SECTION TWO: Surveying and monitoring

Surveying and monitoring native lizards 29
DOC's Inventory and Monitoring Toolbox 29
Why survey or monitor lizards? 30
Planning surveying and monitoring projects 30
Surveying 32
Monitoring 33
Tools of the trade 33
Data collection 36
Submitting location records to DOC 37
Data analysis 37
Marking techniques 40
Handling, holding and transporting lizards 42

DOC ranger Karina Holmes photographs a critically endangered grand skink, *Oligosoma grande*. Photo: James Reardon

Surveying and monitoring native lizards

Lizards can be extremely cryptic and difficult to detect, especially on the mainland in the presence of predator populations. This is due to low population densities caused by introduced predators, a general preference for complex habitats, and activity patterns strongly linked to both weather and seasonal cycles. Lizards are therefore inherently difficult animals to detect and monitor in the field. However, there is an increasing awareness of the requirement to undertake surveys to determine species' presence, and for long-term population monitoring to determine responses to conservation management. Lizards are especially important as a medium-to-long term 'monitoring' species in ecosystem restoration programmes because they are highly susceptible to introduced predators, are slow to recover and are long lived with low reproductive rates. Surveying and monitoring lizards can be challenging, but can have important implications if done correctly.

This section of the Toolkit aims to:

- Provide a primer on lizard surveying and monitoring techniques, including their advantages, disadvantages and some recommendations.

- Introduce users to some of the analytical methods used to answer common questions.

- Suggest possible avenues for reporting outcomes of surveys and monitoring programmes.

- Provide reference material and resources in order for stakeholders to become fully informed about undertaking lizard surveying and monitoring to appropriate standards.

It is not the intention of the Toolkit to supersede DOC's Natural Heritage Management System's (NHMS) Inventory and Monitoring (I&M) Toolbox. The I&M Toolbox is intended to be the standard reference point for designing and developing appropriate surveys and monitoring programmes.

The intention of this Toolkit is more basic: it is an introduction to the options and techniques, and points to standard references and resources, as appropriate.

DOC's Inventory & Monitoring Toolbox

DOC’s I&M Toolbox contains authoritative standards for inventory and monitoring of biodiversity, including lizards. Methods for surveying and monitoring lizards in the field and for monitoring population abundance trends over time are described. It is anticipated that individuals and organisations will consult the I&M Toolbox and adopt standards to ensure national consistency for lizard monitoring.

For each method described in the Toolbox, the following are listed: advantages and disadvantages, the resources and skills needed, sampling and design issues to consider, appropriate data analysis and the application of the method in the field. The Toolbox also has decision frameworks to help users work through inventory and monitoring questions to choose the most appropriate method(s) for their situation.

DOC's I&M Toolbox is currently in preparation, but more information on the Toolbox can be obtained by emailing IandMToolbox@doc.govt.nz.

Why survey or monitor lizards?

There are four primary reasons to survey and monitor lizard populations in New Zealand. These include:

• **Site inventories**. Surveying a site to develop a species inventory. This is often useful for determining what species are present and what their management requirements are.

• **Conservation management**. Surveying and monitoring is a critical component of species conservation management. It enables population trends under different management scenarios to be determined, especially when using a Before-After-Control-Impact experimental design, or a series of 'natural experiments' using study locations with suitable conditions, in cases where directly manipulating potential factors in the field is not realistic. Monitoring programmes may also be required to determine the success of species translocations or relocations.

• **Scientific research**. This research may be complementary to conservation management. Research adds scientific rigour to answering key questions on various aspects of biology. For example, what is a species' behavioural ecology, and what are the implications for conservation and monitoring?

• **Assessment of Environmental Effects (AEEs)**. Assessing species presence, impacts and monitoring outcomes of site development projects, as part of mitigation requirements of the RMA .

Planning surveying and monitoring programmes

• **Identify your needs and learn the basics.** You should be aware of the various surveying and monitoring techniques and analyses available, and have at least a basic understanding of the species, habitat type or situation you are going to be working in.

• **Develop your project, study objectives, and plan.** We suggest asking a series of two types of questions: (1) fundamental questions that assist you to define your goals, and help you determine whether a survey or monitoring programme should be embarked upon in the first place; and (2) specific questions relating to the surveys and monitoring programmes that will help with study design.

(1) Fundamental questions:

→ Why should we survey or monitor lizards?
→ What are our questions (i.e. what information is needed, to what extent, and why?)
→ Do we have the time and resources to collect these data, or are we able to acquire these resources?
→ What are the most appropriate and effective tools that we need to use?
→ How can we analyse the information?
→ What resources are out there?

