SMALL MAMMAL POPULATION MONITORING

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PURPOSE

We need to estimate abundance of small mammals (Lemmings and Voles) for a number of different reasons within the whole project, principally: (i) parameterizing a simulation model of ecosystem dynamics, (ii) tracking population level responses to experimental snow enhancement, (iii) quantifying habitat selection; (iv) testing the accuracy and precision of some of the abundance indices for use in long-term monitoring, (v) tracking regional patterns in abundance.

FOCAL SPECIES

Brown Lemming *Lemmus sibircus*
Collared Lemming *Dicrostonyx spp.*
Tundra (root) Vole *Microtus oeconomus*
Tundra Red-backed Vole *Clethrionomys rutilus*

PROCEDURES - SYNOPSIS

In this section we provide a tabular synopsis of available methods, summarize the methods required to achieve each objective, and then provide detail on how to implement each of the methods.

There are several ways to estimate lemming and vole abundance, summarized in the following table. Different methods require varying degrees of effort. In some cases the accuracy of the estimate depends on habitat type. The table below summarizes the pros and cons and gives a "priority rating" of each method. Priority 1 is the simplest method, and Priority 6 is necessary if you wish detailed, precise data on individuals and population size.

All methods provide a relative abundance estimate of population size, but only the full live-trapping on a grid can provide an absolute density estimate. Monitoring requires a relatively simple and cheap method (which generally precludes live trapping), and so will rely on relative abundance indices. We do not know how well the various relative abundance indices track absolute abundance, and understanding this is an important objective.

Method	Priority	Season of estimate	Equipment required	Time Required	Accuracy and Precision	Species / Habitat	Comments
Winter nest counts	1	Past winter	Pencil & notebook, GPS (optional)	Low – Can be done while walking between sites or doing other protocols	Medium – less accurate than trapping; precision depends on number of nests found	All species / All habitats but detection of nest more difficult in tall grass or sedge	*Pros*: quick, cheap and easy; gives information on overwinter weasel predation; not necessary to kill or capture animals *Cons*: average density overwinter varies in increase and decline phase
Runway transects	2	Current	Pencil & notebook	Medium – 1 person day per transect	Low	*Lemmus*, *Microtus* only / Wet habitats	*Pros*: quick, cheap and easy; not necessary to kill or capture animals *Cons*: limited to brown lemming or *Microtus*s
Burrow counts	3	Current	Pencil & notebook	Medium – 3-4 person hours per ha	Low	*Dicrostonyx* only / Dry habitats	*Pros*: quick, cheap and easy; not necessary to kill or capture animals *Cons*: limited to *Dicrostonyx* in good soils
Snap-trapping	4	Current	Snap traps, peanut butter	Medium – About 6 person hours over 3 days	High	All species / All habitats	*Pros*: good estimates for all species, gives parasite and reproductive data if needed *Cons*: kills the animals, animal ethics concerns
Live trapping (index lines)	5	Current	Trap stakes & flags, Longworth traps, bedding, bait, eartags, tagging pliers, scales	High - 4 person days per 2-day trapping session	High	All species / All habitats	*Pros*: best estimates; definite species identification; demographic data; *Cons*: requires expensive equipment and skills in handling small mammals
Live trapping (grid)	6	Current	Trap stakes and flags, Longworth traps, bedding, bait, eartags, tagging pliers, scales	High – 4-6 person days per 2-day trapping session	High –gives a density estimate for each species	All species / All habitats	*Pros*: best estimates; definite species identification; demographic data; *Cons*: requires expensive equipment and skills in handling small mammals

PROCEDURES - METHODS FOR EACH PROJECT OBJECTIVE

The following table summarizes the methods and minimum sampling regime for each small mammal study objective involving population estimation.

