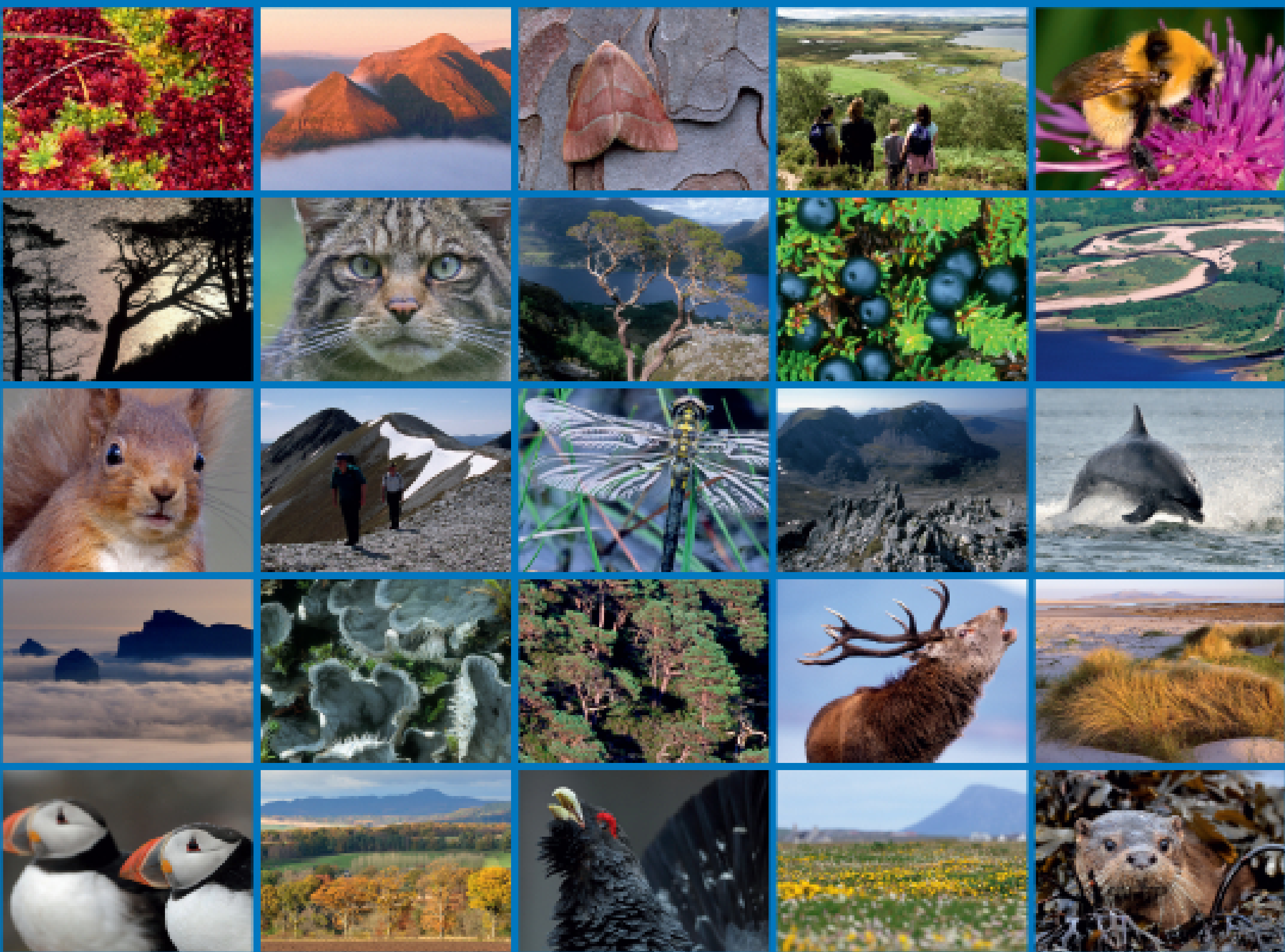
Scottish Natural Heritage
Commissioned Report No. 383

The Scottish Beaver Trial: Ecological monitoring of the European beaver Castor fiber and other riparian mammals – Initial methodological protocols 2009



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COMMISSIONED REPORT

Summary

The Scottish Beaver Trial: Ecological monitoring of the European beaver *Castor fiber* and other riparian mammals – Initial methodological protocols 2009

Commissioned Report No. 383 (iBids No. 7062)
Contractor and Partner: The Wildlife Conservation Research Unit, University of Oxford.
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BACKGROUND

In 2008, the Scottish Government approved a licence for the Scottish Wildlife Trust (SWT) and the Royal Zoological Society of Scotland (RZSS), to undertake a five year trial reintroduction of the European beaver *Castor fiber* after an absence of over 400 years. The aims of the trial include an assessment of the ecology of the beavers, and their effects. The success or failure of the trial will be based on a number of specific criteria, which relate to the ability of the reintroduced population to sustain itself, the effects of the beavers on biodiversity, the economic effects of the beavers, and the cost of their reintroduction and ongoing management.

In order to effectively assess the Scottish Beaver Trial, Scottish Natural Heritage (SNH) is coordinating a monitoring programme, in collaboration with a number of independent organisations. A core element of this is the monitoring of the beaver population itself. SNH is therefore working in partnership with the Wildlife Conservation Research Unit at the University of Oxford (WildCRU) in order to ensure the monitoring of the beavers, and other riparian mammals present at Knapdale, is suitable and appropriate. The aim of this report is to clearly set out the initial methodological protocols to be used when gathering data for the monitoring of the beaver population and other riparian mammals. The methods, devised for use from spring 2009, will be regularly reviewed and any changes reported in subsequent reports.

PROTOCOL OUTLINE

The monitoring work is split into six tasks. These are:

- Trapping
- Observations
- Radio-telemetry
- Argos-telemetry
- Field-sign surveys (beavers)
- Field-sign surveys (other riparian mammals)

For each task, the aims, equipment, techniques, data quality / sample sizes issues and data / sample storage methods are set out. Techniques for trapping and handling of beavers, radio-telemetry and beaver field-sign surveys are expanded in detail in the appendices. Suggestions for integrating data with other Scottish Beaver Trial monitoring projects are provided, and five-year work-plans for data collection and data analyses and interpretation are set out.

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This project was supported through a partnership of Scottish Natural Heritage and the University of Oxford Wildlife Conservation Research Unit as part of the monitoring of the Scottish Beaver Trial. The authors thank the Royal Zoological Society of Scotland (RZSS), the Scottish Wildlife Trust (SWT), and Forestry Commission Scotland for their help and cooperation. RZSS and SWT will also contribute funds to the overall monitoring programme.

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Note - SNH has also been provided with electronic versions of the following spreadsheets for use by SWT and RZSS:

- Trapping and sighting data spreadsheet
- Behavioural observation and location spreadsheet
- Radio-telemetry data spreadsheet
- Beaver field-sign survey data spreadsheet
- Riparian mammal survey data spreadsheet

1 INTRODUCTION

1.1 Background

The European, or Eurasian, beaver *Castor fiber* became extinct in Scotland around the 16th century as a result of over-hunting. Over recent years the potential for restoring this species to the natural fauna has been investigated. These investigations have resulted in a suite of information with regard to the scientific feasibility and desirability of conducting such a reintroduction. Relevant documents published by Scottish Natural Heritage (SNH) can be viewed at www.snh.gov.uk/scottishbeavertrial.

The work undertaken is in line with obligations on the UK Government, under Article 22 of the European Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna (the 'Habitats Directive'), to consider the desirability of reintroducing certain species (listed on Annex IV), including European beaver. No work is currently planned for the restoration of any other species listed in Annex IV of the Habitats Directive.

The Species Action Framework, launched in 2007 by Ministers, sets out a strategic approach to species management in Scotland. In addition, 32 species, including European beaver, were identified as the focus of new management action for five years from 2007. SNH works with a range of partners in developing this work and further information can be found at www.snh.gov.uk/speciesactionframework.

In May 2008, the Scottish Government Deputy Minister for the Environment approved a licence to allow a trial reintroduction of up to four families of European beaver into Knapdale Forest, mid-Argyll.

The licence has been granted to the Scottish Wildlife Trust (SWT) and the Royal Zoological Society of Scotland (RZSS), who are managing the 'Scottish Beaver Trial'. The trial site, Knapdale Forest in Argyll, is owned by Forest Commission Scotland (FCS). Several families of animals were caught in Norway during 2008 and quarantined for six months. Three families were released in spring 2009. The release sites were Loch Coille Bharr, Loch Linne/Loch Fidhle and Creagmhor Loch. The release is being followed by a five-year period of monitoring that will run until Spring 2014. SWT and RZSS have a full time, dedicated Field Officer staff in place to cover this period.

The objectives of the Scottish Beaver Trial, as set out in the original licence application submitted by SWT and RZSS, include the following which are relevant to this report:

- Study the ecology and biology of the European beaver in the Scottish environment.
- Assess the effects of beaver activities on the natural and socio-economic environment.
- Generate information during the proposed trial release that will inform a potential further release of beavers at other sites with different habitat characteristics.

The licence application also sets out success criteria for the project, some of which are specific to the ecology of the beaver (rather than the wider socio-economic and other environmental aspects of the trial). These are:

- Survival of introduced animals is similar to that of successful reintroduction programmes elsewhere in Europe at a similar stage of population establishment.
- A stable or increasing core population is achieved within the limits of the study site.

There are also failure criteria, including:

- Mortality levels preclude establishment of a population.
- Significant and unsustainable damage is incurred by the ecosystem within the study site.
- The area suffers significant economic loss as a result of beaver activities.
- Costs of project/damage/management significantly exceed expectations.

The licence issued by The Scottish Government to the RZSS and SWT came with a number of conditions, a key one being that the monitoring of the project must be independently coordinated by SNH. As part of this process, SNH has therefore entered a partnership with the Wildlife Conservation Research Unit (WildCRU) at the University of Oxford to support and enable the ecological monitoring of the beaver population and other riparian mammals during the trial period. This is one element of a wider monitoring programme set out to fulfil the aims of the trial. Other monitoring elements in this programme coordinated by SNH include:

- Beaver health
- Terrestrial vegetation
- Aquatic/ semi-aquatic macrophytes
- Fish
- Odonata
- Water chemistry
- Hydrology
- Riverine geomorphology
- Socio-economics
- Public health
- Scheduled monuments

WildCRU does not have a lead role with the other monitoring projects listed above, but the intention is to ensure the various elements are coordinated so that data can be efficiently collected and shared by those involved with the monitoring programme.

1.2 Aims of the project

The overall objectives of the Scottish Beaver Trial, and the success and failure criteria as set out in the licence application, were taken into account when identifying the aims of this monitoring project.

The over-arching aim of this project over five years is to contribute towards the development of a programme of 'essential' beaver and riparian mammal ecological monitoring work required to address the aims and success/failure criteria of the trial, and to ensure SNH will have access to suitable, independent information so that it can report to Scottish Government during and after the trial. More specifically, the aims are:

To produce standardised methodological protocols

(i) To produce methodological protocols in time for the release of beaver in spring 2009 for the monitoring of 'essential', key aspects of beaver ecology.

(ii) To produce an associated five year work programme (spring 2009 – spring 2014), for the monitoring of 'essential', key aspects of beaver ecology.

(iii) To ensure the methodology includes the collation of suitable data which will allow the refinement of the existing beaver population model commissioned by SNH (Rushton *et al.* 2002), thereby improving our ability to predict future trends in beaver populations should the trial support the case for further reintroductions.

(iv) To produce a methodology which addresses other relevant mammal monitoring during the trial (in particular otter *Lutra lutra*, but also water vole *Arvicola terrestris*, and the invasive non-native American mink *Mustela vison*).

(v) To produce a detailed protocol for the Field Officer staff which will guide them in the collection, storage and dissemination of beaver-related data during the trial, suitable for later analysis by WildCRU in liaison with SNH.

To produce annual reports:

(vi) To produce annual reports, and other relevant outputs, on the results of monitoring of beaver ecology, using data/information received from the Field Officer staff and other project workers.

To produce an 'end of trial' report:

(vii) To produce a report, and other relevant outputs, at the end of the trial on the results of monitoring of beaver ecology, covering the entire trial period.

This report is concerned with the first five aims on this list i.e. the production of standardised methodological protocols. Field tracking of the beaver population, including radio/Argos telemetry and trapping of the animals, will be undertaken by SWT and RZSS as part of the management of the release population. However, at the same time, SWT and RZSS will be asked to collate ecological data following the standard methodological protocols set out in this document, which be used by SNH and WildCRU for the independent ecological monitoring. SNH will undertake otter monitoring. The first annual report will be due in winter 2010.

In order that beaver welfare issues are properly addressed, and are balanced with the need to meet the aims of this project and the overall trial objectives, some broad principles have been applied in developing these protocols. Tracking methods will always involve some level of disturbance to the animals. The methods appropriate for Knapdale have been selected as the minimum necessary to address the beaver ecological monitoring requirements. The broad principles are:

- The welfare of the beavers during the trial is a priority and will be monitored by the relevant veterinary specialists (both those based at the RZSS and the independent specialists based at the Royal (Dick) School of Veterinary Studies) and kept under continuous review during the trial.
- Disturbance of the beavers, and the use of invasive tracking methods, must be kept to a minimum in order to allow behaviour to be as natural as possible, and to allow a successful establishment of the animals in the trial area. This has to be balanced with the need to track beavers for scientific monitoring and management purposes.
- Tracking methods will be constantly reviewed by RZSS/SWT, SNH and WildCRU during the trial to take account of ongoing experiences, and the development of technical advances.
- Results of ecological monitoring work will be published to allow open debate of the relevant issues.

1.3 Study tasks

In order to address the project aims, the following key information will be obtained during the trial:

- Population change (number of animals) during the trial.
- Fecundity.
- Mortality (and their causes).
- Population density.
- Age structure of the population.
- Number and size of territories.
- Sociality of the population (i.e. family structure and territory ownership).
- Dispersal by sub-adults.
- Movement within and outwith the trial area.
- Territory location (in relation to environment and to other territories).
- Habitat selection by individuals within territories.
- Habitat selection by other riparian mammals.

The key information will be collected during the trial by undertaking six tasks that interlink with each other and, to some extent, with other Scottish Beaver Trial monitoring projects. There is an element of cross-over with some of the tasks in that one task may repeat the information gained from another. For example, the observations task and trapping task have considerable cross-over. This apparent redundancy is essential because one task may not provide the desired information in all situations. Below are listed the six tasks together with the key information from the list above that they will address:

Task	Data	Key information
1. Trapping and 2. Observations	• Presence / absence of individuals • Body metrics (e.g. weight, size, sex and age-class) – trapping only • Reproductive status – trapping only • Relationship between individuals – observations only	- Population change. - Fecundity. - Mortality (and their causes). - Population density. - Age structure of the population. - Sociality of the population. - Dispersal by sub-adults.
3. Radio-telemetry and behavioural observations and 4. Argos-telemetry	• Habitat-use (inside territory) • Territory size • Home-range • Movement (outwith territory)	- Number and size of territories. - Dispersal by sub-adults. - Movement within and outwith the trial area. - Territory location. - Habitat selection by individuals within territories.
5. Field-sign surveys (beavers)	• Presence / absence of beavers • Territory borders • Habitat-use	- Number and size of territories. - Movement within and outwith the trial area. - Territory location. - Habitat selection within territories.
6. Field-sign surveys (other riparian mammals)	• Presence / absence of other riparian mammals	- Habitat selection by other riparian mammals.

