Assessment of wild living beaver populations on the River Exe and River Taw

Natural England Commissioned Report NECR548

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Beaver dam © Roisin Campbell-Palmer

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Beaver, *Castor fiber*, distribution, Exe, population estimate, Taw

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Citation

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Foreword

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 River Exe and River Taw catchments, understanding their impacts, understanding how they are using the catchments, and in the development of a management strategy.

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.

Executive summary

Following increasing reports of wild beavers in both the River Exe and River Taw catchments, Devon, Natural England commissioned a survey of beaver activity within these catchments. These surveys were undertaken during February – April 2023 on foot and canoe. These surveys covered 260 km of channel length in total: 182 km on the Taw and 78 km on the Exe. These areas covered sections of significant tributaries and headwaters on the River Mole, the Little Dart, River Dart, River Clyst, and River Culm.

Less than half of landowners contacted gave permission for access. Out of the originally identified target of 163 km of river that had been identified for survey, access was not available for 43 km (26%). Survey from a canoe was used as far as possible but the majority of both these catchments are not suitable for canoe access. Based upon local knowledge and public reports the survey team expanded the project remit to cover a total of 258 km (based upon this expanded scope this resulted in closer to 17% not being available for survey). We acknowledge these gaps add uncertainty and therefore present our results as a conservative estimate of beaver impacts.

A total of 418 beaver field signs were recorded, with cut wood being the most common. Across both catchments, beaver activity was fairly concentrated in the mid- to lower-main river stems. Only three lodges and three burrows were found, given high water levels during the majority of the survey these are undoubtedly under-recorded. Old and aged field signs were recorded, with coppice aging indicating at least a minimum age of 3–4 years in some parts. Damming throughout the catchments was low, but where found occurred in distinct clusters in clearly active territories.

Populations in both catchments are presumed to be small and mobile given the field signs detected, with dispersing individuals not all settled into breeding territories. An estimated six active territories and further two areas of activity with at least a single individual are estimated for the River Exe and estimated population range of 14-25 individuals before this year's kit emergence. An estimated four active territories and further six areas of activity with at least a single individual are estimated for the River Taw and estimated population range of 10 - 22 individuals before this year's emergence of kits.

Very few management impacts were observed, this is most likely due to such small populations and the populations being in the early establishment phase.

Contents

Introduction

Wild populations of beavers have been identified in small numbers in England since the early 2000s (Heydon et al. 2021). Currently, those beavers living on the River Otter, East Devon constitute the only authorised, free-living population in England, whilst numerous enclosed projects exist (Howe and Crutchley 2020). In August 2020, the UK government announced the River Otter beaver population could remain and naturally expand its range after the successful five-year River Otter Beaver Trial (Howe and Crutchley 2020). In 2021, Defra carried out a national public consultation on the approach to further beaver reintroductions and their management in England. On 1st October 2022 beavers living in the wild in England were given legal protection as a European Protected Species (EPS).

Outside of the River Otter and the enclosures, several populations originating from escapes from enclosures and private collections and/or un-official release have been identified. There are records of small populations of beavers living on the following six catchments:

- River Stour catchments, East Kent
- River Tamar, Cornwall and Devon
- River Avon (including the Frome and By Brook) Somerset, and Wiltshire
- River Taw (including the Little Dart), Devon
- River Exe, Devon
- River Wye, Herefordshire, and Welsh border

Catchment-scale beaver surveys have only previously been undertaken in Scotland, the River Avon, River Otter and on the River Wye (incorporating Wales and England), therefore data of such coverage in a British context is lacking for other areas where known wild beaver populations exist.

Numerous beaver field signs and animal sightings on the Taw and Exe catchments have been reported to Natural England (NE) and the Devon Wildlife Trust over the last couple of years preceding this survey (see Figure 1. overview of previously reported beaver activity provided by NE). No complete survey of beaver presence and distribution has been completed. Therefore, the need for a robust assessment of the wild-living beavers on this catchment was recognised. To date, the field signs and sightings have been fairly sporadic and sparsely distributed, concentrated mainly on the main stem of the River Exe and Taw, along with tributaries of these rivers such as the Culm and Little Dart. Additional social media reports of beaver sightings in the estuaries of both catchments have been reported. NE has provided locations of previously reported field signs as a guide to beaver presence, which has been further supported by landowner information, extensive local knowledge, assessment of suitable beaver habitat and active field sign survey of as wide

an area as possible. The following report aims to provide further information to NE to help understand current beaver presence and distribution on the Taw and Exe catchments.

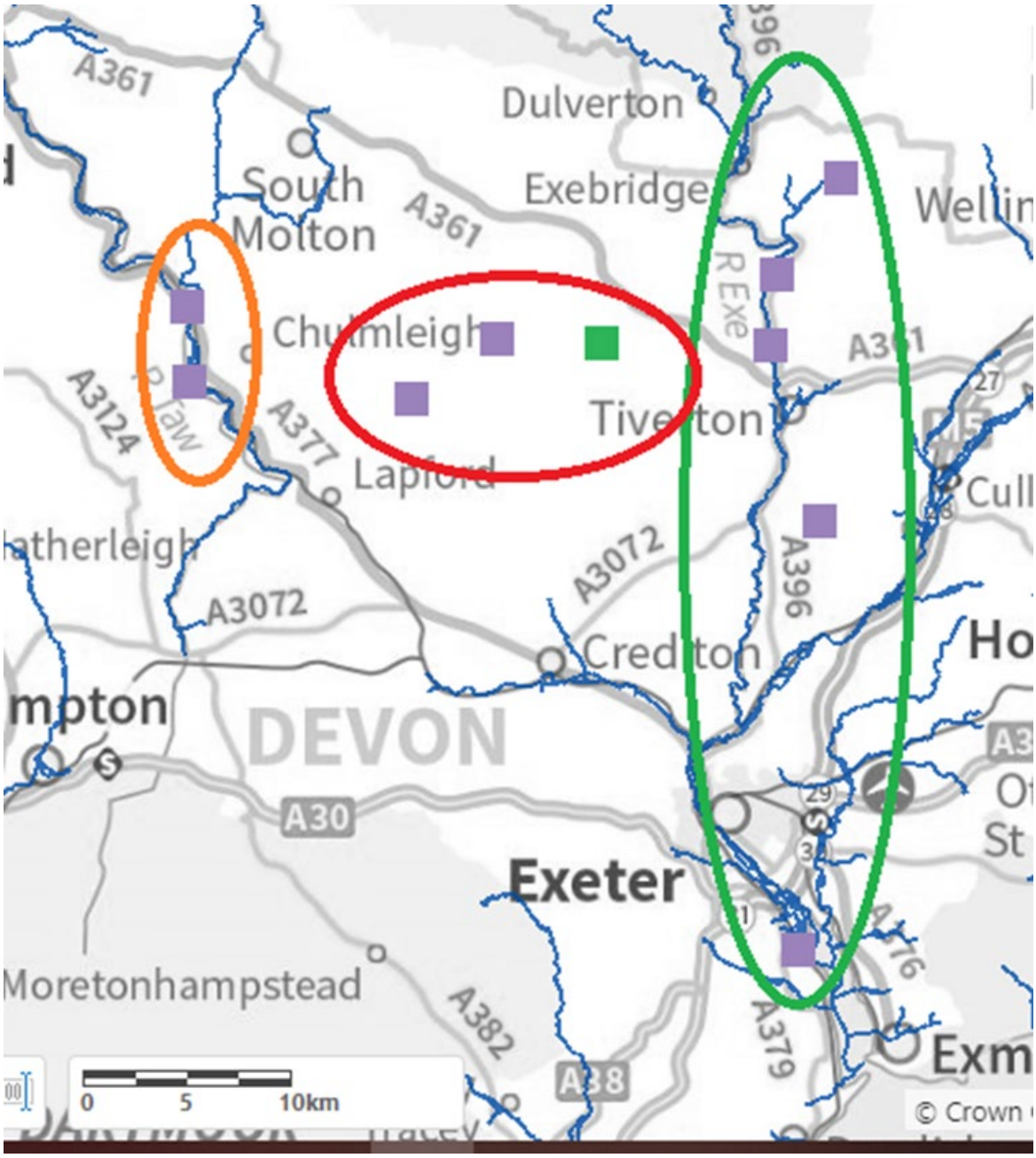

Figure 1: A indicative map of NE records of beavers on the River Taw, Little Dart and Exe, Devon. (Purple ■ Records visual sightings of beaver, Green ■ Records of beaver feeding signs). Map provided by NE to guide survey. Map © Natural England

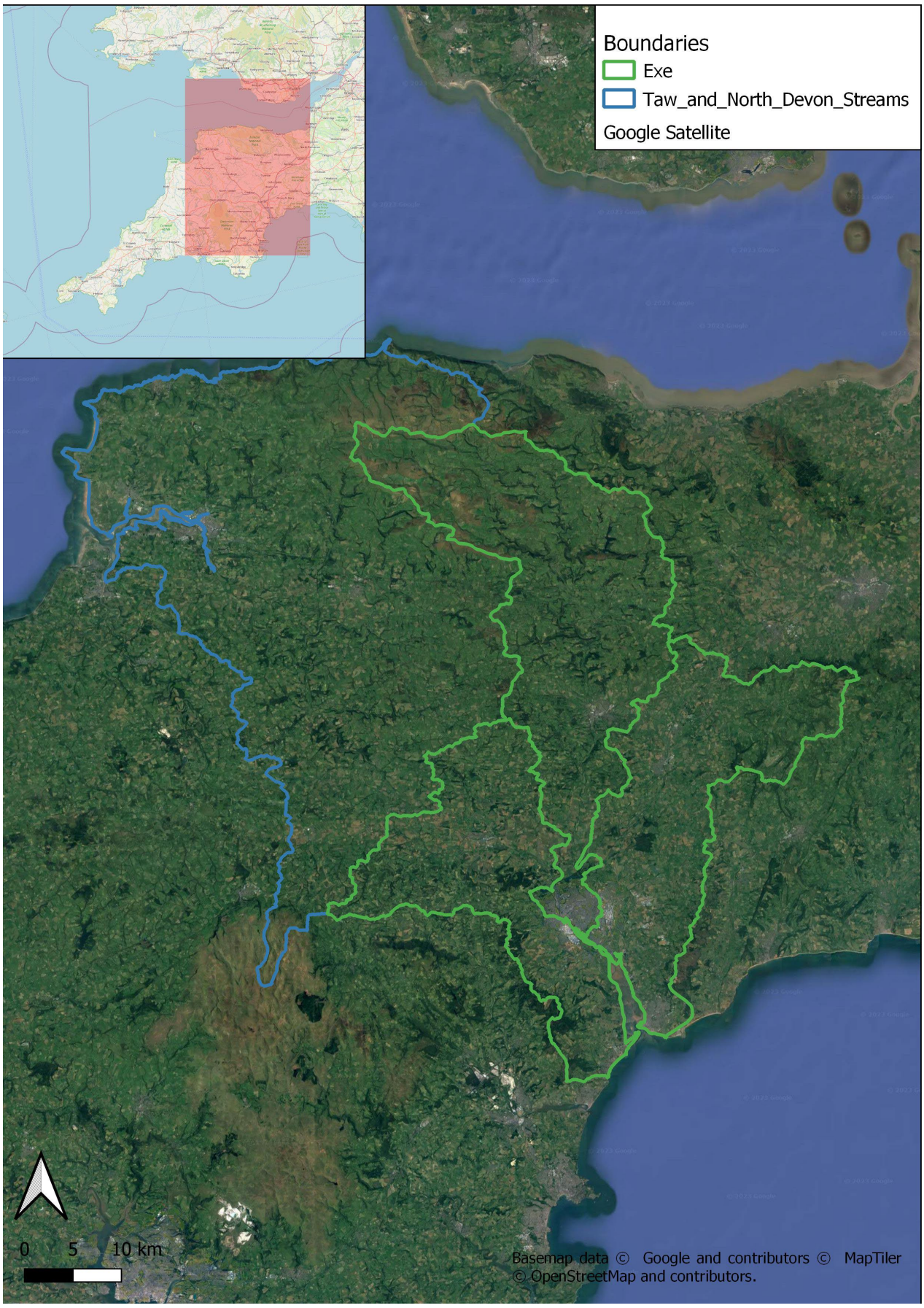

Figure 2. Area of interest for surveys including Exe and Taw catchments. Map © Alan Puttock

Project Scope

This team, comprising Beaver Trust, University of Exeter and Devon Wildlife Trust (DWT), has extensive experience of beaver field sign survey techniques and more importantly how these data can be translated into meaningful mapping of population distributions, highlighting potential conflicts and mitigation requirements. Using the standardised field sign methodology outlined below (and peer-reviewed in Campbell-Palmer et al., 2021), we undertook a comprehensive survey of the Taw and Exe catchments. Initially focusing on rivers identified by NE with anecdotal beaver presence, then expanding the survey area to check for presence/absence within the wider catchments. The survey areas to be prioritised were (according to landowner permission):

- River Exe from Exbridge to confluence of Burn River near Butterleigh (including River Batherm and River Dart, and the River Culm from Cullompton to Uffculme)
- Little Dart River to the headwaters (including Huntacott Water, Adworthy Brook and Sturcombe River)
- River Taw from Bondleigh to Umberleigh (including River Mole to Satterleigh and Bartridge Brook)

Aims

- To liaise with the East Devon Beaver Management Group over the survey plan and identification of further suitable beaver habitat and beaver records.
- To contact landowners / occupiers to arrange access for undertaking field surveys. Seek relevant permissions.
- To undertake a field survey (February 2023 to April 2023) to record and map beaver field signs throughout the survey area using standardised methodology (see Campbell-Palmer et al. 2021, Campbell-Palmer et al. 2020, Campbell-Palmer et al. 2018 & Campbell et al. 2012).
- To analyse and interpret the raw survey data and undertake modelling to indicate beaver distribution, numbers and locations of potential beaver territories.
- To produce a report output to include project scope; description of methodology; recommendations including areas to survey in the future; details of any beaver impacts recorded.
- To provide raw survey data to NE.

Methods

Landowner permission

NE provided an initial list of landowner access permissions, especially related to those giving previous access to any survey work. Contact was made via email and phone to landowners in target survey areas. Additional intelligence (including following up on social media posts and liaising with local angling clubs, river interest groups, farm advisors and a farm facilitation group) was collated by DWT and enabled further approaches to be made. Some landowners were known, and personal approaches were made by the whole team and additional surveys were undertaken by canoe as far as possible, all to ensure as wide an area was surveyed as possible.

Survey Methods

Identify location of suitable beaver habitat

Beavers have been reported officially to NE and the DWT amongst other organisations. Additionally, unverified reports were investigated along with desk-based examination of OS maps and beaver habitat suitability models (Graham et al., 2020) to identify areas of suitable beaver habitat worth exploring.

Undertake full beaver field sign survey of the Taw and Exe catchments to establish beaver presence and distributions

The survey area was based on records (confirmed and suspected) of beaver activity along with an extended area of field surveys to confirm the species presence/absence outside areas of known and suspected existence, including watercourses with suitable habitat (based on hydrology and vegetation availability). While beavers display quite distinct and obvious field signs, at low densities within more naturalised watercourses, these may be relatively inconspicuous and can be missed or mistaken for other species. Mapping field signs can help to identify beaver distribution, allow an assessment of their habitat use and an estimation of the number of active territories present within an area. Field surveys consisted of surveying a watercourse from either canoe or on foot depending on watercourse suitability, accessibility and permission status. Canoe surveys are more likely to reveal more waterside activity with the potential for underreporting inland activity, whilst the opposite tends to be the case for surveys on foot. This general approach is however highly dependent on the structure and size of the watercourse, and the extent of bankside vegetation growth. Additional areas were ‘spot checked’ opportunistically especially in the head water areas outside of the original project scope to determine if any beaver field signs were present. This involved any opportunities where public rights of way or infrastructure such as bridges or roads crossed water courses. At each point a visual

survey was made that may also include areas walked for as far as access was possible to determine if any beaver field signs present and worth further investigation. Typically, such points were <50.

