Scottish Beaver Trial: Draft Field Tracking Methodologies.

SNH, SWT, and RZSS

(Partly based on protocols which are currently being developed by Oxford Wildlife Conservation Research Unit.)

24 April 2009

1. INTRODUCTION.

There is a need to track European beavers during the Scottish Beaver Trial for two main reasons:

- To provide information to support the management of the Trial (e.g. to track the location of animals in relation to the trial site boundary). This is being led by SWT and RZSS.
- To collate ecological information which will be used for the independent monitoring of the trial. This is being led by SNH.

SNH, RZSS and SWT have therefore been liaising over appropriate methodologies to employ during the Trial to ensure their individual requirements are coordinated. This has included the design of suitable protocols, the purchase of equipment and the collation and storage of data.

A range of independent monitoring projects will be being undertaken during the Trial, with the monitoring of the ecology of the beavers being one of the most important. SNH has therefore set up a partnership with the Wildlife Conservation Research Unit (WildCRU) at the University of Oxford to lead on this work. WildCRU have been developing a standardized protocol to support the beaver ecology study, including the field tracking methods to be used, and a final version of this protocol will be published by SNH in summer 2009.

The analysis and interpretation of the beaver ecological data will be coordinated independently by SNH in collaboration with WildCRU. However, the actual tracking of the beavers on the ground, and the collection of the data, will be undertaken by the Scottish Beaver Trial Field Officer and assistants, following the finalized WildCRU protocols published by SNH.

2. DRAFT FIELD METHODOLOGY PROTOCOLS

Field methodologies can be divided into five main types: Trapping, observations, radio-telemetry, GPS telemetry and field-sign surveys. Further details for each of these is provided below. It is anticipated that these methods will be refined further prior to the publication of the finalised protocols in summer 2009.

2.1 Trapping

Aims	To assess population and demographic parameters by marking animals and attach tags. In addition, the aim is to collect samples to assess animal health and welfare. Staff will need to deploy a number of capture methods as the nature of each trapping location will require a specific approach (e.g. ranging from various net types to cage traps).
Equipment	Depending on the suitability of the environment, two alternative techniques are proposed. Different equipment will be required for each technique, these being: motor boat + hand nets + spotlights + waders (live-trapping by boat) OR cage-traps (live-trapping using cage-traps). However, optimal techniques can depend on the environment and workers should consider alternative techniques if the methods (to be outlined in further detail in due course) are not successful. However, if exploring alternative techniques, workers should make sure that the safety and welfare of the animal is not unduly compromised. A detailed list of the equipment required will be provided in the final published protocols.
Techniques	Details on the methods for trapping and methods for handling and sampling will be made available in due course (please contact SNH if more information is required). Weight tables to allow strange animals to be assigned to an age-class will also be made available. All animals should be fitted with both ear-tags and PITs. Metal eartags can be modified by applying reflective tape of different colours.
Data quality and sample sizes	The aim would be to trap every animal at least once per year, ideally through spring-autumn, and more frequently if ear-tags and radio/PTT tags need to be replaced. Young animals (kits) should also be trapped, particularly because finding mortality rates between the kit and yearling age-classes would be useful in assessing 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 other animals 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 the beavers' 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 the case where box-traps are being used, we would recommend that 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.

Experienced workers should take <30min to process an animal.

If a radio/GPS tag is being attached, workers must ensure that any seals are watertight and that the tags have been switched on (either with a magnetic switch or through a computer connection). It is good-practice to ensure the tag is working using the receiver prior to releasing the animal.

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 do not create as many welfare issues. As such, in a capture-mark-recapture (CMR) study, observations of individuals can be treated as recaptures.
Equipment	Boat + Anchor OR Hide Spotlights and binoculars. Binoculars should be bright enough 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. 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 were workers will 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	Observations should be concentrated around the dispersal phase (spring) and the emergence of kits from lodges (mid July-August). There is no rigid requirement for sampling using observations, but we suggest that every known beaver colony should be observed as a minimum for one evening (until approx. midnight) during May and one evening during early August. In addition, observation can then be used in an ad hoc basis prior to the use of cage-traps.

