GUIDELINE FOR MONITORING

PURPOSE

- These Guidelines are to be used by Project Staff conducting invasive species management projects based on the PII Project Process
- The Guidelines describe how to undertake outcome monitoring by measuring indicators to assess the success of the project.
- References can be found in the Reference section of the PII Resource Kit for Invasive Plant Management.

1. TYPES OF MONITORING

- In an invasive species management project there are three types of monitoring:
    - **Project management** (Guidelines on project management monitoring can be found in the Guidelines for Project Managers. Project management monitoring is defined in the Project Governance section of the Project Plan.)
    - **Operational parameters** (Guidelines on operational monitoring can be found in the Guidelines on Planning and Managing an Operation. The detail of the operational monitoring is recorded in the Operational Plan.)
    - **Project outcomes** (The details and work required to monitor project outcomes are recorded in the Monitoring Plan.)

- Outcome monitoring will always include:
    - At least one indicator for each project objective.
    - Monitoring of the presence/absence of the targeted invasive species and other newly invaded species (surveillance*).
    - Monitoring of the outcomes that result from the absence of the target invasive species, e.g. positive (and negative) effects on native species.

NOTES:
*The monitoring used when looking for signs of the target species is referred to as surveillance.

Monitoring can be Qualitative monitoring (visual assessment but can't be measured - based on observations e.g. photo-points), or Quantitative monitoring (this can be measured e.g. marked plots or quadrats where you count actual plants).

2. SELECTING INDICATORS

- Measuring indicators is required so that you can verify and demonstrate that the objectives of the project have been met.
- An indicator is something that is measured that represents the changes in outcomes due to the project and tells you if you have achieved the objectives of the project.
- Select indicators that can be measured before the operation (to give the baseline) and repeatedly after the operation.
- 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:

Plant species	Indicator
Target invasive species	Absence (Eradication) Presence at prescribed density (Control)
Native vegetation	Increase in population of key species Increase in species diversity Increase in diameter at breast height (DBH) of key species

- An invasive plant management project may also be associated with changes in wildlife populations. For example, invasive plants may be covering an area that seabirds use for burrows and removing that vegetation may result in an increase in seabird numbers (as long as predators are not present), or land birds may benefit from an increase in numbers of their food plants.

Bird species	Indicator
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 an outcome monitoring programme that will provide useful information.
- It is important that the people undertaking outcome monitoring are familiar with the biodiversity being measured and are able to repeat sampling in precise and accurate ways (see Section 3.3).

3.1 BASELINES AND COMPARISON SITES

- Establish a baseline measurement for the indicator. Ideally, pre-operational monitoring should be established as a baseline over several years leading up to the operation as this provides a measure of variability in the presence of the invasive(s). Comparing the post-operation monitoring to the pre-operation 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 invasive species management operation.
- Comparison sites are sites that are similar (vegetation, invasive species, native species, etc.) to the operation site, but are not part of the operation. A comparison site (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 that outcomes seen are due to the operation and not due to some other factor, e.g. climatic event.

3.2 CENSUS VS INDEX

- A census is a total count of the indicator. All individuals of a species (mature, juvenile, seedling) on the site 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 an estimate based on a sample of the population. The whole population is not measured, just a sample (a specified amount) 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 an index can be sufficient for measuring population changes, an index derived from sampling is most frequently used in 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 to each other.
- For example, consider two surveys.
    - Survey A. Repeatedly counts the number of plant xx in Forest A.
    - Survey B. Repeatedly counts the number of plant xx in Forest B.

Results:

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

*Standard Deviation

In each forest, the individual measurements are very similar. As the repeated measurements are close together they are considered precise measurements. During the survey period we know the true populations in both forests do not change much.

- Standard deviation (SD) 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 true value we are trying to measure.
- Without knowing the true value it is impossible to know the accuracy of the measurements.
- 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 2,000, then the measurements would be considered inaccurate.
- Sometimes a set of measurements that are precise are (incorrectly) assumed to be accurate.

3.3.3 BIAS

- Bias causes inaccuracy.
- Bias is when the measurements are larger or smaller than the true value because of an underlying issue with the measurement design.
- Consider the two surveys in 3.3.1 above. In survey B, each one 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

- When it is difficult to measure the total value of an indicator, use representative sub-sampling. 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 managed).
- On many sites 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.
- The selected locations should be as similar as possible to most of the project site. Assuming that changes at these locations are representative of changes to the wider population, then sampling 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 mangoes with mangoes.
- The timing of each survey must be consistent. Use a regular event such as the flowering time(s) of a native or invasive plant, but realise that it may be affected by a large number of variables including:
- Time of day.
- Season of year.
- Weather conditions.
- To isolate changes due to the operation, 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 and/or extreme events such as cyclones.
- 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 characteristics 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 new observers not to become biased in future monitoring.

