GUIDELINES ON

MONITORING AND EVALUATION

PURPOSE

- These Guidelines are to be used by Project Managers conducting eradication projects based on the PII Resource Kit for Rodent and Cat Eradication.
- The Guidelines describe how to undertake outcome monitoring by measuring indicators to assess the success of the project.
- Further information on monitoring and evaluation can be found in the Further Information section of the Resource Kit.
- References can be found in the Reference section of the Resource Kit.

1. TYPES OF MONITORING

- In an eradication project there are three types of monitoring:
    - Project outcomes
    - Operational parameters
    - Project management
- The details and work required to monitor project outcomes are recorded in the Monitoring and Evaluation Plan.
- Guidelines on operational monitoring can be found in the Guidelines on Planning and Managing an Eradication Operation. The detail of the operational monitoring is recorded in the Operational Plan.
- Guidelines on project management monitoring can be found in the Guidelines for Project Managers. Project management monitoring will be defined in the Project Governance section of the Project Plan.
- Outcome monitoring will always include:
    - Monitoring for the presence/absence of the targeted invasive species and other newly invaded species.
    - Monitoring of the outcomes that result from the absence of the target invasive species, e.g. effects on native species including positive and negative effects.
    - At least one indicator for each project objective.

2. SELECTING INDICATORS

- An indicator is something that is measured that represents the changes due to the project and tells you if you have achieved the objectives and outcomes of the project.

- Measuring indicators is required so that you can verify and demonstrate that the outcomes of the project have been met.

- Select indicators that can be measured before the eradication (to give the baseline) and repeatedly after the eradication.

- Select a small number of well-thought out meaningful indicators. As outcome monitoring can be time consuming and expensive it is better to concentrate on collecting fewer, better quality data than measuring many indicators less comprehensively.

- Avoid complex data collection. Indicators are better if they are simple and easy to measure repeatedly by you or other people, bearing in mind that in the future other people may be doing the monitoring.

- Example indicators:

Species	Indicator
Target invasive species	Absence/presence
Land birds	Population index e.g. numbers recorded, age structure
Land birds	Diversity index – number of species recorded
Sea birds	Nest index e.g. distribution, numbers, success
Sea birds	Diversity index – number of species recorded present and/or nesting

3. MONITORING DESIGN

- This section contains the basic principles that you need to understand when planning and implementing a useful outcome monitoring program.

- Further information can be found in the Further Information section of the Project Process Stage 3 and Stage 4 of the Resource Kit.

- It is important that the people undertaking the monitoring are familiar with the biota being measured and are able to repeat sampling in precise and accurate ways (see section 3.3).

3.1 BASELINES AND COMPARISON ISLANDS

- Establish a baseline measurement of the indicator. Ideally, pre-eradication monitoring should be established as a baseline over several years leading up to the eradication as this provides a measure of variability in the presence of the invasive(s). Comparing the post-eradication monitoring to the pre-eradication monitoring will demonstrate the effects of the project. Without baseline data you will not be able to show what changes have occurred because of the eradication of the invasive species.

- Comparison islands are islands that are similar (vegetation, invasive species, native species etc) to the eradication site, but are not part of the eradication operation. A comparison island (often called a "control site") enables you to tease out the effects of other potential factors on the short-term responses of biota. A comparison also helps to confirm the outcomes seen are due to the eradication operation and not due to some other factor, e.g. climate.

3.2 TOTAL COUNT VS INDEX

- A census is a total count of the indicator. All individuals of a species, number of nests, breeding pairs etc on the island are identified and counted to give an absolute count of the indicator. Sometimes it is very difficult to achieve this or even know whether it has been achieved (see section 3.3).

- An index is a measurement based on a sample of the population; the whole population is not measured, just a fraction (the sample) of the population. If changes in the sample are representative of changes in the whole population then an index is a useful indicator.

- A census can involve significantly more work and complexity than measuring an index.

- As indices are sufficient in measuring population changes, indices derived from sampling is most frequently used in eradication projects.

3.3 SAMPLING, PRECISION, ACCURACY AND BIAS

- The terms precision, accuracy and bias have specific meanings when applied to monitoring data and need to be well understood to plan a monitoring survey.

3.3.1 PRECISION

- Precision is a measure of how close repeated measurements of the same indicator are from each other.

- For example, consider two surveys.
  Survey A. Repeatedly counts the number of birds in forest A.
  Survey B. Repeatedly counts the number of birds in forest B.

During the survey period we know the true populations in both forests do not change.

Results:

	Count 1	Count 2	Count 3	Count 4	Count 5	**Mean**	**Standard Deviation**
Forest A	490	495	500	505	510	500	7.9
Forest B	590	595	600	605	610	600	7.9

- In each forest, the individual measurements are very similar. As the repeated measurements are close together they are considered precise measurements.
- Standard deviation is used as a measure of the preciseness of a set of measurements.

3.3.2 ACCURACY

- Accuracy is a measure of how close the measurement is to the real value we are trying to measure.
- For example, consider the two cases above. If the true population in forest A was 500, then the measurements are accurate. However, if the true population of forest B was 2000, then those measurements would be considered inaccurate.
- Sometimes a set of measurements that are precise are (incorrectly) assumed to be accurate.
- Without knowing the true value it is impossible to know the accuracy of the measurements.