For each survey point the following data were collected:

1. Activity type (Sign)
2. Ordnance Survey (OS) grid reference
3. Photo No. (if appropriate)
4. Estimated age (fresh, old or mixed)
5. Dam dimensions (if present)
6. River or waterbody name
7. Land use (dominant along watercourse and surrounding area ie, within 100 m radius)
8. Beaver activity effort (low, medium or high)
9. Management impact (NA, low, medium or high)
10. Any other comments
11. Recorder initials

Beaver field signs (see Table 1 for type of signs recorded) were logged as point data using GPS equipped mobile phone devices (a mix of iOS and Android) using the Avenza Maps mapping app (Avenza Systems Inc. version 3.13.1). This allowed the same core data to be collected as in previous British surveys allowing direct comparison with other surveys and between years for any future surveys, in a standardised format reducing the chance of transcriber error or variation between different surveyors or devices. All data were collected in the mobile app before being transferred via email for backup and processing.

‘Beaver activity effort’ (an estimated measure of energy expended by beaver in creating a recorded feeding sign) was categorised as: low (eg, <5 small (<10 cm diameter) tree trunks/woody stems within 10 m radius); medium (eg, 5-10 small diameter trunks/stems within 10 m radius); or high (eg, >10- small diameter trunk/stems within 10 m).

‘Management impact’ is categorised subjectively based on the perceived impact at the time of survey as: ‘NA’ if impact was deemed imperceivable with no mitigation required; ‘low’ if affecting a small area and/or could have been easily mitigated without excessive costs or resources (eg, small scale tree felling); ‘high’ if a large area was affected and/or mitigation was resource intensive (eg, flood bank collapse, multiple collapsed burrows or flooding of large area of crops); with ‘medium’ ranging between these. Measuring this impact involves a level of subjectivity, so the perceived impact was recorded by surveyors

as far as possible using a simple score of ‘NA’, ‘low’, ‘medium’, or ‘high’, without obtaining the views of the landowners/managers in question. It is also critical to note these were signs that ‘could’ have management implications rather than where actual management implications had manifested themselves. The recording of management impact also does not negate or dismiss the possibility that beaver activity in that area could have other benefits, ie, a beaver dam, resulting in localised flooding on private land may be recorded as a high management impact. However, as shown in numerous studies (see Brazier et al. 2020 for a recent review) this same dam may bring significant biodiversity and hydrological benefits. Weighing up the costs versus benefits of individual beaver impacts is important as beaver return to our landscapes.

The ‘sign’ types recorded were the commonly recorded field signs of beaver activity that can be robustly identified by an expert survey team. A full list of sign types is tabulated below:

Table 1. Sign types recorded along with code used herein and description.

Code	Field sign	Description
C	Woody Feeding	Cutting or gnawing of woody vegetation (shrubs, saplings and trees)
H	Soft Feeding	Feeding on herbaceous vegetation
Ag	Crop Feeding	Feeding on agricultural crops. The area affected was measured as m²
D	Dam	Dams were classified as active/maintained or old/breached. Height and width were recorded in metres
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 are usually below normal water levels and can extend inland forming complex underground systems
L	Lodge	Dwellings where the nest chamber protrudes from the surface and has been built up using sticks and mud
SM	Scent Mound	A pile of material (usually mud) scraped together by the beaver on which a distinctive scent (castoreum/ anal-gland secretion) is deposited

Code	Field sign	Description
SS	Scent Site	A small area of concentrated multiple scent mounds
FS	Feeding Station	This is a location at the edge of the water to which a beaver repeatedly takes, for consumption, material obtained elsewhere
FT	Foraging Trail	Created by the frequent passing of a beaver from the water to a location inland

Raw survey data and summary reporting

Field data were quality assured, processed and backed-up weekly. All subsequent mapping and geospatial analysis were undertaken in QGIS 3.16.4 (QGIS.org. 2021) and R 4.0.4 (R Core Team (2021). Figure 2. provides a workflow summary of the data processing and analysis. In addition to primary data collected as part of the field survey. All backdrop mapping layers will be OS data (Crown copyright and database right, 2020) or open access Open Street Map data (copyrighted OpenStreetMap contributors and available from https://www.openstreetmap.org) and Google satellite imagery: Open-Source Google imagery © OpenStreetmap (and) contributors CC-BY-SA. Full details of the data collection and processing methodology can be found in Campbell-Palmer et al., (2020) and Campbell-Palmer et al., (2021).

Analysis of Survey data and territory estimation

Beavers are highly territorial and will actively defend an area comprising a food resource, shelter, overwintering and breeding sites. These tend to follow the shorelines of the particular river or waterbody inhabited. Territory and group size vary greatly within beaver populations (Wilsson 1971; Nolet & Rosell 1994; Herr & Rosell 2004). For example, territory size ranged from 1.1 to 6.8 km of bank length (average 3.7±1.7 km) in Norway based on pair cohesion studies (McClanahan et al. 2020). Previous studies have recorded averages of ~3 km though this was highly variable with watercourse complexity and habitat quality (Herr & Rosell 2004; Campbell et al. 2005). Overlap between territories is minimal (0.5-2.2%), though up to 10% have been observed and typically influenced by population density, habitat type and resource availability (Herr & Rosell 2004). Therefore, at a landscape scale, the distribution of beaver territories is often highly discontinuous (Parker et al. 2001; Schulte 1998).

Beaver territories have been defined previously using a number of methods: scent mound mapping as indicators of territory borders (Campbell et al. 2005); biologging individuals (GPS/RF tags eg, Campbell et al. 2005; Graf et al. 2016); riverbank length with minimum convex polygons or kernel methods (Herr & Rosell 2004); or patterns of beaver field sign density (Fustec et al. 2001). Early colonisation of new habitats / areas is often slow and represented by low numbers of pioneer individuals. As mating opportunities increase, new

territories become established and population density increases. In expanding beaver populations, active territories tend to be further apart as family units select the highest quality habitat (Nolet & Rosell 1994), but as population density increases infilling occurs, territories come closer together and territorial behaviours (including aggression and scent marking) increase (Hartman 1995; Rosell 2002). During spring, scent marking tends to increase in frequency, especially at higher population densities. This is also the time that sub-adults, after reaching sexual maturity (~20 months), disperse from their natal territories to seek territories and mating opportunities of their own (Hartman 1997). At higher population densities dispersal may be delayed with individuals as old as seven years remaining with their parental families to assist with kit rearing and natal territory defence as new territories become scarcer (Mayer et al. 2017). As beaver populations establish, population growth can increase more rapidly until carrying capacity is reached (Hartman 1994). At carrying capacity beaver population density will have a regulatory effect on numbers, especially on reproductive rates (only one pair will breed within each territory) and survival of the dispersers (Parker & Rosell 2012; Campbell et al. 2005). At this stage in population development, territories tend to be smaller, and fecundity is reduced, although this can vary between sites and be influenced by other factors (Campbell et al. 2005; Campbell et al. 2017).

Estimation of territories from survey data

To provide a quantitative and replicable analysis of estimated change in territory numbers and range an automated classification approach, based upon the density and location of recorded signs will be used to model the spatial distribution and number of territories is proposed. Kernel density estimation analysis can be undertaken and then combined with expert knowledge of the survey area to reach a final estimate of territories. Kernel density analysis calculates the density of features in a neighbourhood around those features, thereby allowing the identification of spatially explicit clusters of beaver activity that are assumed to relate to estimated territories (Campbell-Palmer et al., 2018, 2020). The methodological workflow behind this territory modelling is outlined in Figure 2 illustrating how the outputs from kernel density analysis were converted to territories. Additionally, this workflow and the associated data analysis R package have now been peer reviewed and published, providing a framework for standardised field surveys and analysis to be undertaken across Great Britain (Graham et al., 2022).

In summary, survey sign points are used to create a kernel density raster for each survey season using the {spatialEco} R package (Evans 2021). Weights were applied to the points based on their effort category class; low medium and high classes had weights of 1, $1e^{+03}$ and $1e^{+06}$ respectively. A low threshold value of $1e^{-10}$ was used to remove areas of extremely low density, increasing the chance of distinguishing between coincident regions of high-density signs.

The sign density raster layers are then used to generate multi polygon regions of activity, which defined the boundary of the density raster (activity regions) and that defined all regions of density > 95th percentile (central places). These high-density foraging areas

were considered to describe the central places of beaver activity as beavers feed in higher densities closer to their dwelling. If an activity region intersected a central place region, the activity region was classified as a possible territory. If an activity region intersected either a dam or dwelling, this was also flagged as further confirmation.

Using field key signs (lodges, food caches, active feeding stations, burrows, scent marking and dams) as confirmatory signs, adding an extra layer of confidence to estimations where such signs were observed. For example, active territories are more confidently assigned when active food caches are present at lodges from autumn to early spring. Similarly, territorial boundaries are more confidently assigned when scent marking is noticeably active. Using the updated methodology, the presence (or absence) of key signs in each automated territory is flagged giving an extra layer of information for subsequent expert interpretation.

It is recognised that: (1) there may be difficulties in determining between continuous or high density areas of beaver activity; (2) the resolution required for landscape-scale modelling may not pick up locally separate territories ie, in neighbouring lochs/reaches; (3) occasionally it was not possible to carry out full surveys in all areas due to access constraints, resulting in low sign density; (4) the visibility of field signs during the survey period was limited by natural phenomena ie, snow and flooding during the winter months and vegetation during the summer. Therefore, whilst the automated approach gives foundation areas of activity upon which to base territory estimations, it should be cross-referenced with key signs and expert knowledge and interpretation by the authors as described in Campbell-Palmer et al., (2018) to determine the final territory boundaries and number.

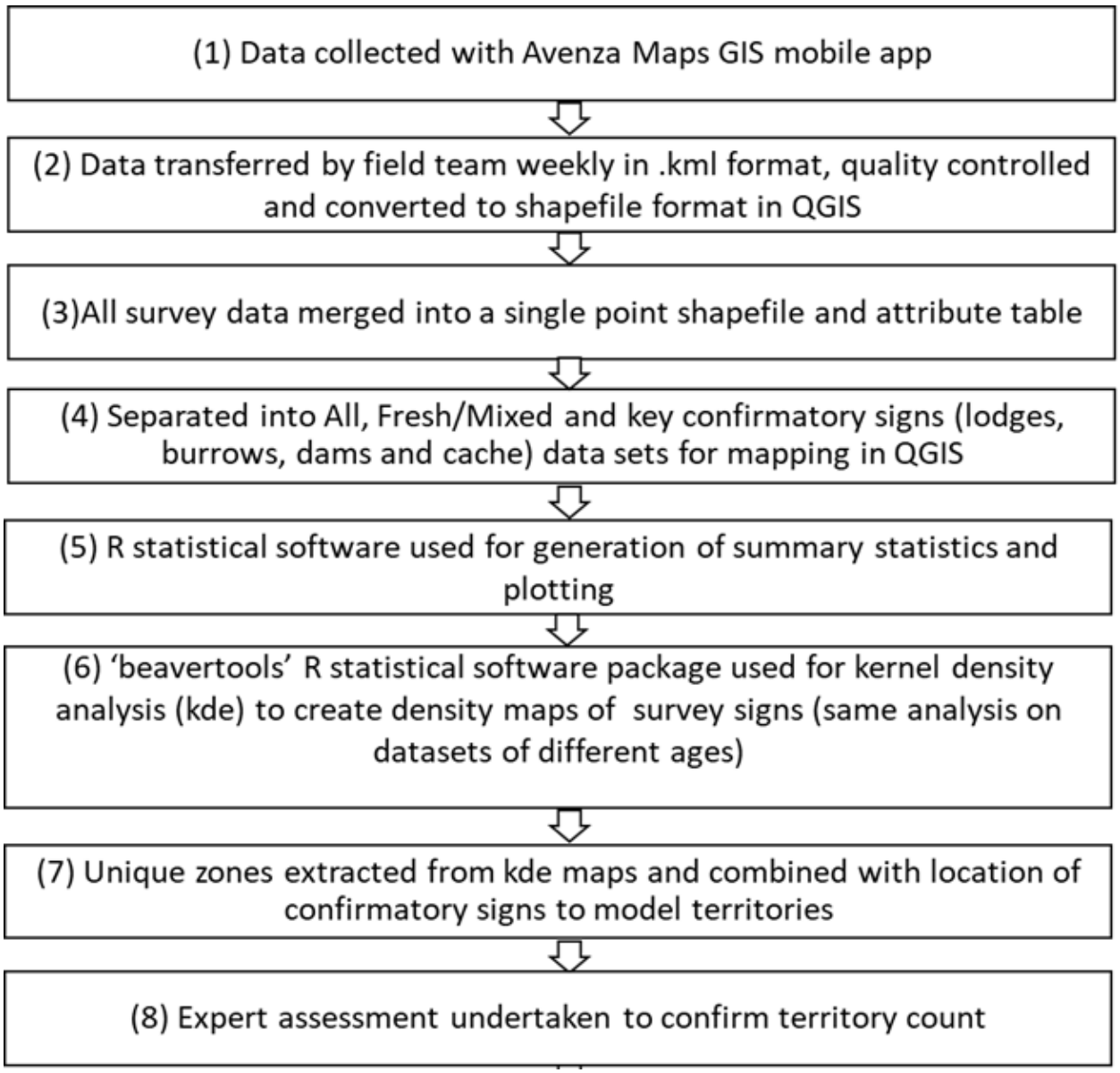

Figure 3. Full data collection and processing flow chart. Steps 1-3 were undertaken in the phase 1 data collection phase of this project, we now propose undertaking steps 4-8.

Results

Landowner permission

Approximately 121 landowners associated with these two catchments were contacted by NE and/ or DWT directly to request permission to undertake the survey. Forty-six gave permission for the survey to take place. In addition, two fishing clubs and one fishing association facilitated access to sections of the Taw which they have access to. Several organisations including the Environment Agency and the National Trust also assisted with beaver activity information and survey access. It should be noted that some landowners throughout both catchment areas did not respond following contact or explicitly refused access permission and because of this, we are able to report a conservative estimate of beaver feeding signs and likely distributions.

Out of the originally identified target of 163 km of river that had been identified for survey, access was not available for 43 km (26%). However, based upon local knowledge and public reports the survey team expanded the project remit to cover a total of 258 km. Therefore, based upon this expanded scope the percentage not available to survey was 17%. We acknowledge these gaps add uncertainty and therefore present our results as a conservative estimate. However, the majority of gaps were fairly short (under 1 km) and we don't think the 17% of river reach we couldn't access changes the strategic spatial pattern of beaver activity mapped across the Exe and Taw.

Survey Data

To accompany this report the following datasets are provided to allow Natural England and project partners to utilise the data in future. The ExeTaw_2023_SurveyData.xlsx contains all processed survey data and can be opened in Excel or similar spreadsheet software, the shapefile and geopackage files require GIS software to utilise, ie, ESRI ArcGIS or QGIS.

Accompanying datasets provided separately:

ExeTaw_2023_SurveyData (provided in ESRI shapefile and geopackage formats): all recorded survey points and associated survey attribute data.

ExeTaw_2023_SurveyTracks (provided in ESRI shapefile and geopackage formats): all field survey tracks taken by field teams during the survey.

