Herpetofauna: artificial retreats

Version 1.0

This specification was prepared by Marieke Lettink in 2012.

Contents

Department of Conservation
Te Papa Atawhai

Synopsis

Artificial retreats are objects that are deliberately placed within a species' habitat to attract that species. They come in a range of shapes, sizes and materials limited only by one's imagination, and are sought out by herpetofauna because they offer shelter, protection from predators and/or thermoregulatory advantages (Lettink 2007a). After being deployed in the field, artificial retreats are typically left undisturbed for some time before being checked. A placement period of several months may be needed to ensure consistent use of artificial retreats by herpetofauna, depending on the target species' tendency to use cover objects and their fidelity to natural retreat sites (Lettink & Cree 2007).

World-wide, the herpetofaunal groups that are commonly sampled with artificial retreats are terrestrial salamanders (Fellers & Drost 1994; Monti et al. 2000; Bailey et al. 2004), frogs (Pearman et al. 1995; Wakelin et al. 2003), and snakes and lizards (Sutton et al. 1999; Webb & Shine 2000; Shah et al. 2003). Within the international literature, artificial retreats are also known as artificial refuges, cover boards or artificial cover objects (ACOs). Collectively, these objects are most effective for herpetofaunal species that regularly use some form of cover (Thompson et al. 1998).

Artificial retreats may be used for inventory (e.g. conducting one or more checks to determine species' presence), monitoring (e.g. conducting multiple checks to estimate abundance or other population measures), restoration (providing additional refuges in degraded habitats or in areas where populations are limited by refuge availability; e.g. Webb & Shine 2000; Souter et al. 2004), and translocation and mitigation (providing both a capture and post-release detection method, and a means of enhancing the carrying capacity of the habitat at release sites; e.g. Lettink 2007b). Only the inventory and monitoring applications of this method are described here.

Despite a long history of use elsewhere, artificial retreats have only recently been adopted for sampling herpetofauna in New Zealand. The first documented use was that of Whitaker (1982), who trialled flat wooden boxes placed on the ground for monitoring common geckos (*Woodworthia maculata*) at Turakirae Head near Wellington. Although animals did use them, Whitaker (1982) opted to use pitfall trapping instead. In the following two decades, there was little use of the method (e.g. Towns (1994) used multi-layered plywood stacks to provide additional cover for Whitaker's skinks (*Oligosoma whitakeri*) released on Korapuki Island). Since 2003, artificial retreat designs have been developed and tested for native frogs (Wakelin et al. 2003), arboreal lizards (Francke 2005; Bell 2009) and terrestrial lizards (Lettink & Cree 2007; Thierry et al. 2009; Hoare et al. 2009; Lettink et al. 2011). Artificial retreats for native frogs are not described here because capture rates proved too low for the method to be useful for population monitoring (A. Haigh, pers. comm.). The method has not been used to sample tuatara or introduced frogs.

Research conducted over the last decade has described herpetofaunal use of various artificial retreat designs (Wakelin et al. 2003; Hare & Hoare 2005; Lettink & Cree 2007; Thierry et al. 2009), investigated their thermal properties (Thierry et al. 2009), compared their effectiveness with that of other commonly used sampling methods (Lettink 2007b,c; Lettink & Cree 2007; Francke 2005; Bell

2009), determined optimal conditions for sampling (Hoare et al. 2009), and evaluated their accuracy and precision for monitoring (Wilson et al. 2007; Lettink et al. 2011).

The main advantages of artificial retreats compared with other sampling methods (e.g. pitfall trapping, systematic searches) are that they are easy to use, relatively inexpensive, insensitive to observer bias, and cause little or no habitat disturbance. Also, there is no requirement to physically handle animals (animals may be identified on sight or photographed when artificial retreats are checked), making it an ideal tool for community groups who may not have Wildlife Act permits to handle animals. The main disadvantages of artificial retreats is that they: (a) do not deliver instantaneous results (they must be set up in advance and left for some time before animals regularly use them); (b) can attract mammalian predators in search of shelter and/or access to prey; (c) can be interfered with by wildlife, livestock and people, potentially causing injury or death of resident herpetofauna (e.g. the majority of Open Bay Island skinks (*Oligosoma taumakae*) found on a survey of Taumaka Island in South Westland were squashed animals recovered from a stack of roofing iron that fur seals had been sleeping on; T. Whitaker, Whitaker Consultants Limited, Motueka, pers. comm.); and (d) represent a habitat manipulation. Regarding the latter, the permanent placement of artificial retreats in long-term studies could alter the distribution, abundance and/or survival of animals using them, meaning that the data collected will be biased because it no longer reflects natural population dynamics (Lettink 2007a).

Most studies that use this method report uncorrected count data, i.e. the number of animals detected per retreat, transect or grid. Such counts are also known as indices of abundance. They are uncorrected counts because variations in detection probability (hereafter 'detectability') have not been taken into account. There are many factors that affect the detectability of herpetofauna, including time-of-year, weather conditions (both preceding and during sampling), sampling method used, observer bias, and behaviours and inherent traits of the animals being sampled, such as their age, size or sex (Mazerolle et al. 2007). Consequently, herpetofauna are often more difficult to sample than other vertebrate groups (Thompson et al. 1998).

Alternatively, variations in detectability can be taken into account (e.g. by using distance sampling, site occupancy modelling or mark-recapture analysis to obtain population estimates). Mark-recapture analysis requires animals to be captured and individually marked (or identifiable from natural markings, which are typically recorded in photographs). In general, population estimates require greater sampling effort than indices of abundance, but their advantage is their greater accuracy and power to detect trends. Mazerolle et al. (2007) encouraged herpetologists to adopt methods that account for detectability and provided a comprehensive review of the methods available for doing so. The amount of sampling effort required will depend on the aims of the study, and on the density and detectability of the target species. See 'Case studies' for examples of potential uses of artificial retreats.

Assumptions

- The target species will use cover objects placed within its home range.
- The artificial retreat design is appropriate for the target species.
- The placement period is sufficiently long for animals to use artificial retreats.

- The sampling area is representative of the wider habitat occupied by the target species.
- Artificial retreats can be checked safely and returned to their original positions without risk of injury to resident animals and observers.
- All observers are able to count and identify or handle animals (animals should only be captured if absolutely necessary, e.g. for species identification).
- All relevant data (e.g. date, weather conditions, artificial retreat number and site) are recorded and used in subsequent analyses, where appropriate.

A range of analytical methods can be used to analyse data collected from artificial retreats. Therefore, additional assumptions may apply depending on the aims of the study. For example, where data from artificial retreats is used to provide indices of abundance, detection probabilities must remain constant (i.e. not vary over time or among sites). There must also be a proportional (usually linear) relationship between the index and abundance (for a full list of assumptions, see 'Herpetofauna: indices of abundance'—docdm-493179).

Advantages

- Very easy and quick to deploy in the field and operate.
- Has minimal or no impact on habitat.
- Requires minimal training and is relatively insensitive to observer bias.
- Less reliant on good weather conditions than other techniques.
- Can be used to locate nocturnal species (particularly terrestrial geckos) by day.
- May be cheaper than live trapping, depending on trap and retreat designs used.
- Very low ongoing costs after set-up.
- Low risk of trap-related mortality associated with live-trapping methods (e.g. desiccation, drowning or predation) because animals can enter and leave artificial retreats of their own volition.
- Sign alone (faecal pellets or sloughed skin) can be used to confirm presence.
- Minimal disturbance, especially if animals are not physically captured.
- Usually easy to repeat and standardise.
- Analysis of count data collected under standardised conditions requires little statistical training.