2.3 Radio-Telemetry

Aims	To find out where and how animals move post-release and the dispersal movements of subadults is a crucial part of the monitoring programme. Furthermore, radio-telemetry should form a back-up to the GPS tracking system (see below) to ensure that enough 'fix' locations on the animals are obtained to allow their home-ranges and habitat use and the family territories to be ascertained.
Equipment	A detailed list of the equipment required will be provided in the final published protocols. Further details on the equipment to be used are provided in Annex A.
Techniques	Techniques are set-out in Annex B.
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 the 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 c.90 fixes over approximately 3 nights (Campbell *et al*. 2005; Schlichter 2008). In those studies, beavers frequently cycled their movement around the territory and thus it should be possible to reduce the number of fixes required but not the time period 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 should be compared between three-month periods and if there is evidence that home-ranges have stabilise, then it should be only 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 and therefore, sample sizes need to be checked to ensure that enough good quality fix locations are obtained. If families are adjacent and contain few tagged animals, then it could be possible to combine field-time by tracking two families in the same night.

2.4 GPS-Telemetry

Aims	The aim is to obtain high quality data on the locations of at least one of the dominant adult members of each family. This can be used to calculate habitat-use and home-range/territory of the animal and, assuming that families will stay together, will allow shifts in territories to be followed easily - even when such shifts take the animals away from the release site.
Equipment	A GPS tag that can upload data to users via satellite (known as PTT tags).
Techniques	Attachment techniques are laid out in the section of this report dealing with the trapping task. Additional information as to the best use of these devices should be provided by the manufacturer.
Data quality and sample sizes	Prior to use, a field test should be run, for example by placing PTT 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 GPS fixes concerns the immersion of the whole device in water. Water severely attenuates GPS 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.

2.5 Field-sign surveys

Aims	A lot of useful information can be gained from field-sign surveys. These data 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). Furthermore, field-sign surveys and general field observations should be considered an essential prerequisite to trapping to avoid missing animals due to a lack of local knowledge regarding locations of beaver families.
Equipment	- GPS - Notebook or field-sheet
Techniques	Workers should walk along loch and river banks and log on their GPS and notebook when they see the following: - lodges/burrows - dams - fresh feeding signs - feeding stations

	- scent-mounds - scent-marking sites For smaller burns, the worker need only walk one bank and note whether a logged GPS location is actually on the opposite bank. 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 the worker to come on-shore.
Data quality and sample sizes	Foot surveys need not be conducted frequently and could indeed be combined with other work such as the otter surveys. All 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.

ANNEX A

TELEMETRY (RADIO AND SATELLITE) DEPLOYMENT FOR RELEASED ANIMALS.

A. Hardware

RF radio tags

Simple RF radio tags have traditionally been used to track animals. Tracking a tagged animal generally involves a radio transmitter that pulses at 1 ping/second which is then picked up using a hand held radio receiver. All release animals will be fitted with an RF tag.

Model	Type	Battery	Mounted weight (g)	Pulse width (ms)	Pulse rate (ppm)	Peak Current (ma)	Antenna length 218MHz (cm)	Power Output dBm	Battery Life (days)
SOM-2380	Multivibrator 2 stage	1.5 v 350mah	9-11	20	45	2.5	12 whip	-25 to -30	294
LPM-3350	3 Stage	3.5 v 350 mah Li	17-26	20	30	9	15 Whip	-3 to -5	123

Table 1. Detailed Specifications – RF tags.

Argos PTT (Platform Terminal Transmitters)

Argos PTT tags are essentially sophisticated RF tags, but instead of using a hand held receiver to track down the tag, a low earth orbiting satellite picks up the signal and using Doppler analysis ascertain where the transmitter is radiating its signal from. For beavers, it is suggested that the PTT be fitted to a cattle ear tag and then fitted to the tail of the beaver. In Norway, the fitting of standard RF tags to beaver is commonly achieved in this manner. One recommendation is that as beavers have very strong jaws and teeth, the PTTs will be armour plated for the purposes of deployment on beavers. Four adult beavers will be fitted with Argos PTT at any one time during the first 2 years of the trial.

