Herpetofauna: systematic searches

Version 1.0

This specification was prepared by Kelly M. Hare in 2012.

Contents

Synopsis

Systematic searches are the most commonly used method for a variety of herpetofaunal surveys. Systematic searches can be used to provide data for distribution, inventory, relative abundance, density estimates, population trends, site occupancy and territory mapping. In some cases systematic searches can be used for catch per unit effort (CPUE) and estimates of survival. Total counts are often destructive to the habitat and are not recommended for herpetofauna, except in exceptional circumstances (e.g. where an area is cleared completely for translocation; tuatara, Moore et al. 2010; native frogs, Germano 2006). Total counts are not discussed further within systematic searches.

Systematic searches are generally easy to conduct and are repeatable over time. They include two techniques that can be used both in isolation and combination—visual searching and hand searching. These techniques may result in sightings of the target species and/or sign of herpetofauna (e.g. faeces, slough, vocalisation). Visual and hand searches can also result in capture and marking of individuals and/or photo-resight identification methods. The method employed depends on the aims of the study and these aims should be well developed and thought through before any searching is undertaken. See 'Case studies' for examples of potential uses of systematic searches.

Many factors can influence the quality of the data and type of systematic searching that should be implemented, including observer experience, weather, habitat type and the behaviour of the species. Furthermore, native herpetofauna are incredibly cryptic, and often the effort to locate animals is high while the probability of seeing an individual can be frustratingly low—in these cases other methods (such as trapping) may be more appropriate. Visual searches are especially useful for gregarious species found in open habitat or open/low scrub. Hand searches are useful for those with easily accessible retreats, for nocturnal species during day hours, and on cold days. Systematic searching is not useful for some species (e.g. species that live in the canopy or spend most of their time beneath the surface of the ground) and other methods should be applied (e.g. pitfall trapping; see 'Herpetofauna: pitfall trapping'—docdm-760240). Some species are very common and ID patterning from photo-resight will not be a suitable method of identification for monitoring based on visual searching. More information on the applicability of whether systematic searches can be undertaken is presented in Table 1.

The total area searched, sample sizes and sampling methodology undertaken (e.g. with mark-recapture v. without mark-recapture) again depend on the aims of the project and the type of data being collected, as well as the species' behaviour and habitat type.

Assumptions

- All observers have equal ability to locate/capture animals, *or* the effect of observer is factored into the analysis.
- The target species is/are observable using the technique employed, *or* detectability of the species can be statistically and accurately modelled.
- All habitats are equal in their ability to be searched, *or* habitat type is included as a factor in the analysis.
- Species of interest are truly absent from the area when none are detected.

- The sample area(s) is/are representative of the wider population(s).

A range of analytical methods can be used in conjunction with systematic searches. Therefore, additional assumptions may apply depending on the capture technique employed and the aims of the study.

Advantages

- Usually cheap and easy to conduct.
- Visual searching is relatively non-destructive.
- Sign can confirm presence of herpetofauna even when individuals cannot be found.
- May be the only method that can be applied in a given situation. For example, systematic searches are the only current method available when: trapping equipment cannot be taken to a given location or installed (e.g. private land, offshore island); when a location can only be visited once.
- Many factors affecting detectability can be controlled by standardisation of techniques (e.g. season, time of day, observer, species, capture technique).
- May be sufficient to describe biological patterns.
- Often easily repeatable between studies and over time.
- Depending on data type being collected, or if data is collected in a standardised manner, then generally this method requires little statistical background.
- Hand systematic searches can be useful techniques in poor weather conditions or where a nocturnal species is being surveyed during the day.
- In poor weather and where herpetofauna are at very low numbers, sign of scat and slough is also suitable to confirm presence of herpetofauna.
- Vocalisation by exotic frogs can be used to confirm presence of species and in some cases can give a rough estimate of abundance.

A range of analytical methods can be used in conjunction with systematic searches. Therefore, additional advantages may apply depending on the capture technique employed and the aims of the study.

Disadvantages

- Observer experience is critical—observer bias and unequal abilities amongst observers exist. For example, observers rarely have a consistent search effort over time or different habitat types.
- Hand searching can be destructive to habitat and individuals if appropriate care is not taken (e.g. crushing of lizards and frogs under rocks, breaking seabird burrows).
- Will often require a significant amount of time and effort. In particular, visual searching can be very time-intensive.
- Sign of herpetofauna does not always accurately identify species or number of individuals present.

- Visual searches are only useful in good herpetofauna-searching weather conditions (species specific) and where the habitat is conducive to searching (e.g. tall canopy and thick bush is difficult to visually search). Capture probabilities are largely weather/temperature dependent.
- Pregnant lizards are often seen disproportionately to other lizards during searches due to their more conspicuous behaviour whilst seeking out heat/sun. Similarly, gravid tuatara are more often seen in nesting rookeries, and male frogs found via calling.
- It may be possible that even within a species capture probabilities are not equivalent in different habitats or within the same habitat over time.
- Can only describe trends unless surveys are designed to include sufficient replication.

A range of analytical methods can be used in conjunction with systematic searches. Therefore, additional disadvantages may apply depending on the capture technique employed and the aims of the study.

Suitability for inventory

Systematic searches (visual- and hand-searching only) can confirm presence, but not absence, of herpetofauna and are suitable for inventory. For example, visual and hand searches have been used to provide inventory of tuatara (e.g. Cree et al. 1995), lizards (e.g. Whitaker 1991), and native frogs (e.g. Green & Tessier 1990). Systematic searches are relatively inexpensive, but are also strongly dependent on observer expertise and knowledge of the species' biology and habitat use. Visual systematic searches are only useful in good weather conditions (see 'Full details of technique and best practice') and where the habitat is favourable for searching (e.g. tall canopy and thick bush is difficult to visually search). Hand systematic searches can be useful techniques in poor weather conditions or where a nocturnal species is being surveyed during the day. In poor weather and where herpetofauna are at very low numbers, sign of scat and slough is also suitable to confirm presence, but sign may not enable identification to the species level. See Table 1 for more information.

Suitability for monitoring

Systematic searches are generally suitable for monitoring of most herpetofauna (see Table 1), and are relatively inexpensive. However, systematic searches are strongly dependent on observer expertise, as well as the biology and habitat use of the species. Systematic searches can be used with or without long-term marking. It is appropriate to use systematic searches in the following situations for monitoring:

Visual searches without capture:

- Species with tags (e.g. coloured beads on tuatara crests) or that have easily identifiable individual marks (e.g. paint spots) attached that can be identified from a distance.
- Diurnal species with long-term ID/patterning (e.g. grand and Otago skinks, jewelled geckos) when a camera is used for photo-resight.
- Species without long-term marks where general changes in gross abundance over long time periods (e.g. between seasons and years) are required. Note: without long-term marking other important data (e.g. longevity) are not collected.

Visual searches with capture and hand searching:

- Species with some sort of individual identification (e.g. paint spots for short-term monitoring and ID patterning or toe-clips for long-term monitoring).
- Species without long-term marks where general changes in gross abundance over long time periods (e.g. between seasons and years) are required. Note: without long-term marking other important data (e.g. longevity) are not collected.

Mark-recapture of permanently marked (or using natural ID marks) is the most robust technique for long-term monitoring for population structure and survival of herpetofauna provided all assumptions can be met and sufficient resources are available for a long-term study. This method is particularly powerful when counts are repeated annually over relatively long time frames (> 10 years), and when variation in observers, time of day, season and environmental conditions are minimised. Unfortunately, controlling for observer effects and changes in habitat is difficult under long-term monitoring scenarios. Short-term monitoring is often confounded by seasonal changes and other disruptions, but may be suitable to determine habitat use and population structure.