ExeTaw_2023_AOA (provided in ESRI shapefile and geopackage formats): all areas of activity/territories.

ExeTaw_2023_AOA_5kmGrid (provided in ESRI shapefile and geopackage formats): all areas of activity/territories anonymised via a 5 km grid link.

ExeTaw_2023_SignAge_5kmGrid (provided in ESRI shapefile and geopackage formats): all signs and age anonymised via a 5 km grid link.

ExeTaw_2023_SurveyData.xlsx (exported full survey record in excel format with associated British National Grid X and Y coordinates)

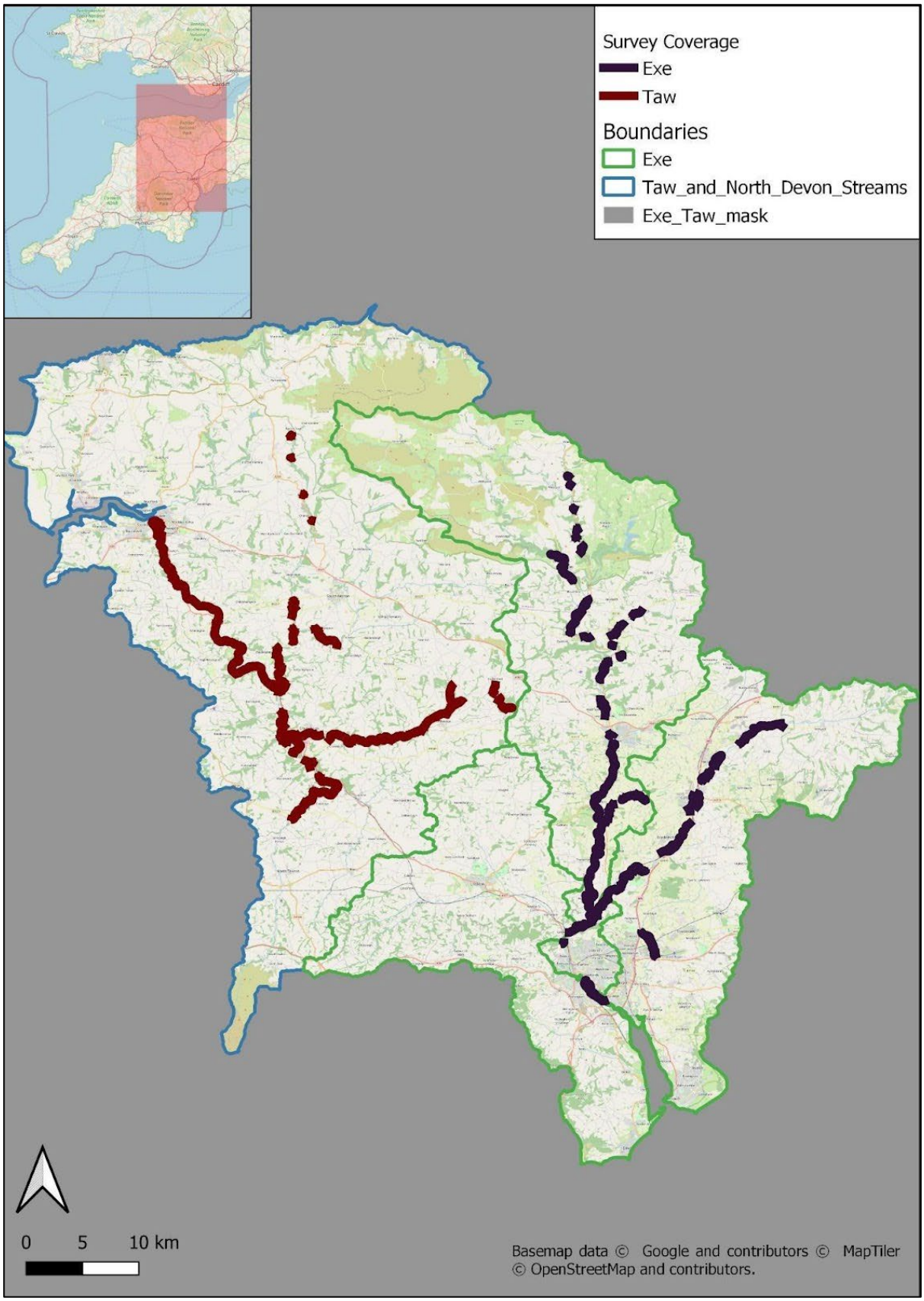

Figure 4. Survey coverage split by catchment, in total 258 km were covered by the survey team; 182 km were covered by surveys in the Taw and 78 km were covered by surveys in the Exe. Map © Alan Puttock

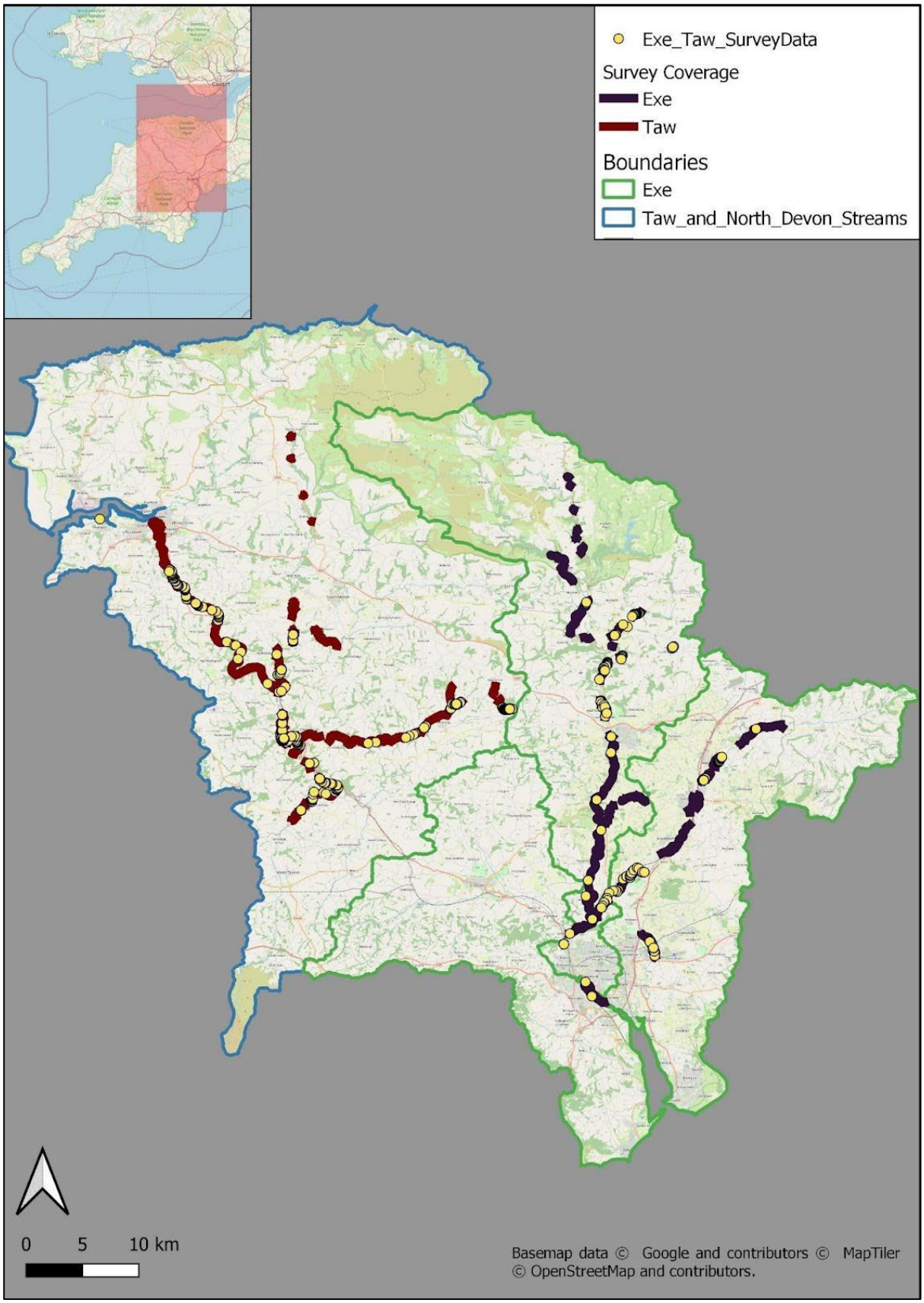

Figure 5. All processed survey data recorded by the field teams overlayed onto surveyed areas. Map © Alan Puttock

Overall beaver field signs were recorded throughout the lower sections of both catchments, particularly concentrated on the main river stems of the Rivers Taw, Exe, Little Dart and Culm. Though evidence of beaver activity in smaller watercourses was also evident, it was less concentrated than signs found on the main rivers. The headwater streams of both catchments were spot-checked for beaver activity and determined as not present in this survey. Sightings of beavers in the estuaries of both catchments had been recently made and verified via social media intelligence at the time of the survey.

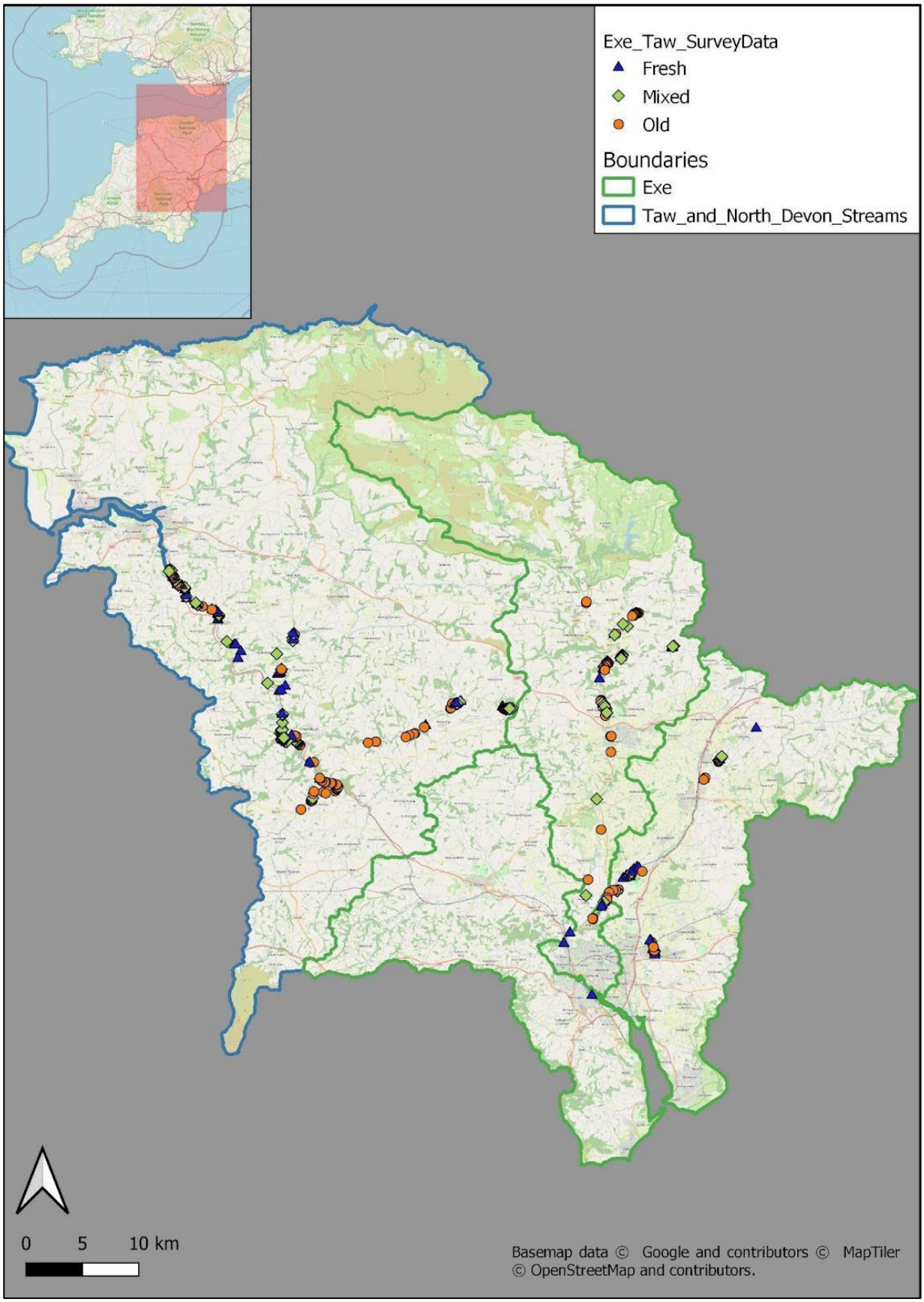

Figure 6. All recorded beaver field signs by age. Map © Alan Puttock

Overview of field sign maps represented by age of field signs. There are clearly clusters of older beaver activity with no fresh signs, indicating beavers have both been present over a number of years but also display movement in colonisation. Such areas can demonstrate areas of abandonment though further analysis of field sign density and type more likely displays a direction of dispersal, with areas of mixed age field signs more reflective of areas of active territories. Low-density fresh signs are also more likely to indicate single dispersing animals moving through the catchment, given the timeframe beavers have been reported over, this may indicate breeding with dispersing offspring (older than two years) looking for mates and suitable territories.

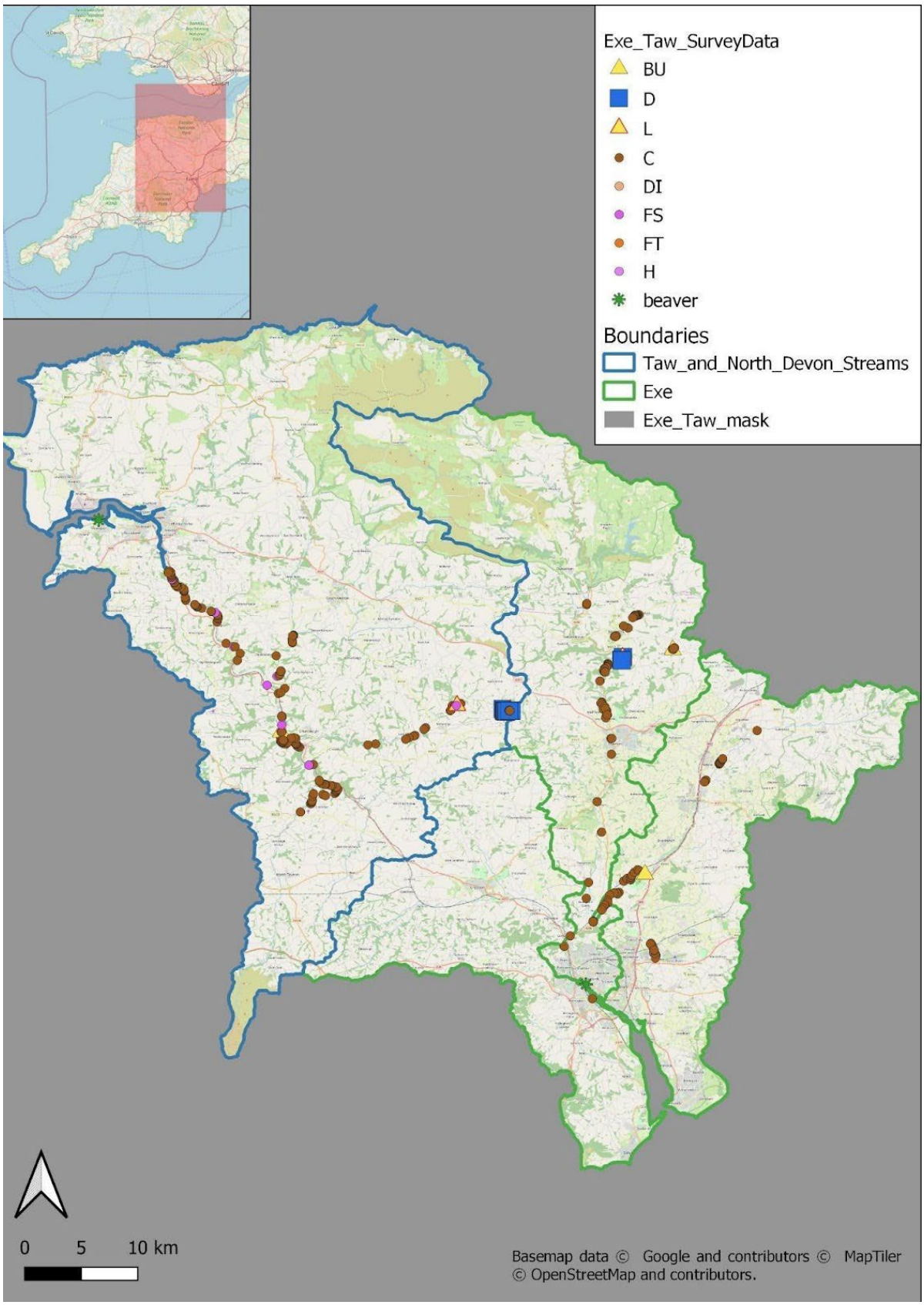

Figure 7. All recorded beaver field signs by sign type across both catchments (see Table 1 for field sign key). Map © Alan Puttock