Disadvantages

- Results are not instantaneous. Requires multiple visits (one to set up the artificial retreats and one or more subsequent visit(s) to check them following an appropriate placement period).
- Requires flexibility to ensure sampling is done under optimal conditions.
- If used in areas where risk of disturbance is high, artificial retreats may be interfered with by wildlife, people or livestock (e.g. chewed up or stood on).
- If left in place for a long time, the vegetation beneath artificial retreats may die.
- Artificial retreats can attract mammalian predators in search of shelter and/or easy access to prey.

- Territoriality (animals defending retreat sites) can reduce the number of animals that will occupy each artificial retreat, resulting in negatively biased counts.
- Not useful for tuatara or frogs.
- Detection probabilities may not be constant (may vary among individuals and species, and are influenced by habitat structure, weather conditions and season).
- Where there is a requirement to capture animals (e.g. in mark-recapture studies), some animals may evade capture, especially where retreats are occupied by multiple individuals and/or sampling is done in warm weather by inexperienced observers.
- Capture probabilities may decline over time (i.e. 'trap-shyness') if checked on successive days, as done in many mark-recapture studies.
- Long-term placement of artificial retreats may alter the distribution, abundance or survival of lizards, meaning that results no longer reflect natural population dynamics.
- Should only be used for monitoring if counts are related to abundance (see 'Herpetofauna: indices of abundance'—docdm-493179) or corrected for detectability (see 'Herpetofauna: population estimates'—docdm-833600).

Suitability for inventory

Artificial retreats can be used for any species that will use surface cover objects. However, the method is not recommended for frogs or tuatara. To date, the best results have been achieved with arboreal geckos on off-shore islands free of introduced mammalian predators, and with terrestrial lizards in open habitats (see 'Case studies'). Some nocturnal gecko species (informally known as the 'brown geckos', e.g. *Hoplodactylus* and *Woodworthia* species) will readily occupy wooden pest control boxes placed on the ground (Hare & Hoare 2005), wedge-shaped plywood boxes mounted in trees (Francke 2005), and closed cell foam covers nailed to tree trunks (Bell 2009). None of the above designs are suitable for *Naultinus* species (commonly known as 'green geckos'), which use dense vegetation as retreat sites (e.g. Hare et al. 2007). Artificial retreats appear to be ineffective in cool, shaded locations, and in habitats where reptiles are difficult to detect and/or present at very low densities. For example, although *Woodworthia* geckos are occasionally encountered in beech (*Nothofagus* spp.) forest in the Eglinton Valley (Fiordland), they have never been found during sporadic checks of 120 plywood boxes mounted at various heights on mature beech trees (C. O'Donnell, unpubl. data 2011).

Artificial retreats should not be used where logistics prevent multiple visits (e.g. one-off surveys of remote off-shore islands). Also, in situations where very large areas must be covered within short time frames (e.g. tenure review surveys of high-country pastoral leases in the South Island, which require properties up to 30,000 ha in size to be surveyed in 3–8 days without regard to weather conditions), time is better spent using alternative methods (e.g. systematic searches).

Suitability for monitoring

This method can potentially be used to monitor all lizard species that consistently use cover objects. However, it is not recommended for low-density populations. Considerable resources may be required to develop and test appropriate sampling designs because the method is still under development. Within New Zealand, only one study has determined optimal conditions for sampling (Hoare et al. 2009) and two studies have rigorously evaluated the suitability of this method for monitoring (notably arriving at different conclusions; Wilson et al. 2007; Lettink et al. 2011).

Population estimates obtained from the analysis of mark-recapture data are the most robust statistics for monitoring abundance (e.g. Lettink et al. 2011), given all assumptions can be met and that sampling is conducted under optimal conditions (e.g. Hoare et al. 2009). For long-term monitoring, permanent placement of artificial retreats should be avoided, unless it can be demonstrated that this does not alter population parameters (Lettink 2007a).

Skills

- The ability to count and identify or capture herpetofauna.
- Alternatively, animals may be photographed (this may be useful to confirm species identity and must be done quickly before they seek cover).
- The ability to record and enter data (Microsoft Excel or other statistical software).
- A basic understanding of statistics.
- See 'Full details of technique and best practice' for more details.

Resources

- One or more skilled observer(s).
- Datasheets/notebooks and pencils.
- GPS to record site locations.
- Stakes and/or flagging tape to mark site locations.
- Artificial retreats.
- Permanent (waterproof) marker to label (number) the artificial retreats.
- Digital thermometer and/or access to records from a nearby weather station.

Additional resources may be required, depending on the nature of the study:

- A means to secure the artificial retreats (e.g. small rocks, pegs or nails).
- Hand sanitiser is useful to prevent spread of *Salmonella* and other pathogens.
- Temporary holding bags (e.g. thin calico/cotton bags).
- Non-toxic permanent markers for individually marking reptiles.
- Animal ethics permits for some techniques (e.g. PIT tagging).
- Installing and checking tree-mounted artificial retreats may require the use of a ladder. If working at heights ≥ 3 m, climbing equipment and a Tree Climbing Certificate are also required. The training is based on the standard operation procedure 'Working at heights: roped tree work (SOP)' (docdm-159363), which is part of the DOC training system.
- Deployment of artificial retreats in tall and dense grassland may require the use of a scrub bar to reduce the length of the grass under the retreats prior to placement to increase detectability of

herpetofauna (e.g. Hoare et al. 2009). This should only be done in warm weather when lizards are active and able to run away when the grass is cut.
- Marking equipment and processing gear (e.g. ruler, Pesola spring balance, weighing bags).

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on your objective. For more information, refer to 'Full details of technique and best practice'. It is recommended that novices obtain training from an expert herpetologist.

Essential attributes

At a minimum, the following should be documented:

- DOC staff must complete a 'Standard inventory and monitoring project plan' (docdm-146272).
- For all herpetofauna, New Zealand Amphibian/Reptile Distribution Scheme (ARDS) cards should be completed and forwarded to the Herpetofauna Administrator (address shown on ARDS card; Fig. 1).[1] Thorough, tidy and clear data entry is vital. Photos (clearly depicting the dorsal, ventral and lateral surfaces of the animal, including close-ups of the head) should be included where species identity is not 100% certain.

At a minimum, the following data should be recorded:

- Observer and/or recorder.
- Date and time.
- Location name/grid reference.
- Weather conditions, particularly ambient (shade air) temperatures recorded 1 m above the ground at the start and end of each sampling session. Alternatively, it may be possible to obtain this information retrospectively if there is access to weather records from a nearby weather station.
- Artificial retreat number.
- Number of individuals of each species present in/under each artificial retreat (including any escapes and zeros if none are present).