Skills

Systematic searches require the following skills and training:

- Species identification.
- Good observational skills, fortitude and patience.
- Experience with the search technique employed.
- Ability to write clear and thorough notes.
- Proficiency using Microsoft Excel or other statistical software.
- Basic understanding of statistics.
- The exact skills required will vary depending on the techniques used to capture animals. For example, if hand searching, the observer must be able to catch the target species (or at least scare it from under the object lifted) in order to move it from harm's way (see 'Full details of technique and best practice').

Resources

Standard equipment for all systematic searching techniques includes:

- 2–6 skilled workers
- Datasheets/notebooks
- Pencils
- GPS
- Small hand torch

Useful, although not always essential items include:

- Binoculars
- Digital camera

For night work a head torch/spotlight is also required.

Studies that require capture of animals will also need flagging tape or tags (to label capture locations), non-toxic permanent markers and temporary holding bags for captured animals. Thin cloth bags are good for reptiles and plastic snap-lock bags are good for amphibians. Capture of amphibians also requires disposable gloves (latex, non-powdered, one pair per individual). Hand sanitiser is also a good idea when handling lizards as some may have *Salmonella* (Middleton et al. 2010); transferral of *Salmonella* within and between species as well as to/from the handler may also be possible.

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. See 'Full details of technique and best practice'. However, it is recommended that novices obtain training from an expert herpetologist. 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.

At a minimum, the following data should be recorded:

- Observer and/or recorder
- Date and time
- Location name/grid reference
- Capture point of each individual
- Weather/temperature data (either collect local temperatures during the study or get weather station data after the fact)

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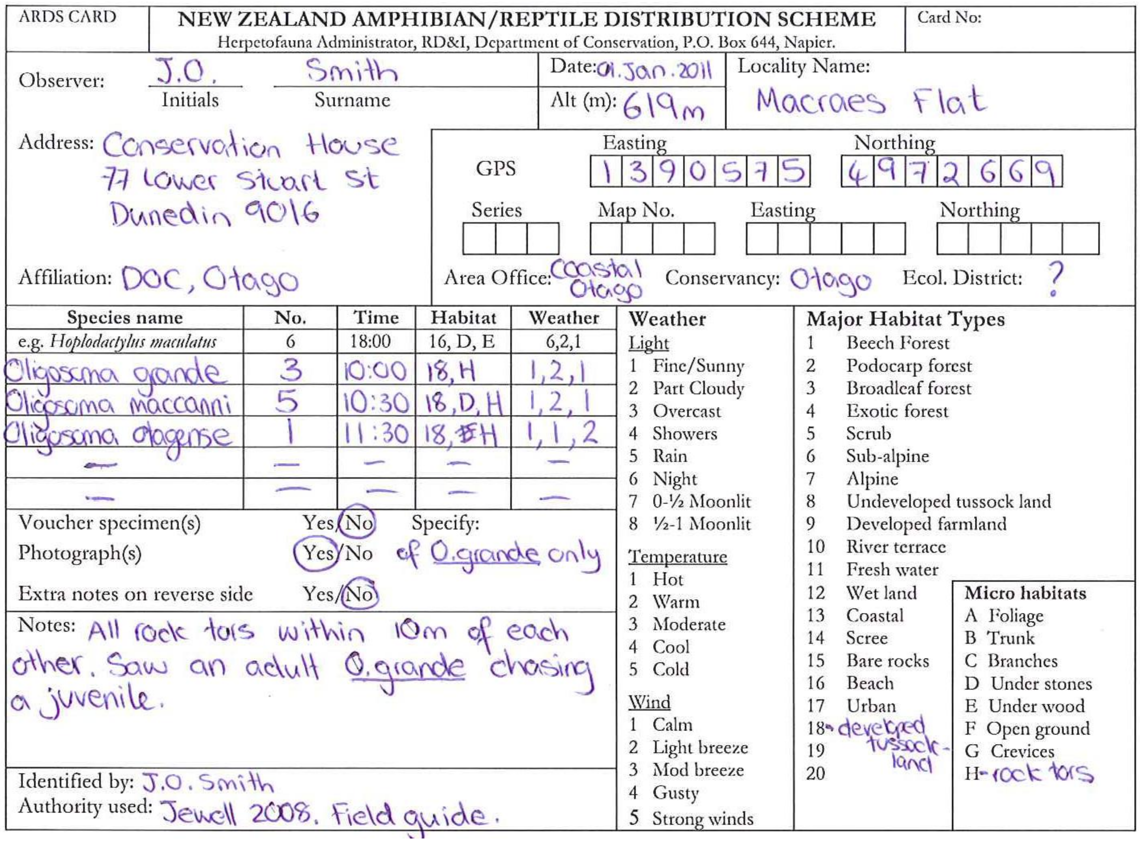
[1] The ARDS card is available online: http://www.doc.govt.nz/conservation/native-animals/reptiles-and-frogs/reptiles-and-frogs-distribution-information/species-sightings-and-data-management/report-a-sighting/



ARDS CARD

NEW ZEALAND AMPHIBIAN/REPTILE DISTRIBUTION SCHEME

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

Card No:

Observer: J.O. (Initials) Smith (Surname)

Date: 01.Jan.2011

Alt (m): 619m

Locality Name: Macraes Flat

Address: Conservation House
77 Lower Stuart St
Dunedin 9016

Affiliation: DOC, Otago

GPS Easting: 1390575 Northing: 4972669

Series: ☐☐☐ Map No.: ☐☐☐☐ Easting: ☐☐☐☐☐ Northing: ☐☐☐☐☐

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
Oligosoma grande	3	10:00	18, H	1,2,1
Oligosoma maccanni	5	10:30	18, D, H	1, 2, 1
Oligosoma otagense	1	11:30	18, ~~E~~H	1, 1, 2
–	–	–	–	–
–	–	–	–	–

Voucher specimen(s) Yes/ [✓ No] Specify:

Photograph(s) [✓ Yes]/No of O.grande only

Extra notes on reverse side Yes/ [✓ No]

Notes: All rock tors within 10m of each other. Saw an adult O.grande chasing a juvenile.

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-land
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.

Based on the specific goals of each project and the capture technique used, other factors may be required. Additional attributes that may be useful to record while in the field, but are generally not required for standard searches, include:

- *Habitat characteristics*: location description, altitude, aspect, vegetation (including dominant plant species), available cover, temperature of substrate.
- *Weather characteristics*: ambient air temperature (shade, 1 m from ground), relative humidity, overnight minimum temperature, daytime maximum temperature, precipitation, cloud cover, wind direction and strength.
- *Individual morphological measurements*: snout-vent length (SVL; mm), mass (g) and records of natural toe-loss. For lizards and tuatara, vent-tail length (mm, include regeneration) can also be obtained.
- *Sex*: the sex of individuals is also a useful parameter to record. See 'Full details of technique and best practice' for more detail.
- *Reproductive status of females*: see 'Full details of technique and best practice' for more detail.

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. For all herpetofauna, ARDS cards should be completed and forwarded to the Herpetofauna Administrator (address shown on ARDS card; Fig. 1).[2]

Collate, consolidate and store survey information securely, 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 site 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. See Fig. 2 for an example.

