Technical manual for monitoring foxes in the Arctic

Version 1

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The first version of this manual has been written and published in 2019.

WARNING: Applying the techniques described in this manual cannot guarantee the welfare of captured animals under all circumstances and thus they should not be used by untrained personnel. Obtaining a permit by relevant authorities is mandatory to conduct field research. Approval by an institutional animal welfare committee is also required in most situations before trapping animals for research purposes.

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1. INTRODUCTION

The arctic fox (*Vulpes lagopus*, syn. *Alopex lagopus*) is endemic to the Arctic and the only mammalian predator that is exclusive to the tundra. It is the most widespread mammal species in the Arctic, where it has a circumpolar distribution and inhabits tundra zones of North America and Eurasia, some alpine zones of Fennoscandia and most Arctic islands. Extremely mobile, it can be found wandering far beyond its terrestrial Arctic breeding grounds, on sea ice up to the North Pole and sometimes far south into the boreal forest. Due to its relatively small size (3-5 kg), the arctic fox may be limited or regulated by larger predators. In particular, the red fox (*Vulpes vulpes*) probably sets the southern range limit of the arctic fox through interspecific competition. The red fox is a relatively newcomer in the Arctic. The species expanded over thousands of kilometers of Arctic tundra during the 20th century and its spectacular expansion sparked concerns over the consequences of a new predator colonizing Arctic ecosystems.

Arctic and red foxes are easy to distinguish as the red fox is larger (> 5 kg) and has proportionally longer ears and tail, and a pointier nose. Four color phenotypes in the arctic fox and seven in the red fox are recognized (Adalsteinsson *et al.* 1987). The majority of arctic foxes occurs in one of two distinct color morphs: white (most individuals) and blue. The respective proportion of the two morphs varies geographically. In summer, the white morph turns brown-grey and yellowish-white while the blue morph remains dark charcoal all year round, but becomes lighter in winter. Red foxes are usually reddish-brown to yellow (red morph), but sometimes mostly black (silver morph) or a combination of both (cross morph). Figure 1 illustrates the most common pelage variations in both species.

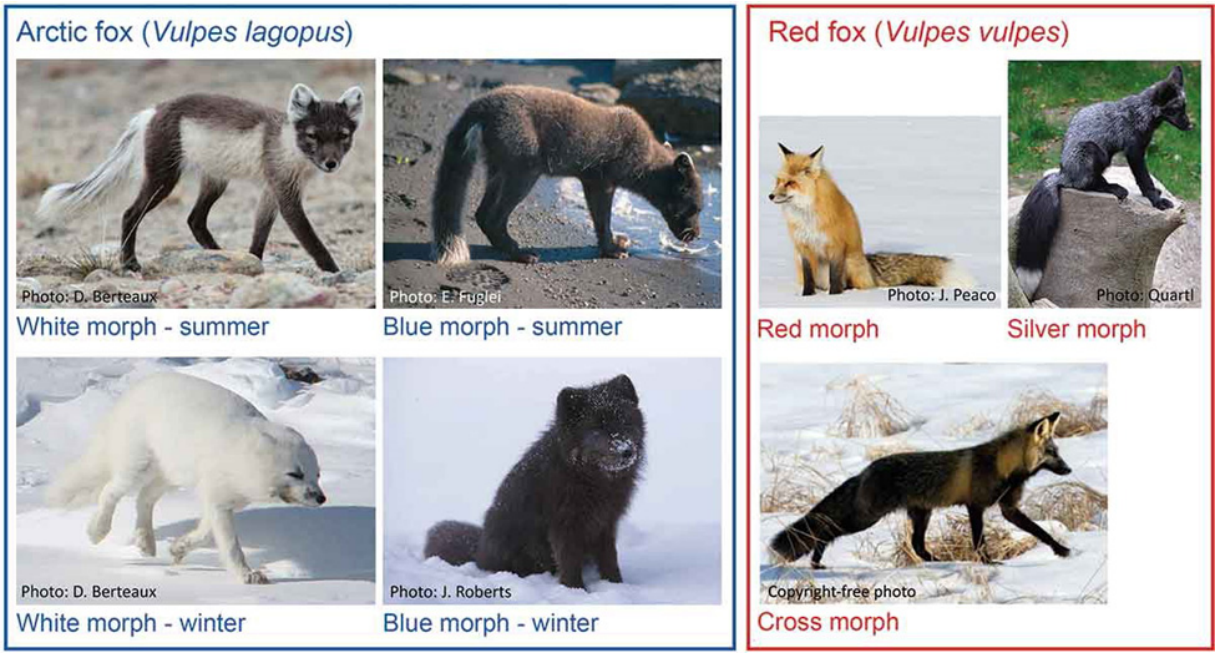

Figure 1. Most common color morphs of the arctic and red fox (from Berteaux *et al.* 2017a).

Long-term monitoring programs are necessary to track biodiversity changes and understand the ecological dynamics of the Arctic. Predators play a fundamental role in ecosystem functioning. Since population trends in predators often reflect changes in the ecosystem, monitoring programs should always include upper trophic level predators.

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An arctic fox in winter coat.

The Conservation of Arctic Flora and Fauna (CAFF), the biodiversity working group of the Arctic Council, has recognized the arctic fox as one of the ecological indicators in the Arctic region and therefore, identified it as a target species for future monitoring (Christensen *et al*. 2013). The choice of the arctic fox was supported by several criteria: a generalist feeding regime both potentially impacting and reflecting the state of the tundra ecosystem, a circumpolar distribution and reliance on Arctic ecosystems, its status as an endangered species in parts of its range, its flagship status for measuring climate change, its economic, scientific and cultural importance, the availability of historical data on the species and the existence of national monitoring programmes already in place (Berteaux et al. 2017b).

The relatively recent range expansion of the red fox can have important consequences on the arctic fox, including population decline, extirpation and range contraction. Understanding the consequences of the arrival of a larger predator in Arctic ecosystems and changes in species interactions also require a tight monitoring.

We define arctic and red fox monitoring as the process of gathering information about some variables describing an arctic and red fox population and its ecological context, at different points in time, to assess the status of the populations and draw inferences about their changes over time (adapted from Yoccoz *et al.* 2001).