4. REPORTING THE RESULTS OF MONITORING

- Compile a report that is clear, concise, accurate, objective, contains measurable information and includes recommendations for any changes or further actions required to allow the monitoring to be more successful.
- 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 data 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:
    - The location (Site ID or GPS co-ordinates are preferred) of each data sample.
    - The time and date of each data sample.
    - Who collected the data.
    - The weather at the time of the measurement(s).
    - 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. time of flowering.
- Using a standard data collection sheet based on a template is the best 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 tropics.
- When back in the office, transfer all monitoring data to a PC - spreadsheets or databases are good data management tools.
- Check that there are no mistakes in transferring the data from a handwritten sheet to a computer file. It is very easy to record numbers back-to-front, or in the wrong place.
- 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 operation.
- Any surveillance programme needs to be clearly designed and, where possible, done in association with visits to the site. Separate trips for surveillance can be a drain on resources.
- If resources allow, permanent plots or transects can be set up, rather than having random efforts every few months. This option is most likely for sites that are frequently visited and have a relatively high chance of re-invasion.
- For any species targeted for eradication, it is necessary to look for plants for as long as the seed remains viable in the soil. Success of any eradication attempt cannot be declared until the seedbank has been exhausted.
- In long-term control projects, it will be very difficult to find just one or two target plants, especially on large, steep or heavily forested islands. Possible areas of infestation (e.g. seeds carried by wind, water, birds, animals) must be identified early in the life of the project.

What surveillance 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. It is 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.
- Permanent surveillance/monitoring stations (e.g. photopoint sites) must be clearly identified as the exact areas need to be photographed each time.

- If the surveillance is solely to confirm the success or failure of an operation (i.e. there is no intention, ability or resources to implement regular biosecurity programme), it is usually not worth the resources to start any sooner than the time flowering and fruiting of the target species would be expected. For some trees, that may be several years – but you must make sure no juvenile plants were left untreated.

Where should I do surveillance?

- Surveillance should cover any possible habitats on the site where the target plant(s) could grow.

How should I do surveillance?

- Determine what resources in terms of people you have to do the work, the regularity at which surveillance needs to be done and whether you can sustain it for the required period.
- Determine the possible areas for target plants to grow (these may not be just in the areas where they were first found) and use visual observation techniques.
- It is really important for all members of an operational or surveillance or monitoring team to be able to recognise the target plant(s) at all stages of vegetative and reproductive growth – from seed to leaves to fruit and (for trees) including bark.
- A high point, e.g. a ridge-top, can provide a good vantage point for detecting flowering trees or a distinctly shaped canopy.
- Quality, as well as quantity, of surveillance activities is very important. It is much better to have few very thorough surveillance trips than many rushed ones.

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

- It should occur (or be repeated as necessary) for as long as is necessary to allow you to be confident that invasive plant targets have been eradicated, or are being controlled to a specified density - AND to convince others (e.g. donors) that sufficient monitoring has been done to confirm this.
- More surveillance to detect any possible re-invasion should also be 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 succeeded with your management option, but the more time and effort that passes, the more confident you can become.

7. NON-TARGET SPECIES

- Techniques for monitoring native plant species vary widely depending on several factors including:
  - Whether the species is conspicuous and easily counted or more cryptic (difficult to detect)
  - Do you just want to know the diversity of species present, e.g. total number of plant species?
  - Do you want an accurate measure of the total population every few years?
  - Do you just want to know the changes in population numbers over time?
  - Do you want more detailed information on productivity (reproductive success) and perhaps health before and after invasive plants are removed?
- Some useful monitoring techniques for different plants and different monitoring questions are described below.

(**Note:** For information on monitoring animals (birds, lizards, insects) as part of the project, see the PII Resource Kit for Rodent and Cat Eradication.