Arctic WOLVES OBJECTIVES	PARAMETERS REQUIRED	STUDY SITES	METHODS	SAMPLING
Parameterize a mass balance simulation model	Biomass density; Cohort structure; Production	Bylot; Herschel; Any others?	Live-trapping on grid for absolute population estimation	(i) Minimum 2 mark-recapture estimates: soon after snow melt, and shortly before snowfall. (ii) Repro status and mass.
Experimental snow depth enhancement	Absolute abundance for treatment & control	Bylot; Herschel	Live-trapping on grid for absolute population estimation	(i) Minimum 2 mark-recapture estimates: shortly before snowfall and soon after snow melt (same as above). (ii) 2 estimates during snow cover (fall and spring) if possible. (iii) Repro status and mass. (iv) Winter nest counts on all grids before and during treatment.
Quantifying habitat selection	Absolute or relative abundance in different habitats	Walker Bay; Herschel	Live-trapping on mini-grid for relative abundance estimation	Minimum 1 estimate at start of habitat assessment and cover treatment (June through July)
Testing Indices for Monitoring	Concurrent absolute and relative abundance	Bylot ?; Herschel; Walker Bay; Komakuk; Shingle Point (for c))	a) Winter nest counts & fall or spring absolute abundance b) Live trap relative abundance & absolute abundance c) Snap trap relative abundance & absolute abundance	a) Run winter nest counts on all grids each spring. b) Run live trap index lines on grids just prior to absolute abundance estimation. c) Run live trap index line just prior to snap trapping the same line
Regional Patterns of Abundance	Relative abundance	All Sites (Bylot, Herschel, Komakuk, Walker Bay, Wapusk, Eureka, Alert)	Live trap index line, or snap trap index line	Minimum 2 estimates, with 1 soon after snow melt, and 1 shortly before snowfall.

PROCEDURE 1 – WINTER NEST COUNTS

Lemming abundance over the previous winter is relatively easy to measure indirectly by a survey for winter nests. Lemmings build winter nests of grasses and sedges under the snow and use them to keep warm. They appear to us like a ball of cut grass, about 12 cm (5 inches) in diameter. Since they are abandoned in spring and not reused, they can be counted and picked up without harming the animals.

Both the brown lemming and the collared lemming build winter nests, as do voles like *Microtus* (tundra vole) and *Clethrionomys* (red-backed vole) in tundra habitats. It may be possible to tell what species constructed the nest from small amounts of hair left in with the grass, but this is relatively difficult and time consuming. In most cases we would simply record the nest and not know what species constructed it. You may find gigantic winter nests 30 cm or more in diameter and lined with fur. These are weasel (ermine) nests. Weasels hunt lemmings and voles under the snow and convert lemming nests to their own use. Often you will find lemming stomachs left behind in weasel nests. We record weasel nests separate from lemming nests, since it gives a rough indication of the amount of weasel predation over the past winter. *All nests should be torn open to check for fur lining (and therefore use by weasels). If there is fur lining, the nest should be collected and searched and small mammal remains collected because we use these for species identification and quantifying predation rate (notably skulls and stomachs), and the area within 50 cm of the nest should be searched for weasel scats (to be collected) and lemming remains (bones and stomachs). All nests found should be ripped apart to avoid re-counting them the next year.*

<u>Time Period</u>

Nest surveys are best done as soon as possible after snow melt (early in summer), since high winds can blow the nests around after the snow melts. At high arctic sites where vegetative growth is low, these searches can happen later in the summer. They cannot be done with great confidence in dense willow habitats or in tussock tundra where the winter nests may often be invisible under the tussocks and willows. Count only fresh winter nests. Nests that are one year old are usually completely flattened and the grass has a grey colour rather than a tan colour.

There are two potential sampling approaches to estimate nest density: (i) complete count on a fixed area; (ii) line transect count.

<u>Fixed area count</u>

We use this approach to count nests on fixed live trapping grids, so that we can compare the overwintering population on the grid between winters, and before and after any experimental treatments affecting winter use (e.g. snow enhancement). This approach requires that the surveyed area (grid) be set up with fixed numbered stakes that help the observer to search the area systematically. The observer walks slowly back and forth across the grid following a series of straight-line transects that are close enough together to allow a complete search and count. It is best to record the location of each nest in x,y Cartesian space using lettered column and numbered row to the nearest decile (e.g. A.7, 1.2).