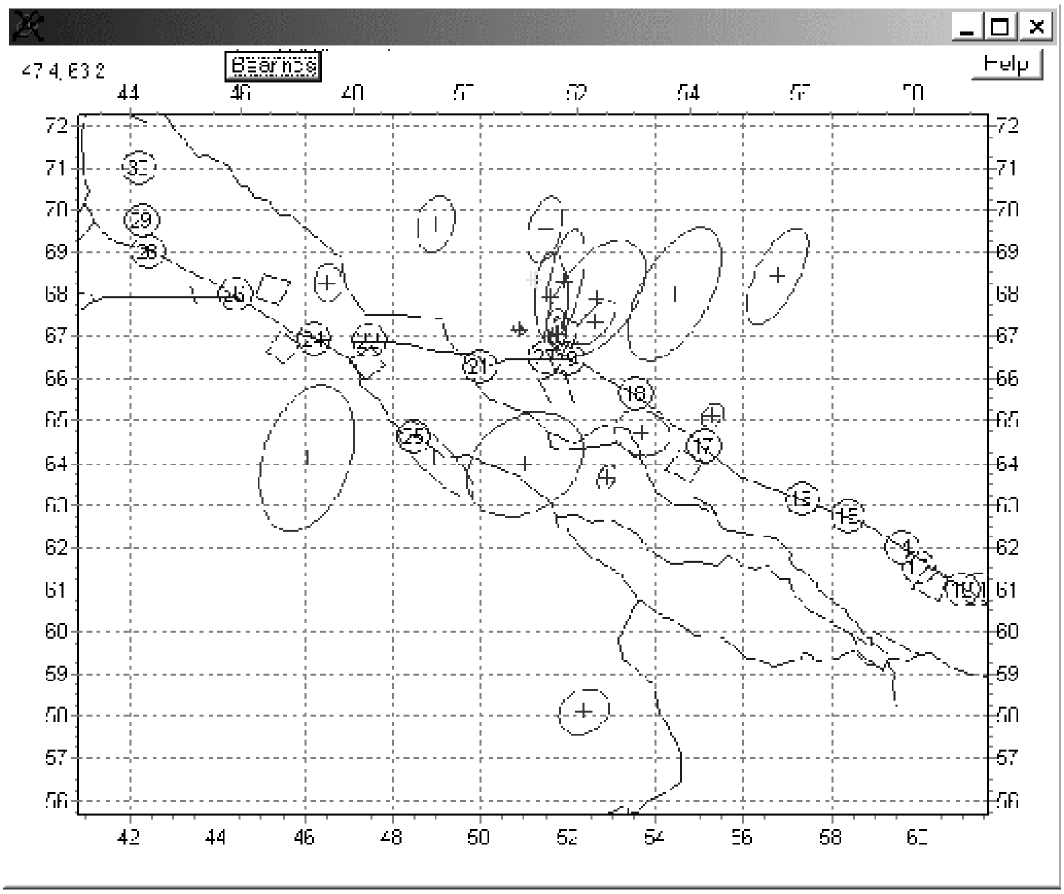
Detailed Specifications – 30g PTT:

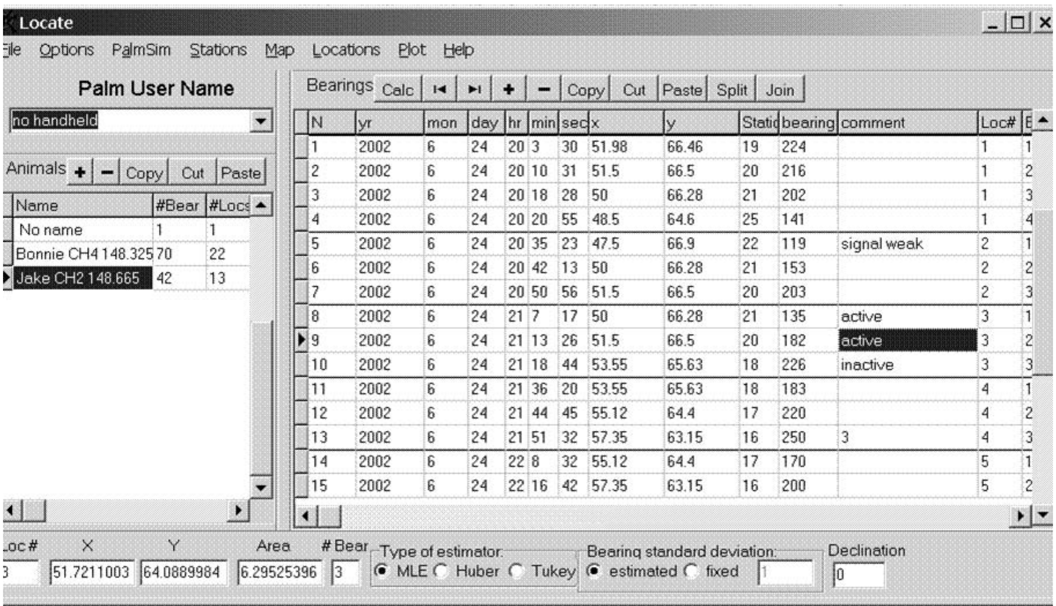
LENGTH:	64.25 mm
WIDTH:	22.86 mm
HEIGHT:	16 mm
WEIGHT:	30-32 grams
ANTENNA LENGTH:	23 cm