In this document, we present several methods that can be used to monitor both fox species, with a focus on breeding activities.

Each method has its own advantages and disadvantages. We thus highlight in the text the pros and cons of each of them. The methods that can be used in the field often depend on limitations imposed by financial or time constraints.

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Arctic fox cubs at a den.

2. MONITORING OF DENS

Foxes are strongly dependent on dens for parturition and rearing of cubs. An effective way to monitor both arctic and red fox populations is to take advantage of their use of den sites for reproduction. Fox dens are usually easily recognisable, but separating species reliably is not possible from den characteristics only. With a good knowledge of every available denning site in a study area, an annual visit of each den at the time of reproduction becomes an effective and rapid method for evaluating the total number of reproductive adults, the number of litters produced and the approximate number of cubs emerging from each den.

2.1. BRIEF DESCRIPTION OF DENS

Arctic fox

Due to the shallow permafrost-free layer in most of the arctic fox's range, new dens are rarely dug and existing ones are often used repeatedly year after year. They can therefore become impressive structures covering more than 500 m². With the accumulation of organic matter from faeces and prey remains, den sites may become covered with lush green vegetation, contrasting with the barren tundra landscape (Gharajehdaghipour *et al.* 2016). Dens are usually situated on mounds, ridges, slopes or river banks, preferably on south facing and early thawed areas, where the soil is well drained and the active layer over permafrost is deeper (Szor *et al.* 2008). Dens can also be found under large rocks and boulders.

The openings of arctic fox dens are round or slightly oval, measuring 15-20 cm in diameter. The number of entrances (holes) may vary between one to more than a hundred in a single den. Cubs and adults gradually dig new openings and dens are progressively excavated deeper and deeper as the permafrost layer drops due to increased ventilation and better soil drainage (Tannerfeldt *et al.* 2003). Where habitat is favourable, complexes of multiple dens separated by only a few meters can sometimes be observed. Arctic fox dens can be used by other species such as the red fox or the arctic hare.

Examples of arctic fox dens.

Red fox

Red foxes may dig their own den, which are small and rarely used more than once, or use those abandoned by other species such as ground squirrels, hares or other foxes. Most dens are found in sandy soil and have several entrances up to 40 cm high. In arctic regions where permafrost is present, red foxes often reproduce in already existent arctic fox dens. Therefore, differentiation of arctic and red fox dens usually requires the observation of an individual at the den. More sophisticated techniques, such as DNA probing of fresh faeces, can also be used.

2.2. FINDING DENS

2.2.1. Ideal procedure: systematic search of the study area by foot

A systematic scan of the entire study area minimizes chances of missing dens. It ensures an optimal monitoring of the species.

- Den search should be conducted by foot, following parallel transects 600 meters apart, and scanning for potential den sites, using binoculars, up to 300 meters on each side of this transect. When the topography is relatively flat, it is fairly easy to spot a den inside this 300 meters range. However, when the topography is rough, observers need to quit the transect line more often to visit potential den sites hidden by topography. A particular attention should be given to river and stream banks, which are highly used by foxes but easily overlooked. Each time a potential den site is spotted, the observer should walk up to that site and verify the presence or absence of a den.
- When a den is found, its position should be recorded using a GPS, and a pair of wood battens can be installed on the den to spot it more easily during future visits.
- We recommend using a 1:50 000 map of the area to gradually record the area surveyed. One person alone can cover an area of approximately 5-8 km² per day when surveying for dens on foot, depending on the topography.

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A pair of painted wood battens marking a den.

2.2.2. Quicker procedure: systematic search of the study area by snowmobile or helicopter

Snowmobile: When a systematic search by foot is impossible, an alternative is to conduct the census by snowmobile in spring. Den search using a snowmobile can be a very efficient method to cover rapidly a large area when there is still a small cover of snow on the ground. Fox dens are usually located on sites with early snowmelt in spring and can therefore be relatively easily spotted among the snow-covered tundra. However, this technique may miss some smaller dens still covered by snow. When using a snowmobile, avoid getting too close to dens as this could

prompt foxes to abandon their den. One person alone can cover an area of approximately 12-25 km² by snowmobile, depending on the topography.

Helicopter: Many dens are missed when search is performed by helicopter. However, the most conspicuous dens can be spotted because of the lush vegetation that grows on the most intensely occupied dens. Therefore, this approach can be adequate if one only aims at identifying a sample of dens in a study area.

2.2.3. Time period

Den search can be carried out at any time during or after snowmelt, but preferably in July and August to maximize the chances of finding them. At this period, dens can be easier to spot due to the lush vegetation present on them. But not all dens possess this characteristic.

2.2.4. Material required

- Binoculars
- Datasheets (or field book) and pencil
- Geographic Positioning System (GPS) receiver
- Map of the area (1:50 000 recommended)
- Wood battens and marker pen to identify dens (if this is allowed in your study area)

2.3. ANNUAL DEN MONITORING

With a good knowledge of every available denning site in a study area, an annual visit of each den at the time of reproduction becomes an effective and rapid method for monitoring the abundance and reproductive success of both fox species. Adequate den monitoring in a given study area provides information on the total number of reproductive adults, the number of litters produced, and the approximate number of cubs emerging from each natal den. A good estimate of the status and trend of each fox species can then be obtained from this information.

2.3.1. Description of the method

The visit of every den is essential to have an adequate monitoring of fox species. Den monitoring should be conducted in the smallest period of time allowing for the visit of every den. This will avoid counting the same individuals twice due, for example, to relocation of a litter during the rearing period.

- Each den of the study area should be consecutively visited and inspected for signs of occupancy by foxes. Before approaching a den, verify from a distance the presence of foxes at the den using your binoculars or spotting scope .
- If foxes are present, identify the species and the minimum number of cubs in the litter. Note the date, time and duration of the observation period.
- If no fox is observed, walk up to the den and observe signs of utilisation. Strong fox odor in the openings, extensive trampling of vegetation, freshly excavated openings, high

abundance of scats (juvenile scats can be differentiated from adult scats by their small size) and fresh prey remains are usually characteristic of a den used for reproduction. Furthermore, arctic fox cubs will often bark from inside the den when approached by a human. If a den seems to be active, try to confirm its status by observing it for an hour from a location at least 500 meters away. Note the date, time and duration of the observation period. Duration is important because it is usually positively correlated with the number of cubs observed.