Data (equipment) required:

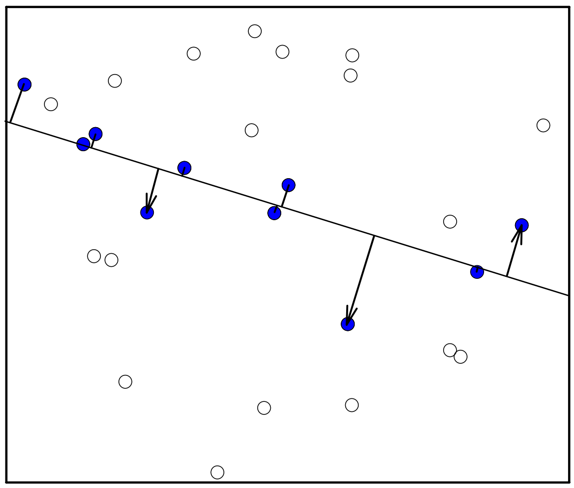
- Grid area (grid established as per Live trapping below)
- Location of each nest (note book, pencil, grid stakes in place)
- Whether or not nest was used by weasel
- Count of small mammal jaws & stomachs per weasel nest (collecting bags and labels)
- Total nest count

<u>Line transect count</u>

This approach is best for long-term monitoring because it traverses a greater variety of habitats than the grid sampling, and is more likely to achieve a reasonable sample size. The procedure is described briefly in Krebs (1999, page 158) and more extensively at http://www.ruwpa.st-and.ac.uk/distance/ (which has a book on-line to explain the details of the line transect method).

The line transect method operates as follows:

a) The observer walks a straight line searching visually for lemming nests. Upon sighting a nest, he or she records the perpendicular distance of the nest from the line of travel. The data set consists of these perpendicular distances and the total length of survey line the observer walks. The procedure can be illustrated schematically as follows: circles represent winter nests, and the line marks the survey line walked by the observer. Solid circles represent winter nests seen by the observer, and the lines mark the perpendicular distances measured to the center of the winter nest. Only one survey line is shown for clarity.



Two key aspects of line transect sampling are shown in the diagram. First, not all winter nests are seen along the travel path. Second, all winter nests exactly on the line of travel are seen. But in general, the farther the nest is from the line of travel, the less likely it is to be seen, so that detection falls off with distance. The perpendicular distance to each nest seen is measured, no matter how far it is from the line of travel.

Line transect sampling should be done until at least 40 nests are seen and their perpendicular distances measured. 60-80 nests would be better, but clearly these sample sizes cannot be obtained in low-density years. In general I would recommend about one day of walking effort per site should be sufficient to generate an estimate of the number of winter nests per hectare. The larger the sample size the more precise the estimate will be.

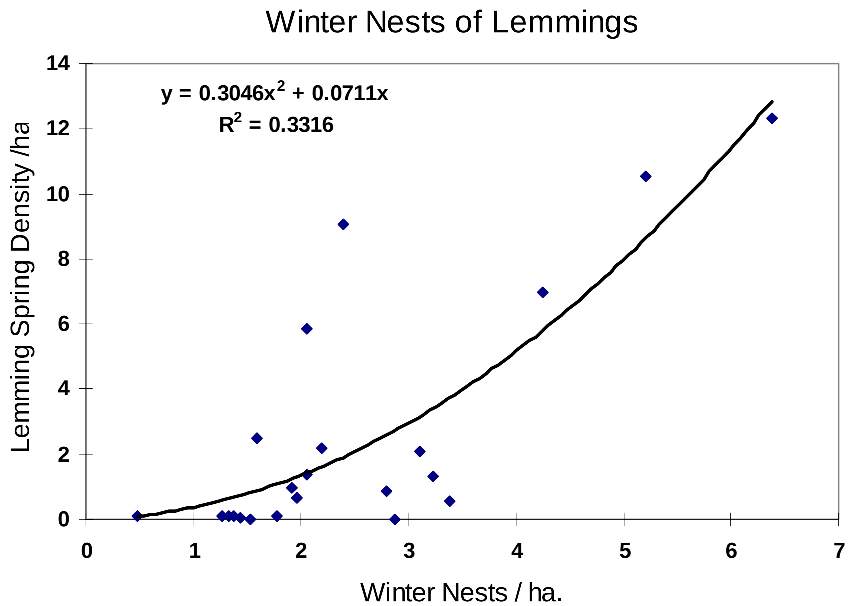
The distance traveled can be determined from a GPS if this is available, or alternatively by estimation of the number of kilometers walked. On the tundra it is clearly impossible to walk a straight line, but this should not matter as long as one does not double back to cover the same ground.