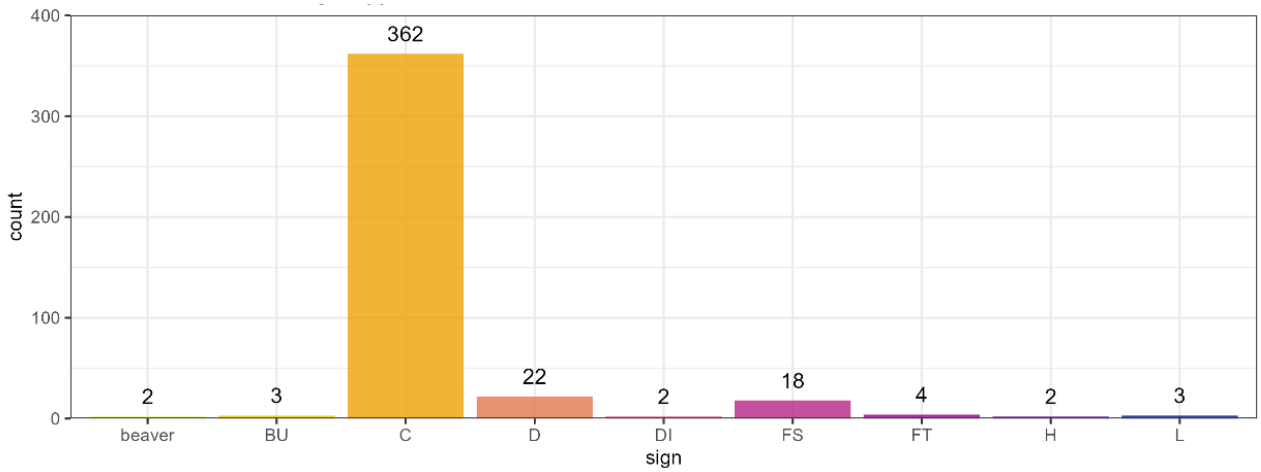

Figure 8. 2023 Exe and Taw sign types recorded. Sign type of all recorded beaver signs for both catchments. In sign coding: BU = burrow, C = woody feeding, D = Dam, DI = digging/canal, FS = feeding station, FT = forage trail, L = lodge.

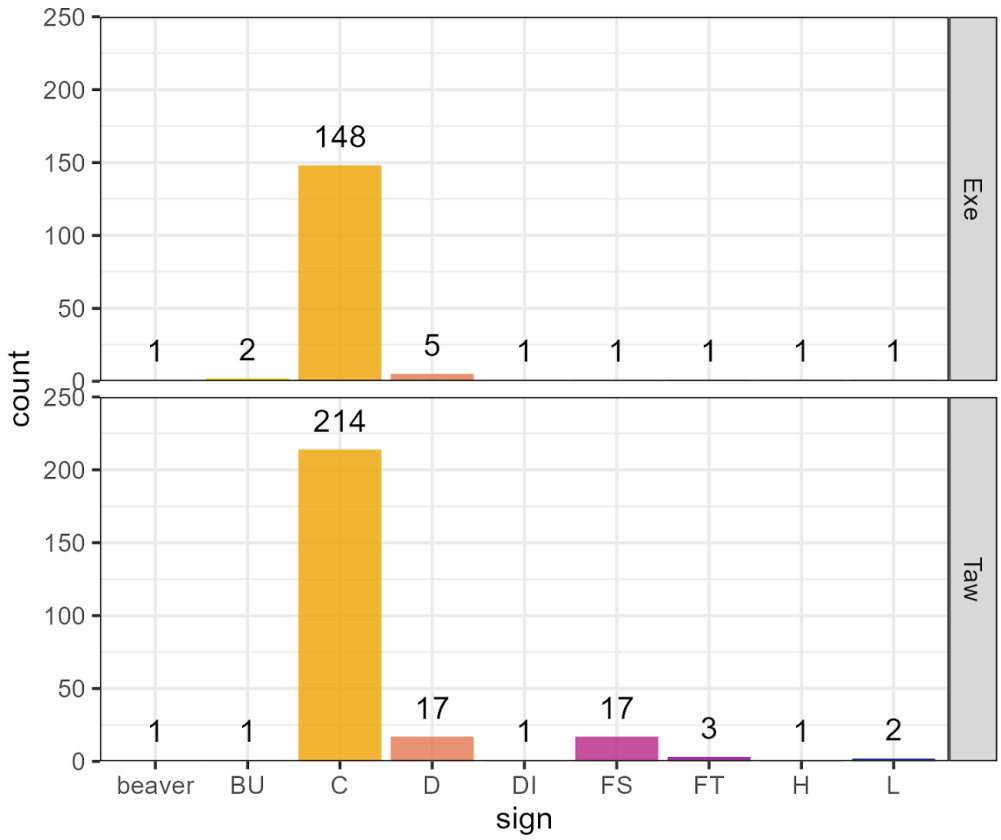

Figure 9. 2023 Exe and Taw sign type recorded Sign type of all recorded beaver signs split by catchment. Field sign coding: BU = burrow, C = woody feeding, D = Dam, DI = digging/canal, FS = feeding station, FT = forage trail, L = lodge.

By far the most commonly recorded field sign type was woody cuts (including cut woody stems, trunk gnawing, full and partially felled trees). Associated foraging signs such as forage trails were present in small numbers and typically associated with areas of more

dense and mixed age beaver activity. Few lodges were identified, but where present could be directly associated with active territories and an indication of longer beaver presence. Very few lodges were found on the main river stem. Undoubtedly, burrows were under-recorded given the recognised difficulty of identification, especially in deeper and dark water. Also given these populations are still presumed to be fairly small, with dispersing individuals, it is most probable that burrows are a more common shelter feature than lodges. Damming throughout both catchments was low, occurring in very distinct clusters in active territories, all situated on small tributaries higher up in the catchment. Recent beaver sightings at the time of the survey are marked, both near the main respective river mouths.

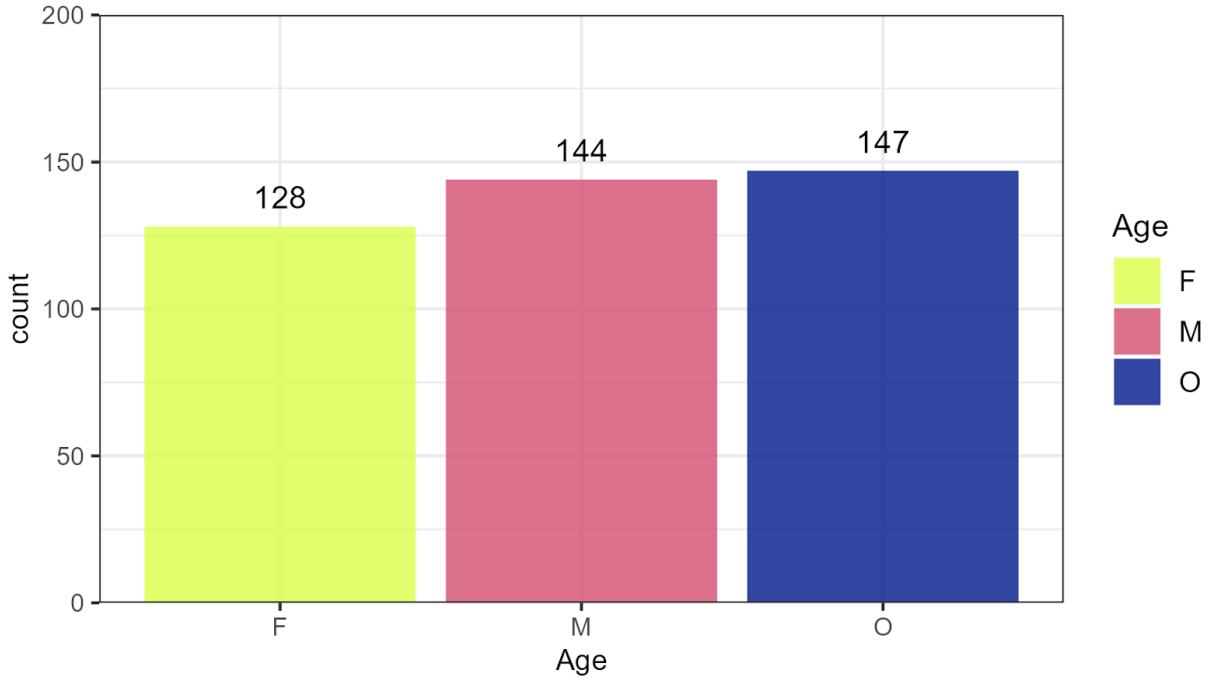

Figure 10. Age of all recorded beaver signs across both the Taw and Exe. F = fresh, M = mixed and O = old

A range of field sign ages were recorded, noting that a good deal of older field signs were present in both catchments and a *strong indication* beavers have been present for several years, at least a minimum of three years.

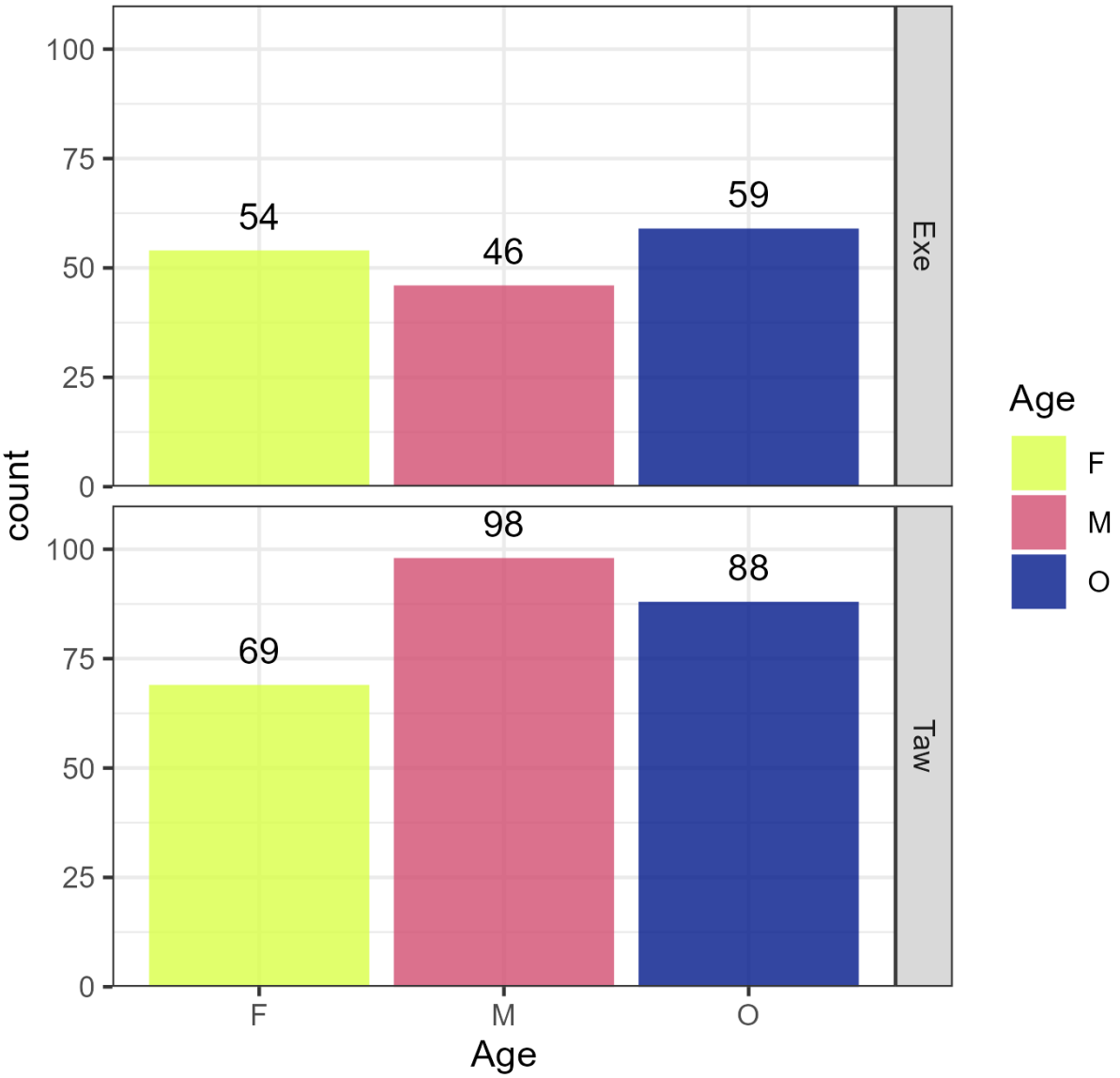

Figure 11. Age of all recorded beaver signs across both the Taw and Exe separated by catchment. F = fresh, M = mixed and O = old.