The remainder of this report sets out a detailed, initial protocol for the ecological monitoring of the beavers and riparian mammals by:

- Outlining the data that needs to be obtained to fulfil the aims listed above.
- Setting out a detailed protocol of data collection, storage and dissemination for the Scottish Beaver Trial Field Officers and other key staff, including:
  - Field equipment and its use.
  - Field techniques.
  - Types of data required.
  - Timing and frequency of data collation.
  - Storage techniques for samples and data.
  - The provision of template field sheets, and survey data spreadsheets.
- Setting out an outline of the data analysis that can be undertaken annually by appropriate mammal specialists.

In ensuring that the relevant key information is collected, a balance needs to be struck between data collection, animal welfare and maintaining natural behaviours within the population. These issues need to be kept in mind when following these protocols, though workers should note that many of the techniques used here have been refined over 11 years of research in Norway where these techniques have not been found to affect the welfare (measured as body mass and reproductive success) of the beavers. Advice on minimising welfare issues has been included in the protocols where necessary.

1.4 Reviewing of methods

A draft of this report was made available to the Scottish Beaver Trial staff prior to the release of beavers at Knapdale in May 2009 to enable appropriate planning to be made. Since the release of the beavers, it has been possible to test these methods in the field and identify successes and problems. SNH and WildCRU will continue to review these methods throughout the Trial in close discussion with SWT and RZSS. Some changes have been made to the methods published here and these, and any further changes, will be identified in future published reports.

2 METHODOLOGY PROTOCOLS

2.1 Trapping

Aims	To assess population and demographic parameters by marking animals and attaching tags. Also, to collect samples for baiting traps, and to obtain additional animal data, and to assess animal health and welfare thereby integrating with another monitoring project of the trial (see section 3). More specifically, the collection of data and samples will assist with the following: − Bait for traps: Anal gland secretion and castoreum − Sexing individuals: Anal gland secretion − Relatedness (genetic data): Hair samples − Relatedness (chemical profiling): Anal gland secretion − Animal welfare and public health (parasite load): Faeces − Animal welfare (endocrinology): Castoreum, faeces, hair − Diet: Faeces Some of this will be for essential monitoring purposes, some will be for research to be undertaken by other parties.
Equipment	Depending on the suitability of the environment, two alternative techniques are proposed: trapping by boat and trapping using cage-traps (Appendix A). However, optimal techniques will depend on the local environment and workers should consider alternative techniques if the methods outlined in Appendix A are not successful. However, when exploring alternative techniques, workers should make sure that the safety and welfare of animals are not unduly compromised. The equipment required for live-trapping by boat and live-trapping using cage traps is listed in Appendix A. The equipment required for beaver handling, measuring, sampling, PIT/ear-tag attachment and radio/Argos tag attachment is listed in Appendix B.
Techniques	Methods for trapping are set out in Appendix A and methods for handling and sampling, including tag attachment, are set out in Appendix B. Weight tables, to allow previously unrecorded animals to be assigned to an age-class, are set out in Appendix F. All animals should be fitted with both ear-tags and PITs. Metal ear-tags can be modified by applying reflective tape of different colours. When trapping by boat, workers should avoid capturing non-target animals by identifying animals with colour ear-tags prior to netting. Part of the trial site is also an SAC, SPA and SSSI so SNH and FCS must be consulted before motor boats are used.
Data quality and sample sizes	The aim is to trap every animal at least once per year, ideally through spring-autumn, and more frequently if ear-tags and telemetry tags need to be replaced. Young animals in their first year (kits) should also be trapped, particularly because finding mortality rates between the kit and yearling age-classes will help assess population viability. However, if an animal remains un-trappable for some reason, then workers should

consider whether it is worth continuing the trapping session both for the sake of the welfare of the target animal, of other beavers in the area (which may be disturbed by the trapping activity) and the workers' time limits. The speed and success of trapping will increase with the experience of the trapping team. If a beaver avoids capture and takes refuge in a lodge, then it is unlikely that the animal will reappear for several hours and therefore, if it is the sole target animal, workers should cease trapping and not attempt to recapture the animal for one week. Similarly, workers should normally trap no more than two nights in succession at the same site since a beaver's behaviour is likely to be affected making further trapping more difficult. Trapping should not then restart at the same site for at least one week. In cases where box-traps are being used, trapping should continue until all target animals have been captured but should the final target animal not be trapped within one week of the penultimate animal then traps should be relocated or trapping should be abandoned and an alternative technique should be employed. Also, where box-trapping results in the repeated trapping of the same individual over three consecutive nights, traps should be relocated or trapping should be abandoned.

Experienced workers should take less than 30 minutes to process an animal.

If a radio- or Argos- tag is being attached, workers must ensure that any seals are watertight and that the tags have been switched on. It is good-practice to use the receiver to ensure the radio-tag is working prior to releasing the animal.

Storage

Data.

Data should be input into a spreadsheet as soon as reasonably possible after data collection in order to minimise errors. One row in the file must correspond to one record of one animal. Each record must be associated with a unique ID (UID) that should also be used to clearly label the containers containing the samples. Locations of trapping should be captured by GPS (cage-traps) or the approximate location recorded (boat-trapping) and uploaded into the GIS Trapping feature class. The UIDs should be used to link the table of trapping data imported into geodatabase with the GPS locations. A template trapping field sheet is provided in Appendix G and a template spreadsheet has been supplied in electronic format to SNH, for use by the Field Officers and other field workers.

Samples.

Samples should be stored as follows:

- Hair – Dry storage.
- Faeces – Within 24 hours of extraction, up to half of the sample should be extracted and transferred to a 100ml plastic vial and covered with 96% ethanol. The remainder of the sample should be retained in the labelled polythene bag and frozen at -20℃. Samples should not be frozen prior to immersion in ethanol.
- Castoreum and anal gland secretion – Frozen at -20℃ within 12 hours of extraction.

We recommend that frozen samples, clearly marked with appropriate biohazard warning labels, should initially be stored in a freezer at the offices of the Field Officers and, when possible, transferred to cold storage facilities at an appropriate facility unless required for use on site. Likewise, non-frozen samples should be placed in a secure cupboard and marked with appropriate biohazard and hazardous chemicals warning labels, at the offices of the Field Officers and eventually transferred to an appropriate facility.

Decisions on the use of these samples will be discussed and agreed by members of the Scottish Beaver Trial Research and Monitoring Coordination Group.

2.2 Observations

Aims	Observations should be conducted where possible in order to assess (1) animal presence at a location, (2) the existence of untagged animals in the population prior to any trapping programme (i.e. to assess whether trapping is required), (3) the existence of young (kits) and (4) the relationships between animals. Observation sessions are a good substitute for trapping when animals are already tagged, and have a minimal effect on animal welfare. Therefore, in a capture-mark-recapture (CMR) study, observations of individuals can be treated as recaptures.
Equipment	Boat and anchor, or a hide. Spotlights and binoculars. Binoculars should be sufficient to allow clear views in low light and therefore ultra-compact models are not recommended.
Techniques	Sit and wait. When a beaver is spotted, observers should record the ear-tag colour/side combination and any interactions between it and any other beavers. Observers should also record the presence or absence of a tail-tag. If the animal has no tags, the observers should note this and attempt to estimate the size of the animal. See Appendix H for a field sheet to record observations. The use of a boat versus a hide will depend on the environment. It is likely that a boat will only be required in the larger lochs where workers may be unable to get close enough for a clear view from the bank. Beavers can habituate very well to human observers, but if they are not used to the observers, or have been recently trapped, they are likely to be very wary.
Data quality and sample sizes	Some observations should be conducted around the dispersal phase (spring) and the emergence of kits from lodges (mid-July to August). Rosell *et al.* (2006) found that estimates of family sizes tended to increase with each successive observation at a lodge, because not all animals might be in the same lodge on every evening. They recommended at least six observation sessions per family (Rosell *et*

al. 2006). Since other work will be conducted on the same families (see 2.1 above and 2.3 below) there should be many opportunities to assess the presence or absence of individuals. Therefore we suggest that every known beaver colony should be observed on at least six occasions, of which as a *minimum* should include one evening during May and one evening during early August (both until approximately midnight) with additional observation on an *ad hoc* basis either prior to the use of cage-traps or whenever a lodge is being watched for other purposes, such as locating lost tags or animals (see Appendix C).

Storage

Observation data in terms of presence/absence should be included on the trapping and observation data spreadsheet so that each row on the file corresponds to one trapping or one observation of an animal. A template spreadsheet has been provided electronically to SNH for the inputting of both trapping and observational data. Observation data is to be recorded on a field-sheet (Appendix H) with locations on paper-maps, or direct into the GIS on a "toughbook", dependant on circumstance. If paper maps are used, maps should be dated and points should be given a number (unique within the observation session) that corresponds to a number on the observation sheet. When locations are transferred into the GIS Observations feature class, location numbers need to be unique (see Behavioural Observations, below).

2.3 Radio-telemetry and behavioural observations

Aims

Ascertaining where and how animals move post-release, and the dispersal movements of sub-adults, is a crucial part of the monitoring programme. The radio-telemetry work must ensure enough 'fix' locations on the animals are obtained to allow their home-ranges and habitat use, and the family territories, to be ascertained.

Equipment

Equipment required for attaching and removing the devices has been listed in Appendices A and B (see Trapping above). For radio-telemetry, workers also need:

- Two Yagi antennas (three or four element, tuned to the tag frequency).
- Two radio-receivers (tuned to the tag frequency).
- Four co-axial antenna-receiver cables (includes two spare cables).
- Two compasses.
- One pair of two-way radios (with sufficient range for purpose).
- Two GPS units and /or clearly marked tracking posts.
- Spotlights and binoculars (where visual observations are possible).

Techniques

Techniques for radio-telemetry are set-out in Appendix C, and tag attachment in Appendix B.

With some of the beaver families, it may be possible to observe the entire family range by boat from the loch. In those cases, then location fixes can usually be obtained visually. The advantages of this technique are that (1) behaviours can also be recorded, and (2) it should be possible to record fixes more frequently. However, workers must ensure that when an animal is not in view, radio-telemetry fixes are obtained. When conducting behavioural observations, workers should:

1. Note the location of the animal on a map (paper or digital) using a unique fix ID number (FID). If paper maps are used:
   - The map should be dated.
   - Each paper-map location only needs to have a number unique for the observation session, which can then be used for all behaviours that occur at that location.
   - When transferred to the GIS, paper-map locations need to be converted to FIDs for each observation.
2. Record the FID (or map location number) with the behaviour of the animal including any additional information such as food type of feeding and interacting beaver(s) if the behaviour is social.
3. Where possible, record locations and behaviours of all animals every 15 minutes exactly (though not all animals in the same minute). If this is not possible, then every 30 minutes. If the animal is out of sight at a fix interval, the behaviour should be recorded as 'out-of-sight' instead of recording the behaviour of the animal when it next reappears (unless this happens to fall on the next fix interval).

See Appendix D for an ethogram of behaviours and Appendix H for a field sheet to record observations.

Data quality and sample sizes

Prior to use, a field test should be run by placing radio-tags at known locations in different habitats and taking bearings. This test should be used both to train workers and to provide a base-line estimate of the likely fix error in different areas in the release site.

Previous studies of beavers in Telemark where animals were located every 15 minutes, found that the minimum number of fixes required to calculate meaningful estimates of home-range and habitat use was about 90 fixes over approximately three nights (Campbell *et al.* 2005; Schlichter 2008). In those studies, beavers frequently moved in a circuit around the territory at least once per night, but the amount of time spent at different locations in the territory varied between nights. Consequently, it should be possible to reduce the number of fixes required to calculate home-ranges (e.g. one to two fixes every hour) but not the number of nights over which these fixes need to be taken. Therefore, one complete night of tracking (or two half-nights with one running over the first half and the other over the second half) should be completed for each family once a month in the first year. This would allow home-ranges to be calculated over three month periods.

In later years, home-ranges will be compared between three-month periods and, if there is evidence that home-ranges have stabilised, thereafter it should only be necessary to collect enough data to calculate home-ranges over six month periods. However, workers should expect to lose a proportion of the data due to high error in fix locations so, therefore, sample sizes need to be checked to ensure that enough good quality fix locations are obtained. To ensure correct sample sizes, radio-telemetry data should be assessed by WildCRU and SNH at three months after the initial release.

If families are adjacent and contain few tagged animals, then it could be possible to save field-time by tracking two families in the same night.

Storage

Data should be input into the template spreadsheet (or a database based on the spreadsheet) and fully documented. If bearing data is input direct into *Locate* software, in addition to saving the data in *Locate*, bearings and locations should be exported into a spreadsheet. GPS points should be recorded using the European Terrestrial Reference System 1989 (ETRS89), downloaded into the GIS and plotted using the Petroleum transformation from ETRS89 (WGS84).

Each set of bearings on an animal should have the same fix ID (FID) so that they can be easily selected to calculate fix locations. The location of the observer needs to be recorded together with the bearing of the observer to the target animal. An example radio-telemetry field-sheet is shown in Appendix I and a template radio-telemetry data spreadsheet has been provided in electronic format to SNH.

Each fix location calculated from the bearings should be saved with an error value calculated by *Locate*. In addition, *Locate* can output the error ellipse as a series of point coordinates. These can be saved with their associated FID in a separate spreadsheet.

2.4 Argos-telemetry

Aims

The aim is to obtain low resolution data on the locations of at least one of the dominant adult members of each family. This cannot be used to calculate habitat-use and home-range/territory of the animal but, assuming that families will stay together, will allow large shifts in home-range to be followed easily, even when such shifts take the animals away from the release site. To this end, the Argos system may be useful for the Scottish Beaver Trial staff for management purposes but it is not an essential component of the ecological monitoring which these protocols are concerned with. However, some further information is provided here.

Equipment

An Argos transmitter. Equipment required for attaching and removing the devices has been referred to above in section 2.1.

Techniques

Attachment techniques are the same as for radio-telemetry tags and are described in Appendix B. Additional information as to the best use of these devices should be provided by the manufacturer.

Data quality and sample sizes

The tag transmits a radio signal at a constant frequency (401.650 MHz ± 30 kHz) plus data on its altitude which is then recorded by a passing Argos satellite. The satellite then transmits the signal to a terrestrial data-processing centre where the location of the tag is calculated based on the Doppler-shift of four or more separate records received by the satellite during its pass using a geometric location principle that is analogous to triangulation. The accuracy of the locations should be within 250m of the true location of the tag. However, the satellites are restricted to only record a signal from the same tag up to once every 45 seconds and therefore it would take a minimum of three minutes to obtain enough data to locate the tag. In three minutes, a beaver can swim 200m, consequently locations of a beaver wile swimming are likely to be relatively inaccurate. Further information is available in CLS (2008).

Prior to use, a field test should be run, for example by placing Argos tags at known locations in different habitats and recording when this was done. Tags should be placed at equivalent height to that which they would be on a live beaver.

An important issue regarding the accuracy of the Argos fixes concerns the immersion of the whole device in water. Water severely attenuates radio signals and therefore even a little water covering the device can greatly reduce fix accuracy. The device should be affixed to the animal so that at least the antenna of the device is usually above water while the animal is swimming.

The cost of using the Argos system is related to the number of hours that the tags are in contact with the satellites. Argos tags can be programmed to record and upload within only one six hour period in 24 hours (e.g. 00:00-06:00hrs, 06:00-12:00hrs, 12:00-18:00hrs and 18:00-00:00hrs) which therefore reduces the cost of deploying the tags. To minimise wasted tag activity when beavers are resting in lodges or burrows, tags should only be active at night between approximately 18:00hrs and 06:00hrs. Ideally, the sample windows for each tag should be allowed to vary so that individual tags are not recording from only one night-time quarter.