These data can be analyzed with program DISTANCE, which is available from the web site given above. Alternatively we could arrange a central data analysis system to which the raw data could be submitted each year. Program DISTANCE will calculate the number of lemming nests per hectare, and the next problem is to convert these into absolute numbers. We do not have enough data to be very precise about this conversion yet. A preliminary regression that we have developed so far is shown in the next figure.

The regression is:

$$\text{Lemming spring density per ha} = 0.0711\,(WN) + 0.3046\,(WN^2)$$

where WN is winter nest density per ha.



Data are from Pearce Point, NT and Walker Bay, NT, collected between 1991 and 1997. It is clear that more data are needed to test this regression and to make it more precise. It has not been validated for all habitat types. In particular if nests can be built underground it will underestimate density. Since populations may be rising or falling over the winter, the predicted spring density will be too low in increasing population and too high in declining populations.

<u>Data (equipment) required</u>

- Perpendicular distances to each nest (nearest dm) (tape measure, note book)
- Total distance of lines surveyed (GPS or map)
- Number of lemming nests taken over by weasels
- Count of small mammal jaws & stomachs per weasel nest (collecting bags and labels)

PROCEDURE 2 – RUNWAY TRANSECTS

Brown lemmings and voles tend to live in wetter habitats and build runways that are clearly seen as mini-superhighways through the grasses and sedges. One indirect way to estimate their abundance is to count active runways intersected by a line of given length. The principle is similar to that of the line transect just described but simpler because the information recorded is the number of active runways crossed by a straight line of length *x* crossing the habitat.

The key decision is whether or not a runway is active or inactive. Lemming runways can last several months to over a year after lemmings have declined so one must check to see if a runway is being used or not. This is done by looking down the runway for fresh fecal pellets (green) or fresh clippings of sedges or grasses, and if one can find this sign within 1 meter on either side of the transect line, the runway can be called active. Do not count inactive runways.

Transects can be done in exactly the same place year after year if permanent stakes are put out in wet habitats. Searching for runways is somewhat tedious since you must crawl along the transect searching carefully for covered runways. The method proceeds as follows:

1. Lay out a tape or rope in a straight line across an area of wet habitat. If possible use permanent stakes to locate these lines.
2. Moving along the line, record for each 15 m segment the number of active runways cut by the line. Some runways will snake back and forth across the transect line and they may be counted several times. It may be possible to distinguish *Microtus* runways from brown lemming runways by their width and by the size of their fecal pellets in areas where these two species both occur.
3. Count enough 15 m segments to obtain a total of 25 or more runway intercepts, if possible. When lemming or vole numbers are low, you may find no active runways in many areas.

<u>Time Period</u>

Transects are best done in late July or August. We estimate that it would take about 1 person-day to survey a wet site for runways.

<u>Data (equipment) required</u>

Number of active runways bisected in each 15 m segment of line searched (measuring tape or rope, stakes, notebook).

PROCEDURE 3 – BURROW COUNTS

Collared lemmings live in dry habitats typically and do not build runways that are obvious. They dig burrows, and can be censused indirectly by counting active burrows in a specified area of dry habitat.