Exe Catchment

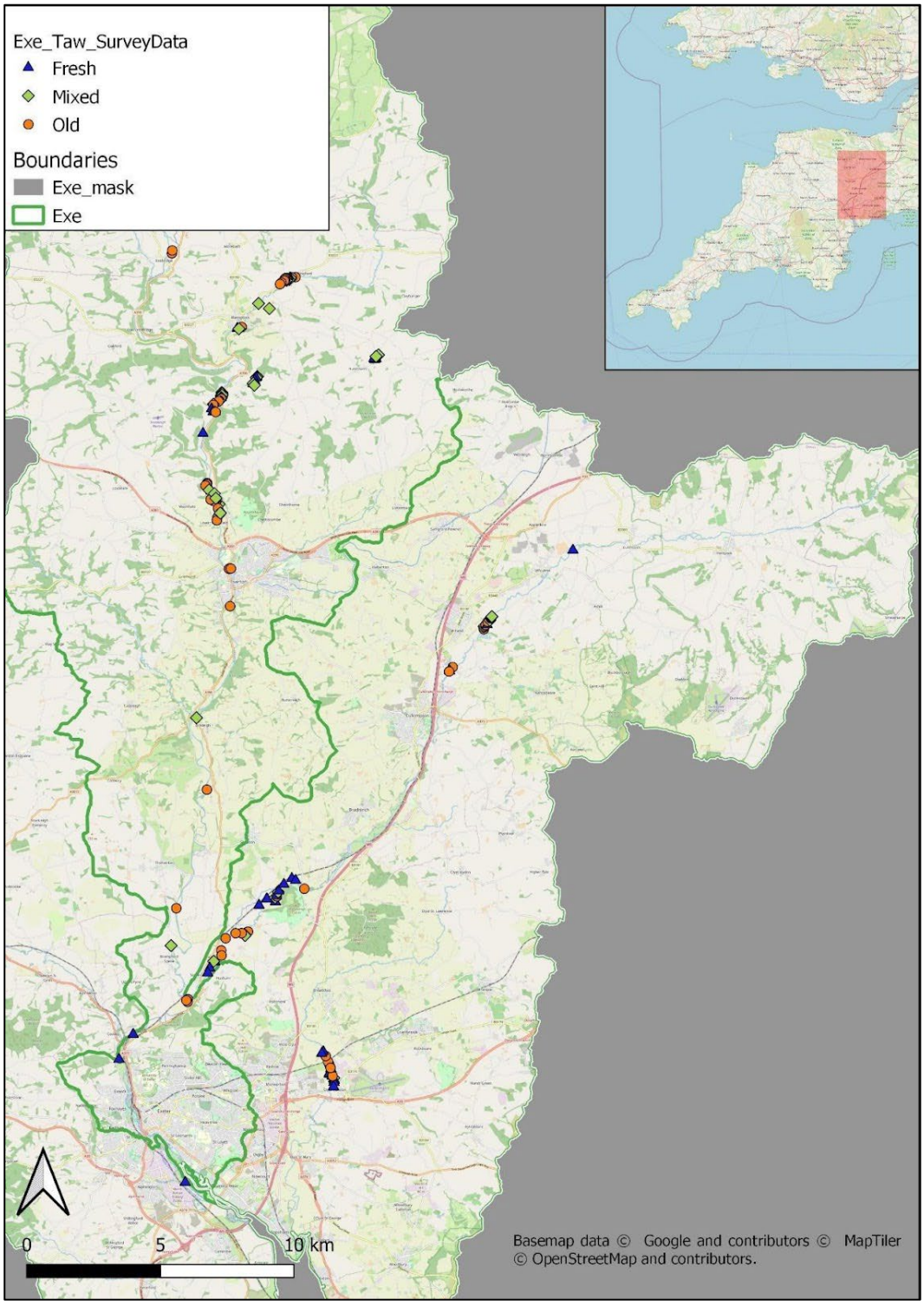

Figure 12. All recorded beaver field signs displayed by age for the Exe survey area. Exe_catchment area is masked out from rest of Devon for clarity (grey Exe_mask area). Map © Alan Puttock

Evidence of older beaver activity is present and indicates some level of movement through the lower catchment (at least a minimum of three years). There are clear clusters of mixed

and fresh activity representing established and establishing territories, and also recent dispersal of offspring.

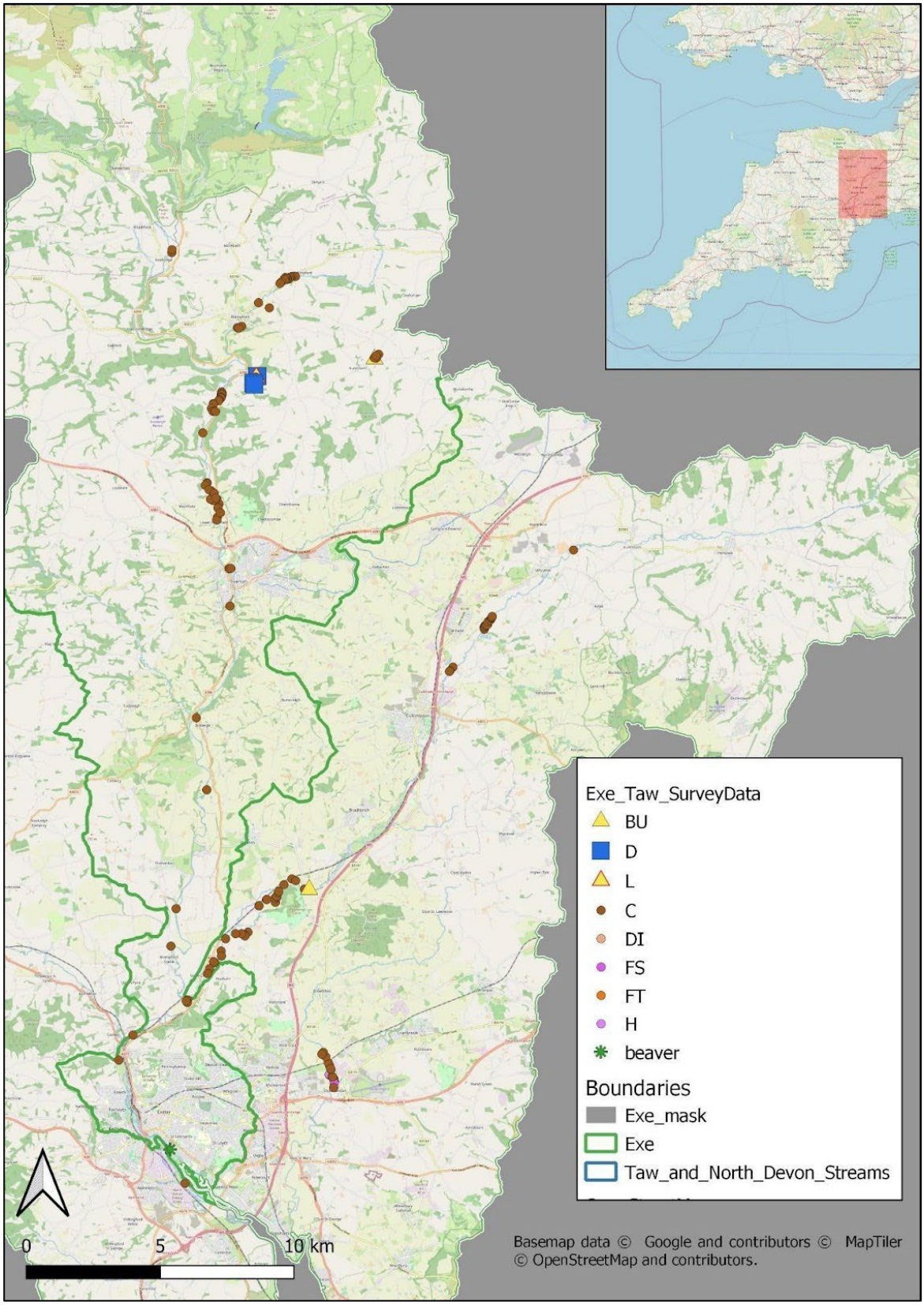

Figure 13. All recorded beaver field signs by sign type for Exe beaver survey area (see Table 1 for field sign key). Exe_catchment area is masked out from rest of Devon for clarity (grey Exe_mask area). Map © Alan Puttock

Taw Catchment

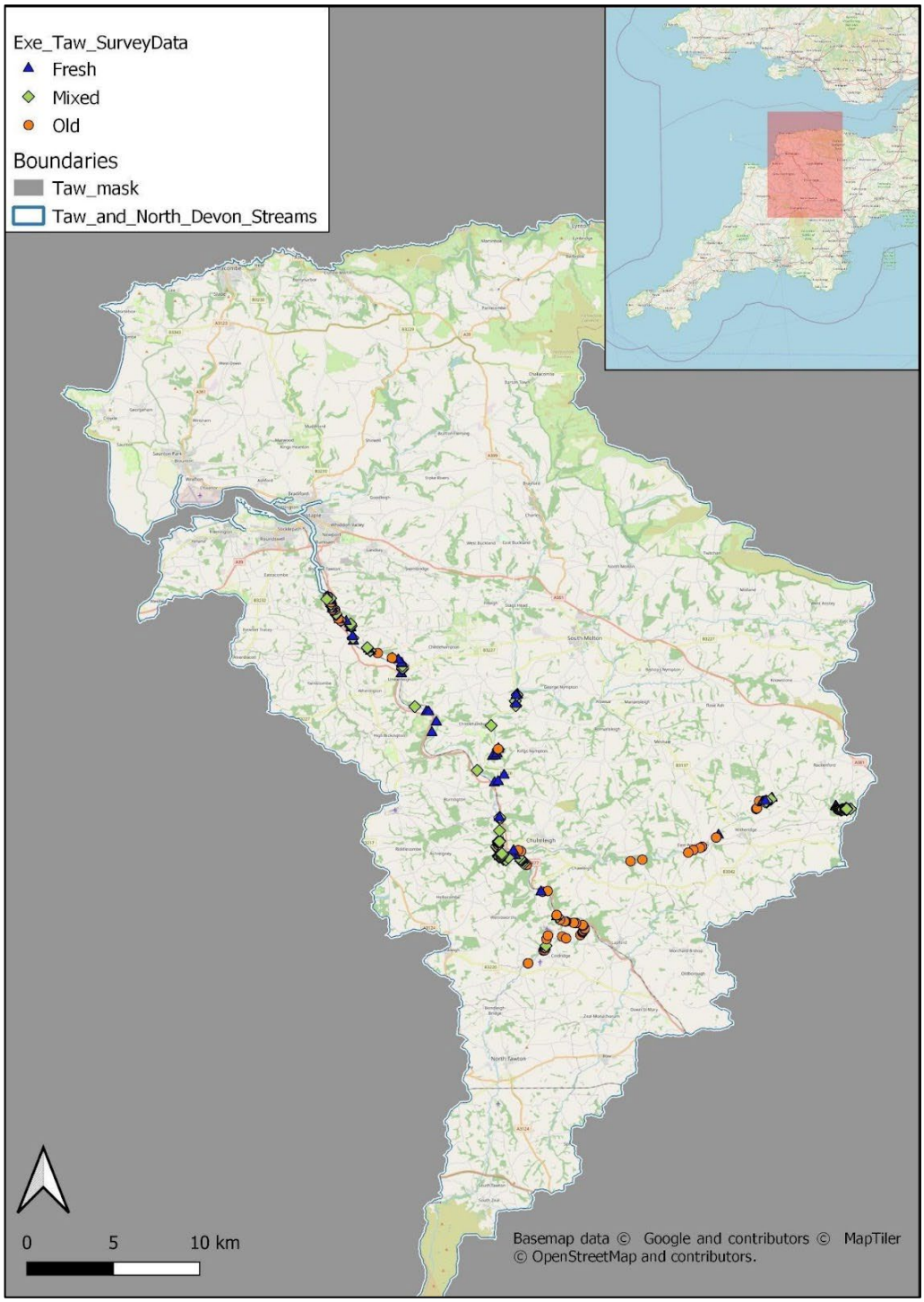

Figure 14. All recorded beaver field signs by age for Taw survey area. Taw catchment area is masked out from rest of Devon for clarity (grey Taw_mask area). Map © Alan Puttock

Evidence of older beaver activity is present and indicates some level of movement through the lower catchment over several years. There are clear clusters of mixed and fresh activity representing established and establishing territories, and also recent dispersal of offspring.

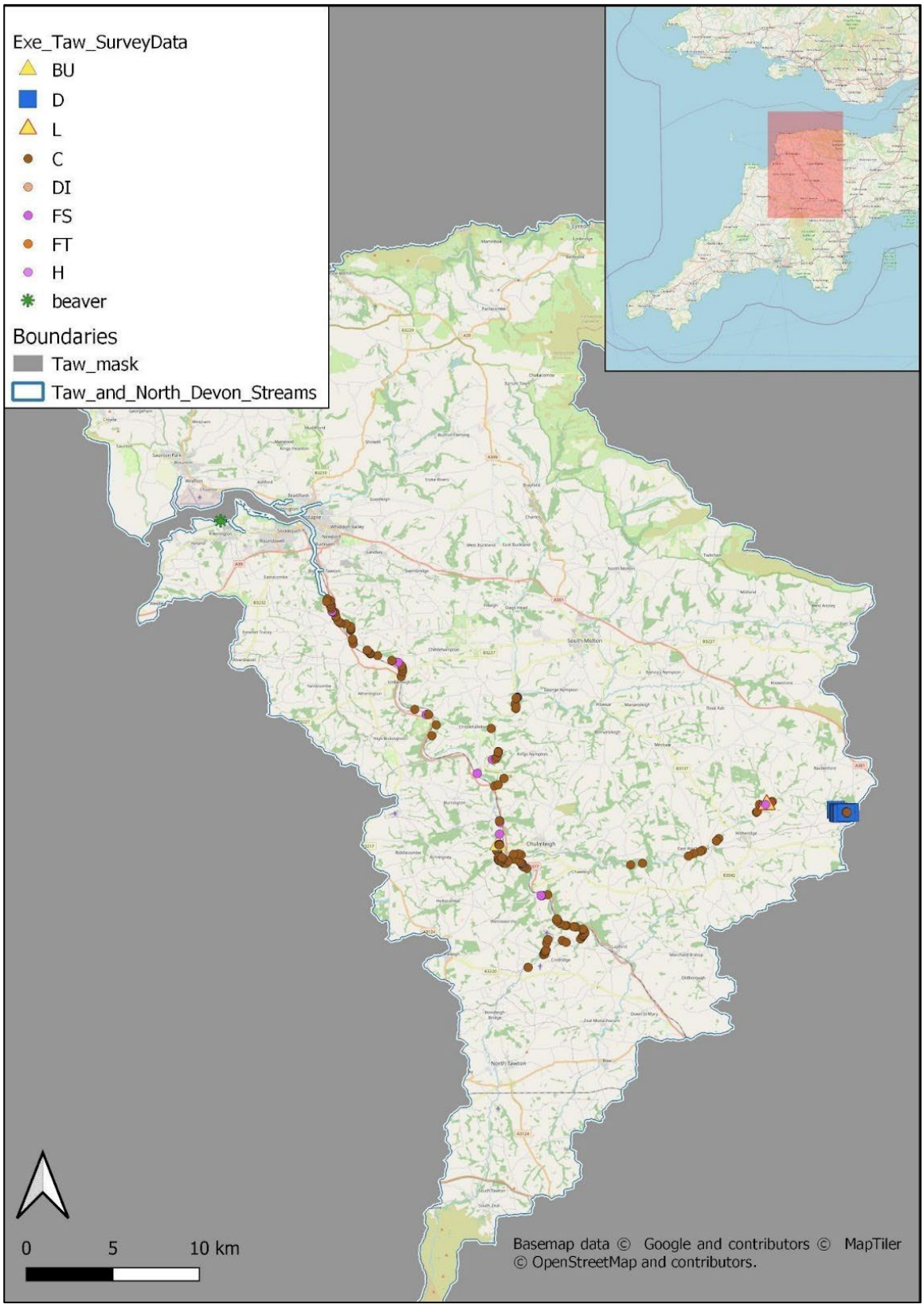

Figure 15. All recorded beaver field signs by sign type for Taw beaver survey area (see Table 1 for field sign key). Taw_catchment area is masked out from rest of Devon for clarity (grey Taw_mask area). Map © Alan Puttock

Field Sign Examples

Figure 16a and b. Lower River Taw - aged beaver cutting with coppiced regrowth of at least two years. Photos © Beaver Trust

Figure 17a and b. Active feeding areas on the Little Dart. Photos © Beaver Trust

Figure 18a, b and c. Examples of various damming activities within the Taw catchment. Photos © Beaver Trust

Figure 19. Active lodge on the Taw catchment. Photo © Beaver Trust

Figure 20. Fresh feeding on the River Clyst. Photo © Beaver Trust

Figure 21a and b. Very aged and very fresh feeding on the River Exe near Tiverton. Photos © Beaver Trust

Figure 22. Partially collapsed burrow on River Exe. Photo © Beaver Trust

Figure 23. Mixed age feeding on the river Culm. Photo © Beaver Trust

Beaver Impacts recorded during the survey

Beaver impacts and potential for conflict were recorded variably across the survey area, noting that for some field signs whether they are considered ‘impacts’ can be subjective to different audiences and stakeholders. Key impacts were recorded below, focusing on more significant conflicts and/or those requiring monitoring and potentially mitigation. These impacts were mainly concentrated in areas where beaver density is likely to be higher and where beavers have been resident over several years. The hydrology of a system, proximity of a feature to the watercourse and bank composition all significantly influence potential conflicts.