- Fresh faeces found on dens may be collected to detect various parasites (see Elmore *et al.* 2013). Always use latex or nitrile gloves to handle fox faeces.

Continuous observation during several hours is required to get an accurate estimate of the number of cubs at an active den. Since every den should be visited in the shortest possible period, we recommend doing a first visit of every den and subsequently coming back and establishing temporary campsites at some of the active dens to estimate accurately the litter size (see Section 4. Determining litter size). It is useful to identify a potential campsite at each active den during the first visit to minimize the disturbance when returning to establish the camp. Try to find a campsite at least 500 meters away from the den, but with a good view on it.

2.3.2. Time period

Visit of dens should be conducted during the cub rearing season, especially during the period when cubs are visible outside the den. For arctic foxes, this corresponds to end of June to beginning of August. For red foxes, this period largely depends on the latitude of the site, and varies between March and July. At high latitudes such as on Bylot Island (73°N), cubs appear on the den between early June and mid July. We recommend doing the den survey at the beginning of July (around July 5th) to maximize the chances of observing the majority of litters from both species. A preliminary survey may be conducted in May, during the snow period, to determine which dens are active (tracks and digging are easier to spot on the snow).

2.3.3. Material required

• Datasheets (or field book) and pencil

• Binoculars or spotting scope

• Map of the area indicating location of every den

• GPS receiver with geographical coordinates of dens

• Optional: latex gloves and paper or plastic bags for fecal samples

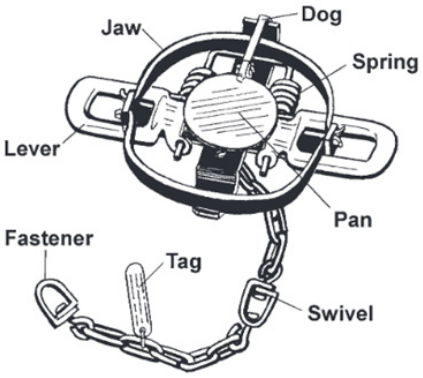
3. MONITORING OF INDIVIDUALS

3.1. TRAPPING FOXES

3.1.1. Description of trap types

A. Padded leghold traps

Steel leghold (or foothold) traps with rubber-padded jaws are used to live capture adult individuals. Victor® Soft-Catch foot traps #1 can be used for both adult arctic and red foxes. Victor® #1.5 may be used for red foxes. As their name indicates, foothold/leghold traps are designed to catch an animal by its foot. Traps are buried in the ground and when an animal steps on the pan, it releases the dog from a notch, allowing the jaws to spring shut, holding firmly the animal's foot until it is freed by the trapper.



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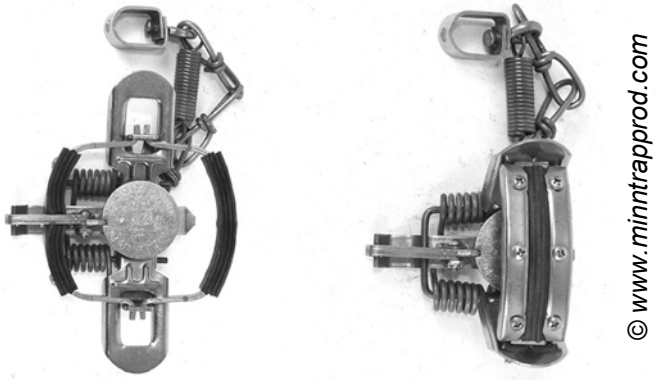
Parts of a regular (unpadded) leghold trap.



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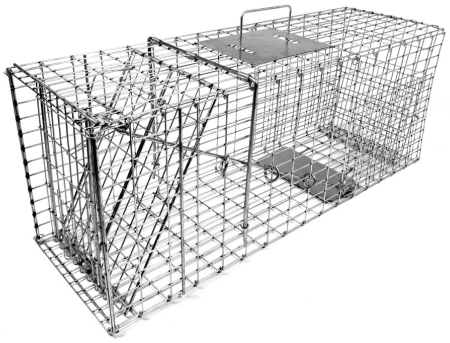
Victor® Soft-Catch foot traps #1
(armed on the left and closed on the right).

PROS	*CONS*
• **Highly effective when used correctly**	• **Some level of training and experience is required**
• **Flexibility of placement and setting type**	• **Risk of injury to animal if not set correctly**
	• **Labor intensive (~ 20-30 min to set one trap)**
	• **Capture of non-target species can occur**
	• **Require regular maintenance**

B. Collapsible cages

Collapsible cage traps, such as Tomahawk Live Traps®, are also commonly used for live trapping. Tomahawk Live Traps® Model 207.5 (~91.5 × 30.5 × 30.5 cm) can be used for adults, while smaller cages such as Model 205 (~66 × 23 × 23 cm) can be used for cubs (cubs will also enter larger cages). The door of collapsible traps is triggered when the animal goes far enough inside the trap and steps on the latch that holds the door open.



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Tomahawk Live Traps®.

PROS	CONS
• Fast and easy to set • Low risk of physical injury to animal • Highly effective for cubs	• Considerably less effective than leghold traps (for adults) • Relatively heavy and hard to transport

3.1.2. Description of the trapping method

A. Field procedures for padded leghold traps

One very important comment: **no manual, including this one, can better teach you how to trap than an experienced trapper showing you in the field.**

- **Choosing a spot**

A good knowledge of the landscape and the habits of the foxes will increase trapping efficiency. Upon arriving in a new area, observing foxes using binoculars or a scope for a few hours to learn about their behavior and movements may help finding good spots to set leghold traps. One very efficient capture technique is to set a trap near a spot where a fox has been caching food, right after the fox leaves the place. Very often, the animal will come back a few hours later to retrieve the item (and will likely find the trap). If foxes are nowhere in sight, prominent points, such as bumps and mounds, or trails leading to a den are usually good sites. At a prominent point, put the trap at the bottom of the mound (not near the top !) to ensure that, if trapped, the fox will be able to lay down safely on flat ground.