Active burrows can be recognized by fresh digging and soil thrown out of the burrow or by the presence of fresh (green) feces partly down the entrance of the burrow. Old burrows may also have spider webs inside them.

To use this method proceed as follows:

1. Stake out an area of at least 1 ha (100 m by 100 m) and preferably about 2 ha with permanent stakes. The same area should be counted each year.
2. Walk parallel lines within this area at approximately 5-7 m intervals looking for all burrows.
3. Examine each burrow and classify as active or inactive. Count all burrows whether active or inactive.

If these burrow counts are done in relatively dry habitats, they will almost entirely be for collared lemmings, since brown lemmings rarely venture out of wet, sedge areas. The time required for one person to search 1 ha thoroughly is approximately 3-4 hours.

<u>Time Period</u>

Burrow counts are best done in late July or August.

<u>Data (equipment) required</u>

Number of active and number of inactive burrows per area of habitat searched (wooden stakes for grid, notebook).

PROCEDURE 4 – SNAP TRAPPING

Snap trap surveys provide an index of rodent population densities and demographic data where live trapping methods are not possible.

Time Period

Snap trapping should be conducted once per summer in late July or August after most juveniles of the year have been weaned.

Procedure

Museum Special snap traps will be placed along 4 transect lines in both wet and dry habitats. The lines will each have 20 stations, 15 metres apart, with each station consisting of 3 traps within a 2 metre radius of the point for a total of 60 traps. This requires a total of 240 traps. Each transect will be trapped for 3 nights for a total of 720 trap nights. This many trap nights are necessary statistically to obtain a reasonably precise estimate.

1- Choose appropriate sites:
    - Choose sites to cover all potential rodent habitats. Brown lemmings and voles prefer wet polygonal areas and sedge marshes; collared lemmings prefer well drained slopes with extensive *Dryas* vegetation.
    - Aim for 2 transects in each habitat type for a total of 4 transects.
2- Set out transect lines:
    - Measure a 300 m long *straight* line. Place a marker (wooden stake or surveyor's flag) every 15 metres. This will result in 20 trapping stations.
    - If there is sufficient space within the habitat patch, transects may be laid parallel to each other with a minimum distance between the transect lines of 100 metres.
3- Setting traps:
    - At each station set 3 Museum Special snap traps within a radius of 2 metres of the station marker. Separate the 3 traps as much as possible and place in areas of fresh rodent sign where possible (runways, burrows, fresh scat or grass clippings). Traps should be placed flat on the ground and clear of any vegetation that could interfere with the trap operation. Make sure you will be able to locate the traps again. If the bushes are high you may need to put flagging above each trap. If there are many ground squirrels or foxes in the area, you may need to tether the traps to a bush with a wire or strong piece of string to be sure they don't carry the trap away. It is useful to paint the bottom of the traps bright orange so you can find them easily if they flip upside down and carried a small distance from where they were initially placed.
4- Baiting Traps:
    - Each trap should be baited with a pea-sized amount of peanut butter on the treadle. A convenient way to carry and deploy the peanut butter is to fill a "Coghlan's squeeze tube" that you can buy from Mountain Equipment Co-op for $2.50.
5- Checking Traps:
    - Traps should be checked once per day, early in the morning, for three days. If an animal is caught, collect the animal and record the line, station number, habitat, species, age (adult, juvenile) and sex. Re-bait the trap with peanut butter and re-set the trap. Traps should be collected and cleaned of remaining peanut butter during the trap check of the third day.

Four transects, each with 60 traps (total of 240 traps) set for 3 nights will result in 720 trap nights. Transects will take two people about 1 hour per transect to set out on the first day. Extra time for walking to the sites needs to be factored in. Subsequent trap checks will take about 1/2 person hour per transect.

If you are limited to 120 traps you can set two transects for 3 nights and then move the traps to the next set of transects and trap for another 3 nights.