(2) Survey or monitoring-specific questions:

Survey questions help determine the characteristics of lizard populations at a particular site. These include:

→ What lizard species are present at the site?
→ Where and how are they distributed across the site?
→ What habitat types do they use?
→ Are the lizards sufficiently abundant at this site, to a degree that a feasible monitoring study or scientific research can potentially be undertaken in the future?

A survey may also be species, rather than site, focussed:
→ What is the distributional range of a particular species across a region, or a number of regions?

Monitoring questions help determine the status of the population and its long-term survival prospects. These include:

→ How large is the population (abundance, density)?
→ Is the population stable, increasing or decreasing?
→ What proportion of the population survives to the next year?
→ What factors influence survival (e.g. age, sex)?
→ Is management having an effect on the population at a site, relative to a reference site? If, so what is the effect and how strong is it?
→ What are the likely environmental effects of a proposed site development project, and how can these be mitigated?

• **Identify the sampling techniques and data analysis methods.** This involves identifying the most appropriate survey or monitoring technique, considering good experimental design and the analytical methods you plan to use to explore your data. It is a very good idea to consult with DOC and lizard experts at this stage. Such experts may be able to assist with determining the most appropriate techniques, time of year, site selection or experimental design; and the number of sampling plots, replicates, traps, and trapping occasions required to undertake a successful study. These experts will also identify factors such as habitat, weather variables and co-variates which need to be taken into account, and provide advice on how to measure these. Finally, they will provide advice on the most appropriate data analysis methods. The NHMS I&M Toolbox is intended to answer many of these questions.

• **Obtain a Wildlife Act Permit.** All our native lizards in New Zealand are protected under the Wildlife Act 1953, hence authorisation is required before carrying out surveys where lizards will be disturbed, captured or sampled. Permits are issued by the Department of Conservation (DOC), and may be given to private individuals competent in the field of herpetology. However, it is usually preferred that the work is co-ordinated through DOC, a research institution, or conservation organisation. A report on the work must be forwarded to DOC as a condition of the permit. Where surveys are conducted, returning ARDS (Amphibian and Reptile Distribution Scheme) cards (see page 37) is usually regarded as a substitute for a written report. It may take up to six weeks to obtain a low impact permit, and longer for high impact permit applications. Further information and application forms are available on the DOC website: www.doc.govt.nz/about-doc/concessions-and-permits/research-collection-and-wildlife-permits/

• **Undertake the field work and data collection.** This is where you encounter reality! Wildlife researchers often run into unforeseen difficulties and challenges when working in the field, so having contingency plans can be helpful. Including an experienced herpetologist can help at the planning and data collection stages and avoid many problems.

• **Analyse the data.** A number of index and modelling methods are available for analysing survey and monitoring data. The method you plan to use should be identified before embarking on your study.

• **Report the results.** Communicating results is one of the more important outcomes of a survey or monitoring study. In AEEs, you will need to be particularly transparent about your survey and monitoring results. Even if your results are unclear, it is often useful for other people to learn what went right, and what went wrong in your study to avoid making the same mistakes. As part of Wildlife Act Permit conditions, you will be required to submit a report to DOC or iwi, and lizard records to DOC's BioWeb *Herpetofauna* database.

Surveying

To undertake a lizard survey at a site is to establish what lizard species are present or potentially present, in what habitat types and how these lizards and their habitat are distributed across a site. In almost all cases, a survey will be required to determine the presence of a lizard species at a specific location (i.e. actually detecting the species). There is no substitute for actual survey effort, particularly for AEEs. Some surveys are not specific to a particular site in question, but instead focus on a particular species in order to identify the extent of that species' distribution across a region. A useful start for planning a survey is to identify the species list for a region. This can be compiled using a variety of sources, including:

- Searching DOC's BioWeb *Herpetofauna* records (observation records and museum voucher material collections). Note this resource is restricted to specialists, and you will need permission to obtain records from this database.
- Using the NZ Lizards Database's regional map to create a species list for an entire DOC or Regional Council boundary (http://nzlizards.landcareresearch.co.nz)
- Incidental records and knowledge via reliable sources and literature. Members of conservation and advocacy groups such as Forest & Bird, SRARNZ and the NZ Herpetological Society, may have local knowledge on lizards.
- Canvassing the public for lizard sightings.

While there are no set standards or qualifications required for those undertaking lizard surveys, a certain degree of skill is required. As accurate identification of lizards requires handling in most cases, a DOC Wildlife Permit to handle wild lizards must be obtained prior to undertaking surveys. In applying for such a permit, DOC will require evidence of the permit applicant's competency to handle lizards. When considering surveys, some recommendations are:

- Use experienced surveyors where possible, to take advantage of their skills in finding cryptic species and species identification.
- Use a wide range of capture techniques to detect as many species as possible.
- Survey a wide range of potential habitat, including exotic vegetation.
- Perform surveys at the right time of the year and during the right weather conditions (i.e. during peak periods of lizard activity).