Storage

Once downloaded from the satellite system, data should be stored in spreadsheet format and incorporated into the GIS.

2.5 Field-sign surveys

Aims

A lot of useful information can be gained from field-sign surveys. Data from field-sign surveys are used to supplement data obtained from the more remote techniques. In particular, these surveys can be used to ascertain locations of dams, lodges and dens, areas of high foraging activity and likely territory borders (if any). Field-sign surveys and general field observations should be considered an essential prerequisite to trapping in order to develop a local knowledge of the locations of beaver families and minimise the risk of missing animals. Furthermore, these surveys can be used to target site selection for other monitoring projects relating to hydrology, geomorphology and water quality (see Section 3). They are also of particular value if there technical problems develop with the more remote techniques.

Equipment	- GPS. - Clipboard and field-sheet. - Collapsible metre rule (optional).
Techniques	A guide to field-signs is set out in Appendix E. Workers should walk along loch and river banks and log on their GPS and beaver field-sign survey sheet, or directly into the GIS using a GPS and "toughbook", (Appendix J) when they see the following: - Lodges/burrows. - Dams. - Food caches (visible in late-autumn and winter only). - Fresh feeding signs (e.g. cut trees, see points 1 and 2 below). - Foraging trails. - Feeding stations. - Scent-mounds. - Scent-marking sites. For smaller burns (e.g. less than approximately 5m wide), workers need only walk one bank and note whether a logged GPS location is actually on the opposite bank. Most of the burns around the trial area should fall within this category. For areas of the site that are difficult to access, workers should consider using boats or canoes. Most field-signs will be visible without the need for a worker to come ashore. When recording tree/sapling cuttings, workers should: − Only record fresh cuttings (where the cut surface has not turned grey-brown). − Log only up to one GPS location per 10 m of bank and then note the approximate percentage of trees that are cut within 5 m of the water and the two most common felled species (or the most common genera where several members of one genus are difficult to quickly distinguish). Dams should be photographed on every survey. Photographs must be taken from the downstream end of the dam so that the impounded water is in the background. Where possible, the entire dam should be visible within the photograph and a standard object such as an A4 clipboard or a metre rule should always be included next to the dam to show scale. Details of each photograph should be recorded on a spreadsheet following the standard SNH protocols.
Data quality and sample sizes	Foot surveys do not need to be conducted frequently and could be combined with other work such as the otter surveys (see below). All the riparian habitat in areas known to contain beavers should be walked at least once every two months and other areas within the release site should be walked every fourth month in approximately November, March and July. It is possible that this survey could involve a large team of volunteers conducting regular sweeps across the release site every four months with the Field Officers filing in gaps in the data on an ad-hoc basis. At least one survey at each site should be conducted in November after autumnal fall and when the die-back of ground vegetation will aid visibility – this survey will be of

particular value in targeting sites for the river habitat monitoring work being undertaken by specialists.

The time spent in each location by the surveyor, and the linear distance travelled by the surveyor, should be recorded on the beaver field-sign survey sheet (Appendix J) to allow the search effort to be calculated.

Storage

A template beaver field-sign survey sheet is provided in Appendix J. GPS points should be recorded using the European Terrestrial Reference System 1989 (ETRS89) and imported into the field-signs feature class in the GIS using the Petroleum transformation. Each GPS point should have a unique code and the notes taken for each point should be input into a spreadsheet using the same code to enable linking to the GPS points. A template beaver field-sign survey data spreadsheet has been provided to SNH in electronic format.

2.6 Surveys of otter and other riparian mammals

Aims

The impact of the beavers on their surrounding environment and other riparian species, particularly otter, is an important aspect of the study.

Both otter and American mink have been associated with beaver dammed ponds in Europe and it is possible that these ponds could also provide suitable habitat for water vole. The aim is to investigate whether there are changes in the habitat use of otter based on the distribution of field signs within the release area over the course of the project. Records of American mink and water vole will also be made opportunistically during otter survey work, and incorporated into the final analysis.

There is some evidence that even experienced workers can misidentify otter spraints and mink scats. To deal with this problem, samples should be taken of all otter spraints and mink scats when surveying is conducted. This will allow cross-checking of species identification and provide a resource of material available for future 'non-essential' research projects (e.g. identification of individual animals using genetic techniques).

Note that currently the analysis of these samples is not considered an 'essential' element of the core monitoring of the Trial. However, the cost in terms of surveyor time is small and the potential benefit to collecting these samples is great should future resourcing be found. Any opportunities for future analysis of these samples will be discussed by the Scottish Beaver Trial Research and Monitoring Coordination Group.

Equipment

- Field-sheet and map.
- 50 ml plastic vials prefilled with c.25 ml 96% ethanol.
- Disposable sticks for handling spraints/scats (e.g. 10 cm wooden 'lollipop' sticks).

Techniques

Survey work will be undertaken by SNH. The technique is based on Strachan (2007). The first task is to identify a suite of ten 100 m survey transects within the release area. SNH will undertake a GIS mapping exercise which will result in all loch banks and rivers in the release area being divided into 100 m sections. The 100 m sections of the rivers will be based on the River Habitat Survey (RHS) sections set up by Gilvear and Mulet (in press.). The release area will also be divided into three zones based on the catchments of the major water bodies in the area in order to provide representative coverage of the major habitats used by otters in the area and avoid bias towards sampling areas where otter density might be expected to be higher (e.g. coastal habitats). The three categories of sample site are:

- Inland watercourse
- Freshwater loch outflow
- Coastal watercourse outflow/shoreline

Two of the sites to be used have been previously surveyed during national otter surveys, and will be included again to enable comparison with previous data (see Strachan (2007) - Loch Fidhle burn, OS grid ref. NR782892 and the burn between Loch Barnluasgan, OS grid ref. NR790910). The other eight sites will be selected randomly taking into account the three categories of sample site above. Therefore, overall, within each of the three catchments, a minimum of three sample sites will be allocated, one from each of above categories. The most southerly catchment (comprising Loch Creagmhor, Loch Buic and Loch McKay) will have an extra inland watercourse site allocated to achieve the required total of ten.

Outwith the Scottish Beaver Trial release area, a control site with similar habitat will be identified, far enough away from the release site to minimise the chance of a single otter territory overlapping both the release site and the control. Ten 100 m sections will be identified using similar methods to those set out for the release area.

Therefore there will be ten sections within the release area and ten control sections outside the release area (the latter will require the agreement of the land owners concerned). The same sections should be revisited every survey.

When surveying at each section, the following signs should be noted:
- Sightings (actual animals seen at survey site).
- Otter spraint count (total of all spraints regardless of age and condition).
- Counts of otter resting places.
- Presence of tracks, runs etc.
- Count of mink scats found.
- Presence of mink tracks.
- Other mink evidence including local reports.
- Counts of water vole latrines if present.
- Presence of water vole burrows, feeding signs etc.

In addition, using the disposable sticks, either the whole otter spraint or mink scat or its tip (should it be too large for the vial) should be placed into the ethanol-filled vial and labelled with the section ID, date and species. The disposable stick should be disposed of after every use.

Strachan (2007) provides a useful guide to the field signs of otter and mink. For field signs of water vole, see Strachan and Moorhouse (2006).

Data quality and sample sizes	Surveys should be conducted once each year during September. It is estimated that a field worker could survey five 100 m sections per day and, based on a total of 20 sections, that the whole survey should take approximately four days.
Storage	Data must be input into the riparian mammal survey data spreadsheet, with each row corresponding to a 100 m survey section. The template riparian mammal survey field sheet is provided in Appendix K, and the spreadsheet has been provided to SNH in an electronic format. Transect lines will be stored in the GIS as a feature class and linked to the spreadsheet and therefore each sections should have a unique ID. Sample vials should be topped-up with 96% ethanol immediately after the survey so that samples are completely covered. These samples should then be kept in the same secure cupboard as the beaver samples (above). The detailed analysis of these samples is not considered an 'essential' element of the core monitoring for the trial. However, the use of these samples in any future scientific work will be discussed by the Scottish Beaver Trial Research and Monitoring Group.

3. INTEGRATION WITH OTHER PROJECTS

3.1 Animal health and welfare

There is the potential for samples of castoreum, faeces and hair obtained during trapping to be used as part of veterinary monitoring work. The precise methods will be agreed between the RZSS veterinary staff and the Scottish Beaver Trial independent veterinary specialists at the Royal (Dick) School of Veterinary Studies (who will also decide which information is 'essential' for the purposes of the Trial). Possibilities might include:

- Use of all three types of samples to extract stress hormones such as cortisol (preliminary work has been done examining stress hormones in such samples by Frank Rosell's team at Telemark University College, Norway).
- Faeces could be used to examine the gut parasite load with the hypothesis that stressed animals or those in relatively poor health will have a higher parasite load. Data may also be of use for the purposes of the independent public health monitoring led by Argyll and Bute Council.
- The additional effects of radio- and Argos-tag attachment, trapping history and season on measures of health and welfare could be considered.
- Body mass could also be potentially used as a surrogate for animal health with the hypothesis that animals that are heavier are in better condition and therefore have better health and lower stress.

3.2 Habitat and environment

Surveys of aquatic vegetation (Willby and Mulet, in press) and river habitat (Gilvear and Mulet, in press) should be integrated with the radio-telemetry (and maybe Argos-telemetry if judged suitable) for analysis of habitat use and choice of home-range location. The monitoring of the effects of the beavers' activity on terrestrial woodland habitats will commence during 2009. Such a project would be useful and again, the habitat data should be integrated with the telemetry data.

4 FIVE-YEAR WORK PLAN

The following initial work plan sets out the minimum requirements for the monitoring. This will be reviewed during the trial when necessary.

4.1 Year 1 – Fieldwork (to be undertaken by SWT/RZSS unless otherwise stated)

Trapping	On an ad-hoc basis but concentrated around October-November 2009 and April-May 2010.
Radio-telemetry	Day-time radio-telemetry: For the first two months, all tagged animals should be checked twice weekly during daytime to ascertain day-rest places (unless data has already been obtained from night-time radio-tracking). From two-six months, animals should be checked weekly during day-time, and from seven-twelve months bi-weekly (unless data has already been obtained from night-time radio-tracking). Night-time radio-telemetry: Throughout the whole trial period, one night per week (on average) should be invested in night-time radio-tracking and workers should rotate through the families so that each month all families have been tracked for one night
Argos-telemetry	Data will be constantly collated and submitted to SNH every five weeks.
Observations	One evening of observation at each active lodge or den (as found from previous daytime radio-telemetry checks) should be undertaken during early August.
Field-sign surveys	The whole site should be surveyed every four months in November, March and July. This could be combined with day-time radio-telemetry checks.
Other riparian mammal surveys	Four days to be invested in survey work during September by SNH.
Data	For all the above survey tasks, data should be collated and sent to SNH every five weeks. SNH will then pass on all the data to WildCRU by 11th June 2010 (and also make data available to inform other essential, independent monitoring projects). SNH should furthermore pass on to WildCRU all radio-telemetry data collected in the first three months post-release by 15th Sept 2009 so that data-quality and the sampling-strategy can be assessed.

Overall, excluding trapping, this timetable would require the Field Officers to be investing two days each week in day-time radio-telemetry checks for the first two months (down to one day each week during the second to sixth months, and then one day each fortnight from the seventh to twelth months) combined with field-sign surveys and one night each week in radio-telemetry. In addition, the Field Officers would expect to spend four evenings in early August observing lodges/dens. SNH staff would expect to spend four days in September surveying otter, mink and water vole.

4.2 Year 1 – Analyses and outputs (to be undertaken by WildCRU in liaison with SNH)

Base-line summary data	Deaths (numbers in each age class) Body metrics: - Body length. - Body mass. - Tail length. - Tail thickness (from four standard points, see Appendix B). Number of dams built and their location. Number of signs of otter/mink/water vole activity in release area and outside beaver release area.
Movement statistics	Distance from release point to final group-territory edge and group-territory centroid for each family. Maximum distance moved per night for each individual tracked by radio-telemetry over each three month period. Distance moved from natal territory by dispersing sub-adults.
Territoriality & home ranges	Final group territory sizes (length of river/loch bank) for each group as elucidated from 100% minimum convex polygons (MCPs) and location of scent-mounds. Three-monthly home-range sizes (length of river/loch bank and total area) of each individual based on 95% kernel analyses.
Habitat use	Group territory location choice: Habitat types (within 40 m of water) and loch/river characteristics within territory versus the mean of habitat types (within 40 m from water) and loch/river characteristics on all connected water bodies within a circle centred on the release location and of radius equal to the distance from release site to furthest edge of group territory. Habitat preference of each family based on compositional habitat use (Aebischer *et al.* 1993). Statistics should be use versus available habitat within each family territory.
Data quality	Assessment of radio-telemetry and Argos-telemetry sample sizes for indicating home-range sizes of each individual (using number of fixes to asymptote of range size). Assessment of trapping and observing effort in providing an indication of family size (trap-nights and observation nights in relation to the number of animals).

4.3 Year 2-5 – Fieldwork (to be undertaken by SWT/RZSS unless otherwise stated)

Depending on its success, the number of beavers and the number of beaver families may increase over the course of the trial. Such an increase may be necessarily accompanied with a reduction in effort per beaver put into trapping, radio-tracking and observing. The only exception to this will be for sub-adult beavers which are likely to disperse, and therefore more effort should be invested in locating them at regular intervals. However, we would also expect that worker efficiency, particularly with trapping, will increase over the trial period and so counter the effect of the drop in effort per beaver.

Trapping	On an ad-hoc basis but concentrated around October-November and April-May.
Radio-telemetry	Day-time radio-telemetry: Animals locations should be checked monthly. Sub-adults of dispersing age should be checked weekly during April-June.
	Night-time radio-telemetry: One night per week should be invested in night-time radio-telemetry and workers should rotate through the families as before.
Argos-telemetry	Data will be constantly collated and submitted to SNH every two weeks.
Observations	One evening of observation at each active lodge or den (as found from previous daytime radio-telemetry checks) should be undertaken during May-June and again during early August.
Field-sign surveys	The whole site should be surveyed every four months in November, March and July. This could be combined with day-time radio-telemetry checks.
Other riparian mammal surveys	Four days to be invested in survey work during September by SNH.
Data	For all the above survey tasks, data should be collated and sent to SNH every five weeks. SNH will then pass on all the data to WildCRU by 11th June each year

4.4 Year 2-5 – Analyses and outputs (to be undertaken by WildCRU in liaison with SNH)

Base-line summary data	Annual deaths (mean by age class).
	Annual births (kits/group, sex-ratio).
	Annual population size and composition (by sex and age class).
	Annual body metrics: - Body length - Body mass - Tail length - Tail thickness (from four standard points, see Appendix B)
	Family sizes and compositions.
	Number of dams each year and their location.
	Number of signs of otter/mink/water vole activity in beaver release area and outside beaver release area.
Movement statistics	Distance from previous year group-territory centroid to current

	year centroid for each established family.
	Maximum distance moved per night for each individual tracked by radio-telemetry over each three month period.
	Distance moved from natal territory by dispersing sub-adults.
Territoriality and home ranges	Final group territory sizes (length of river/loch bank) for each group as elucidated from 100% MCPs and location of scent-mounds.
	Three-monthly home-range sizes (length of river/loch bank and area) of each individual based on 95% kernel analyses.
Habitat use	New territory location choice: Habitat types (within 40 m of water) and loch/river characteristics within territory versus the mean of habitat types (within 40 m from water) and loch/river characteristics on all connected water bodies within a circle centred on the natal territory and of radius equal to the distance from centroid of natal territory to furthest edge of group territory.
	Habitat preference quantification of each family will be based on the compositional habitat methodology of Aebischer *et al.* (1993). The pattern of use of each habitat type is compared with its availability within each family territory.
Data quality	As above, an ongoing review of radio-telemetry sample sizes and trapping and observing effort will be conducted every year.

