Wild beaver population assessment on the River Avon and tributaries

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Project details

This report was commissioned to inform Natural England's advice to government on the reintroduction of beavers in England.

Outside of the River Otter and the enclosures, at least 75 territories of wild-living beavers are believed to exist in England, comprising a total of approximately 350-400 beavers. There is little known about the distribution, population size and origins of these beaver populations. Beaver reintroduction is a topic of increasing interest in England and with the future of wild reintroductions yet to be decided – it is paramount that data is gathered to further understand these populations.

The findings will be used to promote co-existence with beavers throughout the Avon and Frome catchments, understanding their impacts, development of a management strategy and for further research on the genetic origins of the beaver population.

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

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Executive Summary

Following increasing reports of beavers in Somerset and Wiltshire, Natural England commissioned a survey of beaver activity in the River Avon catchment. Surveys were conducted during January-March 2022 on canoe and foot, covering approximately 280km of channel length. Beaver activity (field sign types) was recorded at a 10m resolution. The areas covered included the Avon upstream of Bath, including the Kennet and Avon Canal, the Somerset Frome, By Brook, Semington Brook, Biss Brook (all part of the Avon catchment) and upper reaches of the River Brue.

A total of 771 beaver activity signs were recorded (Table 1). The Avon and Frome sub-catchments contained the most signs whereas no beaver signs were found on the Biss Brook, the River Brue, or the Kennet and Avon Canal. Recorded signs included 13 lodges, four burrows and 20 dams. Burrows will be under recorded because entrances are usually underwater and detection during the normal higher winter water levels is difficult.

From the distribution of beaver signs, 13 established territories are estimated, with an additional six temporary resident individuals, which may go on to form territories. Based on the number of territories, a population of around 50 beavers, excluding kits, is estimated (49 ± 13 within the established territories and potentially six other individuals). Not all locations were accessible to survey and therefore it is likely that some territories were not recorded. As a result, the above population estimate is possibly an underestimate.

These beaver territories occupy a total of 4-11% of the available bankside in the watercourses with a typical bankside length of 7.8km (nearly 4 km watercourse length) per territory. This is higher than reported in some established populations. It appears that beavers have only become established recently in the area, probably since 2016, though possibly earlier. Most beaver activity appears to be more recent (since 2020).

Few management issues were noted, probably because the population is in the early establishment phase. Such issues may increase and a mitigation approach to dealing with these will be needed if we are to live alongside these animals and realise the benefits that they can bring to our environment.

1. Introduction

In the last few years there have been increased reports and validated records of beaver (Fig 1.) sightings and signs across areas of Cornwall, Devon, Somerset, Wiltshire, Kent, and the Wye valley in Wales (see Haydon and others 2021). Assessments of the distribution of beavers and the abundance of these populations are of great importance to understand the impacts (both positive and negative) that these populations of beavers may bring, and to consider the management options going forward, particularly in light of the 2021 national public consultation by Defra on the approach to further beaver reintroductions and their management in England (Defra 2022).

Objectives

The objective of this survey was to provide Natural England with baseline data on the populations of beavers in the River Avon (including By Brook, River Frome, and Kennet & Avon Canal) and River Brue. Specifically:

- Spatial data detailing the location and distribution of beavers.
- An estimate of beaver population size within the Avon catchment.
- An estimate of the number (and location) of beaver territories in the Avon catchment.

To achieve these objectives, it is not necessary to identify every sign of beaver activity in the area (see Data recording).

The aim of the project is to provide key data to facilitate an understanding of beaver population/s in this area, and thus to support necessary future management decisions.

Knowledge of beavers in the area prior to the survey

Heydon and others (2021) provide a detailed overview of beaver records within the River Avon catchment and the River Brue up to 2021. The earliest records are of a deliberate release of beavers into a pond in the upper River Frome near North Brewham and Witham Friary around 2009, and escapes from a private collection into the By Brook near Castle Coombe in the early to mid-2000s. However, it was not until 2019 that the presence of beavers in the River Frome were reported to Natural England, mainly in ponds upstream of the town of Frome and in two tributaries near the town: the Mells River and Rodden Brook. Reports were also received of beaver signs in the upper reaches of the River Brue, which is a separate catchment but with headwaters close to those of the River Frome.

In 2020, sightings of beaver were reported on the River Avon between Bathford and Bathhampton, and possibly in the vicinity of Bath. Additional unconfirmed reports came from the Kennet & Avon Canal in Bath. In 2021, there were further records on the River Avon (east of Chippenham), the By Brook (near Castle Combe), and adjacent to the

Semington Brook (Urchfont near Devizes). Heydon and others (2021) speculated that the latter was likely from a deliberate release.

Figure 1. Image of adult Eurasian beaver (*Castor fiber*). © Elaine Gill

2. Methods and approach

2.1. General approach

A field survey was undertaken over winter (19th January to 26th February 2022), when the vegetation had died back, and beaver signs were readily visible. Surveys were carried out from canoe or on foot, depending on channel navigability and access. 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. To cover a large area within the survey period available, surveying by canoe offered the most efficient method, and was used wherever possible. Non-navigable channels were surveyed on foot. Surveyors recorded all beaver signs, including structures (lodges, dams, and burrows), throughout the planned survey area, following standardized methodology (as described in Campbell-Palmer and others, 2020, and used previously by Campbell and others, 2012 in Tayside, Scotland).

2.2. Survey area

Beaver records were sourced by Natural England. These records were provided by members of the public, Bristol Avon and Frome Beaver Management Group, Natural England and Environment Agency staff and were verified and validated as beaver signs or sightings. The surveyors sourced the latest beaver records within this area from National Biodiversity Network (NBN) and iRecord prior to commencing the survey and collated these with records provided by Natural England. Aerial photography, available through Google/Bing mapping, was also used to identify the location of suitable beaver habitat and further define priority areas for survey.

The survey area included:

- River Avon (centre of Bath to Chippenham), including the following tributaries: the Lam Brook, St Catherine's Brook, Midford Brook, River Biss, Semington Brook, South Brook, Cocklemore Brook, Wid Brook, Pudding Brook and River Marden.
- By Brook, including the following tributaries: Broadmead Brook, Domcombe Brook, Lid Brook.
- River Frome, including the following tributaries: Henhambridge Brook, Mells River, Redford Water and Longleat House lake.
- Kennet and Avon Canal (Bath to Dundas Aqueduct by canoe and Dundas Aqueduct to Devizes on foot).
- River Brue.

Natural England provided the landowner permissions for the survey. Landowners were identified using internal mapping software called Webmap2 which uses Rural Payments

Agency (RPA) data and identifies owners of field parcels or holdings. From this landowners were identified and contacted to gain permissions for the survey.

2.3. Survey methods

The field survey followed the methods first established by Campbell and others, 2012 for beavers in Tayside, Scotland. This method was later modified by Campbell-Palmer and others, 2020 with additional data collected (Table 1). These modifications are incorporated into this survey.

In essence, the method maps the distribution of field signs to estimate the location and limits of beaver territories. This is a usable method for beavers because they live in family groups, with only one breeding pair in the group, and defend territories against other beavers (Wilsson 1971).

Activity types were designated as set out in Table 2. The length (bank to bank in m) and height (on downstream side in m) of dams above water level were measured and recorded. Beaver cut stems were classed as ‘old’ or ‘fresh’ as described in Campbell and others (2012), with ‘mixed’ indicating both ‘old’ and ‘fresh’ signs. The age of other activity signs were classed as ‘fresh’ if there was evidence of recent activity and ‘old’ if not. Again, ‘mixed’ was used to indicate where the activity appeared old but showed additional signs if recent activity. This was a qualitative assessment relying on the experience of the surveyors and intended to provide broad insight into the duration of occupation at a site. In general, ’fresh’ activity may indicate the presence of beavers within the past few months to a year depending on environmental conditions whereas ‘old’ activity may be several months to several years in age.

Table 1: Recorded data, following Campbell and others, 2012. Numbers 9 and 10 are additional data collection following Campbell-Palmer and others, (2020). Classifications of activity types are given in Table 2. For number 9, it is essential for later analysis that the three categories are recorded as 'Low', 'Med', 'High' (for definitions see Campbell-Palmer and others 2021).

N	Recorded data
1	Activity type
2	Location (or waypoint from the original GPS file)
3	Photo file name (if appropriate)
4	Estimated age (categorised as Fresh or Old or a mixture of both, see Annex 2 in Campbell et al. 2012)
5	Distance from water (m)
6	Area affected (in m along the river bank up to a maximum of 10m)
7	River width and approximate depth (m)
8	Land use (on the river bank and in the surrounding area)
9	Effort expended into the activity by beaver (low, medium or high)
10	Management impact (low, medium or high)
11	Other notes and observations

Table 2: Description of activity types following Campbell and others, 2012 and Campbell-Palmer and others, 2020.