To assess whether lizards are present, daytime and night-time searches will be required to detect diurnal, crepuscular and nocturnal lizard species. The timing of the survey, with regards to time of day and season as well as prevailing weather conditions, is crucial to survey success. Ideally surveys should be performed during spring, summer and autumn, and should never be undertaken during adverse or extremely unseasonable weather conditions (e.g. drought, extreme cold or heat and prolonged wet periods). Survey methods will require a diversity of techniques such as using artificial cover objects (ACOs), pitfall trapping, visual searches and spotlighting at night-time, in particular for arboreal species. In assessing presence of lizards as part of AEEs, surveys will usually need to be of sufficient duration to detect lizards within development footprints. This is because it will take most species a few weeks to become familiar with the ACOs and some species can be inactive for long periods of time. Further, while surveys may be able to determine the presence of some species, particularly the more abundant or habitat-generalist species, determining the presence or absence of a cryptic or rare species is more difficult. Has the species simply avoided detection, or is it truly absent?

Surveys that are intended to simply maximise the number of species detected do not need to use a randomized design, nor does the sampling need to be standardized or repeatable, as they are not intended for abundance comparison or monitoring purposes. In fact, biased surveys may improve species detectability, but only if the surveyor has an intimate knowledge and understanding of the potential species in the area.

Surveys may differ in their level of detail, effort and scale, depending on the nature of the task

and resources available. Rapid surveys may be suitable for relatively small sites being considered for development, and may be appropriate where the likely environmental effects are determined to be minimal or temporary. This may be supported with expert opinions on assessments for lizards. However, for particularly large or difficult sites, increased survey effort usually involving experts will be required to accurately determine the presence of lizard species. In these instances where site development is being proposed, several months of survey effort may be required to develop an adequate AEE and mitigation effort.

Monitoring

The purpose of monitoring is usually to evaluate the status of a population by determining abundance or density of animals, identifying and measuring population trends (growth or declines), and identifying population demographics within a study area. Since monitoring requires multiple visits, sampling should be standardized and repeatable, and use some sort of systematic approach. Monitoring is relevant when conservation or management is being undertaken on the species or ecosystem.

However, monitoring is much more difficult than surveying, since experimental design, changes in environmental conditions, and species-specific traits need to be taken into account. Monitoring may not always be feasible in all situations. Expert advice is strongly recommended to improve the chances of a successful outcome in monitoring programmes, especially if a considerable investment is being made. This is important since monitoring programmes are usually expensive.

DOC's NHMS I&M Toolbox is an essential guide for developing monitoring projects, and in obtaining the required guidance and advice to make decisions on monitoring.

Tools of the trade

A number of standard-practice surveying and monitoring techniques are available, each with advantages and disadvantages for sampling different lizards and habitat types. The use of a particular technique depends on the species, their behaviour and habitats, and what kinds of data are required. Furthermore, new and potentially improved techniques are always being developed. Current standard practice techniques include:

Day searching

Day searching (also known as Visual Encounter Surveys, VES) consists of scanning habitat for basking or foraging lizards, and checking refugia during the day time. Surveys may be non-random, randomized by design, and/or use transects or quadrat/plot sampling.

Advantages.

- Suitable for surveying for diurnal species, either terrestrial or arboreal.
- Hand searching during the day may also reveal nocturnal species under objects or within refugia.
- May detect species that would not be recorded using other methods. At present, VES is the only survey or monitoring method available to sample green geckos (*Naultinus* spp).
- Catch-per-unit-effort indexes (e.g. number of animals/total hours of all searchers) may indicate relative abundance (if highly standardized) for some, but not all species.

Disadvantages.

- Strongly weather and season dependent.
- Subject to biases due to observer's skill and environmental variables.
- Individuals or species may have different detection probabilities.
- Cannot be used to indicate the true abundance or density of a population.
- Not suitable for monitoring most lizard species, as it is difficult to compare results over time, at different times of day, across habitat types, or between observers, unless highly standardized.

Night spotlighting

Spotlighting (or nocturnal VES) consists of scanning habitat for foraging lizards at night, using torches mounted on binoculars, or torches alone.

Advantages

- Suitable for surveying for most geckos, whose eyes reflect the spotlight, and also some nocturnal skink species.
- May detect species that would not be recorded using other methods, including green gecko (*Naultinus* spp.).
- Catch-per-unit-effort indexes (number of animals/total hours of all searchers) or time-constrained searching along defined areas may indicate abundance of relatively detectable species.