7.1 VEGETATION

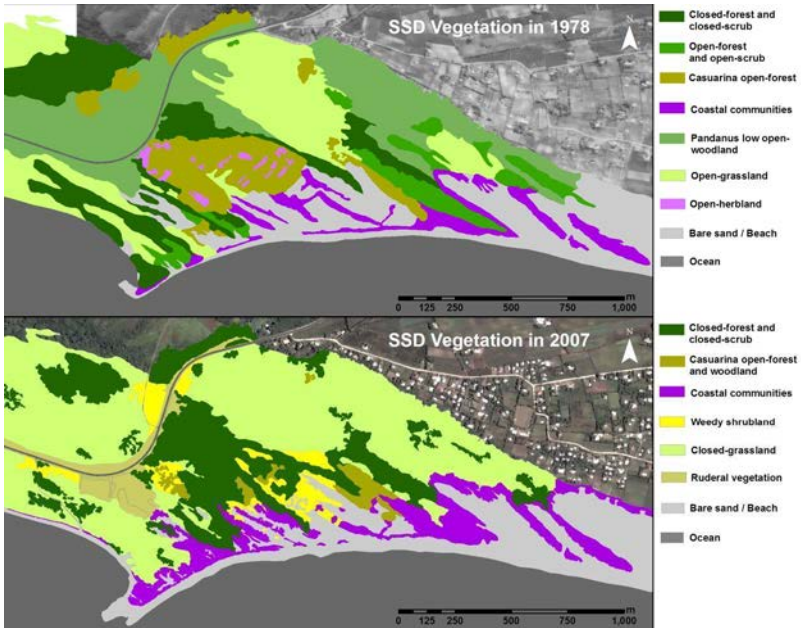
- How do individual plant species and overall vegetation cover respond after removal of invasive plant species?
- Approaches involve combinations of:
  - broad overviews such as species lists,
  - photopoints,
  - transects/plots,
  - species-specific observations.

7.1.1 SPECIES LIST

- Complete surveys of a site and identify all species found – involves sampling all habitats present by either transect or plot/quadrat.
- This should be repeated every 3-5 years as there may be changes in the species observed – some may be native species and others new invasive plants that require rapid assessment and action.

7.1.2 HABITAT MAPPING

- In some instances where the vegetation has been heavily modified by events such as fire or cyclone, 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 unit and walk the boundaries of the zones and save and map the information.



Changes in vegetation cover at Sigatoka Sand Dunes National Park, Fiji, between 1978 and 2007.
(Image courtesy of Shingo Takeda, University of the South Pacific)

7.1.3 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 lens (55mm) photos per site looking N, S, E, W (use a compass and decide whether you are using true north or magnetic north etc and stick to it).
- It is necessary to permanently mark the station at centre of each of the 4 photos and/or take the previous photos into the field to ensure they are consistent each time.
- Try to take photos at the same time of year, but all photos are useful for little-visited sites.
- Try to take photos in sunny conditions.
- Record date, site, location, orientation, species present in photo, photographer.
- If possible, photograph comparison sites in a site with the same (untreated) target species with similar habitat (to help evaluate responses to target species removal, tease out effects of weather patterns, etc).
- Send duplicate photographs (electronic preferable) to stakeholders.
- Because photo monitoring is easy to repeat once set up, it can be combined with site visits for other reasons.

Example of vegetation changes revealed by photopoints taken June 2008 (left) and December 2009 (right) at McKean Island (Phoenix Islands World Heritage Site, Republic of Kiribati). (Photo: Ray Pierce)

7.1.4 TRANSECTS/PLOTS

- Often used for specific (rare) native species, etc.
- Establishment of plots requires knowledge of the ecology of the native species. Ensure you create plots at a number of different locations because factors such as soil condition, exposure and aspect 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 or flagging tape. 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 number of seedlings, fruit on ground untouched, etc.

7.1.5 FREQUENCY

- This depends on how often you are able to visit the site. Annual monitoring is a good guide as some species may take time to recover. Six-monthly may be better for faster growing species.

7.1.6 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	*Ipomoea 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

7.1.7 POINT COUNTS

- Useful for:
    - Number of plant species (diversity)
    - Number of plants of each species (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 plants (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 it is difficult to identify plants throughout the survey area. Also, landscapes may be 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.
- You may wish to clearly identify the point with a plastic tag and the outer limits with flagging tape.

7.1.8 TRANSECT COUNTS

- Useful for:
    - Plant population monitoring.
- Transect surveys along a chosen line (preferably marked with flagging tape) provide a uniform way of counting species, or measuring changes, over time. Usually, a set distance (e.g. 5m) either side of the walked line is observed.
- Transects are walking surveys, and are a good way to monitor plant species because you can cover a lot of ground by walking along the line.
- Generally, transect surveys are used to collect data to compare the differences between pre-treatment and post-treatment periods. This can be used to monitor changes in populations and may be for a particular species or for several species.
- Transects are not practical if it is difficult to walk through a landscape or the area of interest is too small.
- Transects are generally visited regularly (at least yearly) to make sure any changes in an area are being monitored.