Code	Activity type	Description
C	Woody feeding	Cutting or gnawing of woody vegetation (shrubs, saplings and trees)
H	Soft feeding	Feeding on herbaceous or aquatic vegetation. These can include leftover plant material at the water's edge (particularly for aquatic vegetation) unless these constitute a feeding station (see below).
Ag	Crop feeding	Feeding on agricultural crops. The area affected measured as m^2.
D	Dam	Dams classified as active maintained or old breached. Height and width measured in m
Ca	Cache	Cut, stored woody vegetation
Di	Canal / Digging	Beaver digging into substrate or creation of canals leading inland to access more foraging grounds
Bu	Burrow	Entrances may be abbe below normal water levels and extend inland
L	Lodge	Burrows where next chamber has breached the surface and has been built up with sticks and mud
SM	Scent mound	Pile of material (usually mud) scrapped together with scent deposited
SS	Scent site	A small area of multiple scent mounds
FS	Feeding station	Area at the water's edge where beaver repeatedly takes material to feed
FT	Feeding trail	Created by the frequent passing of a beaver on land running from water inland.
B	Beaver	Sighting of a live beaver

Waterways were prioritised for surveys based on beaver records, gross assessment of habitat suitability from aerial mapping data, and access. Priority areas were subject to a full, contiguous, survey (via canoe or on foot) for field signs, where access allowed (see 2.4). When canoeing, both banks could easily be surveyed. Where the survey was conducted on foot, watercourses were narrow enough that both banks could be surveyed by walking one side. Where possible, beaver activity detected from canoe was followed up with a repeat visit on foot to check for signs inland that could have gone undetected. Additional spot checks were undertaken beyond the main (priority) survey area and at locations where access was limited. Spot checks were conducted at the most appropriate points (eg, where there may be backwaters, associated riparian woodland etc) or where public access allowed. If beaver field signs were detected, then the immediate vicinity was surveyed for further signs, subject to access permission. If subsequent survey suggested a resident beaver/beaver group, then a full survey of that stretch of river/stream was undertaken, were possible (dependent on time limitations and access permission, see 2.4). In total, 113 survey legs were covered (84 on foot and seven from canoe) and an additional 22 spot-checks were conducted. Excluding spot-checks (where distance covered was not recorded), 280.8km of channel was surveyed, representing 747km of bank-length (Fig. 1). See Annex A1 for a complete survey log.

2.4. Survey Access Limitations

Some areas were not surveyed due to access restrictions, representing about 38km of channel length (<12% of the total survey area). These are summarised in Table 3. For rivers, small gaps in the survey of <2km channel length where no beaver signs were detected immediately upstream or downstream, are unlikely to have resulted in missed beaver group territories because group territories on rivers are typically larger than the gap (Campbell and others 2005, see also Results). Beaver groups living on ponds may have much smaller territories, possibly only encompassing one pond where this is poorly connected to nearby waterways (RD Campbell, pers. obs., see also Rosell and Campbell-Palmer 2022). Where ponds were missed as a result of access restrictions, this could have therefore resulted in a territory being missed.

Table 3. Total channel length by river of areas not accessible by any means during the survey.

River	Length (km)
River Frome	2.4
River Brue	2.7
By Brook	1.6

River	Length (km)
Rodden Brook	1.2
Redford Water	1.1
Lam Brook	1.4
Cam Brook	5.6
Midford Brook	2.1
Semington Brook	3.7
Semington Brook tributaries	3.2
River Biss / Biss Brook	6.8
Henhambridge Brook	0.4
Mells Stream / Mells River	5.1
Doncombe Brook	0.3
Total	37.6

Other areas with land access restrictions were still surveyed from canoe. This included a stretch on the River Avon between Dundas Aqueduct (ST 785 625) and Avoncliff (ST 804 600), a distance of about 4.7km, and on the River Frome at Beckington from ST 78883 51654 to ST 79540 52099, a distance of 1.3km. It is unlikely that a group territory would have been missed using this method, unless a group lived in a pond near the river and used the river only rarely.

2.5. Data recording

The locations of all beaver activity signs were logged on a GPS device as they were detected, with a 10 m resolution (as detailed in Campbell and others, 2012 and Campbell-Palmer and others, 2020): All signs within a 10 m stretch of riverbank were logged under the same GPS waypoint, and signs located over >10 m riverbank length were logged at 10 m intervals until no more signs were identified. This approach allowed the classification of large stretches (up to hundreds of meters) of continuous beaver activity of the same feeding intensity (low, medium, high) efficiently. Point data (eg, location of lodges, dams,

and burrows) were also recorded. Water courses were surveyed for field signs at least 2 km from the last recorded beaver field signs, where access permitted. A subset of field signs was digitally photographed (Fig. 2.).

Figure 2. Images of beaver field signs that have been photographed; A (left) Fresh beaver feeding activity on a mature tree River Frome © Laura Dalton; B (top right) Constructed beaver lodge River Frome © Giles Wagstaff, C (Bottom right) Partially submerged entrance to a beaver burrow, River Avon © A. Rothwell

2.6. Data analysis (territory delineation and population estimation)

Mapping was undertaken in QGIS v3.4.12. Automated territory estimation was conducted using the beavertools package (Graham 2021) in R (version 4.1.2, R Core Team 2021).

We used Ordnance Survey 'Open Rivers' and 'Vector Map District' data (both 1:15,000 to 1:30,000) for base mapping. To calculate watercourse bank length, we buffered the Open Rivers 'watercourse link' line data by 0.1m to create a polygon and merged this with the surface water area polygon from 'Vector Map District' to create a single polygon feature ('watercourse_poly'). Bank and channel length measurements were obtained by clipping the 'watercourse link' or 'watercourse_poly' with other polygon features of interest (eg, territories, search areas and inter-catchments) and measuring the polygon perimeter. Channel length values from 'watercourse_poly' may underestimate channel lengths on some occasions because some surveyed water features are not included in this dataset (eg notable ponds, some lakes and smaller water features). In contrast, bank length values from 'watercourse_poly' will slightly overestimate bank length because they include the width of the watercourse channels at the edges of the feature they are clipped with.

The widest channel within the area surveyed, the Avon at Bath, is approximately 20m wide. This overestimate would therefore be up to approximately 40m per polygon but typically less. This would have the most significant effect on the smallest polygons, which were the territories, where this represents ≤0.25% of the average territory bank length (see results). For spot checks, channel and bank lengths are only given if the length was recorded, with bank length assumed to be 2× channel length (Annex A1).

Catchment boundaries were obtained from the Environment Agency website. For the purposes of data analysis and presentation, the surveyed watercourses were grouped into six sub-catchments. These sub-catchments were the Avon (from below Bath to Chippenham and including the river Marden); Biss Brook (from the confluence of the Avon to south of Westbury); the Brue (an entirely different catchment from the other sub-catchments, south of the river Frome); By Brook; Frome (including Redford Water, Mells Stream and Longleat); and Semington Brook (Figure 3).

Territory estimation

We estimated the number of beaver territories based on identification of clusters of field signs. We used two methods for this. Firstly, manual estimation, following Campbell and others (2012). 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 since beaver territories can contain several of these. In a low density, expanding population, Hartman and others (1995) found that beavers groups were initially far apart, and it was only later that gaps between groups were in-filled by new recruits. In a high density, established population, when 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 and others 2005).

Since the population in the Avon catchment is relatively new (see results below), we used clusters of beaver activity signs (covering a suitably large area, eg, 2 ± 1 km of river length, see Campbell and others 2005) to delineate individual groups, assuming that gaps with few or no signs between aggregated beaver signs indicated gaps between groups.

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.

