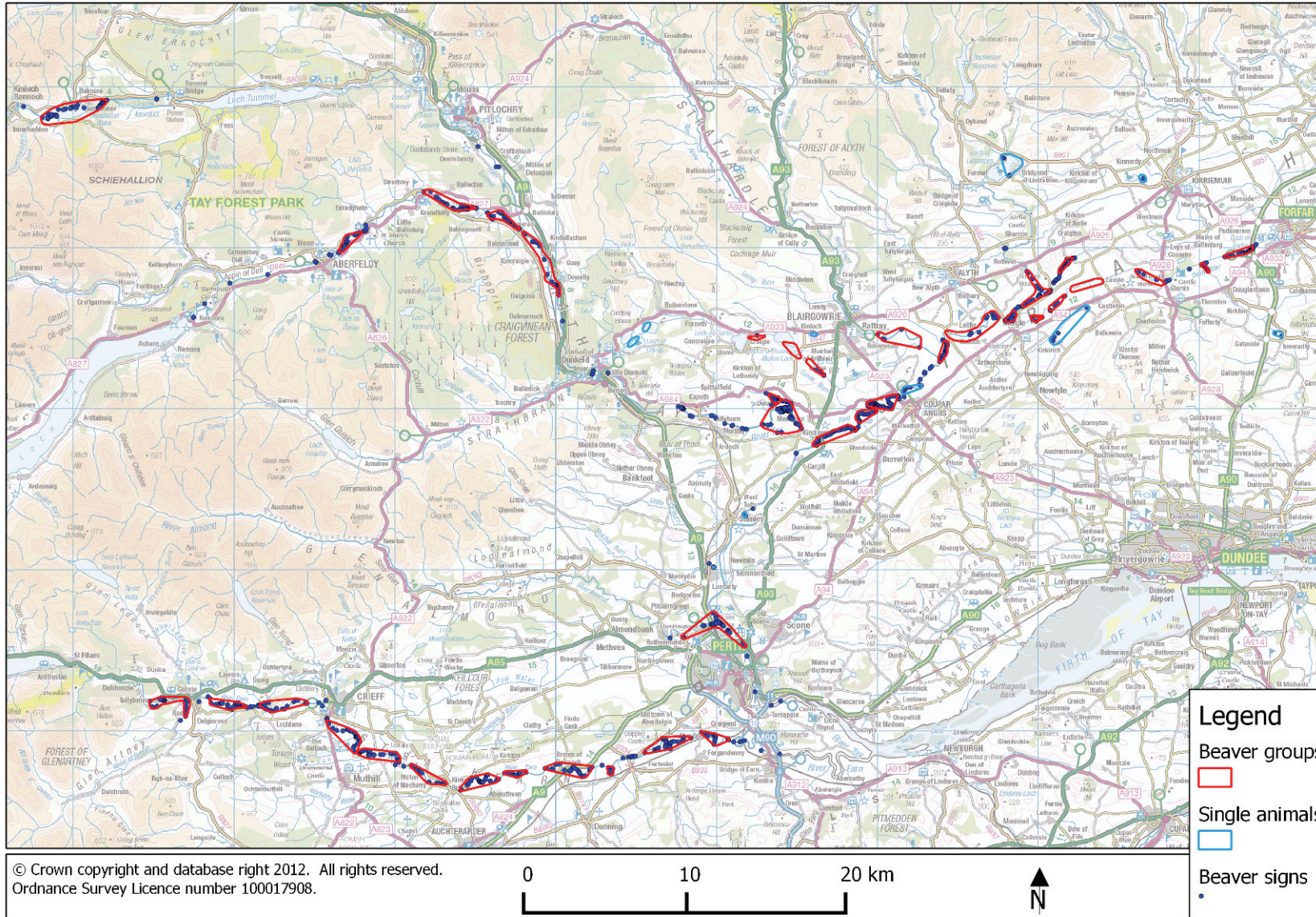


Figure 3. The distribution of beaver groups and locations of single animals based on beaver activity signs.

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- **3.4 Impacts of beaver activity**

- *3.4.1 Dams*

Over the entire survey we recorded seven intact or recently cleared dams, built by three groups (Tay 2 group, Dowie's Hole and Baikie Burn). There was no evidence of dam building activity by the other groups. We were able to measure five of the seven dams: height ranged between < 0.1 and 75 cm (mean = 25.9 cm) and length 1 – 6 m (mean = 3.0 m). The low heights of three of the dams are likely due to dam clearing by landowners. All cleared dams have previously gone through iteration of clearance by landowners followed by rebuilding by the beavers.

One of the dams at Tay 2 had been causing flooding in surrounding pasture, though when we viewed it there was no flooding due to low recent rainfall and dam clearing by the farmer. Two dams at Baikie Burn had been causing flooding issues, particularly the flooding of the yard of a sawmill upstream. Again, due to low rainfall and dam clearance by the landowner, there were no present issues with flooding when we surveyed the area. There were also complaints from the landowners of the Baikie Burn group that damming had led to wind-blow in a stand of poplar trees due to waterlogged soil. It is difficult to conclude whether such an incident would have happened in the absence of waterlogging from dam building. The area affected was not large, with partial wind-blow over an area of 0.67 ha.

The dams within Dowie's Hole had increased the area of an already existing wetland but had not been causing issues with flooding on surrounding farmland.

- *3.4.2 Agricultural feeding*

Over the total survey area, nine incidences of agricultural feeding were detected, three on cereal and six on oilseed rape. The three incidences of feeding on cereal occurred in the Dean Water 8 group, the total area affected was 1.5 m². All six incidences of foraging on oilseed rape occurred over two fields in the Baikie Burn group, the total area affected was 90.3 m². There was also suspected feeding on cereal in the Earn 5 group. Investigations found, however, that the cause was not beaver and the farmer indicated to us that the extent of damage was of no financial consequence. The mean distance from water of beaver foraging on crops was 14 m ± 9 SD (range 6 – 20m) and the mean area affected was 10 m² ± 16 SD. These nine incidences were detected because of evidence of a foraging trail moving into arable land and, in some cases, because of the additional remains of foraged crops left at waterside feeding stations. Other incidences of agricultural feeding may have been missed, particularly on the sections surveyed by canoe due to the lower vantage-point.

- *3.4.3 Other impacts*

In the area occupied by the Dean Water 8 group, there had been gnawing at the base of three large poplar trees growing within a few meters of the A90 (although there were no recent signs of gnawing at the same three trees). Fresh gnawing has since been observed on a neighbouring poplar. In all four trees, the current extent of gnawing is unlikely to cause felling and since the trees have not been ring-barked they should survive. Further gnawing could however create a potential issue if the trees fall over onto the carriageway.

- *3.4.4 Assessment of felling activity*

Willow was the most commonly felled stem, but also the most commonly available (Table 2). The size of the area affected by beaver foraging as recorded during the initial survey (see 2.2.2.1.) was correlated positively but not significantly with either number of cut stems (Pearson's correlation: $r = 0.281$, lower 95% CI = -0.119, upper 95% CI = 0.603) or the proportion of stems cut ($r = 0.323$, lower 95% CI = -0.074, upper 95% CI = 0.631).

The model that included log stem diameter better explained the age of cut stems (AICc = 260.1) than the model without log stem diameter (AICc = 283.5) and since the difference between the AICc of these two models was >4 , only the model that included log stem diameter was used to calculate parameter estimates. Log stem diameter had a positive (and significant) influence on age (estimate = 0.346, lower 95% CI = 0.213, upper 95% CI = 0.480, Figure 4), indicating that smaller trees are more frequently felled than larger trees recently and larger trees more frequently felled in the past. This suggests that as beavers establish at a site they fell fewer larger trees. Note that the majority of stems felled here were willow and a similar pattern may not be evident in other tree species.

- *3.4.5 Stakeholder opinions on the beavers*

We discussed the impacts of beavers with four farmers, four fishermen and two gillies (Annex 5). Note that the sample size is small and the opinions expressed may therefore not be a representative sample of opinions. Only one of these farmers was experiencing direct impacts from beavers, through their damming. Damming aside, none of the farmers expressed issues with the presence of beavers on rivers within or abutting their land. None of the fishermen interviewed had a problem with the presence of beavers, and the general opinion of fishermen was that the presence of beavers (and other wildlife, particularly otter) enriches their fishing experience. Both gillies we interviewed expressed similar opinions on the felling of larger trees by beavers, explaining that fish caught on the line of paying customers may swim under submerged felled trees, entangling the line and resulting in the loss of the fish and a broken line. None of the fishermen expressed this view. Both gillies were against the presence of beavers. One of the gillies, however, had no beavers on his beat and so had no direct experience of beavers.

Table 1 – Density (number of beaver groups per km linear length of waterway) in each river plus bank length (length of river and loch side) and linear length (as density above) of each group territory.

River	Extent	Linear length	N. groups	Density (groups / km)	Group	Bank length (km)	Linear length (km)
Tay	Outflow of Loch Tay – Perth (inc. Dowie's Hole)	84.3	7	0.08	Tay 1	8.6	2.1
					Tay 2	12.1	3.7
					Tay 3	7.0	2.8
					Tay 4	16.0	5.3
					Tay 5	15.6	5.5
					Dowie's Hole	4.0	1.6
					Almond	15.6	5.8
<i>River mean</i>						<i>11.3</i>	<i>3.8</i>
Earn	Outflow of Loch Earn – Bridge of Earn	64.3	12	0.19	Earn 1	15.1	5.1
					Earn 2	8.8	3.1
					Earn 3	9.4	4.1
					Earn 4	9.8	3.7
					Earn 5	8.6	3.4
					Earn 6	6.2	2.8
					Earn 7	7.9	3.7
					Earn 8	12.3	1.7
					Earn 9	10.0	4.2
					Earn 10	3.0	0.9
					Earn 11	12.8	4.7
					Earn 12	7.3	3.0
<i>River mean</i>						<i>9.3</i>	<i>3.4</i>
Tummel	Ouflow of Loch Rannoch – R. Tay	41.5	1	0.02	Dunalastair	22.4	4.8
Isla	Ruthven – R. Tay	28.4	6	0.21	Isla 1	13.4	5.6
					Isla 2	3.7	1.7
					Isla 2b	7.2	3.5
					Isla 3	4.0	2.0
					Isla 4	7.7	3.4
<i>River mean</i>						<i>7.6</i>	<i>3.4</i>
Dean Water	Ouflow of Loch of Forfar – R. Isla	20.6	7 - 8	0.34 - 0.39	Dean Water 1	4.2	2.0
					Dean Water 2	2.1	0.7
					Dean Water 2-3	2.9	1.0
					Dean Water 3	0.4	0.2
					Dean Water 4	3.6	1.7
					Dean Water 5	6.0	2.6
					Dean Water 6	6.3	2.7
					Dean Water 7	2.1	1.0
Dean Water 8	4.4	2.0					
<i>River mean</i>						<i>3.6</i>	<i>1.5</i>
Baikie Burn	33309, 74980 – R. Isla	4.7	1	0.21	Baikie Burn	2.9	1.5
Ericht	Blairgowrie – R. Isla	8	1	0.13	Ericht	10.2	4.2
Lunan burn	Outflow of Loch of Clunie – R. Isla	11.4	3	0.26	Lunan burn 1	2.9	1.3
					Lunan burn 2	3.8	1.6
					Lunan burn 3	6.4	2.0
<i>River mean</i>						<i>4.4</i>	<i>1.6</i>
<i>Isla catchment total or mean</i>		<i>73.1</i>	<i>18 - 19</i>	<i>0.25 - 0.26</i>		<i>5.2</i>	<i>2.2</i>
<i>Overall total or mean</i>		<i>263.2</i>	<i>38 - 39</i>	<i>0.14 - 0.15</i>		<i>7.9</i>	<i>2.9</i>

Table 2 – Summary of stems present and cut by beavers in the 27 quadrats along with the diameter (cm) at cut of beaver-cut stems. Summaries are provided for all species combined and separately for the three most common genera. Number of quadrats in which genera were found is given in parentheses after the total number of stems. Numbers in parentheses after the number of stems cut are percentage cut of total available. The mean and SD for cut stems are based only one quadrats where each genus was found. Numbers in parentheses for mean and SD of cut stems are the means of the percentage cut from available within each quadrat.

	N	Mean	SD
<u>Total stems</u>			
All	3737 (27)	138	122
<i>Salix</i>	3575 (27)	96	122
<i>Alnus</i>	94 (6)	3	10
<i>Betula</i>	9 (1)	0.2	1.7
<u>Stems cut</u>			
All	383 (10%)	14 (14.0%)	17 (16.6%)
<i>Salix</i>	380 (11%)	14 (14.5%)	16.5 (15.9%)
<i>Alnus</i>	2 (2%)	0.33 (25%)	0.52 (42%)
<i>Betula</i>	1 (11%)	1 (11%)	
<u>Diameter of cut stems</u>			
All	378	3.5 cm	3.6
<i>Salix</i>	375	3.5 cm	3.6
<i>Alnus</i>	2	1.5 cm	0
<i>Betula</i>	1	5 cm	

4. DISCUSSION

○ 4.1 Limitations of the current survey

Because the survey was conducted in summer, vegetation growth covered many beaver signs. Beaver lodges were also difficult to locate, and scent-marking may not be at its maximum at this time of year. In this context, surveying in early spring would be optimal since signs would be more visible, food caches outside lodges (when built) would still be visible, and scent-marking would be more frequent. However, river conditions in early spring can be dangerous due to snow melt and the higher water-levels will cover more burrow and lodge entrances.

Surveying from canoe and surveying by foot both provided separate advantages. From canoe, beaver activity further away from the water may be missed, but other signs such as burrow entrances, scent mounds and cutting on trees overhanging the water are more easily seen. Furthermore, using the canoe enabled a much more rapid survey. By foot, on-bank activity such as foraging on herbaceous vegetation or agricultural crops was more apparent,

as were some lodges, but the pace of the survey was much slower. Since most beaver activity is concentrated on the water's edge, using a canoe is

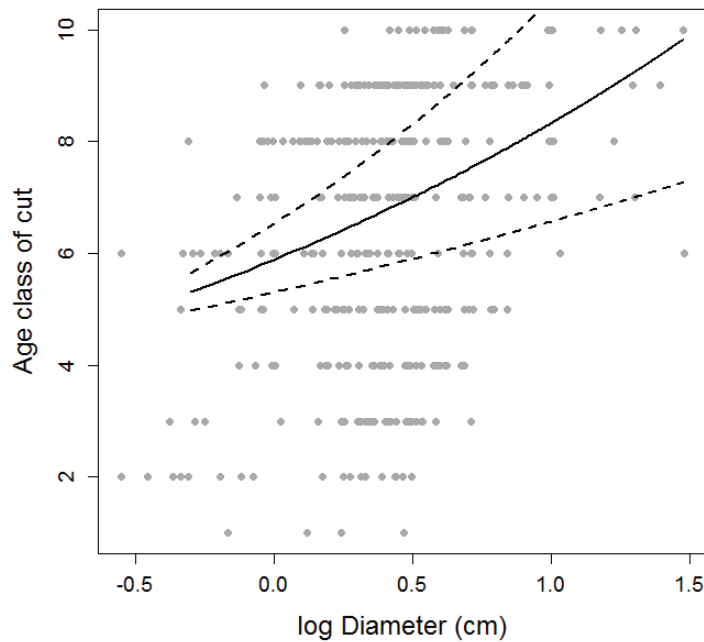


Figure 4. Log diameter of cut stem against the age of the cut (a scale of 1 – 10 where 1 is newest and 10 oldest). Data points are jittered along x-axis. The fit line (solid line) and 95% confidence intervals (dashed lines) were obtained as predictions from the GLMM where stem was blocked within quadrat within river.

overall more effective than walking, but surveyors need to be aware of its limitations. Using a raft in place of an open canoe may be preferable in some situations.