4.5 Final report (to be undertaken by WildCRU in liaison with SNH)

Base-line summary data	Change in death rate over trial.
	Change in birth rate over trial.
	Change in population over trial.
	Change in population composition (sex and age class) over trial.
	Change in family sizes over trial.
	Change in body metrics (as above) over trial.
	Changes in number of dams.
	Change in habitat use and numbers of signs of otter/mink/water vole over trial.
Movement statistics	Annual shift of territory centroid over trial.
	Maximum distance moved from release sites to furthest territory centroid.
	Change in mean distance moved/night over trail (all animals).
Territoriality and home ranges	Mean and change in territory sizes over trial.
	Mean and changes in home-range sizes over trial.

	Analysis of territory sizes with habitat and territory age.
Habitat use	Change in mean habitat preference over trial. Overall mean habitat preference during the course of the trial.

5 REFERENCES

Aebischer, N.J., Robertson, P.A. & Kenward, R.E. 1993. Compositional analysis of habitat use from animal radio- tracking data. *Ecology* **74**, 1313 –1325.

Campbell, R.D., Rosell, F Nolet, B.A. & Dijkstra, V.A.A. 2005. Territoriality and group sizes in Eurasian beavers: Echoes of settlement and reproduction? *Behavioural Ecology and Sociobiology* **58**, 597–607. Available online at: http://hdl.handle.net/2282/335

CLS 2008. Argos user's manual: Worldwide tracking and environmental monitoring by satellite. Available online at: http://www.argos-system.org/manual/

Gilvear, D. & Mulet, R.C. In press. The Scottish Beaver Trial: Collection of fluvial geomorphology and river habitat baseline data, 2008. *Scottish Natural Heritage Commissioned Report.*

Rosell F., Parker H. & Steifetten, Ø. 2006. Use of dawn and dusk sight observations to determine colony size and family composition in Eurasian beaver Castor fiber. *Acta Theriologica* **51**, 107–112. Available online at: http://hdl.handle.net/2282/762

Schlichter J. 2008. Comparison of space use and movement patterns between dominant and subdominant male Eurasian beavers (*Castor fiber*, L. 1758). MSc dissertation. University of Trier.

Strachan, R. 2007. National survey of otter *Lutra lutra* distribution in Scotland 2003–04. Scottish Natural Heritage Commissioned Report No. 211 (ROAME No. F03AC309).

Strachan, R.S. & Moorhouse, T.P. 2006 *The Water Vole Conservation Handbook*. Wildlife Conservation Research Unit & The Environment Agency.

Willby N.J. & Mulet, R.C.. In press. The Scottish Beaver Trial: Baseline survey of the aquatic and semi-aquatic macrophytes of the lochs, 2008. *Scottish Natural Heritage Commissioned Report.*

APPENDIX A: TRAPPING TECHNIQUES

Live trapping from a boat

Equipment required:
- Motor-boat
- Nets
- Spotlights
- Chest waders

The principles set out here will closely follow Rosell and Hovde (2001) but contain subsequent refinements by Frank Rosell and Bjørnar Hovde, Telemark University College.

The basic method is to capture animals by approaching them from a boat equipped with an outboard motor and trapping them using a hand-net. There are three types of net; a land net, a diving net and a scoop net. A land net and a scoop net are basic nets with round mouths and differ from the diving net which illustrated in Figure 1b. All three types of net must have a fine, strong mesh that will not catch on tags and tear them out. The nets are constructed using a tube of mesh with one end (the entrance) attached to the mouth of the net frame and the other (the exit) sealed with a rope or strap while trapping (Figure 1). This allows the beaver to be trapped and then transferred easily to a handling sack by untying the free end of the mesh and coaxing the animal through the exit into the sack.

The technique can be used both when the animal is in water and when it is on land. The minimum number of people in a team is two: a boat pilot and a trapper. It is best to trap in the hours of darkness using spotlights and headlights because these will dazzle the target animal and make it less aware of the trapper behind the lights. As a result, they are considerable slower in reacting to the threat and are much easier to capture. The trapper sits in the front of the boat and both workers use spotlights to search for a target. Usually, the boat should travel 10-30 m from the bank, so often only one bank is searched at a time. When a target is sighted, the team approaches it at a rapid pace keeping the lights trained on the animal. At this point, there will be four possible scenarios, which will require different trapping techniques:

Scenario1: The beaver is on land or moves on to the land as the trapper approaches.

See Figure 1a. The pilot should guide the boat near to, or onto, the bank and the trapper should switch on their head-torch, place the spotlight down and chase the beaver using the land net. The beaver will usually be walking or running away from the trapper and therefore reaching over the animal with the net and scooping back over the nose is a reliable method of capture. Once in the net, the trapper should twist the end of the net over so that the mouth of the net is sealed. The diving net and the scoop net can also be used to capture beavers on land, but often the fine mesh will tangle in undergrowth, impeding capture. The pilot should aid the trapper by lighting the land from the boat using a spotlight.

Scenario 2: The animal dives in deep water.

See fig 1b. Switch on head-torches and pilot the boat over to where the animal dived and, slowing down, follow the direction the animal was last facing (running parallel to the bank), scanning the water using the spotlights. When the animal is resighted (swimming either on the surface or underwater) approach with the boat until the prow is within a meter and on the water-side of the animal. If the water is too deep to trap (ideally the depth should be less than knee height - anything over waist height of the trapper is too deep) then the pilot should attempt to herd the animal towards shallow water or wait until the swimming beaver passes into a shallow area. While following and herding, it is usually better to keep a slightly greater distance from the animal to stop it taking fright and diving under the boat. When the water is considered shallow enough to attempt a trap, the trapper should instruct and guide

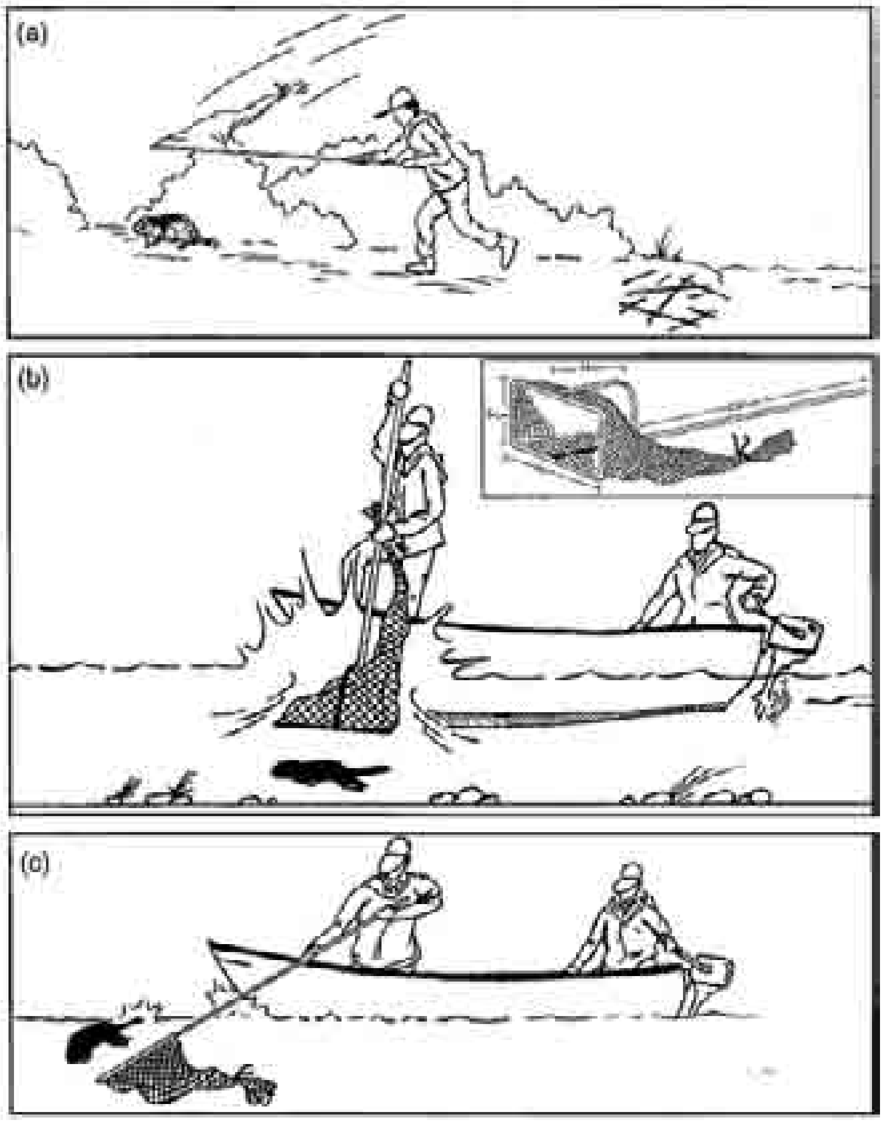


Figure 1. A typical trapping situation involving beavers (a) on land using a net made from a cloth sack (60 cm diameter mouth and 80 cm sack) attached to a long steel pole (187 cm), and (b) in water, using a nylon mesh (≤0.5 cm) diving net (mouth 95 × 80 cm, support bar height 52 cm, handle length 218 cm), and (c) demonstrating how to catch kits with a nylon mesh (≤0.5 cm) scoop net with a 60 cm diameter mouth, 130 cm length of mesh and a long steel pole (220 cm). Illustration from Rosell and Hovde (2001) and reproduced with kind permission of Frank Rosell and the Wildlife Society.

the pilot to position the boat so the prow is as close to the beaver as possible. Once in a correct position, the trapper should place the spotlight at their feet (ensuring that any cables are not likely to trip the trapper) and jump off the boat on top of the beaver with the edge of the diving net at their feet and both hands high up on the handle of the net. Note that Figure 1b does not illustrate the trapper jumping off the boat, but trapping success will be greatly improved by doing so. The loose end of the mesh should either be hung over the trappers shoulder, or hooked onto the end of the handle. The trapper should aim the leading edge of the mouth of the net slightly ahead of the nose of the swimming beaver. Once standing in the water, the trapper must keep their weight and feet on the edge of the net so that the beaver cannot dig out. Once establishing that the trapping has been successful (by feeling around the net with their feet for the beaver), the trapper should force the animal up the tube of the net by holding the free end of the mesh at the surface of the water and nudging the animal with their feet. They will often swim naturally to the surface of the water once trapped, aiding this manoeuvre. At this point, the trapper should tie the net closed just behind the beaver using a rope or strap so that the mouth of the net is sealed. The beaver is then trapped between the two pieces of rope or straps. Using a foot to hook the mesh behind the trapped beaver can help this manoeuvre, but in deep water the pilot may have to assist.

Scenario 3: The beaver dives or swims in shallow water

See Figure 1b. In this situation, the pilot should immediately manoeuvre the boat into position for trapping, prow close to and level with the animal and keeping the boat between the animal and deep water. The trapper should then trap the animal as in scenario 1. If the water is too shallow for the boat, then the trapper can get out and chase the beaver in the water using the diving net and capture it as above.

Scenario 4: The beaver is a kit swimming

Although all the above techniques can be used to capture beaver kits, this is an alternative technique that can be used even in deep water (see Figure 1c.). The team should approach the kit in the water. If it dives, it can be followed underwater using spotlights and the trapper can wait for it to resurface. The pilot should bring the boat alongside the kit, keeping a spotlight trained on it. The trapper should then take the scoop net and get the kit into the net by scooping from the nose to the tail and immediately lifting the net clear of the water. In the case of a land capture, the net mouth can be sealed by flipping the mouth of the net over while the kit hangs beneath.

Transferring captured beavers into handling sacks

Once successfully in the net, the captured beaver needs to be transferred into a hessian sack for measuring and sampling. The beaver needs to be manoeuvred so that it is facing the (currently sealed) exit of the catching net. One worker should kneel behind the beaver holding its head with fingers at the rear of the jaw bone and its shoulders with the thumbs. The beaver should be stopped from reversing out of this grip with a knee. The other worker then lays mouth of the sack so that the bottom edge is under the beaver's fore feet , removes the rope/strap and then covers its head with the top edge of the sack mouth. The beaver can then carefully be coaxed into the sack by loosening the grip on the head and shoulders and gently pushing it from behind. At this point, the beaver will often walk itself into the sack. Care should be taken to ensure that the beaver does not turn as it moves into the sack and escape out of the side of the mouth. Once in the sack, the beaver can be immobilised as described in Appendix B.

Additional comments

Workers should aim to trap an animal within five minutes of giving chase and within no more than 30 minutes under rare circumstances. Such 'rare' circumstances would, for example, include trapping with an inexperienced team who are likely to take longer to successfully capture an animal, or attempting to trap an animal that is particularly elusive and where there may not be another opportunity to capture that animal for several months. Boat-based trapping techniques in Telemark have a success rate of between one and nine beavers per night (depending on experience and number of assistants) with three to five animals being quite typical for a two-person team.

Live trapping of beavers using cage-traps

Equipment required:
- Cage-traps
- Transfer net
- Bait
- Plastic mesh (optional)

Trap designs

The traditional traps used in North America are known as Bailey (or suitcase) traps and Hancock traps. Both types are of a sprung clamshell design made from steel mesh over a steel frame. The trap is set in shallow water with one half of the trap on the ground and the other upright and held in place with a stick. The beaver triggers the trap by moving bait that is attached to a pin. The pin is pulled out releasing the spring mechanism and the base of the trap swings up, pressing the beaver between the two halves of the trap. The spring mechanism is quite powerful since it has to be strong enough to lift a 20+ kg animal. The disadvantages of using such traps includes the risk of the beaver drowning (either by rising water or the trap falling on its side if not properly secure) and the risk of tags being torn off as the beaver struggles in the confined space. Leg-hold traps are also available and are inexpensive, but the welfare issues from their use (e.g. laceration and bruising of the leg and potential fracturing of leg bones) rule them out as a recommended method. There may also be legal issues associated with the above traps.

Alternative designs involve cages or boxes with one or two doors and are set on land. These designs are usually referred to as ‘cage-traps’ or ‘box-traps’, but since they are essentially the same type of trap, both types will be referred to as cage-traps from this point. Therefore, for the purposes of the Scottish Beaver Trial, cage-traps will be used.

Considerations in the design of cage-traps

Cage-traps should be large enough to allow the full (nose to tail) length of an adult beaver (c. 90-110 cm) to be inside the trap when the trigger mechanism is fired. The door mechanism (whether gravity or sprung) should not be so powerful that closing it on a beaver will cause it serious damage but the mechanism needs to be fast enough to ensure the animal does not have time to escape before the trap is sealed. Traps should allow ventilation and also a dark corner where a trapped beaver will feel more secure. Frequently, steel mesh is used in the design, but if the mesh size is too large, beavers will attempt to gnaw at the mesh by hooking their incisors around individual strands of the steel wire used in the construction. This can cause breakage of the incisors which, although the teeth will grow back, may reduce foraging efficiency and therefore impact on the health of the animal. To our knowledge, no study has been conducted on the effects of incisor damage on foraging efficiency in beavers, but following a precautionary principle, traps should be designed to minimise the risk of incisor damage. A single adult incisor is 7-10 mm in width and therefore a mesh size of around 10 mm should minimise the risk incisor breakage. A fine mesh will additionally reduce the risk that the washer on the underside of a tail mounted tag will catch, pulling the tag off the tail.