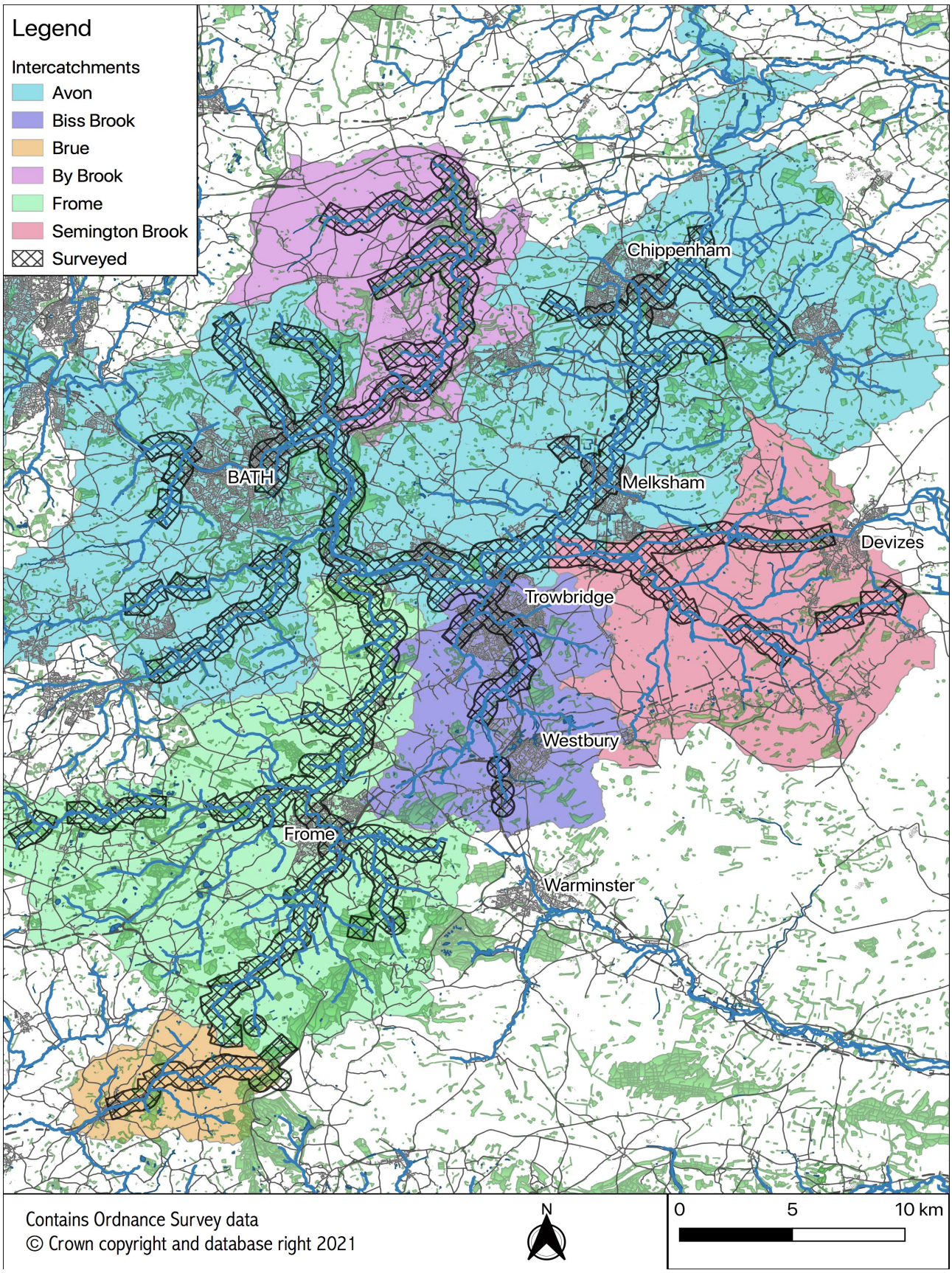

Figure 3. Map of the surveyed area showing the sub-catchment classifications. Survey sections are presented with a 500m buffer and therefore will extend beyond the survey limits by that distance. Contains Ordinance Survey Data. © Crown copyright and database right 2021.

Care should be taken to not confuse a gap in suitable foraging habitat (which may result in a gap in activity signs) with a gap between groups (Campbell and others 2005) and, therefore, gaps in the distribution of signs were cross-referenced with habitat type (particularly an absence of woody vegetation) using field notes and online aerial mapping (Google Maps and Bing).

Based on the amount of activity recorded, beaver territories were further classified as ‘group territories’ (indicative of a resident pair or family) and ‘single territories’ (most likely a temporary resident individual). Whereas ‘group territories’ typically show many recent foraging signs and several key signs such as lodges, dams, burrows and feeding stations, ‘single territories’ are characterised by very few or sparsely distributed feeding signs or key signs, none of which include new lodges, dams or scent sites. The absence of suitable habitat or forage species is considered when identifying low activity areas as ‘single territories’. Single animals may go on to pair and establish a group territory at the location, but at the time of the survey there was no evidence this had occurred.

The second method used involved conducted automatic territory estimation using beavertools, which defines territories using kernel density plots from beaver activity sign data (as in Campbell-Palmer and others 2021), refining these using additional information on location of key signs (lodges/burrows, dams, food caches, scent mounds, feeding stations and digging). Beavertools ascribes a status to each territory as follows: ‘Territory’ (a group territory); ‘Possible’ (analogous to the ‘single territory’ from manual estimation, though possibly a group territory that needs expert review) and ‘Activity’ (not a territory, but an activity hotspot).

Following Campbell-Palmer and others (2021), we created a foraging density raster in beavertools using all recorded fresh and mixed field signs. Grid size was 20 map units (m), kernel bandwidth 250 and weights (for beaver activity effort) set to 1, 1e+03 and 1e+06.

The code used was:

forage density([*all fresh and mixed data*],impact cat="[*Beaver Activity effort*]", grid size=20, kern_bw=250, kd_weights=c(1,1000,1e+06), low thresh=1e-10,standardise=TRUE)

This was then combined with fresh and mixed key signs to estimate territories. For territory estimation, we set the threshold to 1e-10 – 0.95.

The code used was:

estimate territories([forage *density raster*], [*key fresh and mixed signs*], low thresh = 1e-10, upper thresh = 0.95)

These two methods were then combined so that territory status was set manually, and territory extents were defined by beavertools (effectively the smoothing function of the kernel density estimation used by beavertools), except where territory edges crossed onto adjacent, but not connected, watercourses for which we had no evidence of use.

Population estimation

We estimated the total number of beavers present based on the number of family groups ('territories') inferred, with likely family group size assessed on the basis of Rosell and Parker's (1995) 3.8 ± 1.0 SD individuals per group. This figure was based on a review of 13 published studies, which vary in methodology, and Campbell-Palmer and others (2021) argue that this value may be too low. One key aspect of the 3.8 figure is that the inclusion of young-of-the-year (kits) is not necessarily clear. Surveys conducted in the spring and early summer will exclude kits because they have not yet emerged. Surveys conducted later in the year may include kits. Older offspring may have dispersed by this later period too, but these may have established new territories or moved into already established territories. Two more recent studies provide figures for group sizes excluding kits: Campbell and others (2005), 4.5 animals per group in an established population in Telemark, Norway, and Campbell-Palmer and others (2015), 3.0 animals per group in an establishing population in Tayside, Scotland. The mean of those two studies is 3.75 ± 1.1 SD individuals per group, which provides some justification for using Rosell and Parker's (1995) figure as a mean group size excluding kits.

Table 4. Beaver signs recorded, split by type, age class and river sub-catchment. Biss Brook and Brue are not included here because no signs of beavers were recorded.

Signage	Sign code	Sign	Avon	By Brook	Frome	Semington Brook	Total
Fresh	Bu	Burrow	1	0	1	0	2
Fresh	C	Woody feeding	199	20	53	21	293
Fresh	D	Dam	0	1	12	0	13
Fresh	Di	Digging	0	0	2	0	2
Fresh	FS	Feeding station	14	1	7	2	24
Fresh	FT	Feeding trail	9	0	8	0	17
Fresh	L	Lodge	2	1	5	0	8
Fresh	SM	Scent mound	3	0	1	0	4

Signage	Sign code	Sign	Avon	By Brook	Frome	Semington Brook	Total
Fresh	**Total**	**-**	**228**	**23**	**89**	**23**	**363**
Mixed	Bu	Burrow	0	0	2	0	2
Mixed	C	Woody feeding	100	24	33	2	159
Mixed	D	Dam	0	0	2	0	2
Mixed	Di	Digging	0	1	2	0	3
Mixed	FS	Feeding station	2	0	4	0	6
Mixed	FT	Feeding trail	1	4	2	0	7
Mixed	L	Lodge	0	1	1	0	2
Mixed	**Total**	**-**	**103**	**30**	**46**	**2**	**181**
Old	C	Woody feeding	135	19	55	5	214
Old	D	Dam	0	0	5	0	5
Old	Di	Digging	0	0	2	0	2
Old	FS	Feeding station	1	0	2	0	3
Old	L	Lodge	2	0	1	0	3
Old	**Total**	**-**	**138**	**19**	**65**	**5**	**227**
All	**Total**	**-**	**469**	**72**	**200**	**30**	**771**

Previously, evidence of single animals has been ignored for the purpose of population estimates since these may be beavers temporarily living away from their natal group.

However, there may be some justification in including these individuals in population estimates for new populations where it appears that the individual may be resident but has not paired with another beaver (perhaps because of the low population density). See results below.

3. Results

3.1 Beaver activity signs

A total of 771 beaver activity signs were recorded between January and March 2022 (Table 4). The Avon and Frome sub-catchments contained the most signs whereas no beaver signs were found on the Biss Brook or the River Brue.

Table 5. Characteristics of dams recorded during the survey.

Sub-catchment	Age	Water-course width	Water-course depth	Surrounding land use type	Length (m)	Height (m)
Frome	Old	-	-	Woodland	2	0.2
Frome	Old	-	-	Woodland	2	0.2
Frome	Old	-	-	Woodland	3	0.1
Frome	Old	-	-	Woodland	-	-
Frome	Mixed	-	-	Lake / Woodland	10	0.3
Frome	Fresh	-	-	Lake / Woodland	5	0.2
Frome	Fresh	-	-	Wetland / Rough Grassland / NR	10	0.2
Frome	Fresh	-	-	Woodland	6	0.4
Frome	Fresh	-	-	Woodland	20	0.5

Sub-catchment	Age	Water-course width	Water-course depth	Surrounding land use type	Length (m)	Height (m)
Frome	Fresh	3.5m	> 2m	Wetland / Urban	5	2
Frome	Fresh	1.5 to 2m	0.5m	Woodland / Grazing / Rough grass	5	0.3
Frome	Fresh	2m	0.5m	Woodland / Grazing / Rough grass	3	0.3
Frome	Fresh	1.5 to 2m	0.5m	Woodland / Grazing / Rough grass	2	0.5
Frome	Fresh	1.5 to 2m	0.5m	Woodland / Grazing / Rough grass	1	0.2
Frome	Fresh	30x20m pond	>1m	Lake / Woodland / Rough grass	2	0.2
Frome	Fresh	30x20m pond	>1m	Lake / Woodland / Rough grass	6	0.1
Frome	Old	1m	0.5m	Woodland / Rough grass	2	0.2
Frome	Fresh	50x30m pond	>1m	Lake / Woodland / Rough grass	2	0.2
Frome	Mixed	1.5m	0.5m	Urban / Grazing	-	-

Sub-catchment	Age	Water-course width	Water-course depth	Surrounding land use type	Length (m)	Height (m)
By Brook	Fresh	8 to 10m	1.5 to 2m	Rough grass wetland / Woodland	6	0.1
Mean	-	-	-	-	5.1	0.3
SD	-	-	-	-	4.6	0.4

A total of 13 lodges and four burrows were recorded. However, it is likely that many burrows went undetected because burrows normally have entrances below the water. As this survey was conducted in winter, no soft feeding (on herbs, grasses etc) or feeding on crops was recorded. The most common sign was feeding on woody plants (666 of the recorded signs). All but one of the 20 dams recorded were found in the Frome sub-catchment (Table 5). Sizes ranged from 1-20m (see Fig. 4) in length (mean 5m, median 4m) and 0.1-2m in height (mean 0.4m) (Table 5). None of the dams were associated with farmland used for arable or other high value crops.