Both catchments have extensive areas of agricultural land use that may generate sources of conflict in the future and at higher beaver densities. Arable is fairly limited on the Taw and Exe, with more pasture and woodland coverage. Some significant tributaries such as the Little Dart for example have extensive areas of riparian woodland.

Very few obvious management impacts were observed during the survey, though this is most likely due to the low numbers of animals present in both catchments. In the early

colonisation phases of beaver population growth, beavers typically select the best quality habitats, often those needing less modification or if they are modifying, often in areas and habitat use which is less competing with human land use.

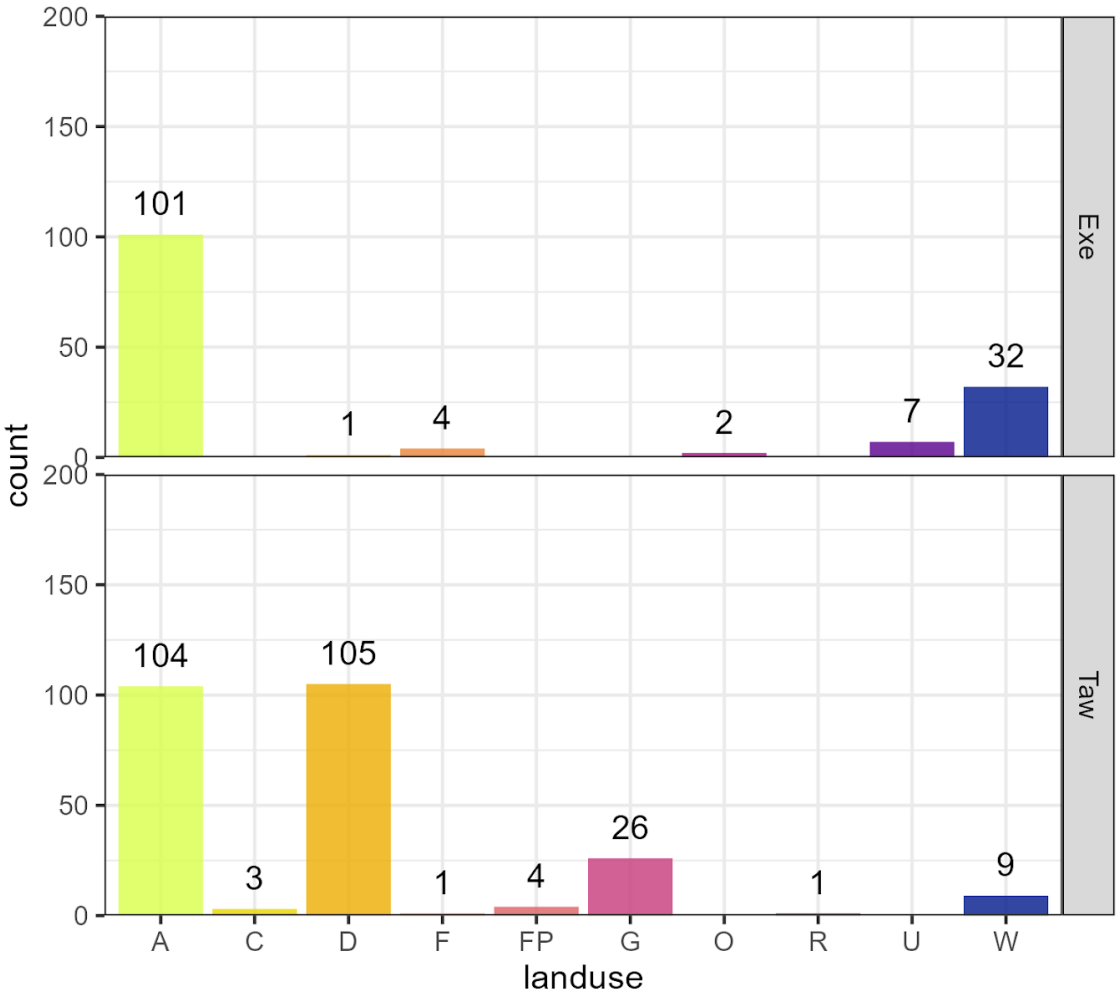

Figure 24. Land use of all recorded beaver signs separated by catchment. Landuse key: A = agricultural, C = conifer/commercial forestry, D = deciduous woodland, F = fishing/recreation, FP = off channel fishing pond, G = grassland, O = other, R = residential, U = utility / infrastructure / road and rail, W = wet marsh or other wetland

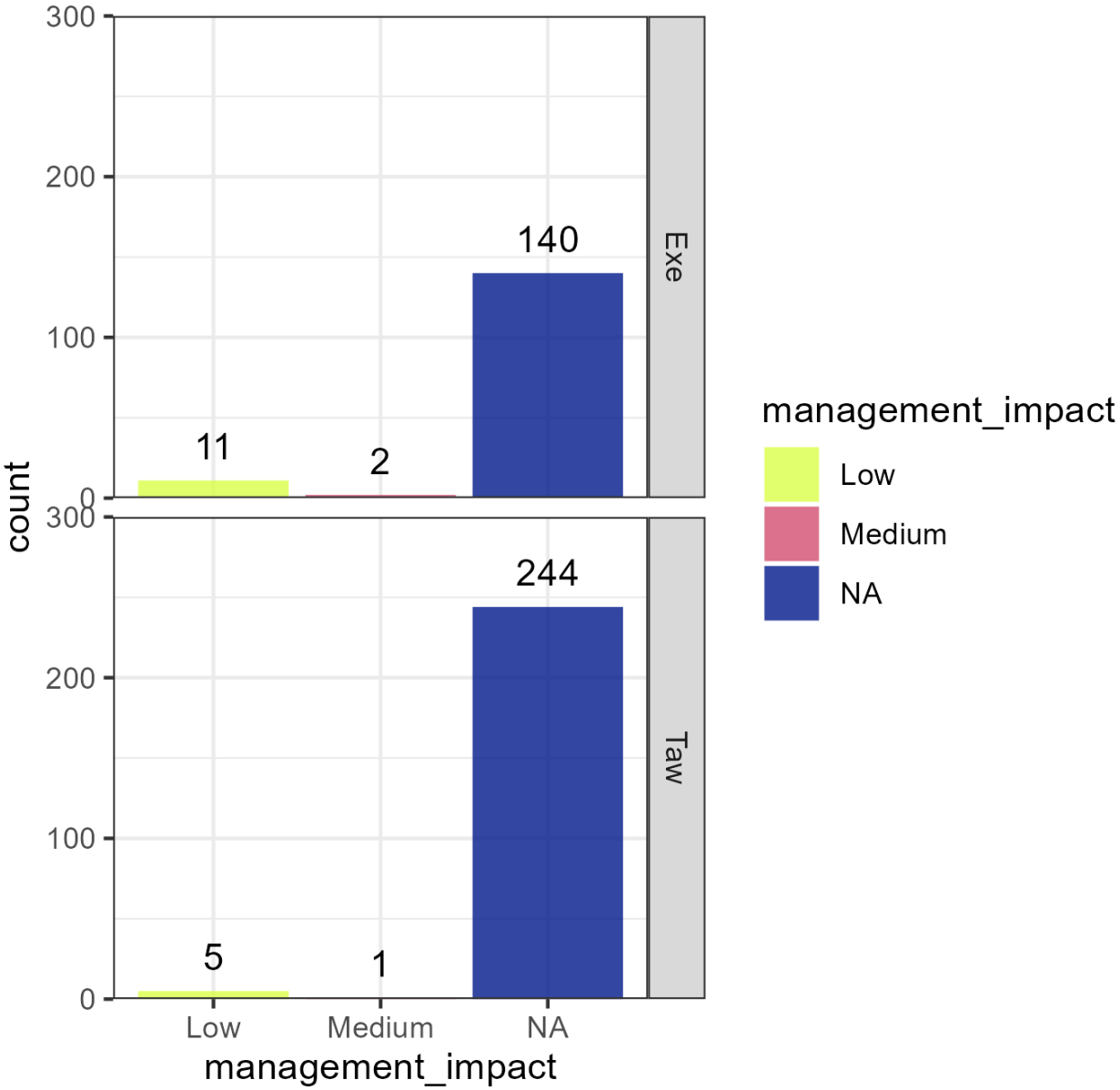

Figure 25. Management impact of all recorded beaver signs split by catchment.

Territory Identification

The stepwise process to identify the likely active territories is represented in the modelling outputs below (Figures 26-31). These have been split into confidence, with pink borders representing areas that are highly likely to be active territory currently, and blue borders indicating an area of activity that goes beyond a few field signs. In these latter areas we are less confident that they represent an active family territory and are more likely to represent an area in which a singleton may be residing (potentially dispersing from a family group at an age of > 2 years old or an unpaired adult for example); or the fringes of an active territory. These areas may become abandoned or equally become a territory in the following seasons.

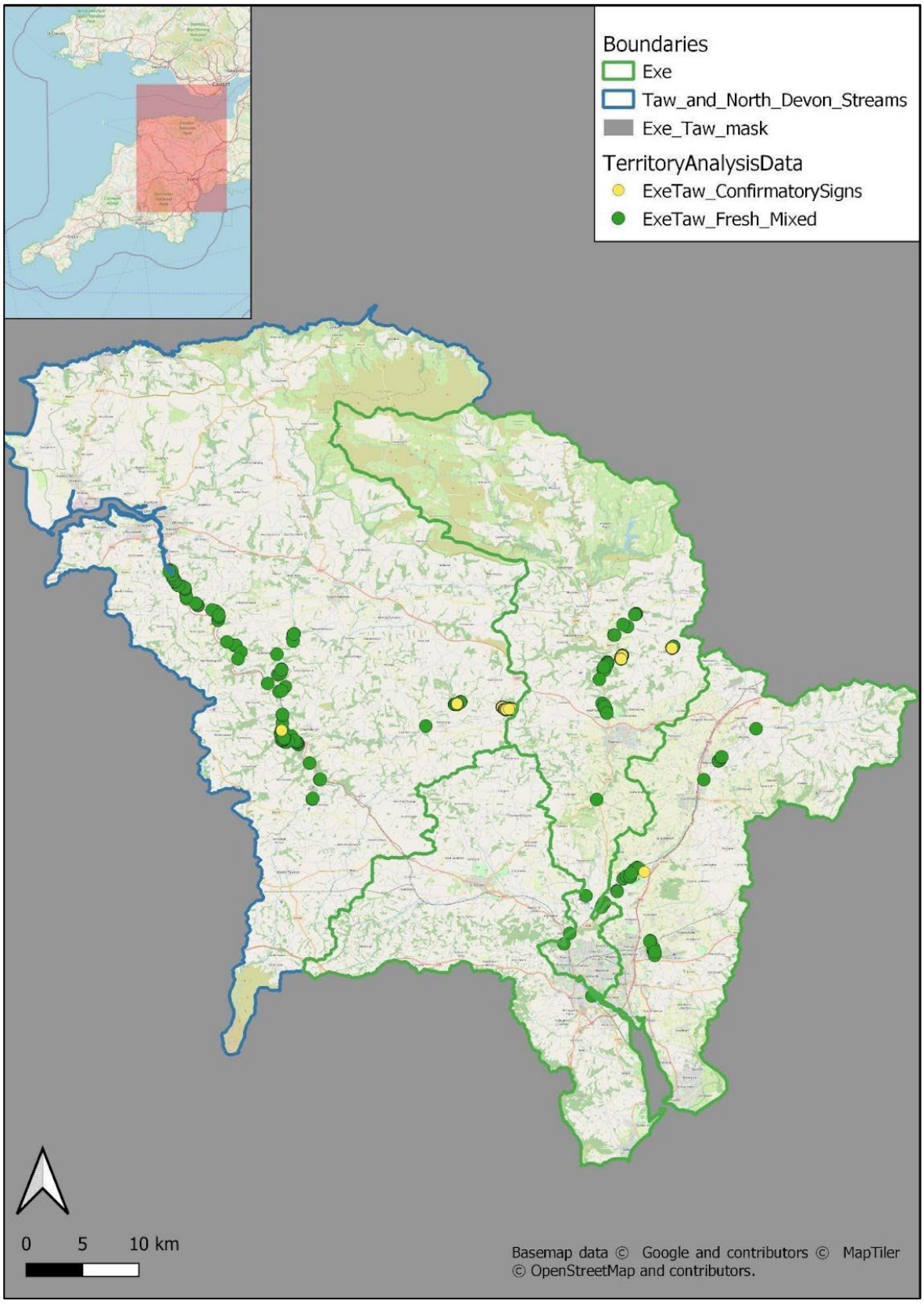

Figure 26. Data used for territory delineation ie, fresh and mixed signs, in addition to key dam and dwelling signs used for confirmation or increased confidence in territory identification. Exe and Taw catchment areas are masked out from rest of Devon for clarity (grey Exe Taw mask area). Map © Alan Puttock

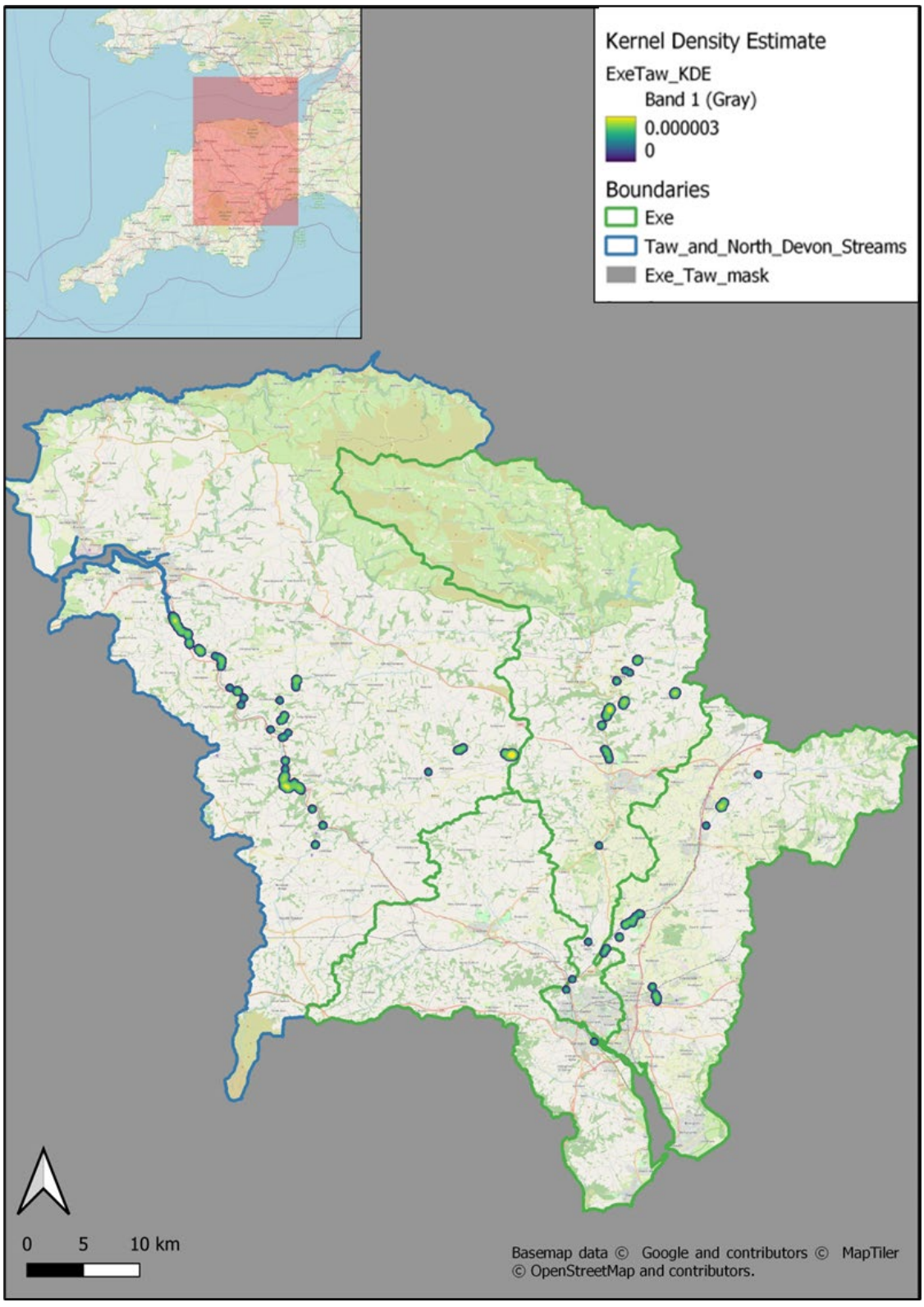

Figure 27. Initial 'heatmapping' of fresh and mixed signs via kernel density estimate KDE analysis to enable automated territory determination. Exe and Taw catchment areas are masked out from rest of Devon for clarity (grey Exe Taw mask area). In the KDE scaling, yellow areas represents 'hotspots' where the higher density of signs recorded, reducing through green to purple for lower density of recorded signs. Map © Alan Puttock