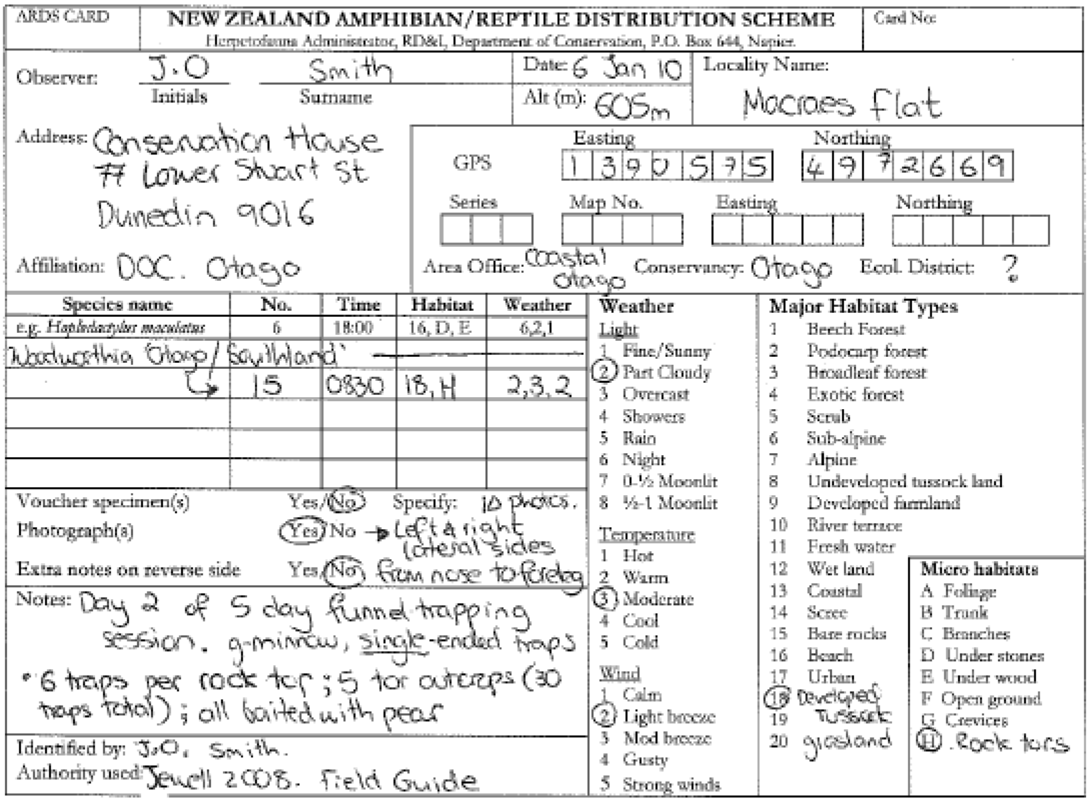
Optional attributes

Depending on the aims of the study, it may be useful to record other information:

- Habitat and micro-habitat characteristics (e.g. altitude, aspect, vegetation description, amount and composition of natural cover surrounding each retreat)

[1] The ARDS card is available online: http://www.doc.govt.nz/conservation/native-animals/reptiles-and-frogs/reptiles-and-frogs-distribution-information/species-sightings-and-data-management/report-a-sighting/

- Additional weather variables (e.g. relative humidity, overnight minimum temperature, daytime maximum temperature, precipitation, cloud cover, wind direction and strength)
- Individual morphological measurements (snout-vent length and vent-tail length (in mm, include regeneration), mass (g) and records of natural toe-loss)
- Sex of mature individuals
- Reproductive status of females (pregnant/gravid or not gravid)



ARDS CARD | NEW ZEALAND AMPHIBIAN/REPTILE DISTRIBUTION SCHEME | Card No:

Herpetofauna Administrator, RD&I, Department of Conservation, P.O. Box 644, Napier.

Observer: J.O (Initials) Smith (Surname) | Date: 6 Jan 10 | Alt (m): 605m | Locality Name: Macraes Flat

Address: Conservation House, 77 Lower Stuart St, Dunedin 9016

GPS Easting: 1390575 Northing: 4972669

Series | Map No. | Easting | Northing

Affiliation: DOC. Otago | Area Office: Coastal Otago | Conservancy: Otago | Ecol. District: ?

Species name	No.	Time	Habitat	Weather
e.g. *Hoplodactylus maculatus*	6	18:00	16, D, E	6,2,1
Woodworthia 'Otago/Southland'				
↳	15	0830	18, H	2,3,2

Voucher specimen(s) Yes/(No) Specify: 10 photos, left & right lateral sides

Photograph(s) (Yes)/No

Extra notes on reverse side Yes/(No) from nose to feet/leg

Notes: Day 2 of 5 day funnel trapping session. g-minnow, single-ended traps
• 6 traps per rock tor; 5 tor outcrops (30 traps total); all baited with pear

Identified by: J.O. Smith.

Authority used: Jewell 2008. Field Guide

Weather — Light: 1 Fine/Sunny, (2) Part Cloudy, 3 Overcast, 4 Showers, 5 Rain, 6 Night, 7 0-½ Moonlit, 8 ½-1 Moonlit

Temperature: 1 Hot, 2 Warm, (3) Moderate, 4 Cool, 5 Cold

Wind: 1 Calm, (2) Light breeze, 3 Mod breeze, 4 Gusty, 5 Strong winds

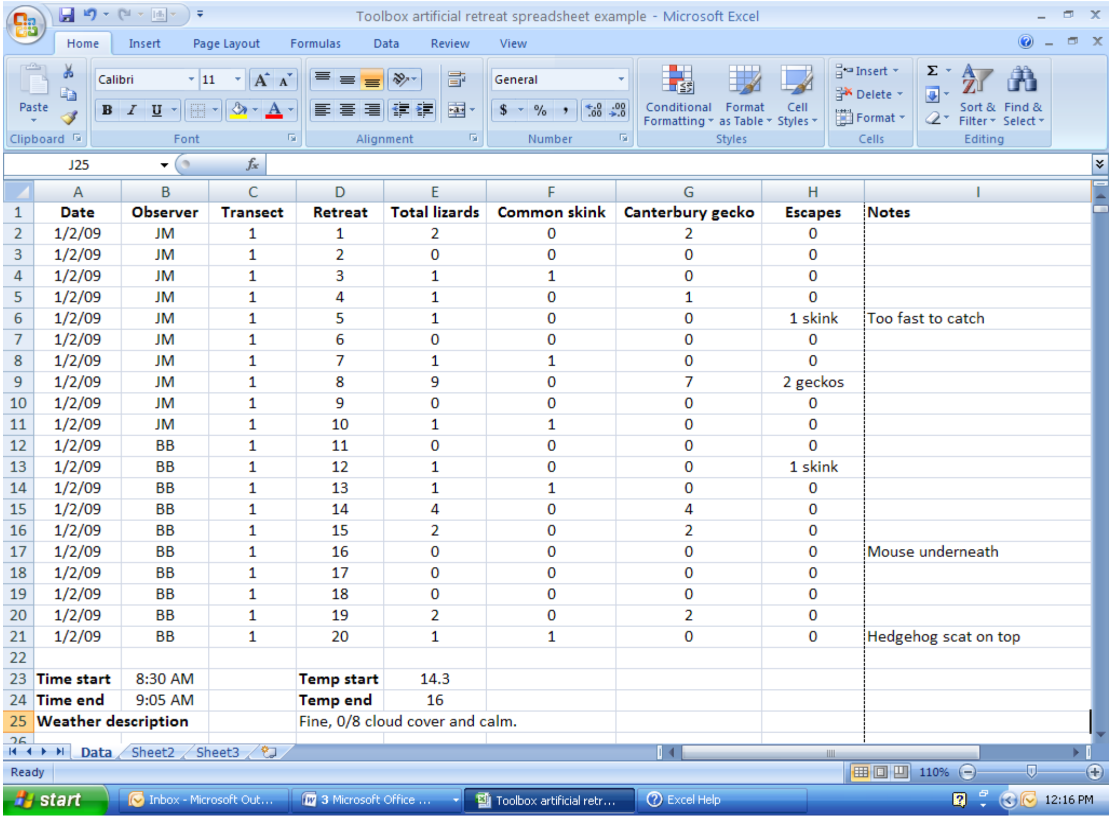
Major Habitat Types: 1 Beech Forest, 2 Podocarp forest, 3 Broadleaf forest, 4 Exotic forest, 5 Scrub, 6 Sub-alpine, 7 Alpine, 8 Undeveloped tussock land, 9 Developed farmland, 10 River terrace, 11 Fresh water, 12 Wet land, 13 Coastal, 14 Scree, 15 Bare rocks, 16 Beach, 17 Urban, (18) Developed tussock grassland, 19, 20

Micro habitats: A Foliage, B Trunk, C Branches, D Under stones, E Under wood, F Open ground, G Crevices, (H) Rock tors

Figure 1. Example of how to fill in a New Zealand Amphibian/Reptile Distribution Scheme (ARDS) card. Note that either a GPS location or a map series number is sufficient. Also, try not to leave blank spaces—instead leave an indication that those data were not available or collected. If further notes are collected these can be included under 'Notes', and continue on the back of the page if necessary.