Figure 4. An impressive dam of approx. 20m in length in woodland in the Frome sub-catchment (territory 'Frome 6'). © A. Rothwell

As is typical for beavers, most beaver activity was close to the water's edge (e.g., see Haarberg and Rosell 2006), with over 80% of signs within 1m, 95% within 5m and none over 30m from water (Fig. 5).

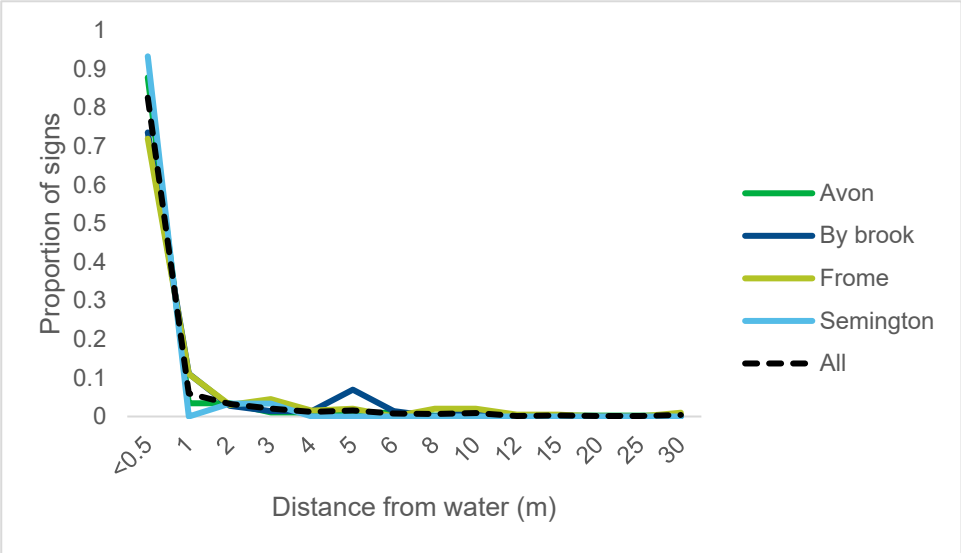

Figure 5. Proportion of beaver activity (signs recorded) with distance from water, and summarised by sub-catchment.

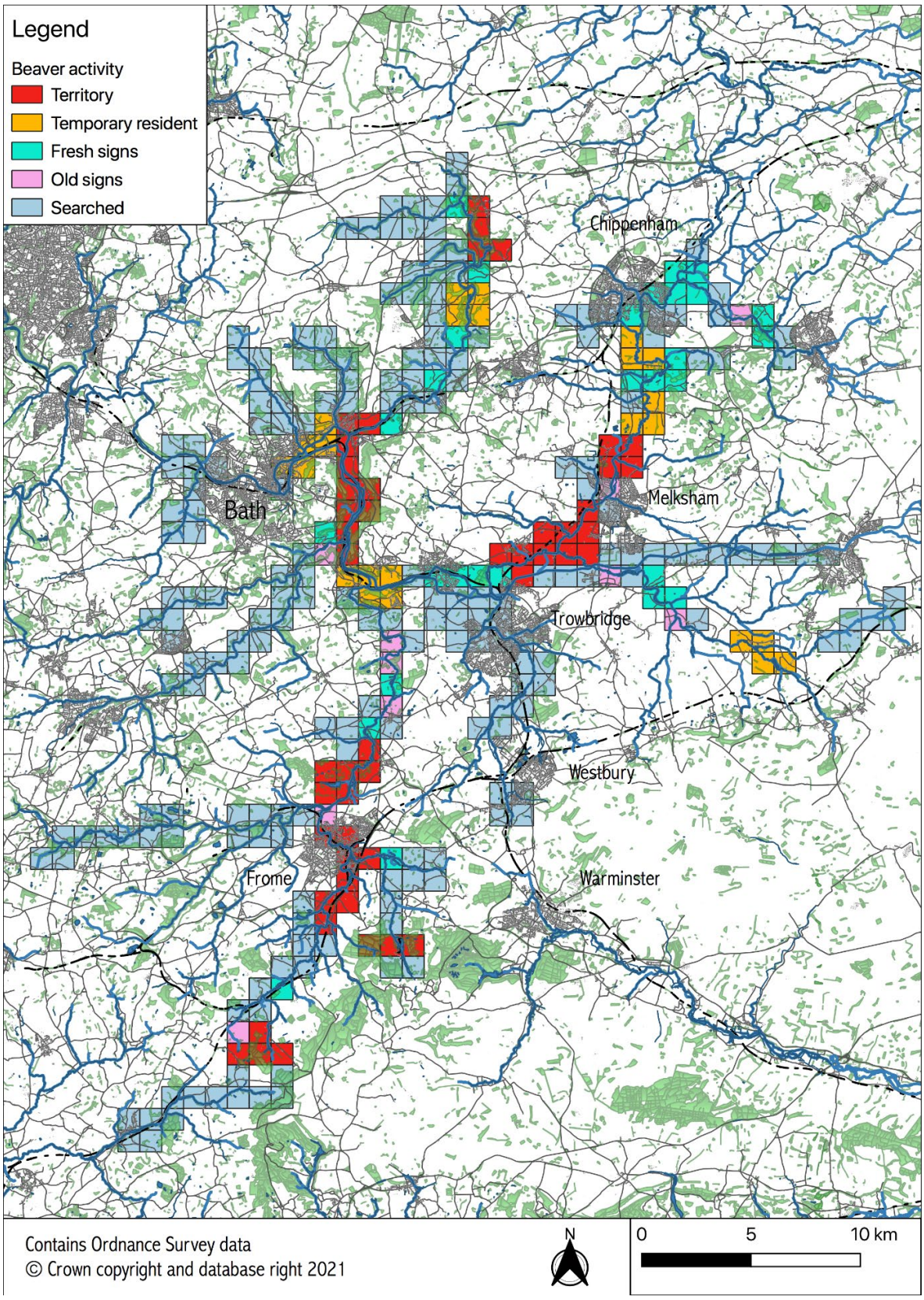

Figure 6. 1km resolution overview of beaver activity in the surveyed area. Grid squares are classified according to the most significant level of activity that falls within the square (descending order in the map legend). 'Searched' means no activity was recorded. A finer scale version is provided in Annex A2. Contains Ordinance Survey Data. © Crown copyright and database right 2021.

3.2 Beaver territories

Number of territories

Our estimate is of a total of 13 beaver group territories in the areas surveyed, with an additional six temporary resident individuals, which may go on to form territories (Table 6, Fig. 6, Confidential annex C1). Manual (expert-led) and automatic (beavertools) territory estimates were very similar, but not identical (Table 4, Confidential annex C2). Beavertools estimates are usually adjusted following expert review (see Campbell-Palmer and others 2021) and are included here for interest and for comparison with other surveys that adopt the estimation approach. Detailed maps of beaver signs and territories are provided in Confidential annex C3.

Table 6. Numbers of group territories and single animal or possible territories estimated by manual (expert-led) and automatic (beavertools) methods. Note that some territories cross sub-catchments, e.g. most notably one territory centred on the Avon also occupies the lowest reach of Semington Brook.

Sub-catchment	Manual group territories	Automatic territories	Manual single animal territories	Automatic possible territories
Avon	4	6	4	1
By Brook	1	2	1	0
Frome	8	8	0	0
Semington	0	1	1	0
All	13	17	6	1

Territory occupancy

The 13 territories occupy 11% of the watercourses surveyed (Table 7), though only 4% of the total available watercourses in the sub-catchments. The Frome sub-catchment contained the most territories and the greatest proportion of watercourse occupied.

Table 7. Sub-catchment level summaries of occupancy by territories. Note that some territories cross sub-catchments (see Table 4).