3.3.3 BIAS

- Bias is when the measurements are larger or smaller than the true value due to an underlying issue with the measurement design. Bias causes inaccuracy.
- Consider the two surveys above. In survey B, each of the five measurements is systematically below the true value of 2000. There is bias in the measurements and they are inaccurate. While in survey A, there is no bias in the measurements and the values are accurate.
- Bias can also come about from many other factors such as inaccurate observations, erratic sampling times, poor equipment, different people using slightly different methods.

3.4 SAMPLING STRATEGIES

- Use representative sub-sampling when it is difficult to measure the total value of an indicator. In restoration projects a common indicator is population size of a native species (the outcome being that the population size will increase once the invasive species has been eradicated). On many islands and for some species it would be very demanding to count all individuals of a species. As an alternative, the indicator is only measured at a number of selected locations. Assuming that changes at these locations are representative of changes of the wider population then such monitoring will provide an accurate view of the wider changes.

- Each survey must use the exact same technique to measure the indicators. This will allow you to compare apples with apples.

- The timing of each survey must be consistent. Consider the case of using the Point Count method to measure bird populations (See Techniques Section). At a location the number of birds visible or audible is going to be affected by a large number of variables including:
    - Time of day.
    - Season of year.
    - Weather conditions.

- Much tropical bird sampling requires particular weather for observations to be valid, e.g. sampling on dry days, trade wind below local threshold speeds for effective listening (threshold speeds are lower in forest than in the open).

- To isolate changes due to the eradication, all other variables should be constant between each survey. For example, always monitor at the same time of year. If not your results may be biased by seasonal changes, for example, migratory or breeding behaviour.

- If using any form of location-based monitoring it is generally advisable to use the same set of monitoring locations at each survey. Using different locations between surveys may bias the results with geographical variations rather than changes due to the absence of the invasive species.

- Knowledge of the behaviour of the indicator species will be required to devise a robust monitoring plan.

- A key need is for the observers to be experienced and, in particular, to be familiar with the species being monitored as well as other species that can be confused with it. It may require several observers to be trained in order for future monitoring to not become biased by new observers.

4. REPORTING THE RESULTS OF MONITORING

- Results of the outcome monitoring should be regularly communicated to stakeholders as part of the project management reporting.
- The frequency and method of reporting the results of the outcome monitoring are defined in the Project Plan.

5. DATA MANAGEMENT

- The tools for recording the monitoring in the field will depend on the project.
- Ensure that you collect and store relevant information about how and when the indicator was measured. Typical information to record includes:
    - Who measured the data.
    - The location (GPS co-ordinates are preferred) of each data sample.
    - The time and date of each data sample.
    - The weather at the time of the measurement.
    - A description of the technique used to collect the data.
    - Other data specific to the project and which can vary from year to year, e.g. vegetation structure.
- Using a standard data collection sheet based on a template is a useful way of reminding the person doing the monitoring to collect all of the required information.
- Water proof notebooks and paper can be extremely useful in the tropical climate.
- When back in the office, transfer all monitoring data to a PC - Microsoft excel spread sheets is a very good data management tool.
- Creating computer copies of the monitoring data allows easy sharing of the data between team members. It also provides a safe backup of the data in case field note books are lost or damaged.

6. TARGET SPECIES

- If you are implementing a comprehensive surveillance programme as part of the Biosecurity Plan there is no need for separate monitoring to assess the success of the eradication: an effective permanent or regularly run biosecurity network of traps, bait stations and tracking tunnels will relatively quickly tell you if rodents are still present on the island or have arrived again. If resources allow, a permanent network of detection devices is

recommended, rather than having periodic efforts every six months or so. This option is most likely for islands that are frequently visited and have a relatively high chance of re-invasion.

- If the monitoring is solely to confirm the success or failure of an eradication attempt (i.e. there is no intention, ability or resources to implement a regular biosecurity network), it is usually not worth the resources to start any sooner than 1 year after the eradication operation has concluded (i.e. about a year after the last of the poison has been placed out). If there are surviving rodents it will be extremely difficult to remove them as they will obviously be shy of whatever techniques you tried during the eradication – it these cases it is usually best to consider the eradication as a failure, and plan for another attempt sometime in the future, rather than continue pouring money and resources into trying to remove an unknown number of survivors.

- In cooler climates such as New Zealand the recommended waiting period is 2 years before monitoring for the success of the eradication attempt, so that any remaining rodents breed and become more obvious – it is very difficult to find any sign of just one or two rodents, especially on large, steep or heavily forested islands. In warmer climates such as on tropical Pacific islands, rodents will breed year-round so will quickly re-populate an island (within a year) if the eradication has been unsuccessful. For monitoring of success in this scenario, a single intensive monitoring effort is usually all that is required. This option is especially useful for remote, rarely visited islands.

What monitoring should I undertake?

- It's important that you tailor your techniques to all of the species you are targeting and the environment you are working in (e.g. a rat trap that is crab proof and can withstand sandy conditions). It's likely you will need to use a range of monitoring techniques. This is for 2 main reasons:
    - No one technique can monitor for all invasive species groups.
    - Using a range of techniques increases the chances of detecting your target species.