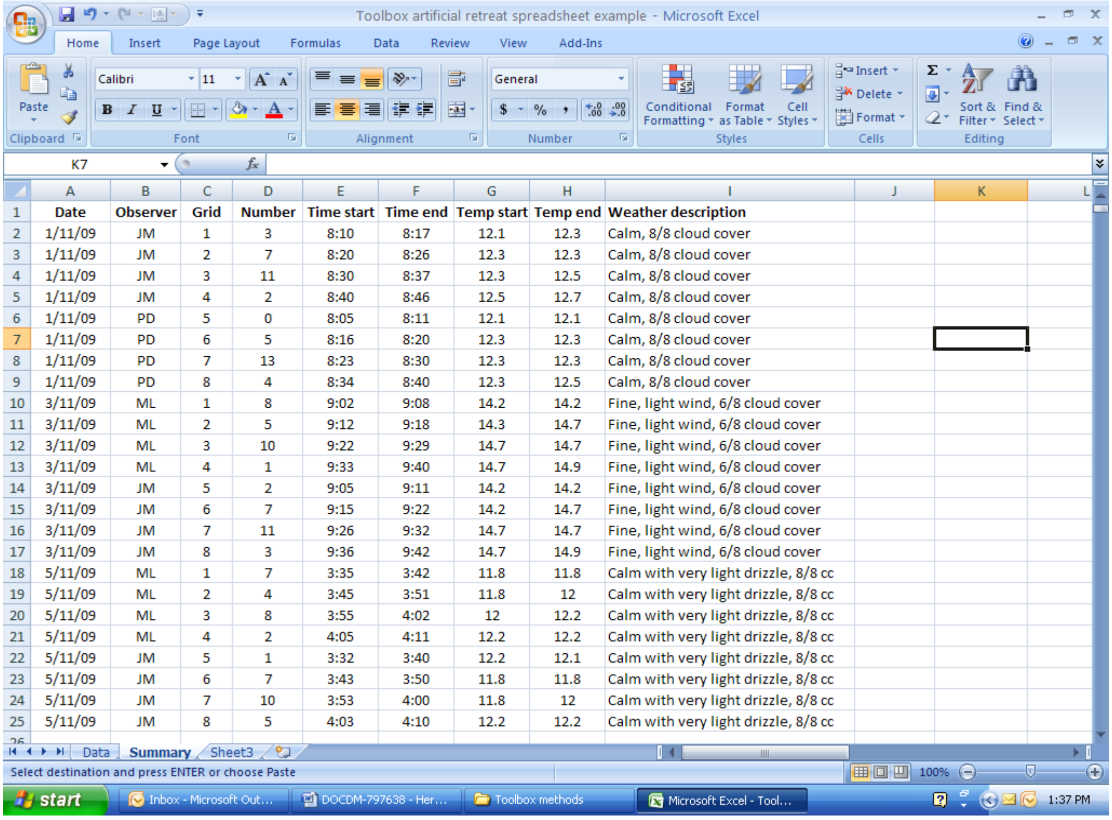
Data storage

The following instructions should be followed when storing data obtained from this method. Forward copies of completed survey sheets to the survey administrator, or enter data into an appropriate spreadsheet as soon as possible. Collate, consolidate and store survey information securely, also as soon as possible, and preferably immediately on return from the field. The key steps here are data entry, storage and maintenance for later analysis, followed by copying and data backup for security. Summarise the results in a spreadsheet or equivalent. Arrange data as 'column variables'—i.e. arrange data from each field on the data sheet (date, time, location, plot designation, number seen, identity, etc.) in columns, with each row representing the occasion on which a given survey plot was sampled. Below are examples of spreadsheets with data collected from one transect containing 25 artificial retreats (Fig. 2) and a summary of data collected from eight sampling grids (Fig. 3).



	A	B	C	D	E	F	G	H	I
1	**Date**	**Observer**	**Transect**	**Retreat**	**Total lizards**	**Common skink**	**Canterbury gecko**	**Escapes**	**Notes**
2	1/2/09	JM	1	1	2	0	2	0	
3	1/2/09	JM	1	2	0	0	0	0	
4	1/2/09	JM	1	3	1	1	0	0	
5	1/2/09	JM	1	4	1	0	1	0	
6	1/2/09	JM	1	5	1	0	0	1 skink	Too fast to catch
7	1/2/09	JM	1	6	0	0	0	0	
8	1/2/09	JM	1	7	1	1	0	0	
9	1/2/09	JM	1	8	9	0	7	2 geckos	
10	1/2/09	JM	1	9	0	0	0	0	
11	1/2/09	JM	1	10	1	1	0	0	
12	1/2/09	BB	1	11	0	0	0	0	
13	1/2/09	BB	1	12	1	0	0	1 skink	
14	1/2/09	BB	1	13	1	1	0	0	
15	1/2/09	BB	1	14	4	0	4	0	
16	1/2/09	BB	1	15	2	0	2	0	
17	1/2/09	BB	1	16	0	0	0	0	Mouse underneath
18	1/2/09	BB	1	17	0	0	0	0	
19	1/2/09	BB	1	18	0	0	0	0	
20	1/2/09	BB	1	19	2	0	2	0	
21	1/2/09	BB	1	20	1	1	0	0	Hedgehog scat on top
22									
23	**Time start**	8:30 AM		**Temp start**	14.3				
24	**Time end**	9:05 AM		**Temp end**	16				
25	**Weather description**			Fine, 0/8 cloud cover and calm.					

Figure 2. Excel spreadsheet containing lizard data collected from one transect containing 25 artificial retreats. The 'Notes' column should be used to record any interesting observations, such as the presence of lizard predators and/or their sign.