The Bavarian beaver trap (Figure 2) fulfils many of the requirements laid out above. However, beavers can damage incisors not only on the mesh, but also around the edges of the doors and therefore we would recommend both a finer mesh and also ensuring that the gaps around the edges of the doors are as tight as possible without impeding smooth closing of the doors. Furthermore, the traps are extremely heavy and could be made lighter by using aluminium in the construction, though this may reduce the traps resilience against beaver gnawing. Moreover, the doors are also heavy and, because they swing shut under gravity, they have the potential to cause damage to the beaver at the entrance. Again, the use of aluminium in the door construction should reduce this risk. Constructing the trap with loops that allow carry-bars to be fitted along the length of the trap on both sides will greatly improve manoeuvrability of these traps. Schwab and Schmidbauer (2003) detail several versions of this trap including an aluminium model.

Tomahawk (a US based trap manufacturer), amongst others, make basic mesh cage traps that, although they do not fulfil all the requirements set out above, may be suitable for use in areas where access is difficult and transporting heavy traps would be a problem.

Experience gained by the Scottish Agricultural Science Agency (SASA) and the RZSS in the design of appropriate cage-traps (and other methods) for re-capturing un-licensed, escaped beavers in eastern Scotland during 2007-2009 can also be applied to the Scottish Beaver Trial.

Placing, setting and checking the trap

Traps should be placed near water with one entrance facing the bank. The ideal locations would be in areas where beavers frequently forage, for example along a forage trail (see Appendix E). Obstructions, such as lengths of plastic mesh strung out to form a fence line, can be helpful in guiding the animals into the mouth of the trap. For Bavarian traps, both doors should be open, though trapping can still be successful using just one door. The traps should be baited with food (aspen branches, carrots etc.), or if this is unsuccessful, castoreum or anal-gland secretion can also be used (Rosell and Kvinlaug 1998). Food should be left in the trap even when baiting with scent-secretions so that trapped animals are able to feed. It is extremely important to ensure that the mechanism of the trap is operating properly prior to use. The doors should close immediately the trigger has been activated and the door clasps should catch the doors on both sides. Traps should be set in the late afternoon-evening and checked early the following morning. Prolonged exposure of trapped animals to extreme cold or hot sun should be avoided and therefore during cold (subzero) winter nights, traps could be checked around midnight and in summer traps could be checked before 6am.

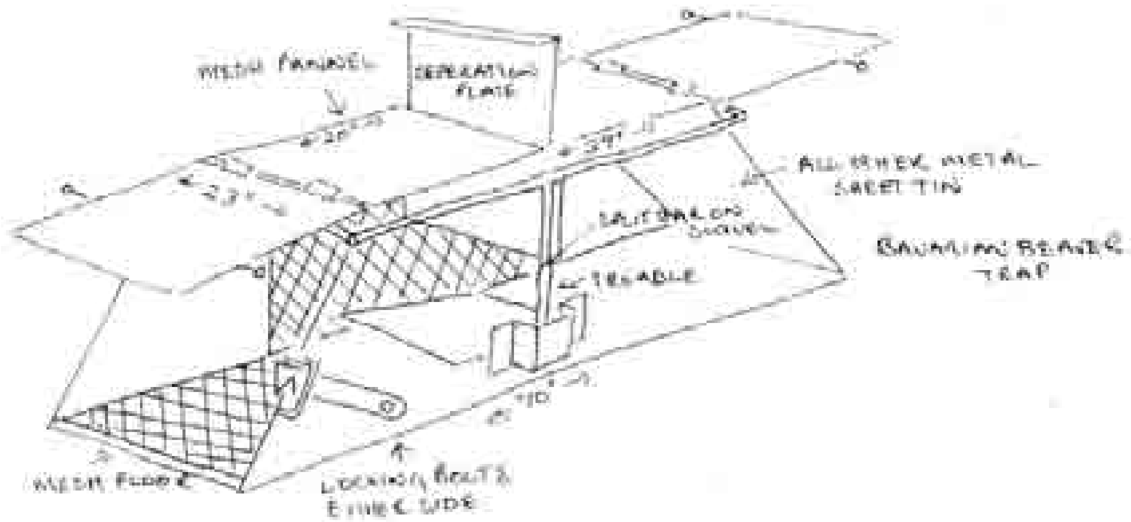


Figure 2. Bavarian beaver trap design (from Gow 2002). See main text for recommended modifications.

Transferring beavers from trap to sack

Once trapped, the beaver needs to be transferred to a hessian sack for measuring and sampling. Workers could either use a catching net to capture the animal inside the trap (or even as it exits the trap, though there is a risk that the animal will escape) or, they could use a net designed to fit the mouth of the trap. Coaxing the animal from the relative safety of the trap may not be straightforward however, and so a transfer net should be designed to be as inviting as possible. For example, it should be tented so that the animal has a clear space to move into and it should be designed so that it can be handled from the side so that no person is standing in view of the beaver as it enters the net. However, there is no hard and fast method for transferring beavers from traps (traps are principally designed to simply catch and release beavers) and so workers may have to experiment with techniques.

Alternative trapping methods

Stretching nets across streams so that swimming beavers are caught in the net is a technique that has been utilised in Russia. A beaver caught in a net using this technique may drown if not hauled out within minutes of capture and therefore nets should never be left unattended. However, the same caveats concerning the mesh size of nets referred to above also apply to this method and so it is unlikely that the fine mesh needed to minimise damage to tags could be practically employed for this method. Another potential technique would be to locate the active lodge or burrow and place a catching net over the entrance. If there is more than one entrance then these should be blocked or additional nets used. Trappers would then wait for the beaver to exit or encourage the animal to exit by creating a disturbance over the main chamber.

References and further information

Gow, D. 2002. The transport, quarantine and captive management of European beaver *Castor fiber.* Unpublished report for SNH. 20 pp.

Rosell, F. and Kvinlaug, J.K. 1998. Methods for live-trapping beaver (*Castor* spp.). *Fauna norvegica* Ser. A **19**, 1-28. Available online at: http://hdl.handle.net/2282/326

Rosell, F. and Hovde, B. 2001. Methods of aquatic and terrestrial netting to capture Eurasian beavers. Wildlife Society Bulletin. **29**, 269-274. Available online at: http://hdl.handle.net/2282/795

Schwab, G. and Schmidbauer, M. 2003. The Bavarian beaver traps. Poster presented at the Third International Beaver Symposium, Arnhem, The Netherlands. Available online at: *http://www.gerhardschwab.de/Veroeffentlichungen/Bavarian_beaver_traps.jpg*

A Norwegian film showing some of the trapping and handling techniques can be found here: *http://www1.nrk.no/nett-tv/klipp/197093* (length 30 min approx).

APPENDIX B: HANDLING AND SAMPLING OF UN-ANAESTHETIZED BEAVERS

Having successfully trapped the beaver and transferred it into a hessian sack (c. 50 x 80+ cm), the workers can begin the process of measuring and sampling the animal. Many of the procedures require two people, one to hold the beaver still (the handler) and one to take measurements and samples (the sampler). The steps below are presented in the order that the procedures should be undertaken. Note that we do not recommend picking up a beaver by the tail; this method will not only put the handler at greater risk of being bitten, but may cause damage to the tail of the beaver and at the very least will cause it considerable stress.

Handling – Equipment required:
- Hessian sacks (one per beaver).
- Rope/strap (40-60 cm).

1. Move the beaver within the sack so that its nose is in one corner. The whole of the body should be in the sack but the tail should be free of the sack. The animal can be immobilised in this position by firmly placing one hand on its rump and exerting forward pressure so that the animal is pushed further into the corner of the sack. If the animal struggles, the other hand can be placed on the animal's shoulder and gently pushed down. Record the time and check for, and record, ID (identification) of PITs.

Measuring – Equipment required:
- Calliper (accurate to 0.1 mm, minimum depth of arms should be 8 cm).
- Scales/balance (accurate to 100 g with a max load ≥30 kg).
- Tailors measuring tape (c.1.5 m).

2. *Body length:* Measure the length of the animal from tip of the nose (avoid placing fingers directly in front of the beaver's mouth) to the base of the tail where the fur meets the scales. Ensure that the measuring tape follows the spine of the animal. Measure to the nearest 5 mm.
3. *Tail length and width:* Measure the length of the tail from base (as above) to tip and the width of the tail at the mid-point of the tail length. Measurement should be recorded to the nearest millimetre.
4. *Tail thickness:* Using the callipers, record the thickness of the tail at the following four points (see Figure 1):
    a. On the mid-line of the tail at its base next to the fur.
    b. On the mid-line of the tail one third along its length from the base.
    c. On the point of the tail half-way between the mid-line and the edge and level with point 'b' (choose one side only)
    d. 5 mm in from the edge of the tail level with 'a' and 'b' (use the same side of the tail as point 'c' above).

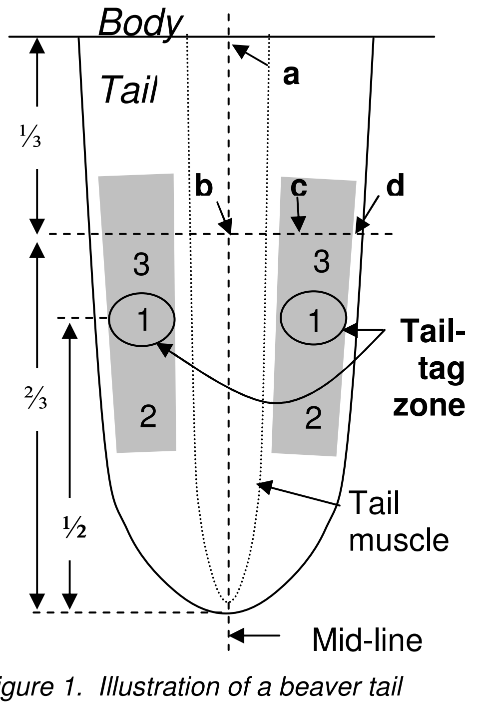


Figure 1. Illustration of a beaver tail showing measurement points for tail thickness (a-d) and zones for tail-tags (grey zones) with order of preference of location (1-3). See Paras 4 and 11 for further details.

For points ‘c’ and ‘d’, workers should choose the side of the tail to measure that is unaffected by tail-scars. If no scar-free areas are available at the required point, the worker should take measurements ‘c’ and ‘d’ twice at points equal distances either side and record the mean of each measurement. Measurements should be recorded to the nearest $^{1}/_{10}{}^{th}$ millimetre.

5. *Tail-scars:* Record the number of tail-scars, and sketch onto the tail-diagram in the field-sheet. Tail-scars provide a valuable back-up should all other ID tags fail. Alternatively, tails can be photographed with a ruler for scale and the filename noted in place. If taking photographs, images must be downloaded and recorded.

Sampling – Equipment required:
- Surgical-gloves
- 50 ml glass vials, ideally with Teflon caps (two per beaver plus two spare).
- 100 ml plastic vials (for later storage of faecal samples).
- Polythene bags (e.g. freezer bags used in food storage).
- Small paper envelopes (for hair).
- Surgical gloves.
- Alcohol (96% ethanol).
- Fine permanent marker pen.

6. *Hair samples:* A minimum of 20 hairs with follicles should be plucked from the base of the spine using gloved hands and placed in a small paper envelope. The envelope should be sealed and the date and the animal ID written on it.

At this point the handler should kneel facing the tail of the beaver with the shoulders of the animal (which *must* still be immobilised in the corner of the sack) under the crotch so that the head is protruding behind the handler and *not* in contact with any part of the handler. The handler should not be sitting on top of the beaver as their weight could damage the animal. Instead, the handler should lock knees on each side of the animal and there should be a small gap between the handler’s crotch and the shoulders of the animal. The handler should then lean forward and with one hand gently lift the tail of the beaver at the base so that the sampler can freely access the animal’s cloaca. The handler can then use their free hand to hold vials for the sampler to fill (see below). In beavers, the digestive, excretory and genital tracts all pass through a single vent (the cloaca). The proper techniques for all the procedures below will require practical training.

7. *Faecal samples:* Using gloved hands, the sampler should feel above (i.e. towards the spine) the anus for lumps that indicate faeces in the colon and gently press these out and into a plastic bag. Beavers have hind-gut fermentation and have two types of faeces, the first type being watery (these are re-ingested) and the second usually solid and sawdust like. After faeces have been collected, place the bag to one side but do not seal it as more faeces may be collected during the next two steps.

8. *Castoreum samples:* Still using gloves hands, the sampler should feel for two large lumps towards the nose of the animal from the cloaca. These are the castor sacs where castoreum is created. Using their forefingers and thumbs, the sampler should press-out the anal-glands from the cloaca. The anal-glands look like a pair of very large nipples. Simultaneously, with the remaining fingers, gently but firmly press on the castor sacs. With some practice, this should force castoreum out of the urinary tract. The urinary tract is located between the anal-glands and just towards the nose. The handler should hold a vial in one gloved hand at the exit of the urinary tract to collect the castoreum. The sampler should attempt to collect at least 5 ml but preferably >20 ml. The speed by which the sampler can extract the castoreum will depend on experience. Occasionally there will be no castoreum available. The sampler should use their experience to decide when to stop attempting castoreum extraction but obviously the longer the sampling takes, the more stress this will cause

the animal. After collection, the vial should be sealed and the animal ID and trapping code should be written on the vial using a permanent marker.

9. *Anal-gland secretion (AGS) samples:* With the anal-glands extruded from the cloaca with thumbs and fore-fingers (see above), the sampler should use their remaining fingers to squeeze one of the anal-glands. The gland will attempt to withdraw and so it takes considerable dexterity to manage this manoeuvre. Extraction of AGS can be quite difficult, particularly in females where the AGS tends to be much thicker, and so the sampler should be prepared to squeeze very firmly. AGS will flow from the tip of the anal-gland and, as before, the handler should hold a vial under the tip of the gland to collect the sample. The same caveats, concerning effort expended in extraction, apply as for castoreum (above) but the sampler should only expect to collect around 1-20 ml. After collection the vial should be sealed and the animal ID and trapping code should be written on the vial using a permanent marker. At this point, the faeces bag should be sealed, marked with ID and code and all samples should then be sealed in a single plastic bag. Note that examining the colour and viscosity of the AGS is the best way to assess sex in un-anaesthetized beavers. For Eurasian beavers, if the AGS is yellow and liquid it is male and if it is grey-white and thick-liquid or like a paste, then it is female.

At this point, the handler should get off the animal and move around to its rear, using their body to keep the animal forced into the corner of the sack.

PIT/Ear-tag attachment – Equipment required:
- Ear-tags (Dalton rototags, Dalton minitags and National Band and Tag Co. Monel metal ear-tags 1005-3 or 1005-1, see Appendix B).
- Applicators for the ear-tags
- PIT reader
- PITs and PIT applicator
- Reflective tape (several colours, for attaching to metal ear-tags, if one needs to identify animals using spotlights)
- Scissors

10. *Ear-tags:* The sampler should feel for the ears under the sack and carefully cut a 3-4cm slit in the sack above the ear, taking great care not to cut the ear. It may be helpful for the handler to temporarily release some pressure on the rear of the animal so that enough loose cloth can be grabbed for cutting. Then protrude the ear from the slit and examine it. At this point, the sampler is presented with four scenarios:

    a. The ear contains one or more ear-tags (depending on type used).

    b. The ear contains a hole where a tag once was (if this is the case, it was probably a plastic ear-tag that has been cut off during allogrooming).

    c. The ear is torn and has no tag (in which case the ear was either torn in a fight or there had been an ear-tag but it has been torn out).

    d. The ear has no tag and no tears or holes (in which case it never contained a tag).