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 (i.e. weather description, habitat description, date, time, search effort, etc.) 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 offline if the primary storage location is part of a networked system. Store the copy at a separate location for security purposes.

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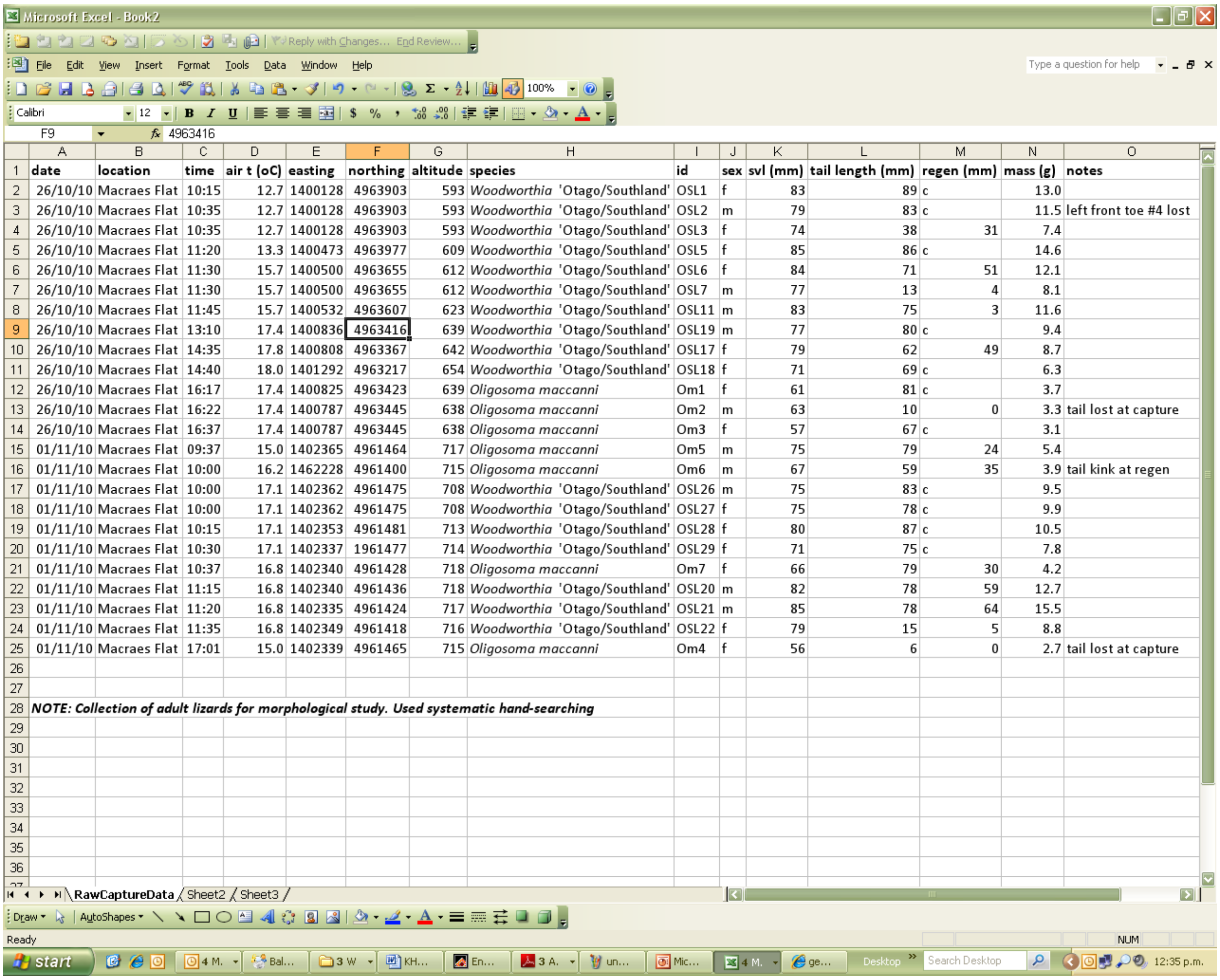
[2] The ARDS card is available online: http://www.doc.govt.nz/conservation/native-animals/reptiles-and-frogs/reptiles-and-frogs-distribution-information/species-sightings-and-data-management/report-a-sighting/



date	location	time	air t (oC)	easting	northing	altitude	species	id	sex	svl (mm)	tail length (mm)	regen (mm)	mass (g)	notes
26/10/10	Macraes Flat	10:15	12.7	1400128	4963903	593	*Woodworthia* 'Otago/Southland'	OSL1	f	83	89	c	13.0	
26/10/10	Macraes Flat	10:35	12.7	1400128	4963903	593	*Woodworthia* 'Otago/Southland'	OSL2	m	79	83	c	11.5	left front toe #4 lost
26/10/10	Macraes Flat	10:35	12.7	1400128	4963903	593	*Woodworthia* 'Otago/Southland'	OSL3	f	74	38	31	7.4	
26/10/10	Macraes Flat	11:20	13.3	1400473	4963977	609	*Woodworthia* 'Otago/Southland'	OSL5	f	85	86	c	14.6	
26/10/10	Macraes Flat	11:30	15.7	1400500	4963655	612	*Woodworthia* 'Otago/Southland'	OSL6	f	84	71	51	12.1	
26/10/10	Macraes Flat	11:30	15.7	1400500	4963655	612	*Woodworthia* 'Otago/Southland'	OSL7	m	77	13	4	8.1	
26/10/10	Macraes Flat	11:45	15.7	1400532	4963607	623	*Woodworthia* 'Otago/Southland'	OSL11	m	83	75	3	11.6	
26/10/10	Macraes Flat	13:10	17.4	1400836	4963416	639	*Woodworthia* 'Otago/Southland'	OSL19	m	77	80	c	9.4	
26/10/10	Macraes Flat	14:35	17.8	1400808	4963367	642	*Woodworthia* 'Otago/Southland'	OSL17	f	79	62	49	8.7	
26/10/10	Macraes Flat	14:40	18.0	1401292	4963217	654	*Woodworthia* 'Otago/Southland'	OSL18	f	71	69	c	6.3	
26/10/10	Macraes Flat	16:17	17.4	1400825	4963423	639	*Oligosoma maccanni*	Om1	f	61	81	c	3.7	
26/10/10	Macraes Flat	16:22	17.4	1400787	4963445	638	*Oligosoma maccanni*	Om2	m	63	10	0	3.3	tail lost at capture
26/10/10	Macraes Flat	16:37	17.4	1400787	4963445	638	*Oligosoma maccanni*	Om3	f	57	67	c	3.1	
01/11/10	Macraes Flat	09:37	15.0	1402365	4961464	717	*Oligosoma maccanni*	Om5	m	75	79	24	5.4	
01/11/10	Macraes Flat	10:00	16.2	1462228	4961400	715	*Oligosoma maccanni*	Om6	m	67	59	35	3.9	tail kink at regen
01/11/10	Macraes Flat	10:00	17.1	1402362	4961475	708	*Woodworthia* 'Otago/Southland'	OSL26	m	75	83	c	9.5	
01/11/10	Macraes Flat	10:00	17.1	1402362	4961475	708	*Woodworthia* 'Otago/Southland'	OSL27	f	75	78	c	9.9	
01/11/10	Macraes Flat	10:15	17.1	1402353	4961481	713	*Woodworthia* 'Otago/Southland'	OSL28	f	80	87	c	10.5	
01/11/10	Macraes Flat	10:30	17.1	1402337	1961477	714	*Woodworthia* 'Otago/Southland'	OSL29	f	71	75	c	7.8	
01/11/10	Macraes Flat	10:37	16.8	1402340	4961428	718	*Oligosoma maccanni*	Om7	f	66	79	30	4.2	
01/11/10	Macraes Flat	11:15	16.8	1402340	4961436	718	*Woodworthia* 'Otago/Southland'	OSL20	m	82	78	59	12.7	
01/11/10	Macraes Flat	11:20	16.8	1402335	4961424	717	*Woodworthia* 'Otago/Southland'	OSL21	m	85	78	64	15.5	
01/11/10	Macraes Flat	11:35	16.8	1402349	4961418	716	*Woodworthia* 'Otago/Southland'	OSL22	f	79	15	5	8.8	
01/11/10	Macraes Flat	17:01	15.0	1402339	4961465	715	*Oligosoma maccanni*	Om4	f	56	6	0	2.7	tail lost at capture