- The Permanent Monitoring Stations for Rodents tool (in the Guidelines on Rodent Surveillance Techniques) is an example of 3 different techniques (tracking tunnels, wax tags and snap traps) which are being used effectively in the Pacific to detect rodents.

Where should I monitor?

- Monitoring should cover as wide a range of habitats on the island as possible to maximize the chances of picking up any survivors.

- See the Guidelines on Rodent Surveillance Techniques and the Guidelines on Cat Eradication and Monitoring Techniques for further details on where and how to monitor.

How should I monitor?

- Use your eyes – often the most effective way of detecting rodents and cats (and which also avoids native species interfering with monitoring devices) is to look for rodents directly along with their signs. This should

involve day-time searching for evidence of predation (gnaw marks) on birds' eggs in particular and gnawing on carcasses/bones. It should include spotlight/headlamp searches during the evening and at night. An awareness of sign from native species (e.g. curlews) on egg shell will help.

- Monitoring devices. The number of devices to be used is dependent on the size of the island, and what resources you have available to undertake the monitoring. However, the more devices you have out, and for longer, the more reliable the monitoring will be, and the more confident you can be of success. Consider the recommended spacing for traps and tracking tunnels provided in Index Trapping and How to Use Tracking Tunnels (within the Guidelines on Rodent Surveillance) as a guide, but if resources do not allow this, then consider what coverage you can achieve with the resources available. Determine what resources in terms of people you have to do the work, the regularity at which monitoring needs to be done and whether you can sustain it for the required monitoring period.

- Quality, as well as quantity, of detection devices is also very important. It is much better to have a few very well set and maintained monitoring devices than a lot of poorly set and rarely maintained devices. The latter increases the chances that a targeted species may visit a poorly set device and either not get caught or get a fright and stay away from all devices – thereby increasing the chance that it may not be detected or ever get caught.

How often should I repeat the monitoring and how long should I do it for?

- Monitoring to confirm whether an eradication is successful is often a single, intensive monitoring effort, but can also be a prolonged period in which normal biosecurity monitoring has not detected any sign of rodent presence (see 'When do I start', above).

- It should occur (or be repeated as necessary) for as long as necessary to allow you to be confident that rodents no longer remain, and to convince others that sufficient monitoring has been done to confirm this.

- More monitoring will occur later, but is effectively monitoring to detect any possible re-invasion, and is part of the Biosecurity procedures.

- Consider also that 'absence of evidence is not always evidence of absence' – you can rarely be absolutely sure that you have completely eradicated the pest, but the more time and effort that passes the more confident you can become. If for example some rodents have survived and are at very low levels it may take some time to detect them. Under optimal conditions individual rodents can survive for up to 3 years in the wild. However, if you have checked regularly and/or thoroughly for rodents for at least 1 and ideally up to 2 years since the eradication project without finding any rodents or sign of rodents, then you can safely assume you have been successful and can declare the eradication project a success.

7. NON-TARGET SPECIES

Techniques for monitoring native species vary widely depending on several factors including:

- Whether the species is sedentary (present all the time) or seasonal

- Whether the species is conspicuous and easily counted or more cryptic (difficult to detect)
- Do you want to know just the diversity of species present, e.g. total plants or total seabird species?
- Do you want an accurate measure of the total population every few years?
- Do you just want to know the trends in population numbers over time?
- Do you want more detailed information on productivity (breeding success) before and after IAS removal and perhaps health (individual fitness) of individual animals?

Some useful monitoring techniques are described for different plants and animals below and different monitoring questions.

7.1 SEA BIRDS

WARNING! Approach all birds with care. Avoid walking through colonies of frigatebirds as these can desert nests easily and avoid trampling dense ground vegetation where there may be seabird nests and areas with burrows in sand.

7.1.1 DIVERSITY

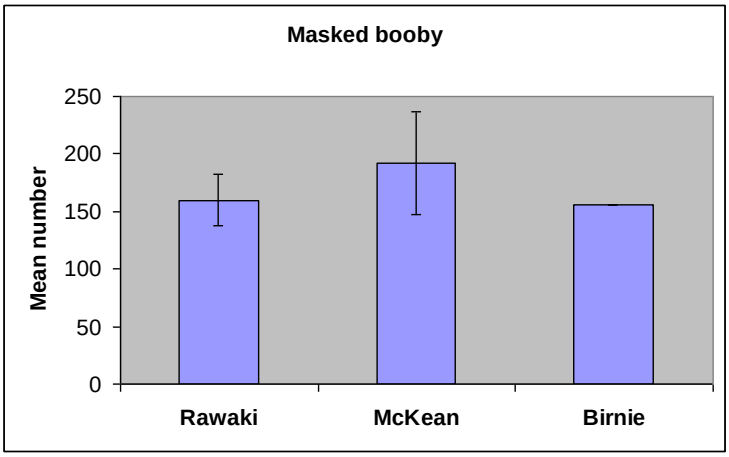
How do I know what species are present now (at or before IAS eradication) and in the future and are they nesting?