POWER SOURCE:	Lithium Cell
OUTPUT POWER:	160-175 mW (adjustable)
TRANSMISSION FREQUENCY:	401.650 MHz +/- 2 kHz
TRANSMIT CYCLE:	61 second repetition rate (adjustable)
OPERATIONAL LIFE:	1,100* hours continuous; less in high temps.
OPERATING TEMPERATURE RANGE:	-20 TO 50 Degrees Celsius
SENSOR DATA:	4 bytes
SENSORS:	Battery voltage, Duty Cycle Season, Activity, Temp.
DUTY CYCLES:	Programmable, up to 8 different “seasons” possible

B. Software

The Locate III Radio-telemetry triangulation program will be used to compile datasets from the fixes taken on animals throughout the trial.





Name	#Bear	#Locs
No name	1	1
Bonnie CH4 148.325	70	22
Jake CH2 148.665	42	13

N	yr	mon	day	hr	min	sec	x	y	Statio	bearing	comment	Loc#	B
1	2002	6	24	20	3	30	51.98	66.46	19	224		1	1
2	2002	6	24	20	10	31	51.5	66.5	20	216		1	2
3	2002	6	24	20	18	28	50	66.28	21	202		1	3
4	2002	6	24	20	20	55	48.5	64.6	25	141		1	4
5	2002	6	24	20	35	23	47.5	66.9	22	119	signal weak	2	1
6	2002	6	24	20	42	13	50	66.28	21	153		2	2
7	2002	6	24	20	50	56	51.5	66.5	20	203		2	3
8	2002	6	24	21	7	17	50	66.28	21	135	active	3	1
9	2002	6	24	21	13	26	51.5	66.5	20	182	active	3	2
10	2002	6	24	21	18	44	53.55	65.63	18	226	inactive	3	3
11	2002	6	24	21	36	20	53.55	65.63	18	183		4	1
12	2002	6	24	21	44	45	55.12	64.4	17	220		4	2
13	2002	6	24	21	51	32	57.35	63.15	16	250	3	4	3
14	2002	6	24	22	8	32	55.12	64.4	17	170		5	1
15	2002	6	24	22	16	42	57.35	63.15	16	200		5	2

ANNEX B

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 3-element Yagi antenna, see fig 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 the 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 attenuate (weaken) the signal, reducing the range and therefore making signal direction more difficult to estimate. The fewer obstructions the better the signal, therefore it is often a good idea to get above the area that the animal is in, e.g. 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, but this pheunomenon also results in interference around tree-trunks thus making it difficult to obtain accurate bearings in woodland. Furthermore, if there is an abrupt woodland boundary, this effect will continue for up to around 50m 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 the receiver. The Yagi antenna has pairs of elements (3 pairs for a 3-element model) that project out from its boom (central shaft) along a single plane (fig 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

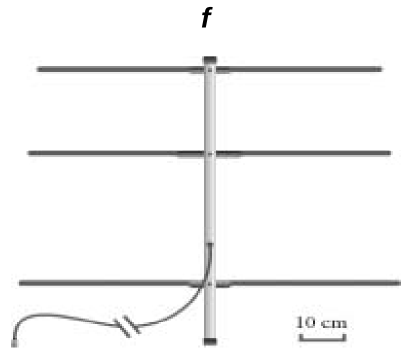


Fig 1. An example of a 3-element Yagi antenna. The front (the end at which it is most sensitive to a signal) is indicated with '*f*'.