The lack of a significant correlation between our gross assessment of area covered by beaver activity (collected during the initial survey) and the number and proportion of stems actually cut by beavers (collected during the detailed assessment of beaver felling activity) indicates that the rapid survey technique we employed could be improved in this area. The lack of a correlation probably arises because two or three stems felled over a 10 m length of riverbank are recorded as covering the same area as 20-30 stems over 10 m. Errors may also have occurred in relocating the exact location of each 10m block by GPS, resulting in a poor match between points from the initial survey and those from the vegetation plots.. In future, it would be more suitable to record a gross assessment of felling activity within the 10m sections (e.g., <5% cut, 5-25% cut, 25-50% cut and >50% cut) instead of noting only the length of riverbank affected.

○ 4.2 Comparison with the previous records

There was general agreement on the presence of beavers when comparing previous records gained from an aerial survey and public sightings (see Figure 1 and section 3.1) with the ground based survey, although prior

records were less detailed, missed smaller signs of beaver activity, and could not be used to delineate beaver groups in the way achieved here. Prior records occasionally directed us to locations where we could not find beaver activity signs and the aerial survey in particular may have confused wind-blown trees for beaver-felled trees on some of these occasions. If all the beavers in the area continue to build winter food caches, a winter aerial survey would, however, enable an estimation of the number of active groups since each group will usually only build one food cache at the lodge or burrow in which they choose to over-winter (Wilsson 1971; Muller-Schwarze & Sun 2003). When faced with consistently milder winter conditions, beavers elsewhere have been found to cease cache building (Hartman & Axelsson 2004) and therefore the suitability of this method would need to be continually reassessed.

○ **4.3 Population status and development**

While the precise source(s) and time-line of beaver releases or escapes is unknown to us, evidence suggests that animals were living wild in the Tay catchment from as early as 2001. In particular, a canoeist observed a beaver on the Earn in 2001 while AR recorded beaver activity signs on the Lunan and Isla in 2003. It is possible that only a handful of animals founded the population, though these may have been supplemented by later escapes and releases (e.g. to Dunalastair water). The current estimate of around 146 individuals, increasing from very few nine years ago, compares very favourably with a reintroduction of beavers (sourced from the Elbe) to the Biesbosch reserve in the Netherlands. Between 1988 and 1991, 42 animals were released at the Biesbosch reserve; by 2004, the population was estimated at 115 animals in 28 groups (Nolet et al. 2006). It has been suggested that the Biesbosch population suffers unusually low reproductive success, perhaps due to a mismatch in their breeding phenology (Nolet et al. 2005). Indeed, the development of the population may be more similar to experiences in the Gemenc National Park in Hungary (a four-fold increase over five years from eight founders) and in Estonia (an eight-fold increase over 10 years from 50 animals) (Halley & Rosell 2002). As long as human-caused mortality is maintained at a low level in the Tay catchment, we would expect that the population will continue to grow without human assistance.

Many of the beaver group territories were longer than the mean reported elsewhere (cf. 2 ± 1 km, Campbell et al. 2005) though the overall average (2.9km) falls within this range. Note however that there is an element of circularity here since we used the 2 ± 1 km to help decide the territory extent of some groups. We may nevertheless have been unable distinguished between some groups living very close together, leading to higher territory size values and presumably an underestimate in the population size. Larger territory size are however expected in recently establishing low density populations (Campbell et al. 2005) and therefore the territory sizes here may be representative of populations at this stage in their development.

From observations by us and reports from others it appears that young beavers ('kits') in the Tay catchment often emerge from the natal lodge around mid-late June. This is earlier than in other northern populations where

kits are usually born in mid-May and emerge at two months of age in mid-July (Wilsson 1971; Parker & Rosell 2001; Nolet et al. 2005). This early breeding may arise from the relatively mild-winters in lowland Scotland, though beaver kits at Knapdale, where winters will be warmer than in the Tay catchment, usually also emerge around mid-July. We do not know if the source population (most likely in Bavaria) also exhibits a similar early breeding phenology or the influence this will have on breeding success and population growth. If lethal control is ever applied to beaver in the Tay, attention should be paid to this early parturition date, since culling of mothers immediately post parturition would be considered cruel (Parker & Rosell 2001).

- **4.4 Land-use impacts and mitigation**

- *4.4.1 Terrestrial land-use*

Currently, only two of the 38 – 39 beaver groups were coming into conflict with human terrestrial land-use, with a third group showing some very minor foraging on cereal crops next to the river. In both these groups, the main issues arose from the dam-building activities of the beavers and associated flooding. Both landowners responded by repeated removal of the dams, but these were continuously rebuilt by the beavers, causing frustration for the landowner. Installation of a flow-control device (also known as a ‘beaver-deceiver’, Lisle 2003) may solve the issue without requiring lethal control of the animals (which may, in any case, simply result in new individuals moving in). The employment of an advisor to provide consultancy on managing and mitigating land-use conflicts with beavers may be useful in the future. One other group had built dams, but this had not led to land-use conflict because the area surrounding the site was not in use.

We noted a section of several hundred meters of riverbank within the range of Dean Water 4 where willow trees had been uprooted by heavy machinery, possibly in an attempt to dissuade beavers from settling in the area. This type of habitat manipulation is likely to have severe impacts on wildlife and on the integrity of the riverbank. Land-owners need to be dissuaded from undertaking such actions, and provided with advice and guidelines on better and less destructive methods of land-management in the presence of beavers (see below for examples).

- *4.4.2 Fishing*

The concern from gillies regarding the impacts of deadwood on fishing is interesting. Generally, the fishermen we spoke to were in favour of seeing wildlife such as beavers and otters in the rivers. Further, our assessment of beaver felling activity suggested that, as beavers establish within an area, the felling of larger trees declines, though the sample was predominantly of willow trees and the relationship may be different for other tree species. The felling of larger trees during initial establishment may be due to the requirement of larger logs for construction and repair of dams and lodges (e.g. Fustec & Cormier 2007), or because there are too few of the preferred (Haarberg & Rosell 2006; Margaletić et al. 2007) smaller saplings available. If the proportion of larger trees felled declines as beaver establish at a site, the impact of beaver activity on anglers through line loss may also decline over time, without necessitating any active management of the beavers. We also

noted that there was woody debris in the rivers from sources other than beavers. The impact of beaver-created woody debris on line loss by fishermen needs further investigation. Beaver tree felling and damming activity can also have a beneficial impact on fisheries such as providing refuge and foraging areas for young fish (felled trees and dams) and purifying water (dams) (Rosell et al. 2005; Kemp et al. 2010). These potentially positive influences should also be considered when assessing management options for beavers living in angling rivers.

▪ *4.4.3 Mitigation*

As the population of beavers in the Tay catchment increases however, there may be an overall increase in issues arising from dam-building and, to a lesser extent, tree-felling. This is because most of the current groups are living in rivers and burns that are big enough to negate dam-building. But as these areas are occupied by beavers, new recruits into the population will be pushed into less optimal habitat, where dam building may be required, and where there are narrower riparian belts in which beavers can forage without impacting other land-uses. While more active management of the beavers may be required in the future, the need for management could potentially be reduced by acting now to ensure that burns and ditches have an adequate width of riparian belt and by planting riparian trees such as willow along watercourses (Schwab & Schmidbauer 2003). Other non-lethal management options include:

1. Installing flow-control devices at problem dams (Lisle 2003).
2. Protecting large trees that are valuable, or that the felling of will create other issues, using wire netting or anti-browsing paints (these are paints containing sand originally designed to reduce deer damage) (Nolte et al. 2003).
3. Protecting the wooden roofs of lodges and bank-dens with wire netting fixed to the ground to stop roofs being washed away by flood water. While previously untested, this action could reduce the need for the beavers to fell larger trees to repair the damaged lodge roof.

○ **4.5 Recommendations for further research and monitoring**

The presence of beavers in a river catchment that is important in terms of fishing and agriculture provides a useful opportunity to assess the impacts of beavers on this landscape, and so inform decisions on reintroductions to similar landscapes in Britain. On-going monitoring and investigations into positive and negative impacts, and the mitigation and management of negative impacts should continue. We recommend:

1. Annual repeat surveys to monitor the persistence, growth and spread of the current beaver population. This should be considered a priority if information on the Tayside beavers is to usefully inform any future decision as to the desirability of reintroducing beavers to Scotland. Such monitoring could take the form of aerial surveys

followed by ground surveying, directed by the results of the aerial surveys, as in this survey.

2. It would be useful to explore likely population growth and spread of the Tayside beaver population over the foreseeable future, but to do that requires accurate estimates of population structure, survival and reproductive rates. Reproductive rates could be monitored relatively easily by observations of known lodges during kit emergence (but would nevertheless be relatively labour intensive, in terms of the man-hours required to obtain a representative estimate of number of families that produce kits and number of kits per family); improved data on population structure would also require extensive observations of beaver families; survival estimation would require trapping and marking a large number of animals (which is even more labour intensive, and also requires considerable animal handling, which may raise animal welfare questions). The question to be answered is to what extent these parameters can reliably be estimated from the existing literature on beavers elsewhere. We therefore suggest the use of matrix population models, using estimates of population structure and relevant demographic parameters (survival and fecundity) from the literature, to explore likely population growth scenarios. The most important output from this type of exercise would be the use of sensitivity analyses to identify those demographic parameters that require more precise estimation, and thus to identify field research priorities. This type of relatively simple modelling exercise would also form a useful first step prior to more complex spatial modelling of beaver population spread as in, for example, Rushton et al. (2000, 2002). Recommendations regarding further field work would be dependent on the results of the sensitivity analyses.
3. A more extensive questionnaire survey of stakeholders, to assess widespread attitudes to beaver presence in the area of the Tay catchment, estimate damage experienced (both real and perceived) and, thus, assess the level and type of mitigation required.
4. A study examining the effects of land management practices (for example, width of riparian belt) on land-use conflict with beaver would inform the management and mitigation of these conflicts.

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ANNEX 1: METADATA

Field sign codes

Code	Description
A	Feeding on aquatic vegetation. Evidence of this consists of remnants of aquatic vegetation left at the location where the animal consumed the plants on the water's edge. Area affected can't be measured.
Ag	Feeding on agricultural crops. The area affected was measured as m ²
C	Cutting or gnawing of woody vegetation (shrubs, saplings and trees). Area affected was measured as linear length along the water's edge (up to 10m) with '0' indicating a single cut stem.
Ca	Food cache. Cut woody vegetation stored in front of the main lodge over winter. These rarely remain through to summer.
H	Feeding on herbaceous vegetation, usually evidenced by concentrated patches of cropped vegetation associated with a foraging trail. Area affected was measured as linear length along the water's edge (up to 10m).
B	Sighting of a beaver.
Bu	Burrow. Entrances may be below normal water levels and so invisible except during low water
D	Dam. Height (from water level on downstream side to the rim) and width (bank to bank) were recorded in m.
FS	Feeding station. This is a location at the edge of the water where a beaver repeatedly takes material obtained elsewhere to consume.
FT	Foraging trail - created by the frequent passing of a beaver on land. These run from the water and are distinguishable from other animal trails in that vegetation is usually more flattened due to the low stance of the beaver, trails do not usually continue for more than 20m inland and there is often no matching trail on the opposite bank (created by other species uses the location as a crossing point).
L	Lodge. These are often burrows where the nest chamber has breached the surface and has been protected using sticks and mud.
O	Other field signs. For example, dredging, where material is pushed from the bottom of a pond or stream to the edge to increase depth.
SM	Scent mound. A pile of material (usually mud) scrapped together by the beaver on which scent (castoreum and sometimes anal-gland secretion) is deposited. Beaver scent-mark sporadically throughout their territories and more intensely nearer the borders, with a peak in scent-marking activity occurring in spring. Freshness can be checked by sniffing the mound for castoreum. While a distinctive sign of recent beaver activity, note that otters can also build scent mounds. Examining tracks, looking for otter 'jelly' on top of the mound and sniffing the mound can all be used to distinguish the source.
SS	A small area of concentrated scent mound activity. These can be associated with established territory borders where animals from the neighbouring territory visit and over-mark.
T	Tracks of beaver.

Map data source

Vector map data of waterways, used to calculate bank length was extracted from Ordnance Survey OS) VectorMap™ District data, obtained from OS OpenData™ (see <http://www.ordnancesurvey.co.uk/oswebsite/products/os-opendata.html>). Licence details are available at <http://www.nationalarchives.gov.uk/doc/open-government-licence/>. The scale of the waterway vector data is not provided by the OS, but appears to be ≤1:25,000.

ANNEX 2: AGE CLASSIFICATION OF CUT STEMS

Figure A2. Age classification of cut stems used during the vegetation survey, where 1 is the most fresh and 10 the least fresh cut. Age was discerned by the gradual darkening (1-4) and then silvering (5-10) of the wood, the spread of mildew with age and the extent of regeneration (if any). Classes 1-5 are equivalent of 'fresh' and classes 6-10 equivalent of 'old' in the rapid field survey. The rate that the cut surface changes will be related to species and the prevailing environmental conditions, including exposure to the elements (determined by vegetation cover) and frequency of immersion. This classification is not therefore a rigid standard but instead an approximate estimate. Overall however, classes 1-5 are roughly equivalent to stems cut at some point during or since the previous winter while classes 6-10 are older with classes 9-10 in particular being ≥ 2 years old.





ANNEX 3: BEAVER GROUP SUMMARIES

River Earn

Beavers foraging signs on the Earn were found most frequently on young willow growth in the gravel bars along the length of the river. Water levels were low during the survey and many burrow entrances were visible. Some of these were several meters above the current water-level, indicating that the beavers are behaviourally adapting to the high fluctuations in the levels of the Earn by building burrows at different heights.

Earn 1

The core area of this group is centred on a series of disused fishponds and the stretch of the Earn running alongside. The nest chamber of the main lodge sits half-way between the river and a ditch behind, which connects two fish-ponds, with the entrance to the lodge from the river. The ponds are approximately three meters above river level and, with less than 10m of bank between the nest-chamber and the ditch, a breach in the fish-pond bank could conceivably be created by beaver digging from the ditch towards the lodge. A small amount of beaver foraging was seen in the Water of Ruchill near to its confluence with the Earn. This most likely falls within the Earn 1 territory, but is probably seldom used.

Earn 2

A local fisherman reported that he has seen otter using some of the higher burrows created by the beavers.

Earn 3

Classed as separate from Earn 2 upstream, because of a c. 1km stretch of river with no recent (new) beaver activity. The more recent activity is concentrated within the downstream part of the territory suggesting that the beavers there have shifted their core area.

Earn 4 & Earn 5

A large (>2km) gap in recent activity between this and Earn 3 are a good indication that this is a separate group. On the downstream side however, there is no obvious gap between this group and Earn 5. The combined size of Earn 4 and 5 is however very large and it is likely that there are two separate groups in Earn 4 and 5. Scent-marking activity appears to be concentrated around foraging sites with no obvious scent-marking activity in other areas that would indicate a border between groups. A border has therefore been suggested at approximately half way along the combined length of these territories, coinciding with a small gap in beaver activity and a short section of rapids. It is also possible that the area comprises one family group with single individuals resident at one or both ends.

Earn 6

A gap of >1km from Earn 5 to here is a good indication that this is a separate group. Only one burrow was detected, but others may have been missed during the survey.

Earn 7

A gap of >1km from Earn 6 to here is a good indication that this is also a separate group. Signs of foraging on submerged aquatics was detected here.

Earn 8

There is a short (0.5km) gap between this and Earn 7 upstream. This is a small territory with fewer old foraging signs and so may be relatively recently formed. Signs of foraging on submerged aquatics were also detected here.

Earn 9

A c. 1.5km gaps between this and Earn 8 is a good indication this is a separate group. Activity is focussed on a series of gravel bars within sight of the A9 trunk road. Surveying took place after 7pm and an adult was witnessed diving from an above-water burrow entrance into the water. Further downstream another individual, possibly a yearling, was seen to tail-slap.

Earn 10

This is a small territory with signs of quite intensive foraging. Again, surveying took place after 7pm immediately after the surveying in Earn 9, and two individuals were seen swimming. Despite the small size, the >1km gap in activity between this and the next nearest group (Earn 9) and the successive sightings of beavers in both groups suggests that this is a separate group from Earn 9. As with Earn 8, the low frequency of older beaver signs suggests this is a more recently established group.