* CAUTION! – Locations to avoid

Avoid setting a trap near a snowy owl's nest (within 600 meters), or even a snow goose nest (within 30 meters). Angry birds may continuously harass a trapped fox.

Large rocks are usually attractive places for foxes. However, sufficient space must be left between the rock and the trap to avoid injuries. A trapped fox trying to escape should never be able to touch the rock, or it may hurt itself upon it.

Make sure a trapped fox will not have access to a water body, or it could get wet and suffer from hypothermia.

Extra care should be taken when trapping near dens with cubs. Depending on the topography, a safety distance of 500-600 m should be kept around breeding dens after cub emergence to avoid catching a cub. When cubs reach 1 kg, their feet are able to withstand a leghold trap, but this method of capture should be avoided.

- **Setting a leghold trap**

We briefly explain how to set and bed a padded leghold trap but we highly recommend reading regular trapping manuals, such as Pete and Ron Leggett's Fox Trapping Methods or Russ Carman's Professional Fox Trapping Methods, for additional tips. Note however that these books are written with the intent to kill the animals. When live trapping, we highly emphasise on the importance of ensuring the animal's safety.

1. To minimize the transfer of human scent, wear gardening rubber gloves and lay a small tarpaulin on the floor if you need to put your knees down.

2. Dig a hole slightly larger than the size of the trap and deep enough to hold the chain trap and anchoring system. Keep the soil in your sifter.

3. Anchor the trap securely in the hole. Different types of soil (permafrost, ground, sand…) hold stakes differently and this should be taken into consideration (see our next tips below). Test if the trap is anchored properly by holding the base of the chain (not the leghold !) and pulling in all directions.

4. Arm the trap and place the trap chain in the trap bed. Cover the trap chain with soil and pack it with your hands.

5. Place the trap in the trap bed. Contrary to what is sometimes recommended in regular trapping manuals, the jaws of the leghold trap must be **perpendicular to the fox's expected walking direction** (white arrow in picture 5). This way, its front paw will

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be enclosed right between the rubber-padded jaws, and not where the rubber is absent.

Press the trap firmly in the soil and pack soil under the trap parts until nothing moves. Traps should be set very slightly below level of the soil around it. Be careful not to let anything go under the pan, or the mechanism will not work. You can check the stability of the trap by pressing lightly on each jaw and each spring lever (four-point system check). If the trap feels unsteady at any point, pack more soil under that part and repeat the four-point system check.

6. Put a mesh cover on the pan and sift soil over the whole set to hide it.

7. Spread and arrange evenly the sifted soil. It should be nearly level with the surrounding area. Make sure no objects above the jaws (small branches or rocks) might keep the jaws from closing properly.

8. Record the position of your trap with a GPS.

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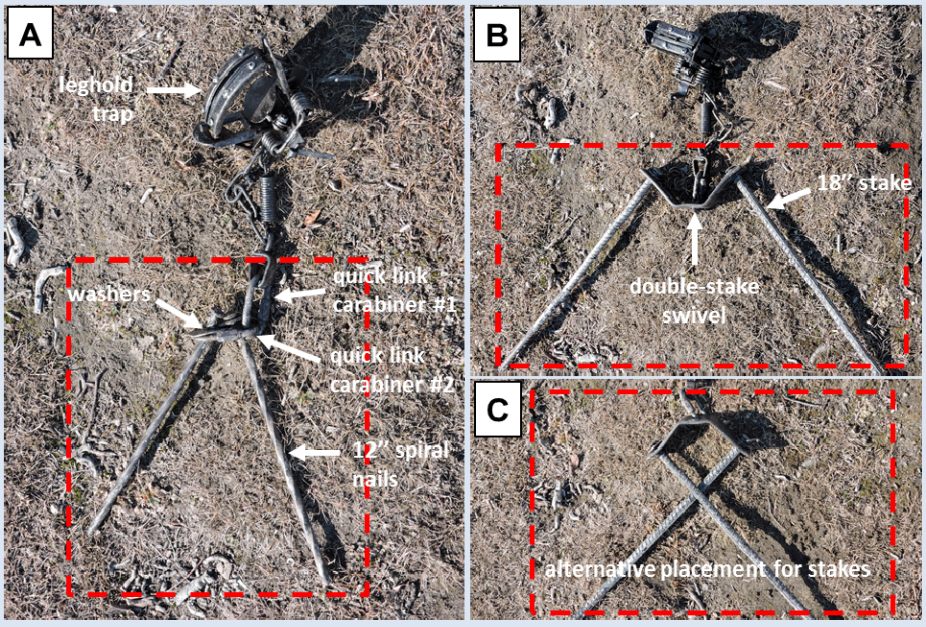
* TIPS! – Anchoring systems

In solid permafrost, 12-inches spiral nails (with flat washers on top) can be driven into the ground through quick link carabiners to anchor the trap (**A**). Spiral nails will enter and come out of permafrost more easily, but always use two quick link carabiners and drive at least two nails in the second carabiner for security. When the upper layer of the permafrost is soft, the most secure anchoring system is a double-stake swivel with two 12-inches or 18-inches steel stakes (**B**). The regular way to anchor a double-stake swivel is shown in (**C**) but the version shown in B is easier to carry out when digging in frozen grounds.



- **Types of settings**

A good set must achieve two goals. First, it must attract a fox to the trapping site from a distance. This is done using olfactory or visual lures. Second, it must attract the fox to the trap itself so that the fox puts one of its front paws on the trap pan. This is achieved using a bait.

<u>Dirt hole set</u>

The dirt hole set is a common setting for foxes. To ensure a safe capture, it is very important to make sure that the fox will be coming from the right direction.

1. Choose a place where grass or natural ground features (small bumps) can provide a backing for your setting. At an angle, dig a small hole (about the size of a lemming hole) that slants back about 15 cm deep under the backing.

2. Dig a bed in front of the dirt hole for the leghold trap.

3. Anchor the trap, arm it and arrange it in the bed, as described in the previous section. The dog of the trap should be pointing **towards** the dirt hole. The center of the trap should be placed about 12 cm from the hole, but **very slightly shifted towards the right or left**. Visualize where a fox would need to place its right or left paw if it had its head extended and muzzle in front of the hole.