Date	Observer	Grid	Number	Time start	Time end	Temp start	Temp end	Weather description
1/11/09	JM	1	3	8:10	8:17	12.1	12.3	Calm, 8/8 cloud cover
1/11/09	JM	2	7	8:20	8:26	12.3	12.3	Calm, 8/8 cloud cover
1/11/09	JM	3	11	8:30	8:37	12.3	12.5	Calm, 8/8 cloud cover
1/11/09	JM	4	2	8:40	8:46	12.5	12.7	Calm, 8/8 cloud cover
1/11/09	PD	5	0	8:05	8:11	12.1	12.1	Calm, 8/8 cloud cover
1/11/09	PD	6	5	8:16	8:20	12.3	12.3	Calm, 8/8 cloud cover
1/11/09	PD	7	13	8:23	8:30	12.3	12.3	Calm, 8/8 cloud cover
1/11/09	PD	8	4	8:34	8:40	12.3	12.5	Calm, 8/8 cloud cover
3/11/09	ML	1	8	9:02	9:08	14.2	14.2	Fine, light wind, 6/8 cloud cover
3/11/09	ML	2	5	9:12	9:18	14.3	14.7	Fine, light wind, 6/8 cloud cover
3/11/09	ML	3	10	9:22	9:29	14.7	14.7	Fine, light wind, 6/8 cloud cover
3/11/09	ML	4	1	9:33	9:40	14.7	14.9	Fine, light wind, 6/8 cloud cover
3/11/09	JM	5	2	9:05	9:11	14.2	14.2	Fine, light wind, 6/8 cloud cover
3/11/09	JM	6	7	9:15	9:22	14.2	14.7	Fine, light wind, 6/8 cloud cover
3/11/09	JM	7	11	9:26	9:32	14.7	14.7	Fine, light wind, 6/8 cloud cover
3/11/09	JM	8	3	9:36	9:42	14.7	14.9	Fine, light wind, 6/8 cloud cover
5/11/09	ML	1	7	3:35	3:42	11.8	11.8	Calm with very light drizzle, 8/8 cc
5/11/09	ML	2	4	3:45	3:51	11.8	12	Calm with very light drizzle, 8/8 cc
5/11/09	ML	3	8	3:55	4:02	12	12.2	Calm with very light drizzle, 8/8 cc
5/11/09	ML	4	2	4:05	4:11	12.2	12.2	Calm with very light drizzle, 8/8 cc
5/11/09	JM	5	1	3:32	3:40	12.2	12.1	Calm with very light drizzle, 8/8 cc
5/11/09	JM	6	7	3:43	3:50	11.8	11.8	Calm with very light drizzle, 8/8 cc
5/11/09	JM	7	10	3:53	4:00	11.8	12	Calm with very light drizzle, 8/8 cc
5/11/09	JM	8	5	4:03	4:10	12.2	12.2	Calm with very light drizzle, 8/8 cc

Figure 3. Excel spreadsheet containing summarised lizard data (skink sightings) collected from eight sampling grids.

If data storage is designed well at the outset, it will make the job of analysis and interpretation much easier. Before storing data, check for missing information and errors, and ensure metadata are recorded.

Storage tools can be either manual or electronic systems (or both, preferably). They will usually be summary sheets, other physical filing systems, or electronic spreadsheets and databases. Use appropriate file formats such as .xls, .txt, .dbf or specific analysis software formats. Copy and/or backup all data, whether electronic, data sheets, metadata or site access descriptions, preferably off-line if the primary storage location is part of a networked system. Store the copy at a separate location for security purposes.

Analysis, interpretation and reporting

Standardised analysis and interpretation allows comparisons to be made at different sites and at different times. Follow these instructions when analysing and interpreting data:

- Summarise the number of individuals of each species found at each site.
- For each new site, fill out a separate ARDS card with the above information and submit this to the Herpetofauna Administrator.[2]

[2] The ARDS card is available online: http://www.doc.govt.nz/conservation/native-animals/reptiles-and-frogs/reptiles-and-frogs-distribution-information/species-sightings-and-data-management/report-a-sighting/

- Analytical protocols are not covered in this section. If using artificial retreats for monitoring, seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis.
- Report results in a timely manner (usually within a year of the data collection).

Case study A

Case study A: artificial retreats for arboreal lizards

Synopsis

Bell (2009) compared the effectiveness of closed cell foam covers (as artificial retreats nailed to trees and branches) with that of the following methods used for detecting cryptic lizard species living in forests:

- Tree-mounted 'lizard houses' based on the plywood box design of Francke (2005)
- Spotlighting with hand-held torches
- Funnel traps
- Pitfall traps
- Onduline artificial retreats (see 'Case study B')

Lizards living in forests use bark and tree hollows as refuges. It was therefore anticipated that they would also use foam covers nailed to tree trunks and branches. The overall aim of this study was to develop a method that would increase detectability of cryptic lizard species living in forests (hereafter 'forest lizards').

Objectives

- To determine if forest lizards would use foam covers
- To compare detection rates from foam covers to that of other field methods

Sampling design and methods

Sampling was undertaken at three sites used for ecological restoration: (1) Fanal Island, a 73-ha pest-mammal-free wildlife sanctuary in the Mokohinau Island Group; (2) the Windy Hill Pest Management Project on Great Barrier Island, a 270-ha site where intensive pest-mammal control has been undertaken since 1999; (3) Zealandia (formerly Karori Sanctuary), a 230-ha pest-exclusion fenced sanctuary in Wellington. At each site, at least 80 foam covers of various dimensions were nailed to trees along transects or in grids. The foam covers were checked approximately 1 year later (by peeling them off the trunk through the nail holes and pushing the cover back into place afterwards). Occupancy rates were calculated by dividing the number of lizards found at each site by the number of covers. These rates were then compared to occupancy, capture or catch-per-unit-effort (CPUE) measures obtained using plywood boxes, spotlighting, funnel traps, pitfall traps and Onduline artificial retreats. CPUE was calculated by dividing the total number of lizards encountered by the number of sampling devices. To provide an example, five lizards caught in 10 traps set for 2 nights (i.e. 20 trap nights) would give a CPUE of 5 divided by 20 = 0.25.

Results

Three species of gecko were encountered under foam covers (Duvaucel's gecko *Hoplodactylus duvaucelii*, Pacific gecko *Dactylocnemis pacificus* and forest gecko *Mokopirirakau granulatus*). Gecko occupancy of foam covers was highest on Fanal Island (0.39; *n* = 31 geckos recorded from 80 covers), followed by Windy Hill (0.04; *n* = 7 geckos from 196 covers), and lowest at Zealandia (0.02; *n* = 4 geckos from 226 covers). Skinks were not encountered under foam covers. Pitfall trapping was the most effective method for detecting lizards on Fanal Island and at Zealandia, as indicated by CPUE for all species combined (note: this was calculated retrospectively from information in Table 1 in Bell (2009), who came to different conclusions because he omitted skinks from his calculations). CPUE for pitfall traps (all species combined) was 0.42 on Fanal Island (*n* = 14 skinks caught over 33 trap nights) and 0.59 at Zealandia (*n* = 48 skinks caught over 81 trap days). Pitfall trapping was not conducted at Windy Hill. At that site, Onduline artificial retreats returned the greatest occupancy/CPUE (0.45; 9 skinks caught over 20 trap nights). Foam covers and spotlighting proved the most effective sampling methods for detecting geckos (i.e. excluding skinks from analyses). The statistics given for these methods are not directly comparable for reasons outlined below.

Limitations and points to consider

Limitations:

- Not all field methods were used at each site. For example, lizard houses were not used on Fanal Island or at Windy Hill.
- Sampling effort was not standardised within or among sites (e.g. inconsistencies in the number of sampling devices used, sampling areas and timing of sampling).
- The influence of weather conditions on detection rates was not considered.
- Some of the time-based comparisons were not valid because they compared CPUE from instantaneous sampling (e.g. number of geckos encountered per person-hour of spotlighting) with occupancy rates from artificial retreats (e.g. number of geckos found per person-hour spent checking foam covers) that did not include the substantial amount of time required to install the covers (7 h for 80 covers).
- The 'spotlighting' technique of Bell (2009) involved searching for emerged animals at night with hand-held torches. This is less effective than the spotlighting technique pioneered by Tony Whitaker. That method entails using a custom-made binocular-mounted spotlight and is more effective because it enables detection of geckos over distances of up to 100 m (Whitaker 1994).
- The study drew conclusions about the suitability of foam covers for monitoring when it only demonstrated their use as a detection method.