Disadvantages.

- As for day searching.

Artificial Retreats or Cover Objects (ARs/ACOs)

A range of possible cover objects may act as artificial retreats, such as corrugated iron, plywood, plastic, and other materials. It is useful to mix different types of cover objects to maximise detectability, especially under different weather conditions. In New Zealand, two materials are commonly used. They are:

- **Onduline ACOs.** Onduline is a lightweight corrugated roofing and cladding product that is widely available. Onduline ACOs consist of two or three layers of Onduline material (400 × 280 mm) with small wooden inserts creating 1–2 cm spaces between the layers for crevices.

Onduline ACO. Photo: Trent Bell.

- **Closed-cell foam covers.** This is a recently developed method used to sample arboreal lizard species. Closed-cell-foam covers (standard size 70 × 30 cm) are nailed onto tree trunks and effectively mimic refugia such as loose bark. At present, this is useful for obtaining an index of abundance, but trials are being undertaken to develop occupancy and mark-recapture applications.

Advantages.

- Unlike trapping, ACOs do not require daily checking as lizards are free to come and go.
- There is a lower risk of predation or injury to lizards in ACOs compared with trapping methods.
- Lizards may be more likely to be detected using ACOs compared with other methods.
- ACOs can be standardized in the way they are deployed, and results can be comparable if an appropriate experimental design is used.
- ACOs can be checked in the day or at night, and have less observer bias in comparison with other methods (although expertise is required to prevent lizards escaping when the ACO is lifted).
- Onduline ACOs are particularly good in open, sunny sites for terrestrial geckos and skinks.
- Foam ACOs are good for detecting nocturnal arboreal gecko species, and have detected cryptic geckos at low population densities.
- Both Onduline and foam ACOs are good for survey and monitoring studies.

Closed-cell foam cover. Photo: Trent Bell.

Disadvantages.

• ACOs usually need time in the environment before lizards find and start using them. However, the optimum time for this is not known, or is yet to be published.

• ACOs may need regular maintenance and replacement to ensure permanent ACO units are not lost over time. Onduline ACOs are particularly susceptible to rank grass growth, and foam ACOs to tree trunk growth.

• Lizards using ACOs are vulnerable to loss of shelter if ACOs are vandalised or removed. ACOs are therefore best for short-term placement only.

• Lizards are more likely to escape from Onduline ACOs than traps, especially during warmer times of the day. A barrier around the ACO may be required to prevent escapes when the edges are lifted.

• Foam ACOs do not sample green geckos (*Naultinus* spp.), nor are skinks recorded particularly well, although the latter have been recorded in covers.

• ACOs may alter the survival, behaviour and habitat use of the lizards that use them.

• ACOs can distort capture probabilities (which may violate mark-recapture assumptions).

Live trapping

• **Pitfall traps.** Pitfall traps are plastic pottles or paint tins that are buried into the soil with the lip flush to the surface. They can be baited with banana, canned pears or fish. Plywood covers are placed over the trap to protect trapped lizards from predators, dessication or heat stress, and drainage holes are punched into the base of the trap to prevent drowning. The base of the trap contains damp sponges to prevent dessication of lizards, and may also contain additional cover for shelter.

• **G-minnow traps.** G-minnow traps are fish traps, and are proving to be an effective trapping technique for some terrestrial lizard species (either diurnal or nocturnal). Traps are placed on the ground and can be baited with banana, canned pears or fish. These traps are a new technique currently being applied in several locations around the country but as yet there are no publications on their use in New Zealand. These traps may be used for both surveying and monitoring.

Advantages.

• Pitfall traps are effective for diurnal and nocturnal terrestrial skinks.

• G-minnow traps may be used where pitfall traps are difficult to use, such as rocky areas.

• Both trap types integrate captures over the course of a day or night, and therefore can be less sensitive to biases caused by variation in activity or detectability than methods which restrict sampling to the precise time during which the observer is sampling.

• Either trap may be suitable for survey, index, mark-recapture or occupancy studies, and may be useful for some of the more cryptic species.

Disadvantages.

• Both trapping methods are strongly weather-dependent, since lizards need to be active during the time the traps are open.

Pitfall trap. Photo: Trent Bell.


G-minnow trap. Photo: Trent Bell.

• Animals may become trap-shy, affecting recapture rates and thus biasing results for mark-recapture studies.
• Live traps need to be checked daily when open to meet animal ethics and Wildlife Act requirements in New Zealand.
• Mortality in traps can occur more frequently than with other methods. Lizards have been preyed upon in traps, and have also died when traps are in hot, dry and exposed places. G-minnow traps may also trap lizard predators.
• Lizards have drowned in traps in areas where there is a shallow water table. Depending on the habitat, traps may need rafts added to allow captured animals to float if the water table rises.
• Pitfall traps are not as effective for geckos as they can climb out unless the inner walls of the trap are coated with the compound fluon.
• G-minnow traps are expensive and need to be imported into New Zealand, but a cheap, alternative trap is currently under development.