    If the scenario is 'a', then unless the worker wishes to fit an additional tag or exchange the current one, all that needs to be done is to note the tag number/colour. For all other scenarios, the worker will probably want to fit an ear-tag (unless the ear is so badly torn in scenario 'c' that fitting even a small metal tag is impossible).

    <u>Location on ear to attach tag</u>: If available, the best place along the ear is the middle. The ears of a beaver are very small and so the tag needs to be positioned with great care to ensure that it is not too close to the outer-edge (where it can easily be torn out) and not too near the cartilage at the base (where it can damage the whole ear).

The thickened cartilage at the base of the ear ends approximately halfway toward the outer edge, and the remainder of the ear is thinner soft tissue. The sampler should aim to attach the eartag into the soft tissue but close to the thicker cartilage. For hinged ear-tags (where the closed tag forms a loop), it is important that there is not too much of the tag protruding beyond the edge of the ear as this can catch on objects and cause the tag to be torn out. Where a hole in the ear already exists (scenario 'b'), then it is generally best to apply the tag to the old hole instead of attaching it to unaffected tissue (unless the hole is very large and the tag will slip through).

Attaching ear-tags: Before the applicator is placed on the ear, the handler must, while maintaining position at the rear of the beaver, lean over and grasp the head of the beaver firmly using fingers to feel for and hold the rear of the jaw-bone and thumbs to hold the back of the skull. This is very important because if the animal moves its head while applying ear-tags the ear will tear. The handler should be prepared for the beaver to jerk its head and body rapidly upwards or sideways away from the sampler. As soon as the tag locks into the ear, the sampler should adjust their grasp on the applicator so that it can be pulled from the hand by the beaver, should it manage to move its head. For both hinged metal and plastic rotating tags, the male part of the tag should be applied to the underside of the ear so that any sharp edges remain away from its head. For plastic rotating tags, the tip of the male part should be cut-off with scissors to reduce the likelihood that it will catch on the sack or a handling net. For metal hinged tags, the sampler should ensure that the tip of the male part has folded over the female part and if it has not, then this can be done with pliers.

Issues concerning size of ear and tag: Kits should only be fitted with small metal ear-tags (e.g. The National Band & Tag Company's 1005-1 Monel tag (10×3 mm) and 1005-3 Monel tag (15×4 mm)). Yearlings and smaller two-year olds can be fitted with small metal ear-tags as above and small plastic tags such as the Dalton Minitag® (20×5 mm). Adults and larger two-year olds can be fitted with all the above tags or larger plastic tags such as the Dalton Rototag® (35×10 mm).

11. *PIT:* The sampler should cut a c.7-10 cm slit in the sack over the shoulders and neck of the beaver. The handler should still be positioned at the rear of the animal, applying gentle forward pressure. Grasping the loose skin around the nape firmly, the sampler can inject a PIT tag under the loose skin. Do not push the needle into the shoulder muscle. Ensure that the needle is not protruding out the other side of the skin and, when withdrawing the needle, hold thumb and finger around the entrance point and slide the needle past the fingers so that the sampler can relocate the entrance point of the needle and check whether the PIT is fully under the skin. If the PIT is exposed, remove it and inject a new PIT. Test the PIT using the reader.

At this point, the handler should move back around to the nose of the animal and immobilise as before.

Tail tag-attachment – Equipment required:
- Surgical-gloves
- Anti-septic spray and ointment
- Ice-spray
- Alcohol
- Scissors
- Ø4 mm (M4) nylock® stainless-steel nuts
- Ø4 mm (M4) stainless-steel screws
- Ø5 mm leather belt-hole punch (belt-pliers)
- Ø5 mm nylon tubing (internal: Ø~4 mm)
- Pliers and screwdriver (or a leatherman style multi-tool)

– Stainless steel washers to fit 4 mm screw. Ø~30 mm
– Neoprene washers to fit 4 mm screw (these can be cut from sheeting). Ø~30 mm
– Bolt-cutters
– Glue (e.g. Quick cure 5 from KHL marine (www.epoxysystems.co.uk), but only required if tag attachment will involve gluing)

12. *Tail-tag attachment: [Note - Telemark University College have tested a method for attaching radio or Argos tags to the backs of animals using an epoxy glue. This method of attachment is now being used during the Scottish Beaver Trial instead of the method set out here. Further information on the gluing method will be published in due course].* Tail-tags should be placed approximately halfway down the length of the tail and far enough away from the edge of the tail so that the tag is not protruding, yet not too close to the muscular mid-line of the tail. *Do not* pierce the tail muscle. Apart from this muscle, the rest of the tail is adipose (fat) tissue with a limited blood supply and so can be pierced without causing excessive distress to the beaver. See Figure 1 for the recommended zones for tail-tag attachment. If there are scars on the tag attachment zones (either due to fighting or to previously attached tags), then we recommend that you place slightly further down towards the tip of the tail but no further than three quarters of the way down from the base. If this is not possible, then the tag can be placed up towards the base of the tail instead. The reason for this preference is that tags in the lower half of the tail tend to tear out more easily, thereby reducing the risk of the animal drowning if it gets the tag caught on an underwater object. To attach the tag, the following procedure needs to be followed:
    a. Clean all equipment that will come into contact with the tail in alcohol. This includes the belt-pliers, plastic tubing, scissors, screw, washers and nut. Don fresh surgical gloves.
    b. Swab the dorsal and ventral areas of the tail to be pierced with alcohol.
    c. Liberally spray the area to be pierced with a cooling ‘ice’ spray. Remember to spray both dorsal and ventral side. The skin of the tail should frost as the spray evaporates.
    d. Before the tissue of the tail warms again, pierce the tail using belt pliers set to *Ø*5 mm hole. A little bleeding may occur. Again, *do not pierce the tail-muscle*.
    e. Spray the hole using antiseptic spray or spray-on plaster (e.g. Elastoplast® Spray Plaster).
    f. Coat the outside of a short section of *Ø*5 mm nylon tubing with antiseptic ointment, insert into tail-hole and cut with scissors so that the tubing is no longer than the depth of the hole (i.e. the end of the tube on both sides of the tail should be flush with or slightly inset into the tail-surface).
    g. From the *ventral* surface of the tail insert through the tube a *Ø*4 mm (M4) stainless steel screw with a neoprene washer and a stainless steel washer (both c. *Ø*10-15 mm). The neoprene washer should be nearest the tail. The screw needs to be long enough to pass through the tail and have room to attach the washers, tail-tag and nut.
    h. On the *dorsal* tail surface, thread onto the screw another neoprene washer followed by a stainless steel washer (same size as above). Then thread on the tail-tag and tighten in place using a nylon-locking stainless steel nut. Check the tightness of the tag. The tag should be snug (to reduce the risk of it catching on objects) but not too tight otherwise necrosis of the tissue underneath will occur and the tag will fall off. A rule-of-thumb is that you

should be able to rotate the tag in the tail using your finger but otherwise the tag should not move.

i. Cut off any excess length of screw using bolt-cutters.

j. Check that the tail-tag is switched on and is working.

13. *Tail-tag removal:* If a previously attached tail-tag needs to be removed, it should simply be unscrewed and removed together with the screw, washers, bolt and nylon tube. We recommend that the tail-hole should be left to heal naturally.

14. *Reproductive status:* If the animal is female and ≥ 2 years of age (or ≥ 1 year if the workers suspect the yearling female has established a territory with a male), then one worker should check reproductive status by assessing the size of the nipples. If the nipples are significantly larger than 0.5 cm then it is possible that the female is lactating. Nipples can be assessed by the sampler kneeling at the posterior of the beaver and holding its head and shoulders immobile using one hand. With the other hand, the sampler should reach into the sack and feel for the nipple located near the fore-leg. It is extremely important that the animal is not able to move its head and bite the sampler while they are assessing the nipples. If the sampler maintains one hand on the head and shoulders, then they should be able to detect if the animal moves its head and so remove their hand to avoid being bitten. However, in practice the beaver usually remains immobile throughout this procedure and therefore the risk of being bitten is low.

15. *Weight:* Weigh the animal in the sack using either a hanging balance or a portable electronic platform balance. Workers should ensure that the animal is motionless before noting the weight. Weight should be recorded to the nearest 100 g where possible. Ensure, prior to lifting the animal in the sack, that the ear-tags are not caught in any holes.

16. Release the animal from the sack with the animal facing the water. Ensure that ear-tags and the tail-tag are not caught in the sack and that the animal has an unobstructed route to deeper water. Record the time of release.

17. Weigh the empty sack, unless the sack came into contact with water during the release - in which case the weight of a fresh dry sack (of the same type) should be recorded instead.

Further information

A Norwegian film showing some of the handling techniques can be found here: *http://www1.nrk.no/nett-tv/klipp/197093* (length 30 min approx).

APPENDIX C: RADIO-TELEMETRY TECHNIQUES

General principles

The radio transmitter attached to the study animal emits a relatively low-power pulse at a set frequency that should be unique from all other transmitters used in the study. In the UK, the frequencies are usually in the 173.000-173.999 or 433.000-433.999 MHz range. Trackers use a directional antenna attached to a radio receiver (usually a three-element Yagi antenna, see Figure 1). The Yagi antenna will pick up the signal from all sides, but it is most sensitive to signals coming to the front end (and to a lesser extent, signals arriving at the rear). A tracker should be able to pinpoint the direction of the tag by finding the direction from which the signal is at its strongest. To help, the receiver will often have not only a frequency selector, but also a volume control and a gain control. The gain dial sets the signal to noise ratio and so high gain allows detection of weak signals but also increases noise (and potentially accuracy). It is usually best to have the gain set at the lowest setting on which the tracker can still clearly detect a signal. Although this sounds simple, there are caveats to this process. These are:

1. The receiver must be along the line-of-sight to the transmitter. Objects between transmitter and receiver such as a hill, building or dense vegetation will attenuated (weaken) the signal reducing the range and therefore making signal direction more difficult to estimate. The fewer obstructions the better the signal so therefore it helps to get above the area that the animal is in, for example by climbing a hill-side.
2. The signal can, however, be diffracted around objects which can allow a tracker to detect a signal even if the transmitter is behind an obstruction. However, this process also results in interference around tree-trunks and so makes it difficult to obtain accurate bearings in woodland. Furthermore, if there is an abrupt woodland boundary, this effect will continue for up to around 50 m from the woodland edge.
3. The signal can be reflected by objects such as cliffs, hill-sides, woodland and water which can give trackers a false bearing.
4. Due to reflection and attenuation, ground clutter will reduce fix accuracy and therefore transmitters located lower to the ground will have greater location errors than those higher up.
5. The signal can be either horizontally or vertically polarised when it reaches in receiver. The Yagi antenna has pairs of elements (three pairs for a three-element model) that project out from its boom (central shaft) along a single plane (Figure 1). Holding the antenna so that these elements are vertical will give the maximum sensitivity to a vertically polarised signal and holding it so the elements are horizontal will work best for a horizontally polarised signal. This issue is only important when the signal is already weak.
6. If close to the transmitter, the tracker may receive signals reflected by many of the factors listed above and it can be difficult to pinpoint the true bearing. Often turning the gain on the receiver down will help reduce the reflected signals received and enable better accuracy.

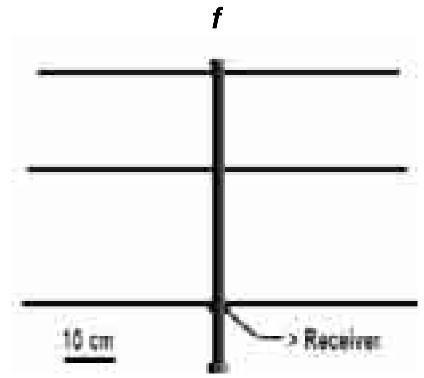


Figure 1. An example of a three-element Yagi antenna. The front (the end at which it is most sensitive to a signal) is indicated with 'f'.

From the above, it is clear that obtaining accurate bearings on a tagged animal's location can be difficult. However, location errors can be greatly reduced by collecting several bearings over a short time interval from at least three locations, or by using the signal to visually locate the animal.

Day-time location checks

There are two options for locating an animal at its day-rest place (for beavers, this would usually be a lodge or a burrow). The first is to collect a series of bearings (this process simply follows the night-time tracking methods set out below, but bear in mind that an animal inside a lodge or burrow will have a strongly attenuated signal). The second is to follow the signal using the receiver-antenna until you find the exact location of the beaver (assuming that it is in the lodge/burrow and therefore will remain undisturbed). The process is relatively simple and can be used to quickly check locations once the animals are established and have one or two lodges/burrows that they regularly use.

Following a signal to the within 10-20 m of the tagged animal's actual location is usually straightforward. However, locating the animal to within a metre (useful to find the exact location of a burrow, or to find a transmitter that has fallen off, or one that is attached to an animal that you believe may have died) may not be so easy. Once the tracker is within a few metres, the signal can be strongly reflected and it can be impossible to get a sense of its direction, even with the gain set to its minimum and the attenuator switch (if the receiver has one) switched on. At this point, it can often be helpful to remove the antenna from the receiver while keeping the antenna cable attached (if the antenna comes with a built-in cable, then carry a spare cable for this purpose). Turn the gain on the receiver up and, holding the free end of the cable close to the ground, the tracker should then quarter the ground to find the spot where the signal is at its strongest. It should become immediately apparent if they are moving too far away because the signal will be lost.

Night-time radio-tracking

The basic aim is to take a series of bearings (at least three, but the more bearings the greater the accuracy) on the target tagged animal and from this calculate its location (known as a 'fix') and an error value associated with that fix so that its accuracy can be verified. The error value at its simplest is the area contained within three bearings drawn on a map (Figure 2). It would be possible to acquire a fix with just two bearings, but this would not allow the calculation of the error and therefore we would have no way of telling whether the fix location had any basis in reality. Calculating fixes based on series of bearings would be a laborious process. However, software is available (e.g. *Locate III*, see Online resources below) that will process the bearings and provide a fix location with a more sophisticated measures of error that the simple error polygon in Figure 2.

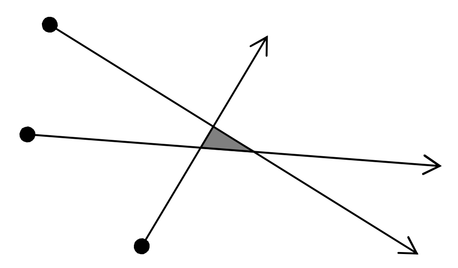


Figure 2. A fix location based on three bearings. The animal is probably somewhere in the grey polygon formed by the crossed bearings (though this is not necessarily the case). The error value, at its simplest, is the area of the polygon.

In addition to the numbers of bearings obtained, another key consideration is the relative direction the bearings have to each other. A series of bearings that are all in a similar direction (either because the animal is far away, or because the animal is directly between two trackers) will provide very poor accuracy compared with three bearings that cross at angles of around 60° or four bearings that cross at angles of around 45° (Figure 3). For this reason, trackers working in a team should contact each other regularly to confer on the position of the target animals in relation to themselves. Approximations can be made by the trackers explaining to each other the direction in which they think the animal is from themselves, or by passing on the bearings and locations from which these bearings were taken and inputting them into a field computer or hand-held PDA to calculate the actual fix location from the bearings. The latter option can be difficult, but is also extremely useful in providing regular updates on the accuracy of different trackers, enabling trackers to be corrected or the location of trackers to be changed if a problem arises.