Point to consider:

- Foam covers appear to be ineffective at sites with low lizard densities.
- Deploying foam covers 1 year before sampling may not be feasible or cost-effective where other methods can be used to provide instantaneous results.
- Even within a year, the placement of foam covers could alter the distribution of animals (e.g. geckos may abandon natural retreat sites in favour of foam covers).
- There were a number of escapes from foam covers (e.g. four of the seven geckos encountered at Windy Hill evaded capture). Capture rates could be improved by using multiple observers with lizard-handling experience.
- Methods that require animals to be active and/or emerged (e.g. spotlighting, funnel traps, pitfall traps) may require different sampling conditions than methods that rely on inactive animals being located within their retreat sites.
- Bell (2009) concluded that 'pitfall trapping and Onduline artificial covers were biased towards terrestrial skinks'. By the same reasoning, foam covers could be said to be biased towards arboreal geckos. However, it would be incorrect to make either claim: all comparisons made in this study remain relative because actual abundance was not determined for any species.
- Bell (2009) also identified and counted macro-invertebrates found under foam covers. This is worth documenting, as it can reveal the presence of noteworthy species (e.g. peripatus *Peripatoides novaezealandiae*).

References for case study A

Bell, T.P. 2009: A novel technique for monitoring highly cryptic lizard species in forests. *Herpetological Conservation and Biology 4*: 415–425.

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Case study B

Case study B: artificial retreats for terrestrial lizards

Synopsis

Lettink & Cree (2007) compared the relative use of three artificial retreat designs by terrestrial lizards in coastal shrubland near Birdlings Flat, Canterbury. Two sampling grids consisting of 90 artificial retreats each (30 of each design) were checked monthly for a 1-year period. Pitfall traps were operated at the same sites. Use of artificial retreats by skinks (McCann's skink *Oligosoma maccanni* and common skink *O. polychroma*) and geckos (Canterbury gecko *Woodworthia brunneus*) showed seasonal variation and was lowest in winter. Skinks did not discriminate between the different designs, but geckos strongly preferred the Onduline design. Captures from artificial retreats were dominated by geckos and those from pitfall traps were dominated by skinks. The researchers recommended their Onduline artificial retreat design for detection of terrestrial geckos in open habitats. They also suggested it may have merit for skinks.

Objectives

- To test whether use of artificial retreats by lizards was influenced by retreat design, time-of-year and site
- To compare sample characteristics of lizards (species, size, and sex) caught from artificial retreats with those captured in pitfall traps

Sampling design and methods

Two sampling grids, each containing 30 clusters of the three retreat designs spaced 5 m apart in a 5 × 6 grid, were deployed in coastal shrubland near Birdlings Flat. The three retreat designs were: (1) a triple-layered Onduline stack, made up of three 400 mm × 280 mm sheets separated by small (short lengths of 10-mm diameter pine dowel) spacers; (2) a triple-layered corrugated iron stack, made up of 450 mm × 230 mm sheets set up with small spacers; and (3) a single 390 mm × 320 mm concrete roofing tile (Fig. 4). Iron and Onduline stacks were weighed down small rocks.

Figure 4. Artificial retreats designs tested by Lettink & Cree (2007): (1) concrete roofing tile; (2) triple-layered Onduline stack; (3) triple-layered corrugated iron stack (photo: Marieke Lettink).

After a ‘settling-in’ period of 6 weeks, artificial retreats were checked monthly under standardised conditions (early in the morning under an overcast sky with cool or cold ambient temperatures, usually ≤ 15°C at the start of capture sessions). Animals were caught by hand, processed (marked, measured, sexed (adults only) and weighed) and returned to their original capture locations in the re-assembled retreats. Pitfall trapping was also done on a monthly basis, with sampling being offset by 2 weeks from the artificial retreat checks. This was done to obtain independent samples (had the methods been used simultaneously, any animals caught in pitfall traps would not have been available to occupy artificial retreats).

Artificial retreat data were analysed using species-specific generalised linear mixed models (GLMMs). These models included 'retreat use' (number of lizards per artificial retreat encountered during each check) as the response variable, and time-of-year (month), trapping grid (A or B) and retreat design (Onduline, corrugated iron or concrete tile) as the predictor variables. Because artificial retreats were clustered in groups of three, a random effect ('retreat station') was also included in the GLMMs. Chi-square analysis was used to compare sample characteristics (species, size and sex distributions) obtained from artificial retreats versus pitfall traps.

Results

A total of 898 captures of 388 individual lizards of three species were made during 2160 retreat checks (i.e. 180 artificial retreats × 12 monthly checks). The majority (82.2%) of captures were of Canterbury geckos. Geckos were commonly encountered in pairs or groups and showed a strong preference for the Onduline design (81.6% of captures). Within multi-layered retreats, geckos favoured the spaces between the top two layers to the space between the bottom layer and the ground. Common and McCann's skinks did not favour any particular design and were usually encountered alone. All species used artificial retreats infrequently during the winter months. Artificial retreats yielded gecko-dominated samples, whereas pitfall traps produced skink-dominated samples. There were no differences in the relative size-class distributions between the methods and minor differences observed in sex ratios.

Limitations and points to consider

Limitations:

- Artificial retreats were only used in one habitat type (shrubland).
- The study did not test the influence of climate variables on capture rates.
- The triple-layered Onduline and corrugated iron retreat designs provided approximately three times the surface area of the single-layered concrete tiles. Making all designs either single- or triple-layered would have provided a better comparison. Alternatively, differences in the relative surface areas of the three retreat designs could have been corrected for in the analysis.
- Because this study required the physical capture of animals, capture sessions were undertaken early in the day under cool conditions and overcast skies to minimise the risk of escapes. Despite this, some animals (< 5% of the total) were still able to evade capture.

Points to consider:

- A direct comparison of the effectiveness of the two methods in terms of CPUE (i.e. number of animals/the number of sampling devices) was not done because it was not considered possible to effectively standardise sampling effort. Ideally, this would require sampling the same area simultaneously with both methods, using the same number of sampling devices, a standardised placement period, and consistent use of bait (i.e. used for both or neither method). Even then, results would not be directly comparable, because pitfall trap captures are cumulative (usually the number of lizards caught over 24 h), whereas captures from artificial retreats merely reflect the number of animals that happen to be occupying a retreat at the exact time when it is checked.

- Large animals can chew, stand or lie on artificial retreats, potentially injuring or killing resident herpetofauna. In this study, a temporary electric fence had to be installed around each grid when cattle were present (both sites were used for winter grazing). In another study where exclusion fencing was not used, resident horses ate/destroyed Onduline artificial retreats positioned in vegetation in an attempt to attract arboreal geckos (R. Muller, pers. comm.).
- Long-term placement of artificial retreats can attract predators. One year after this study had finished (i.e. approximately 2 years following their initial deployment), time-lapse video recorders were set up near two artificial retreats known to be intensively used by lizards. The video footage revealed regular visits by neighbouring domestic cats. One cat returned seven times over a 24-h period, each time quietly sitting and watching the artificial retreat, and on one occasion making an (unsuccessful) pounce (Lettink & Bowie, unpubl. data 2008).
- The three retreat designs have different heat-retaining properties. Although it was expected that geckos preferred the Onduline design because of its thermal properties, structural properties were found to be more important in retreat-site selection experiments conducted in captivity (Thierry et al. 2009).
- Skinks did not favour any particular design in this and another study (Thierry et al. 2009). However, logistics favour the use of Onduline design because corrugated iron is difficult to cut to size (requires use of a circular saw with a metal-cutting blade, leaving razor-sharp edges) and concrete tiles are heavy.

References for case study B

Lettink, M.; Cree, A. 2007: Relative use of three types of artificial retreats by terrestrial lizards in grazed coastal shrubland, New Zealand. *Applied Herpetology 4*: 227–243.

Thierry, A.; Lettink, M.; Besson, A.A.; Cree, A. 2009: Thermal properties of artificial refuges and their implications for retreat-site selection in lizards. *Applied Herpetology 6*: 307–326.

Full details of technique and best practice

This section applies only to lizards because the method is not currently used for tuatara or frogs.