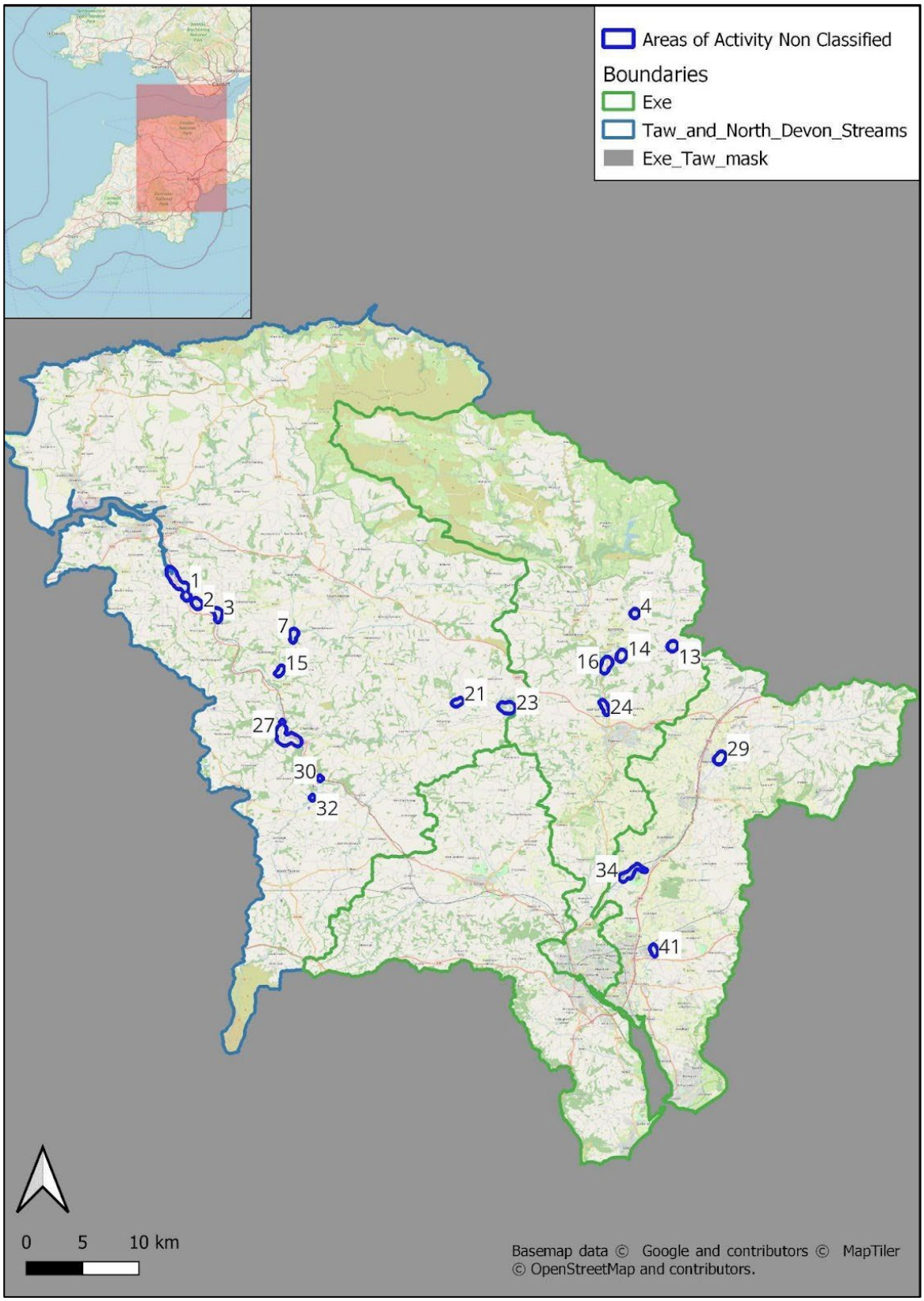

Figure 28. All identified 'areas of activity' within the Exe and Taw catchments labelled via nonsequential numbering. Exe_and Taw catchment areas are masked out from rest of Devon for clarity (grey Exe_Taw_mask area). Map © Alan Puttock

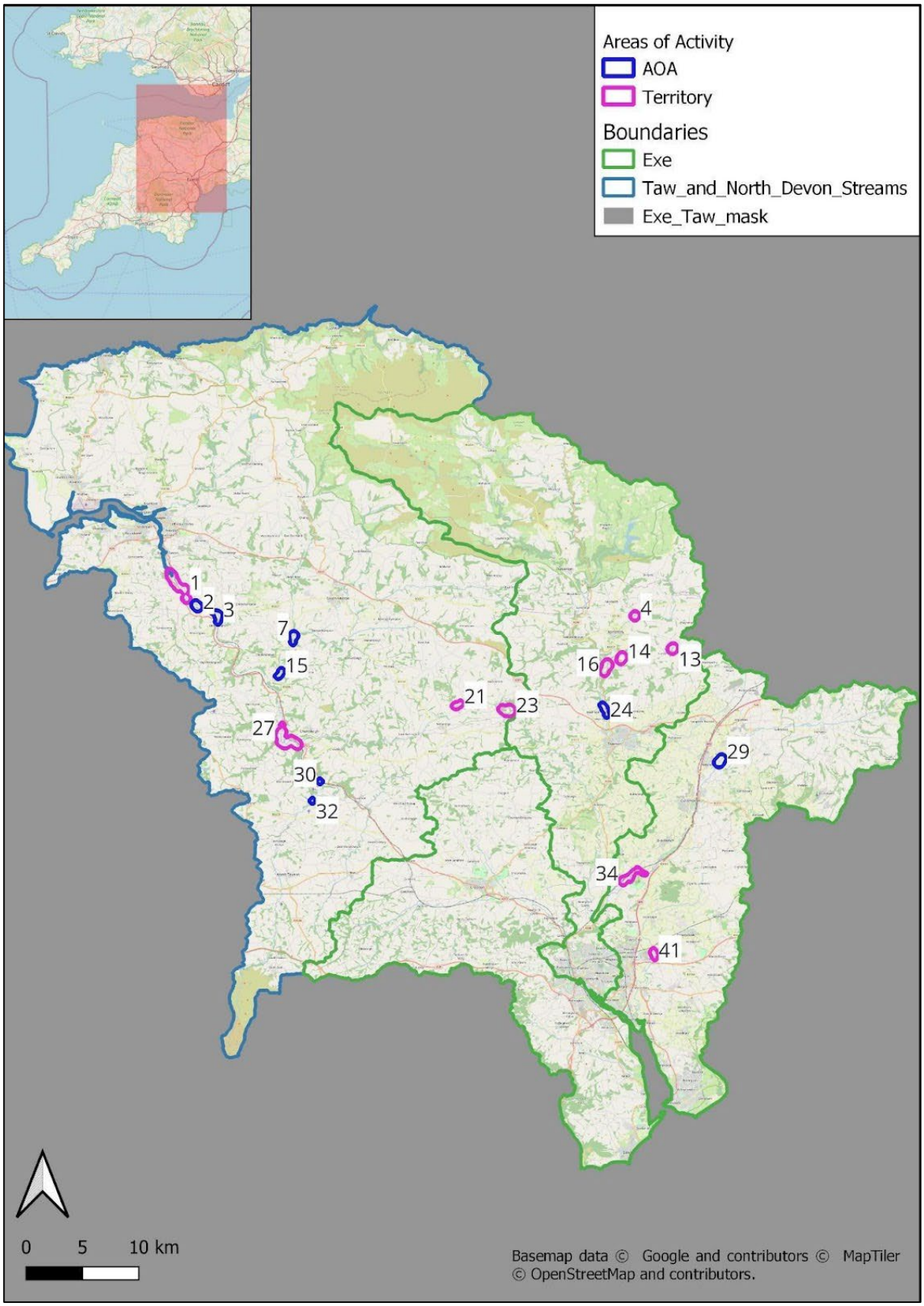

Figure 29. All core areas of beaver activity are classified as either a territory or an area of activity. Exe_and Taw catchment areas are masked out from rest of Devon for clarity (grey Exe_Taw_mask area). Map © Alan Puttock

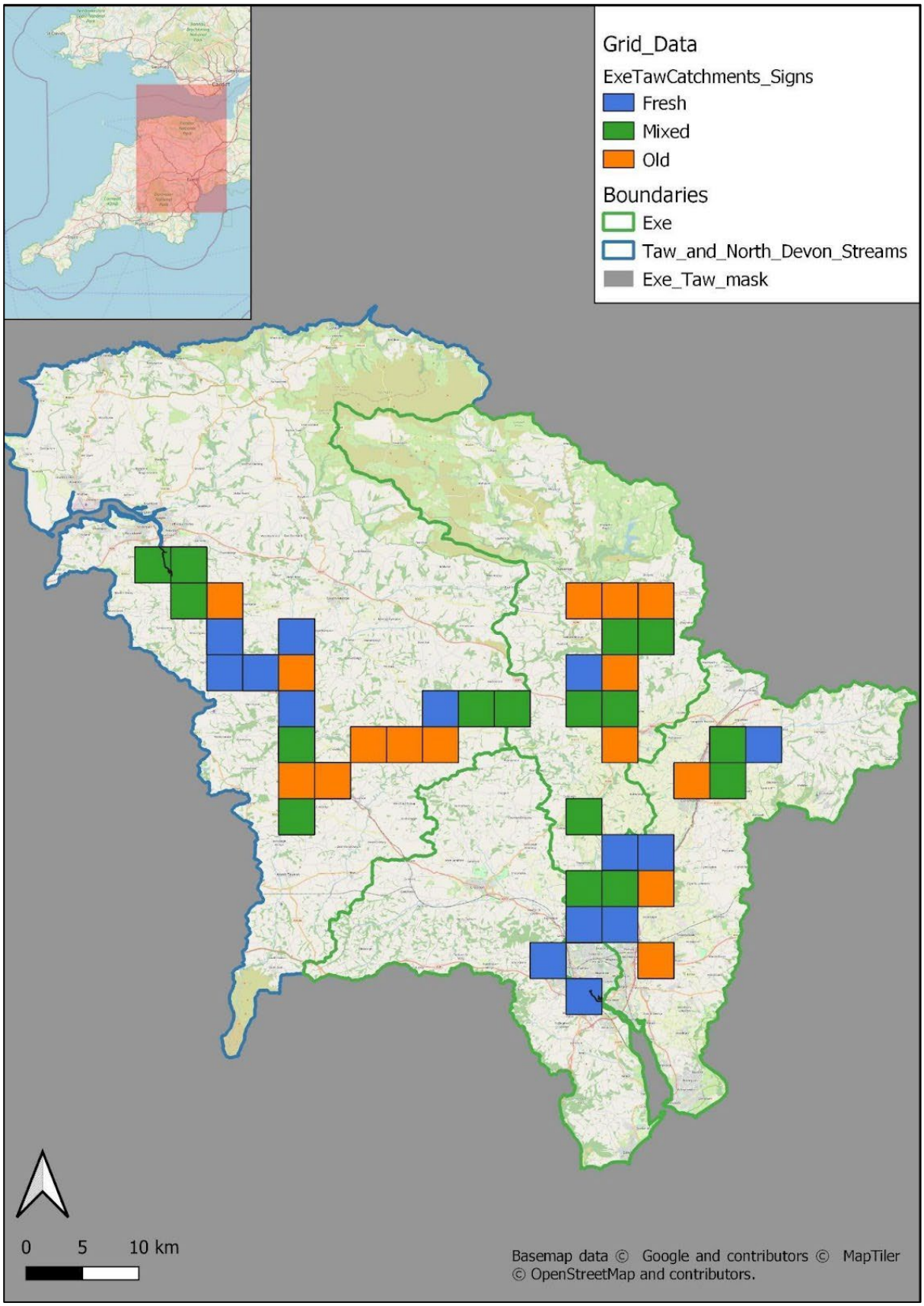

Figure 30. gridded data anonymising exact location. Each 5 km square is classified by the dominant age of beaver signs falling within it. Exe_and Taw catchment areas are masked out from rest of Devon for clarity (grey Exe_Taw_mask area). Map © Alan Puttock