4. Put a mesh cover on the pan and sift some of the soil on top.

5. When given the choice, foxes will prefer not to walk on an uneven surface and will step over obstacles on the ground. To take advantage of this behavior, larger bits of soil can be arranged right next to the levers and the jaw that is furthest from the hole (to mimic soil that has been dug out by an animal). Elevating very slightly both sides of the trap with soil or vegetation will usually make the fox go check the hole from the front. Some leaves, grass or even small sticks can be placed strategically to guide the fox's paw towards the pan (where the soil is clean and even). As always, make sure these items will not block the jaws when they close.

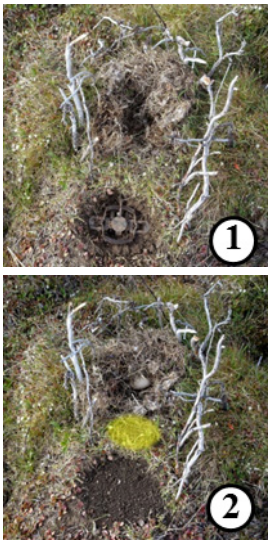
6. Place a small amount of bait or an eggshell in the dirt hole. If using an egg, partly cover it with some dirt to prevent birds of prey from seeing it. Scent lures can be applied on a stick or a long feather placed above the hole. Make sure no bait or lure gets on the trap bed, or worst, on the trap. A wood batten sprayed with a bright color (red or orange) may also be placed on top of the mound to attract the attention of foxes from a distance. Arctic foxes are very curious and will usually check new things placed in their environment.

Artificial nest set

Artificial nests are very efficient settings and will especially work with foxes used to hunting in goose colonies. To make an artificial nest, you will need one or two empty eggshells (from white chicken eggs), or abandoned goose eggs. You will also need as many dry twigs (about 20 cm long) as you can find in the tundra.

1. Arrange the artificial nest in front of a buried leghold trap. Plant twigs vertically around the "nest" to force the fox to access the nest from the area where the trap is set. Intertwine the twigs to prevent the fox from reaching the egg with its paw. Foxes will usually go around the twigs to find the entrance.

2. Within the twigs, the eggshell can be kept in place using dry grass or feathers (down from an old nest). The nest does not have to look like a real nest. Eggs (even empty) act as a very attractive visual lure for foxes. It is not necessary to use scent lures with artificial nests.



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Leave a small space between the buried trap and the nest (yellow area).

Birds, such a jaegers or ravens, are also very attracted to artificial nest settings. To avoid catching a bird, partly cover the egg with some light vegetation or down, or try bending twigs over the egg to make it less conspicuous from the sky. A bird will also land very near or directly on the nest, so leaving a small space between the buried trap and the nest will let a bird land without getting caught in the trap.

- **Checking leghold traps**

Leghold traps must be checked at least **every 6 hours**. Leghold traps must not be checked from afar with binoculars or a scope; the observer must walk all the way to each trap to check it. If not moving, a trapped fox may not be easy to spot from a distance. In addition, misfires may have occurred and traps have to be re-set in that case (bring rubber or nitrile gloves with you when you check a trap line). If a fox is trapped, call your partner and finish checking the whole trapline before handling the animal (there might be another fox caught in another trap).

* Tips! – Scent lures and baits

Many commercial scent lures and baits exist for foxes. They are usually made to attract red foxes but will work with arctic foxes as well. Using a good variety and varying the combination of scent and bait will prevent the animals from associating them with a trapping experience. On Bylot Island, we use Forget's lures (*Cachottier, Indispensable, Extreme #01, XLDC*...) and Loys' lures (*Carnifort, Fox, Fish oil*...). For baits, we use abandoned eggs, empty chicken eggs (white eggshells work best), dead lemmings, sardines in oil, or commercial baits such as Hawbaker's *Fox and coyote bait* and Loys' *Champion*.

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Various scent lures.

Traps must be closed immediately if it starts to snow or rain. Cover closed traps with soil, or they may get peed on by foxes. Alternatively, if available in your study area, a large flat rock can be placed very carefully on the open jaws of the leghold, without touching the pan, to cover the whole set (cover the dirt hole and bait with a smaller rock or vegetation as well). This will make re-activating the trapline a lot faster, but make sure the rocks are heavy enough to prevent a fox from moving them.

- **Time period**

Trapping with leghold traps can start around snowmelt, when some ground appears. Avoid using leghold traps if temperatures are still significantly dropping at night, as a trapped fox will not be able to shelter itself correctly, and manipulating a fox in very cold conditions is not recommended. The soil may also freeze and block the leghold mechanism (although soil coated with paraffin wax may be used to prevent this).

- **Materiel required**

• Datasheets (or field book) and pencil
• Gardening rubber gloves
• GPS receiver
• Double-stake swivels
• Hammer, trowel and nail bar
• Flat washers
• Leghold traps
• Logwood trap dye and paraffin wax
• Mesh covers
• Quick link carabiners
• Spiral nails (8- or 12-inches)
• Steel stakes (12- or 18-inches)
• Sifter
• Tarpaulin
• Scent lures and baits

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Use a flat heavy rock to cover a leghold a trap without triggering it.

* TIPS! – Pre-treating the trapping material

To conceal human scent, leghold traps, stakes, quick link carabiners, washers and tools (trowel, hammer, nail bar) must be pre-treated with logwood trap dye and paraffin wax. The process of dyeing and waxing traps can be found on trapping sites.

Once dry, keep everything in large and sturdy plastic bags at all times. To prevent the transfer of human scent on traps, keep the trapping material in a designated bag and always wear rubber gloves that are only used for that purpose while handling the pre-treated material and setting traps.

Never touch traps and lure bottles with the same gloves !

Logwood trap dye.

B. Field procedures for Tomahawk cages

- **Choosing a spot**

Collapsible cages are much easier to deploy than leghold traps, but generally perform well only when placed directly on dens.

- **Setting and baiting cages**

If possible, bring the cages (3 to 5) at the den when foxes are less active (usually, the middle of the day).