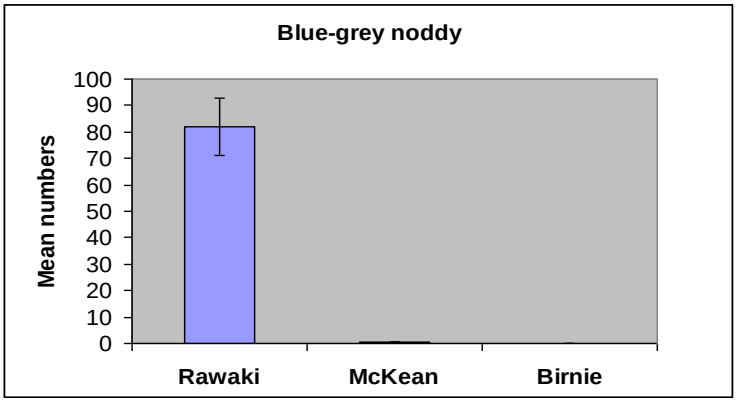
- Searches - undertake searches through representative habitat on the island during the day and at night, ensuring that trees, burrows and dense vegetation is checked for nests and roosts. The night surveys are critical given that many species return to the island at dusk or after dark to roost, replace a mate on the nest, feed chicks, etc, but have departed the island by first light the next morning. Record evidence of nesting, including numbers of nests and their stages e.g. nest scrapes/platforms, egg(s), chick(s), juvenile(s). Keep a record (map) of where you searched. Be careful to avoid standing on burrows, nests in dense grass, etc.
- Fly-ons - evening observations of seabirds returning to the island for the night. For this method to be effective position yourself on the leeward (sheltered from wind) side of the island as most birds return to the island by flying and landing facing into the wind. It is best to observe for the last 1.5 hours of daylight, beginning about one hour before sunset. It is best to adopt a search image for particular rare species, e.g. petrels, storm-petrels, shearwaters, boobies, etc that might occur on the island either now or in the future. You will become skilled at ignoring the more common birds. This method can also be used for obtaining a crude index of

abundance of these species. All that is needed is a comfortable seat, note-book and binoculars, and a torch for getting back to camp later.

- Both the above techniques (searches and fly-ons) should be used together and repeated at different times of the year. Most seabirds have a mid-year and a late-year peak in nesting so observations in April-June and November-January are useful to cover both breeding timetables. However, observations at other times of the year are also useful.

- The graphs below show relatively consistent numbers of birds (mean and standard error) of masked boobies and blue noddies returning to three study islands in the Phoenix Islands each evening and can be used for long-term indexing of this species' numbers. The boobies appear to be unaffected by the presence of rabbits (on Rawaki) and rats (on McKean and Birnie), but noddies were absent on the rat-infested islands.





7.1.2 POPULATION

How do I know the numbers present/nesting and their trends over time?

- Indicators - there may not be time for you to estimate total populations of all species on your island, in which case it is best to focus on ideal indicator and/or threatened species. Ideal indicators are those that are particularly susceptible to rats and cats, i.e. ground-nesting noddies (blue and brown noddy) and terns (e.g. grey-backed, sooty, black-naped tern) are ideal. These are also rapid breeders and can respond quickly to the removal of rats.

- Colonies - for large dense colonies of terns, noddies and shearwaters (but not frigatebirds), use a GPS to map the perimeter and calculate the area of the colony. Then carry out a series of 2m wide parallel transects completely through the colony and count the number of nests along each transect line. Aim for a transect line every 50m along the colony. Then use the GPS to measure the length of each transect from which you can calculate the number of nests per unit area (the area covered in each transect). A 2m long pole, stick or coconut frond with heavy string at both ends enables an accurate assessment of the 2m wide strip. This can be done effectively in pairs.

- Rare species - petrels, storm-petrels, etc may be best mapped initially as colonies, then carry out a contact search of either a large proportion of that area or the full amount to arrive at an estimate of breeding pairs using the GPS as before. Fix the position of each nest on GPS. It helps to have a good knowledge of what the nest site of each particular species looks like, so training of observers is important.

- Banding rare species - in some cases there may be justification to individually mark birds with a metal band or ring, each with a unique number. It enables you to keep track of individuals as well as providing a more accurate estimate of total numbers using the data number previously banded, number checked, proportion of birds checked that were banded. This is specialist work however – contact NZ Department of Conservation Banding Office for guidelines and training.

- Large birds - on open islands it may be relatively easy to count all booby and frigatebird nesting pairs from one or more vantage points. If this is not possible it is usually possible for a team of people to walk at c.50 m intervals along/across an island and record the number of nesting pairs. If time permits, repeat this to determine variability between observers.

- Trends - to measure trends over time it is best to repeat measures annually initially using the same methods, time of year and day. If interyear variability is high, review monitoring questions and methodology.

- Day versus night observations - If you are happy with your technique for finding nests during the day, there may not be a need to do supplementary night work. However, observations at night may reveal the non-breeding numbers of your target birds – these may form single or a few large flocks, e.g. masked boobies may flock together in groups of many hundreds and noddies in their thousands. These counts have the benefit of telling you whether there are healthy numbers of non-breeders in the population at that time of year. Avoid shining intense light on seabirds – keep to diffuse lighting or put red cellophane over lamps.