Earn 11

There is a long gap (>2km) between Earn 10 and here. This is a comparatively large territory (c. 4.5km in length).

Earn 12

A short gap from Earn 11 to here (about 0.75km). Further downstream towards Bridge of Earn the habitat was slightly less suitable (less willow and tidal fluctuations in water levels) and few further signs of beavers were detected.

River Isla

Isla 1

Three of the five lodges exhibit signs of flood damage. Scent mounds were noted throughout the territory. Based on foraging signs, beavers have been resident here for at least five years.

Isla 2

Several old flood damaged lodges noted in territory. Kits observed in this group in 2010, 2011 and 2012 with suspected breeding in earlier years.

Isla 2b

Foraging signs indicate that beavers have been active here for several years, possibly as part of the Isla 3 group. The extent of fresh activity does however suggest that this may now be a separate group to Isla 3. There may also be a single animal occupying the stretch of river between here and Isla 2.

Isla 3

All lodges on the north bank. Main activity centre is upstream of the Lunnan burn confluence. Feeding evidence on willows would suggest the colony has been active for approximately 5 years. Observations in 2011 confirmed 6 – 7 beavers in colony, including 3 kits. Kits also confirmed in 2012.

Isla 4

Most of the activity here is concentrated near the confluence with the Tay, though there are significant amounts of activity at the upstream end also. Unconfirmed reports indicate that one or more of these animals may have been culled.

Isla 5

Very little data on this group. Most activity here is concentrated around the confluence with the Baikie Burn.

Lunan burn

Three main groups were recorded on the Lunnan burn, together with signs of individual beavers foraging as far up as the Loch of the Lowes and Rae Loch. Groups here are not as established as in the Isla.

Lunan burn 1

Very little data on this group, though fresh scent mounds were noted during the survey.

Lunan burn 2

This group may have been originally resident in the area currently occupied by Lunan burn 3, before moving upstream in 2012.

Lunan burn 3

The beavers in this group possibly took over from Lunan burn 2. Fresh foraging and scent mounds were noted during the survey. Two adult beavers were also seen in 2012, with one seen using the main lodge. Several burrows are evident downstream of the lodge. A dam built by the previous occupants was washed out and is no longer functioning. The spatial activity of beaver groups around here may change as this group becomes established.

River Ericht

Only one group has been recorded, downstream of Blairgowrie. Upstream of Blairgowrie, feeding signs are sporadic and ranged from fresh to several years old. A dead female was found three miles upstream of Blairgowrie, but no active group has been noticed and so this may have been a dispersing individual.

Ericht

Feeding signs were scattered throughout the territory range and, the extent of feeding would suggest it is possible sub adults are using other old lodges and burrows within the territory. Kits observed in 2011 and 2012. The downstream extent of the territory was evidenced by concentrations of scent mounds.

Dean Water

Several territories exist on the Dean Water. Field signs would indicate beavers have been present for eight years or more.

Dean Water 1

This group is centred on the confluence with the Isla. Kits were noted on 24/06/2012 at the furthest downstream lodge. The other main lodge experienced flood damage in 2011 and 2012, but was still in use at the time of survey in 2012.

Dean Water 2 – Dean Water 3

Beavers have been active in this stretch for eight years. It is not obvious whether there are one or two groups. Simultaneous observations at the lodges of both the posited groups proved inconclusive. Two adults at DW2 were observed, of which one swam upstream towards DW3. Within 10 minutes an adult was observed at DW3 and therefore could have been the same individual as seen in DW2. A juvenile was also noted at DW3.

Dean Water 4

Old lodges in this group have been damaged, either from flooding or by people. Fresh feeding and fresh scent mounds were found at most willow patches with few exceptions within 1km upstream of the lodge. Concentrations of scent mounds also indicated territory borders. Several hundred metres of bankside willows have been destroyed by heavy plant machinery through up-rooting. This is likely to have a severe impact upon river banks and associated wildlife.

Dean Water 5

No obvious lodge or burrows seen in dense vegetation, but many fresh scent mounds and feeding signs over 2km.

Dean Water 6

Many fresh scent mounds for hundreds of metres in either direction of the main lodge. Few fresh tree feeding, but grasses taken at regular foraging trails. There is another lodge and several burrows throughout the territory.

Dean Water 7

Little is known about this group, but the survey suggests that it is still active, with fresh scent mounds. It was initially thought that this group occasionally moved up to DW8 (see below), but the simultaneous activity signs suggest these are two separate groups.

Dean Water 8

Many burrows and two lodges noted in this group. Very few trees along most of the lower section of this territory. The beavers appear to be feeding frequently on grasses and herbaceous vegetation along the field margins. Frequent fresh scent mounds. The area has been previously occupied in the past with recent activity suggesting that it has been reoccupied. There had been gnawing at the base of three large poplar trees growing within a few meters of the A90, though no recent signs of gnawing at the same three trees. Further gnawing could create a potential issue of the trees falling over onto the carriageway. Recent observations indicate fresh gnawing on another tree within the same group of poplars.

Baikie Burn

Baikie Burn

This group first established over two years ago. Blame for the felling of the first tree, when noticed by householders living next to the burn, was attributed to the son of one of the residents. As more trees were felled however it quickly became clear that the boy was blameless. Residents occasionally see

individuals near a spot they frequently dam. Damming has been causing issues with local landowners due to flooding. Two dams are regularly created and are cleared every few weeks with some being rebuilt by the beavers over the course of several days. Beavers are also foraging on oil-seed rape in this area.

River Tay

This is the largest river in the area, with fewer and more widely spaced groups. The wide spacing is at least partially due to habitat suitability with some sections being poor due to flow characteristics (e.g. large rapids) and others due to mowing and cutting of bankside vegetation to allow fly-fishing. There is however suitable habitat currently unoccupied by beavers. As found in the Earn, beavers appear to be making frequent use of young willow growth on gravel bars, as well as backwaters connected to the main channel.

Tay 1

The extent and age of activity here suggests that beavers have been resident here for at least two years and possibly longer. An intensively foraged section of willow around a burrow appears to have been largely abandoned with more recent foraging activity visible elsewhere. A stem of giant hogweed (*Heracleum mantegazzianum*) had been felled but was left largely unconsumed. Residents of Aberfeldy, upstream of here, had witnessed a beaver swimming under the bridge during high water two years previously.

Tay 2

Most of the activity is concentrated at the downstream end of this territory. This group has built two dams in ditches off the main river, which require repeated clearing by the farmer. Evidence from felled trees suggests that beavers have been resident in the main channel here for several years, with some of the most weathered beaver-cut stumps seen during the survey found in this group.

Tay 3

One of the main concentrations of activity is at the upstream edge of this territory, where an area of willow has been extensively thinned. An adult beaver was seen here during the survey. There is more activity downstream and a concentration of scent mounds just before the confluence with the River Tummel, suggesting a border here. No burrows or lodges were located, though river levels were not low and so entrances would have been underwater.

Tay 4

This group cover a very large area. There are few concentrated foraging signs, with the majority being recent. Signs are widely spaced, particularly through the centre. No lodges or burrows were found, but as with Tay 3,

water levels were not low and so burrows and lodges would have been difficult to detect from canoe. The beaver activity signs suggest a relatively recent residency and the paucity of signs may indicate a very small group, possible just a pair of animals, or perhaps two single animals at each end of this posited territory.

Abandoned site between Tay 4 and 5

Approximately 5.4km upstream from the top of Tay 5 is an area of concentrated foraging activity together with two burrows set in a backwater. Almost all the signs are old, suggesting this area has been abandoned. We cannot tell whether the animals died or moved to a new area.

Tay 5

There is a very large gap (c.19km of river length) between Tay 4 and here. The group is geographically much closer to Isla 4 (c. 1.3km). A large number of recent and old foraging signs are visible in the gravel bars and backwaters in the middle of this territory. When asked, a gillie on the upstream end of this territory indicated no knowledge of the presence of beavers in this stretch. The main lodge shows signs of having been burnt, though evidence indicates that the beavers are still residents in the area and may be using other chambers in the same lodge. The farmer who cultivates the land adjacent to this lodge had no knowledge of the burning and indicated that he was not troubled by the presence of the beavers. Recent activity around the oxbow at the south of the territory could be a separate individual, or possible a subadult from the Tay 5 group living separately over the summer. Feeding activity suggest the group has been resident for 3 – 4 years.

Dowie's Hole

The group is centred in a wetland area off of the Tay. Two active dams were located during the survey, though more may be present as access was difficult due to the water-levels cause by the damming. Canals have also been observed. The raised water-levels do not appear to be causing issues with other land-use as this area was already wet. The frequent scent mounds between here and Tay 5 indicate this is a separate territory from Tay 5. . A dam built on a burn upstream of here is still largely intact but has not been maintained recently. Evidence from field signs would suggest colony has been in existence for 6 years. Unconfirmed reports from locals and gillies indicate beavers were present here 20 years ago.

Almond

There is large gap (c. 15km) between here and the nearest group upstream (Isla 4). This could be due to many large rapids between here and the Isla. In this gap there is evidence of one or two individual animals. The centre of activity for this group is near a path and cycle route on the edge of Perth. Human recreation nearby appears not to disturb the beavers and they are relatively easily observed. Observations during June yielded a sighting of an

adult female showing enlarged nipples, indicating she was lactating. Two beaver kits were later seen by a member of the public. Further observation found also a yearling present indicating, as a minimum, a breeding pair that successfully bred in 2011 and 2012 with a current group size (including kits) of ≥ 5 animals.

River Tummel

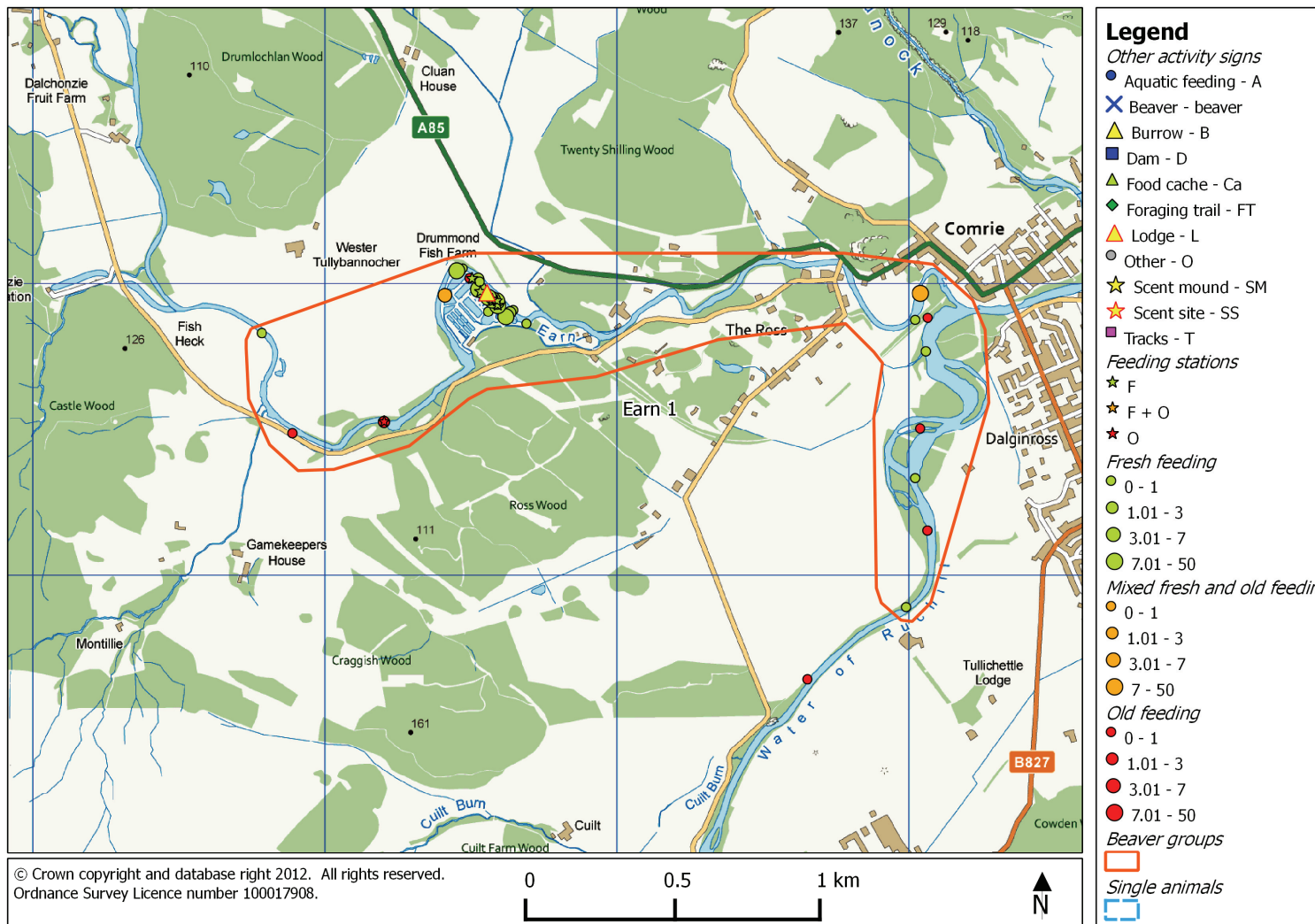
Dunalastair Water

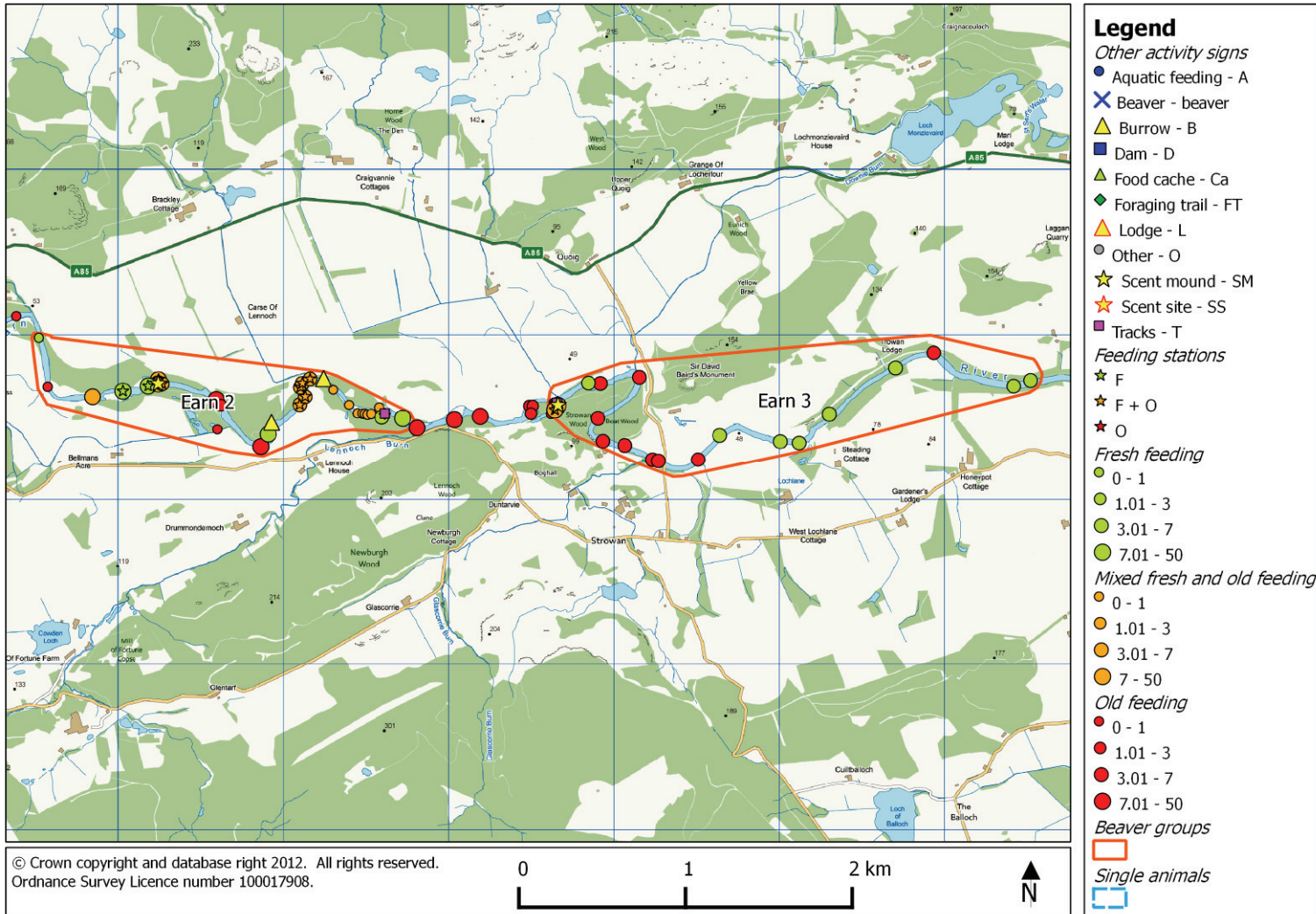
Foraging activity here has shifted from the downstream end of this territory to the upstream end. Several large birch (*Betula* spp.) of a diameter c. 30-40cm were felled in the downstream area, probably last year. Most recent felling activity is of much smaller willow saplings upstream. No lodges or burrows were located. No very old signs were seen, suggesting that the animals have been resident here for ≤ 2 years. This group is the most northerly and is over 30km upstream from the next nearest beaver group, with a very steep-edged dam to negotiate at the bottom of Dunalastair Water as well as a dam at Pitlochry. Dunalastair Water is also reasonably accessible from the road and is obviously of good quality habitat. While dispersal of this distance is possible and occasional activity signs were located between this group and the next nearest, intentional release of beavers directly to Dunalastair Water could also explain their presence here. The fresh signs (a couch, food cache and felled tree) detected in spring 2011 3km downstream of the Dunalastair Water group may indicate that dispersing animals from downstream have travelled as far up as here, but the signs could have also been left by an exploring animal from the Dunalastair Water group.