Tracking tunnels

Tracking tunnels are useful for sampling both nocturnal and diurnal terrestrial lizards. The concept is similar to pest mammal tracking tunnels, but special dyes and tracking paper are used to improve recording of lizard prints. However, they may be of limited use for arboreal species. Tracking tunnels rates are useful as indices of abundance.

Tracking tunnel. Photo: Trent Bell.

Data collection

Standard measurement and data collection for lizards involves recording the following on a standardized data sheet:

• **Individual identifying mark** (paint pen, toe-clip or photo-ID; see page 39 for explanations).

• **Snout-vent length (SVL)** from the tip of the snout to the vent at the base of the tail, using a transparent plastic ruler. SVL is used as the standard measurement instead of total length, because lizards often lose parts of their tails as a result of predator attacks or fights.

• **Vent-tail length (VTL)**, including separate measurements for regenerating tails, using the same ruler as above. The total length of the lizard is the sum of SVL plus VTL.

• **Weight.** Lizards may be weighed by placing them in a zip-lock plastic bag and using either a Pesola spring scale or an electronic scale. Scale range should be a minimum of 30 g for most species, and up to 130 g for larger lizards. The weight of the bag must always be removed from the gross weight.

• **Sex and life stage.** Lizards, and especially skinks, can sometimes be difficult to sex for inexperienced people. Mature male geckos have a swelling at the base of the tail (the hemipenial sac, which contains a pair of mating organs), as well as pre-cloacal and sometimes femoral pores. Adult male skinks may have a 'flatter' tail base below the vent, and hemipenes can be everted by skilled experts to determine sex of adult and subadult skinks. Life stages are broadly categorized as neonate (young from the current year), juvenile, subadult and adult, although this can sometimes be arbitrary. SVL measurements may aid in sorting animals which are difficult to categorize.

• **Photographs**. Photographs are invaluable in identifying species or individual animals. When taking photos, record the photograph file numbers along with the lizard data on a datasheet, so that reconcilation of the data and photograph is possible later.

• **Comments.** Comments can be invaluable in recording interesting observations. These may be injuries, evident pregnancy, behaviour, body condition, habitat and microhabitats, etc.

Submitting locality records to DOC

DOC has a national data repository for lizard records (BioWeb *Herpetofauna* database), which contributes to the online Atlas of Amphibians and Reptiles of New Zealand. Observational records are contributed via a submission of ARDS (Amphibian and Reptile Distribution Scheme) cards, which are then entered into BioWeb *Herpetofauna*.

Lizard records can be submitted to DOC by anyone from any location in New Zealand. To record lizard sightings to DOC by submitting an ARDS card, visit: www.doc.govt.nz/conservation/native-animals/reptiles-and-frogs/reptiles-and-frogs-distribution-information/species-sightings-and-data-management/report-a-sighting/

You may also submit ARDS cards electronically by visiting: www.ecogecko.co.nz/ards.php

To see the Atlas of Amphibians and Reptiles of NZ, visit: www.doc.govt.nz/conservation/native-animals/reptiles-and-frogs/reptiles-and-frogs-distribution-information/atlas-of-the-amphibians-and-reptiles-of-nz/

People spotting lizards on a DOC reserve, Coastal Otago. Photo: Riki Mules.

Data analysis

Once you have completed surveying or monitoring and have collected the data, it must then be analysed to complete the study. The type of study, and its objectives and questions must be taken into account when looking at the results. Finally, the data analyses are only as good as the quality of data collected. There are four major study types for lizard surveying or monitoring. These are:

Incidental observations

Inventory and recording of incidental observations of lizards in the wild, including canvassing the general public or from surveys.

Advantages.
• New records of lizards may be obtained from a wide geographical area or specific site and then followed up.

Disadvantages.
• Species identification is often an issue, although the prevalence of digital and phone cameras may help.
• Not a monitoring method.

Indices of abundance

Indices are simple counts of animals against the number of sampling units (catch-per-unit-effort) which may be traps, artificial retreats, tracking tunnels or visual searches. Index studies are the cheapest way to monitor cryptic populations, but are not able to incorporate detection probability as a nuisance parameter. However, indexes can be 'corrected' by calibration if there is mark-recapture data incorporating detection probability information. Index studies have sometimes failed to demonstrate population trends in lizard monitoring programmes in New Zealand, and are not usually recommended. Two types of count-based index studies are commonly used:

1. **Catch-per-unit-effort.** Lizards are caught or detected over a specified period of time (e.g. total person hours, where the number of hours is multiplied by the number of active searchers; or by time-constrained searching).