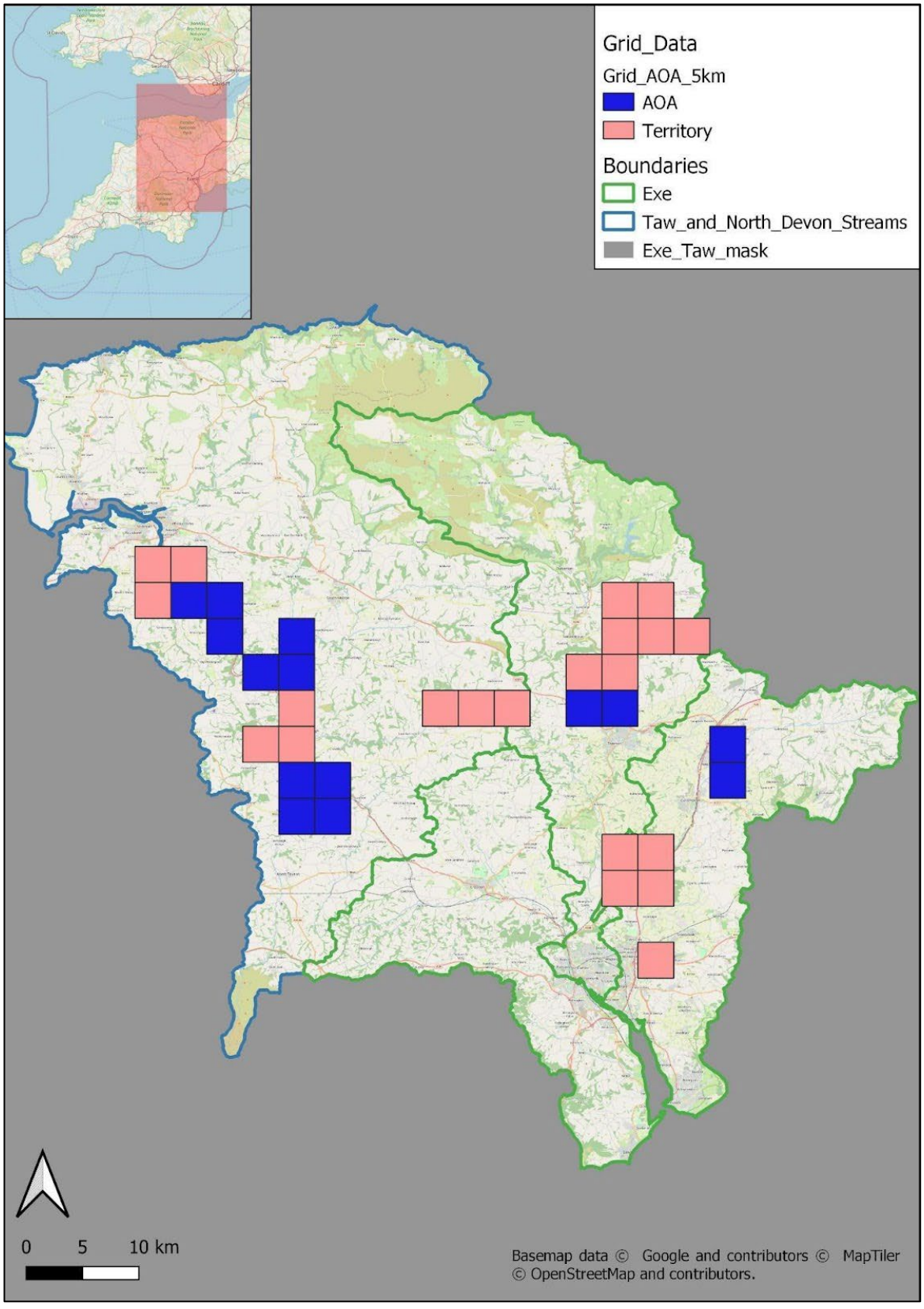

Figure 31. Gridded 5 km square data for territories and areas of activity. It is important to note that If a single territory intersects multiple squares, multiple 5 km squares will be classified as containing part of a beaver territory. Exe_and Taw catchment areas are masked out from rest of Devon for clarity (grey Exe_Taw_mask area). Map © Alan Puttock

From this data analysis and ground truthing by experienced staff it is suggested that at least six active territories are present through the Exe catchment, with a further two areas of clustered and fresh activity. While on the River Taw, at least four active territories are confidently identified with a further six areas of clustered and fresh activity. It should be noted that for both catchments there may be some overlap of the same individuals between marked territories and areas of activity. Further information on breeding status and age-class survival would greatly refine any population estimates.

There seems no obvious ecological reason why each of these territories does not already or will shortly include breeding adults with dependent offspring. Therefore, using conservative estimates of an active territory at the start of the breeding season composing 3.8 ± 1.0 SD individuals on average (Rosell and Parker 1995) the following population estimate range is given as.

River Exe catchment

- 6 active territories = 22.8
- 2 areas of activity with a minimum of a single individual = 2
- Total expected minimum of c.a. 25 individuals

River Taw catchment

- 4 active territories = 15.2
- 6 areas of activity with a minimum of a single individual = 6
- Total expected minimum of c.a. 22 individuals

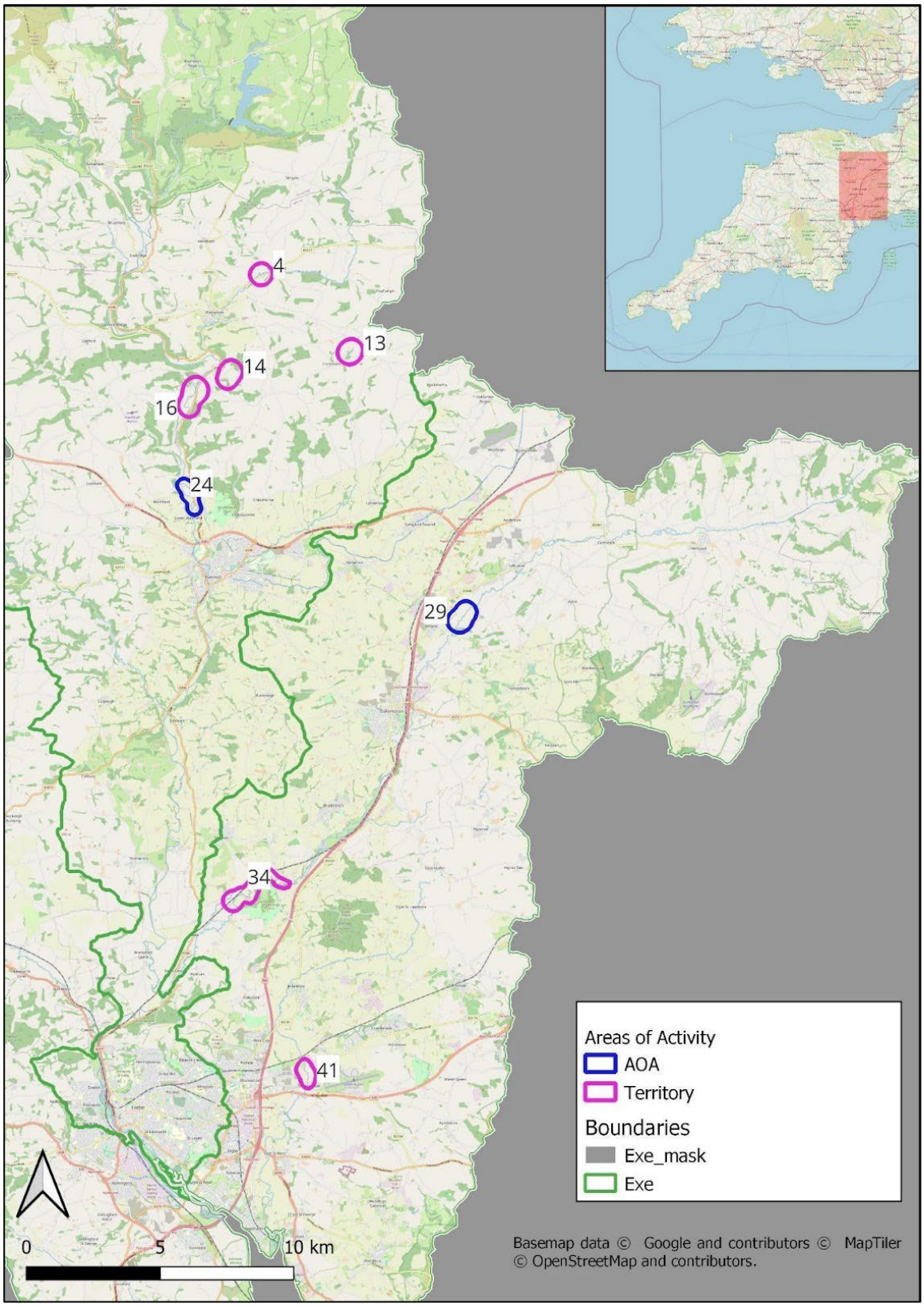

Figure 32. Beaver territories and areas of activity for the Exe. Exe_ catchment area are masked out from rest of Devon for clarity (grey Exe _mask area). Map © Alan Puttock

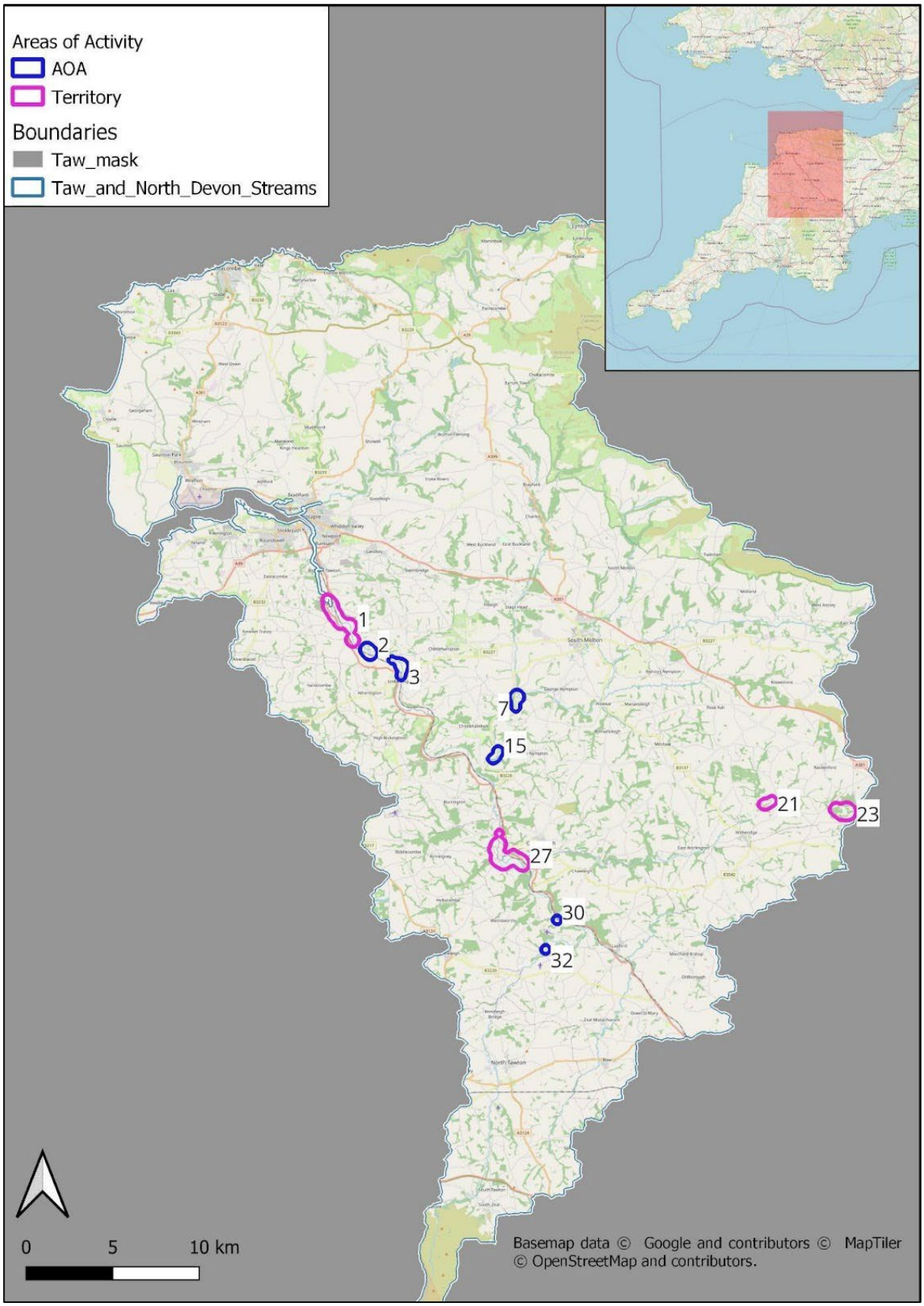

Figure 33. Beaver territories and areas of activity for Taw. Taw catchment areas are masked out from rest of Devon for clarity (grey Taw_mask area). Map © Alan Puttock

Recommendations for future surveys

Initial findings from this report suggest that beavers are currently existing in low densities, in the lower parts of both catchments and fairly sparsely distanced from each other. Distribution maps and field sign ages also suggest mobile individuals searching for mates and establishing territories. Therefore, repeated survey efforts (every 3 - 5 years) are probably required in future years to map how these populations develop (both expansion and contraction are of course possible). A central database of beaver presence recording between surveys is highly recommended to assist in full surveying efforts and to enable the targeting of future surveys. Additionally, landowner permission and riparian ownership identification would assist in future efforts. This survey did reveal that further survey effort and landowner access permission is particularly recommended for the Rivers Culm and Clyst as beavers do appear to be establishing and potentially breeding in these two catchments, though access was restricted and more animals could be present. Such surveys could also determine if colonisation from the River Otter was also potential source.

In addition, given the sensitivity of certain watercourses to potential beaver burrowing impacts, regular monitoring of certain features would provide additional information ahead of any repeated survey efforts. These features may include infrastructure close to watercourses, flood banks, public rights of way, the limited canal systems (Grand Western canal east of Tiverton) and fishing lake embankments.

Conclusion

This study aimed to undertake a thorough beaver field sign survey in order to obtain estimates on current beaver distribution and estimate population size in both the Taw and Exe catchments, Devon. A field sign survey was undertaken to cover as many riparian areas within these catchments as permitted by landowners wishing to grant access, with additional main river stem access by canoe. Survey efforts were focused on the main river stems and significant tributaries in which beavers had been previously recorded to some extent on both catchments. Therefore, the headwaters and smaller watercourses were not fully surveyed. In addition, landowner permission was either not given or not possible to gain to enable total coverage of every watercourse in the catchments. Consequently, some areas of activity may have been missed. Future efforts, for example, should focus on the upper River Culm and Clyst, where quality of habitat suggests that beaver territories could be supported.

Field sign type and distribution are presented alongside a kernel density estimation method to establish approximate population sizes. Through detailed analysis of the data, it is evident that beavers are distinctly distributed throughout the mid to lower sections of both catchments. Patterns of current colonisation are patchy and may be explained by

expansion from historic, unofficial releases, though it should be noted that natural colonisation from existing territories on the River Otter catchment may also explain patterns of expansion. This could have occurred from three routes (with the least likely listed first); via River Otter mouth into the mouth of River Exe; into River Culm via Otterhead Lakes; and into the River Clyst via the River Tale headwaters. Either way these are all viable future dispersal routes. Natural colonisation of the Taw catchment is not as clear-cut as it is more distant and less directly accessible to other known beaver populations. However, natural colonisation from the Lower Exe, via the Little Dart into the River Taw is a plausible route, especially given the distances that beaver can travel overnight on main river systems (>40km).

A variety of field sign types were recorded with woody cutting being the most abundant followed by damming activity, forage trails and feeding stations respectively. There are clear clusters of older beaver activity with no fresh signs in both catchments, indicating beavers have been present over a number of years but also display movement during the establishment phase of the population. Records of isolated fresh feeding signs are likely to indicate individual dispersing animals moving through the catchments. Areas of mixed age field signs are however more reflective of areas of active territories. Three lodges were observed, two on the Taw and one on the Exe. Despite there being only three records of burrowing, it is important to note that it is very likely burrows were under-reported given water depth and clarity and associated visibility. Damming activity was greater on the upper Taw catchment and likely to represent longer established active territories (dams = 17) compared to the Exe (dams = 5) and although watercourse width along many of the smaller tributaries would facilitate dam building, water depth is most likely to be the main limiting factor. No signs of scent marking were noted, presumably attributed to the low population density and a lack of resource / territorial competition currently.

Beaver impacts were recorded in both catchments, albeit low, most likely due to the low population density. Agricultural land is abundant in both catchments. With population expansion it is highly likely an increase in management impacts will be observed in the future. The Rivers Taw and Exe are important for recreational angling with a focus on game fishing for salmon, sea trout and brown trout and as the beaver population increases it is probable that concerns in relation to dams and fish passage may arise. As the weight of evidence shows beaver impacts to be positive with regard to salmonid populations at the catchment scale, these concerns may be unfounded, but may warrant further investigation.

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