Data analysis

The abundance index is described as the number of animals per 100 trap nights.

PROCEDURE 5 – LIVE TRAPPING - RELATIVE ABUNDANCE TRANSECTS

Use live trapping on relative abundance transects to obtain an index of abundance and demographic data where snap trapping (killing the animals) is not allowed (e.g., National Parks).

Time Period

Live trapping transects should ideally be run at least twice a year, once in spring as soon as all the snow has melted and once in late summer before snow stays. This is the best way to infer stage in a cycle, because populations can change dramatically during the summer, and mid-summer trapping alone does not give a picture of population trend. The technique can also be applied repeatedly during the summer.

Setting up Transect

Use a 50 m or longer measuring tape and compass to set out one or two transects, totalling 600 m. (The total length is less than snap trapping transects because live traps are less available). If two transects of 300 m are used, they should be at least 100 m apart. Trap stations are located every 15m along the transect (40 stations total), and marked with a numbered wooden lathe stake. At each station place 3 Longworth traps, within 5 m of the stake, searching for runways or burrows where animal activity is likely.(120 traps total).

Setting and Checking Traps

Follow the procedures outlined in the Live Trapping Grid section below. Note that the trapping session should be 48 hours (shorter than the snap trapping session, because of the risk of stress to trap-happy individuals), with trap checks every 4-6 hours.

Equipment required

As per Live trapping Grids below

PROCEDURE 6 – LIVE TRAPPING - ABSOLUTE GRIDS

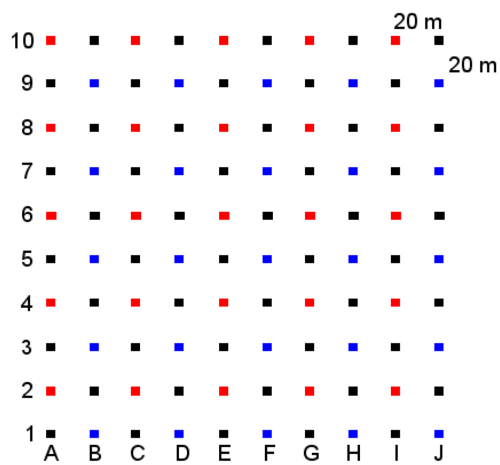
Use live trapping on trapping grids to obtain density estimates of each rodent species present as well as data on sex, age and breeding condition.

Time Period

Live trapping should be done at least twice every year, once soon after spring melt, and once before the snow sticks in late summer. This is the best way to infer stage in a cycle, because populations can change dramatically during the summer, and mid-summer trapping alone does not give a picture of population trend. It is also advantageous to run other sessions during the course of the summer.

Trapping grid setup

Use a 100 m long measuring tape and a compass to measure out a 10x10 trapping grid with 20 meter spacing (3.24 ha), or a grid of larger square shape, such as a 16x 16 grid with 20 m spacing (9 ha). This can be done with 2 people but 3 people are most efficient. Mark each grid point with a wooden stake (wooden surveyor's lathe, 60 cm lengths) labelled with the row and column. Place a Longworth trap at a suitable site within 5 m of every second grid station for a total of 50 or more depending on the size of the grid (or every grid station if the population density is high and the large majority of traps are occupied each check). Stagger the trap placement so they are evenly spaced over the area (black squares represent traps in the schematic below). It is useful to colour code the rows to help with orientation while in the middle of the grid. One way to do this is to temporarily place red and blue surveyor flags next to each station. These can be picked up at the end of trapping session (or laid flat on the ground) to minimize wind damage to the flags.



Setting traps

Oats – Place a small handful of whole oats in the box of the Longworth traps

Bedding - Line the box of the Longworth traps with upholstery cotton or wool fleece for bedding. Use just enough cotton or fleece to create a warm nest. If too much cotton is stuffed in the box, the lemmings may view it as a blockage as opposed to nesting material.