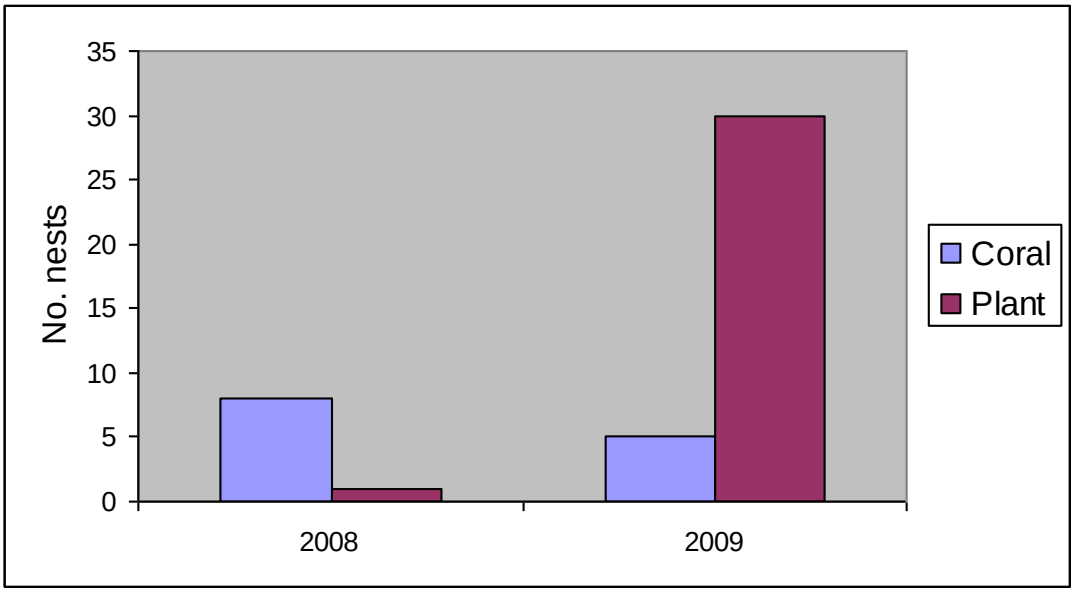
7.1.3 BREEDING

Has breeding success changed over time?

- Often one of the fastest parameters to change after invasive species are removed is bird breeding success. In the absence of rats and cats most seabirds have a greatly improved hatching and fledging success. Observing eggs and chicks is also a good surveillance tool in the future when you are searching for signs of invasive species presence – if rats are present you will see rat-gnawed egg shells and if cats are present you will see adult and juvenile birds with eaten or gnawed heads.

- The easiest approach is simply to record the number of chicks and juveniles seen during a visit to the island. In the presence of some rat species, virtually all eggs or chicks are eaten so it is normal to observe few if any large chicks or juveniles (and you will see rat-gnawed egg shells). However, once rats are removed any pairs of seabirds attempting to nest should have a high breeding success so there should be many chicks and juveniles present (and any infertile or addled eggs will be left intact). For example, many small islets in Kiritimati Lagoon were de-ratted by Kiribati wildlife staff and within 18 months there was a noticeable increase in nest survival (many eggs, chicks and flying young of terns and noddies) and abandoned eggs were still intact (not rat-gnawed, Pierce et al 2010). Simply record this on an Excel spread-sheet or island data sheet.

- Other changes can occur after pest removal. For example nesting habitat can improve for seabirds following rat or rabbit removal. The graph below demonstrates the switch in blue noddy nest sites (restricted largely to coral slabs when rabbits were present) to nesting beneath vegetation (*Portulaca, Sida* and *Boerhavia*) that was recovering 18 months after rabbit removal, Rawaki, Phoenix Islands 2008-09.



- With many changes occurring in the oceans (e.g. food depletion from over-fishing and warming events) there can be serious impacts on local breeding success. Keep good records of any unusual events, e.g. chick die-offs, apparent starvation, etc. It is useful to have Pesola balances (500g) to enable you to measure weights of birds and compare with healthy specimens (either locally or from the literature).

- A more scientific way that allows greater accuracy is to follow the progress of nests individually from early incubation to fledging, but few of you will have the time and resources to do this. If you can do this for some indicator species such as terns, boobies and frigatebirds, then that will provide you with additional data on population health and potentially reveal other issues, e.g. chick mortality from marine food shortages. In this situation you would individually mark nest sites (GPS and cryptic marker near nest) to help you to relocate nests for ongoing monitoring at appropriate intervals to measure success – typically 1-2 week intervals.

7.2 LAND BIRDS

7.2.1 DIVERSITY

What is the diversity of landbirds?

- The main method is to carry out many diurnal observations (plus nocturnal if owls and other night birds may be present) and invite all visitors to contribute observations via logbooks, reporting cards, etc.
- Carry out targeted surveys for species that are suspected to visit or could visit. This could involve specific observations and taped play-back calls (see Bokikokiko example below).

7.2.2 POPULATION

What are the total numbers and/or how do I monitor population trends?

- This can involve quite specialised methods aimed at detecting a high proportion of the population or the area sampled. Methods will depend on the species in question and the particular questions and level of accuracy needed.
- Standard approaches involve indexing the population through the use of point counts or line counts, either of which are fine to measure trends in populations (refer box below). In most cases it is more important to know the trends of the population rather than exactly how many birds there are.

7.2.3 POINT COUNTS

- Useful for:
    - Species of birds
    - Bird density
- Point counts are a stationary type of survey and involve counts from a specific location. For example, you would count the number of individual birds (of each species) within a circle of a certain radius. In most cases, especially when gathering data to compare one point count to the next, radius size should be consistent.