1. Set up the cages at a distance from the den before bringing them on it.

2. Place every cage on a flat surface on the den, making sure that it will not topple down a slope even if it falls over.

3. Cover the bottom of the cage with vegetation (this is not necessary for cubs).

4. Place a small amount of bait at the back of the cage, behind the latch. For cubs, cat food or sardines can be used. Add a trail of small bits of bait starting from the entrance and leading to the back of the cage. A visual attractor (shiny piece of foil) may also be attached at the back of the cage to attract curious cubs.

© Elisabeth Tremblay

Flag tape attached to the door will allow to easily see if a cage is opened (cage in the front) or closed (cages in the back).

© Jeanne Clermont

When trapping adult foxes, lining the bottom of the cage with dirt and vegetation makes cages appear less suspicious.

- **Checking cages**

Cage traps can be checked with a spotting scope. If trapping cubs, cages must be under continuous surveillance (checked at least every 15 min). Attach a few pieces of brightly-colored flag tape (pink or orange) at the bottom of the swing door to easily spot if the cage is opened or closed from afar. If trapping adults, cages can be checked every 6 hours.

Same as with leghold traps, cages must be closed immediately if it starts to snow or rain.

- **Time period**

Cages can be used at any time. From our experience, trapping adults with cages mostly works on dens and when snow is still covering the ground. They are less effective during the rest of the summer. Cages work very well for cubs, especially when they are very young (1-2 weeks after emergence).

- **Material required**

• Datasheets (or field book) and pencil

• Bait (eggshells, cat food, sardines)

• Cages

• Flag tape

• Spotting scope

3.2. MANIPULATING FOXES

3.2.1. Handling a trapped fox

How to transfer a fox into a capture bag differs depending on the trap type (leghold or cage). In any case, always wear latex or nitrile gloves paired with resistant work gloves, such as Kevlar® red gloves, to protect you from bites. Before releasing an animal from a trap, have your capture material ready nearby (~100 m away). Two people are required to handle a fox.

A. Handling procedure for a leghold trap

If a fox is trapped in a leghold trap, you will need an animal restraining pole and a capture bag.

- One person uses the restraining pole to contain the fox by quickly maneuvering the pole's cable around the animal's neck, tightening the cable and gently but firmly pinning the animal on the ground. If the animal is very aggressive, it can be anesthetized now (see section 3.2.4. Anesthetizing a fox).
- Once the fox is restrained by the pole, a second person can grab firmly the fox by the nape of its neck with one hand and around its muzzle with the other hand. **This is the safest method for both the handler and the animal.** If the animal seems stressed out, place the capture bag over its head before trying to handle it.
- Once the animal is securely restrained, the person holding the pole releases the pole's cable, then releases the fox's leg from the leghold trap and holds open the capture bag.

© Aude Lalis

Using an animal restraining pole.

- The person holding the fox lifts the animal (with the loose cable still around its neck) and puts it in the capture bag. Once the fox is in the bag, close the opening, slowly remove the cable and tie the capture bag.

B. Handling procedure for a cage

If a fox is trapped in a cage, you will only need a capture bag.

- One person puts the capture bag tightly around the opening of the (closed) cage and, through the fabric of the capture bag, opens the door with one hand (the door will open inside the bag).
- The other person lifts gently the cage. The fox should be moving towards the bag by itself. If it does not, blowing on it will usually make it move forward. Once the fox is inside the bag, close and tie the bag.

3.2.2. Manipulating a fox

For each capture, you should:

- Weigh the bag with the animal inside using a pesola scale.
- Securely remove the animal from the capture bag. We recommend covering the fox's eyes with a piece of clothing to lower its stress (for example, use a tube made from cutting the bottom of a loose dark wool sock).
- If it is a marked individual, record the color code and tag numbers on a datasheet. If it does not have tags, it needs to be marked (see section 3.2.3 Marking a fox).
- Determine the sex and reproductive condition (for females: *pregnant*, *lactating*, *non-reproductive* or *unknown*; for males: *scrotal* is testes are descended or *abdominal* if they are not).
- At this point, a collar (e.g., GPS, ARGOS)

© Aude Lalis

Hold the fox by grabbing the nape of its neck and around its muzzle.

© Jeanne Clermont

Cover the fox's eyes with a tube sock.

*** IMPORTANT!**

Depending on the region, foxes may carry diseases that can be transmitted to humans, such as rabies and echinococcosis. Check if it is the case in your study area and take the appropriate precautions (vaccination of personnel, protective gloves and gear, evacuation procedure, etc.).

can be placed on the fox and samples such as blood, hair, whiskers or claws can be taken if needed. We do not describe each sampling technique since sampling may vary depending on the research questions addressed.

- Additional measures can be taken. The easiest variable to measure is the length of the right hind foot (from the heel to the tip of the toes). Total length (from the tip of the nose to the last vertebra of the tail) or length without the tail (from the tip of the nose to the beginning of the tail) may also be useful, but are rather difficult to take with precision, and repeatability is poor on a live fox. Pictures of the dentition can be taken to estimate age (see Chevallier *et al.* 2017).
- Weigh the bag and subtract from the initial weight of the animal with the bag to obtain the weight of the animal itself.
- After completing all the previous manipulations, release the animal at the capture site.

Before leaving the site, the leghold trap can be reset. Traps that have caught one animal will often attract another one (especially the pair mate).

© Dominique Berteaux

Blood can be drawn from the cephalic vein (on the dorsal side of the foreleg) but prior training with a veterinarian is recommended.

© Dominique Berteaux

Measure the right hind foot's length by placing the foot flat against a ruler.

3.2.3. Marking a fox

A. Description of the marking technique (ear-tagging)

Individual identification is an important part of population monitoring. It can ultimately be used for estimating population densities using capture-mark-recapture methods. Ear-tags are small markers placed on the animal's ear flaps using specially designed pliers. Rototags® work well for arctic foxes. A Rototag® is a two piece dangle tag about 35 mm × 10 mm available in different colors. With two (one "female" tag and one "male" tag) per ear, unique 4-color combinations allow the identification of individuals from a distance. In addition, custom printing can be done on these tags using unique 2- to 6-digit codes.