Advantages.
• Minimal time and effort.
• Appropriate measure of survey effort for day and night search techniques.

Disadvantages.
• Not an estimate of abundance or density, unless detection is relatively high and constant, and searches are highly standardized.
• Searches are affected by the searcher's skill and variation in the environment, weather conditions, and season.
• Habitats may change over time, altering ability to detect lizards
• Counts cannot be compared between studies.

2. Tracking rates. Tracking tunnel cards have been developed for detecting, identifying and monitoring lizards.

Advantages.
• Minimal time and effort.
• Some species identification may be possible.
• Cards may be left out for weeks at a time, and are useful for surveys.

Disadvantages.
• Not an estimate of abundance or density.
• It is not always possible to quantify the individual number of animals counted on one tracking pad.

Mark–recapture studies

This involves temporary or permanent marking of individual lizards (such as by toe-clipping or photo ‘mark-recapture’), and recapturing these animals, plus additional unmarked animals over time, to build up a 'capture history' of individual animals to estimate abundance and/or individual survival rates. Mark-recapture studies are more robust and precise than indices of abundance, but are expensive and time-consuming, and require considerable expertise in field work and data analyses. Several models are available within the mark-recapture framework, generally separated into 'open-population' and 'closed-population' model types, each of which has its own assumptions. 'Open population' models allow for changes in the population size (such as birth, death, immigration and emigration) and are used for estimating survival. 'Closed population' models do not allow for population change, and are used to estimate abundance. However, there is a robust design model which incorporates both situations, and may assist in estimating both abundance and survival simultaneously. Data are analysed using software programme MARK (www.phidot.org/software/mark/).

Assumptions
• When the model requires a closed population state (i.e. no movements into, or out of the study site), the timing and duration of a study will need to consider whether the population is likely to be in a 'closed' state.
• Capture probability is constant (equal catchability of all animals), or is explained by models incorporating effects of time, behaviour or both, or animal heterogeneity (size classes, or sex), on captures.
• Animals are captured independently of each other, and upon release, have had sufficient time to mix freely within the existing population before the population is sampled again.
• Identifying marks are not lost (see page 39).

Advantages
• Sophisticated method for estimating population abundance, density or survival.
• Estimates can be compared over time or to other locations.

Disadvantages
• Time-intensive, and requires expertise.
• Permanent marking of lizards is usually required.
• The study must be carefully designed so as not to violate assumptions. However this is not always possible leading to the need to engage a statistician to custom build a model to fit the data.
• A number of repeated site visits are required over a short time frame for 'closed-population' (no birth, death, immigration and emigration) studies.
• Data are sometimes insufficient to model outcomes with precision.

For further information on analysis of capture-

mark-recapture data, the following book is an excellent primer:

Amstrup, S.C., McDonald, T.L. and Manly, B.F.J. 2005. *Handbook of capture-recapture analysis.* Princeton University Press. 313p.

Site occupancy studies

This method combines elements of index studies and mark-recapture type studies, as it incorporates detection probability (as mark-recapture studies do) but replaces identification of individual animals by recording species presence in sampling units (e.g. traps, artificial cover objects) over repeated surveys. Occupancy can be defined as the proportion of sites occupied by a species, and is ideal for monitoring sparse species over a large area. This method, while requiring multiple visits to a site in a closed-population sampling design, is less intensive or complicated than mark-recapture, and ideally suited for non-experts, provided expertise in data analyses is available. Data are analysed using the following software programmes MARK and PRESENCE (www.mbr-pwrc.usgs.gov/software/presence.html).

Assumptions.

- The population is in a closed occupancy state during the sampling period (i.e. there are no movements into, or out of the study site). The timing and duration of a study will need to consider whether the population is likely to be in a 'closed' state.
- Sites are independent, such that detection at one site does not influence detection at another site. Location of sites needs to be planned in such a way to meet this assumption.
- No unexplained heterogeneity in site occupancy. Differences should be explained through site covariates (such as habitat type). Standardization and randomization of sites is likely to be required.
- No unexplained heterogeneity in detectability. Detectability should either be the same across all sites, or can be related to covariates such as temperature or rainfall.

Advantages.

- Data can easily be collected by non-experts.
- Individual marking of lizards is not required.
- Ideal for monitoring populations long-term or at landscape scales, particularly for rare or sparse species.

Disadvantages.