- The radius should be as large as possible to maximize information gathering, but not so large that birds cannot be seen or heard throughout the survey area. Also, landscapes are very different from one survey site to the next. It is difficult to select a radius that works for every situation.
- A radius of 20m is a good guide for most situations. Keeping the surveyed areas the same makes comparing different point counts easier.
- In some cases, due to obstacles, the entire circle may not be possible to survey. Try to find a location where you can survey 100% of the circle. If this is not possible report the percentage of the circle that could be surveyed.

7.2.4 TRANSECT COUNTS

- Useful for:
    - Bird population monitoring.
- Transect surveys provide a uniform way of counting a species over time or across locations. Transects are walking surveys, so you can cover large areas. It is a good way to monitor species such as birds (and crabs) because you can cover a lot of ground by walking along a route.
- Transects are generally visited over a period of several days or longer to assess how many and what types of the species being monitored are in an area. To increase accuracy, simply increase the quantity of transect surveys and the number of days a transect survey is repeated.
- Generally, transect surveys are used to compare the differences in a particular species between sites. They can be used to monitor changes in populations before and after a baiting programme or to study seasonal and annual fluctuations in bird populations. Transects are not practical if it is difficult to walk through a landscape or the area of interest is too small.

7.2.5 COMPARISON BETWEEN POINT AND TRANSECT COUNTS

From: Gregory R.D., Gibbons D.W. and Donald P.F. (2004).

Transect Counts	**Point Counts**
Suit extensive, open and uniform habitats	Suit dense habitats such as forest and scrub
Suit mobile, large or conspicuous species and those that easily flush.	Suit cryptic, shy and skulking species
Suit populations at low density and more species	Suit populations at higher density and more

poor.	species rich.
Cover the ground quickly and efficiently recording many birds	Time is lost moving between points, but counts give time to spot and identify shy birds.
Double counting of birds is a minor issue, as the observer is continually on the move	Double counting of birds is a concern within the count period especially for longer counts.
Birds are less likely to be attracted to the observer	Birds may be attracted to the presence of observers at counting stations
Suited to situations where access is good	Suited to situations where access is restricted
Can be used for bird-habitat studies	Better suited to bird-habitat studies
Errors in distance estimation have a smaller influence on density estimates (because the area sampled increases linearly from the transect line)	Errors in distance estimation can have a larger influence on density estimates (because the area sampled increases geometrically from the transect line)

7.2.6 TAPED PLAYBACK CALLS

- Taped playback calls – this can be extremely effective at detecting most or all of the birds within the target area – an example is Christmas Island warbler monitoring of trend counts where transect lines each of 10 stations are precise in detecting territorial adults which are very responsive to taped calls of apparent intruders (Pierce et al 2007).

- Case Study of the use of taped playback calls from (Pierce et al 2007)

CASE STUDY OF USING TAPED PLAYBACK CALLS

Used in Bokikokiko monitoring by Wildlife conservation Unit at Kiritimati, Kiribati (Pierce et al 2007)

- A study in 2007 determined that all adults are responsive to tapes during the breeding season and are detected visually or audibly very quickly by the observers (often within

seconds of onset of tape playing).

- Monitoring is undertaken at the start of the breeding season April-May when birds are most territorial and responsive.
- Stations are in areas where black rats have recently invaded and in other areas where no black rats are present to help answer questions about population trends after rats have arrived.
- 10 stations per line.
- Choose days of low to moderate wind speed and no rain.
- Operate during the morning or late afternoon only, avoiding the of midday hours when birds are less responsive.
- Play taped call for 1 minute.
- Listen during that minute and the next minute.
- Record total number of Bokikokiko detected.
- Record age (adult/juvenile) if known.
- Tabulate and graph data.
- Disseminate information.

7.2.7 BREEDING

Has breeding success changed over time?

- This question is less often asked of landbirds than it is of seabirds. This is simply because landbirds tend to be resident and they mature and breed earlier than do seabirds, so population responses above are usually unequivocal. However, if there are still questions of breeding success in relation to other factors e.g. habitat quality, presence of ants, etc, then the same approach applies as per seabirds – either assign all observed birds to an age class and/or follow pairs of birds through the nesting cycle to measure success (fledglings/eggs laid).
- Other approaches include simply using the data in the Bokikokiko example provided above – does the proportion of juveniles in the sampled population change after rats arrive? If there is a negative change in the number or proportion of juveniles then this could be followed up with more intensive nest studies and perhaps involving the control of some rat populations and doing the appropriate nest monitoring.

7.3 LIZARDS AND OTHER SMALL ANIMALS

7.3.1 VISUAL OBSERVATION

- It is possible to develop an index of abundance based on simple observations, e.g. numbers of skinks observed per hour of random searching. Ideally this should be repeated over several consecutive hours per island and repeated at the same time of year in later years.
- For example, at some of the Kiritimati Island lagoon islets where rats were eradicated in 2009, there had been no lizards observed on these islets indicating that they were at best very rare. One year after the rats were removed however, lizards (skinks) were being recorded basking on tree trunks indicating that they were now becoming sufficiently common to be detected. Counting numbers seen per hour during sunny days is a simple way of indexing their abundance on an annual basis.
- Record details of island, date, observer, time, total area searched and weather.