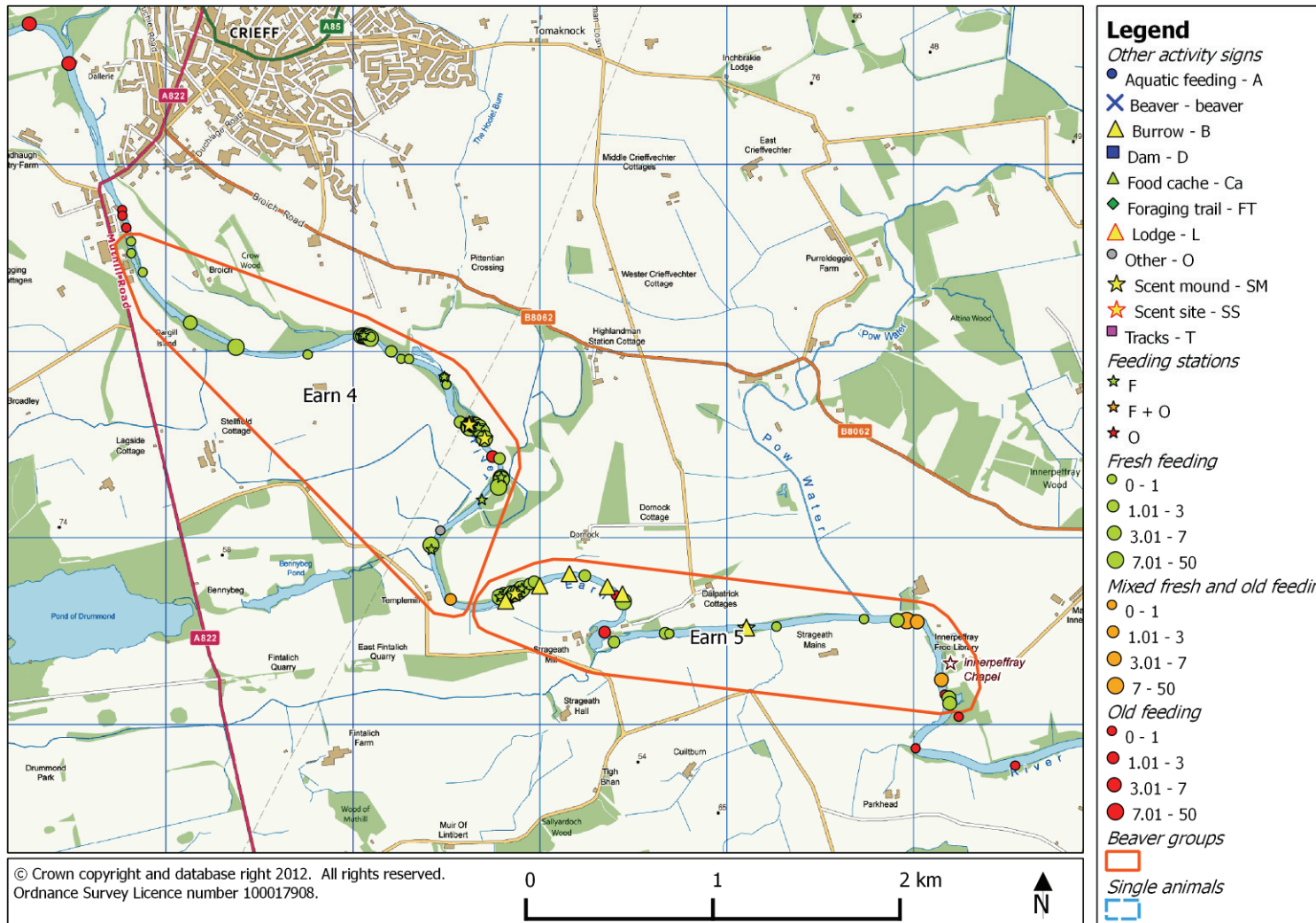
ANNEX 4: DETAILED MAPS

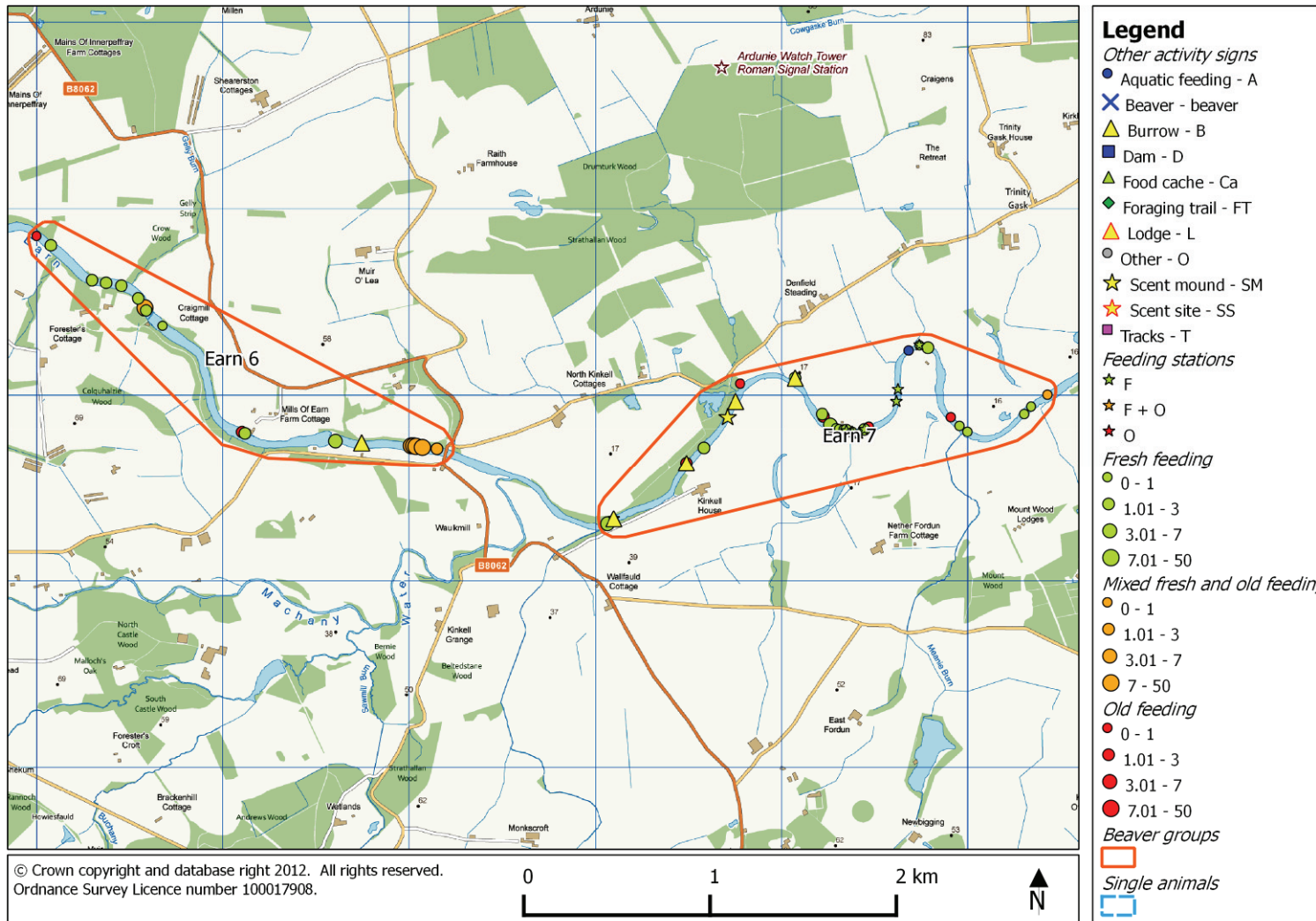
The following are detailed maps showing the type of activity signs and the delineation of beaver group or individual ranges. Beaver groups are named after the river they occur on (see Table 1 and Annex 3 for further details). Maps are labelled with these group names. The ranges of individual beavers are not named. Beaver activity signs are split into:

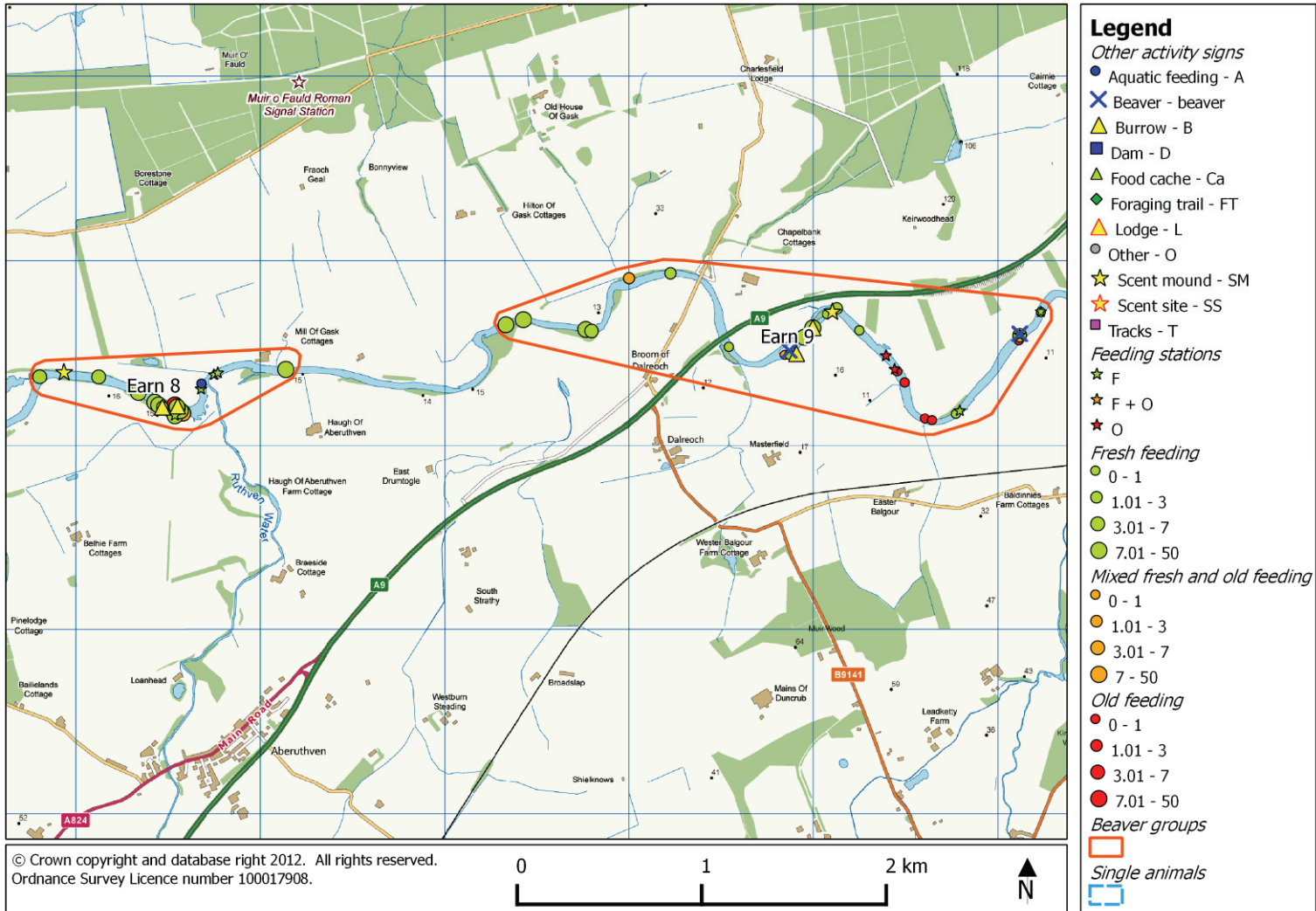
- Feeding signs where the extent of activity is measurable. This consists of tree felling and feeding on crops, but not feeding on submerged aquatic vegetation. Activity extent is measured by linear length of waterfront affected (up to 10m) for felling of trees; or area (m²) affected for foraging on crops. The size of the map points is dependent on these measures. This category was further split into locations where only fresh feeding signs were found, those where old feeding signs were found and locations where both fresh and old feeding signs were found. Displaying the feeding signs data in this way allows an easy visual assessment of the current and old activity hot-spots for beavers, as measured by these two types of foraging activity.
- Feeding stations, where discarded vegetation was either fresh (F), old (O) or a mix of fresh and old (F + O). Again, dividing the points in this way aids in assessing current versus old beaver activity.
- All other beaver signs. Scent mounds and scent-sites are, by their nature, relatively fresh signs whereas it is not always obvious whether lodges or burrows are in current use. A food cache would indicate whether the lodge next to the cache was in use during the previous winter.