- The study must be carefully designed to avoid violating assumptions.
- A number of repeated site visits are required over a short time frame, and may require a large number of sites.
- The model is currently unable to consider species abundance, as opposed to presence or absence (i.e. the data are binary, and are unable to account for more than one animal under a single sampling unit). The method is excellent proxy for abundance but is conservative. To compensate for this, complementary index data collected at the same time could be presented.

For further information on site occupancy estimation and modelling, the following book is an excellent primer:

Mackenzie, D.I., Royle, J.A., Pollock, K.H., Bailey, L.L. and Hines, J.E. 2006. *Occupancy estimation and modeling.* Elsevier Academic Press. 324p.

University of Otago students assisting a Landcare Research study, monitoring skinks in tussock grassland, Coastal Otago. Photo: Trent Bell.

Marking techniques

To be monitored by mark-recapture methods, lizards need a unique mark so that individuals can be identified again on recapture. Permanent marking is not always necessary in short-term studies where temporary marking may be used. However, permanent marking is necessary in longer term studies in order to determine detection probabilities and subsequent abundance or survival rate estimates with a degree of precision. Data obtained by marking lizards can provide information on individual longevity, age, growth rates, changes in body condition, spatial movements, territories and ranging patterns, as well as population sizes and survival.

Mark-recapture studies make two major assumptions regarding marking animals: (1) marks are not lost or misinterpreted; and (2) marking does not affect lizard behaviour. Marks that are 'lost' or unclear, or changes in behaviour can make data analysis difficult or inaccurate. If these assumptions are violated, population abundance estimates and survival probabilities will then be inaccurate.

Temporary marking techniques

Paint pen marks. These can be applied to the body of a lizard, and a symbol, numeral or colour-coding system can be devised.

Advantages.
- Quick and easy to apply.
- No harm to individual lizards.

Disadvantages.
- Suitable for short-term studies only, as paint wears off and lizards shed their skin regularly.
- Lizards with paint marks may be more visible to predators.
- Difficult, if not impossible, to apply on wet skin.

Permanent marking techniques

Some monitoring programmes require animals to be identifiable over long time-frames. e.g. within the same season, or several years later. This is because many statistical models use the proportion of 'recaptured' versus 'new' animals over time in order to estimate the number of animals at a site. In addition to creating a permanent record of individual animals at a location, the data can be used by any researcher wishing to conduct additional studies within the life span of previously-marked lizards (which may be decades later). In addition, if all 'founder' animals are permanently marked prior to release at a new site, it may be possible to determine post-release survival of these animals over time.

With lizards, there are a very limited number of ways to permanently mark an animal. It is not possible to attach an object to a lizard (like leg bands in birds), or permanently 'write' on the lizard's body (because lizards shed their skin regularly). Toe-clipping and photo identification are the two major identification methods used in New Zealand, although toe-clipping has recently fallen out of favour as a standard practice method. Implanted microchips can be used for adults of the larger species.

1. Toe-clips. Toe-clipping is the most reliable permanent marking method available for lizards, and is regarded internationally as the standard practice for this purpose. DOC, Landcare Research and universities have used this method for decades. However, as a result of community and iwi concerns, this technique has fallen out of favour and is now approved by DOC only in exceptional circumstances. Toes are clipped using small, clean and sharp scissors according to a coding system which may provide hundreds of combinations. If possible, it is good practice to remove as little of the toe as necessary. The practice is generally not recommended for arboreal species or other species with thick, fleshy toes.

Advantages.
- Individuals can be marked rapidly.
- Rapid and usually accurate identification of individual lizards.

• Relatively inexpensive.
• Unique cohort or individual marks can be incorporated (such as natural toe losses).
• Suitable for many species in which individual photo-marking is not feasible.
• Cuts heal rapidly and have been demonstrated to cause little stress, as measured by stress hormone production.
• Toe-clipped animals have lived for several decades after marking.
• Can be backed-up by photo-ID.

Disadvantages.
• May have potential to harm animals through infection, decreased survival or hindering mobility.
• DOC, animal ethics committee and iwi approval of the method may sometimes be difficult to obtain.