Sub-catchment	Total bank length (km)	Searched bank length (km)	Total territory bank length (km)	% searched occupied by territories	% total occupied by territories	Total temp resident bank length (km)
Avon	1055	359	39	11%	4%	40
Biss Brook	179	54	0	0%	0%	0
Brue	77	28	0	0%	0%	0
By Brook	156	129	13	10%	8%	6
Frome	556	233	43	18%	8%	0
Semington Brook	301	95	5	5%	2%	16
All	2326	901	101	11%	4%	64

Territory sizes

The mean group territory size, as estimated by bank length, was 7.8km (Table 8). Single territories, with a mean of 10.6km bank length, were larger, but not significantly so (Welch two-sample t-test, t=-1.21, df=11.56, n=19, p=0.250). Territory sizes varied greatly however, from <1km bank length to over 20km. Smaller territories were associated with lakes, ponds and small watercourses (streams and ditches), whereas larger territories were found in the main channels of the Avon and Frome rivers. The mean river territory size was 10.9 ± 4.1km compared with 2.7 ± 1.3km for other territories. This size difference was significant (t=-5.20, df=9.12, n=13, p<0.001).

All territories not on rivers were associated with one or more dams, with dams recorded in only two of the eight river territories (none on the main river channel). Mean territory size

for territories with dams was 5.6 ± 4.5km versus 9.6 ± 5.6km for those without. This difference was not statistically significant (t=1.42, df=10.98, n=13, p=0.184).

Table 8. Summaries of length (bank length, approx. 2× watercourse length) for each group territory and single (temporary resident) activity area. See Confidential Annex C3 for territory maps.

Status	Name	Bank length (km)	Water-course type	Damming noted	Notes
Territory	Avon 2	7.1	River	No	-
Territory	Avon 3	11.8	River	No	Split from Avon 2 on the basis of size, activity levels and scent mound locations.
Territory	Avon 5	20.3	River	No	Large territory at the confluence with Semington Brook.
Territory	Avon 6	8.2	River	No	Based on long-term foraging activity only.
Territory	By 2	11.1	River	Yes	-
Territory	Frome 1	9.4	River	No	Split from Frome 2 on the basis that movement between the Frome and lake is very difficult.
Territory	Frome 2	3.4	Lake	Yes	Limited access to view site.
Territory	Frome 3	11.4	River	Yes	Most likely one group. Breeding in 2020 & 2021 (camera trap images of a kit both years).
Territory	Frome 4	8.3	River	No	-
Territory	Frome 5	2.1	Lake	No	Breeding known from camera trap images in 2020 and 2021 (at least one kit in each year).

Status	Name	Bank length (km)	Water-course type	Damming noted	Notes
Territory	Frome 6	3.6	Stream	Yes	Limited access but lots of activity reported. Beavers since at least 2021.
Territory	Frome 7	3.8	Lake	Yes	-
Territory	Frome 8	0.6	Ditch	Yes	-
Territory	Mean	7.8	-	-	-
Territory	SD	5.3	-	-	-
Single	Avon 1	13.2	River	No	Based on forging signs only.
Single	Avon 4	13.6	River	No	Based on foraging evidence alone. Possibly a group territory.
Single	Avon 7	6.3	River	No	New resident or possibly group with Avon 6.
Single	Avon 8	7.9	River	No	-
Single	By 1	6.0	River	No	-
Single	Semingt on 1	16.7	River	No	Limited access so extent not known. Possibly a group territory if more activity outside survey area.
Single	Mean	10.6	-	-	-
Single	SD	4.4	-	-	-

3.3 Beaver management issues

Very few beaver activity signs were associated with anything other than low impact for the landowners (Table 9), as assessed by the surveyors. All medium-high impact activities were associated with the Frome sub-catchment. Of those, most were from woody feeding (9 high impact and 5 medium impact). No dam was classed as having a high impact, although two dams were classed as having a medium impact, both for the same landowner. One was a result of the dam blocking a culvert under an access track, requiring the landowner to remove the structure repeatedly (Fig. 7). The other was due to flooding caused across an access track (Fig. 8). One lodge had potentially high impact because it was situated next to a jetty on a lake where guests can swim. Swimming very close to an active beaver lodge during summer is not recommended because beavers may defend the area from other animals in the water, with attacks on human swimmers and dogs recorded (Rosell and Campbell-Palmer 2022). Such incidences are very rare, however. The owner has since cordoned off the lodge to keep swimmers at a safe distance. At the same site, tree felling around the lake was causing some problems for the landowner. Protecting selected individual trees against felling by beavers using weldmesh or Wöbra™ paint is a relatively simple solution for this (Campbell-Palmer and others 2016). An additional future management issue noted during the survey was the proximity of suitable sections of the River Avon to a railway line, where tree felling onto the line could present a risk to trains, as will trees felled near roads for road users (Campbell-Palmer and others 2016; Rosell and Campbell-Palmer 2022).

Table 9. Summary of management impacts associated with beaver activity signs as assessed by the surveyors.

Sub-catchment	Low	Medium	High	Total
Avon	469	0	0	469
By Brook	72	0	0	72
Frome	177	8	15	200
Semington Brook	30	0	0	30
All	748	8	15	771

Figure 7. Dam at a track culvert resulting in some management issues. © A. Rothwell

Figure 8. Dam flooding a track resulting in some management issues. © A. Rothwell

4. Discussion

4.1. Number of territories and population estimate

Based on the 13 territories identified, we estimate population size as 49 ± 13 individuals. There were an additional six locations where single animals were suspected of having recently moved to. Arguably, for low density populations such as this, single resident animals are more likely (R. D. Campbell, pers. obs.). Counting these individuals separately would bring this figure to 55 individuals.

The surveyors were not granted access to all watercourse sections that were suspected of holding beavers based on habitat. Therefore, the total number of territories in the area may be higher than estimated here. The amount of beaver habitat not surveyed by any method was nevertheless a small proportion of the total surveyed (<12%). Most gaps in the survey were too small to miss beaver groups on rivers but groups living on ponds could have been missed. The impression of the surveyors from speaking to landowners who declined access was that access was most commonly denied because the landowner did not believe there to be beavers on their ground. Therefore, the number of beaver group territories undetected during the survey is likely to be very low.

The beavertools R package provided a similar overall territory estimate to that obtained via manual delineation of field signs. The main differences were that this automatic system tended to combine some territories that were close together (reducing the total number of territories) and allocate territory status to locations where there were just one or two key signs (therefore increasing the total number). The latter issue presumably arises because all key signs are given equal weight. However, whilst some key signs such as lodges, dams, burrows, scent mound sites (aggregates of scent mounds) and digging, are clearly indicative of resident beavers, others such as individual scent mounds, feeding stations and feeding trails could be created in a very short timescale by an individual, non-resident beaver. An improvement to the beavertools package would be to allocate weights to key signs so that construction activities and scent mound sites are given much greater weight and other key signs are given lesser weight.

4.2. Overall assessment of beaver activity

Two of the territories in the Frome sub-catchment (Frome 3 and 5) were reported to have seen activity since at least 2020, according to the managers responsible for the land where these territories are located. Given breeding occurred in both territories in 2020, it is possible that beavers arrived at these locations in 2019. Based on evidence from beaver-cut saplings, these could be among the earliest beavers in the area. Most of the woody feeding classified as ‘old’ during the survey were estimated to have been cut within the last two years, although reliable identification of cut age is difficult as the rate of discoloration at the cut depends on local climatic conditions. The Frome sub-catchment contained most of the oldest signs (see Fig. 9 for an example), whereas very few older signs were found in

the upper reaches of the Avon, By Brook or Semington Brook. For comparison, Fig 10 shows the typical age range of most signs elsewhere. The Frome also contained the most established territories, with no temporary resident or single animal territories. Overall. the data suggest that most of the beavers in the Avon catchment came from releases or escapes into the Frome, which fits with Haydon and others (2021) reporting of beaver releases in the upper Frome around 2009. The few old signs and lack of many territories in the By Brook suggest that escapes near Castle Coombe in the early to mid-2000s may not have led to beaver establishing there. However, it is also possible that some individuals came from more recent additional releases or escapes into the River Avon and By Brook, in addition to the Semington Brook release reported in Haydon and others (2021).

Despite their being records from the River Brue prior to the survey, the lack of evidence for beaver presence there during the survey suggests that these records come from one or two individuals. In the absence of other beavers to pair with, it is likely that the beaver(s) in the River Brue, if still there, are moving widely in search of a mate and will be difficult to locate without the help of opportunistic records from the public.

Figure 9. The oldest (based on appearance) beaver felling activity recorded, this example from the Frome. This is one of the few signs that look to be older than two years.
© A. Rothwell

Figure 10. Mixed age feeding signs from the River Avon, showing a fresh cutting to the right and older cuttings to the left. Most 'old' foraging signs looked younger than this example. © A. Rothwell

4.3. Long-term prospects for beavers in the catchment

The Avon catchment contains many watercourses, lakes and ponds that are suitable for beavers. With the current population of an estimated 13 territories, it is reasonable to expect the population to increase without further human intervention. However, if the population is to be supported, we would recommend attention is paid to ensuring that genetic diversity is maximised (Sarrazin and Barbault 1996). This could be achieved by conducting genetic testing (McEwing and others 2015) on some individuals to assess the likely source(s) and supplementing the population using individuals from other areas.

The population in Tayside appears to have followed a classical sigmoid population growth curve, with population growth rate (as measured by number of territories) initially slow, before increasing to a current annual rate of 30% (Campbell-Palmer and others 2021). The Tayside population is thought to have resulted from escapes or releases in the early 2000s and so this slow growth phase may have continued for nearly 20 years. Assuming that the 2009 releases in the Frome were the main source of the current population in the Avon catchment, it is likely the beavers there are still at the slow growth phase, though the growth rate may be increasing.