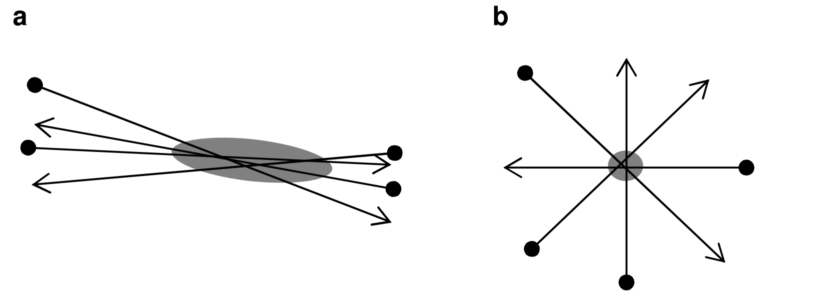


Figure 3. Two series of bearings (lines) showing error around fix location (grey shading). Poor quality fix locations can result if all bearings are taken along a similar axis (a), whereas the best fixes will be obtained by ensuring that bearings are obtained from an even spread of tracking points (b).

Detailed setup and protocols

In order to obtain the best quality fix locations and in order to maximise the safety of the workers, we recommend that trackers work in teams of two and communicate via two-way radios.

Each tracker should carry a GPS in order to log locations from which bearings are taken. These locations should be chosen with consideration to the points laid out in the General principles section above. For example, open ground further than 50 m from woodland and away from cliffs or buildings would be preferable. In addition to using GPS, it can be helpful to set up a series of tracking stations early in the project. These could be points considered suitable for tracking that are marked with a post bearing an ID number, and whose precise coordinates have been noted. The advantages to this set up are twofold. Firstly, trackers need not note down long series of map coordinates while tracking but instead record the tracking station ID. Secondly, having a series of tracking stations with a well defined route between them will reduce the risk of a tracker getting lost or stumbling over obstacles while working in darkness. Tracking stations should be laid out so that they provide the optimum coverage of the target area (Figure 3b).

One tracking night should either consist of one session of tracking over the entire night (e.g. from approximately 20:00 hrs to 06:00 hrs) or two session running over separate nights with one covering one half and the other covering the remaining half of the night (e.g. 20:00 hrs to 01:00 hrs then 01:00 hrs to 06:00 hrs or 01:00 hrs to 06:00 hrs and then 20:00 hrs to 01:00 hrs). This is to ensure no bias is introduced into the location data by any cyclic patterns in movement over the night that might exist. For example, an animal might have a tendency to spend the early part of the night foraging close to the lodge and only later move further away to assess territory borders or forage elsewhere. Therefore, fix locations only from the first half of the night would underestimate territory size and bias measures of habitat preference.

A bearing is obtained by the following process (following Cresswell 2009):

1. Find the direction where the signal is at its strongest and turn the gain down so that with the antenna pointing in the direction of the strongest signal, the tracker can only just hear the pulses.
2. Sweep the antenna slowly to the side until the signal disappears, and then sweep back until the tracker can just hear it again, and note the bearing along the line of the antenna boom.
3. Repeat this on the other side and the true bearing is the line that bisects the angle between these two directions.

Trackers will obtain the most accurate bearings by noting a landmark on the sight-line of the antenna boom and using a sighting compass to obtain the bearing. An alternative, quick method involves attaching a compass to the shaft of the antenna, ensuring that it is precisely aligned, and reading a bearing from the compass. This latter method will only work if the antenna is constructed from non-magnetic material such as aluminium and therefore trackers should ensure that the antennas will not influence the compass bearing before using this approach.

Prior to beginning a session, trackers should cycle through all currently active tags in the release area (even if the animal is usually in a different location) and, based on which animals are within range, write out a time-table of which target animals will be located and when, so that both trackers are taking bearings on the same animal at the same time. Each tracker should obtain two bearings from two separate locations on each animal for each fix. The longer the time interval between bearings, the more likely that the fix will be inaccurate due to the animal moving between bearings. On the other hand, if trackers were to constantly shift tracking stations between each individual bearing, then they would be wasting time and energy. As a compromise, we recommend that trackers obtain bearings on up to four animals at a time at each tracking station before shifting to another tracking station. If a signal is weak or the direction is very difficult to ascertain, then the tracker should move on to the next animal and try to obtain another bearing on the dropped animal at the next tracking station. Trackers should aim to obtain all the bearings needed at one tracking station within five minutes. Trackers should aim to obtain one location fix on each animal once every hour over the tracking session resulting in approximately 10 fixes / night on each animal. For each bearing, trackers should note down in a datasheet (Appendix H) the animal ID, tracking-station ID (or GPS coordinate), time (to nearest minute) and bearing (degrees from magnetic north). Therefore, the tracking process should roughly match the following scenario:

1. Tracking station (TS) 1: Obtain one bearing each on one-four animals.
2. Move on to TS2 and obtain a further bearing on each animal in range.
3. Move on to TS3 and TS4 to obtain further bearing on animals that were not within the range of TS1 or TS2.

OR

4. Return to TS1 to repeat the process or to obtain bearings on different animals if there are >4 with tags in range.
5. Once each hour, the radio-tracking partners should update each other on location statuses.

What to do if no signal can be found?

If no signal can be detected for a target animal while radio-tracking, trackers should concentrate on the remaining animals for the session but regularly recheck the missing animal's frequency to confirm that the animal was not, for example, behind an obstruction or temporarily out of range.

If no signal can be found, there are several possible reasons:

1. The receiver/antenna is not working properly. This should be easy to confirm by checking for other tags within range. Common causes of receiver/antenna failure are:
    a. The receiver attenuator switch is switched on or some settings have accidentally been adjusted. Trackers should always check these settings if the signal is lost.
    b. The cable has been damaged by the constant twisting movement associated with swinging and rotating the antenna. Trackers should always carry a spare.
    c. The battery has no charge. Trackers should carry a spare.
2. The transmitter is broken or has run out of battery power. This can be confirmed by observing the lodge of the missing animal and attempting to spot it.
3. The animal is out of range. In this case, the first option is to get to high ground to increase range. If there is still no signal, then (during daylight) the tracker should move around the release area until a signal is detected, paying particular attention to areas that are connected by water to the animal's last known location. If the animal has moved a great distance then it might be possible to track it from an aircraft, but the expense of using such method is likely to preclude it during the current trial.

Other potential problems

If the location of a radio-tag does not change over a 48 hour period, workers should check that the tag has not fallen off or that the animal is not dead, by:

a) trying to recover the tag on the ground or, if it is located underground by
b) attempting to spot the animal to which the tag is supposed to be attached.

Online resources

Locate III, a program that allows calculation of animal locations from bearings using PCs or Palm PDAs can be found at: *http://www.locateiii.com/*

A home range extension for ArcGIS can be found at: *http://blue.lakeheadu.ca/hre/*

Ranges, the comprehensive home range analysis tool can be found at: *http://www.anatrack.com/*

References and further reading

Cresswell, B. 2009. *Practical radio-tracking*. Biotrack Ltd. Available at: http://www.biotrack.co.uk/pdf/howtoradiotrack.pdf

Harris S., Cresswell, W.J., Forde, P.G., Trewhella, W.J., Woollard, T., Wray S. 1990. Home-range analysis using radio-tracking data - a review of problems and techniques particularly as applied to the study of mammals. *Mammal Review* **20**, 97-123

Kenward, R.E. 2001. A Manual for Wildlife Radio Tagging. Academic Press, London.

Mech, L.D. 1983. A Handbook of Animal Radio-Tracking. University of Minnesota Press, Minneapolis.

APPENDIX D: ETHOGRAM OF BEAVER BEHAVIOURS

	Behaviour	Code	Description
Loco-motion	Swim	Sw	Swimming
	Walk	Wa	Walking
	Dive	D	Swimming underwater
Forage	Forage / Eat (aquatic)	Fa Ea	The beaver swims out from the shore, dives and then reappears swimming to shore. On arriving at the shore, it consumes the aquatic vegetation it has collected and carried (which is usually not visible to the observers until this point). The behaviour can therefore be split into the searching+handling component (Forage (aquatic) – Fa) and the consumption component (Eat (aquatic) – Ea). Often, the beaver will repeat this behavioural sequence several times as it returns to the same location to collect more aquatic plants.
	Forage / Eat (herb)	Fh Eh	The beaver will be seen grazing on grasses and herbs on land. Occasionally, the animal may bring a clump of herbs/grasses back to the water to consume at the shore. However, often it simply consumes the vegetation where it grows and so it can be difficult to separate the searching+handling (Fh) and consumption components (Eh).
	Forage / Eat (woody)	Fw Ew	The beaver will select and tree or sapling and begin gnawing at the stem. For sapling, this process can take a few seconds or minutes and when the sapling falls, the beaver will usually drag it to shore and consume it there – though it may swim to a favourite location further along the shore for consumption. For larger trees, the beaver is unlikely to complete the felling of the tree in one visit and may return to the tree several times before it falls. Once fallen, the tree will be further cut into manageable sections that can be transported back to the water. Occasionally, the beaver may consume the bark of larger logs *in situ*. As with aquatic plants, the behaviour can easily be split into the searching+handling (Fw) and the consumption (Ew) components.
Territorial	Scent-mark	SM	While close to and facing the water, the beaver will scrape dirt and debris from the ground in front and push it underneath its body to form a mound (not yet visible to the observer) using its forepaws. The beaver will then scent-mark on top of this mound. During the scent-marking moment the observer will see the beaver waggle its hind-quarters. Almost always, the beaver will *immediately* enter the water after it has scent-marked. Beavers may sniff the ground or old scent-mounds prior to scent-marking.
	Fight	Fi	Fighting is very rare, but very serious when it occurs. The behaviour can involve wrestling (see below) but also biting of the opponent, particularly around the shoulders and the spine near the base of the tail.

	Stick-display	SD	The beaver picks up an object (a stick if available), rises up on its hind legs, and moves its upper body rapidly up and down while holding the object with mouth and forepaws (see Thomsen *et al.* 2006, includes video). This behaviour is rare, and usually associated with intense territorial conflict.
Social	Nose-to-nose	NN	Two beaver face each other and touch noses. The behaviour usually occurs when two familiar beaver meet each other and probably allows individuals to identify each other.
Social	Wrestle	Wr	Two beaver face each other, press fore-paws against their opponent and rise up on their hind-quarters. The behaviour is accompanied by loud whining vocalisations and usually occurs in shallow water. It occurs between two family members, and no physical damage is sustained.
Social	Allogroom	AG	Grooming (see below) of another beaver (always a family member). Allogrooming can involve one beaver grooming the other, or two (or more) beaver grooming each other.
Social	Caravan	C	A young beaver kit may latch on to the hind-quarters of an older animal as it swims. This usually only occurs with newly emerged beaver kits in July and August.
Miscellaneous	Build	B	Building can involve carrying and placing branches onto lodges and dams, or applying mud to the surface of a lodge and dam by shovelling the mud up from underwater in is forepaws.
Miscellaneous	Groom	G	Beavers have a 'comb' (a double claw) on their forepaws and use this and their incisors to groom their fur. Grooming usually occurs on the shore and the animal will usually be sitting up on its hind-quarters.
Miscellaneous	Sit / Still	S	Sometimes beavers sit still on the shore, or lie still in the water. This category is difficult to interpret and probably covers a host of different behaviours.
Miscellaneous	Alert	A	While motionless on land or in water, the beaver will be raising its nose repeatedly as it sniffs the air.
Miscellaneous	Provision	P	Beavers may occasionally dive into the lodge carrying a branch. Though this can happened at any time of year, it frequently occurs June-August, when it is likely that the animal is providing food for the newly weaned kits in the lodge. Any family member may provision the young.
Miscellaneous	Tail-slap	T	The beaver raises its tail above the water and slaps it down on the surface, before diving. This creates a loud splash and depending on the situation, is either a warning to a would-be predator that it has been spotted, or part of an agonistic interaction between two strange beavers.

References and further reading

Thomsen LR, Campbell RD and Rosell F. 2007. Use of tools in agonistic display by a rodent. *Animal Cognition* **10**:477-482. Available online at: http://hdl.handle.net/2282/530

Wilsson L. 1971. Observations and experiments on the ethology of the European beaver (*Castor fiber* L.). *Vitrevy* **8**:115-266

A Norwegian film showing beaver behaviours can be found at: *http://www1.nrk.no/nett-tv/klipp/197093* (length 30 min approx).

APPENDIX E: FIELD-SIGN SURVEYS

A guide to identifying and decoding some beaver signs.

The main beaver signs are:

1. Lodges and burrows
2. Food caches
3. Dams
4. Tree / sapling cutting
5. Feeding stations
6. Foraging trails and canals
7. Tracks
8. Scent-mounds and scent sites

Each of these signs is covered below, with explanations on what they can indicate to a surveyor.

Lodges & burrows

Beavers generally prefer to dig burrows, but if the ground conditions are not suitable then a lodge will be built instead. Lodges are obvious piles of beaver-cut sticks (often stripped of bark) bound together with mud. The entrance to both lodges and burrows is usually under the surface of the water and therefore burrows can be difficult to spot. Lodges often develop from burrows when the burrow breaches the surface of the ground and the beavers cover the gap with sticks. As a result, such lodges can be found several metres inland, connected to the water via the original burrow system. Strictly speaking, this type of lodge should be referred to as a bank lodge. Additionally, some lodges may consist of a tunnel constructed of sticks and mud leading to an underground chamber further up the bank. Finding a lodge or burrow tells a surveyor very little of the current beaver activity at a sight, since these signs can remain long after the beavers have abandoned them. However, if a lodge has signs of fresh mud having been applied to its exterior (generally by being pushed up from the water by a beaver), then this indicates that the lodge is in use. Another reason that lodges and burrows are poor indicators of the numbers of beaver families is that one beaver family can create and regularly use more than one lodge or burrow. Work in 2000 on the Telemark beavers found that beaver families were regularly using an average of six or seven lodges and burrows of which only one or two were used as day-rest places (R. Campbell, L. Thomsen and F. Rosell unpublished).

Food caches

In colder climates, beaver will build underwater stores of cut saplings and branches to provide food over the winter. These caches are built up by initially forcing the ends of saplings or branches into the sediment in the water in front of the lodge or burrow and then later by knitting each fresh sapling into the growing food pile. Eventually, the cache is visible emerging from the water surface. This is one reason why beavers need deep water next to their main lodge/burrow. Food caches are built in late autumn and are most visible in early winter before they are depleted. The presence of a food cache outside a lodge/burrow is a good sign that it is being used over the winter and furthermore, usually only one cache is built per family and so a count of food caches is a good indicator of the number of beaver families.

The source population for the Scottish Beaver Trial was southern Norway, where food caches are created every winter. However, caching behaviour is known to be quite adaptable to changes in wintering conditions and it is quite possible that within a few years, none of the beaver families will create food caches in the relatively mild west-coast winters.

Dams

Dams are the most obvious sign of beaver activity. There are usually made from beaver-cut branches (often stripped of their bark) and partially sealed with mud or other vegetation. As with lodges, dams can last for several years after a site has been abandoned, so their presence does not indicate an active beaver colony. Furthermore, families can build several dams or not build dams at all, and so their number is not a good indicator of the number of beaver families.