Legend

Other activity signs

- Aquatic feeding - A
- ✕ Beaver - beaver
- ▲ Burrow - B
- Dam - D
- ▲ Food cache - Ca
- ◆ Foraging trail - FT
- ▲ Lodge - L
- Other - O
- ★ Scent mound - SM
- ★ Scent site - SS
- Tracks - T

Feeding stations

- ★ F
- ★ F + O
- ★ O

Fresh feeding

- 0 - 1
- 1.01 - 3
- 3.01 - 7
- 7.01 - 50

Mixed fresh and old feeding

- 0 - 1
- 1.01 - 3
- 3.01 - 7
- 7 - 50

Old feeding

- 0 - 1
- 1.01 - 3
- 3.01 - 7
- 7.01 - 50

Beaver groups

- ▭

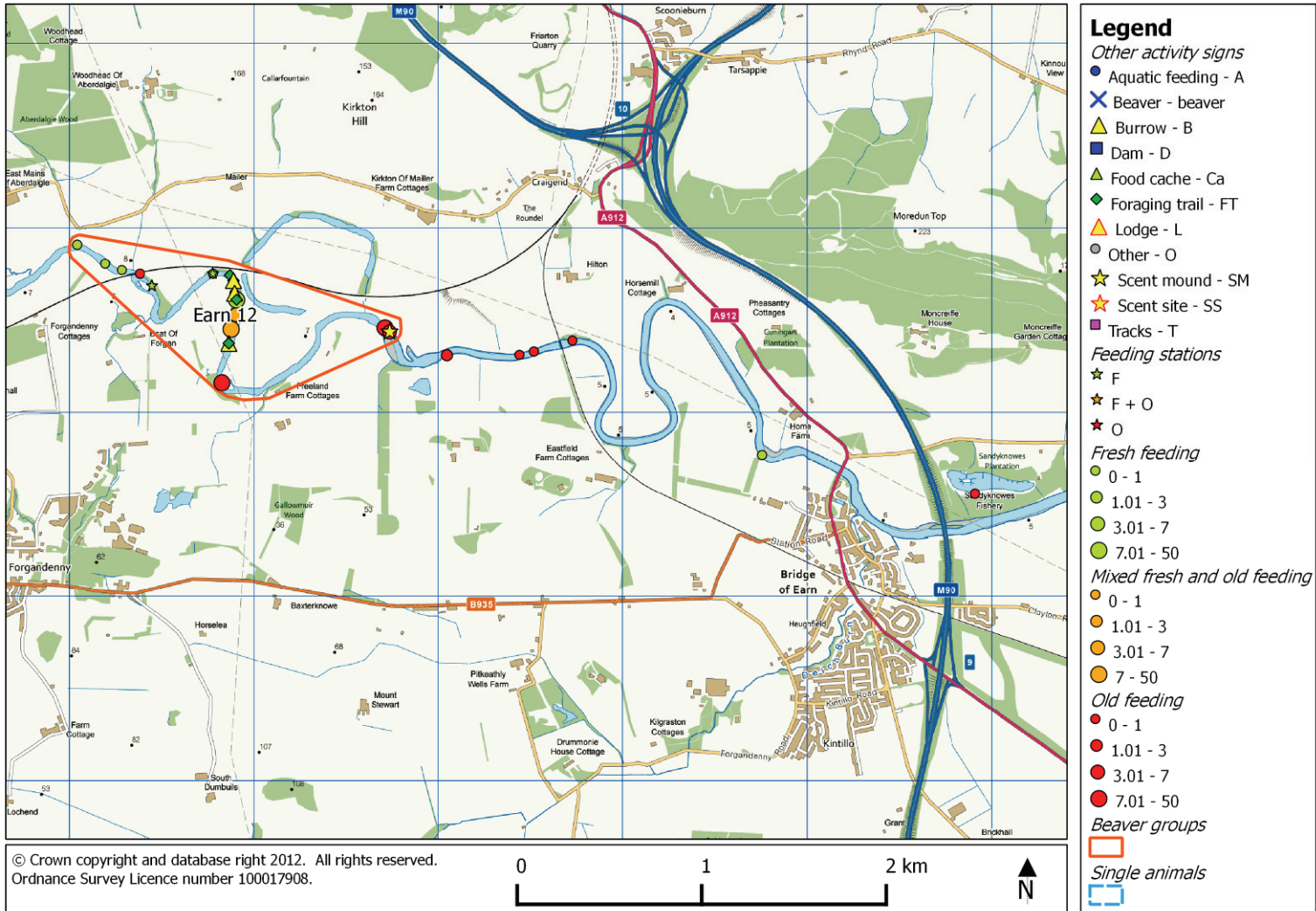
Single animals

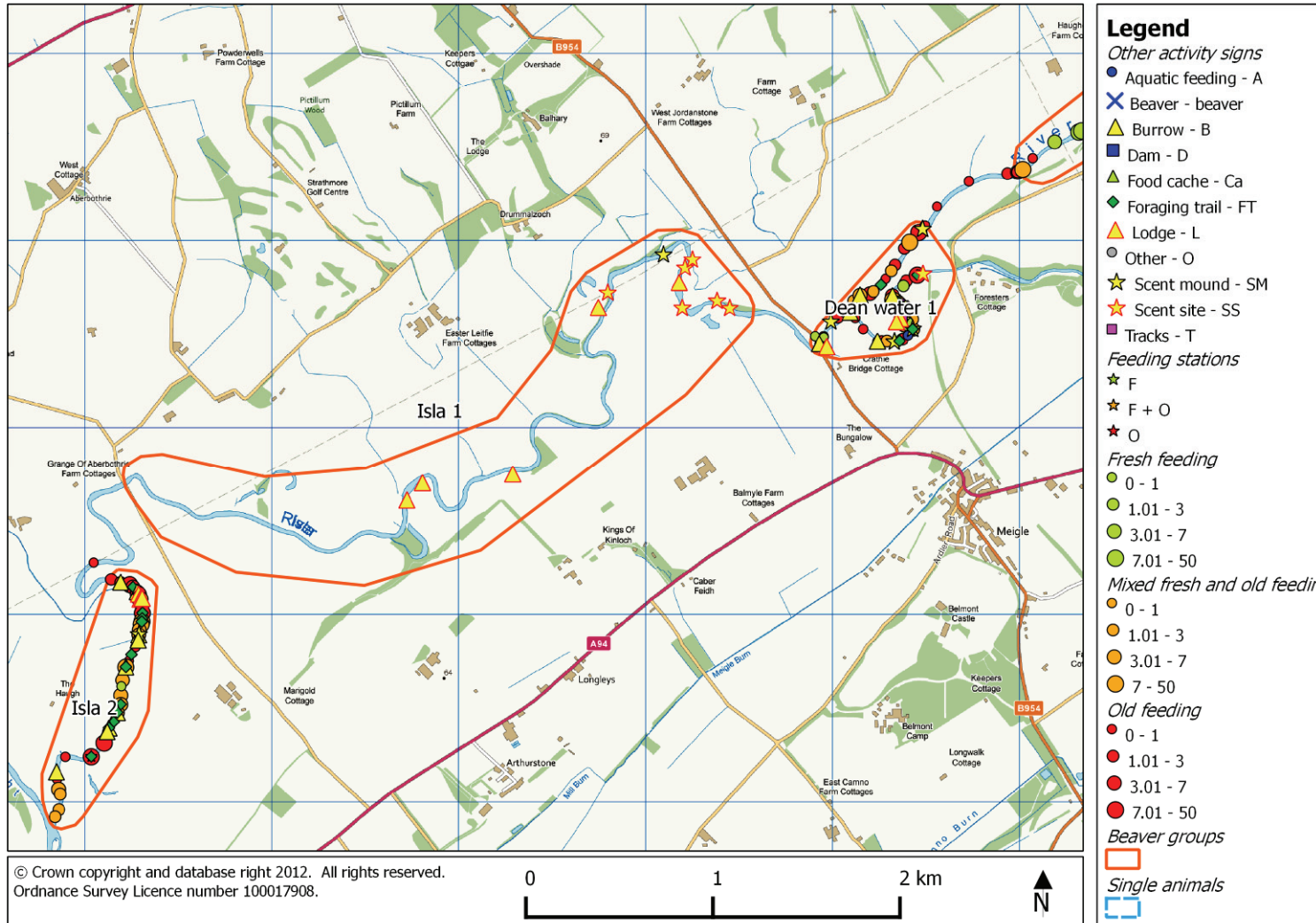
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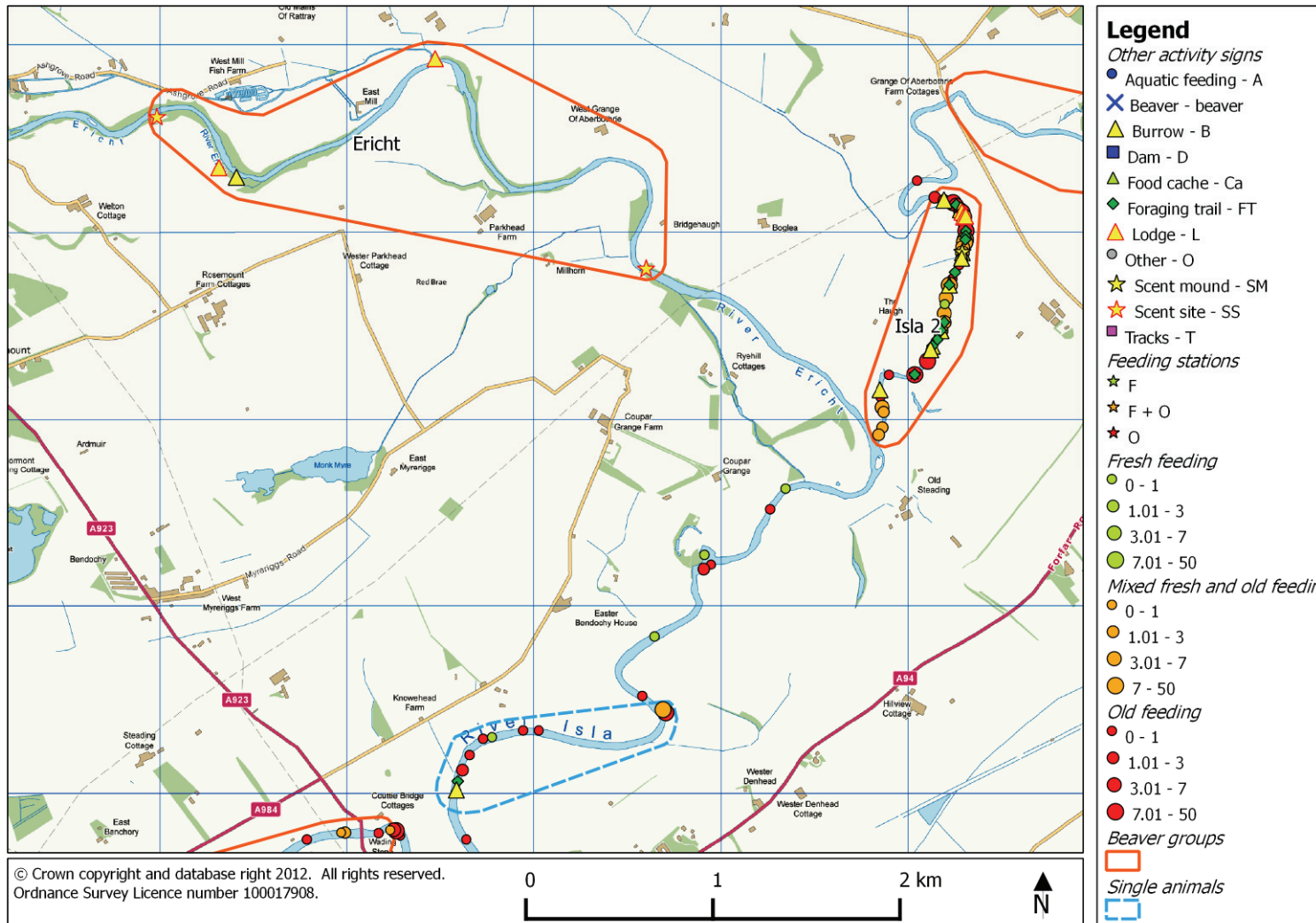
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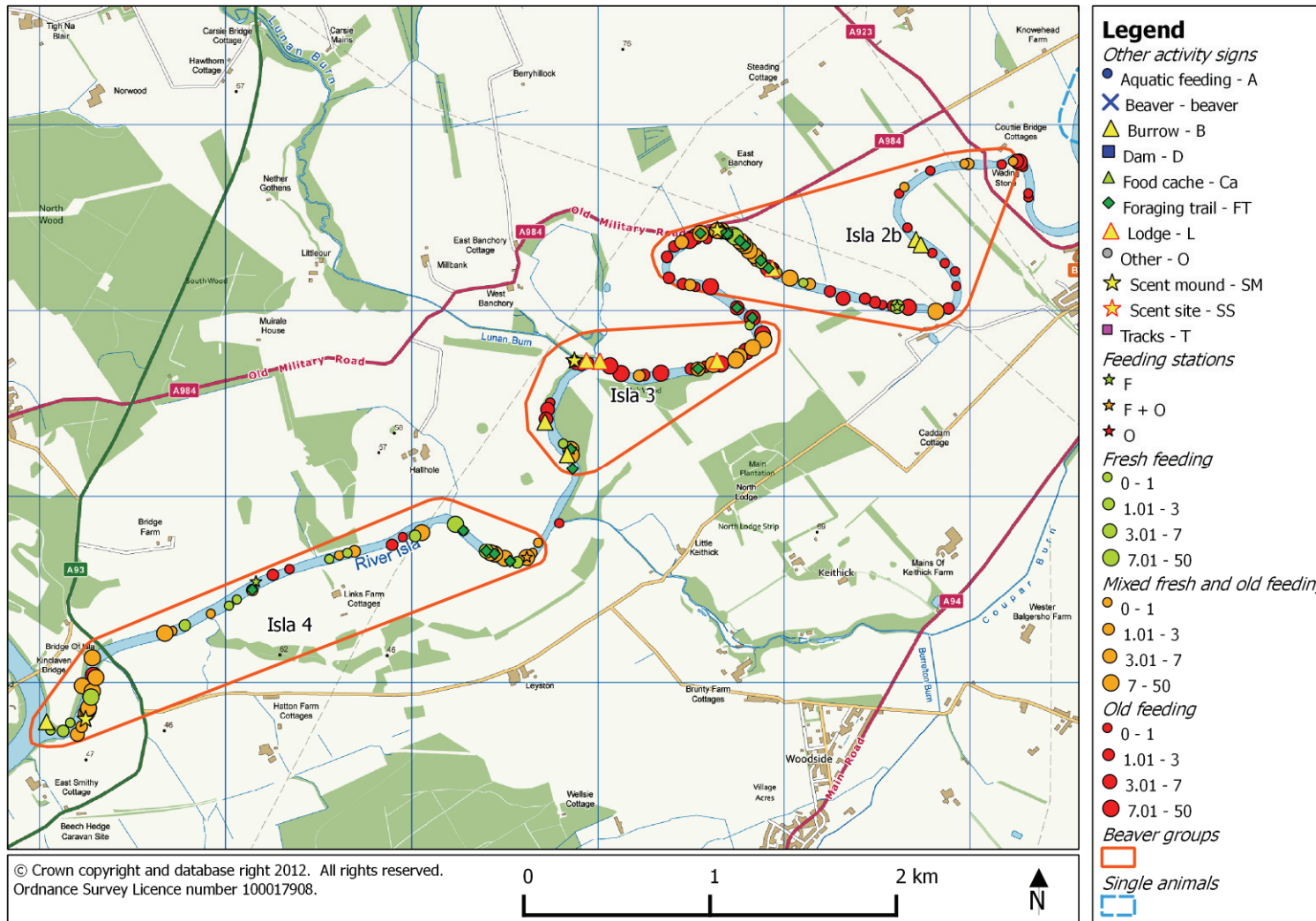
0 1 2 km