NOTE: Collection of adult lizards for morphological study. Used systematic hand-searching

Figure 2. Example of good data entry of field data collected during a systematic search. Note that the data are arranged in columns, the column titles have enough detail that anyone reading the spreadsheet at a later date will know what data are included, and the notes section is used to record other interesting facts. More or fewer columns can be added as required.

Analysis, interpretation and reporting

Analytical protocols are not covered in this section. More complete analytical protocols are under development. However, as a minimum it is advisable to:

- Seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis.
- Report results in a timely manner. This would usually be within a year of the data collection.

Case study A

Case study A: distribution of the small-scaled skink

Synopsis

Whitaker (1991) used systematic searches to define the habitat of and determine the local distribution of the small-scaled skink, *Oligosoma microlepis* (as *Leiolopisma microlepis* in Whitaker 1991). The study was undertaken within a 20–25 km radius of the original location of the type specimens near Springvale Bridge on the Napier-Taihape Road and was ultimately undertaken to determine the conservation status of this newly described, and data-poor, skink (first described by Patterson & Daugherty 1990).

Whitaker (1991) describes in detail his survey methods, personnel, and other potentially confounding factors (such as poor weather). His survey method included familiarisation with the species, determining preferred habitat and assessing distribution and status of small-scaled skinks within the 150 000 ha study area. He used the full suite of systematic searching techniques, including visual searching and hand searching, as well as sign of lizards (scat). In this way, Whitaker (1991) was able to make a strong assessment and determined that small-scaled skinks were located in loose rocky areas (e.g. scree, river-bed) of (mainly) greywacke composition. He also established that: 1) all the small-scaled skink populations were very small and isolated due to limited potential habitat, and 2) the species should be regarded as rare (currently regarded as at risk/declining in Hitchmough et al. 2010).

Whitaker (1991) recommended continued monitoring, management, research and reassessment of some populations, and wider surveys for other populations where suitable habitat existed.

Objectives

- Define the habitat of small-scaled skinks.
- Determine the local distribution of small-scaled skinks within the immediate vicinity of the original sites.
- Determine the wider distribution of small-scaled skinks in the district by surveying for other populations within a 20–25 km vicinity of the original sites.
- Comment on the conservation procedures and future survey research needs for the species.

Sampling design and methods

Familiarisation with the species

As no previous studies had been undertaken on this species, no literature or experts were available from which to learn more about the habits and biology of small-scaled skinks. Therefore, Whitaker (1991) initially focused his efforts at a site where small-scaled skinks were known to occur (the type locality), surveying this site on five separate occasions (over 3 days). In this way he was able to learn more about its behaviour and habitat use. Whitaker (1991) continued using the same methods at other sites in order to complete a systematic analysis of behaviour and habitat use. During these surveys he made note of the weather and ambient temperatures as well as above- and below-rock temperatures.

Determining preferred habitat

To ensure that appropriate habitats were being searched, Whitaker (1991) also searched all potential lizard habitats in a wider area around the core study site to see if they were also used by the species. This included systematic searches of bluffs and outcrops, scrub, pasture, and tussock grassland, as well as sub-alpine vegetation elsewhere in the study area. Whitaker (1991) recorded grid reference, altitude, aspect, general habitat description, lithology (description of the physical character of the rock), vegetation cover, and flora at each site as well as number of searchers, times that searches were undertaken and a crude estimate of the amount of lizard droppings present (none, few and lots).

Assessing the distribution and status

After determining the preferred habitat of small-scaled skinks (and thus reducing the potential search areas to a manageable size) Whitaker (1991) set about locating potential areas of habitat using geological and topographical maps to identify places with appropriate lithology and slopes steep enough to have outcrops. Potential screes and rock-falls were then located by visually scanning from vantage points.

Once apparently suitable habitat was located, Whitaker and up to four field assistants used systematic searches to locate the lizards from 14 to 21 January 1991. Whitaker and his assistants started with visual searches by scanning the habitat from a distance using binoculars to see if basking or active lizards were visible. The habitat was then slowly approached and examined more closely with the naked eye. If no lizards were seen or if the weather was unsuitable for activity (either too hot or too cold) a hand search was made beneath the stones and for lizard sign (faeces and slough).

Thirteen small-scaled skinks were captured to collect some morphometric data on the species, including: colour and colour pattern, scale counts, age class, sex, snout-vent length, tail regeneration, mass, and pregnancy status of adult females.

Other observations

Along with the weather and temperature records, Whitaker (1991) also recorded the locations of other herpetofauna seen and statements of sightings of lizards from members of the public.

Results

Familiarisation with the species

By making note of the weather and temperatures Whitaker (1991) was able to confirm when small-scaled skinks are likely to emerge and be visible. He found that small-scaled skinks are heliotherms (an organism that warms its body in the direct rays of the sun) that respond rapidly to the appearance of the sun by basking on the surface. When temperatures are high they expose only a small section of their body, typically the head, and are difficult to see, or they may not appear on the surface at all.

Whitaker (1991) also noted that small-scaled skinks will defecate on prominent stones within their habitat more often than any other lizard species in the central North Island, so sites where it occurs are often recognisable by sign.

Determining preferred habitat

The elevation of sites where small-scaled skinks were located ranged from 550–840 m and all sites had aspects well lit by the sun, varying between east and north-west. Small-scaled skinks were found to be saxicolous (living among rocks) and were found only at rocky sites (boulders, talus slopes, scree and rock falls). All but one of these sites consisted of greywacke substrate.

Assessing the distribution and status

Small-scaled skinks were located at seven new sites, and its continued occurrence was confirmed at two previously known sites. All sites were small (c. 414 m^2) and isolated, being 'many hundreds of metres from the nearest potential habitat (not necessarily with populations of [*Oligosoma*] *microlepis*) and many are several kilometres away'. The skinks were locally abundant in some areas.

Other observations

Three other species of lizards were found during the survey and their locations were recorded. This included a new population of speckled skinks (*O. infrapunctatum*), which is a rare species from localised areas in the North Island.

Limitations and points to consider

Limitations:

- The birth of young was estimated as being in 'late summer' based on the capture of heavily pregnant females and data on captive breeding (Larsen 1990; Patterson & Daugherty 1990), but this cannot be confirmed without surveys over a longer time frame.