7.3.2 ARTIFICIAL LIZARD SHELTERS FOR GROUND-DWELLING LIZARDS

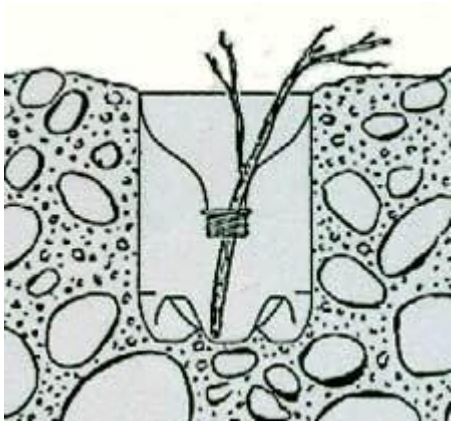
- Lizards and invertebrates adapt well to artificial shelters which can also be used as monitoring stations.
- Onduline corrugated roofing tiles (500mm by 500mm) are made of a bitumen saturated material and are light weight and have suitable thermal properties; corrugated iron sheets also work.
- Lay these out in a series (e.g. 10 stations) on the ground taking care to hide them from view of walking tracks. Spread natural woody material or stones over the sheets so that they do not become too hot in the sun.
- These can be checked seasonally or annually by carefully lifting the cover towards the observer to identify and count the lizards present.
- Record details of location, date, time, observer, shelter type, habitat and details of species and numbers of lizards per shelter.
- It can be useful to initially trial these methods in sites where the target lizards are common to arrive at an optimal sample size (i.e. how many stations are needed).
- These shelters are also being trialled in New Zealand for arboreal lizards (especially geckos) and it may be possible to monitor geckos by this method. However, you should seek advice and also carry out trials with your target species.

7.3.3 SPOTLIGHTING/HEADLAMPS

- Geckos can be detected at night via their eye-shine.
- As with skinks, an index of numbers per hour of searching can be used.
- Individuals may need to be captured to confirm the species.
- Record details as per skinks above.

7.3.4 PITFALL TRAPS

- Animals that enter a pitfall trap are unable to escape and may be killed by the trap or remain unharmed. Pitfall traps can be used to estimate species richness (number of species present) and abundances (number of individuals) and this combined information may be used to calculate biodiversity indices.
- Pitfall traps are either dry or wet and come in a variety of sizes and designs.
- Dry pitfall traps consist of a container (tins, jars, plastic drink bottle or drums) buried in the ground with its rim at surface level which is used to trap mobile animals that fall into it. The openings are partially covered by a sloped stone or lid to reduce the amount of rain and debris from entering and to prevent trapped animals from being drowned (when it rains), overheated (during the day) and this also helps to keep out predators.
- One problem with dry pitfalls is that predatory animals (mammals, birds and larger lizards) can also enter and consume the trapped animals. This problem can be minimised to some degree by providing a refuge area in the form of chicken netting in the bottom of the trap.
- Alternatively, wet pitfall traps contain a solution designed to trap, kill and preserve an animal or several animals. The fluids used in these traps include ethylene glycol or some other alcohol and water mixture.
- One or more fence-lines may also be added which channel targets into the trap. The trap may also be baited to increase the capture rate of a certain target species or group. Place bait or lures in or near the trap. Examples of baits include meat, dung and fruit.



7.3.5 POINT AND TRANSECT COUNTS

- Point and transect counts can also be used to monitor small animals.
- See Sections 7.2.3 to 7.2.5 for details on the techniques.

CASE STUDY OF A LINE COUNT

Used to monitor crab densities on McKean (50ha) and Rawaki (73ha) Islands in Kiribati to help answer questions about crab depletion of rodent bait from Pierce R. 2008.

- 2x25 m transects per island along stratified sampling route
- follow the existing taped transect lines
- use every 4th line and sample every 100m along the line
- use a 25m length of string gently secured at start and when at end of 25m pull in the string before walking to the next sample site
- during the count hold a 2m length pipe or branch in front of you, strings dangling vertically from either end to gauge the 2m width of transect
- count the number of hermit crabs that are over 2cm in body diameter
- count other large crabs separately
- repeat the transects once on Rawaki.
- note that quadrants can also be used but there is greater risk of animals responding positively or negatively to the presence of the observer, so counts maybe biased

- Indigenous and invasive ants can be surveyed using similar techniques:
    - Transect lines in target areas, e.g. dwellings, landing areas and surrounds if surveying for invasives.
    - Paired stations at intervals along a transect line
    - Sugar lure and protein lure in separate stations of the pair
    - Operate in shade if possible
    - Collect before lures completely dry out (this may be less than one hour in hot areas)
    - Preserve in ethanol/formalin for identification using microscope/hand lens.

7.4 VEGETATION

How do plant species and overall vegetation respond after invasive species removal?

- Approaches involve combinations of broad overviews such as species lists, photos, transects/plots, as well as targeting species-specific observations. Examples of these are provided below.

7.4.1 SPECIES LIST

Complete surveys of an island and identify all species found – involves sampling all habitats present.