Apple – Place a chunk of apple in the box in front of the bedding. We get 32 squares from a large apple. Cut in squares rather than slices to minimize surface area and desiccation.

Trap assembly - Unlock the locking mechanism of the Longworth tunnel and check that the door falls properly when the treadle is depressed. Adjust the mechanism if necessary and when all is in good working order, set the trap and connect the tunnel with the box. Make sure that the apple is not too close to the treadle.

Trap placement – Place traps as close to the stake marking the location as possible (maximum 5 meters radius from stake). Search the area carefully for fresh sign such as an active burrow or runway. If you find a good runway, place the trap right on the runway. If there is a burrow, place the trap in front of the entrance but do not block the entrance. If there is no sign, place the trap under cover if possible. Make sure the trap is flat and stable and make sure that the door hasn't fallen shut or the apple rolled under the treadle while placing the trap. Place a board or cover over the live trap to shelter it from too much sun or rain.

<u>Checking traps</u>

A trapping session should last 2 days (48 hours) and all traps should be checked every 4-6 hours. (If you do not want to check traps at night (we prefer not to), it is acceptable to set the traps early in the morning, check every 4-6 hours and then lock the traps open at the last evening trap check. Traps will have to be re-opened the next morning.) You should have at least 12 trap checks in a 2 day trapping period. Do not trap more than 2 days in a row or "trap-happy" individuals will be caught too often and may die in the trap. At the last trap check the doors should be locked open and the traps should be left in 2 pieces so that there is no chance of an animal being caught by mistake.

Place a few cm of oats in the bottom of your trapping bucket and walk past every trap. If you find a trap with the door closed, gently open the trap in the bucket and tip the animal out onto the oats. The oats provide a soft landing surface for them. At this point you can check species and get your tagging equipment prepared. Scoop the animal up with a gloved hand[*]. Use the other un-gloved hand to get a good grasp of the tail. Be careful not to squeeze the animal and keep the eyes covered to minimize squirming. Check carefully for an eartag and record the number if it's already tagged. If a new tag is required and the species is *Dicrostonyx* you will need 2 people to tag properly. The person handling the lemming can use both hands to hold it so that its right ear is exposed but eyes covered. The person tagging can use the blunt tweezers to gently extend the ear flap with one hand and tag with the other hand. Make sure the tag point has pierced through the ear flap and tag hole and folded over properly (check each tag's alignment before placing in the pliers). Be careful to not catch too much skin in the tag (increases chance of infection) but place the tag far enough in so that it doesn't easily rip out. The ears of brown lemmings and voles are big enough that they can be successfully tagged without the use of tweezers. Record the tag number.

Check the sex, reproductive condition and weight of the animal. Record the data and release the animal. Reset the trap with fresh bait and dry bedding.

If the animal caught already has a tag and was caught earlier in the same trapping period, you do not need to check the sex and weigh the animal. Simply record the tag number, location, and which check number it is then release the animal.

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[*] Another method for handling is to place a clear plastic bag around the trap. Hold the bag shut and work through the bag to break the trap open and release the animal into the bag. Scruff the animal through the bag so that you can open the bag and remove the trap without letting the animal escape. Suzanne Carrière is preparing a video of this technique.

Equipment needed

- 100m measuring tape and compass for setting up trapping grids
- 20 litre bucket with minimum 40 cm high sides for holding animals
- Traps and trap boards
- Whole oats
- Apple (preferably Granny Smith)
- Upholstery cotton or wool fleece for bedding
- Eartags & tagging pliers (or injectable transponder tags and readers if you have lots of money)
- Blunt tweezers for holding tiny *Dicrostonyx* ears when tagging
- 100 g Pesola scales for weighing adults; 30 g scale for juveniles; 300 g scale for some pregnant females.
- Light drawstring bag for holding the animal while weighing
- Trapping gloves
- Bandaids

Data analysis

Data should be entered into a database and checked immediately for errors. Density estimates can be computed using Program Capture or Program MARK, or by the simpler Petersen or Schnabel estimators.