Blue, green, red, orange, yellow are good color choices, although similar hues (blue/green or red/orange) are sometimes hard to distinguish on individuals in the field. Based on our

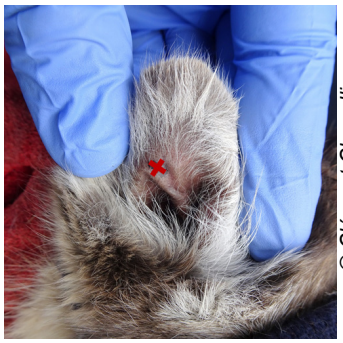
experience, purple is difficult to see against the arctic fox's fur. Obviously, black, white and grey should not be used. We do not recommend the use of the larger Jumbotags® , which are easier to spot but carry a higher risk of tearing the ears.

B. Ear-tagging foxes

- Place the male tag on the side of the plier where there is no hole and the female tag where there is a hole. Check that the tip of the male tag is aligned properly with the hollow end of the female tag. Disinfect the tags with ethanol.
- Clean the external and internal surface of the ears with ethanol. If the fox has a lot of fur on its ears, use a tweezer to remove some where the male (outer) tags are supposed to go (too much hair will jam inside the tags).
- Hold the left ear and locate an area in the middle of the ear cartilage where no blood vessels run.
- Place the plier on the ear (male tag behind the ear, female tag in the inner part of the ear). Clamp the tags in place, making sure the male tag passed completely through the female tag hole. When in place, the pointy end of the male tag should be in the inner part of the ear.
- Use a tweezer to collect the punched-out piece of ear cartilage and keep it in a microtube with ethanol.
- Drip a few drops of iodine where the tags transpierced the ear to prevent infections.

© Clément Chevallier

Male tag (pointy end) and female tag (hollow end).



© Clément Chevallier

The red cross shows where the tag can go through the ear.

- Repeat these steps for the right ear and keep the second piece of ear cartilage with the first one.

© Aude Lalis

Examples of ear-tags showcasing the 4-color code, unique for each individual, on an adult (read: yellow red / yellow red) and on a young fox (read: blue blue / purple green).

3.2.4. Anesthetizing a fox

Adults are anesthetized only if they are too aggressive to be handled safely, or if observers have little prior experience. Avoid as much as possible anesthetizing a lactating female (sex and reproductive status may be quickly checked when the animal is pinned by the restraining pole). Cubs are never anesthetized.

A. Description of the drugs

Medetomidine (Dexdomitor®, 0.5 mg/mL) in combination with ketamine (Vetelar®, 100 mg/ mL) can be used for induction of anesthesia. Atipemazole (Antisedan®, 5 mg/mL) is used as an antidote. All three drugs are administered by intramuscular injection. These are intended for veterinary use and require a veterinary prescription to be obtained. **We highly recommend getting some training from a veterinarian.**

The recommended dosage for arctic foxes is 0.05 mL/kg of medetomidine mixed with 0.025 mL/kg of ketamine, reversed with 0.05 mL/kg of atipemazole.

	ANESTHETICS			ANTIDOTE
Weight (kg)	**Medetomidine (mL)**	**Ketamine (mL)**	**Total volume (mL)**	**Atipemazole (mL)**
1	0.05	0.03	0.08	0.05
1.5	0.08	0.04	0.11	0.08
2	0.10	0.05	0.15	0.10
2.5	0.13	0.06	0.19	0.13
3	0.15	0.08	0.23	0.15
4	0.20	0.10	0.30	0.20
5	0.25	0.13	0.38	0.25
6	0.30	0.15	0.45	0.30

For safety reasons, the recommended dosage corresponds to half the amount needed to completely anesthetize an animal. Therefore, the animal is only chemically immobilized, it is not fully “asleep”. As with a regular capture, remain silent and avoid unnecessary noises.

As with any anesthetic agents, the individual response to medetomidine-ketamine may vary depending upon the dose, general condition and age of the animal. From our experience, it takes less than 5 min for the drugs to take effect and the animal will stay put for about 30-45 min.

B. Administering the drugs

Animals can be anesthetized anytime during a capture, if necessary.

- Prepare the medetomidine-ketamine drug mix in a 1 mL syringe according to the weight of the animal: draw the required volume of medetomidine first and complete to the total volume with ketamine. If it is not possible to weigh the individual, you can administer a 3 -kg dose for an arctic fox and a 5-kg dose for a red fox. You may adjust the dose after you weigh the animal (for example, if you gave a 3-kg dose to a fox weighing 4.5 kg, you can

give another shot corresponding to a dose of 1.5 kg), but this is not necessary if the fox is already calm enough after the first injection.

- Pinch firmly the muscle of the hind leg and insert the needle perpendicular to the skin. Slowly and evenly inject the drug mix in the muscle. Gently massage the area to facilitate dispersion of the drugs.
- Once the animal is completely anesthetized (sedated), note the time of induction and proceed with the manipulations. Regularly check its vital signs (pulse and breathing).
- At the end of the capture, inject a dose of antidote in the hind leg muscle and place the animal back in the capture bag to allow it to recover. Leave the bag open so that the animal can go out by itself when ready. Make sure the surroundings are safe for an animal that may not be fully awake (i.e., not close to water or a steep slope).

In case of problem during the anesthesia, immediately inject a dose of antidote. If the animal wakes up before the end of the manipulations, it is possible to administer a second shot. Do not exceed three injections.

3.2.5. Materiel required

• Datasheets (or field book) and pencil
• 70% ethanol
• Anesthetics and antidote
• Capture bag
• Cotton pads
• Tube socks
• Iodine
• Kevlar® red gloves
• Latex or nitrile gloves
• Micro-tubes (0.5 or 1 mL)
• Pesola scales (5-kg for arctic foxes; 10-kg for red foxes)
• Restraining pole
• Rototags
• Rototag pliers
• Tweezer
• Syringes and needles (25G or 27G)
• Tarpaulin
• Optional: claw clippers, measuring tape, small stainless steel ruler, small envelopes (for hair or whiskers samples)...

© Sandra Lai

Custom made capture bag with double zipper at the bottom.

© Jeanne Clermont

Tape the metal tip of the restraining pole to prevent injuries if the fox bites it.