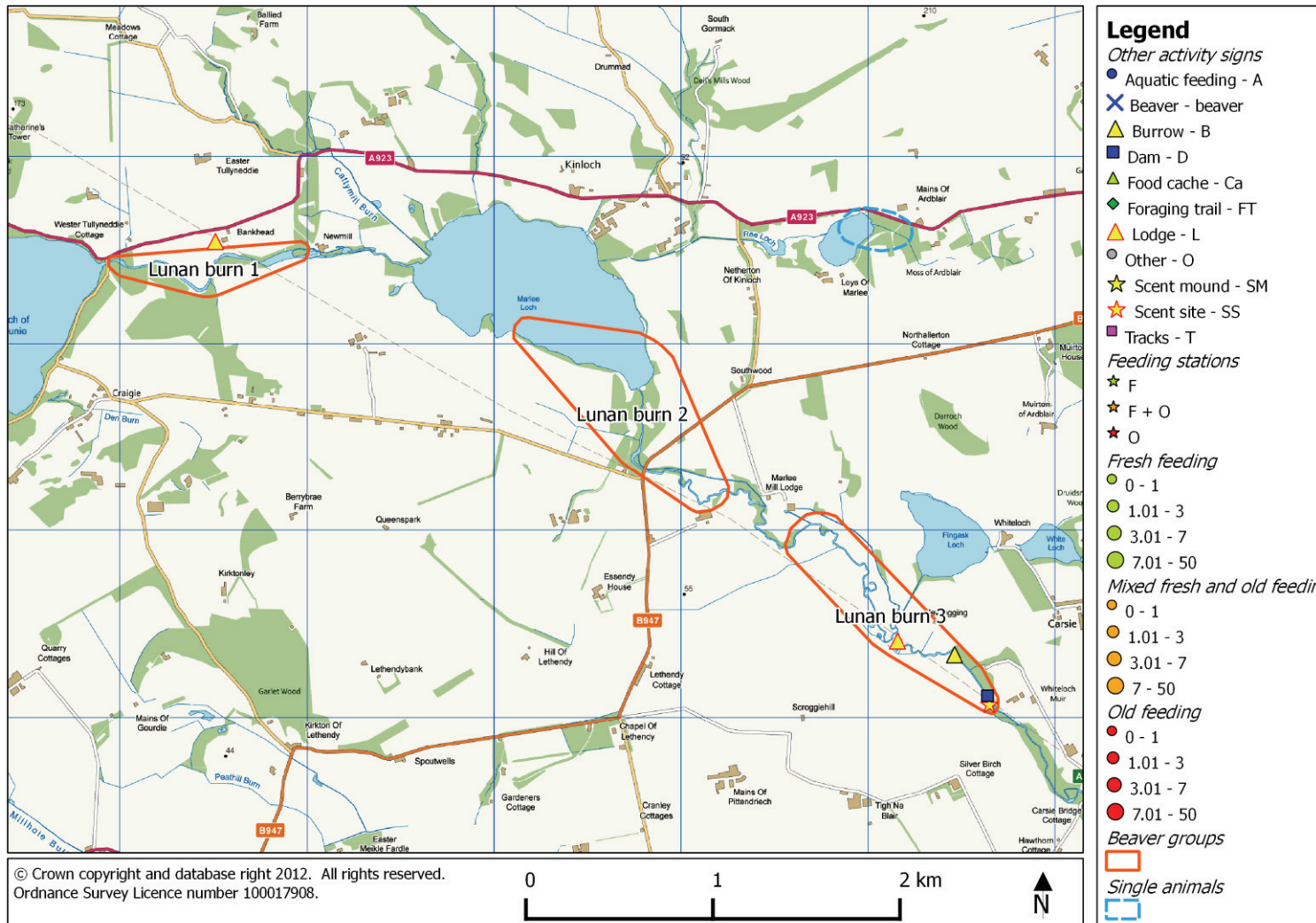
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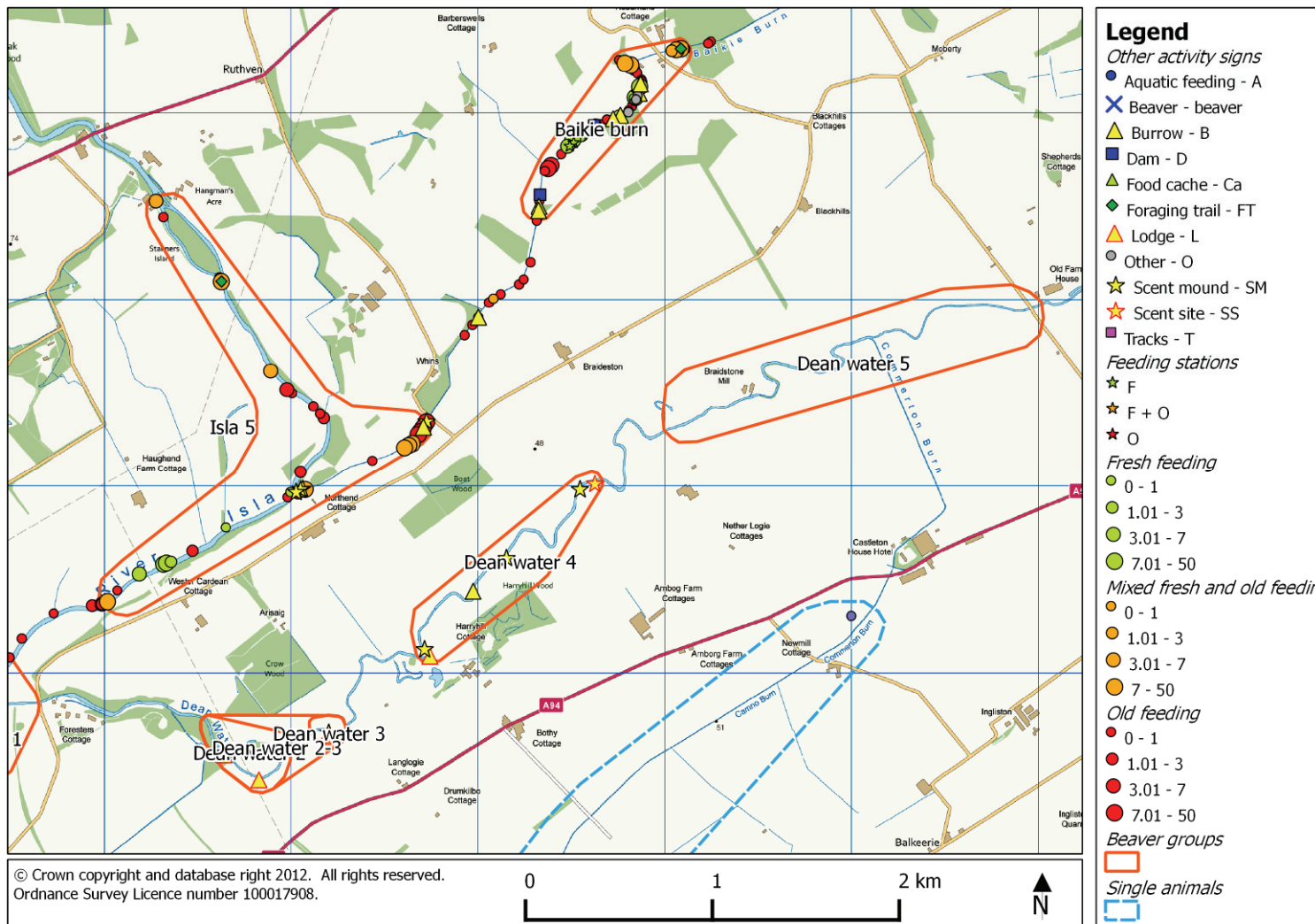