As the population expands, alongside the environmental benefits that the beavers bring (eg, see Stringer & Gaywood 2016; Puttock and others 2018; Law and others 2019; Howe

2020; Larsen and others 2021; Puttock and others 2021), there will be increasing conflict with some land-uses (Howe 2020; NatureScot 2021). In addition, the Kennet and Avon Canal, though currently unoccupied by beavers, is adjacent to several rivers containing beavers and has some suitable habitat. Much of the canal lining appears to include metal reinforcement, which would stop beaver burrowing into the banks and may stop territories establishing. However, where there are bays with suitable forage and unlined banks, beavers are likely to establish territories. Burrowing by beavers into the canal bank may create problems and mitigation to protect such banking can be expensive (see Campbell-Palmer and others. 2016, p59). It will be important to ensure that appropriate expertise and mitigation methods, alongside a management strategy and support system, are available to allow landowners to adapt to the presence of beavers.

Despite unconfirmed reports of beavers in the River Brue, there was no evidence of their presence in the upper reaches surveyed. The Brue is in a separate catchment to the Avon and watersheds can be significant, though not impenetrable, barriers to the movement of dispersing beavers (Hartman 1995). The Brue flows downstream through the Somerset Levels, which contains an extensive network of modified drainage ditches. The presence of beavers in the Levels could present a challenge to existing land management practices there. As with the increase in beavers elsewhere in Britain, planning will be needed to anticipate how we, as a society, deal with this challenge.

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Annexes

All annexes are provided as image files with filenames beginning with the respective annex code (A1, A2).

Annex A1

Survey log detailing the river sections surveyed and spot-checked, with start and (if applicable) end points of each survey leg provided at a 1km resolution.

Survey log showing dates and locations (1km OS grid square resolution) of surveys and spot checks. Some locations were repeat surveys on foot following initial surveys from canoe. Under ‘notes’, SB = most banks suitable for burrows; UB = most banks unsuitable for burrows.

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Surv.	19/01/2022	St Catherine's Brook	ST7671	ST7868	3.4	4.9	14.7	Walk	Negative	-
Surv.	19/01/2022	Broadmead Brook	ST7876	ST8377	5.4	6.9	21.2	Walk	Negative	-
Surv.	19/01/2022	By Brook	ST8377	ST8379	2.2	2.9	9.5	Walk	Positive	-
Surv.	20/01/2022	River Avon	ST7767	ST7564	4.0	5.0	11.3	Canoe	Positive	SB
Surv.	20/01/2022	Kennet and Avon Canal	ST7564	ST7862	3.3	9.2	20.5	Canoe	Negative	-
Surv.	20/01/2022	River Avon	ST7862	ST7767	4.8	6.2	14.3	Canoe	Positive	SB

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Surv.	21/01/2022	Kennet and Avon Canal	SU0061	ST7862	21.5	27.8	63.7	Walk	Negative	-
Surv.	21/01/2022	Lid Brook	ST8170	ST8369	2.0	1.9	3.8	Walk	Negative	-
Surv.	22/01/2022	River Avon	ST9064	ST7862	12.1	21.0	45.7	Canoe	Positive	SB
Surv.	23/01/2022	By Brook	ST8474	ST7867	9.9	18.4	49.6	Walk	Positive	Largely UB (low banks), except downstream from the weir at Shockerwick to the River Avon).
Surv.	24/01/2022	River Avon	ST9373	ST9064	9.7	18.8	42.6	Canoe	Positive	SB
Surv.	25/01/2022	Semington Brook plus fishing lakes	SU0358	SU0258	0.8	0.6	1.2	Walk	Negative	-
Surv.	25/01/2022	Semington Brook	SU0358	SU0258	0.9	1.0	1.9	Walk	Negative	-
Surv.	25/01/2022	Semington Brook	SU0157	SU0057	1.0	1.1	2.2	Walk	Negative	-
Surv.	25/01/2022	Semington Brook plus fishing lakes	ST9856	ST9657	2.1	3.3	15.1	Walk	Positive	-
Surv.	25/01/2022	Semington Brook	ST9458	ST9259	2.0	3.2	10.3	Walk	Positive	Majority SB
Surv.	25/01/2022	Semington Brook	ST9259	ST9160	1.4	2.4	7.0	Walk	Positive	Majority SB

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Surv.	25/01/2022	(Semington Brook) mill race, then onto the Brook	ST9160	ST8861	3.1	4.0	12.2	Walk	Positive	Majority SB
Surv.	26/01/2022	River Biss	ST8559	ST8559	0.7	1.2	2.8	Walk	Negative	-
Surv.	26/01/2022	River Biss	ST8557	ST8656	2.2	3.3	9.8	Walk	Negative	-
Surv.	26/01/2022	River Biss	ST8655	ST8655	0.2	0.2	0.7	Walk	Negative	-
Surv.	26/01/2022	River Biss / Biss Brook	ST8654	ST8553	2.1	3.1	10.5	Walk	Negative	-
Surv.	26/01/2022	Lambrok Stream	ST8458	ST8357	1.3	1.5	4.9	Walk	Negative	-
Surv.	26/01/2022	Pudding Brook	ST9171	ST9172	1.0	1.1	3.9	Walk	Negative	-
Surv.	26/01/2022	Pudding Brook	ST8872	ST8872	0.4	0.4	0.9	Walk	Negative	-
Surv.	26/01/2022	River Avon	ST9373	ST9374	0.5	0.5	1.0	Walk	Positive	-
Surv.	26/01/2022	River Marden	ST9374	ST9572	2.3	3.9	9.9	Walk	Positive	-
Surv.	26/01/2022	River Marden	ST9870	ST9772	1.6	2.1	7.0	Walk	Positive	-
Spot	26/01/2022	Biss Brook [100m downstream / 100m upstream spot check only]	ST8550	NA	-	0.2	0.4	Walk	Negative	-
Spot	26/01/2022	Biss Brook [100m upstream spot check only]	ST8549	NA	-	0.1	0.2	Walk	Negative	-

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Spot	26/01/2022	Biss Brook [100m downstream spot check only]	ST8549	NA	-	0.1	0.2	Walk	Negative	-
Spot	26/01/2022	Pudding Brook [100m upstream spot check only]	ST9072	NA	-	0.1	0.2	Walk	Negative	-
Spot	26/01/2022	Pudding Brook [100m upstream spot check only]	ST9072	NA	-	0.1	0.2	Walk	Negative	-
Spot	26/01/2022	Pudding Brook [250m upstream spot check only]	ST8972	NA	-	0.3	0.5	Walk	Negative	-
Surv.	27/01/2022	River Marden	ST9572	ST9772	1.7	2.5	6.5	Walk	Positive	-
Surv.	27/01/2022	South Brook	ST8865	ST8865	0.2	0.0	0.4	Walk	Negative	-
Surv.	27/01/2022	South Brook	ST8963	ST8963	0.1	0.1	0.3	Walk	Negative	Heavy urban influence, canalised very unsuitable
Surv.	27/01/2022	Wid Brook	ST8359	ST8359	0.3	0.4	1.1	Walk	Negative	-
Surv.	27/01/2022	River Avon (Revisit A) - south banks	ST8761	ST8661	0.8	1.0	2.1	Walk	Positive	Revisit to areas seen by canoe on 22 Jan

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Surv.	27/01/2022	River Avon (Revisit B) - west banks	ST7866	ST7865	0.3	0.3	0.6	Walk	Positive	Revisit to areas seen by canoe on 20 Jan
Spot	27/01/2022	South Brook [Spot check at point only]	ST8964	NA	-	-	-	Walk	Negative	-
Spot	27/01/2022	South Brook [Spot check at point only]	ST8965	NA	-	-	-	Walk	Negative	-
Spot	27/01/2022	Wid Brook [Spot check at point only]	ST8358	NA	-	-	-	Walk	Negative	-
Spot	27/01/2022	Wid Brook [Spot check at point only]	ST8358	NA	-	-	-	Walk	Negative	-
Spot	27/01/2022	Wid Brook [Spot check at point only]	ST8359	NA	-	-	-	Walk	Negative	-
Spot	27/01/2022	Wid Brook [Spot check at point only]	ST8359	NA	-	-	-	Walk	Negative	-
Surv.	28/01/2022	Rodden Brook	ST8246	ST8146	0.8	0.9	2.9	Walk	Negative	-
Surv.	28/01/2022	Orchardleigh Lake	ST7851	ST7750	0.9	0.9	2.6	Walk	Positive	-

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Surv.	28/01/2022	Rodden NR (north) / River Frome	ST7847	ST7748	1.1	1.6	4.7	Walk	Positive	-
Surv.	03/02/2022	Un-named brook in Lower Woods	ST7943	ST7943	0.1	0.2	0.5	Walk	Positive	Limited time allowed with chaperone – lots of activity here covering a large area
Surv.	03/02/2022	Redford Water	ST8043	ST8046	2.9	4.1	12.4	Walk	Positive	-
Spot	03/02/2022	Half Mile Pond (Longleat Estate)	ST8143	NA	-	-	-	Walk	Positive	Limited access/time allowed with chaperone
Spot	03/02/2022	Half Mile Pond (Longleat Estate)	ST8143	NA	-	-	-	Walk	Positive	Limited access/time allowed with chaperone
Spot	03/02/2022	Rodden NR (south) / Rodden Brook	ST7847	NA	-	-	-	Walk	Positive	Limited access/time allowed with chaperone
Surv.	04/02/2022	River Frome	ST7847	ST8053	7.0	12.8	34.3	Canoe	Positive	Area with lots of alder trees along the banks with few patches of willow - large stretch of river with no activity
Surv.	05/02/2022	River Frome	ST7338	ST7339	1.0	1.1	2.3	Walk	Positive	-
Surv.	05/02/2022	River Frome	ST7339	ST7340	0.5	0.5	1.7	Walk	Negative	-