Background preparation

Depending on the methods used, field work may require DOC Animal Ethics Committee (AEC) approval and a Wildlife Act permit. AEC approval is usually needed where there is a requirement for animals to be permanently marked (e.g. by toe-clipping or PIT-tagging). The AEC meet infrequently; hence, it is prudent to apply 6 months prior to the commencement of field work. DOC staff may capture, handle and measure herpetofauna without permits, and tail-tipping (for genetic sampling) is covered by a standard operating procedure (‘Sampling avian blood and feathers, and reptilian tissue (SOP)’—docdm-531081). For the above activities, a ‘Low Impact Research & Collection’ permit is sufficient. The application form can be downloaded from the DOC website and is usually processed within 6 weeks.[3] The processing fee may be waived if the work is of benefit to DOC. People with no experience handling herpetofauna will require training by an experienced practitioner if this is required for the study. Training should be completed before the start of any field work.

Sampling design

Artificial retreats are usually laid out in grids or transect lines, depending on the aims of the study. Transects tend to provide greater coverage of an area, while grids are more suitable for detailed studies of animal movements and densities at particular sites. The choice of layout may be constrained by size, shape and accessibility of the study area. For example, herpetofauna living in cobble strand along the foreshore tend to be sampled with transects rather than grids due to the linear shape of the habitat.

For inventory without prior knowledge of species’ presence and distribution, artificial retreats should be set up in transects to maximise coverage. There is no minimum number of artificial retreats that should be used, but more is generally better as this will increase detectability. A minimum of 5–10 transects containing 10 artificial retreats each is recommended, with transects spaced at least 100 m apart. Retreats should be spaced at least 5 m apart for small species and 10–20 m for large species or a mixture of both sizes. Alternatively, where herpetofaunal habitat is known to be limited in size or shape (e.g. diurnal skinks may be restricted to grassy clearings or river margins in a forest), artificial retreats should be concentrated in the area or habitat of interest. In some situations, it may be desirable to deliberately position artificial retreats next to microhabitat features known to be important to herpetofauna (‘micro-siting’) to maximise detectability. For example, artificial retreats in rocky habitats may be deliberately positioned next to crevices with lizard sign (faeces and/or sloughed skins) and/or in areas with fruit-bearing vines that provide an important food source for lizards (Lettink 2007b).

For monitoring, artificial retreats may be deployed in transects or grids. A biometrician or suitably experienced person should be consulted to develop monitoring protocols because the method is still in development. Study designs should always include random allocation of sampling units (usually transects or grids) within the habitat(s) of interest and replication (i.e. multiple sampling units). The optimal number of sampling units, artificial retreats and spacing will depend on the aims of the study, and vary among and within species depending on their density. Studies conducted to date on small terrestrial species in open habitats have used grids of 16 artificial retreats spaced 5 m apart in a 4 × 4 configuration (i.e. four rows and four columns containing four artificial retreats each; Wilson et al. 2007) or 25 artificial retreats spaced 2 m apart in a 5 × 5 pattern (Lettink et al. 2011).

[3] http://www.doc.govt.nz/about-doc/concessions-and-permits/research-collection-and-wildlife-permits/application-forms/

In these studies, the number of sampling units (grids) were six per habitat type (gully or ridge; Wilson et al. 2007) and eight, all in one habitat (grassland; Lettink et al. 2011).

For population estimates, grids are preferable to transects and using optimal spacing is crucial. As a general guide, there should be at least one (and ideally several) artificial retreats within an individual’s home range to maximise capture rates. If home range estimates (usually reported as home range lengths) are not available, spacing may be determined from average movements instead. These are calculated from telemetry studies or by averaging the distances between successive captures of marked individuals in a trapping grid. At high lizard densities, spacing may need to be reduced further to maximise capture rates. For example, Lettink et al. (2011) reduced spacing from 4 m to 2 m to increase capture rates of common skinks (*Oligosoma polychroma*) in the Eglinton Valley, Fiordland. Similarly, Wilson et al. (2007) found that their 5-m spacing was excessive for sampling skinks at Macraes Flat, Otago, and recommended 3-m spacing for future studies. A pilot study may be required to determine optimal trap spacing and sampling design for monitoring, particularly where there is little or no information available about the study species.

Placement period and sampling frequency

Artificial retreats should be deployed at least 1–3 months before their first check, excluding the winter months where there is little or no herpetofaunal activity. Some species tend to have strong attachments to specific natural retreats (e.g. terrestrial *Woodworthia* geckos favour dry and narrow rock crevices that exclude predators). Consequently, it will take longer for them to start using artificial retreats. For such species, the placement period should be at least 3 months. Permanent placement is generally not recommended, unless it can be shown that this does not alter population parameters. For long-term monitoring, sampling should be conducted at the same time each year following a standardised placement period, after which the artificial retreats are removed and replaced before the next sampling session (e.g. Lettink et al. 2011).

Artificial retreats should be checked no more than once per day and less often in mark-recapture studies. Successive daily checks can induce a negative ‘trap response’ (i.e. reduce the number of animals present over time; Lettink 2007a, Wilson et al. 2007), though this may be avoided if animals are simply counted and not handled (e.g. Hoare et al. 2009).

Optimal sampling conditions

Artificial retreat designs that readily absorb solar radiation and are used in open habitats (e.g. Onduline artificial retreats) will vary in their attractiveness to herpetofauna depending on the prevailing weather conditions. For example, counts of common skinks in the Eglinton Valley were found to be highest and least variable at moderate ambient temperatures (12–18°C), during light or no rain, and at low levels of relative humidity (Hoare et al. 2009). Optimal conditions will vary among species and between habitats, making it difficult to provide generic recommendations. In general, artificial retreats should not be checked at extremes of temperatures (< 5°C and > 25°C) or during winter months when occupancy is low. If there is a requirement to physically capture animals, sampling is best done on overcast days at moderate temperatures (≤ 15°C) to minimise escapes (Lettink & Cree 2007).

Artificial retreat designs for arboreal lizards

Two designs have been used for arboreal lizards in New Zealand: closed cell foam covers (see 'Case study A') and plywood boxes (Fig. 5). These designs are known to be effective for detecting *Hoplodactylus* and *Woodworthia* geckos on islands free of mammalian predators (Francke 2005; Bell 2009). However, they appear to be ineffective in areas with low lizard densities and are not used by some species (e.g. *Naultinus* geckos; R. Muller, pers. comm.). Skinks have occasionally been found when checking foam covers (Bell 2009), suggesting that they may be useful for detecting arboreal species (e.g. striped skink *Oligosoma striatum*). Construction details are described in Francke (2005) and Bell (2009).

Figure 5. Closed cell foam cover (left) and plywood box (right) mounted on trees. These designs were developed by Bell (2009) and Francke (2005), respectively (photos: Marieke Lettink).

Artificial retreat designs for terrestrial lizards

Terrestrial lizards are commonly sampled with Onduline artificial retreats (see **'**Case study B**'**, Lettink 2007a,b,c; Wilson et al. 2007; Hoare et al. 2009, Thierry et al. 2009; Lettink et al. 2011). For skinks, it is generally sufficient to have one layer, whereas multiple (two or three) layers should be used for terrestrial geckos, particularly for *Woodworthia* species (Fig. 6). Minimum size should be 400 mm × 280 mm. Larger (670 mm × 420 mm) artificial retreats have also been used (e.g. Hoare et al 2009; Lettink et al. 2011). Artificial retreats need to be secured with pegs (requires pre-drilling of holes) or small rocks if there is a possibility that they could get blown away. Large rocks should not be used because they will indent and permanently misshape the Onduline. Onduline is not suitable for long-term use in permanently moist environments because mould tends to accumulate underneath.