Points to consider:

- Whitaker (1991) undertook a thorough survey and kept meticulous and detailed records. This meant that a lot of additional and useful information (beyond just determining the distribution and status of small-scaled skinks) was obtained. For example, a new population of speckled skinks was located and potential new locations outside the search area where small-scaled skinks may be found were presented.
- Through necessity (contract time frames) the study was conducted within an 8-day period in summer within a limited area and thus may present a distorted analysis of the species status. Whitaker (1991) points out the necessity of follow-up surveys to ensure the species is not declining in number, as well as extending the survey areas to determine whether distribution is more widespread. Studies at other times of the year may also indicate the likely timing of the reproductive cycle.

References for case study A

Gebauer, K. 1999: Trapping and identification techniques for small-scaled skinks (*Oligosoma microlepis*). *Research and Development Series, No. 318*. Department of Conservation, Wellington. 24 p.

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Case study B

Case study B: census methods for tuatara

Synopsis

Moore et al. (2010) used systematic searches coupled with mark-recapture and census-removal techniques to determine an accurate method for predicting true census size of a population of tuatara (*Sphenodon punctatus*). The research by Moore et al. (2010) resulted from a study within a 1290 m^2 fenced enclosure on Stephens Island/Takapourewa which was originally set up to: 1) remove tuatara from Hamilton's frog (*Leiopelma hamiltoni*) habitat (tuatara prey upon Hamilton's frogs; Newman 1977), and 2) provide tuatara for a translocation to neighbouring Wakaterepapanui Island. Moore et al. (2010) took the opportunity to use the removal and translocation of tuatara to determine whether a simple and effective method to estimate tuatara population size with minimal effort could be established.

Moore et al. (2010) used visual searches at night coupled with mark-recapture over 9 days, and employed the Lincoln-Peterson estimator to estimate population-census on each capture day. They described environmental, behavioural and observer variation as potential factors influencing population estimates. At the completion of the mark-recapture survey, Moore et al. (2010) then spent 6 days using visual searches during both the day and night coupled with hand-capture to remove all tuatara within the fenced area. After 3 days of mark-recapture, the population-census estimate using the Lincoln-Peterson estimator method closely fit that of the census-removal (Moore et al. 2010).

Moore et al. (2010) recommend the Lincoln-Peterson estimator as a cost-effective way to accurately estimate population size for isolated, inaccessible tuatara populations, because it requires limited personnel, expertise, and time, and has low environmental impact on fragile sites. However, they caution that: 1) the Lincoln-Peterson estimator has limitations and will not be the solution for every situation (e.g. large islands with complex habitat), and 2) the method does not provide accurate estimates of sex-ratio after 3 days due to males being more easily captured than females.

Objectives

To provide a simple, effective method for estimating tuatara population size with minimal effort and cost. Specifically, the authors wanted to determine whether mark-recapture and Lincoln-Peterson estimates are accurate methods for providing population-census for a closed tuatara population.

Sampling design and methods

Mark-recapture

Over 9 consecutive nights three people with varying expertise walked three transects that ran the length of the 1290 m^2 enclosure. The area was searched once per night, but transects were surveyed 1–3 times per night (i.e. 1–3 sweeps of transects), until no new animals were seen. Tuatara were captured by hand, recaptures recorded (on nights 1–3 and 7–9 only) and any new individuals were marked by applying a small dot of white correction fluid on the snout (all 9 nights). The sex of adults (based on external sexually dimorphic characteristics) was also recorded. Marks remained visible through the remainder of the study. Search effort per night varied from 0.75 person-hours to 3.0 person-hours. No hand-searches were undertaken. Other variables that were recorded include temperature, wind, humidity and moon phase as these are all known to influence tuatara activity (Moore et al. 2010).

Removal-census

Over two 3-day periods visual systematic searches were used to locate and capture all emerged tuatara. These tuatara were then removed from the fenced area. Teams of 4–5 people searched the fenced area during both the day and night to ensure all tuatara were captured and removed. For 2 weeks following the initial removal the fenced area was periodically scanned and no further tuatara were located.

Estimation of population size and census size

To assess the minimum number of mark-recapture survey nights necessary to achieve accurate population estimates, the Lincoln-Peterson estimator (Peterson 1896; Lincoln 1930) was used to calculate a population estimate for each night where recaptures were recorded. The removal-census provided a total population size of the tuatara within the fenced area. The accuracy of the Lincoln-Peterson estimator was evaluated by comparing the census-removal size and the Lincoln-Peterson estimator for each night by using a percent error equation (McCullough & Hirth 1988).

Other data recorded

Upon final capture of the tuatara for translocation, the snout-vent length, tail length and mass of all individuals were recorded. The sex of adults was also documented.

Results

Over the 9 days of night searches 87 tuatara (20 females, 45 males and 22 juveniles) were marked within the fenced area. The removal-census removed 87 tuatara (27 females, 54 males and 6 juveniles) from the fenced area. For both the mark-recapture and removal-census surveys adult males were the easiest to locate. After the third day of mark-recapture sampling, 52 animals had been marked and the Lincoln-Peterson estimator gave a population estimate of 85.3 (95% CI = 62 and 133) individuals with an error (compared to the removal-census) of ±1.92%. Population estimates increased in precision with more survey days, reaching a relatively constant rate of estimation of 83–89 individuals from day 6 onwards. Based on the census, the population density within the fence was estimated at 674.4 tuatara/ha.

Limitations and points to consider

Limitations:

- As stated by Moore et al. (2010) the Peterson-Lincoln estimator is a simplistic model that only takes into account the number of captured animals (marked and unmarked) within a session. It cannot incorporate other important variables such as observer, environment and animal behaviour into the models.
- As the tuatara did not have unique marks, more complex statistical modelling (e.g. that includes behaviour, environment, etc.) could not be undertaken.
- Despite no further tuatara being seen within the fenced area, and the total number of animals being the same for mark-recapture and census-removal methods, the numbers of individuals of each sex/age group seen during the mark-recapture and removal-census do not add-up. For example, 22 juveniles were captured for the mark-recapture study, but only six juveniles were captured during the removal-census. Thus, the removal-census was not completely accurate, and nor was the Lincoln-Peterson estimator. At a minimum (adding up the largest numbers of tuatara: 27 females + 54 males (removal-census) + 22 juveniles (mark-recapture) there were 97 tuatara within the fenced area. It is also unknown whether all the individuals seen during the mark-recapture were captured for the removal-census.

Points to consider:

- The researchers were very familiar with tuatara, and also used previous studies and knowledge which outlined expected tuatara biology and behavioural traits. For example, they knew that ‘Adult tuatara are sexually dimorphic and sedentary, and males maintain stable territories… (Moore et al. 2009)’. Thus, Moore et al. (2010) had a good basis on which to pin the study, and were able to set up a robust survey design for both mark-recapture and removal-census.

- Tuatara spend much of their time within burrows, making detection difficult (Newman 1987), and in order to provide as little disturbance to the frog habitat as possible only emerged tuatara were removed. Thus, it was a huge task for the researchers to try and remove all tuatara. Under the circumstances, and with the immense search effort that was undertaken, a good job was done.
- Although not mentioned in the text, spotlighting was used for the night searches (J. Moore, pers. comm.). Often the most common methods are not included within recent published journal articles as word- and page-counts are limited by publishers and funding.

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Case study C

Case study C: distribution and abundance of frogs

Synopsis

Green & Tessier (1990) used systematic hand-searches during the day to determine relative abundance of Hochstetter's frog (*Leiopelma hochstetteri*) within streams throughout its range. The study was undertaken at 12 sites from the Rangitoto Range north (including East Cape) to near Waipu (including Great Barrier Island). The authors ultimately set out to collect frogs from across their known range for chromosomal work, but during the course of the collecting also attempted to document the distribution and relative abundance of individual populations.