- This should be repeated every 3-5 years as there may be changes in the species observed – some may be native species and others weeds that require rapid assessment and action.
- An example is at Rawaki in the Phoenix Islands, where 18 months after rabbit removal, the highly palatable kaura or *Sida fallax* suddenly became visible in patches throughout the island. Rodents could have a similar effect. Equally visitors need to be aware of potential invasives, e.g. lantana, that could get a foothold in the absence of mammals.

7.4.2 HABITAT MAPPING

- In some instances where the vegetation has been heavily modified by rats or other pests, it is useful to map the plant zones every 5 years or so as these could change significantly. Use the mapping feature of a GPS and walk the boundaries of the zones and save and map the information.

7.4.3 PHOTOPOINTS

- These can provide good visual information on broad changes over time, e.g. density and height of vegetation.
- Select sites that are representative of the island, but they do not need to be random.
- Preferably select sites that are easily relocated and GPS these sites.

- Take at least 4 standard (55mm) lens photos per site looking N, S, E, W – decide whether you are using true north or magnetic north etc and stick to it.
- It is useful to permanently mark the centre of each of the 4 photos per station and/or take the previous photos into the field to ensure they are consistently lined up.
- Try to take photos at the same time of year, but all photos are useful for little-visited islands.
- Try to take photos in sunny conditions.
- Record island, location, orientation, species present in photo, photographer.
- If possible, photograph comparison (control) sites on a pest-inhabited island with similar habitat (to help evaluate responses to pest removal, tease out effects of weather patterns, etc).
- Send duplicate photographs (electronic preferable) to stakeholders.

Example of vegetation changes revealed by photopoints taken at Rawaki (Phoenix Is) N Point Survey Plaque looking S June 2008 (left) and December 2009 (right)

7.4.4 TRANSECTS/PLOTS

- Often used for specific rare native species, invasive species, etc.
- Establishment of plots requires knowledge of the ecology of the target native species or the invasive species you are eradicating and what plant species they impact upon. For example rats will target many species with fleshy fruits and seeds. Identify 2-3 indicator species (i.e. plant species where rat damage is common) and establish plots containing these species. Ensure you create plots at a number of different locations because factors such as soil condition and exposure may also affect the recovery of that plant species.

- Once the sites have been identified, mark them so you can easily find them again. GPS or a compass is best but they may also be marked on the ground with a peg. The size of your plot will depend on the characteristics of the selected plant species and the type of camera being used. Set up the plot so you can quickly take one or two photos at each site. You might choose to take one photo of the overall plot and one photo of the forest floor to monitor seedling recovery and seed fall.
- Record the species being monitored and any relevant comments such as many seedlings, fruit on ground untouched etc.

7.4.5 FREQUENCY

- This depends on how often you are able to visit the island. Annual monitoring is a good guide as some species may take time to recover. Six monthly may be better for faster growing species. Because photo monitoring is easy to repeat once set up, it can be combined with monitoring visits for other reasons.

7.4.6 EXAMPLE OF PERMANENT VEGETATION MONITORING

Example from First Monitoring Survey of Mabualau Island, Fiji 9-12 December 2008. Seniloli E. for Birdlife International

- PERMANENT VEGETATION PLOT 2
- *Location* S17°58' 28.1'', E 178°45' 24.2'', marked as waypoint 008, Elevation 9.6m, Accuracy 6.1

No	Species	Fijian name	Comment
1	*Scaevola taccada*	Veveda	two trees growing on plot 2
2	*Impomea macrantha*		common
3	*Sesuvium portalucastrum*		common on the edges covering a large area
4	*Pisonia grandis*	Dredre	tree growing
5	*Hibiscus tiliaceous*	Vau	Spreading common vegetation on the south end of the island
6	*Wallastonia biflora*	kovekove	common on plot 2

7.5 SURVEYS FROM SHIPS

- Useful for:
    - Seabird baseline species diversity and relative abundance in different seasons and trends in these statistics over longer periods of time.
    - Monitoring marine mammals and turtles.
- Can provide seasonal comparisons of relative abundance, e.g. three trips to the Phoenix Islands region enabled sampling of relative abundance over 6 months of the year (Pierce at al 2009).
- By restricting the area sampled from a ship it is also possible to determine actual densities of seabirds e.g. in Tuamotu (VanderWerf et al 2004, refer diagram below).

- Also useful at a local level, e.g. this technique was used around the Ringgold Islands in Fiji (Seniloli E. and Rasalato S. 2009) where GPS tracks were run during the course of the trip to survey seabirds at sea. Waypoints were taken every 10 minutes or at every sighting of a seabird.

- Generally there is a need to limit data with basic setup as follows:

    - 8 hours of observation per day divided into one hour blocks.
    - Enter waypoint number from GPS at start and finish of each hour.
    - Enter time start of each hour's observation.
    - Enter species code or 4-letter abbreviation e.g. PHPE = Phoenix petrel, GRFB = great frigatebird
    - Record sea conditions and viewing conditions on 1-5 scales.
    - Enter other relevant details such as bird behaviour; feeding; flock or single birds seen.
    - Take photos or make sketches of any difficult birds.
    - Analyse and graph birds per hour or birds per day and a measure of variation (e.g. SD or SE of the mean).
    - Record and photograph other useful sightings e.g. marine mammals, marine debris and other vessels (the latter especially if you are travelling through a marine protected area).