4. DETERMINING LITTER SIZE

Litter size usually refers to the number of cubs when they are old enough to emerge from their den. Since it is very difficult to determine litter size with absolute confidence, "minimum litter size" (maximum number of cubs observed at the same time) is usually reported.

4.1. DESCRIPTION OF THE METHOD

To estimate minimum litter size, establish a tent at least 500 meters away from the den but with a good view on it. Cubs are mostly active from dusk until dawn but can also be observed during daytime. A continuous observation for 48 hours is usually required to have the best estimate of litter size. Very young cubs usually come out when a parent arrives at the den. As they get older, they start to spend more time outside the den by themselves. Note the date, time and exact duration of the observation session. If cub trapping occurs concurrently with visual observations, the number of untagged cubs (if any) seen after the end of each trapping session can be added to the number of newly-tagged cubs.

If the establishment of a temporary camp for 48 hours is impossible, one or several shorter observation periods can also be conducted at active dens from a location at least 500 meters away. Note the date, time and duration of the observations to ease the subsequent interpretation of data on litter size.

On Bylot Island, we conduct at least 3 observation sessions lasting 12 consecutive hours each. These 12-hour observation sessions can span over consecutive days or not, depending on the weather. Each observation session is divided in two 6-hour shifts, with one person observing from 3 p.m. to 9 p.m., and then another from 9 p.m. to 3 a.m.

4.2. TIME PERIOD

Minimal litter sizes should be determined a few weeks after cub emergence. On Bylot Island, cubs start to emerge in mid-June and minimal litter sizes are determined in July. The phenology may vary depending on the area.

4.3. MATERIEL REQUIRED

- Datasheets (or field book) and pencil
- Small tent
- Spotting scope and binoculars
- Optional: Insulated foam mat, thermos, Thermarest chair, and other things to keep you warm...

Observation tent with spotting scope.

5. CAMERA TRAPS

When time and personnel are lacking, remote cameras are your best friends. In the recent years, camera traps have become an efficient, cost-effective and relatively non-invasive method to monitor wildlife.

5.1. DESCRIPTION OF THE CAMERAS

Camera traps can be set to run continuously, to take pictures at specific time intervals or to be motion-triggered. An infrared flash allows cameras to take pictures in the dark. Several companies manufacture camera traps: Bushnell®, Reconyx®, Acorn®, Spypoint®, etc. Prices vary depending on the model and range from 100 $US to 600 $US per camera. Additional costs include memory cards, batteries, physical supports (e.g. tripods) to deploy the cameras in the field and external hard drives to store the pictures. On Bylot Island, we have been using Reconyx® RapidFire Professional PC85, HyperFire PC800 and HyperFire 2. These models are very sturdy and perform well under an array of weather conditions, including extreme cold, snow and rain.

© Sandra Lai

An automated camera. The model shown is an HyperFire 2 camera from Reconyx®.

While camera traps present several advantages in the field, they can generate large numbers of images (thousands or millions of pictures) in short periods of time, which may rapidly become an overwhelming amount of data to treat once the cameras are recovered. Several software packages are available to facilitate data storage and management (e.g, Cpw Photo Warehouse; CamtrapR), while various automatic image analysis software packages are now being developed.

Examples of pictures taken by Reconyx® cameras.

5.2. DESCRIPTION OF THE METHOD

Camera traps are useful for monitoring dens during both summer and winter, providing batteries and memory cards can be changed regularly. This method is useful for confirming the status of a den (occupied, reproductive or inactive), species using the den (red or arctic foxes), identifying adults (tagged or untagged), determining date of cub emergence and litter size. It is particularly useful for detecting easily missed events, such as litter splitting or moving. It can also record interspecies interactions or predation events occurring at the dens.

5.2.1. Preparing cameras

Reconyx® cameras can be set to be automatically triggered by movements. This option is the most adequate for monitoring dens.

We recommend using the advanced options to set the camera with the motion sensor on, high sensitivity, 5 pictures per trigger, RapidFire mode and no quiet period. When cubs have emerged, the number of pictures per trigger can be lowered to 3 per trigger. Programming may vary depending on your needs, size of memory cards, battery life and the frequency at which cameras can be visited to replace cards and batteries.

5.2.2. Installing cameras on dens

Dens showing signs of activity (tracks, digging, prey remains, hair, etc.) at the beginning of the field season may receive two camera traps. Using two cameras will allow a better assessment of fox activities by covering a larger surface, but if strategically placed, one camera is enough. Ideally, one camera should be aimed towards the most active hole while the other should be oriented in order to get a global view of the den.

Avoid pointing the camera too upwards as the sun may trigger it repeatedly. Similarly, try to avoid a water source or river in the background since solar glare may also trigger cameras.

- Use a tripod (or steel T-bar) to fix the camera and anchor the tripod to the ground using large nails and steel wire. Firmly anchor the tripods to ensure that cameras will not move even under strong winds.
- Enter the den's code name in the camera ("User label" option) and proceed to a walking test for each camera.
- Once everything is set, arm the cameras. Before leaving, you may walk in front of the cameras to trigger them so you know at what time they were activated from the first pictures.

© Nicolas Trudel

Installing a camera trap near a fox den.

5.2.3. Checking and retrieving cameras

Cameras should be checked regularly during the field season to change the memory cards and

replace batteries.

All pictures taken should be saved on a hard drive (ideally, two different hard drives).

Pictures may be analysed after the end of the field season.

5.2.3. Time period

Camera traps can be used during all seasons. They are most useful in summer (May to August), as they help following the breeding activities.

5.2.4. Materiel required

- Datasheets (or field book) and pencil
- Automated cameras
- Batteries for the cameras
- Computer
- External hard drives for back-ups (optional)
- Hammer
- Large nails
- Memory cards for the cameras
- Memory card reader (if needed)
- Physical supports (e.g. tripods, steel T-bars)
- Steel wire

PROS	CONS
• Automated system with a high detection capacity	• Costly but this depends on camera type
• Can be used during any season	• Data space requirements are high
• Require a low time investment once installed	• Processing pictures is time consuming
• Not necessary to kill or capture animals	• Requires an effective battery management plan

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