Green & Tessier (1990) provide a one page description of areas surveyed, including general location, date, time searched and length of stream searched. Eighty-five frogs were collected for the genetics study and some morphometrics of these were taken. A summary table provides number of frogs, number of collectors and frogs per hour, frogs per person-hour and frogs per 100 m of stream gives some idea of the abundance of frogs and the ease at which they can be located. Green & Tessier (1990) also provided information on the size ranges, most densely populated sites, and which types of watercourses were likely to have frogs present. They also presented some anecdotal behavioural observations and recommend careful replacement of cover objects to limit micro-habitat disturbance to the frogs.

Objectives

- Collect Hochstetter's frogs for chromosomal work.
- Document the distribution and abundance of Hochstetter's frog from across the entire known range.

Sampling design and methods

Daytime surveys

Surveys were conducted during the day within selected streams in every part of the known range of Hochstetter's frog. For most streams a section was hand-searched by traversing its length and turning over all stones or other potential hiding places for frogs. For those on Great Barrier Island the whole stream was surveyed from coast to summit. The survey continued until an insurmountable barrier (e.g. high waterfall) blocked the way or no frogs were found within half an hour of searching. The authors recorded the approximate length of the stream that was searched, the number of frogs found, and the time spent searching, as well as other characteristics such as general flow of the stream (trickle to large flow), silting, cover available, and some behavioural characteristics of frogs.

Collection of frogs

Green & Tessier (1990) collected 85 frogs from across its range and accurately measured mass and snout-vent length in the laboratory. As there is little external sexual dimorphism in the species, sex was confirmed in some animals via dissection (presumably by examining the gonads).

Statistical analyses

For all streams, except those on Great Barrier Island that included sections without frogs, estimates of frogs per hour, frogs per person-hour and frogs per 100 m of stream were calculated.

Results

Green & Tessier (1990) collected 85 Hochstetter's frogs from 18 streams, and located an additional 27 frogs (total 112 frogs seen during the survey). Streams varied in abundance of frogs from 1.0 to 50.0 frogs/100 m. Similarly the ease of capture of frogs varied among streams searched from 0.6 to 18.0 frogs/person-hour, but streams of high abundance were not necessarily those with the highest catch rate. Frogs ranged in size from 13 to 47 mm snout-vent length and all frogs over 37 mm were female. Length-weight data appeared to cluster into four size classes.

The sizes of inhabited streams varied considerably, from trickles and seepages to large flows several metres wide and deep; muddy trickles at the headwaters of streams were usually without frogs. In larger streams prone to flooding, frogs were found at or just above the flood level of the stream. Similarly, frogs could withstand 'moderate' levels of silting, but no frogs were found in streams with high silt levels or without cover and adjacent forest. Some frogs that originally evaded capture would return after around 10–20 minutes to the same rock under which they were originally found.

Limitations and points to consider

Limitations:

- Green & Tessier (1990) provide data on where Hochstetter's frogs are less likely to be found, but as data are only provided for streams that had frogs present it is unclear whether they surveyed some streams that had no frogs and excluded these from the article. These data would be useful as they may provide the basis for future studies on distribution and abundance and translocations.
- Sex of individuals was confirmed via dissection. This is a destructive technique and is not recommended for *Leiopelma* spp. Sex steroid levels within urine are a useful, non-destructive way of sexing frogs (Germano et al. 2009).

Points to consider:

- It is important to remember that catch rate (frogs per person-hour) is not only a reflection of the abundance of frogs present, but dependent on how accessible the habitat is to the observer.
- Hochstetter's frogs are nocturnal, so daytime searches by necessity had to be hand searches. Visual searching during the day would have been ineffective in this regard, but spotlighting at night would be feasible.
- Although primarily interested in capturing and removing frogs for other studies, the authors documented a little more data and provided some useful additional information on Hochstetter's frogs (e.g. behavioural observations of frogs returning to the same site within a short period of time). These data point to the potential for high site-fidelity in Hochstetter's frog and subsequently Green & Tessier (1990) recommend carefully replacing cover objects to the original position in order to maintain as little micro-habitat disturbance as possible.

References for case study C

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Full details of technique and best practice

Before undertaking any field work, explore whether animal ethics approvals and capture permits are required. All herpetofauna in New Zealand are fully protected by the Wildlife Act, and you may need permits and ethics approvals if you are going to manipulate a reptile or amphibian. 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). However, DOC staff will require animal ethics permits for other techniques (e.g. toe-clipping). A Wildlife Act Permit will be required if exporting samples overseas (e.g. for genetic analyses).

The techniques outlined in this section can be used during systematic searches to locate and/or capture reptiles and amphibians in New Zealand. Capture techniques will not be equally effective on different species; consult Table 1 to identify which techniques may be appropriate for the target species and habit types. If you have no experience with the capture technique you would like to employ, consult with someone who has experience prior to conducting field work. Subtle details will be important for maximising captures and ensuring the well-being of reptiles and amphibians. Also provided are techniques to identify sex of individuals and determine reproductive status of adult females. The following is only an overview to provide a general idea of the practical considerations and the implementation of the techniques. Pairing up with an experienced person is critical to the success of your project.

For a particularly useful and valuable document on survey methods for lizards, please refer to Tony Whitaker's 1994 document titled 'Survey methods for lizards'. In the following sections, the methods first documented by Whitaker (1994) are summarised and extended to cover tuatara and frogs.

Visual searching

Visual searching includes a variety of techniques which should be tailored to the given species and habitat. Visual searching includes: scanning the site (with or without binoculars), using a torch to examine cracks, crevices and burrows, etc., and spotlighting at night. Visual searching is appropriate for tuatara, terrestrial lizards and some arboreal lizards, diurnal and nocturnal lizards, and both native and exotic frogs. It is not appropriate for fossorial species that are rarely seen above the ground (Table 1).

Search areas must be defined prior to searching. The size and shape of the search area will depend on the goals of the study, the habitat, and the target species. The number of searches at each site will depend on the goals of the study. For most types of data, searches at each site should be conducted over multiple capture occasions, and one capture occasion is the sampling unit.

Visual searching generally follows an orderly approach, but some habitats may not allow this approach and the observer should use their discretion (e.g. terrestrial forest-dwelling reptiles will not require binoculars).

For example, if searching for skinks on rock tors during the day one could:

- Scan a potential tor from c. 10 m away with binoculars (or using the zoom function of a good quality camera) to try and see basking or foraging lizards.
- Move closer to the site to look for basking or active lizards—at this stage you may see or hear disturbed animals.
- Keep looking. Often lizards will 'appear' seemingly out of nowhere. Patience is key.
- Check for sign of lizards (see 'Sign of herpetofauna' below).
- Finally check retreats for inactive animals using your flashlight.

Some useful tips to remember while searching for herpetofauna:

- All herpetofauna are particularly jumpy during windy conditions. Check the sheltered sides of rocks/bushes.
- Amphibians may not emerge at all in dry conditions.
- Exotic frogs (males) are very vocal during their breeding season, which will make locating them easier.
- Be patient!