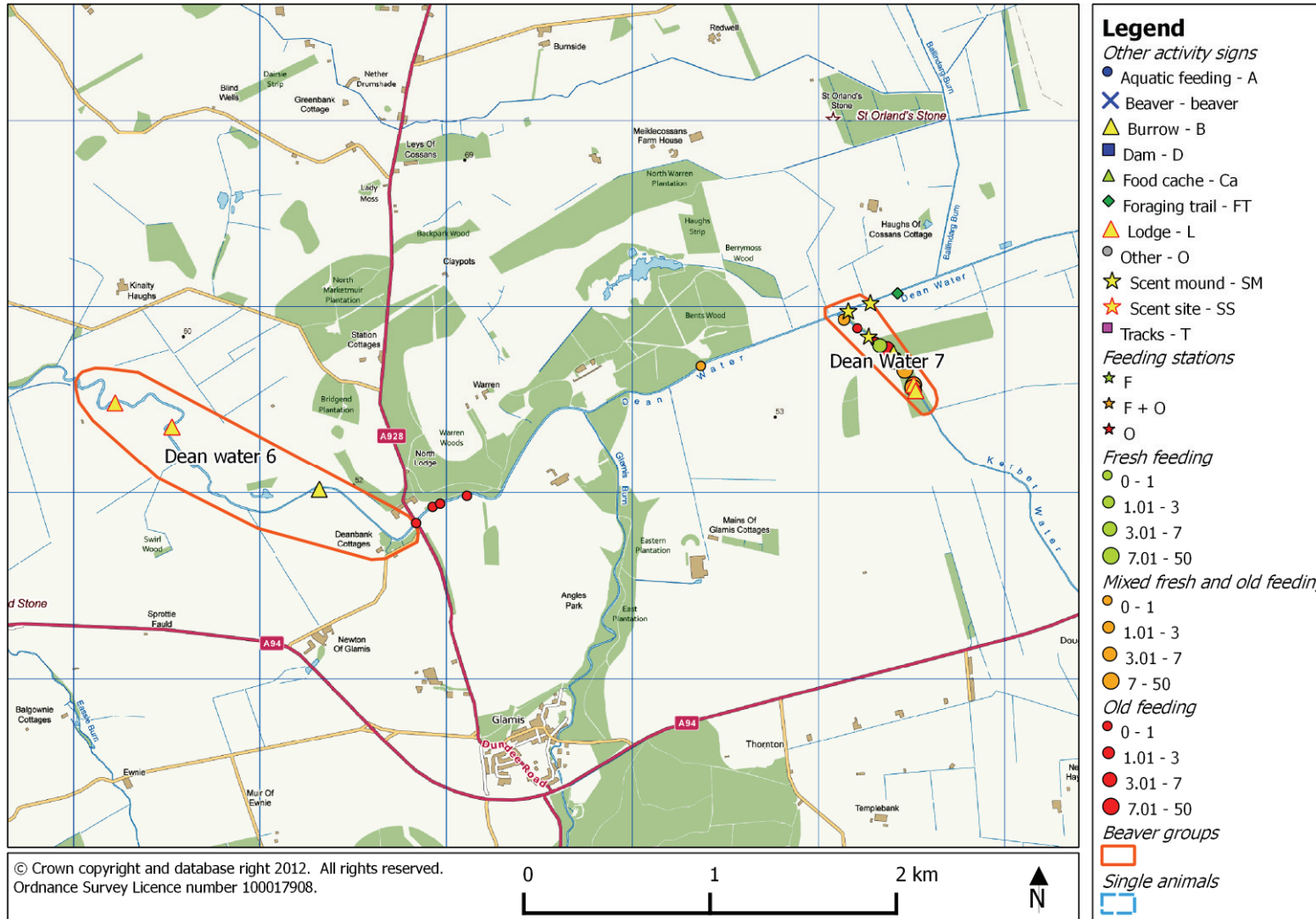


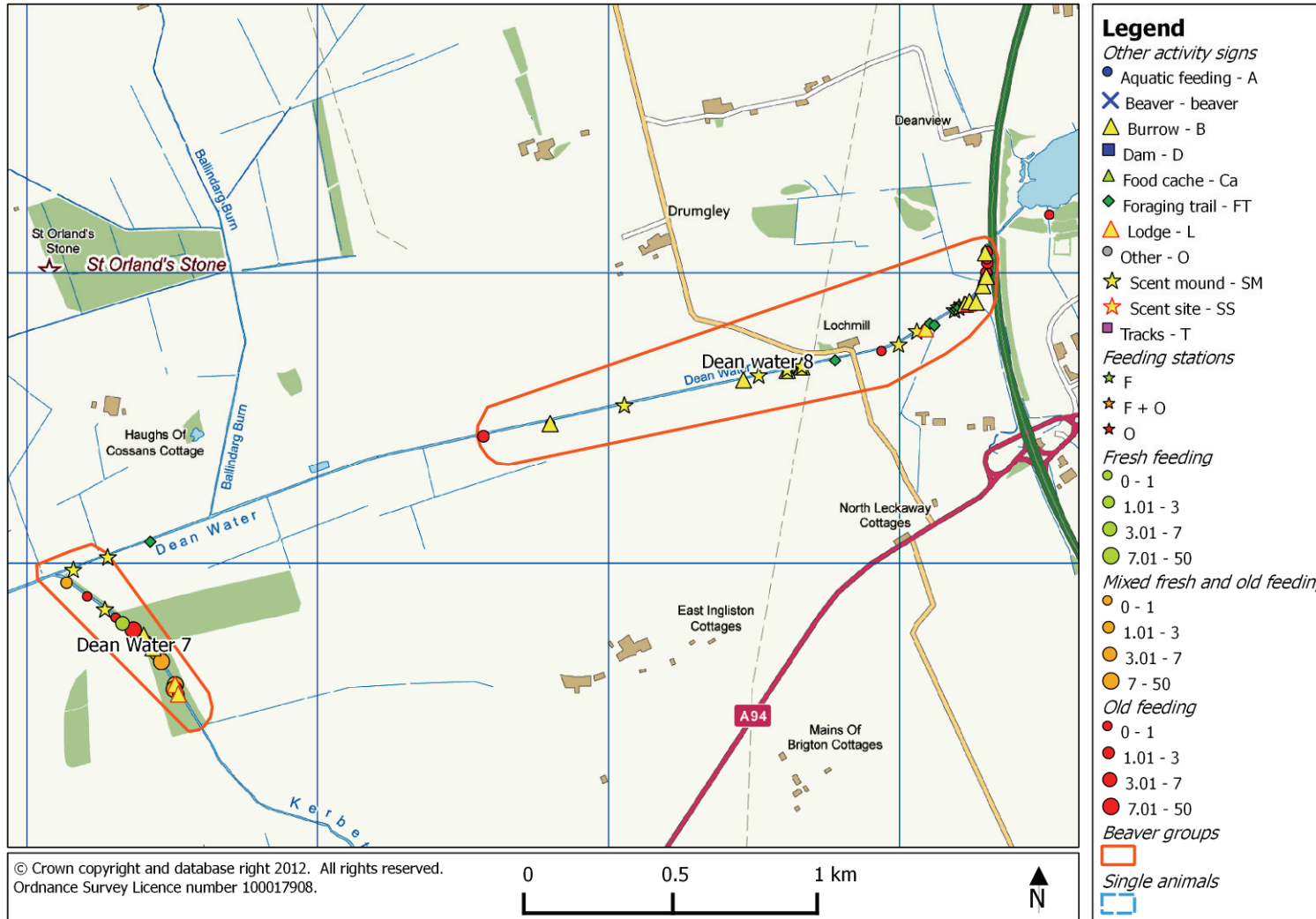


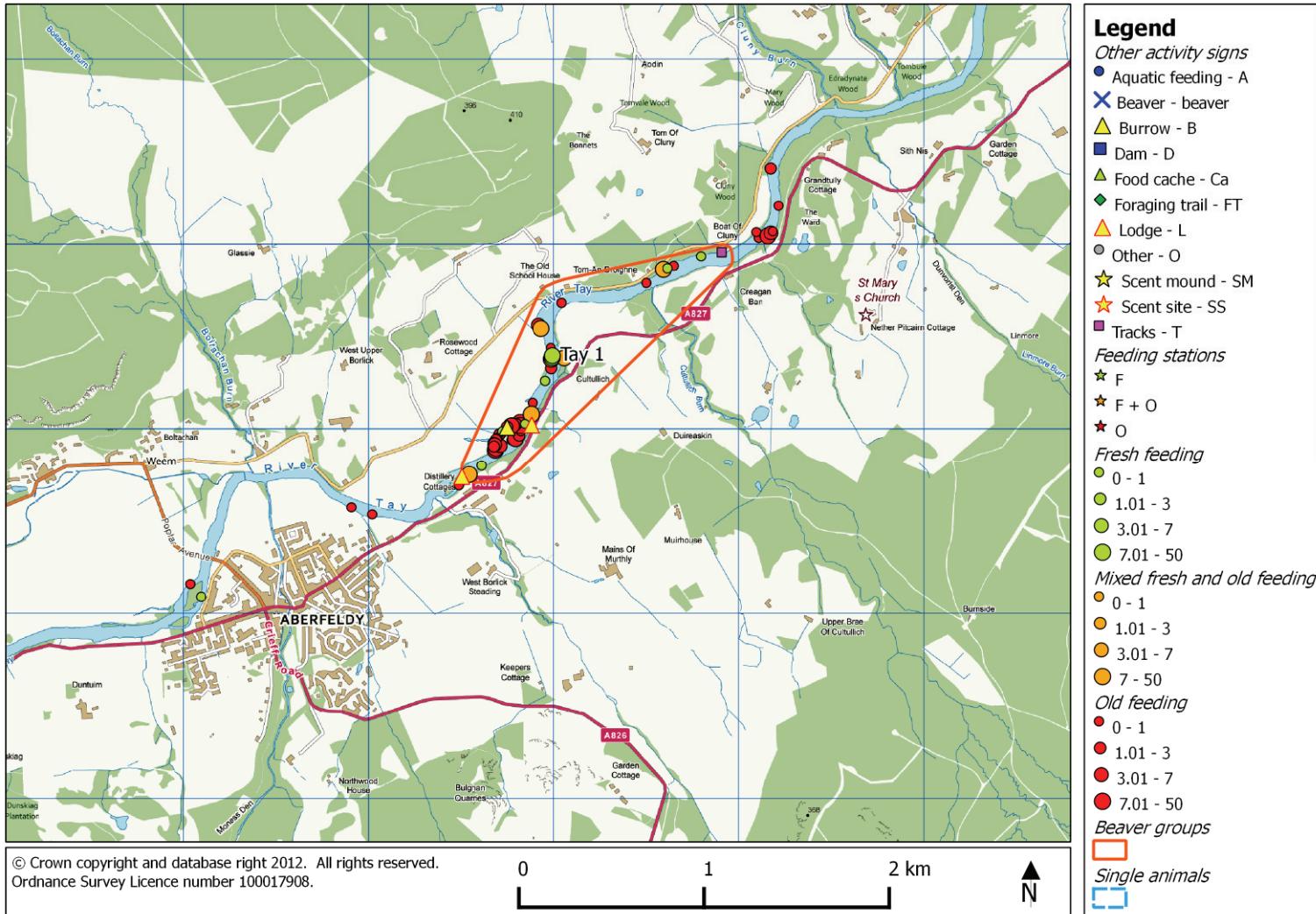


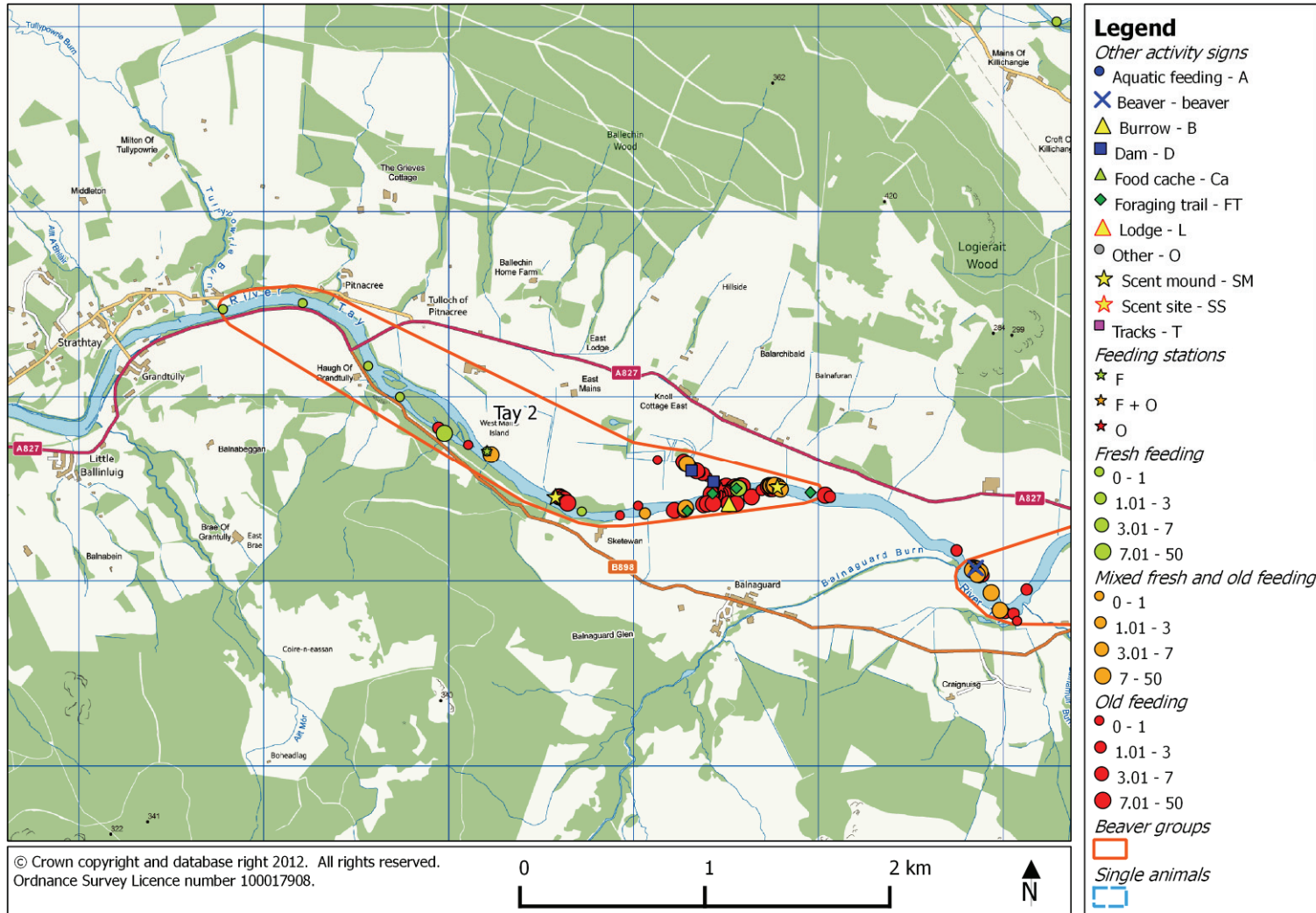


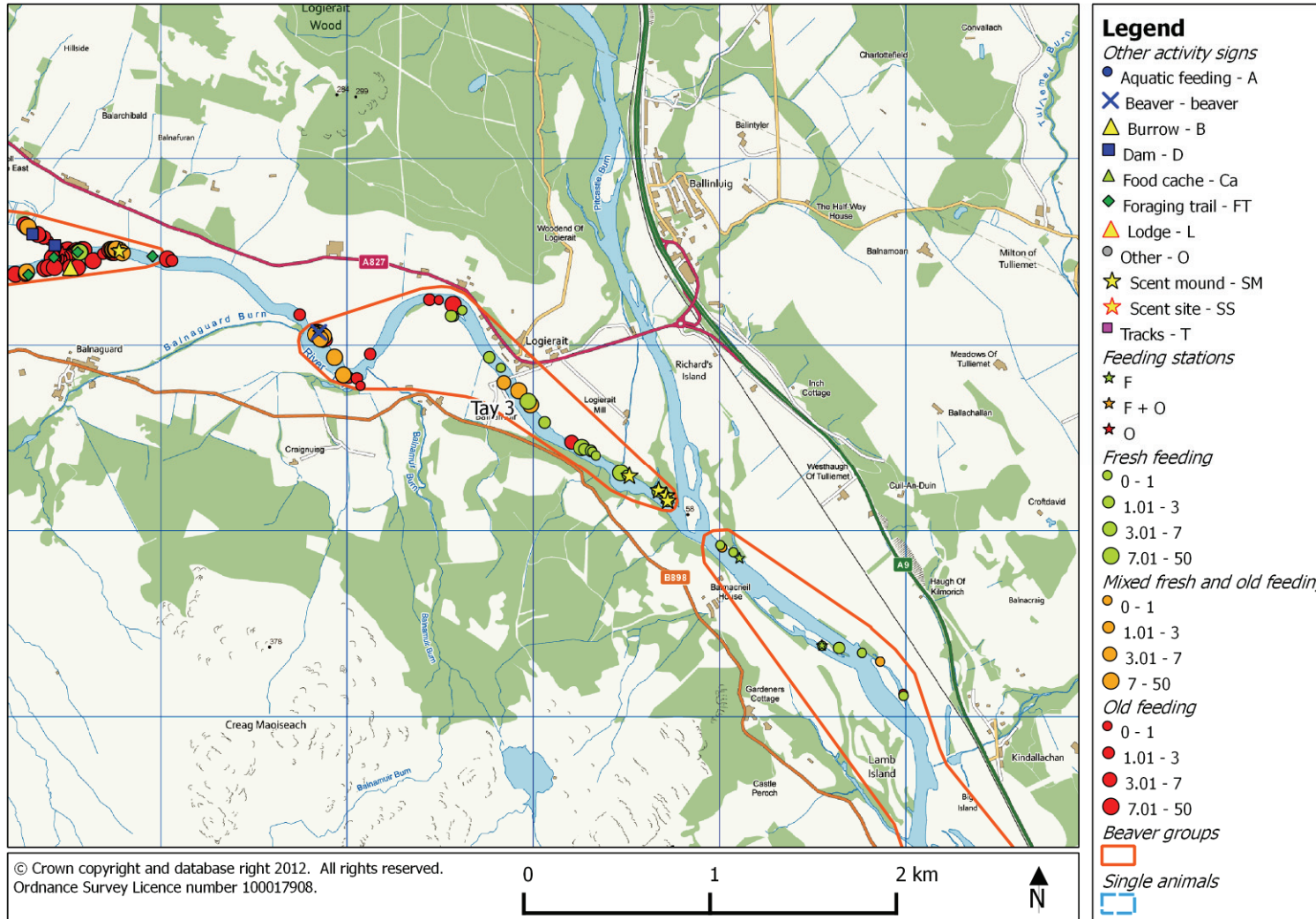


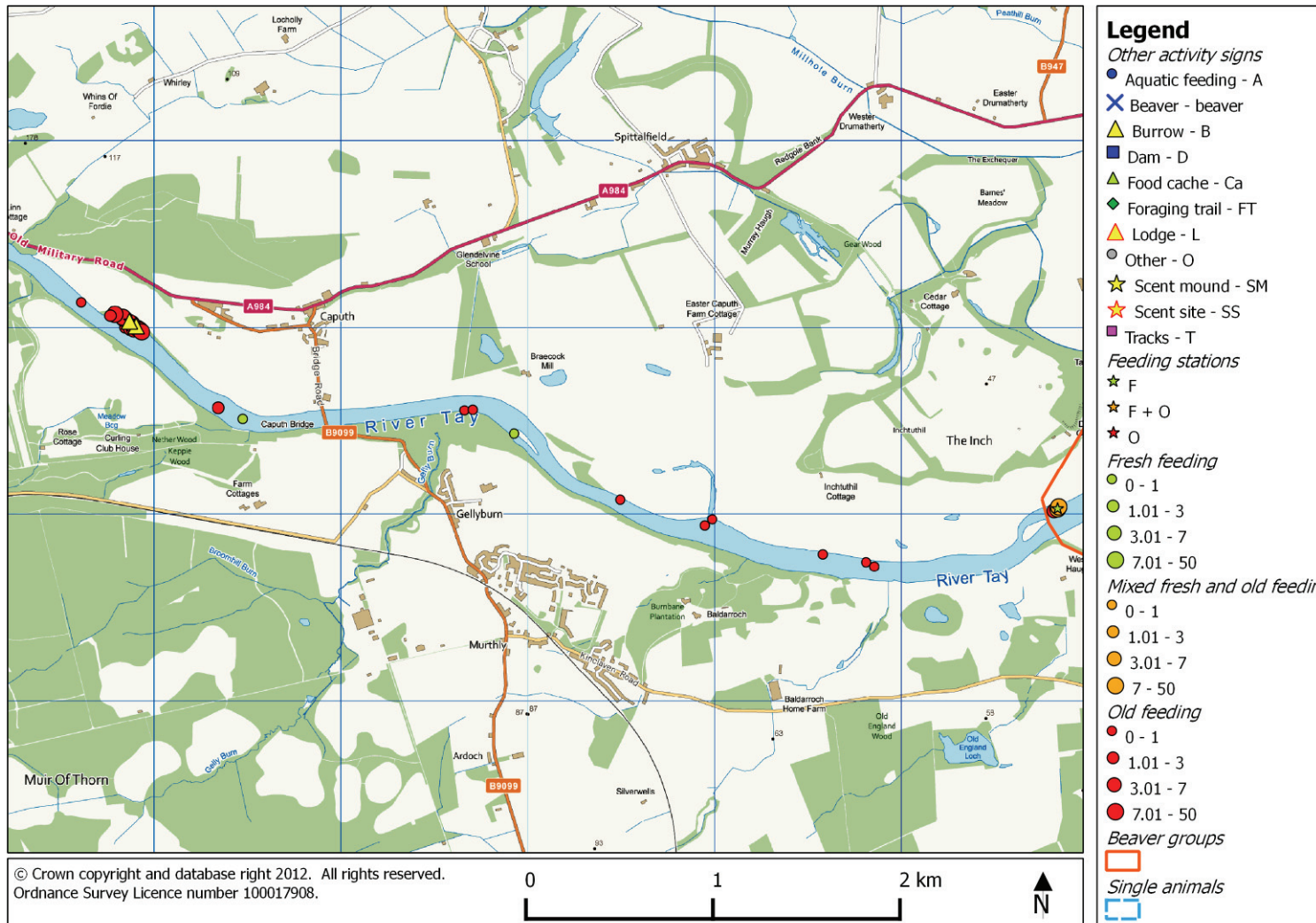


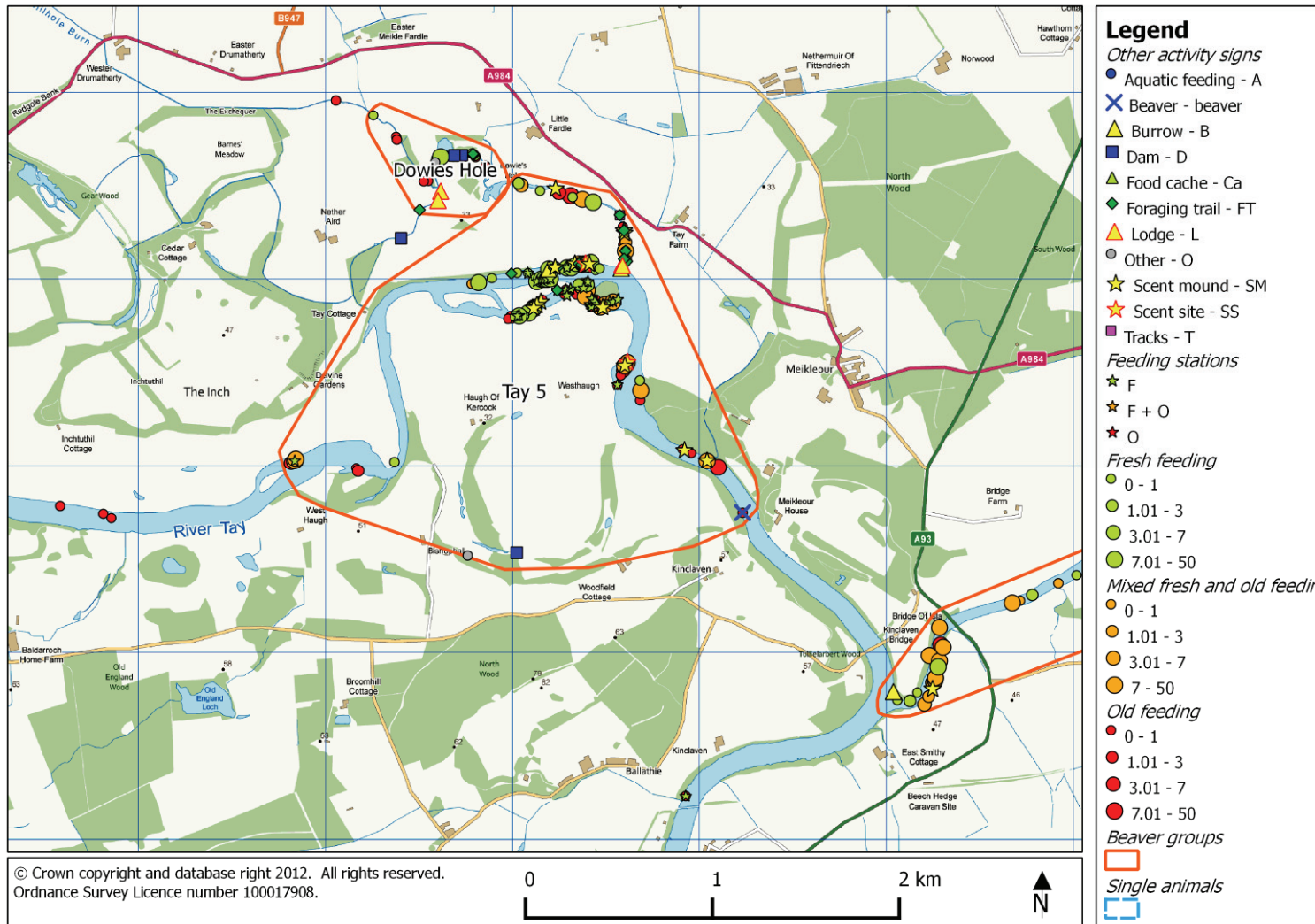


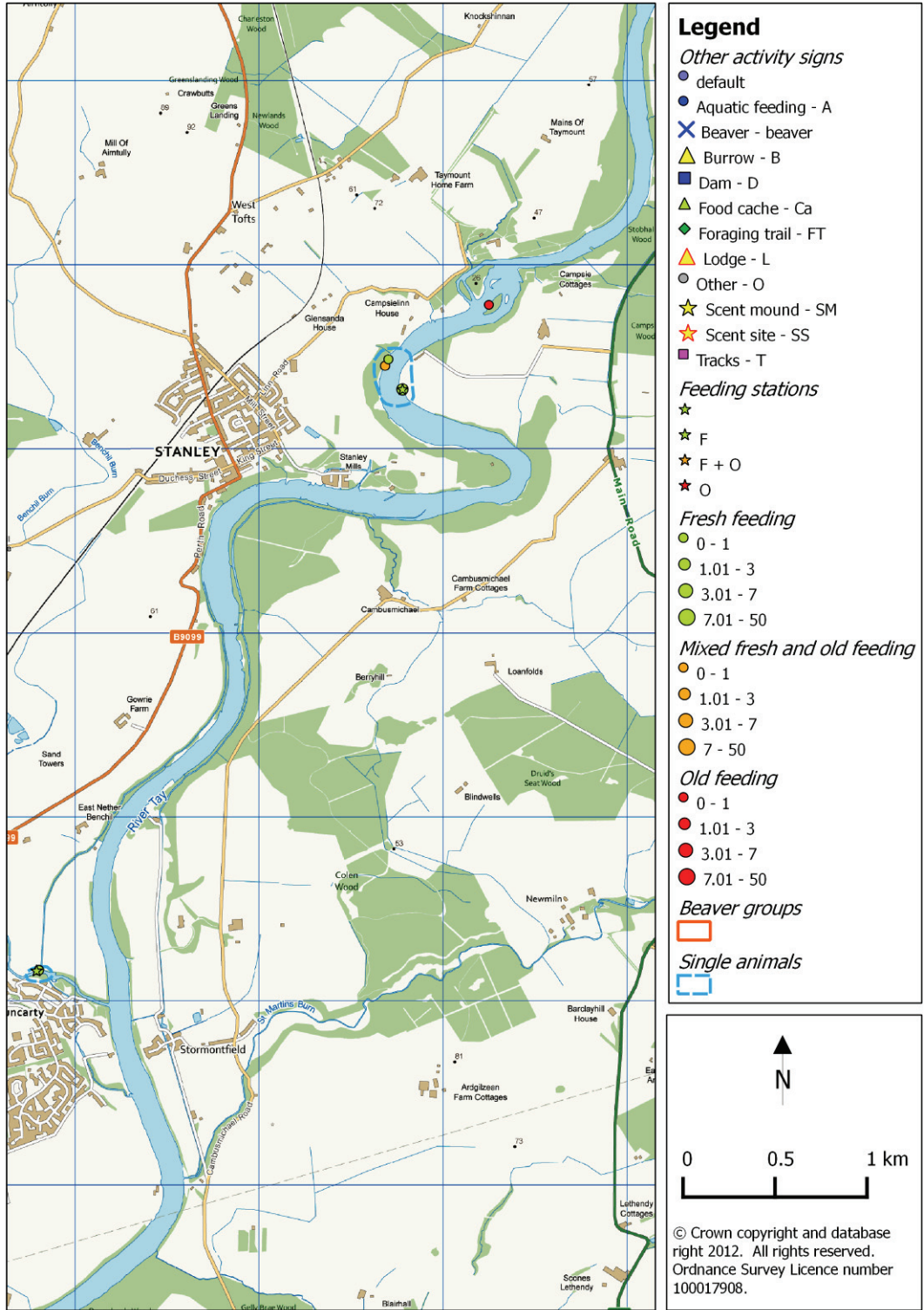


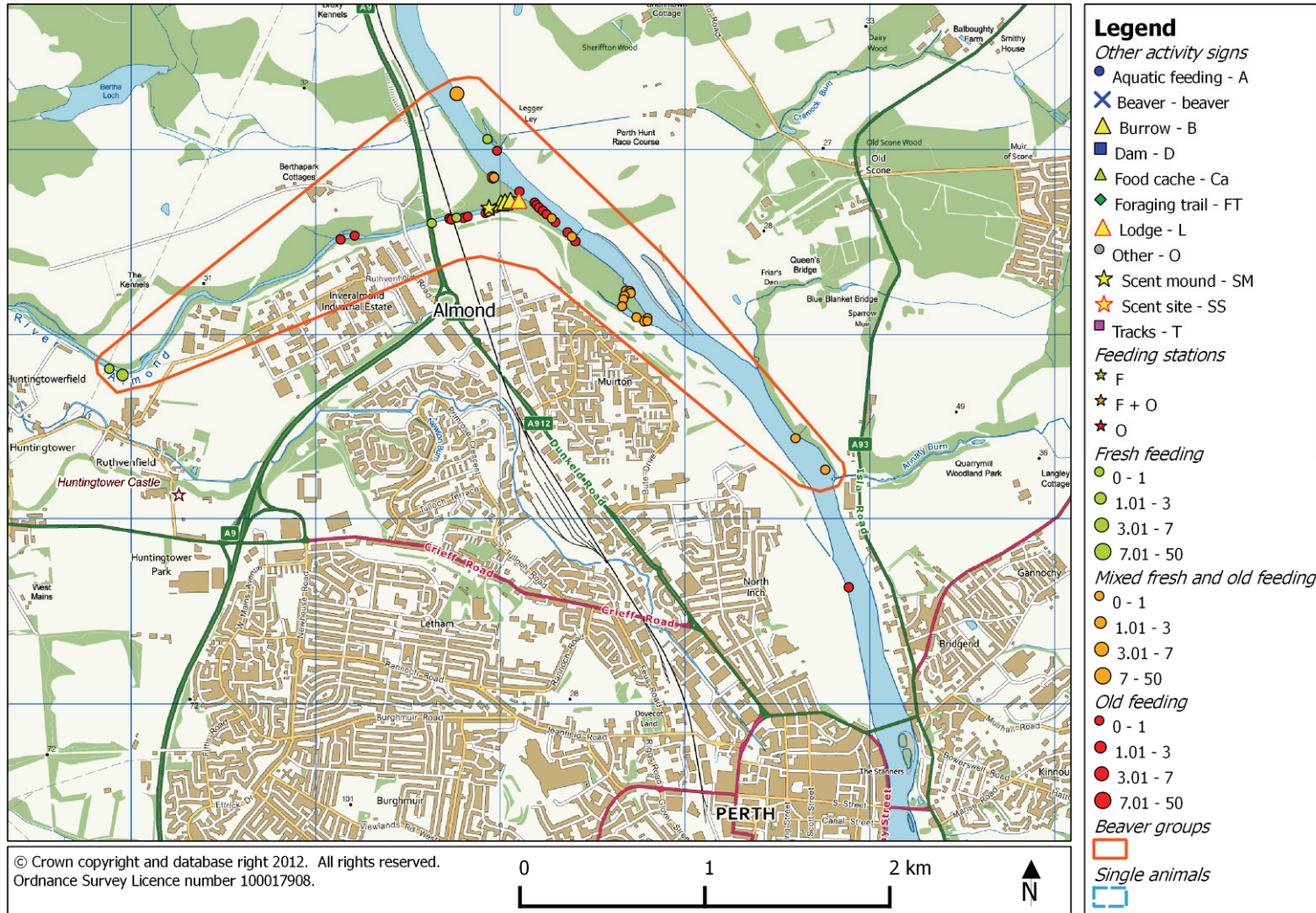














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0 1 2 km

N

Legend

Other activity signs

- Aquatic feeding - A
- ✕ Beaver - beaver
- ▲ Burrow - B
- Dam - D
- ▲ Food cache - Ca
- ◆ Foraging trail - FT
- ▲ Lodge - L
- Other - O
- ★ Scent mound - SM
- ★ Scent site - SS
- Tracks - T

Feeding stations

- ★ F
- ★ F + O
- ★ O

Fresh feeding

- 0 - 1
- 1.01 - 3
- 3.01 - 7
- 7.01 - 50

Mixed fresh and old feeding

- 0 - 1
- 1.01 - 3
- 3.01 - 7
- 7 - 50

Old feeding

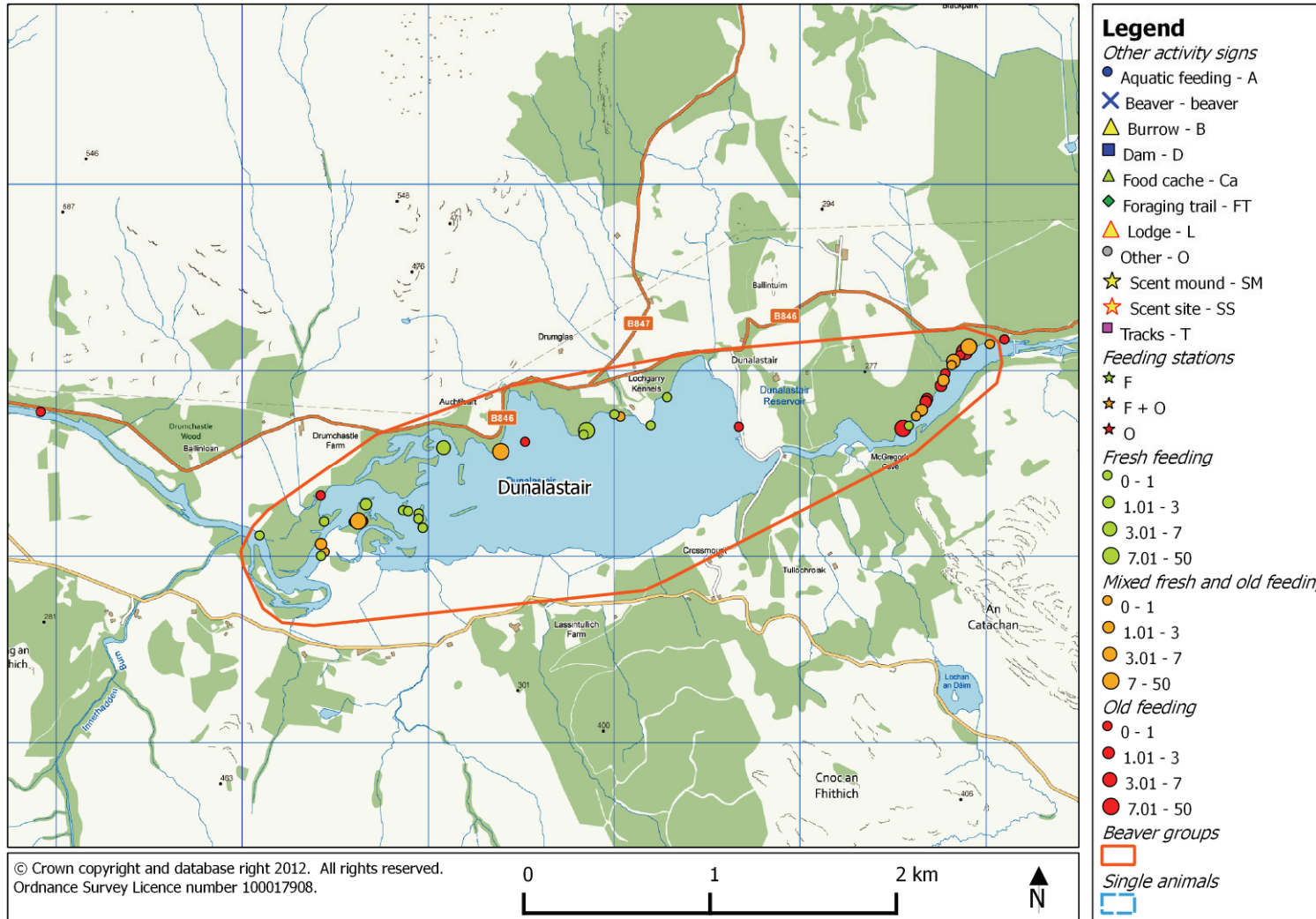
- 0 - 1
- 1.01 - 3
- 3.01 - 7
- 7.01 - 50

Beaver groups

-

Single animals

-



ANNEX 5: STAKEHOLDER OPINIONS

Below we summarise the opinions given to us by stakeholders we interviewed during the field-survey. Stakeholders are ordered by type: farmers, fishermen and gillies.

Farmers

The general opinion from the farmers we spoke to was that they had no problem with the presence of beavers as long as they didn't cause any issues.

Farmer adjacent to the Tay 5 and Dowie's Hole groups

This farmer was aware that beavers were resident in water within and near the area he farms. He was not experiencing any issues with the presence of beavers and was currently happy to have beavers living there.

Farmer adjacent to the Tay 2 group

This farmer was experiencing issues with the beavers damming a ditch off the main channel, with one dam causing a particular issue. The dam had to be cleared regularly to avoid flooding or waterlogging of the surrounding pastures. The farmer did not have any problems with beaver activity in the main river and stated that he would be happy to have beavers living on his land were it not for the dam-building. He expressed an interest in the use of mitigation through a flow-control device ('beaver-deceiver').

Farmer adjacent to the Tay 3 group

This farmer was aware that beavers were resident in water within and near the area he farms, largely because of the issues that activity by the Tay 2 group was creating for his neighbour. He was not experiencing any issues with the presence of beavers and was currently happy to have beavers living there.

Farmer adjacent to the Earn 5 group

This farmer was unaware that beavers were active in the river abutting the land he farms. When asked if he had seen any signs of foraging on crops that could be attributed to beavers he thought there may be a small area of cereal crop in the corner of one riverside field being foraged. He further stated that the amount of loss to the crop was inconsequential and, were this to be caused by beaver, he had no problem with the continuing presence of beavers adjacent to his farm. Further investigation by RC and AH indicated that the damage to the cereal crop was not due to beavers.