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Surv.	05/02/2022	Un-named brook (trib) / River Frome	ST7340	ST7440	1.1	1.4	4.2	Walk	Negative	-
Surv.	05/02/2022	River Frome	ST7441	ST7744	4.3	7.4	21.8	Walk	Positive	-
Surv.	05/02/2022	River Frome	ST7745	ST7847	1.9	3.8	9.1	Walk	Positive	-
Spot	05/02/2022	Marston Pond circumference check	ST7644	NA	-	-	-	Walk	Negative	-
Surv.	06/02/2022	Un-named trib of Mells Stream	ST6447	ST6548	1.0	1.1	3.2	Walk	Negative	-
Surv.	06/02/2022	Mells Stream	ST6748	ST6748	0.4	0.5	1.3	Walk	Negative	Largely UB (low banks)
Surv.	06/02/2022	Mells Stream	ST6748	ST6848	0.7	1.2	3.0	Walk	Negative	Largely UB (low banks)
Surv.	06/02/2022	Mells Stream	ST6948	ST7049	1.3	1.8	6.8	Walk	Negative	Majority SB
Surv.	06/02/2022	Mells Stream / Mells River	ST7348	ST7649	3.1	4.8	12.5	Walk	Negative	Majority SB
Surv.	06/02/2022	Mells River	ST7649	ST7749	0.6	0.8	3.6	Walk	Negative	Majority SB
Surv.	06/02/2022	Egford Brook	ST7549	ST7548	0.5	0.6	1.4	Walk	Negative	Largely UB (low banks)
Surv.	06/02/2022	Fordbury Water	ST7448	ST7449	0.8	0.9	2.4	Walk	Negative	Largely UB (low banks)
Surv.	06/02/2022	Henhambridge Brook	ST7753	ST7753	0.4	0.4	1.4	Walk	Negative	Largely UB (low banks)

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Surv.	06/02/2022	Henhambridge Brook	ST7853	ST7953	1.2	1.5	4.3	Walk	Negative	Largely UB (low banks)
Surv.	07/02/2022	River Frome headwaters and associated ponds	ST7338	ST7338	0.3	0.0	0.2	Walk	Positive	Limited time allowed with chaperone – Spot check of lodge and hotspot areas only
Surv.	07/02/2022	River Frome headwaters and associated ponds	ST7338	ST7338	0.3	0.1	0.4	Walk	Positive	Limited time allowed with chaperone – Spot check of lodge and hotspot areas only
Surv.	07/02/2022	Rodden Brook	ST8147	ST7947	1.7	2.6	9.2	Walk	Positive	-
Surv.	07/02/2022	Redford Water	ST8047	ST8047	0.2	0.2	0.9	Walk	Negative	-
Spot	07/02/2022	Hermitage Pond	ST7438	NA	-	-	-	Walk	Positive	Limited time allowed with chaperone – Spot check of lodge and hotspot areas only
Surv.	08/02/2022	Wellow Brook	ST7055	ST7660	7.7	13.3	33.3	Walk	Negative	SB
Surv.	08/02/2022	Midford Brook	ST7661	ST7761	0.7	0.7	2.1	Walk	Positive	-
Surv.	08/02/2022	Midford Brook	ST7762	ST7862	0.7	0.9	2.6	Walk	Positive	-
Surv.	08/02/2022	Cam Brook	ST7159	ST7259	0.7	1.0	2.3	Walk	Negative	Majority SB
Surv.	08/02/2022	Cam Brook	ST6958	ST7059	0.9	1.2	3.2	Walk	Negative	Majority SB
Surv.	08/02/2022	Cam Brook	ST7660	ST7560	1.0	1.4	3.6	Walk	Negative	Majority SB

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Surv.	08/02/2022	Newton Brook	ST7163	ST7062	0.6	0.8	2.4	Walk	Negative	Majority UB
Surv.	08/02/2022	Newton Brook	ST7165	ST7164	0.8	1.0	2.5	Walk	Negative	Majority UB
Surv.	09/02/2022	River Frome	ST8053	ST7960	6.1	11.6	30.6	Canoe	Positive	-
Surv.	10/02/2022	Extreme upper reaches of the River Frome (spring trickles)	ST7637	ST7537	0.6	0.0	0.0	Walk	Negative	Extreme upper reaches of the River Frome in West End Wood (spring trickles)
Surv.	10/02/2022	River Brue headwaters (tributary)/River Brue	ST7436	ST7336	1.1	2.0	6.5	Walk	Negative	Majority UB
Surv.	10/02/2022	River Brue	ST7236	ST7236	0.5	0.7	2.6	Walk	Negative	Majority UB
Surv.	10/02/2022	River Brue	ST7136	ST7036	1.4	1.9	5.3	Walk	Negative	Majority UB
Surv.	10/02/2022	River Brue	ST7035	ST6834	1.5	1.9	5.2	Walk	Negative	Majority UB
Spot	10/02/2022	Historic field drain (dry) at edge of King's Wood Warren	ST7536	NA	-	-	-	Walk	Negative	Historic field drain (dry) at top of hill of King's Wood Warren.
Spot	10/02/2022	Extreme upper reaches of the River Brue (spring trickles)	ST7536	NA	-	-	-	Walk	Negative	Extreme upper reaches of the River Brue in King's Wood Wartren (spring trickles)

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Spot	10/02/2022	Extreme upper reaches of the River Brue (spring trickles)	ST7536	NA	-	-	-	Walk	Negative	Extreme upper reaches of the River Brue in King's Wood Wartren (spring trickles)
Surv.	11/02/2022	River Avon (Revisit C) - east banks	ST7866	ST7864	1.5	1.8	3.7	Walk	Positive	Revisit to areas seen by canoe on 20 Jan
Surv.	20/02/2022	Lam Brook	ST7371	ST7469	2.1	2.7	8.0	Walk	Negative	Majority of banks relatively SB. Dominated by alders, with some hazel
Surv.	20/02/2022	Lam Brook	ST7469	ST7667	2.6	3.1	9.6	Walk	Negative	Majority of banks relatively SB. Dominated by alders, with some hazel
Surv.	20/02/2022	Lam Brook	ST7666	ST7666	0.2	0.2	0.9	Walk	Negative	Majority of banks relatively SB. Dominated by alders, with some hazel
Surv.	20/02/2022	Unnamed trib of the By Brook	ST8274	ST8475	2.0	3.3	8.9	Walk	Negative	Largely UB (low banks)
Surv.	20/02/2022	Doncombe Brook	ST8374	ST8374	0.1	0.2	0.4	Walk	Negative	Majority UB
Surv.	21/02/2022	Cocklemore Brook	ST9570	ST9370	2.1	2.9	8.7	Walk	Negative	Majority UB. Dominated by hazel

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
Surv.	21/02/2022	Doncombe Brook	ST8073	ST8374	3.4	3.6	11.5	Walk	Negative	Majority UB. Dominated by hazel
Surv.	21/02/2022	Unnamed trib of the Doncombe Brook	ST8274	ST8274	0.3	0.0	0.6	Walk	Negative	Majority UB. Dominated by hazel
Spot	21/02/2022	Batheaston 'ox bow lake' and wetland area [spot check area] (plus River Avon (Revisit D - south banks)	ST7867	NA	-	-	-	Walk	Negative	Majority SB.
Surv.	22/02/2022	River Avon (Revisit E) - west banks	ST7964	ST7964	0.3	0.4	1.4	Walk	Positive	Short stretch of the River Avon revisited. No additional field signs found from the canoe survey on the 20th Jan.
Surv.	23/02/2022	By Brook	ST8477	ST8476	0.9	1.2	4.6	Walk	Positive	Excellent habitat, however difficult to survey due to deep water & multiple mid-channel islands. In spate! Most of survey conducted on east side of river and west side of mill race channel. There is

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
										likely to be a lot more activity out of view on the western side of the river.
Surv.	23/02/2022	By Brook	ST8475	ST8474	1.1	2.1	8.1	Walk	Positive	Majority SB
Surv.	24/02/2022	River Frome	ST7745	ST7745	0.3	0.5	1.2	Walk	Positive	SB
Spot	24/02/2022	Orchardleigh Park - Church Lake	ST7750	NA	-	-	-	Walk	Positive	SB
Surv.	25/02/2022	River Avon (Revisit F) - east banks	ST7862	ST7963	1.5	1.5	3.1	Walk	Positive	Revisit to areas seen by canoe on 20 Jan
Surv.	25/02/2022	By Brook (Revisit)	ST8372	ST8373	1.0	1.7	4.0	Walk	Positive	Revisit to small area seen on 23 Jan
Surv.	25/02/2022	River Avon	ST7165	ST7065	1.5	1.9	4.0	Walk	Negative	SB
Surv.	26/02/2022	River Avon	ST9475	ST9374	1.5	2.9	7.8	Walk	Positive	SB
Surv.	26/02/2022	River Avon	ST9374	ST9374	0.3	0.3	0.6	Walk	Positive	SB
-	-	Sub-total	-	-	47.0	84.6	199.1	Canoe	-	-
-	-	Sub-total	-	-	123.8	196.2	547.9	Walk	-	-

Type	Date	River	Start 1km grid sq	End 1km grid sq	Straight-line distance (km)	Channel length (km)	Bank length (km)	Method	Present	Notes
-	-	Total	-	-	186.8	280.8	747.0	All	-	-

Annex A2

1 km resolution overview (at a smaller scale than in Figure 4) of beaver activity in the surveyed area. Grid squares are classified according to the most significant level of activity that falls within the square (descending order in the map legend). ‘Searched’ means no activity was recorded.