Onduline can be purchased from a number of sites (see www.onduline.co.nz for a local supplier). Full-sized sheets are 2 m × 950 mm and available in four colours (red, green, brown and black). While sheets can be cut to size with a hand saw, it is much easier to use a circular (skill) saw, which can cut stacks of five sheets simultaneously (or ask the supplier to cut it to size; this may require a small fee). Length-wise cuts should follow the troughs of the corrugations, making sure that the material is the right way up when it is cut (i.e. with the coloured and waterproof side facing up). To create multi-layered Onduline retreats, short (1–2 cm) lengths of 10-mm circular pine dowel are glued under the top sheets (see Lettink & Cree 2007).

Figure 6. Checking a multi-layered Onduline artificial retreat. Small rocks were used to secure the retreat (left). Lifting the top sheet revealed a large group of geckos (right; photos: Marieke Lettink).

Counting animals

Artificial retreats should be approached quietly. It may be of interest to look for animals basking on top or in the vicinity of artificial retreats by using binoculars and/or the naked eye. The way in which artificial retreats are checked will depend on their construction. Foam covers are checked by peeling the foam back and away from the nails; plywood boxes by unscrewing and lifting the hinged lid upwards; and Onduline retreats by sequential over-turning of the layers. Observers should note the number and species found in/under each artificial retreat, taking care to return the retreat to its original position without harming (squashing) any animals present. For most studies, sightings (rather than captures) of animals will be sufficient. However, hand-capture may be required to confirm species identification or when checking tree-mounted retreats that are positioned high off the ground and open in such a way that there is a risk of animals falling to the ground. Hand-capture will also be required for population estimation using mark-recapture methods (see 'Herpetofauna: population estimates'—docdm-833600).

Capturing and processing animals

Multiple observers are useful if there is a requirement to capture animals: one person should carefully disassemble the artificial retreat while the other(s) stand by ready to hand-catch any animal(s) present. *It is crucial that this does not harm the animal.* This could happen by inexperienced observers being too 'heavy-handed', attempting to capture too many animals at once, or by accidentally squashing animals that evade capture and seek cover nearby (e.g. lizards may run and hide under the boot of the nearest person). Observers should never attempt to capture a lizard by its tail because this will induce caudal autotomy (the tail being dropped through the severing of tissue at a pre-determined fracture plane in the tail). Animals should be released at their point of capture after the artificial retreats have been re-assembled.

Unless lizards can be processed immediately, it is best to temporarily store them in breathable cloth bags firmly tied at the top with cord. Lizards should not be handled for longer than necessary and bags containing lizards should never be left in the sun: both can induce heat stress and result in lizard deaths. It is generally best to use one bag per animal, the exception being for pairs/groups of geckos that are found together (though adult males of any species should never be confined together). As a minimum, lizards should be identified to species and released beside the (re-assembled) artificial retreat they were caught from. If there is any doubt about species identity, photographs should be taken of the dorsal, ventral and lateral surfaces (including close-ups of the head) and sent to an expert for identification.

Other useful attributes to record include size measurements (snout-vent length, vent-tail length and the length of tail regeneration if present; all in mm using a clear plastic ruler), sex of mature individuals (see 'Sex identification of lizards' below), reproductive status of mature females (see 'Determining reproductive status of female lizards' below) and mass (in grams using a Pesola spring balance or small portable scales). Animals may be weighed in small zip-lock bags, making sure to subtract the weight of the empty bag afterwards. Hands-on training by an experienced person is the best way to gain lizard handling and processing skills.

Sex identification of lizards

Geckos

Some species of geckos (or populations of species) have external sexual colour-dimorphism (see Jewell 2008 with corrections in Chapple & Hitchmough 2009 for details). Sex of all mature geckos can be easily identified—males have externally visible hemipenial sacs and femoral pores; females have no visible sacs or femoral pores (Fig. 7). The sex of immature geckos cannot be easily identified.

Skinks

Accurate sex identification of mature *Oligosoma* skinks is relatively straightforward as hemipenes (the paired intromittent organs) are easily everted in males, particularly during the mating season in late summer/early autumn (Molinia et al. 2010). Pregnant/gravid adult females are also easily diagnosed via abdominal palpation (see 'Determining reproductive status of female lizards' below; Holmes & Cree 2006) coupled with negative hemipenial eversion. However, for most juvenile *Oligosoma* skinks hemipenial eversion is not a reliable method of sex identification (Hare & Cree 2010, but see Hare et al. 2002). Hemipenial eversion requires training from an expert as incorrect technique can damage the lizard.

Determining reproductive status of female lizards

This section is only relevant during the breeding season when females are pregnant/gravid. Gentle palpation of the abdomen of females can provide an accurate assessment of reproductive status and often the number of embryos/eggs (e.g. skinks, Hare et al. 2010; geckos, Cree & Guillette 1995). However, palpation should *only* be used after training has been received from an expert due to the potential to rupture eggs/embryos (Gartrell et al. 2002). Always seek appropriate training and expert help.

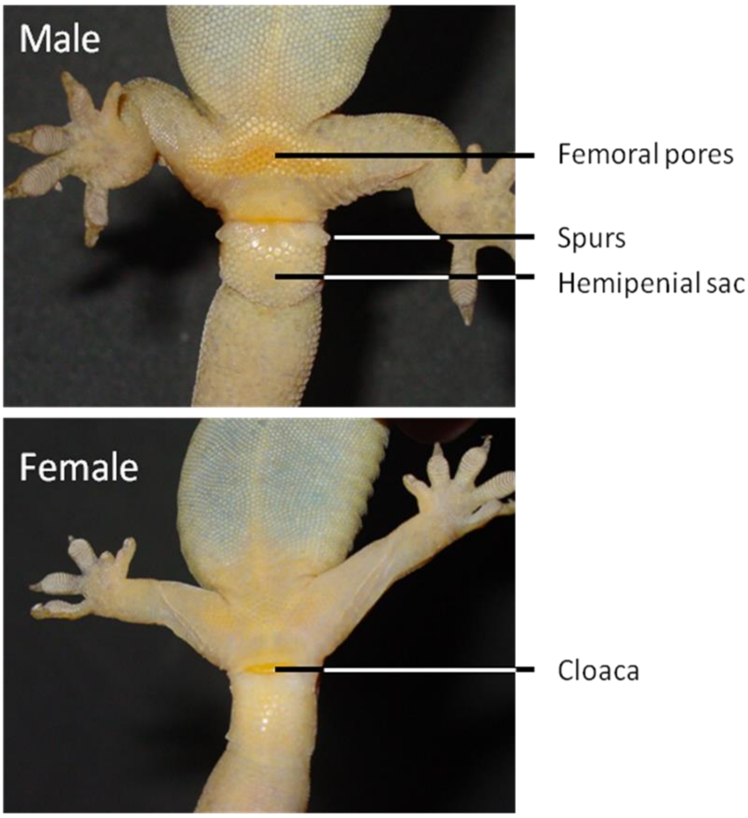

Figure 7. Cloacal region of mature male and female common geckos (*Woodworthia maculatus*). For simplification the cloaca is shown on the female only. The male shows the femoral pores, spurs and hemipenial sac, which are not present in females (photos: Jo Hoare).

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Appendix A

The following Department of Conservation documents are referred to in this method:

docdm-493179	Herpetofauna: indices of abundance
docdm-833600	Herpetofauna: population estimates
docdm-146272	Standard inventory and monitoring project plan
docdm-159361	Working at heights: roped tree work (SOP)
docdm-531081	Sampling avian blood and feathers, and reptilian tissue (SOP)