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 affected 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.

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 lodge/burrow that they regularly use.

Following a signal to within 10-20m of the tagged animal's precise 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 the tracker believes 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 minimum and the attenuator switch (if the receiver has one) turned 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 come with a built-in cable, then alternatively 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 the tracker is moving too far away because the signal will be lost.

Night-time radio-tracking

The basic aim during night-time radio-tracking 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 (fig 2.). It

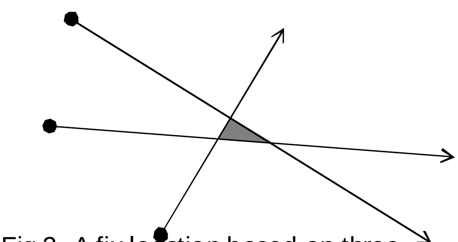


Fig 2. A fix location based on three bearings. The animal is probably somewhere in the grey polygon formed by the crossed bearings (though this is not necessarily the case). The error value would be the area of the polygon.

would be possible to acquire a fix with just two bearings, but this would not allow the calculation of the error and therefore there would be no way of telling whether the fix location had any basis in reality. Calculating fixes based on a 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 than the simple error polygon in fig 2.

Along with 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° (fig 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. This can be done roughly by 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 to implement but can be extremely useful by also providing regular updates as to the accuracy of different trackers and enabling trackers to be corrected or the location of trackers to be changed if a problem arises.

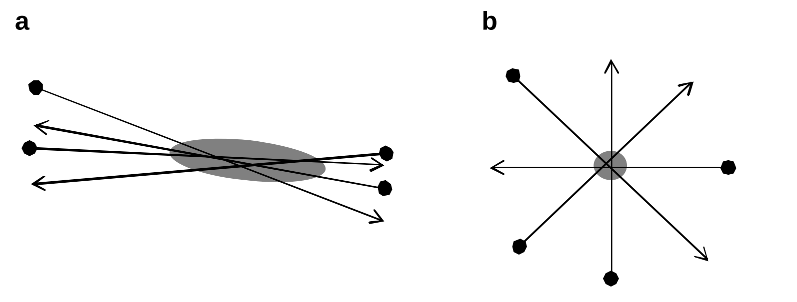


Fig 3. Two series of bearings (lines) showing error around fix location (grey shading). Poor quality fix locations can result if all bearings are taken along a similar axis (a), whereas the best fixes will be obtained by ensuring that bearings are obtained from an even spread of tracking points (b).

Detailed setup and protocols

In order to obtain the best quality fix locations and 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' (above). For example, open ground further than 50m from woodland, and not near 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 (identification) 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 (see fig 3b).

One tracking night should either consist of one session of tracking over the entire night (e.g. from approximately 8pm to 6am) or two sessions running over separate nights with one covering one half and the other covering the remaining half of the night (e.g. 8pm-1am then 1am-6pm or 1am-6pm and then 8pm-1am). 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 (based on 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, you can only just hear the pulses.*
2. *Sweep the antenna slowly to the side until the signal disappears, and then sweep back until you 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 method that is quick involves attaching a compass to the shaft of the antenna, ensuring that it is precisely aligned, and using that compass to read the bearing. 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 cycle through all currently active tags in the release area (even if the animal is usually in a different location) and based on who is available, 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 changing location 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 which will result in approximately 10 fixes / night for each animal. For each bearing, trackers should note down in a datasheet 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 typical two scenarios:

1. Tracking station 1 (TS1): 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 >four with tags in range.
5. Once each hour, radio tracking partner to update location statuses.

What to do if no signal can be found

If no signal can be detected on 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 scenarios:

1. The receiver/antenna is not working properly. This should be easy to confirm by checking for other tags within range. Common cause 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 setting if a 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 spotting 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.

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/*

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