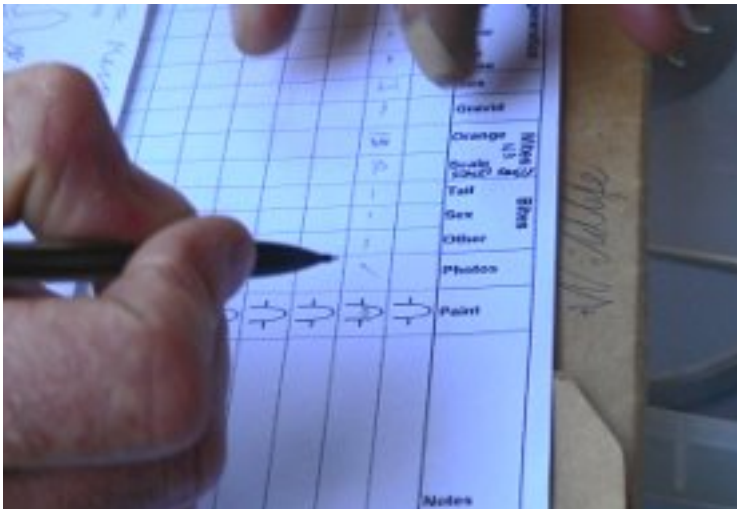
Lizards often do not react when clipped, especially if conducted by someone highly experienced with toe-clipping animals. Some animals do react momentarily, but this reaction is only temporary. Lizards are often seen to resume normal behaviour soon after release.

2. Photo-mark-recapture. Photo-mark-recapture is increasingly recognised as an efficient and non-intrusive method of identifying individual lizards. Lizard species with unique or irregular pattern marking can easily recognised again using a series of photographs (photo-mark-recapture). Photographs can be taken either in situ or upon capture.

Advantages.
• No harm to individual animals when 'marking'.
• Individual identification possible with unique patterns or spots which may either be on the dorsal, lateral or ventral sides of animals.
• Marks are not usually lost over time.
• In-situ (but not capture based) photography reduces the risk of recapture bias (trap shyness).

Disadvantages.
• Not suitable for species of lizard which are very uniform in pattern.
• Tonal changes in skin colour by geckos can cause problems.
• Identifying individuals from photographs can be time consuming, and therefore may not be suitable for superabundant species.


Marking an Otago skink with temporary mark. Photo: Trent Bell.



Recording data on a data sheet. Photo: Trent Bell.


Weighing a forest gecko (*Mokopirirakau granulatus*) using an electronic scale. Photo: Trent Bell.

Handling, holding & transporting lizards

Wildlife Act Permits are required for handling, holding and transporting lizards.

Handling lizards

The best way to handle lizards is to secure them between the thumb and fingers, either by their shoulders, pelvis, or feet. Lizards will often struggle or bite, but bites are not usually painful. Take care not to hold lizards by their tail, as autotomy (tail loss) may occur. This can also occur without handling the tail if the lizard is extremely frightened. Tail loss can affect fitness as fat is stored in the tail, and social interactions may also be affected.

Holding lizards

The holding of lizards may be required in some cases, such as during processing in the field, or for later identification by experts.

Cloth bags, such as calico, are suitable for holding lizards, as they provide ventilation. These bags require careful gap-free sewing, and should be fastened by an external knot. Drawstring ties are not suitable, as escape is possible through narrow openings. However, care needs to be taken that lizards contained in a bag are not accidentally crushed. A small container with ventilation is another option. Packaging material, such as leaves or dense twigs, helps provide protection and space from other lizards. Several lizards can usually be safely held in one bag or container. However, larger lizards should not be held with smaller lizards, as predation may occur, and extra care must be taken to avoid escapes when adding additional lizards to a bag or container.

Lizards held in storage must be kept in a cool place, away from direct sunlight or heat, to avoid overheating and death. If being held less than a week, lizards do not usually need to be fed. However, some misting by a water sprayer for hydration should be provided daily, and a shallow water dish provided for longer periods.

If animals are to be kept in captivity for extended periods (i.e. longer than a week), proper housing and husbandry of the lizards is required. Contact DOC for advice. Additional information on husbandry is also available from the NZ Herpetological Society (www.reptiles.org.nz).

Transporting lizards

At times it may be necessary to transport live lizards, for example for species identification of particularly unusual animals. They should be transported by car or plane (booking ahead is necessary). A number of precautions are also necessary:

- Only small, robust containers should be used. These should have a tightly-fitting and secure lid, adequate ventilation, and should be lightly misted by a water sprayer but not sodden. The lid of the container should be taped on.
- Packaging such as leaves or twigs, or a cloth bag, should be provided within this container to provide the lizard(s) with some protection during transit.
- Before sending the package, advise the intended recipient and confirm that someone is there to receive it.

Dead lizards

Dead lizards usually have some scientific or taxonomic value, such as for confirming the identity of specimens for locality records, or as DNA material or vouchers. Decomposed or mummified lizards can still be of value, especially if they are of a rare species or from an unusual location. Dead lizards may be found in the field or in a trap, in captivity, accidentally crushed, brought in by a domestic cat, or recovered from the gut contents of a predator. The ideal preservative is 70-95% ethanol in a jar. The Museum of New Zealand Te Papa Tongarewa, in Wellington, is usual repository for specimens, but your local DOC office should be consulted first.