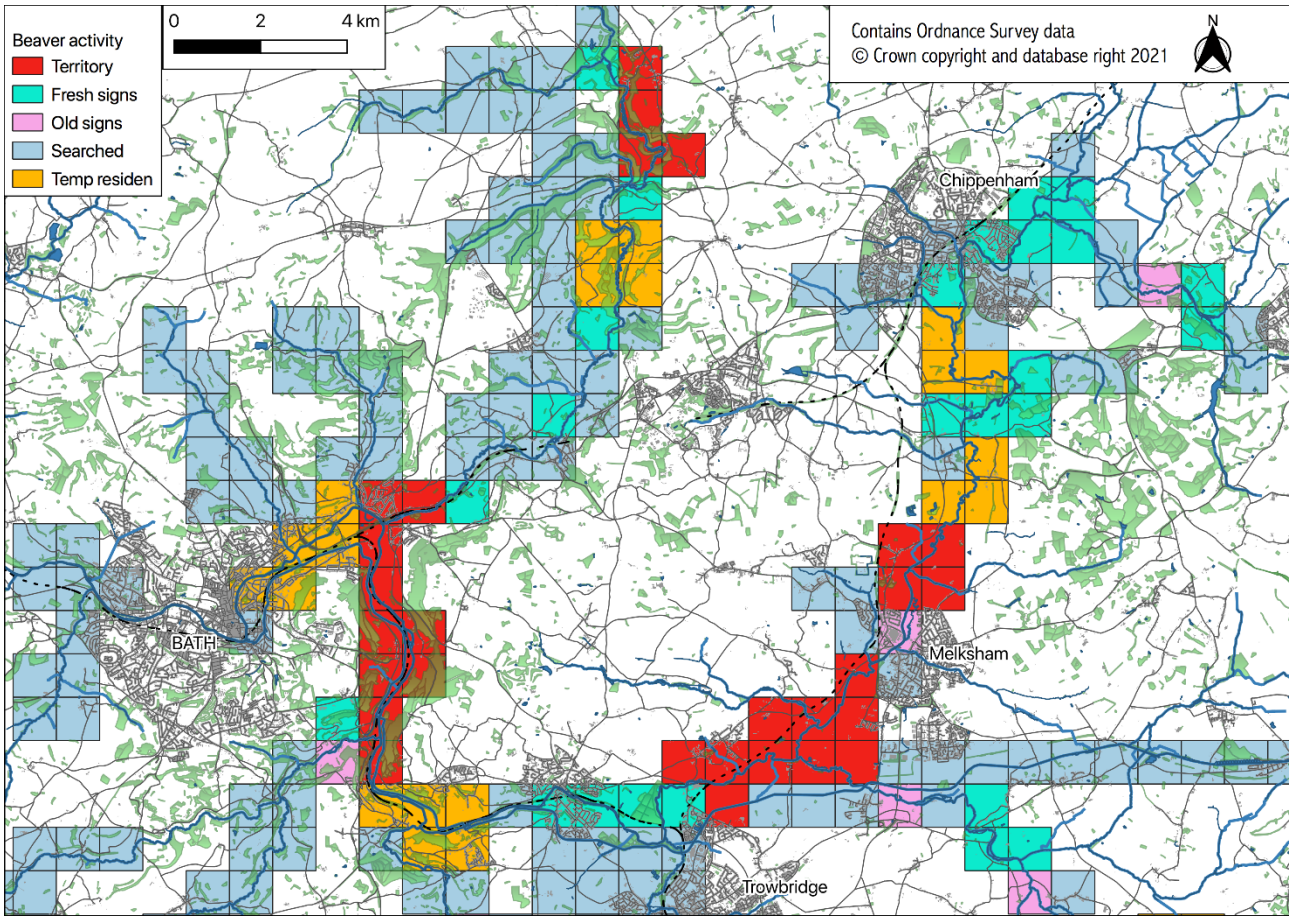

Figure 1: 1km resolution overview of beaver activity in the surveyed area for the River Avon around Bath. Grid squares are classified according to the most significant level of activity that falls within the square (descending order in the map legend). ‘Searched’ means no activity was recorded. Contains Ordinance Survey Data. © Crown copyright and database right 2021.

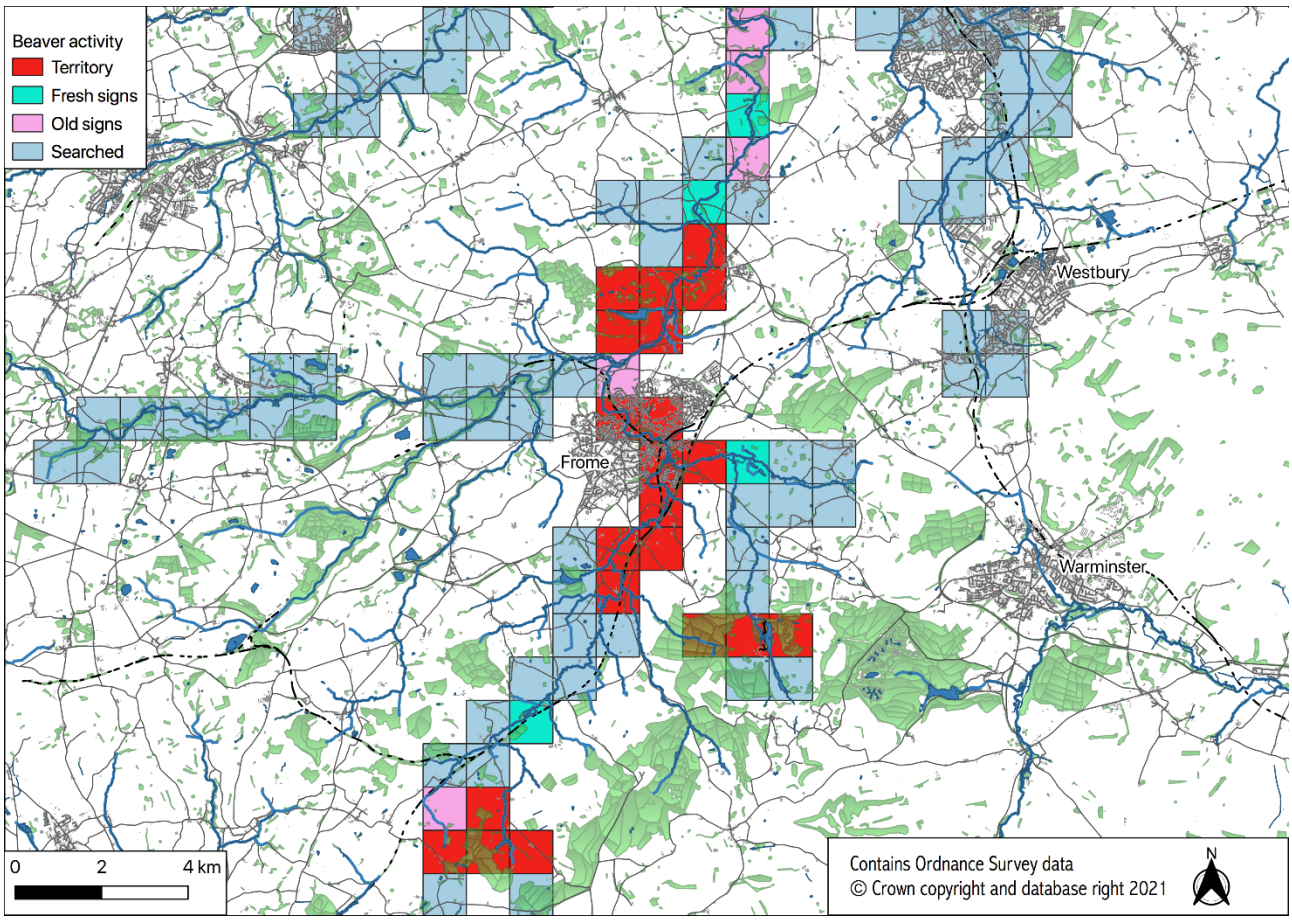

Figure 2: 1km resolution overview of beaver activity in the surveyed area for the River Frome around Frome. Grid squares are classified according to the most significant level of activity that falls within the square (descending order in the map legend). 'Searched' means no activity was recorded. Contains Ordinance Survey Data. © Crown copyright and database right 2021.

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