Fishermen

All the fishermen we spoke to were local and fisher regularly on the rivers. The general opinion of fishermen was that the presence of beavers (and other

wildlife, particularly otter) enriches their fishing experience. No fisherman expressed a problem with felled trees catching fishing lines.

Fisherman at Dean Water 1

This fisherman was unaware that beavers were living on the stretch he was fishing (despite there being a lodge 50m upstream, though the lodge is not very visible). He expressed an interest in seeing beavers while fishing and recounted tales of previous sightings of otter. He was pleased to see otter around and would also be happy to sight a beaver while fishing.

Fisherman at Earn 2, #1

This fisherman was unaware that beavers were living on the stretch he was fishing, despite their being several beaver feeding-stations (with abandoned felled sapling stems and branches) on the opposite bank to where he was fishing. He has no issue with the presence of beavers there and thought he would like to see one while fishing.

Fisherman at Earn 2, #2

This fisherman was also unaware that beavers were living on the stretch he was fishing. Opposite his location was a beaver burrow high above current water level, which he informed us was being used by a family of otter. He expressed no issue with the presence of beavers.

Fisherman on the Tay

There was no resident group where this person was fishing, but he was aware that beavers were present in the river. He expressed no issue with the presence of beavers.

Gillies

We spoke to two gillies, both of whom expressed similar opinions of the potential risks of entangling fishing lines in submerged felled trees. Both were against the presence of beavers.

Gillie on the River Isla

The beat of this gillie encompassed Isla 2 and stretches downstream. He expressed concern on the felling of larger trees by beavers, explaining that a fish caught on the line of one of his paying customers may swim under submerged felled trees, entangling the line and resulting in the loss of the fish and a broken line. Beavers had begun to gnaw at some trees in his beat. His reaction was to cut the trees down, presumably to avoid them falling into the river and creating the problem described above.

Gillie on the River Lyon

No evidence that beavers are present in this river was found and the gillie did not believe them to be resident there. As with the River Isla gillie, he was concerned about the potential for felled trees to cause line entanglement and did not want beavers on his beat.

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