Diurnal, sun-loving species:

- If possible, search with the sun behind you as your shadow may elicit movement.
- The best time of day is early morning and late afternoon because it is often too hot in the middle of the day and lizards will seek shelter.
- The best time of year is spring and autumn as the weather is more variable.
- The best weather is immediately after a cold spell or when weather clears from rain as lizards will come out to bask at the first opportunity.
- Diurnal animals will generally only be out in sunny weather. When air temperatures are low they will bask in sheltered sites (even surrounded by snow).
- Wait for spooked animals to return, they will usually return to the same basking site within a few minutes.
- Use binoculars to search bigger areas and more distant sites.

Nocturnal species:

- Look everywhere—even native frogs and tuatara will be found up trees.
- Check potential food sources (e.g. flowering plants for lizards).
- Look for visual anomalies (e.g. pale geckos against normal foliage colour).

- Native frogs will be particularly prevalent on wet, warm and calm nights. Watch where you stand!
- Spotlight for eye reflections. Spotlighting for eye-shine works particularly well when the light source is kept as close as possible to the observer's line of sight, and is useful for distances over 3 m (Whitaker 1967). Eyes of nocturnal geckos show large shine that is pink to white, diurnal geckos show smaller white shine, and nocturnal skinks have small white eye-shine (c.f., red/green/blue, small bright twinkling for spiders and moths; Whitaker 1994). Gecko eyes noticeably dim when a bright light is shone on them (the pupil contracts). Frog eye-shine is white and not as bright as that of geckos (Whitaker 1967).

Hand searching

Hand searching is most useful for lizards and amphibians, and not so useful for tuatara (you are likely to be bitten if you put your hand down a burrow). Good hand searching should first include the same methods as visual searching, with the final addition of lifting stones/logs, etc. to find the herpetofauna while in its retreat. Also a useful technique is to gently rustle vegetation to elicit an escape response by lizards. Hand searching should be used with care as misplacement of cover objects can change the thermal and hydric components of the habitat (see Pike et al. 2010 for details). When moving objects *always* make sure the animal is moved from harm's way—replace the item first, *then* release the animal. In this way you will reduce the chances of accidently crushing an animal. Similarly, *only* lift items when you are certain to be able to catch and remove the animal; that is, the lifter(s) *must* be able to hold the item up long enough for a catcher to remove the animal. Crushing is a serious possibility if care is not taken and is not acceptable.

Sign of herpetofauna

Herpetofauna are often cryptic and/or in low numbers (or the weather may not be suitable) meaning that the only indication of their presence at a site may be various sign. Sign is especially useful when searching for lizards (Whitaker 1967). Sign may include:

Droppings: The scat of lizards and tuatara generally have coarse fragments of their prey items within them, especially the harder exoskeletons of insects. Tuatara droppings are generally cigar shaped and brown to black (depending on their diet) with a squirt of uric acid (white substance). Lizard droppings have a uric acid cap on an irregular to cigar shaped faecal element (Fig. 3). Note: lizard droppings differ from bird droppings which have finer fragments, a more uniform shape and a splash of white along the sides of the scat. Uric acid deposits that are within dry crevices or beneath substrate can be very persistent; if it is under a rock it must be a lizard dropping. Droppings of frogs rarely persist and are not useful sign.

Skin: Lizards and tuatara slough (regularly peel off the old outer layer of skin). Scales and skin fragments can be small and require careful searching. Geckos often moult in one entire sheet (like an inside out pyjama) making their slough easily identifiable.

Activity:

- Tuatara will utilise seabird burrows as well as dig their own. During the nesting season females will also dig scrapes and nests for their eggs in open areas. They can also be heard rustling in vegetation and in leaf litter.
- Lizards often leave smooth 'polished' surfaces from frequent passage coupled with a lack of vegetation or cobwebs in crevices (ultimately needs to be coupled with another sign to distinguish from small mammals). Can be heard rustling in vegetation and in leaf litter as well as soft scraping of scales on rocks.
- Native frogs generally 'freeze', but may jump away when you get too close.
- Exotic frogs generally jump/swim away when you approach.

Calls:

- Tuatara can make a croaking noise when agitated or while being held. Similarly, fighting males may make aggravated noises and mating individuals have been heard to make soft grunts. However, generally the kerfuffle of the interaction between the individuals is more obvious than the vocalisation.
- Geckos have two types of calls—alarm calls that sound like a bark and communication calls which are softer, but distinctive, chirps.
- Larger skink species may also vocalise, but this is *very* rare and sounds like a soft 'click' or gasp and is mostly heard when holding the animal. Small skinks do not have audible vocalisation.
- Exotic frogs have a range of calls that they use during the breeding season.
- Native frogs have a soft squeak that may be heard; again this is most likely heard when the animal is aggravated (such as during capture) and is unlikely to be useful as sign of a native frog.

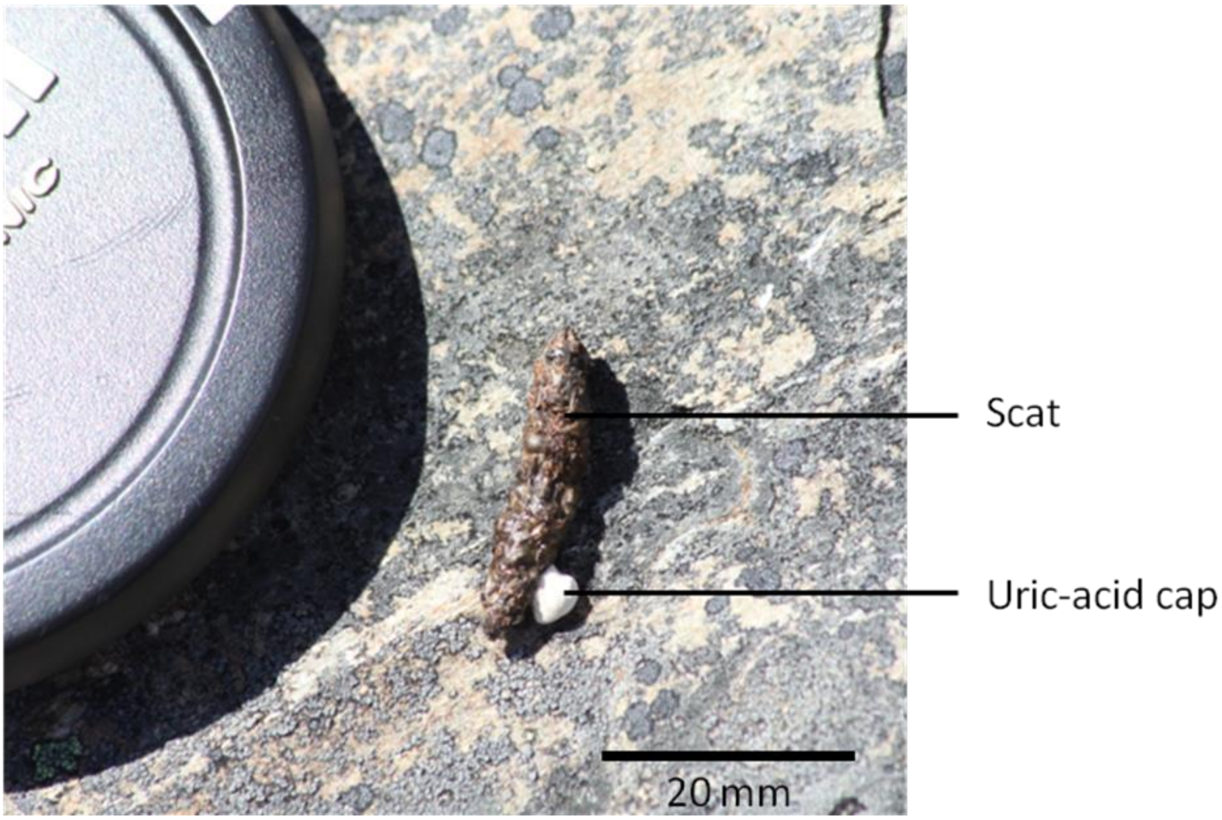

Figure 3. Dropping from a large lizard (likely to be *Oligosoma grande* as a mature skink was seen within 2 m of the dropping. Note the white uric acid cap and cigar shape (photo: Kelly Hare).