Tree cutting

Felled trees and cut tree stumps are a clear sign that beavers are foraging in the area. Beaver can fell a range of sizes of trees but most frequently fell small saplings (≤5 cm diameter and therefore the true extent of beaver activity at a site may not be obvious until closer inspection. Trees cut by beavers will display gnawing marks with larger trees sometimes being gnawed around the entire circumference and small saplings cleanly cut at an oblique angle. Whether a cutting is fresh or not should become apparent from inspection of the cut stump for regeneration together with inspection of the cut face which will discolour over time. The stripped sections of wood left around after the beaver has finished are another clear sign of foraging activity (see below). However, just because there are few signs of felled trees and cut wood at a site does not mean that beavers are not active there. Beavers frequently forage on herbs, forbs and aquatic plants and such activity is very difficult to spot when conducting a field-sign survey.

Beaver gnawing on bark can leave marks of their incisors on the wood. Some researchers claim that they can tell if a branch has been stripped of its bark by a beaver kit or an adult based on the width of the incisor marks. However, no study has been conducted to verify this claim and a pilot study by R. Campbell examining incisor marks on cut ends of saplings from captive beaver families did not find a good relationship between incisor widths and incisor marks (though gnawing marks left on the bark may well provide a better guide to incisor width than marks on the cut-end of a branch).

Feeding stations

Instead of eating saplings wherever they are felled, beavers usually take felled trees back to the water and often will go further and swim with the tree to a favourite spot to eat. As a result, feeding stations develop and are clearly visible because much of the waterside vegetation has been scoured away and lots of stripped wood is left both on the bank and under the surrounding water. Feeding stations also tend to develop at the water-end of foraging trails (see below). Feeding stations are therefore a good indicator of activity but not necessarily a good indicator of favoured habitat.

Foraging trails and canals

Beavers will create clear paths at particular spots where they regularly forage away from water. This is a good sign that beavers are foraging in that area. However, the number of foraging trails is probably not a good correlate to beaver activity since beavers do not always use such trails. Ultimately, if the beavers are regularly using trails to transport felled trees, they may begin to dig at the water end of the trail, eventually creating a water filled canal.

Tracks

The hind feet are webbed, although this may not be visible in the track, and are much larger than the un-webbed fore feet. Both feet have five digits. Kits also have large hind feet, although smaller than adults and therefore an experienced surveyor may be able to estimate whether the animal was young or full-grown. Often the marks of the tail will also be visible where the tip has been dragged along the surface.

Scent mounds and scent marking sites

Beavers use scent marking as a means of communicating their presence both to other family members and to non-family members such as neighbours and wandering strangers. When scent marking, the beaver gathers together mud and other debris from the ground around it using its fore feet, forms it into a small mound with its hind feet and sprays scent (castoreum and possibly anal gland secretion) on to it. These mounds can be over-marked by other beavers when they find them. They are usually at the waterside and are often not difficult to spot. A surveyor can confirm that the mound is fresh by smelling for castoreum. Scent mounds can be located throughout a family territory. However, scent mounds tend to be concentrated nearer the territory edges (Rosell *et al.* 1998), especially in areas where two or more territories are in close proximity. Indeed, when there is a shared border between two territories, the frequent scent-mound building and over-marking can result in a clearly delineated boundary over a short stretch of bank (as short as 10-20 m). These borders are visible to surveyors because the constant activity has scoured away the waterside vegetation.

References

Rosell, F., Bergan, F. & Parker, H. 1998. Scent-marking in the Eurasian beaver (*Castor fiber*) as a means of territory defense. *Journal of Chemical Ecology* **24**, 207-219.

Example field signs

Below are photographs of some of the field signs (all images by RDC unless otherwise stated). These are:

1. Beaver lodge.
2. Beaver dam.
3. Gnawed tree.
4. Cut sapling stump.
5. Beaver tracks (photo Hannes De Geest).
6. Foraging trail (with cut tree stumps near the trail and a bank-lodge in the background).
7. Scent mound.
8. Scent site with two recent mounds (arrows). The vegetation has been scoured away by frequent scent-marking, as is typical of these sites.

1

2

3

4

5

6

7

8

APPENDIX F: WEIGHT TABLE FOR EURASIAN BEAVERS

This weight table has been obtained from the weighing of wild beavers in Telemark, Norway of known age (i.e. from animals which where originally trapped as kits (0 years) or, for the 2yr and 3+yr columns, as yearlings (1 year)). Beavers were sampled between 1998 and 2006. Samples sizes were 51, 26, 12 and 18 for age classes 0–3+yrs respectively. These tables were created from the linear regression of beaver weights with the day of the year for each age class. The regression line is *Exp weight* and each regression line is associated with a non-linear 95% Confidence Interval (CI).

The table can be used to estimate the likely age of previously uncaught beavers (0, 1, 2 or 3+ years of age). If an animal falls within more than one age-class 95% CI limit, it should be ascribed to the range of all age-classes it could belong to. However, mass gain with age and time of year may not follow the same patterns in the reintroduced Knapdale population as has been recorded in the Norwegian source population and therefore these tables are not absolute.

Date of capture (DD.MM.xx)	Day (1= 1st Jan)	Exp kit weight (kg)	*Lower 95% CI kit*	*Upper 95% CI kit*	Exp 1yr weight (kg)	*Lower 95% CI 1y*	*Upper 95% CI 1y*	Exp 2yr weight (kg)	*Lower 95% CI 2y*	*Upper 95% CI 2y*	Exp 3+yr weight (kg)	*Lower 95% CI 3+y*	*Upper 95% CI 3+y*
15.03.xx	74				**6.41**	*3.82*	*9.02*	**12.59**	*8.47*	*16.73*	**18.88**	*13.62*	*24.15*
23.03.xx	82				**6.76**	*4.18*	*9.34*	**12.81**	*8.72*	*16.92*	**19.00**	*13.77*	*24.24*
01.04.xx	91				**7.15**	*4.59*	*9.71*	**13.06**	*9.01*	*17.14*	**19.14**	*13.93*	*24.34*
07.04.xx	97				**7.40**	*4.86*	*9.96*	**13.23**	*9.19*	*17.30*	**19.23**	*14.04*	*24.42*
15.04.xx	105				**7.75**	*5.22*	*10.29*	**13.45**	*9.44*	*17.50*	**19.35**	*14.18*	*24.52*
23.04.xx	113				**8.09**	*5.57*	*10.62*	**13.68**	*9.68*	*17.70*	**19.47**	*14.31*	*24.63*
01.05.xx	121				**8.44**	*5.93*	*10.96*	**13.90**	*9.93*	*17.91*	**19.59**	*14.45*	*24.73*
07.05.xx	127				**8.69**	*6.19*	*11.21*	**14.07**	*10.11*	*18.07*	**19.68**	*14.54*	*24.82*
15.05.xx	135				**9.04**	*6.54*	*11.55*	**14.29**	*10.34*	*18.29*	**19.80**	*14.67*	*24.93*
23.05.xx	143				**9.38**	*6.89*	*11.88*	**14.52**	*10.58*	*18.50*	**19.92**	*14.79*	*25.05*
01.06.xx	152				**9.77**	*7.28*	*12.27*	**14.77**	*10.84*	*18.75*	**20.05**	*14.92*	*25.19*
07.06.xx	158				**10.03**	*7.54*	*12.53*	**14.94**	*11.01*	*18.91*	**20.14**	*15.01*	*25.28*
15.06.xx	166				**10.37**	*7.88*	*12.87*	**15.16**	*11.24*	*19.14*	**20.26**	*15.12*	*25.41*
23.06.xx	174				**10.71**	*8.22*	*13.22*	**15.39**	*11.46*	*19.37*	**20.38**	*15.23*	*25.55*
01.07.xx	182				**11.06**	*8.56*	*13.56*	**15.61**	*11.68*	*19.59*	**20.50**	*15.33*	*25.68*
07.07.xx	188				**11.32**	*8.82*	*13.83*	**15.78**	*11.85*	*19.77*	**20.59**	*15.41*	*25.79*
15.07.xx	196	**2.93**	*0.85*	*5.21*	**11.66**	*9.15*	*14.18*	**16.00**	*12.06*	*20.00*	**20.71**	*15.51*	*25.93*
23.07.xx	204	**3.16**	*1.10*	*5.43*	**12.00**	*9.49*	*14.53*	**16.23**	*12.28*	*20.24*	**20.83**	*15.60*	*26.08*
01.08.xx	213	**3.42**	*1.37*	*5.68*	**12.39**	*9.86*	*14.93*	**16.48**	*12.51*	*20.51*	**20.97**	*15.70*	*26.25*
07.08.xx	219	**3.60**	*1.56*	*5.85*	**12.65**	*10.11*	*15.20*	**16.65**	*12.67*	*20.69*	**21.06**	*15.77*	*26.36*
15.08.xx	227	**3.83**	*1.79*	*6.09*	**12.99**	*10.44*	*15.55*	**16.87**	*12.88*	*20.94*	**21.18**	*15.85*	*26.52*
23.08.xx	235	**4.06**	*2.03*	*6.32*	**13.34**	*10.76*	*15.91*	**17.09**	*13.08*	*21.18*	**21.30**	*15.93*	*26.68*
01.09.xx	244	**4.32**	*2.29*	*6.60*	**13.72**	*11.13*	*16.32*	**17.35**	*13.31*	*21.47*	**21.43**	*16.02*	*26.87*
07.09.xx	250	**4.50**	*2.46*	*6.78*	**13.98**	*11.37*	*16.59*	**17.51**	*13.46*	*21.66*	**21.52**	*16.08*	*26.99*
15.09.xx	258	**4.73**	*2.68*	*7.03*	**14.33**	*11.69*	*16.96*	**17.74**	*13.65*	*21.91*	**21.64**	*16.15*	*27.17*
23.09.xx	266	**4.96**	*2.90*	*7.28*	**14.67**	*12.01*	*17.32*	**17.96**	*13.84*	*22.17*	**21.76**	*16.21*	*27.34*
30.09.xx	273	**5.16**	*3.08*	*7.51*	**14.97**	*12.29*	*17.65*	**18.16**	*14.01*	*22.40*	**21.87**	*16.27*	*27.50*

APPENDIX G: LIVE-TRAPPING OF BEAVERS – FIELD SHEET

Date of capture ☐ Trapper ☐ Sampler ☐ Handler ☐

ID of trapped animal (Animal ID+trapping code+name) ☐

Locality [colony name + where in territory or map coordinates]

☐

Time of capture ☐ Time at start of handling ☐

Body length – nose to base of tail (following spine) ☐ cm

Tail length ☐ & width ☐ cm. **Tail** thickness at **a** ☐ **b** ☐ **c** ☐ **d** ☐ cm

(*see diagram of tail for location*). Tail thickness taken on **left** ☐ **right** ☐ *(cross in correct box)*

Tail scars and notches on the sides ☐ & on top ☐ *(sketch scars on diagram below)*

<u>Samples taken</u>

Hair ☐ faeces ☐ castoreum ☐ AGS (anal gland secretion) ☐ tissue ☐

Sex ☐

Eartag in left ear (type, colour + number) ☐

Eartag in right ear (type, colour + number) ☐

PIT code ☐

Tail tag type ☐

Tail tag ID / frequency ☐

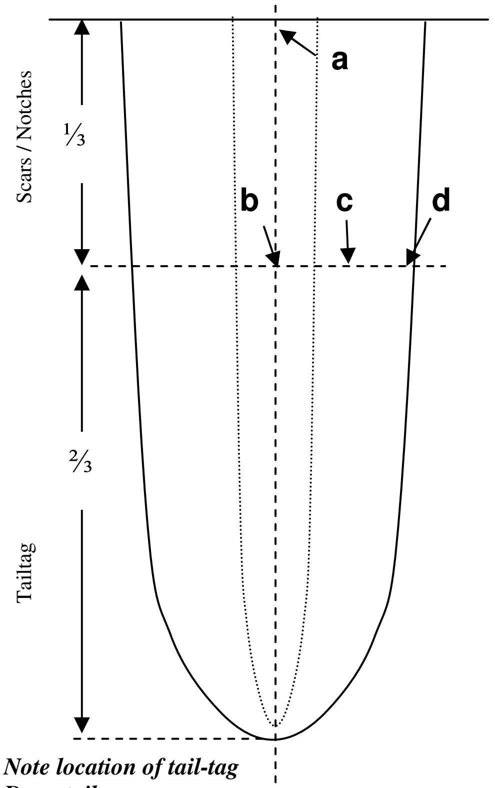
Size of nipples ☐ cm

Weight of beaver + sack ☐ just sack ☐ kg

Time of release ☐

General comments

Diagram of tail



Note location of tail-tag
Draw tail scars

Field sheets are to be filled out in the field. Completed sheets should be stored to allow verification of data where necessary.

APPENDIX H: BEHAVIOURAL OBSERVATION & LOCATION FIELD SHEET

Date: Location: Observation type: Lodge ☐ Fix location ☐

Observer(s):

Animal	Fix #	Time (HH:MM)	Behaviour code	Forage type	Interacting animal	Comments

BEHAVIOUR CODES MUST BE AS FOLLOWS (see Appendix D ethogram for descriptions of behaviours):

Locomotion: Sw Swim, Wa Walk, D Dive

Forage: F Forage, E Eat. **Forage type:** a aquatic, h herb, w wood

Territorial: Sm Scent-mark, Fi Fight, SD Stick-display

Social: NN Nose-nose, Wr Wrestle, AG Allogroom, C Caravan

Misc: B Build, G Groom, S Sit/Stll, A Alert, P Provision, T Tail-slap, O Other

Field sheets are to be filled out in the field. Completed sheets should be stored to allow verification of data where necessary.

APPENDIX I: RADIO-TELEMETRY FIELD SHEET

Date: Tracking session: Tracker:

Time	Animal ID	Fix #	Bearing #	Station ID (or Easting, Northing)	Bearing (°)	Comments

Field sheets are to be f`illed out in the field. Completed sheets should be stored to allow verification of data where necessary.

Field sheets are to be filled out in the field. Completed sheets should be stored to allow verification of data where necessary.

APPENDIX J: BEAVER FIELD-SIGN SURVEY SHEET

Date:___________ Surveyor:_____________ Start time:_____ Finish time:_____

Time taken (h):_____ RHS Reach no:______________ Route length (km):____

Field-sign*	GPS-waypoint			Cut trees†			Image‡ No.	Comments
	ID	Easting	Northing	% cut	Spp 1	Spp 2		

Codes

B	Burrow	**FC**	Foraging canal	**SM**	Scent mound
C	Cutting (trees/saplings)	**FS**	Feeding station	**SS**	Scent site
Ca	Food cache	**FT**	Foraging trail	**T**	Tracks
D	Dam	**L**	Lodge		
		O	Other signs (note)		

*For foraging signs (e.g. field-sign=‘C’), max one record per 10m length of bank. Only record fresh foraging signs.
†For cut trees, ‘% cut’ is a rough visual estimate of the percentage of trees cut within 5m of the water in the 10m section around the GPS point. Spp 1 and Spp 2 are respectively the first and second most frequently cut tree species (or genus) in the section.
‡File number of photograph of dam, but also to be used if other field-signs are photographed. Also complete SNH photo spreadsheet.

APPENDIX K: RIPARIAN MAMMAL SURVEY FIELD SHEET

Section ID									
Section length (m)									
Location									
Date									
Surveyor									
Otter sightings	*count*								
Otter spraints	*count*								
Otter resting places	*count*								
Otter tracks / runs etc	✓ / ×								
Mink sightings	*count*								
Mink scats	*count*								
Mink tracks	✓ / ×								
Other mink evidence	✓ / ×								
Water vole sightings	*count*								
Water vole latrines	*count*								
Water vole burrows / feeding signs etc	✓ / ×								

Field sheets are to be filled out in the field. Completed sheets should be stored to allow verification of data where necessary.

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