Sex identification of herpetofauna

Exotic frogs—generally have externally visualised sexual dimorphism (mature males and females are morphologically different). Mature males of the southern bell frog (*Litoria raniformis*) and green and golden bell frog (*Li. aurea*) are generally smaller than the females. Mature males tend to have dark yellow-brown throats (*Li. raniformis*) or yellowish throats (*Li. aurea*) and show nuptial pads on their thumbs during the breeding season. The females of both species can be identified by their white throats and lack of nuptial pads. The brown tree frog (*Li. ewingii*) breeds all year round and males have nuptial pads present all year. See www.nzfrogs.org for more detailed descriptions of exotic frogs.

Native leiopelmatid frogs—are monomorphic (externally males and females look the same). However, females of each species reach larger sizes than males, meaning that one can be 100% sure of female identification based on size and less sure of male identification (see Germano et al. 2011).

Tuatara—adult tuatara are strongly sexually dimorphic. Male tuatara are larger than females, but have a narrower abdomen. The spiny crest of males is also more fleshy and larger than that of females, and, along with the throat region, can be enlarged during display.

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 as males have externally visible hemipenial sacs and femoral pores, whereas females have no visible sacs or femoral pores (Fig. 4). 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 herpetofauna' 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 techniques require training from an expert.

Determining reproductive status of female herpetofauna

This section is only relevant during the breeding season when females are pregnant/gravid.

Frogs—often eggs of gravid females can be seen through the thin skin of the abdomen, especially when it is moistened (Germano et al. 2011), but this technique takes practice to perfect.

Lizards and tuatara—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; tuatara, Refsnider et al. 2009). 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). Furthermore, the abdominal ribs of tuatara make palpation of oviducts difficult (Cree et al. 1991), but not impossible, and the potential to break ribs during palpation is a real threat. Always seek appropriate training and expert help.

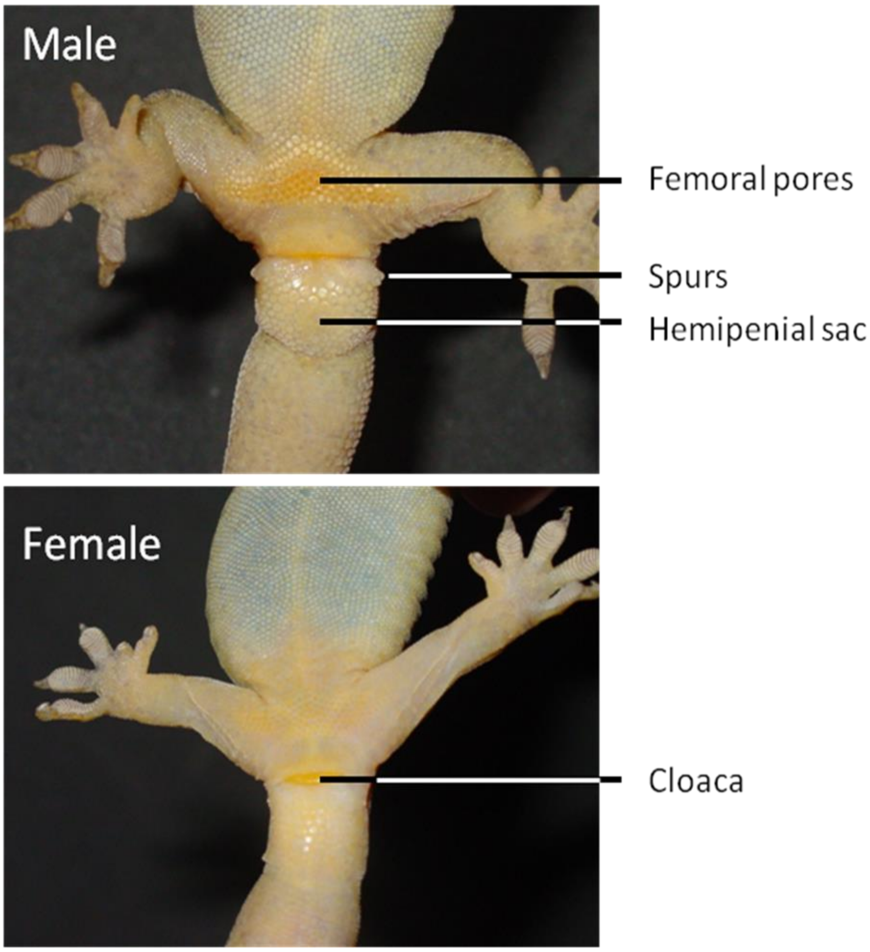

Figure 4. Cloacal region of mature male and female common geckos (*Woodworthia maculatus*). For simplification the cloaca is shown on the female only. The male shows the femoral pores, spurs and hemipenial sac, which are not present in females (photos: Jo Hoare).

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Table 1. An indication of whether systematic searches are an appropriate method for broad groups of herpetofauna of New Zealand. The groups are further broken down into habit (i.e. whether they are primarily diurnal or nocturnal and primarily terrestrial, arboreal or semi-fossorial). Note: this table provides very broad generalisations of whether systematic searches are likely to be appropriate. If you don't know what the habit of your study organism is, or are doing a general search for multiple species, then it's a good idea to start with systematic searches during both day and night, coupled with other methods (such as G-minnows, pitfall traps, etc.). In this way you may find the most appropriate method for that species/habitat.

Group	**Habit**	**Habitat**	**Are systematic searches appropriate?**			**Notes**
			Visual searches	**Hand searches**	**Sign**	
Tuatara	Primarily nocturnal & terrestrial [a]	Grassland	Yes	No	Sometimes [b]	[a] Can be used day and night; will climb trees; [b] especially during nesting
		Forest	Yes	No	Yes [c]	[c] particularly burrowing
		Shore	Yes	No	No	
Frogs	Nocturnal & diurnal; terrestrial & arboreal	All habitat types	Yes	Yes	Sometimes [d]	[d] calls of exotic frogs may be useful
Lizards	Diurnal & nocturnal; terrestrial & arboreal	Grassland, rocky areas, shore, short scrub within open areas, forest floor	Yes	Yes [e]	Sometimes [f]	[e] hand searching may influence behaviour and future capture rate; [f] Sign may be used for presence/absence only and is unlikely to distinguish to species level
		Forest canopy, thick scrub [g]	No	No	No	[g] arboreal lizards in trees over 2 m high are very difficult to locate using this method; thick scrub is also difficult to search
	Diurnal & nocturnal; semi-fossorial	Burrows and beneath rock piles	No [h]	No	No	[h] some individuals may emerge from their retreats, but accurate estimates of population size, etc. will not be possible

Appendix A

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

docdm-760240	Herpetofauna: pitfall trapping
docdm-531081	Sampling avian blood and feathers, and reptilian tissue (SOP)
docdm-146272	Standard inventory and monitoring project plan